

INTERNATIONAL ASSOCIATION OF SEDIMENTOLOGISTS  
HUNGARIAN GEOLOGICAL SOCIETY



# ABSTRACTS

Edited by  
M. Kázmér

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## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

Use of Well Logs as a Stratigraphic Tool in Carbonate Series:  
an example in Southern Iberian Ranges (Spain)

ENRIQUE ARACIL

Instituto de Geología Económica (CSIC-UCM)

SPAIN

Continuous core samples are the best tools used in sedimentological analysis in subsurface regions. For both technical and economical reasons, the substitutes for coring are well logs.

Nowadays well logs are one of the most important tools used by sedimentologists to know the lithostratigraphy and the geometry of rock units of a shale-sand serie in subsurface studies. However, it is well known that changes in log morphology are difficult to explain in a carbonate serie, because diagenetic effects could originate variations in the shape of the curves (Serra, 1973).

The purpose of the present work is: (1) to emphasize the importance of qualitative interpretation of continuous well logs as a stratigraphic and sedimentological tool, and (2) to establish the Cretaceous stratigraphy in Sierra Perenchiza (Perenchiza-1 deep well), unknown because of its lack of outcrops.

Lithology was interpreted from the Composite log: Gamma Ray, Resistivity, Spontaneous Potential, Sonic and Neutron log.

Well logs could be divided into several fragments with the same log response tacking into account small breaks in their trends. Two types of "electro sequences" were determined in these fragments: first order sequences, which represent the general trend of a fragment, and second order sequences, which are small variations within first order sequences.

The establishment of Lithostratigraphic Units defined by Vilas et al. (1982), was performed from this data. The main application of sequential and lithostratigraphic analysis is the reconstruction of the Cretaceous serie in Sierra Perenchiza.

A field log in Sierra Martés, Giménez (1987), has been used to compare the Upper Cretaceous serie between the vertical profile of Sierra Martés and the well log of Sierra Perenchiza. Both lithology and sequences (1st and 2nd order) are quite similar. On the other hand, thickness of Lithostratigraphic Units also analogous in both series, but in some cases (Margas de Chera Formation, Dolomías de Alatoz Fm., Dolomías Tableadas de Villa de Vés Fm. and Dolomías de la Ciudad Encantada Fm.) the thickness in Perenchiza-1 is 10 per cent smaller than in Sierra Martés.

When Composite log quality is good, like in Perenchiza-1 well, and carbonate serie is not anomalous (due to karstification, fracturation, high radioactive minerals content) it is possible to establish Lithostratigraphic Units and first and second order sequences in a well log.

By means of the use of well logs, the Cretaceous serie of Sierra Perenchiza has been determined: Upper Cretaceous is unconformable over Jurassic and its thickness is smaller than Upper Cretaceous in rest of Iberian Ranges because of the situation of Perenchiza-1 well over the Valencian Massif, a paleogeographic threshold (García, 1977).

ACKNOWLEDGMENTS

The author thanks Dr. Vilas and Dra. Giménez, Facultad de Ciencias Geológicas (Madrid) for their invaluable contributions to some aspects about the Upper Cretaceous stratigraphy in SW Iberian Ranges.

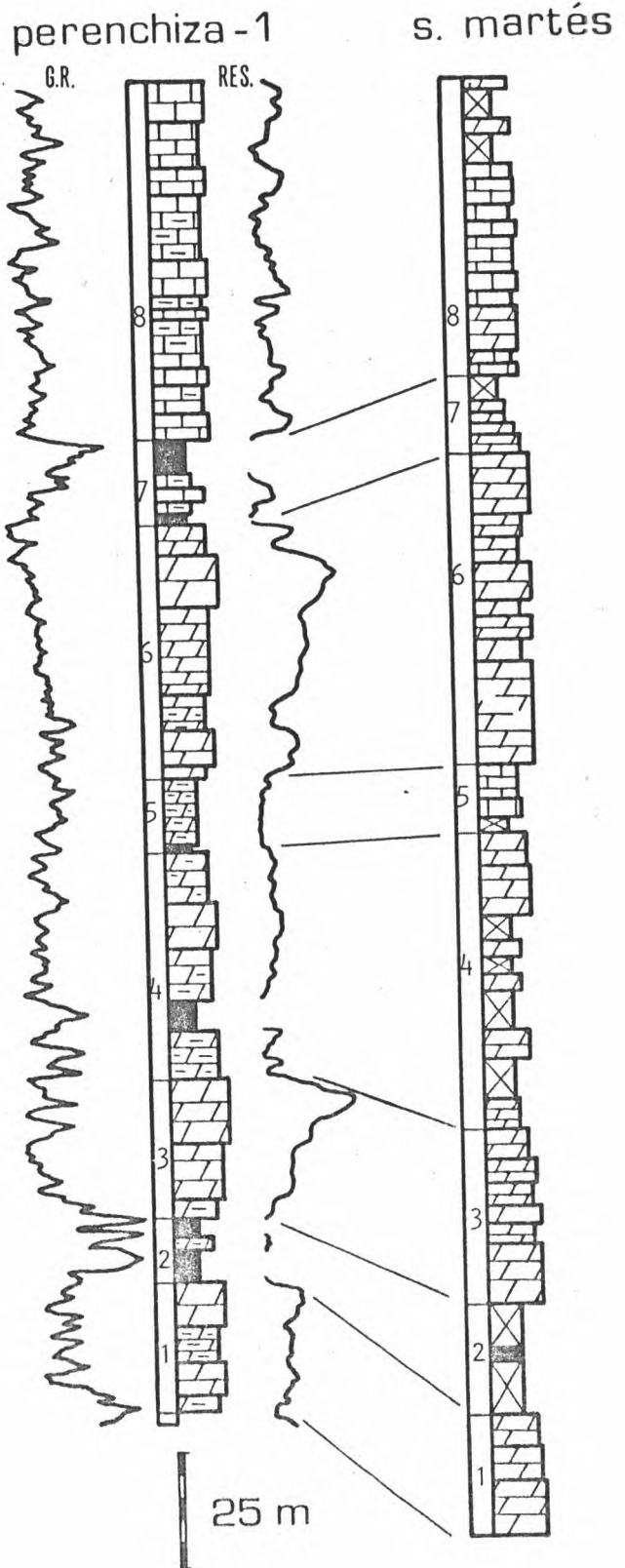
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LEGEND

- 1: CALIZAS DE LA BICUERCA MB.
- 2: MARGAS DE CHERA FM.
- 3: DOLOMITAS DE ALATOZ FM.
- 4: DOLOMITAS TABLEADAS DE VILLA DE VÉS FM.
- 5: CALIZAS Y MARGAS DE CASA MEDINA FM.
- 6: DOLOMITAS DE LA CIUDAD ENCANTADA FM.
- 7: MARGAS DE ALARCÓN FM.
- 8: CALIZAS Y BRECHAS CALCÁREAS DE SIERRA DE UTIEL FM.



10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

Early diagenetic processes in lacustrine and in related flood plain sediments from the Lower Cretaceous (Central Spain).

M.A. ARRIBAS\*, J.C. GOMEZ FERNANDEZ\*\*, & N. MELENDEZ\*\*

\*Dpto. Petrología y Geoquímica. Fac. CC. Geológicas. 28040 MADRID (SPAIN).

\*\*Dpto. Estratigrafía. Fac. CC. Geológicas. 28040 MADRID (SPAIN).

The Lower Cretaceous of the southwestern Iberian Ranges (Spain), is characterized by the installation of many continental systems in a NW-SE oriented trough, in which some Depositional Sequences, controlled by a tectonic of blocks with differential subsidence, were developed.

During the Upper Hauterivian-Lower Barremian, a wide lacustrine system, with related extensive alluvial-palustrine areas, was installed in the studied area (east of Cuenca province, in Central Spain).

The sedimentological and petrological study of the carbonate facies from the lower Cretaceous shows a continental diagenesis. Several early subaerial diagenetic processes have been distinguished: edaphic bioturbation due to roots (vertical prismatic structures); nodulization (at microscopic and macroscopic scale), with clotted textures and nodular structures; brecciation with horizontal and oblique planar fissures formation (skew planes, FREYTET & PLAZIAT, 1982); and marmorization. All these diagenetic processes are related with a generalized pedogenesis development on a previous sediment (limestones, marls or mudstones). Several pedogenetic facies have been identified: limestones with vertical prismatic structures, nodular limestones, brecciated limestones and marmorized limestones. These pedogenetic facies, appear at the top of lacustrine retraction sequences and on flood plain sediments like calcimorphic soils (Fig.), marking phreatic water-table fluctuations. The superposition of early diagenetic processes (pedogenetic processes) within a previous sediment (lacustrine or flood plain deposits) is frequently found, which indicate longer or shorter periods of subaerial exposure.

The timing of subaerial exposure periods (stage of pedogenesis) is analyzed in facies associations by abundance, development and variety of pedogenetic processes. These facies associations are (Fig.):

A) Lacustrine retraction sequences with short periods of subaerial exposure. Only shows a bioturbation processes developed on lacustrine carbonate sediments (vertical prismatic structures).

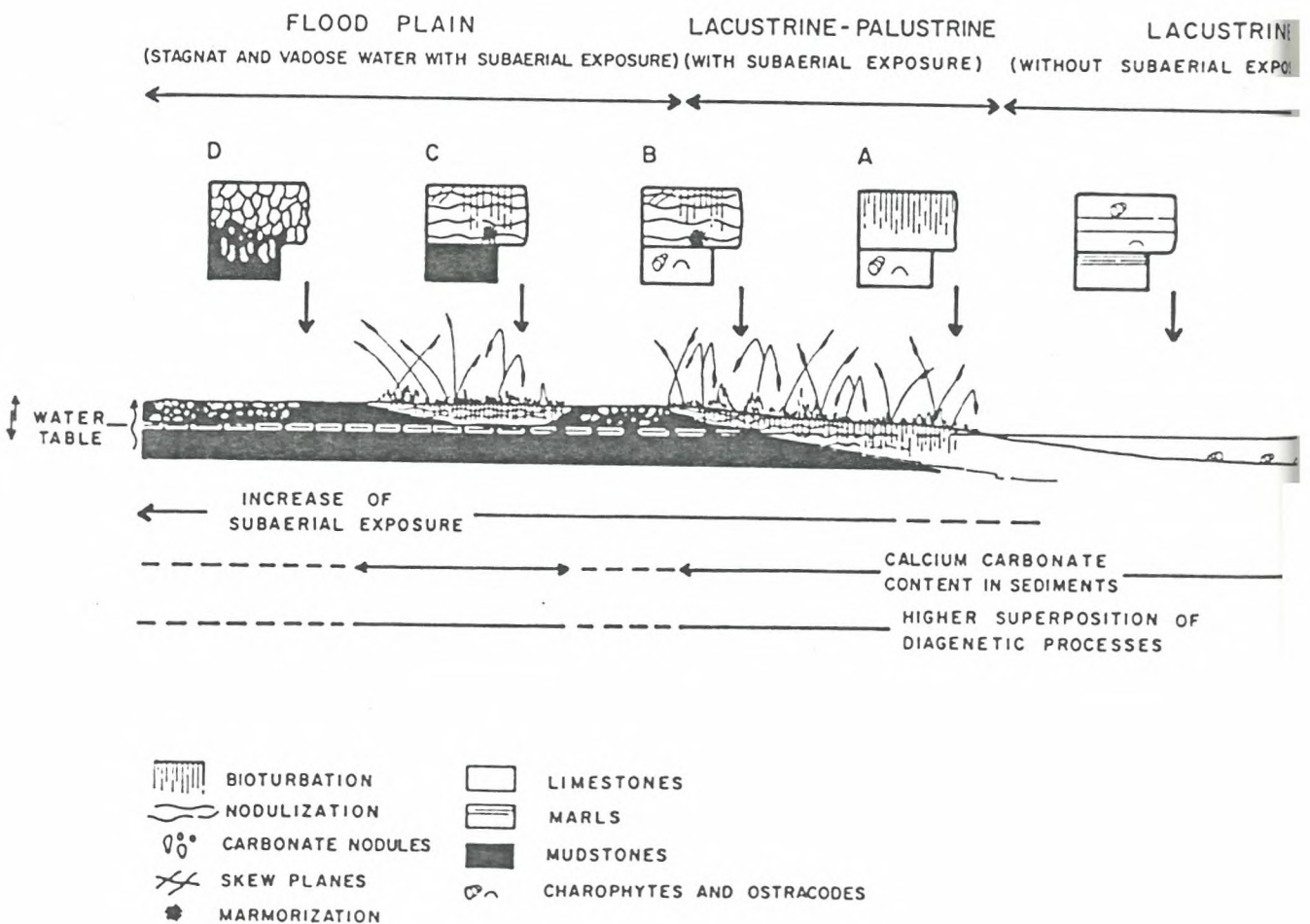
B) Lacustrine retraction sequences with prolonged subaerial exposure. several pedogenetic processes are developed on lacustrine-palustrine carbonate sediments, these are: brecciation, bioturbation, nodulization and marmorization. The prolonged subaerial exposure produces a strong pedogenesis with hypercalcimorphic soil formation (paleosols).

C) Flood plain sediments (mudstones) with stagnant water and prolonged subaerial exposure. A variety of pedogenetic processes are developed on a palustrine carbonate sediment from the flood plain sediments: bioturbation, nodulization, marmorization and brecciation. Pedogenesis is prolonged and continuous in time, and it produces hypercalcimorphic soils (paleosols).

D) Nodules and nodular carbonate levels developed within flood plain sediments (mudstones). In this subenvironment calcium carbonate content is smaller than in other ones (palustrine and lacustrine areas), and it is produced by a pumping evaporation processes of carbonate rich waters above the phreatic level.

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Petrology of the Terrigenous Middle-Upper Albian Series  
(Basque-Coast, Northern Spain)

J.M. BADILLO-LARRIETA\* & F. GARCIA-GARMILLA\*\*

\* Dpto. Estratigrafía, Geodinámica y Paleontología. UPV/EHU. 48080-Bilbao (Spain)

\*\* Dpto. Mineralogía y Petrología. UPV/EHU. 48080-Bilbao (Spain)

The so-called Pyrenean Black Flysch is largely exposed along the Basque-Coast (Bizkaia and Gipuzkoa Provinces). This stratigraphic ensemble is almost exclusively composed by terrigenous sediments of middle-Albian-lower Cenomanian age. To sum up, it has been possible to differentiate several units of the Black Flysch between Elantxobe and Deba towns (BADILLO et al., 1988). Perhaps there are four of them which are particularly propitious for petrologic studies under the microscope owing to:

- a) their grain-size (sandstones and conglomerates)
- b) their mutual lateral and vertical relationships (chronological and geographical) which involve significative age and environmental differences.

These four units are as follows:

1) Name: Ondarroa Conglomerates. Age: middle Albian. Environment: canyon/deep-sea channel complex. Lithology: ortho- and paraconglomerates of siliceous clasts up to 35 cm. in diameter. They are composed by quartz, quartzites, silex, sandstone and mudstone fragments, siderites and rarely calcareous grains. The sandstones (quartzarenites, litharenites, sublitharenites and graywackes) are coarse-grained with normal gradations and siliceous grains (quartz, very fine-grained sandstone fragments, silex and quartzites), but scarce calcareous components (algal bioclasts and several species of orbitolinids). Another characteristic features are the presence of shaly matrix and blocky calcite cement. There are also black carbonate pyrite-bearing organic-rich lutites.

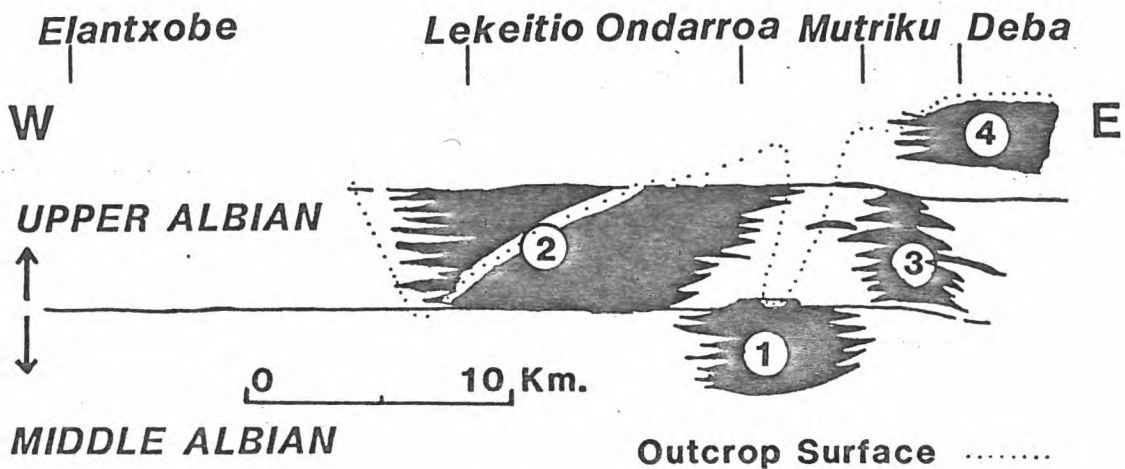
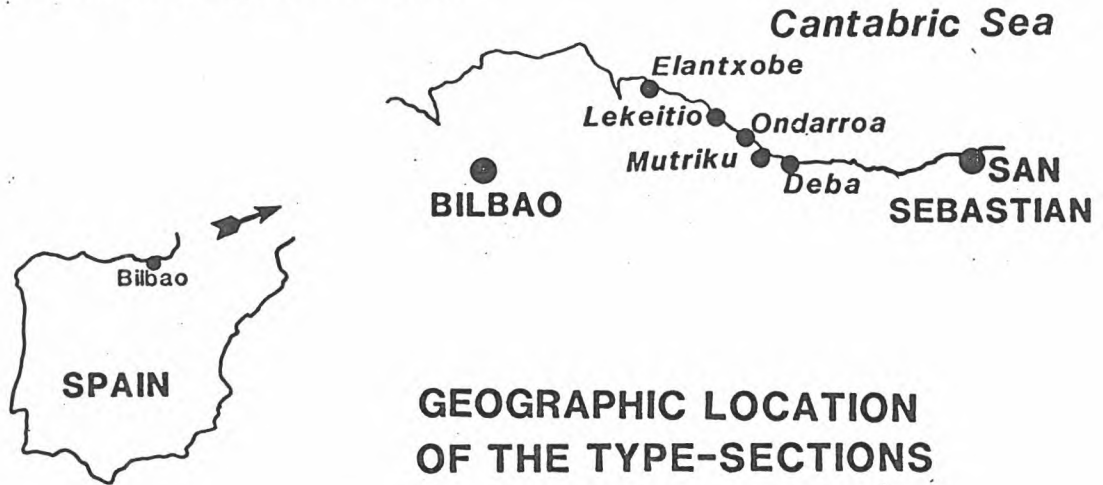
2) Name: Lekeitio Turbidites and Conglomerates. Age: upper Albian (low part). Environment: channel system and deep-sea fan. Lithology: sandstones (quartzarenites) very similar than those of the Ondarroa Conglomerates unit, but the bioclasts and sandstone-lithoclasts are not frequent. On the other hand the argillaceous matrix is relatively rare. The conglomerates are mainly siliceous and their grain-size is only about a few cm. Low-carbonate mudstones are ill-represented in this unit.

3) Name: Mutriku Sandstones. Age: upper Albian (low part). Environment: deltaic-distributary distal bar. Lithology: fine-grained quartz-rich sandstones (quartzarenites, sublitharenites and graywackes) with a few bioclasts. The argillaceous matrix is very frequent and the blocky calcite cement is not uncommon. There are also carbonate organic-rich pyrite-bearing black shales.

4) Name: Deba Turbidites. Age: upper Albian (late). Environment: deep-sea fan. Lithology: well-graded medium-grained siliceous sandstones (litharenites and sublitharenites) composed by quartz, quartzite and sandstone fragments, silex and scarce bioclasts. But the more characteristic

lithological feature is the presence of clasts of volcanic provenance, particularly abundant at the upper part of the unit. The argillaceous matrix and the blocky calcite cement are common. Ill-carbonate mudstones are less-rich in organic matter and pyrite.

The compositional features of the studied units suggest sedimentary dynamics consisting on high-subsidence rythmic tectodepositional episodes. The abundance of sedimentary and volcanic rock-fragments lead us to think in at least periodically rapid burial conditions provoking mineralogical-inmature deposits. On the contrary, the Ondarroa siliceous conglomerates are indicative of important reworking processes and thus a relevant mineralogical maturity.



10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Results of complex sedimentological prospecting of secondary raw  
materials in Hungary

P

P.Badinszky - M.Mészáros - Cs. Szabó  
FTV, Budapest

The round 1 milliard tons of material mass dumped at mine dirt hillocks and on by-product- and waste-heaps in the course of centuries can be found in about 5 thousand objects in Hungary. These include the almost total verticum corresponding to the geological structure in the form of a heterogeneous mixture. The sedimentological features of the material mixtures are influenced also by the short term geological processes and antropogene effects. Taken into consideration that an important part of mine dirt hillocks forms secondary raw material from the point of view of building, agriculture and environmental protection, therefore their detailed sedimentological prospecting and special geological basic qualification became necessary.

The paper informs about the results gained in the course of ten years of the national prospecting directed by the Central Geological Office and in the frame of this about the sedimentological classification and qualification resp. of dump materials.

The Ordovician sediments in the northern Puna of Argentina:  
Correlation of sedimentologic, tectonic and sea level change  
events

HEINRICH BAHLBURG

Institut für Geologie und Paläontologie, Technische  
Universität, Ernst-Reuter-Platz 1, 1000 Berlin 10,  
FEDERAL REPUBLIC GERMANY.

In the southern Central Andes of NW Argentina Ordovician clastics occur in shelf facies in the Cordillera Oriental and as basinal turbidites in the westwardly adjacent Puna highlands. Measurement of detailed sections in the northern Puna (north of approx. 24°30'S) and new finds of graptolites led to more precise stratigraphic dating of sedimentary sequences.

In the Tremadocian, sedimentation in the eastern part of the northern Puna began with a transgressive sequence of quartzarenites and intercalated pebbly mudstones giving way to turbidites. In the western part the oldest fossiliferous rocks occur in the north Chilean Puna in the middle Arenigian Aguada de la Perdiz Formation. This formation consists of an approx. 3000 m thick fining upward succession mainly of submarine gravity massflow deposits of volcanic apron facies. The volcanoclastics were deposited on the submarine flank of a zone of mainly subaerial silicic volcanism. Geochemical features of ash flow tuffs and rare basaltic lavas characterize their source as a volcanic arc, which was located west of the back-arc basin. There is no evidence of active volcanism after the Arenigian.

From the late Arenigian onwards minor amounts of basement and sedimentary detritus, derived presumably from the Cordillera Oriental, reached the basin together with debris of the volcanic arc. A 700 m thick coarsening upward cycle formed during the Arenigian-Llanvirnian transition and was probably connected with the initiation of uplift of the Cordillera Oriental (Guandacol diastrophic phase) and tectonic instability in the volcanic arc domain to the west. However, tectonic activity and high sedimentation rate at this time coincide with a global regression event (Fortey, 1984). Upper Llanvirnian and lower Llandeilian turbidites were deposited in a longstanding composite fining upward cycle although the Cordillera Oriental emerged in the Late Llanvirnian. Ordovician sediments younger than Llanvirnian are not known to occur in the Cordillera Oriental.

During the Llandeilian a thick coarsening upward sequence formed which is not related to any known, distinct tectonic event but is coeval to a world wide regression. It was

succeeded by an even thicker fining upward trend possibly extending into the Caradocian. In the Caradocian the stratigraphic record comes to an end and the approx. 6000 to 7000 m thick basin fill was folded without dominant vergency in the Oclóyic orogeny during the Ordovician-Silurian transition. Parallel to these developments, in the Early Caradocian, a eustatic rise in sea level took place which at the end of the Caradocian and through the Ashgillian gives way to a major world wide regression.

Immaturity and bad sorting of the turbidite greywackes in fining upward as well as in coarsening upward megacycles attest to short transport paths and minor reworking in shelf areas during both cycles. Shelf areas and coastal lowlands were rather small due to uplift of Cordillera Oriental and volcanic arc. Sedimentary trends and sea level changes are primarily related to tectonic instability and uplift of source regions induced by active eastward subduction under the east Pacific margin of Gondwana. The various global regressions most likely complemented the influence of tectonic movements on depositional patterns.

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Cambrian black shale formations of the Siberian  
platform

SERGEY BAKHTUROV  
Institute of Geology and Geophysics  
USSR

1. The conditions favourable for the accumulation of the deposits enriched by the organic matter appeared more than once in the sedimentation basins situated in Cambrian on the Siberian platform. In Early Middle Cambrian the accumulation of carbonate-argillo-silicon sediments occurred in the north-western, northern and eastern parts of the Siberian platform and in the Yudom-Maysky trough. In Taimyr peninsula and Kharaulakh similar deposits were formed in Upper Cambrian.

2. At present time Kuonamskaya black shale formation combining the deposits of Kuonamskaya, Inikanskaya, Shumninskaya, Sinskaya and the upper part of Sektenskaya suites, is the most studied. In the formation composition the argillites enriched by the organic matter, silicon rocks, various limestones and the rocks of mixed composition are widely spread. Its thickness is 40-70m on the average and the estimated area of development is approximately 750 th. km<sup>2</sup>. The main mineral components of the deposits of Kuonamskaya formation are carbonates, clayey material and authigenous chalcocedony. The organic matter often plays the role of the important rock-forming component - up to 50% in a rock.

3. In Kuonamskaya formation three groups of elements are singled out according to their relation to the organic matter: 1) accumulating with the organic matter - Mo, Cd, Bi, V, etc., 2) indifferent to the organic matter - Sc, Sn, Be, Zr, etc., 3) antagonistic to the organic matter - Nb, Sr, Ba, Y, etc. In Kuonamskaya formation three levels with the increased phosphate content are established: between Kuonamskaya formation and underlying deposits, on

the base of the formation and in its Amginskaya part.

4. The formation of Kuonamskaya black shale formation takes place within the zone, occupying the intermediate position between a large salt-bearing basin in the southwest and the open sea of normal salinity in the east, north-east and north. The reefogenous barrier on one side and isolated areas of land, forming the system of isles, on the other side, were the natural boundaries. The accumulation of sediments, enriched by the organic matter, is caused by two factors: high bioproductivity of the sedimentation basins and existence of anoxic environment of sedimentation. The first is explained by palaeogeographical specific features of the Kuonamsky black shale basin. The second could be caused by two reasons. The existence of stagnant benthic waters could be related to untiestuarine circulation of sea waters to the evaporite basin and to the possible mixtures of waters of increased salinity with sea waters and their flowing down the bottom of the Kuonamsky basin. In both cases anoxic environments appeared in the benthic part due to water stratification.

Diagenetical history of Dachstein Limestone in the vicinity of Vác

ANNA BALOG  
Technical University  
HUNGARY

JÁNOS HAAS  
Central Office of Geology  
HUNGARY

Norian Dachstein Limestone in the vicinity of Vác has been investigated with respect to sedimentology, diagenesis, dolomitization and porosity.

Carbonates rich in coated grains (ooids, oncoides, grapestones) were accumulated in the high energy outer shelf zone.

Due to diagenetical processes took place in several phasis composition, texture and porosity of the primary sediments significantly changed as a rule.

In the early diagenetic phase carbonate grains were cemented under marine phreatic condition. Due to dissolution of Mg-calcite and aragonite vugs and molds were formed. In the deep burial i.e. anadiagenetic phase pores and cavities were filled by coarse sparite.

Dolomitization was partly syndiagenetic but mainly anadiagenetic and could be influenced by hydrothermal processes as well.

Dedolomitization and formation of calcitic infillings in the fissures could be taken place in the epidiagenetical phase.

## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY – BUDAPEST, 1989

Clay mineralogy of the lutites of the Peraltilla Formation (Oligocene, NE Spain)

BASTIDA, J.\*, MACIAS, I.\*\*, ESTRADA, R.\*\*\* & RAMPONE, G.\*\*\*\*

\* Dpto. Geología. Universidad de Valencia

\*\*\* Dpto Geología. U.A.B.

\*\* I.E.S. Pau Picasso. Terrassa

\*\*\*\* Avda. Verge de Montserrat, 180. Barcelona

The Peraltilla Formation is a succession of Early Oligocene age, cropping-out in the south of the Sierras Marginales that represent the frontal part of the South-central Pyrenees overthrust.

Previous studies of facies( Macias 1985, Macias et al. 1986 and Macias et al. in press) have allowed to interpretate the materials of the Peraltilla Formation as deposits characteristics of the distal front of a wet fluvial fan.

The lower part of the stratigraphic succession consists mainly of sand beds with climbing ripples, included in flood silts and lacustrine and palustrine limestones. In the upper part, these materials are not so frequent while multistorey, lower sinuosity paleochannels appear, increasing their size upward. This vertical evolution indicates a progradation of the system, due to the tectonic uplift of the Sierras Marginales.

A selected sampling of the finest materials of the Peraltilla Formation has been carried out in order to know their mineralogy.

The observed clay mineral assemblages in lutites are: illite + chlorite ± kaolinite ± mixed layer chlorite-smectite ± smectite.

Quartz, calcite, hematite (± siderite ± gypsum ± pyrite) are present as non clay minerals. Analcime is sometimes found.

Illite is the major component of the clay fraction; there are also mixed layer illite-vermiculite and illite-chlorite. Illite and kaolinite are detritical minerals.

Chlorite-smectite interlayer content increases when chlorite content decreases so there could be a genetic relation between them because chlorite is a detritical but unstable mineral (Velde, 1985).

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Major erosional discontinuities in the Numidian flysch of Tunisia

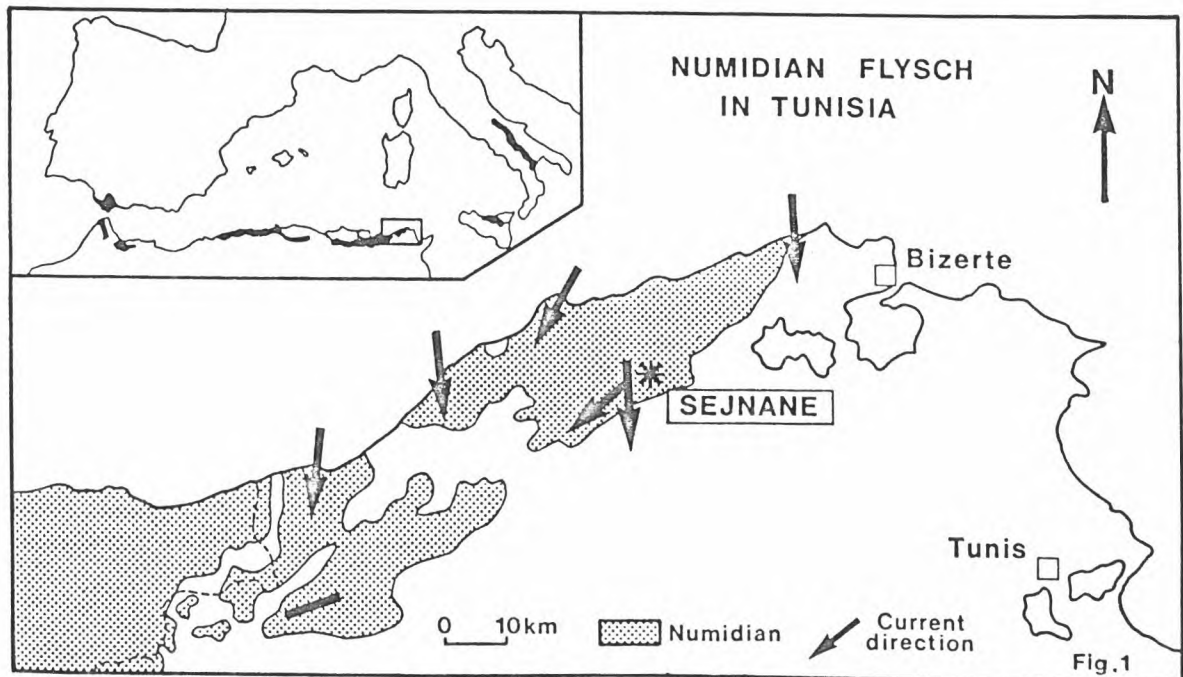
Bernard BEAUDOIN, Chokri EL MAHERSSI  
Ecole des Mines de Paris  
C.G.G.M.-Sédimentologie  
35, Rue Saint-Honoré  
77305 Fontainebleau cédex  
FRANCE

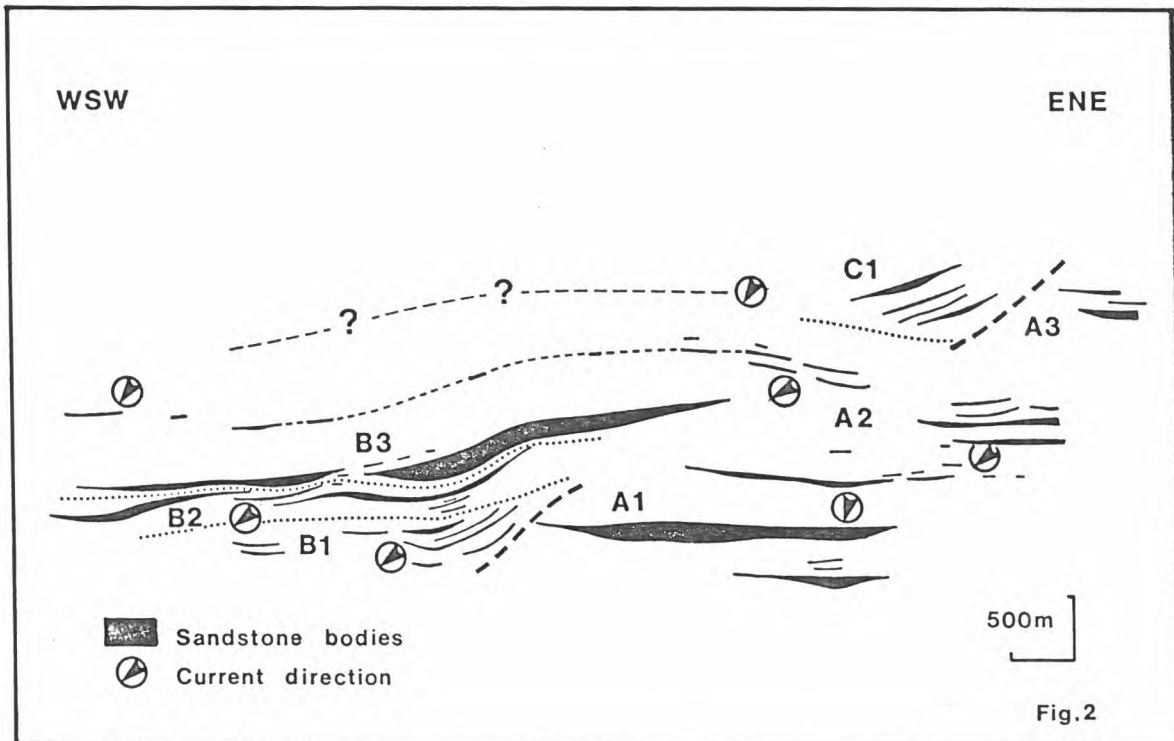
The Numidian flysch appears as a Nappe overthrust on Paleocene and Cretaceous series, from NW to SE, during Upper Miocene. That thick Oligocene-Miocene formation is well exposed along the northern coast of Tunisia and also in land : in all points current directions have been measured by sole marks, indicating a general N --> S orientation (fig. 1).

In Sejname area the sandstone beds influence strongly the morphology : these elongate lenticular bodies are up to 150 m thick, and of hecto-to kilometeric length ; they are intercalated in brown shales, and represent less than a quarter of the total thickness ( $\cong$  3000 m). They are formed by stacked turbiditic and fluxoturbiditic sequences.

A first detailed mapping of part of Sejname area allowed to identify more than 50 of these sandy lenses on a 4 km x 8 km surface ; each one has been followed and characterised in terms of geometry, facies and current direction. After rotation of tectonic dips, correlation and reconstruction of the sedimentary columns by both direct information and geometric reconstructions, a N.NE-S.SW profile may be drawn which concern about 2500 m of sediment along 8 km.

The first evidence is that sedimentation was not continuous, but interrupted by successive erosional surfaces which separate sedimentary units.





Two of these surfaces may be easily drawn : between  $A_1$  and  $B_1$ , and  $A_3/C_1$ . Other relations are more hypothetical. These two surfaces present the same characters : the underlying unit is made of horizontal sandy bodies while the overlying one shows smaller bodies dipping southwestward ( $20 - 30^\circ$ ). When considering the entire succession, two groups of units may be distinguished : in the eastern part ( $A_1, A_2, A_3$ ) sediments appear horizontal, and current direction is southward ; in the western part ( $B_1, B_2, B_3, C_1$ ) the sandstone beds are grouped in prograding (westward) systems, dipping also westward, with current directions (sole marks) towards W - S.W : these units are some hundreds meters thick, and some kilometers long.

What may represent such an organisation ? These patterns of erosion (800-1000 m when decompacted, or more), onlap and progradation during the shaly-sandy turbiditic sedimentation of the Numidian flysch (Up. Oligocene - L. Miocene) represent major events that may record, in that basin, variations of sea level. Before correlations at global scale, we have to recognize these erosional discontinuities in other W-Mediterranean sections and to identify and date the major ones. Nevertheless it gives immediately new guides for the analysis of that part of the basin,

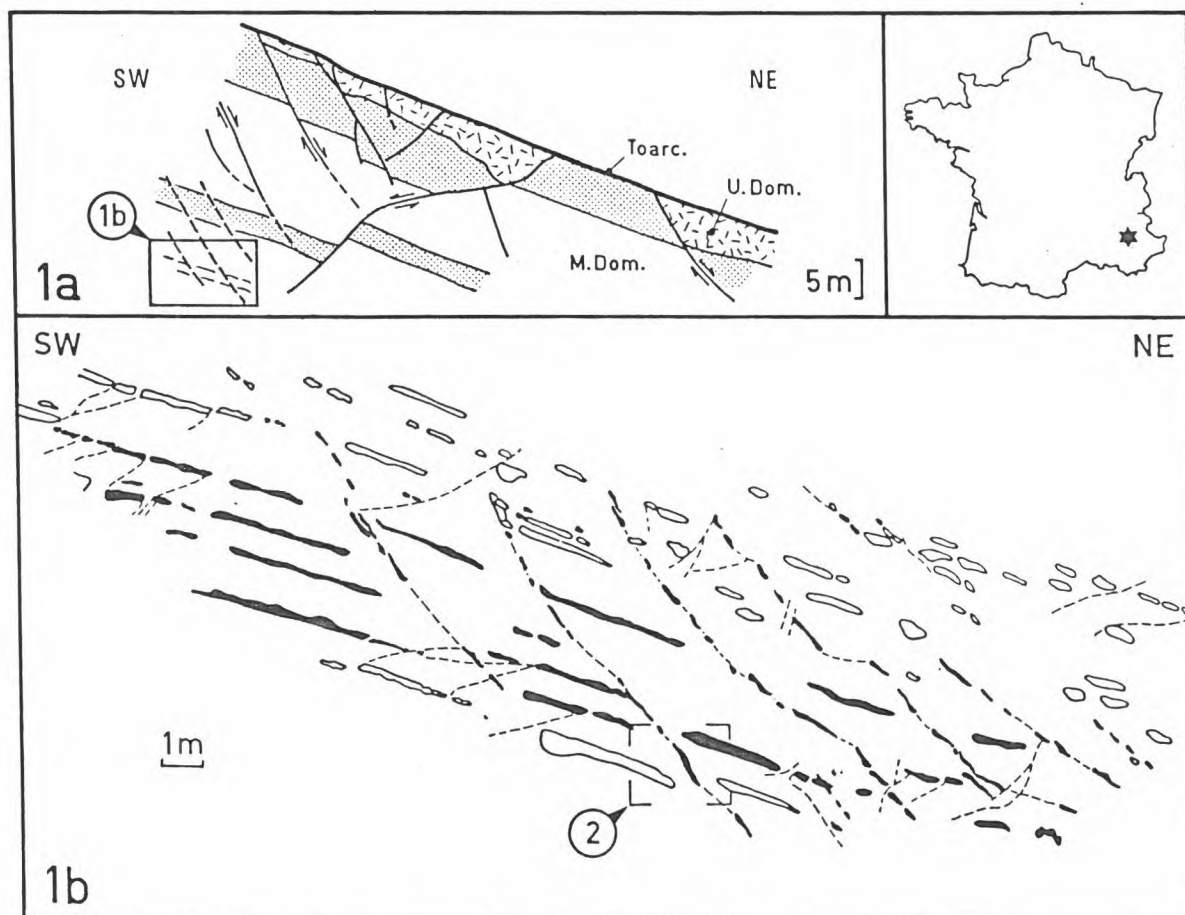
10 Th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

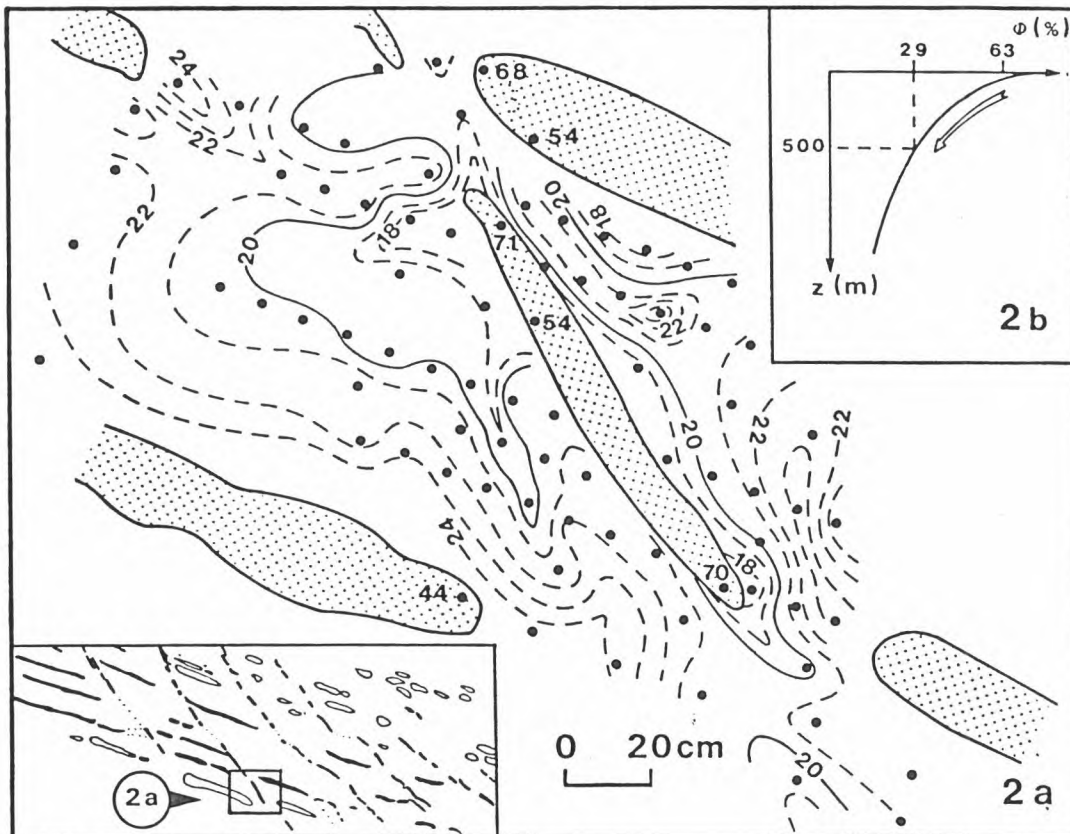
Bedding and pseudo bedding in alternating limestones and marls :  
origin and age in Middle Domerian, S. France

Bernard BEAUDOIN, Jérôme MAILLART, Daniel MERCIER  
Ecole des Mines de Paris, C.G.G.M. - Sédimentologie  
35, rue Saint-Honoré, 77305 Fontainebleau Cédex  
FRANCE

The well known "Clue du Vançon" outcrop, E of Sisteron, presents evidences of Domerian and Toarcian faulting, examples of active synsedimentary tectonics in that part of the Tethys (fig. 1a). Precise observation of the Domerian marls leads also to new ideas on the origin of bedding in such type of sediment.

A simple description as "marls and interbedded nodular limestones" could not be here sufficient ; the best part of the exposure shows in fact a double system of calcareous nodules (fig. 1b). The first one is roughly parallel to the general bedding : the elements are arranged in rows, but present different sizes and spacing. The second system cut the previous one at high angle (up to 45°) and is made by lines of discontinuous nodules ; moreover the envelopes of the nodules sets of the first family are also parallel to the second one. In some places the similarity between the two networks is such that it is impossible to determine the true bedding.





Following the geometry of the oblique lines of nodules, it appears that the dip depends of lithology, looking as some refraction : the lowest dip values are observed in zones devoid in nodules. So that this seems due to differential compaction between the two facies. An hypothesis of plane geometry for the oblique lines leads to a compaction ratio of 1,8 ; decompaction gives then a very simple network for the nodules, disposed according four directions (tectonic dip rotated) : horizontal, vertical, two oblique planes at  $45^\circ$ . The last two ones are exactly parallel to the faults in the limy Upper Domerian level (fig. 1a).

All this means that all nodules are diagenetic (bedding and oblique bedding), formed during compaction processes. Calcium carbonate distribution allows to precise the nodulization timing. As often, carbonate content maps present high heterogeneity (fig. 2a) : both nodules and marls show important contrasts, reflecting :

- a continuous evolution in nodules along burial, recorded by porosity (carbonate values from 71 % to 44 % correspond to  $\phi = 63\%$  up to  $29\%$ , *i.e.*  $z$  from 50 m to 500 m, fig. 2b).
- "pumping" of  $\text{CaCO}_3$  from marls to nodules, shown by depleted/halo around the nodules : here also different orientations can be observed, the earliest being rotated by compaction.

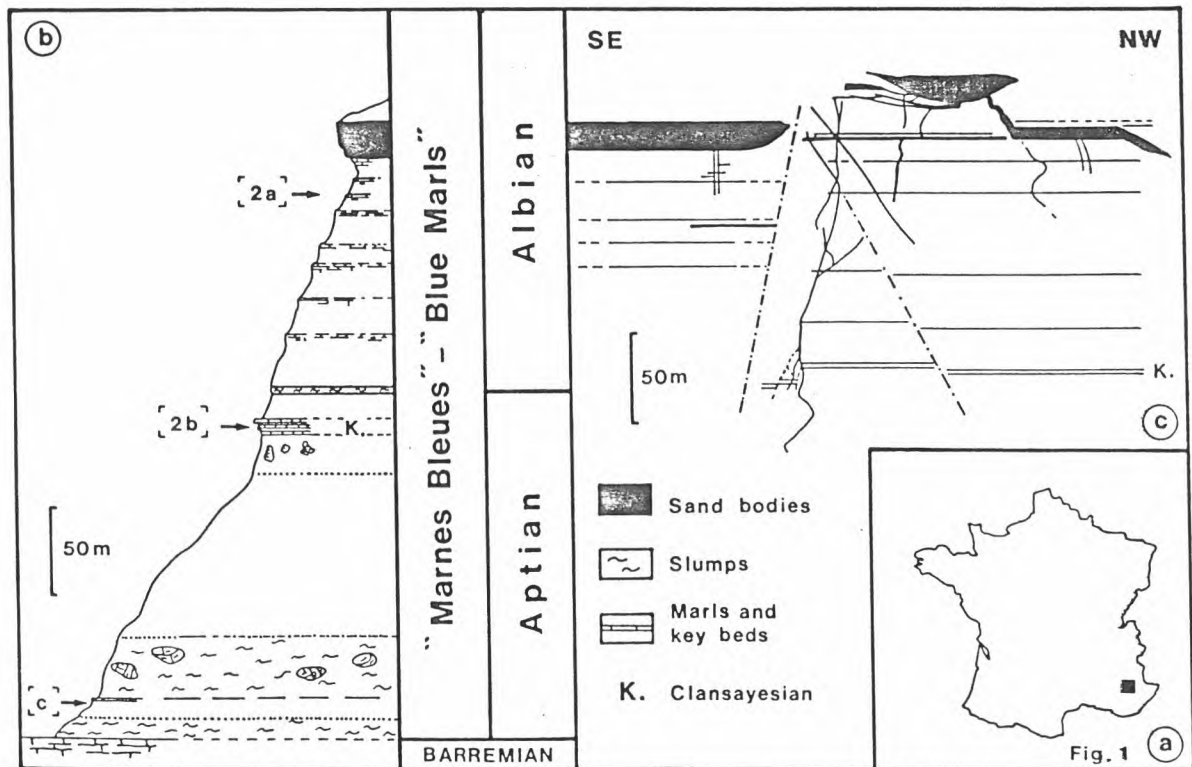
Other exposures of the Domerian marls present the same phenomena : it can so be proposed that carbonatation take place along burial, beginning early (some meters or tens of m.), by an internal migration of carbonate governed by anisotropy of the sediment, *i.e.* gravity and cleavages related to tectonics, morphology ... Simple bedding is then a very simple case where only gravity was present.

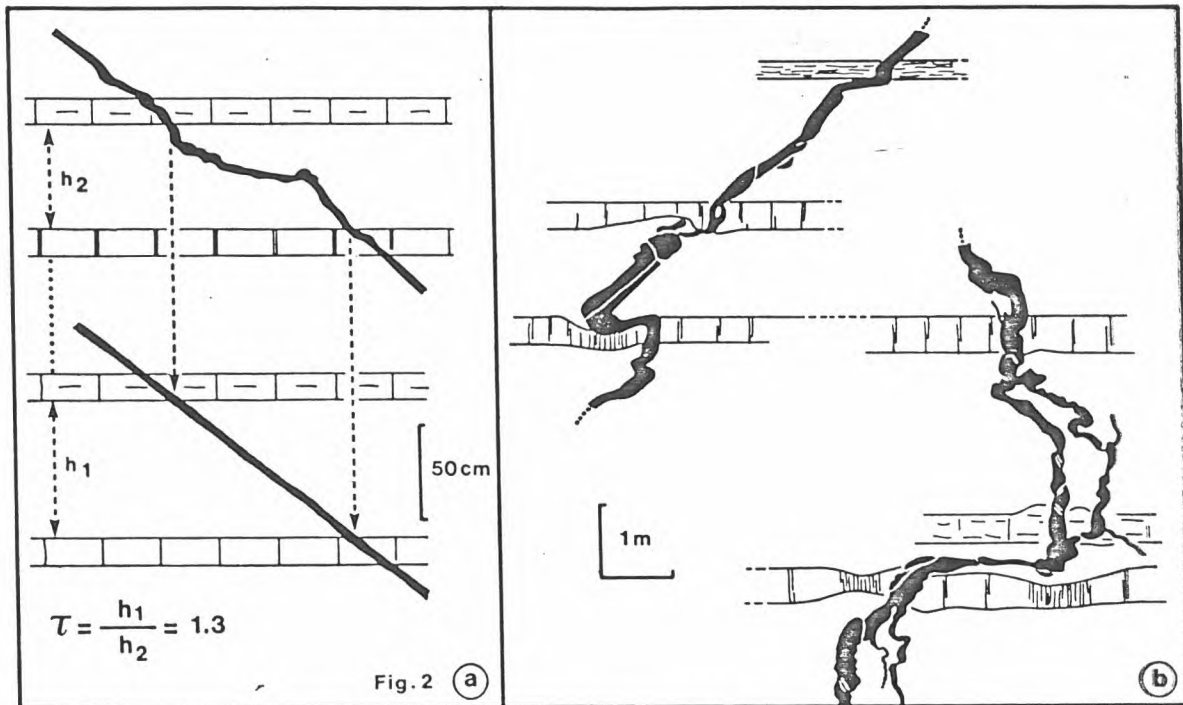
Differential mechanical behaviour during diagenesis and compaction in an alternating marl-limestone formation.

Bernard BEAUDOIN, Olivier PARIZE  
 Ecole des Mines de Paris  
 C.G.G.M.-Sédimentologie  
 35, Rue Saint-Honoré  
 77305 Fontainebleau Cédex - FRANCE

Numerous sedimentary sandstone sills and dykes cut through shales, slumps and intercalated sandstone beds in some turbiditic formations. They have been studied in the marl-limestone Lower Cretaceous "Blue Marls" (Marnes Bleues) of the Vocontian basin in the western part of the northern margin of the Alpine-Tethys sea. Bevens sections, near Sisteron, South-East of France (Fig. 1a), allow to illustrate the "Marnes Bleues" succession (300 meters thick). This pelagic formation is disposed at the top of the Barremian limestone, occurring upon a lower Aptian discontinuity (hardground, debris flow deposit). Upward it is mainly marly with interbedded slumps and turbidites. The Clansayesian limy beds (fig. 1b, K) underline the evolution to Albian marls where calcareous beds are more frequent up section ; the very top of Bevens sections is capped by thick channel-filling turbiditic sandstones (Fig. 1b).

Contemporaneously a complex network of horizontal, oblique and vertical syndimentary joints was also fossilized by a downward injection from these "in situ" sandy sources. Clastic sills and dykes communicate and so divide the marly massif into blocks. The width of the dykes is usually less than 1 meter but locally may reach 3 meters. Sills may exceed 5 meters in thickness and several hundred meters in lateral extension covering up to tens of square kilometers. The depth of penetration below this source is of the order of 30 meters for the sills and 250 m for the dykes as measured on the Bevens outcrops, without decompaction (Fig. 1c).





Burial of sediment leads to mechanical compaction with diminution of initial thickness **mostly** by lost of porosity. The dykes are often folded in a ptygmatic fashion, while the sills and some dykes are little deformed and behave as pillars in the series. These occurrences allow direct quantification of the post-injection compaction ratio of the marly sediments which ranges between 1.2 and 2.8. These **direct** measurements permit to determine the compaction law from the sea-floor to a depth of 400 meters just before the sand injection.

Decompaction is necessarily to study clastic dyke geometry i.e. joint geometry at time of sand injection (Fig. 2a). Immediately below the Upper Albian sand-source, i.e. just below the sea-floor, **clastic** dykes cut through Albian deposits, marl or calcareous shale and limestone, with continuous dip and **trend**.

When they reach a depth of 100 to 150 meters, when they cut through the upper Aptian **deposits** (Clansaysesian) these dykes underline the marl-limestone contrasts : refractions, dichotomies, differential compaction rates, anastomosis, thickness discontinuities are very frequent (fig. 2b).

Some clastic dykes (connected with Upper Albian sand source) cut through Lower Aptian **marls** ; they are not compacted and fossilized a simple network of vertical and 45° dip joints (fig. 1b, c).

What does such a vertical evolution reflect ?

- Variation of compaction rate along the first 400 m below sea floor.
- Mechanical progressive differentiation with burial between marls and limestone ; **one** may suggest that this is due to carbonate transfer during diagenesis/compaction.

Ann Occurrence of Badenian Rhyolitic Volcanoclastic Rocks in  
the Middle Part of Dilj Mountain (Eastern Croatia)

MIRKO BELAK, DAVOR PAVELIĆ and MILKA SARKOTIĆ ŠLAT  
Institute of Geology, Yugoslavia  
41000 Zagreb, Sachsova 2

The aim of the paper is to present data on sedimentology and petrology of Badenian pyroclastic rocks from Dilj Mt. Polyphase volcanic activity, which took place in the area of Dilj Mt. during the Badenian, controlled paleoenvironmental changes and thus essentially influenced the growth of biolithite bodies. Carbonate rocks with red algae and/or corals as reef-forming organisms were deposited during the calm periods. By contrast, the periods of volcanic activity gave rise to a larger influx of volcanoclastic materials stopping the growth of reefs.

It is of a particular petrological and sedimentological interest a bed of poorly cemented monomictic gravel which occurs in lower parts of the lithostratigraphic column Zdenci-I. (Šparica et al., 1988).

Very sandy conglomeratic bioclastic limestone grades into poorly cemented monomictic gravel. All its examined fragments and insoluble residue of bioclastic limestone (solved in dil. HCl) is of rhyolitic composition. The following rocks were determined: spherulitic rhyolite, aphyric alkali feldspar rhyolite, slightly porphyritic alkali feldspar rhyolite and crystallovitrophyric rhyolitic tuff.

The chemical composition is documented by six chemical analyses and petrochemical calculations. They are highly silicic rhyolites characterized by a high content of  $\text{SiO}_2$  ranging between 71% and 76%, low content of  $\text{FeO}^x$ , MgO and CaO and comparatively high content of alkalis, commonly with potassium predominant over sodium.

Very similar highly silicic alkali feldspar rhyolites occur in Upper Cretaceous bimodal volcanic association in the neighbouring Požeška gora.

Mineral assemblage of rhyolite varieties mentioned above includes: quartz, K-feldspar (sanidine-orthoclase), albite, chlorite, sericite and magnetite.

Modal mineral composition varies for some samples depending on the degree of devitrification of glassy groundmass. In the first published paper dealing with

Badenian volcanic activity of Dilj Mt. (Pamić et Šparica, 1988) it was emphasized its synsedimentary character. New additional informations on products of Badenian volcanic activity, with the possibility of correlation of some localities, would make possible the explanation of mutual facies relationships in the Badenian of northern Croatia and the Pannonian basin, respectively.

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10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
 SEDIMENTOLOGICAL CHARACTERS OF THE PLEISTOCENE GRAVELLY-SANDY  
 BEACHES IN THE SURROUNDINGS OF ROME, ITALY

P. Bellotti\*, U. Chiocchini\*\*, N. Cipriani\*\*\*, S. Milli\*

\*Dipartimento di Scienze della Terra, Università di Roma  
 "La Sapienza", Italy

\*\* Facoltà di Agraria, Università della Tuscia, Viterbo, Italy

\*\*\* Dipartimento di Scienze della Terra, Università di Firenze,  
 Italy

The Pleistocene clastic deposits outcrop extensively in the hill area between Rome and the tyrrhenian coast. They have been intensively studied from the bio and chronostratigraphic point of view but their physic stratigraphy and facies analysis is practically unknown. The analyzed clastic deposits constitute the upper portion of the Sicilian-early Middle Pleistocene Ponte Galeria Formation which consists of a 40m thick complete transgressive-regressive cycle.

Two cuts in a quarry with a roughly parallel and normal trend to the ancient shoreline (ENE-WSW) allowed to recognize the following lithostratigraphic and environmental succession (Fig.1) from the bottom:

- 1) two meters thick sandy pelites and fine sands with even to parallel bedding and rare hummocky cross-bedding. Sands show poor bioturbation, pebbles alignments along bedding planes and even to low angle lamination often gradind upwards to wave ripples laminations. The above laminations are interpreted as due to decreasing phases of storm events. Erosional troughs connected to rip currents are filled by medium to coarse sands with oblique-planar lamination interpreted as longshore bars (lower shoreface deposits);
- 2) five meters thick medium-fine and medium-coarse sands interfingering with gravelly beds. The whole sequence shows an offlapping geometry. Foresets dipping up to 15° are characterized by tangential contact on the underlying deposits. Sands and gravels interfinger downslope. Gravels constitute lenticular bodies with an erosional base and consist of spheroidal pebbles with abundant sandy matrix. Sands show an oblique-planar lamination dipping landwards. This depositional setting is probably due to storm events respectively during their acme and decreasing phases (upper shoreface deposits).

Foresets become richer of sand upslope, are laterally continuous and texturally omogeneous. Pebbles constitute thin

levels and show an oblate to prolate shape with imbricated fabric dipping seawards. The whole sequence is truncated upwards by an erosional surface with a pebbly lag (foreshore deposits);

- 3) beds of medium-coarse sands and gravels with a thickness of 4m lying above the erosional surface. In the section normal to the shoreline, gravelly beds show parallel to even-concave geometry with erosional base. The gravelly even-concave beds are interpreted as longshore bars filling rip channels with oblique trend to the shoreline. Sands show a parallel to oblique-planar lamination dipping landwards (upper shoreface deposits).

The above mentioned sequence grades upwards to sands with frequent bioturbation (probable foreshore deposits) and lagoon pelites followed by volcanoclastic deposits of the Sabatino volcanism.

The depositional setting of the whole succession is due to reworking of fluvial and deltaic deposits by waves. Storm events played an important role in this context. The erosional surface constitutes a ravinement surface connected to eustatic control and/or tectonic event. It separates an underlying depositional motif characterized by a regressive phase from an overlying depositional motif characterized by a transgressive-regressive phase which recorded fluctuations of the shoreline.

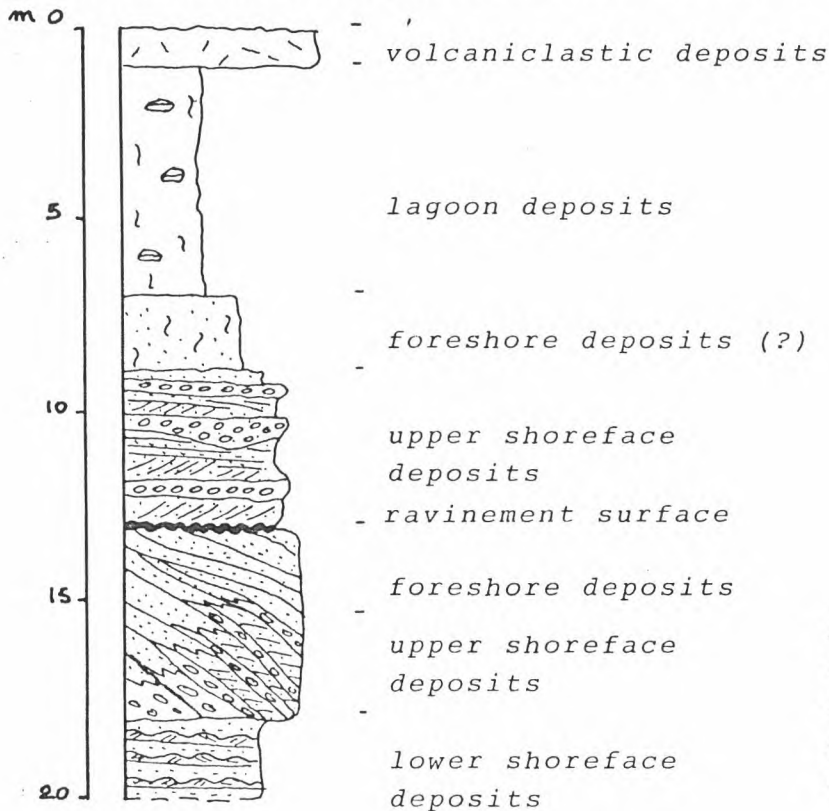


Fig.1- Log showing the general depositional trend of the gravelly-sandy deposits.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Sediment-geological experience of mineral raw material  
prospecting for the building material industry

P

Z. Bernáth - F. Tarnóczy  
FTV, Budapest

The FTV Consulting Engineering has been dealing with geological prospecting of raw material for the stone-, gravel-, lime- and cement-industry since more than 30 years. The prospecting results and their modern geostatistical evaluations have indicated several, often surprising sediment-geological relations. The sediment-geological experience could be utilized in the direction of the geological prospecting work, as well as in the preparation of mining activity.

Lacustrine fan-delta deposits of the Plio-Pleistocene Valdarno Basin, Italy.

PAOLO BILLI, MAURIZIO MAGI and MARIO SAGRI  
University of Florence  
ITALY

The Valdarno is an intermontane basin located 30 Km southeast of Florence. It has been filled with Middle Pliocene to Pleistocene fluvio-lacustrine deposits belonging to three distinct sedimentary cycles (Abbate, 1983). The first one consists mainly of lacustrine shales (Middle Pliocene Castelnovo Group) with interbeds of lignite levels which are industrially exploited. Such deposits are unconformably overlain by the fluvio-lacustrine sediments of Lower Pleistocene Montevarchi Group which makes up the second cycle and is followed by Middle Pleistocene Monticello Group (Billi et al., 1985). The latter consists of coarse-grained low-sinuosity river deposits (Billi et al., 1987) and represents the third sedimentary cycle through which the complete infilling of the basin occurred. The basin was bounded by lacustrine fan-delta and alluvial fan systems which gave way to coarse gravel and sand deposits (Pratomagno Group) whose thickness partly reflects the fast uplifting of the basin margins. The fan-delta and the alluvial fan deposits are marginal with respect to those of the second and the third cycle respectively.

Object of this presentation is the facies analysis and interpretation of the lacustrine fan-delta deposits.

The very proximal subaerial portion is characterized by disorganized, very coarse conglomerates with abundant sandy matrix; the prevailing sedimentary process is mass flow (debris flood and subordinately debris flow). Downcurrent, such disorganized conglomerates make lateral transition to sequences of channellized conglomerates overlain by structureless coarse sand and silt intensely bioturbated and pedogenized. The conglomerate beds are either massive or trough cross-stratified and generally display distinctive imbrication. They have been interpreted as braided channel deposits.

The fan-delta transitional zone is characterized by channellized bodies included within massive mud deposits intensely bioturbated and rich in organic matter. The channel fill consists of trough cross-bedded pebbly sand and massive silt intensely bioturbated and locally pedogenized. Such sediments have been interpreted as deposited by braided distributary channels migrating on a mud flat intermittently subjected to shallow water conditions.

The distal, subaqueous portion of the lacustrine fan-delta consists of massive mudstone, rich in organic matter, graded or planar cross-laminated sands and channellized, trough cross-laminated pebbly sands arranged in upward thicke-

ning and coarsening sequences, two meters thick on average. These sediments are interpreted as mouth bar deposits laid down in the lake at the channel outlets.

The Pratomagno fan-delta deposition was largely controlled by tectonic uplifting of the basin margins. Such sedimentary system prograded in a very shallow palustrine/lacustrine environment commonly subjected to water level fluctuations connected with Pleistocene climatic variations.

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Facies environments of epicalcedonian intercontinental  
carbonate basins (USSR)

VLADISLAV BLAGOVIDOV

Institute of Geology and Geophysics  
Siberian Branch of the USSR Academy  
of Sciences  
USSR

The basins continued to epicalcedonian "intermountain" depressions occupy a special place among varied marine intercontinental sedimentation basins of the past. A wide development of terrigenous sediments in these basins defines the peculiarities of paleotectonic and paleogeographic position. At the same time the carbonate sequences sometimes of considerable thickness are a compulsory member of sequences of facies of depressions. The examples of this are known in the composition of sedimentary series of Minusinskaya, Chebakovo-Balakhtinskaya and Nazarovskaya depressions of the Altai-Sayan folded region and also Chu-Sarysuiskaya, Dzhezkazganskaya and Tenizskaya depressions of Central-Kazakhstan folded region.

As a rule, sedimentation in these basins occurs against the background of prolonged developing transgression. Maximum of the transgression fell on the epoch of carbonate accumulation. In the Altai-Sayan region two stages of carbonate accumulation are singled out: Upper Eifelian and Upper Givetian. In Central Kazakhstan the accumulation of carbonate sediments began in Famennian and continued up to Upper Visean. Different times of epochs of carbonate deposition were reflected by the peculiarity of local conditions of the folded regions.

Epicalcedonian seas had smaller dimensions and a complicated form than epiplatform ones. The accumulation of carbonate deposits occurred in the basins surrounded by land usually at all their sides. At the same time it is important that terrigenous rocks represented mainly by quartz sandsto-

nes and aleurolites, are present chiefly in basal and peripheral parts of carbonate formation. This testifies to the low relief of land and maturity of the source of detrital material and aridization of the climate. The latter is substantiated by gypsum content of upper littoral deposits.

A comparative characteristic of carbonate formations of various regions allows to conclude that their composition and structure substantially depend on form and size of paleobasins. Clay and clay-carbonate deposits were considerably spread in relatively small narrow basins which existed in the Altai-Sayan area. Here were no sedimentary dolomites, as a rule, fossils were not numerous and their species composition is rather poor. But blue-green algae are wide-spread. The abundance of fossils of a wide species composition is characteristic of larger isometric basins of the Central Kazakhstan region. It is interesting that the carbonate series formed in these basins contain thick and stratigraphically persistent members of dolomite rocks. The registered peculiarities of the basins are stipulated by many parameters: bottom morphology, depth and character of water circulation, etc. We think that the main factor was desalination effect of waters coming from the land. In small and narrow basins their effect on salinity fluctuation was likely to be maximum.

Discussing the general model of carbonate accumulation in the epicaledonian basins, it is necessary to note the absence of its direct analogues in the modern sedimentation basins. At the same time separate elements of facial zonality and sediment types are characteristic of the environments in Sharp bay (western Australia) and on the western coast of the Persian Gulf.

Cementation of cavities in Middle Frasnian micritic mounds (Belgium;  
France)

Frédéric BOULVAIN

Boursier CEE, Laboratoire de Pétrologie Sédimentaire, bât. 504, Université de Paris-XI, 91405 ORSAY CEDEX, FRANCE.

Some one hundred Middle Frasnian micritic mounds, commonly called "red marble bioherms" are scattered in the Dinant synclinorium (Belgium). They are embedded in shales and argillaceous limestones. Their shape is commonly lenticular, with a thickness ranging from 20 to 80 m. Limestone color is variable, from grey to red. Main facies are (fig.1), (Boulvain, 1988): brown spiculitic argillaceous wackestones (1); grey crinoidal grainstones (9) (=debris-flows on the slopes of the buildups); red *Stromatactis*-spiculitic mudstones (3); red spiculitic coral fenestral wackestones (4); red crinoid algal peloid fenestral wackestones (5); pink irregular-fenestral wackestones (6); grey (crypt)algal coral sponge bindstones (7); grey algal wackestones (8).

*Fenestrae* are abundant and of diverse origins. All cavities show the same characteristic cementation sequence (Boulvain, 1988b), identical for all bioherms studied (11 buildups, scattered in an area of 100 x 50 km):

- 1) inclusion-rich radiaxial calcite;
- 2) clear, non-cathodoluminescent euhedral sparry calcite (99,2% CaO, 0,8% MgO [microprobe analysis]);
- 3) clear, brightly orange luminescent euhedral sparry calcite, syntaxial with (2) (98% CaO, 0,8% MgO, 1,2% MnO);
- 4) clear, anhedral sparry calcite, with a dull orange luminescence (98% CaO, 0,8% MgO, 0,2% MnO, 1% FeO);
- 5) Fe-dolomite (52% CaO, 31% MgO, 16% FeO), with eventually a 6th stage of dedolomite.

This sequence reflects decreasing redox potential of pore fluids with time (MILLER, 1986). Infra- and peri-biohermal limestones are characterized by one single cement type which is identical to stage 4 of micritic mounds. This cement is related to the opening of a fracture system, leading to a diagenesis in a more open system, identical for all the basin. From stage (4), carbonate supply seems to originate from development of pressure-solution phenomena. Fe-dolomite is related to a late burial stage.

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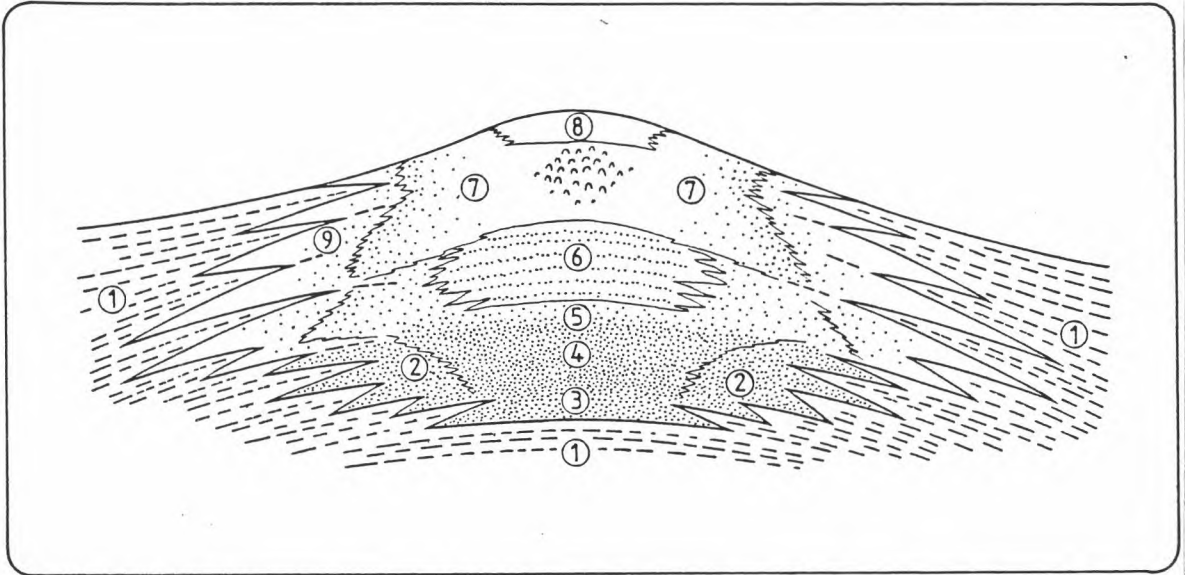


Fig. 1: Model of Frasnian "red marble" bioherm. Thickness is approximately 80 m. Microfacies numbers see text. Density of stippled=density of red Fe pigment.

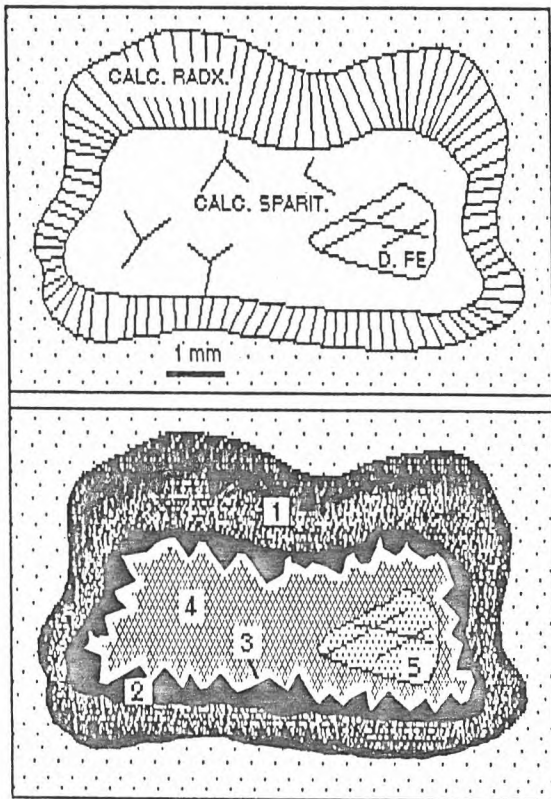


Fig. 2: cementation sequency, normal light and cathodoluminescence. 1,2,3,4: cement stages.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1988  
Liassic Palaeogeography of the Northeastern  
Calcareous Alps

FLORIAN BÖHM

Paläontologisches Institut, Universität Erlangen  
W-Germany

During the Upper Triassic the large carbonate platform of the Northern Calcareous Alps began to break. Basins began to develop inside the platform, which were rimmed by buildups and ooid bars.

During the Liassic the breakage was increased. The Rhaetian basins were connected by a narrow longstretched trough, which may be followed along the whole length of the northeastern Alps from near Salzburg onto Wien.

This can be seen from the distribution of facies drawn on a palinspastically reconstructed map. Three different types of grey basinal facies are distinguished which are assumed to be situated at the slopes of the trough (spicula-rich, cherty marls and thin bedded limestones with nodular cherts) or within the trough (bioturbated marls, Fleckenmergel). Mass flows and slumps are common there.

On top of the ridges aside the trough erosion and condensation took place, which resulted in formation of iron-manganese crusts and red crinoidal micrites. On the steep upper slope thick bedded encrinites, rich in brachiopods were laid down, interfingering with cherty spiculitic marls.

On gently dipping slopes, grading into grey basinal limestones, the red nodular beds of the Adneter Knollenkalk were formed.

The distribution of the different facies types shows an asymmetry of the trough with a steep slope or escarpment in the north and a more gentle slope in the south. It may be interpreted as a halfgraben with its thrust plane dipping southward. This is in contrast to the north oriented halfgraben systems of the Upper Jurassic described by some authors.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1988  
Modern and Triassic carbonate slope "stromatolites"

BRACHERT, T.C. & DULLO, W.-Chr.  
Institut für Paläontologie, Loewenichstr. 28, D-852 Erlangen  
W-Germany

During a deep diving survey using the submersible GEO (max depth -200m) in the Red Sea (coast of Sudan), below a mean water depth of -120m micritic stromatolites were found. They occur along slopes of any reef type developed: fringing reefs, barriers and atolls. Secondly there is no influence visible of current exposition (windward/leeward) controlling their distribution. The only factor visible is availability of rock substrates. That is the reason why they preferably cover steep cliffs and are of minor importance on gently inclined muddy to sandy slopes of fringing reefs, where they are restricted to the walls of steps or allochthonous blocks.

The stromatolithic crusts form ledge like overhangs and are composed of thinly laminated micrite forming often SH or LLH fabrics. The single hemispheroids are always oriented vertically. The lamination is due to rhythmic staining by ferromanganese hydroxides. In contrast to peritidal stromatolites they contain abundant plancton (globigerinids and pteropods), whereas they lack fenestral fabrics. Intense multiple bioerosion (bivalves, sponges, annelids and others) on the undersides of the ledges is as typical as incrustations by serpulids and bryozoans. Pore filling cement are either fibrous aragonite fans or isopachous rims. HMC occurs only subordinately.

Very similar structures can be found in the Upper Triassic of the Dolomites in N-Italy (Seiser Alm). They are best preserved on huge blocks slumped into vulcano clastics by debris flows. Due to this sharp weathering boundary the fossil stromatolithic (spongiostromata) crusts exhibit a very similar surface. Even the internal structure is strikingly similar. Early diagenetic features as fibrous cements and fans of botroidal aragonite (although transformed into calcite) are still recognizable as well. Furthermore there is a distinct similarity in the biotic content with one exception: there are only few borers. This may be due to the fact, that during the Triassic they were not as diverse as they are today.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
Distribution of Mn in carbonatic rocks of Eastern Thuringia

SIMONE BRÜCKNER and ROLF LANGBEIN  
University of Greifswald  
G.D.R.

In the literature on limestones the Mn-contents are generally used for bathymetric interpretations, with high contents being typical of deep water and low ones of shallow water. However, the relation is not always a linear one. The determinations of the Mn-contents of Thuringian carbonatic rocks are therefor used for discussing the rules of distribution.

In the Ockerkalk (Silurian) and the Tentakulitenknollenkalk (Lower Devonian) there is the well-known direct relation between siliciclastic impurities and Mn-contents. With about 500 ppm the relatively pure Ockerkalk(OK) contains lower concentrations in comparison with the more impure Tentakulitenkalk(TKK) which contains about 2500 ppm (1:5). But samples rich in dolomite have a higher amount of Manganese. In the Upper Devonian of the Schwarzburg Anticline (SA) with its prevailing facies of nodular limestones, the contents of Mn are markedly higher, i.e. 1000 up to 6000 ppm. Obviously it is not only the amount of clayey impurities but also their composition which influence the concentration of Mn in the carbonate. In the nodular limestones manganese is enriched in the cemented nodules and not in the compacted matrix. The Mn-ratio of cementites to that of compactites is about 6.5:1 (3000 : 600 ppm).

In the Upper Devonian of the Berga Anticline (BA), where the platy and massive limestones indicate shallow water environment, the Mn-contents are commonly below 1000 ppm. They allow a difficile bathymetric differentiation and a subdivision into cyclothemes. Three shallowing upward and one deepening upward cycles can be found in the Upper Devonian. However, the cyclic interpretation of the Mn-distribution may also be misleading. At the boundary region between Devonian and Carboniferous for instance, the Mn-contents decrease with increasing sedimentation depth.

Taking this results into account and comparing them with the distribution of the carbonate minerals, the following conclusions can be drawn:

1. Manganese can be found in the carbonate lattice in the form of  $MnCO_3$ , i.e. in an oxic environment an incorporation is hardly possible. Shells and the resulting rocks with the minerals aragonite, high-magnesian-calcite, and low-magnesian-calcite contain only low concentrations of Mn as far as they were cemented in an oxic environment.

2. Under suboxic conditions Manganese is incorporated into diagenetic carbonate minerals, which may also incorporate the geochemically analogous iron, i.e. into ferro-calcite and ferrous dolomite.

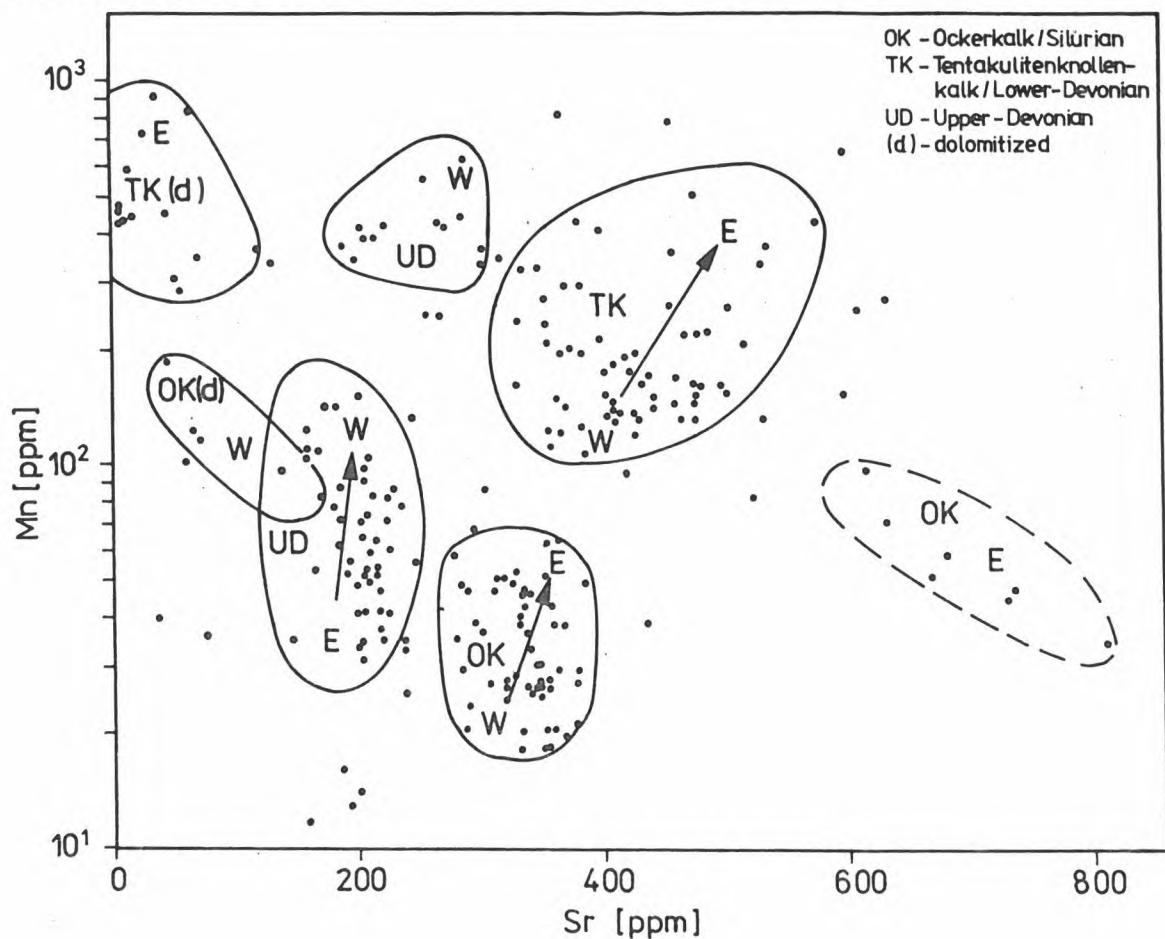
3. Maximum content of Manganese also needs a sediment rich in Mn (basaltic pyroclastics, siderite) or their neighbourhood of a spilite contact.

4. Carbonatic rocks rich in Mn can be expected if carbonate muds are cemented eodiagenetically by ferro-calcite in a suboxic environment, which is usually the case in a deepwater or quiet water environment.

5. Carbonatic rocks rich in Mn can also be expected, if calcitic muds are replaced by dolomite. That is possible in a deepwater environment below the C C D-line where primary deepwater dolomite or Low-Concentration-Dolomite grow.

6. Below the D C D-line the calcite and the dolomite are only solved and a cementation cannot take place and thus the Mn-contents are very low.

7. Since the Mn-distribution is preferably controlled by the early diagenesis, the Sr-Mn-diagramm is suitable for demonstrating the different conditions of Mn-enrichments in carbonatic rocks.



## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY—BUDAPEST, 1989

### Sedimentological and Paleoenvironmental Significance of armored mud balls in the Pliocene deposits of the Adriatic Foredeep (Italy).

NICOLA CAPUANO, GIANLUIGI TONELLI & FRANCESCO VENERI  
Istituto di Geologia Applicata, Università di Urbino,  
ITALY

Armored mud balls found in the deposits of the Montecalvo in Foglia basin (Northern Marche, Italy) (Fig. 1) have been studied. This piggy-back basin of pliocenic foredeep of the Northern Apennines, is filled with marine sediments, and the sedimentological and paleoecological features are typical of a fan-delta complex, where processes of risedimentation have been recognized (CAPUANO *et al.*, 1986; 1987).

Sand bodies, constituting these deposits contain numerous armored mud balls, well preserved, made up of pebbles of various sizes. The genetic processes concerning these structures hitherto found in a wide range of environment, either in present or in ancient sediments (FRITZ & HARRISON, 1983; HALL & FRITZ, 1984; KUGLER & SAUNDERS 1959; LENEY & LENEY, 1957; LITTLE, 1982; OJAKANGAS & THOMPSON, 1977; OSBORNE, 1953; RODRIGUEZ

-FERNANDEZ & VERA, 1981; STANLEY, 1964; 1969), are not at all clear. However, the presence of armored mud balls gives information about the paleogeography of the depositional basin. Different parameters concerning the armored mud ball, provided by:

- morphometric analyses of the whole structure
- morphometric and compositional analyses of the pebbles characterizing the armour
- paleoecological, compositional and physical analyses of the muddy nucleus
- paleoecological and compositional analyses of the embedding sediment,

have been considered to re-construct, besides the paleoenviron

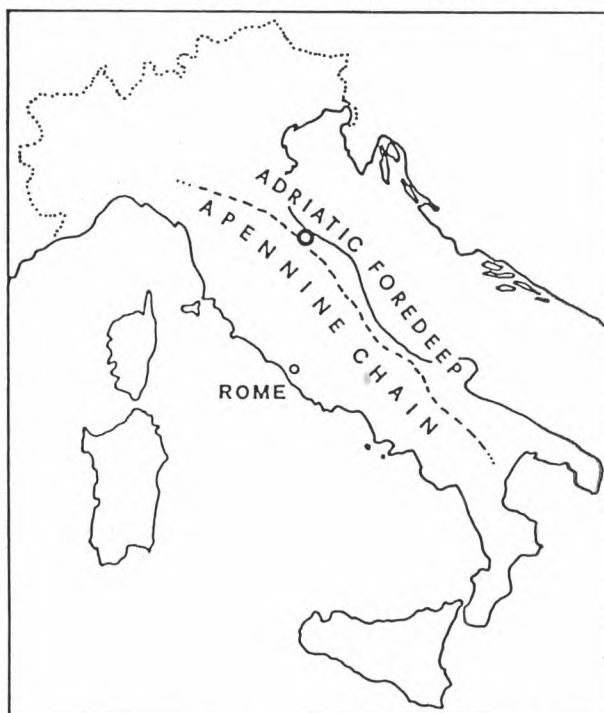


Fig. 1 - ○ Location of the Montecalvo in Foglia basin.

mental conditions and the dynamic phases which have determined their formation and their emplacement, the paleogeographical and paleoenvironmental characteristics relating to the pliocenic basin within which such armored mud balls have been found.

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10th IAS REGIONAL MEETING ON SEDIMENTOLOGY— BUDAPEST, 1989

Restricted to open shelf carbonate sedimentation in northwestern Sardinia (ITALY).

CARANNANTE GABRIELE\*, CHERCHI ANTONIETTA\*\*, D'ARGENIO BRUNO\*, SCHROEDER ROLF\*\*\* and SIMONE LUCIA\*.

(\*)Dip. Scienze della Terra, Università, Napoli, ITALY.

(\*\*)Dip. Scienze della Terra, Università, Cagliari, ITALY.

(\*\*\*)Geol. Palaeont. Inst., Frankfurt-Main, W. GERMANY.

The Jurassic-Cretaceous Carbonate Platform deposits of northwestern Sardinia, are currently considered to belong to the carbonatic belt characterizing the southern edge of the European plate in the Mesozoic times. The Jurassic sediments show in general a cyclic pattern: in shallow marine environments (sediments rich in green algae, gastropods, non skeletal grains), oolitic shoals (tidal bar and/or marine ooids sand belts) created more restricted conditions with local brackish lagoons. Such lagoonal sequences may change quite rapidly into coastal-lake systems with fresh water or brackish ponds (sediments of Furbeckian facies). The sporadic intercalation of bioclastic storm layers document adjacent marine source areas in which mollusks, green algae and large corals were growing. After the brief Furbeckian episode, marine conditions started again in the early Valanginian, and continued, at least up to the early Aptian, with massive limestones of Urgonian Facies formed by bioclastic grainstones and packstones rich in green algae, mollusks, large benthic forams and corals (Chlorozoan-Chloralgal association). Limited non skeletal grains such as intraclasts and ooids are also present. Such deposits suggest a non restricted carbonate platform covered by mobil detritic sediments. We can here recognize in the Urgonian facies the basic characteristics of an open tropical shelf deposition. A greater stratigraphic break later occurs during which bauxite developed, resting over deeply eroded (even pre-Urgonian) levels.

All together this sequence documents the development of depositional environments that well match the classic tropical carbonate platform model (rimmed and open shelf type) both in terms of presence of non-skeletal grains (large oolitic shoals in the Jurassic times as well as the accessory grains in the Urgonian facies) and nature of biological assemblages (Chlorozoan-Chloralgal association which characterizes the Jurassic-lower Cretaceous bioclastic facies). Development of bauxite deposits, during the stratigraphic gap, seems to confirm, additionally, such paleolatitudinal interpretation.

In the late Cretaceous, locally preceded by blackish, schizohaline deposition, first evidence of a transgressive phase, a shallow sea encroached again previously emerged carbonates, with well bedded limestones rich in rudists

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locally forming patch-reefs. In these rudistid limestones we can recognize a clear evolution from muddy-pellettiferous sediments rich in benthonic foraminifera, mollusk, chetetids and green algae to sediments with abundant red algae, bryozoa, echinoids, mollusk and benthonic foraminifera. On the whole these neritic lithofacies seem to witness a bioclastic veneer in areas characterized, at first, by low energy, than by more open, deeper and shaphile conditions in which small skeletal build-ups (rudistid patch reefs) arise. The existence of large bottoms characterized by rodolites, as source area of sediment, is finally suggested by the presence of sediments rich in red algae, bryozoa, echinoids, benthic and planktonic foraminifera, green glauconitic and red stained grains in a matrix of pelagic mud.

This late Cretaceous shallow sea seems, hence, to show a gradual, pronounced, evolutionary trend from a low energy, shallow inner shelf to more open and deeper marine conditions, while we assist, in the biological assemblages, to a gradual change from Chlorozoan-Chloralgal associations to Foramol-type associations. Parallel to the disappearance of green algae and of corals, the non skeletal grains tend to disappear. We can, hence, hypothesize in the Senonian a change in environmental parameters that, controlling the biological assemblage and precluding the non skeletal production, produced a substantial variation in the sediment characteristics, such to give a temperate-type (Foramol s.l.) carbonate deposits.

Such sequence shows tropical characteristics starting from Jurassic to the early Cretaceous, when an emersion took place with the formation of bauxite deposits. In the subsequent late Cretaceous transgressive phase, neritic deposits give witness of an evolution towards temperate-type conditions. The evolution from classic infralittoral Chlorozoan sediments, which may testify a tropical-type platform to circalittoral Foramol type sediments characteristics of open, temperate type shelves, seems to document at first a gradual climatic- paleolatitudinal change but may be also consistent with changes in the current pattern.

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Ephemeral and long lasting emersion episodes and related paleokarst and bauxites in the Cretaceous carbonates of Southern Apennines (Italy).

CARANNANTE GABRIELE\*, D'ARGENIO BRUNO\*, FERRERI VITTORIA\*, MINDSZENTY ANDREA\*\* and SIMONE LUCIA\*.

(\*) Dip. Scienze della Terra, Università, Napoli, ITALY.

(\*\*) Eotvos L., University, Budapest, HUNGARY.

Paleokarstic features are widely spread in the Mesozoic carbonate platform sequences of Southern Italy because of frequent emersion of the original infralittoral- littoral depositional areas. Here paleokarstic processes are analyzed in the time interval between Albian and late Turonian-Coniacian, when both eustatic sea level oscillations and tectonic events have been intense and spread in the Periadriatic Region. Often the emersion surfaces are characterized by bauxite accumulation possibly derived from wind blown materials.

Main problems discussed in this paper are:

- 1) Underground karst in the Albian limestones may be connected with short early emersion which preceded the formation of the main bauxitic horizon. During such emersion vadose waters periodically interacted with phreathic marine and/or meteoric waters and produced a light cementation with more or less important moldic solution of aragonitic bioclasts. Afterwards more or less pervasive microsolution of limestones produced cristal silt (sensu Dunham) freeing particles of the sediment; both the components percolated in the microcavity network carrying in unaltered grains from the muddy calcareous matrix, including grains with geopetal fillings undergone rotation. Siltitic and muddy fillings, locally with fresh and/or brackish water ostracods, and radiaxial cements seem to suggest the alternation of different diagenetic conditions and strong influx of the mixing zone during the evolution of the sediment.
- 2) Similar processes may have produced karstification of the Cenomanian limestones which are overlying the main bauxitic horizon (Monte Maggiore) or outcropping where the above horizon is lacking. In both cases the process seems more intensive with larger and more complex cavity development and associated radiaxial cements. The fluctuations of the phreathic surface in a very shallow lagoonal area most probably influenced strongly the diagenetic environment. Long permanence in the mixing zone did favour the development of complex cavity systems. Here the flux of surficial waters, carrying large siltitic fractions, produced brackish pools where biomicritic sediments were covered by siltitic deposits, sometime with ostracods; in addition large amount of this fraction percolated in the microkarstic network.

3) Surface karst-forms filled by bauxite are irregular and shallow. They reflect a gentle erosional morphology. Only locally (e.g. Mte Maggiore) there occur sinkhole-type depressions of larger dimensions, suggesting more intense karstification. The phreatic watertable was apparently quite shallow: deferrification phenomena and reduction processes having affected the then unlithified parts of the deposits are frequent (Regia Piana, Dragoni). Unequivocal evidence of transportation in deposits which otherwise exhibit an intensely oxidized character, may be explained by assuming either a strong variation of the pluviometric conditions, or episodic changes of relief resulted by synsedimentary tectonism. The latter would explain also the apparently different intensity of paleodrainage as indicated by different evolution of the cavity-systems and different lithofacies of the bauxite-fillings in different "blocks" of the paleokarst terrain (Pesco Rosito, Campo Sauro).

4) In a general way, may be also noticed that, where the already karstified limestones are fractured, late Cretaceous transgressive deposits show a trend towards more open sea facies, which in the Mte Campo Sauro area show, from the very beginning, characteristics of open-shelf bioclastic deposits.

**MIOCENE DETRITAL MODES AND GEODYNAMICS OF THE CALABRIA -  
PELORITANI ARC (SOUTHERN ITALY)**

**WILLIAM CAVAZZA**

Dipartimento di Scienze Mineralogiche *and*  
Universita' di Bologna  
ITALIA

Dept. Earth & Space Sciences  
Univ. of California, Los Angeles  
U. S. A.

The Stilo - Capo d'Orlando Formation (SCO Fm) is a clastic unit of early-middle Miocene age nonconformably covering the basement of the southern portion of the Calabria - Peloritani Arc (CPA), a small-scale exotic terrane which was accreted onto the Apennines-Maghrebides orogenic system. The SCO Fm is composed of conglomerate, sandstone and mudrock deposited in a deep-marine environment through the action of gravity currents.

Detrital modes of sandstones and conglomerates of the SCO Fm indicate a local provenance. In fact, petrologic parameters can be matched directly with nearby basement lithologies. Two petrofacies with distinctive parameters are present. A northern petrofacies is predominantly composed of plutonic and low-grade metamorphic detritus, and was derived from the Serre massif (southern Calabria), which is mostly made of Hercynian plutons intruded into metasedimentary rocks. A southern petrofacies is mostly composed of metamorphic detritus and was derived from the Aspromonte (southernmost Calabria) and the Peloritani Mountains (northeastern Sicily), which are predominantly composed of middle-to-high-grade metamorphic rocks.

Petrologic results place important constraints on the geodynamic evolution of the CPA. According to several authors, the arc is composed of two sectors (microterranes) with different geologic histories and partly composed of contrasting rock types, whose timing of juxtaposition is debated (Early Cretaceous vs. middle-late Miocene; that is, much before or soon after deposition of the SCO Fm). The SCO Fm crops out only in the southern sector of the CPA and does not contain any detritus derived from the northern sector, in spite of a favorable sediment paleodispersal system. This fact indicates that the amalgamation of the two sectors probably took place after deposition of the SCO Fm.

Despite the wide acceptance and use of sandstone petrology to determine the overall plate-tectonic setting of the sediment source area, detrital modes of sediments/sedimentary rocks have been rarely used to constraint the geodynamic setting of a sedimentary unit on a smaller, more detailed scale. This study demonstrates how sandstone/conglomerate petrology can be used effectively also to discriminate between contrasting geodynamic evolutionary models proposed for a relatively small region.

Dolomitization and Diagenetic History of Massive Dolomites in the late Precambrian Carbonate Sequences, Xuhuai Region (East China)

Xiaobing Chen

China University of Geosciences (Beijing)

CHINA

Dolomites can be found widely in the late Precambrian carbonate sequences of Xuhuai region. The carbonates deposited on gently inclined "platform-ramp" transitional systems in which the sedimentary environments involve peritidal, shallow-restricted subtidal to intertidal, shallow-restricted ramp, lagoon, open shallow ramp, deep ramp and basin. The massive dolomites occur in shallow water environments, but not in deep water (deep ramp and basin) environments. The composition of dolomitization fluids changes from nearshore mixing seawater and freshwater to offshore normal to slightly hypersaline seawater. The hydrological regime of dolomitization fluids presents the feature of gradual change from nearshore to offshore on the "platform-ramp" transitional systems.

Four types of massive dolomites have been distinguished: 1/. seawater-freshwater mixing nonsabkha tidal flat dolomite, including peritidal dolomite interstratified with chert and shallow-restricted subtidal to intertidal relict pelletal dolomite, mainly composed of clear euhedral to subhedral dolomite crystals about 3 to 100 microns in diameter and a small amount of quartz grains, with subaerial exposure structure but absence of evaporite minerals or preexisting evidences; 2/. mixed-water ramp columnar stromatolite dolomite, underlain parallel unconformity contact or subaerial exposure surface, with clear subhedral 3 to 50 microns dolomite crystals and solution vugs in light laminae of stromatolite; 3/. "Coorong" type restricted lagoon dolomite, with tepee structure, dessication breccias and a few evaporitic pseudomorphs, euhedral to anhedral 3 to 100 microns in dolomite crystal size, showing clear or cloudy centre to limpid rim in crystals

4/. normal to slightly hypersaline seawater shallow subtidal dolomite, situated in landward side of open shallow ramp, composed of cloudy dolomite crystals about 3 to 300 microns in diameter.

The diagenetic history of the platform dolomites experienced four different stages: 1/. penecontemporaneous diagenetic stage, mainly forming micritic dolomite (micron sized crystals); 2/. early diagenetic stage, forming euhedral to subhedral mosaic dolomite (20 to 100 microns in crystal size); 3/. intermediate diagenetic stage, forming subhedral to anhedral mosaic dolomite (about 100 microns in crystal diameter); 4/. late diagenetic stage, forming anhedral coarse mosaic dolomite (about 100 to 300 microns), showing irregular to curved crystal faces and wavy extinction, finer euhedral dolomite rhombs (about 5 to 30 microns in diameter) contained in the coarser anhedral dolomite crystals, indicating neomorphic recrystallization dolomitization occurred.

Provenance and evolution of the Miocene turbidite  
sedimentation in the Central Apennines

UGO CHIOCCHINI

University of Tuscia - Viterbo

Italy

NICOLA CIPRIANI

University of Florence

Italy

The present work is a synthesis of the petrographic studies of the Miocene turbidite deposits of the Central Apennines which was carried out during a period of about ten years on the basis of contemporaneous facies and basin analysis studies.

The Central Apennines are characterized by the contact of the Western Umbro-Marchide domain and the Eastern Latium-Abruzzi one along the "Ancona-Anzio" line. It has been active since the Jurassic as a normal fault which separated the basinal Umbro-Marchide area from the uplifted Latium-Abruzzi carbonate platform.

During the Early Miocene an inversion of the relations between the two domains took place and the platform was split into several large blocks separated by three narrow elongated depressions (Tagliacozzo, Liri and Salto basins) which joined together northwards to form the Salto basin.

From the end of the Tortonian to the end of the Messinian the "Ancona-Anzio" line behaved as a dexter transcurrent fault.

Turbidite sedimentation is characterized by the eastward shifting of the Apennines thrust belt-foredeep system, which started in the Burdigalian in the Umbro-Marchide foredeep (Marnoso-Arenacea foreland basin) and continued up to the Serravallian. Detrital supply is mainly derived from the Northern Alps with sporadic mixed carbonate-siliciclastic and arkosic supply of western alpine provenance.

During the Tortonian folding and thrust deformations produced the Monte Vicino piggy-back basin, the Camerino and S. Donato-Cantia satellite basins, they were filled with sediments from the Apennines and the Western Alps; while the Urbania and Serraspina satellite basins were filled with sediments from the Northern Alps.

During the same period turbidite sedimentation began in the Latium-Abruzzi basins deriving from the Apennines and Western Alps. Between the end of the Tortonian and the beginning of the Messinian the relative uplifting of the Latium-Abruzzi platform stopped the turbidite sedimentation in the basins included within the platform.

During the Messinian turbidite sedimentation, deriving from the Apennines and Western Alps, shifted within the foredeep eastwards to the Laga basin. As a consequence the northern alpine supply fed only the Umbro-

Marchide foredeep (Marnoso-Arenacea foreland basin) and the Urbania and Serraspina satellite basins. At the same time the apennine and western alpine supply evolved in time. They began in the Burdigalian in the inner part of the Marnoso-Arenacea, during the Tortonian the supplies affected either the outer Monte Vicino, Camerino and S. Donato-Cantia basins or the Latium-Abruzzi basins and during the Messinian the Umbro-Marchide foredeep (Laga foreland basins).

The continuity of the alpine arc in the tyrrhenian area strongly suggests the connection between western crystalline units and turbidite sedimentation in the examined basins. The crystalline units are associated with an alpine chain fragment tectonically linked to the Ligurides nappes (apennine source areas) during the eastward migration of the Apennines' deformation. The crystalline units were gradually eroded from the Burdigalian to the Early Pliocene when the Laga basin was completely filled.

To date "alpine" has been used synonymously for northern provenance. As we have recognized for many years a western alpine supply associated with an apennine source area, we suggested distinguishing the northern alpine provenance from the western alpine one.

10th REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Findings of Holocene sapropel breccia in the bottom sedi-  
ments of the Western half of the Black sea

SPARTAC DEMOSTENOV CHOCHOV, STEFAN BOIANOV SHANOV  
geological institute of Bulgarian Academy of Sciences  
BULGARIA

The sapropel muds are widespread on the Black sea continental slope and abysal plane. Findings in these deposits of Holocene age of so-called sapropel breccia-pieces up to 4-5 cm organic sapropelitic material among a muddy matrix are of particulate interest. Such breccia found on a area of about 40000 km<sup>2</sup> are normaly included into turbidity cycles from 15 to 40 cm thick. The sapropel breccia was formed during the initial phases of the Holocene transgression. As a result of the action of catastrophic earthquakes, which took place once to about every 500 years, the sapropel was cut into pieces and by means of turbidity currents and muddy flows were redeposited in the lower parts of the basin( Chochov&Shanov,1987) The sapropel breccia are of great importance for the evaluation the sources of organic material for the Black sea and for the determination of the mechanism of deep sea transport and sedimentation. Using this phenomena the periods of intensive seismic activity can be traced along too.

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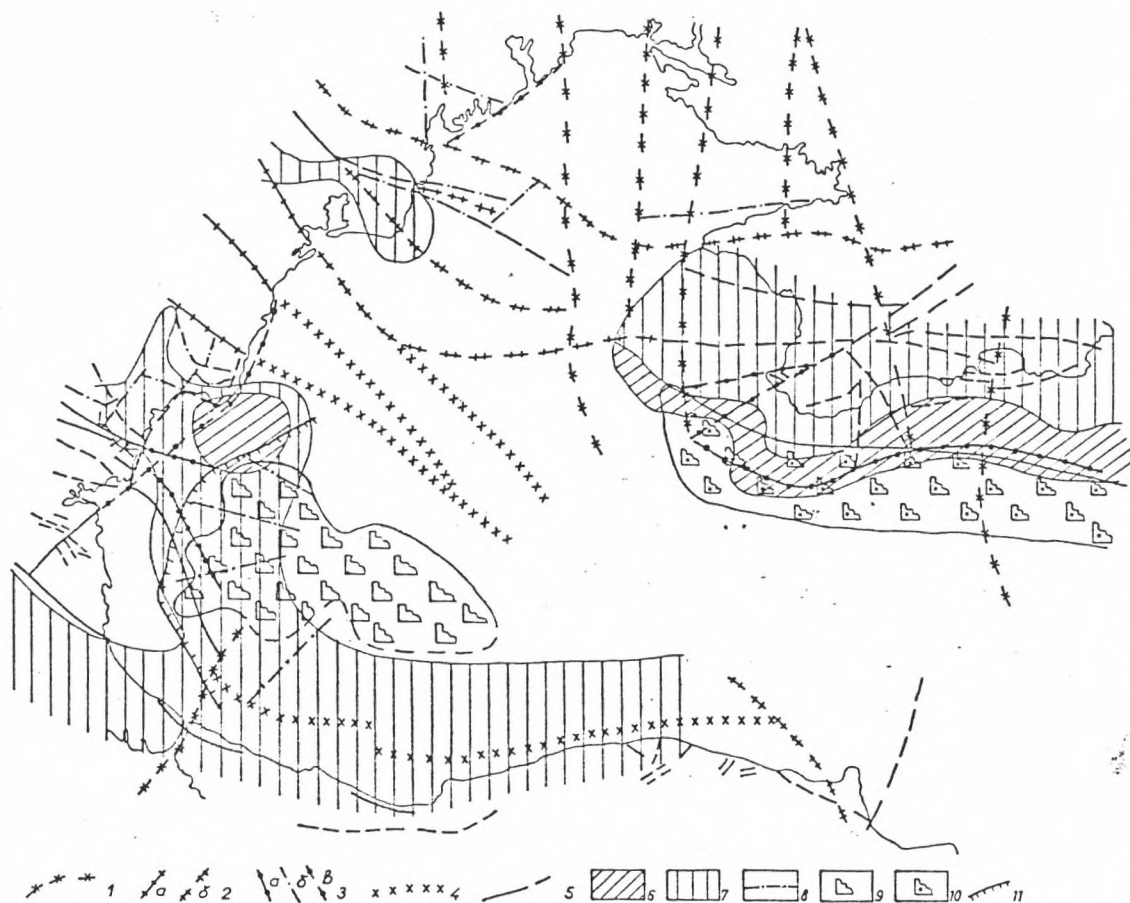


Fig. Scheme of the faults, the seismicgenerating zones and the distribution of the sapropel breccia. Faults: I-active during the Pre-Riphean stage; 2-active during the Paleozoic according to geological (a) and geophysical(b) data; 3-active during the Alpine stage according to geological(a), geophysical(b) and satellite(c) data; 4-lineaments according to geomorphological and geophysical data; 5-big faults; seismicgenerating zones(Gorshkov,1973); 6-strong earthquakes; 7-moderate to weak earthquakes Distribution of the sapropel breccia: 8-axis of the bigger canyons; 9-region of distribution of the sapropel breccia; IO-zone of distribution of the turbidites with sapropelitic material south of the Crimea peninsular(Сараев и др., 1985 ); II-the shelf edge.

Argillogenesis in the sedimentary basins of region Bohemian massiv (Czechoslovakia)

Ludvík ČIHOVSKÝ, Irena BYLOVÁ<sup>+</sup>

Dept. of Petrology, Charles University, Prague  
 +Dept. of Spec. Geol. Sci., n.e. Geindustria Prague  
 CZECHOSLOVAKIA

We studied 23 basins and sedimentary regions as a conti-  
 nual part of sedimentary lithosphere of Bohemian Massiv. The  
 age of lithostratigraphic units and members are included the  
 Cambrium to Recent. The investigation of clay matter in frac-  
 tion below 5  $\mu\text{m}$  in sedimentary profiles (>1.200 m) documented  
 the evolution of clay matter = argillogenesis. This processes  
 dependet to presedimentary, synsedimentary and postsedimentary  
 evolution of sedimentary Basins. The changing of silicate mi-  
 nerals in to clay matter are documented in table 1. as the va-  
 lues of index stability  $I_{KO}$ , the content of stable oxides  
 $\text{SiO}_2 + \text{Al}_2\text{O}_3$  and transformation trends: (1) smectitization, (2)  
 vermiculization, (3) chloritization, (4) illitization and (5)  
 kaolinization. We explained this tendency of transformation  
 silicate non clay minerals and clay minerals in to others types  
 of clay minerals by the changes of primary rocks by climatic,  
 geological, geochemical, hydrological and thermodynamic condi-  
 tions for sedimentary unites various age.

Table 1 - The scheme of reconstruction various pathway silicate  
 minerals in clay matter. The explanation of symbols:  
 V= vermiculite, S=sericite, Ch1=chlorite, Ch2=chlorite  
 secondary, Sm=smectite, I= illite and K=kaolinite.

Primary minerals	Secondary mineral (clay minerals)						
	V	Se	Ch1	Ch2	Sm	I	K
$I_{KO}/\text{SiO}_2 + \text{Al}_2\text{O}_3$							
Olivine <+76,+78>/ 40,47							

$I_{K_2O}/SiO_2+Al_2O_3$	Secondary minerals (clay minerals)						
	V	Se	Ch1	Ch2	Sm	I	K
Pyroxenes <28,+46>/<46,58>	→→→→→→→						
↓							
Amphiboles <12,+35>/<41,69>	←→→→→→→						
	→→→→→→→						
Biotite <+24/ 54>	→→→→→→→						
	←→→→→→→						
	→→→→→→→						
K-feldspar <+3/82>	→→→→→→→						
Albite <+3/87>	←→→→→→→						
Oligoclase <+4/86>	→→→→→→→						
Andesine <+6/84>	→→→→→→→						
Labradorite <+8/82>	→→→→→→→						
Bytownite <+12/81>	→→→→→→→						
Anortite <+13/80>	→→→→→→→						
Muscovite -illite <-7/80>	→→→→→→→						
	←→→→→→→						
	→→→→→→→						
Chlorites <+20,-2>/<41,60>	→→→→→→→						
	←→→→→→→						
	→→→→→→→						
$I_{K_2O}/SiO_2+Al_2O_3$	+2/47	-16/83			-9/71	-9/79	-41/80

The kvantitative determination of structural arrangement of sedimentary rocks various types and facies

Ludvík ČIHOVSKÝ, Pavla DAVIDOVÁ<sup>+</sup>

<sup>+</sup>Dept. of Petrology, Charles University, Prague  
<sup>+</sup>Dept. of Spec. geol. Sci., n.e. Geindustria Prague  
 CZECHOSLOVAKIA

The each sedimentary types of rock has typical textu-  
 ral and structural features. This suitable parameters determine  
 arrangement of mineral particle size composition and the ty-  
 pe of sedimentological facies. We defined the structural pa-  
 rameters -S<sub>p</sub> and structural factor - S<sub>f</sub> in kvantitative for-  
 mulation. This kvantitative formulation we used (1) in field  
 work application and (2) in laboratory tests. This method we  
 can applied by using: (a) imagine bild analyses, (b) polari-  
 zation microscope and (c) combination of fotogrammetry and  
 optical analyses.

$$S_f = S_p + 100.V \quad (1)$$

$$S_p = \frac{A \cdot B \cdot 10}{C} \quad (2)$$

$$A = \frac{R}{100 - V - R} \quad (3)$$

$$R = \sqrt{\pi} \cdot (d_1 \cdot 0.2^2 + d_2 \cdot 0.28^2 + d_3 \cdot 0.4^2 + d_4 \cdot 0.56^2 + d_5 \cdot 0.8^2 + d_6 \cdot 1.1^2 + d_7 \cdot 1.6^2 + d_8 \cdot 2.2^2) - K_1 - K_2 \dots \dots - K_8$$

d<sub>1</sub> to 8 = kvantitative value of grain size interval  
 K<sub>1</sub> to 8 = correction factor of shape grain to ideal circle  
 V = the area (mm<sup>2</sup>) of pores >50 nm (determine by mercury porosimeter)

$$B = \frac{P_{16} + P_{25} + P_{50} + P_{75} + P_{84}}{5} \quad (4)$$

B = coefficient of fraction sizes (determine from cumula-

lative curve of grain size of sediment or by imagin bild analyses.

$$C = n^2 + 1 \quad (5)$$

n = the average value of contact grain particles.

We presented the results documented the types of sedimentary rock as the dependence to facial variability and evolution of sedimentary basins. The results of kvantitative determination of structural arrangement are possible used in petrology, structural geology, metalography, medicin, keramik, macromolekular chemistry, biology, genetic engineering, technology, mortar te chnology and other application.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Interdraa and draa plinth deposits of the Early Permian Sand  
Sea (Yellow Sands), NE England

LARS B. CLEMMENSEN  
Institute of General Geology  
DENMARK

Flat-bedded aeolian deposits form in different modern environments including sand sheets, interdunes (or interdraas) and dune (or draa) aprons and lower plinths (cf. Kocurek, 1986). Such deposits are also common in ancient aeolian successions where they frequently occur at the base of or closely interbedded with cross-bedded aeolian deposits. A correct interpretation of these flat-bedded aeolian deposits is crucial for the understanding of ancient erg dynamics as illustrated by an example from the Yellow Sands of NE England.

#### Flat-bedded aeolian deposits

The Yellow Sands form at least eight well-defined sand ridges of linear draa origin (Steele, 1983; Chrintz, 1988) separated by 0.8-2.0 km wide interdraa corridors. The aeolian landscape was preserved to a large extent beneath the Marl Slate (Zechstein). The interdraa corridors most likely are composed of flat-bedded aeolian deposits, but no good exposures exist. Flat-bedded aeolian deposits also occur in two intervals in the basal part of the draa ridges (Fig. 1). These flat-bedded deposits are composed of relatively coarse-grained (mean = 0.35 mm) wind-ripple strata deposited during uniform dry conditions. The flat-bedded strata form up to 9 m thick, tabular sand-bodies that are composed of basal horizontally to sub-horizontally stratified deposits, which are gradationally overlain by low-angle stratified deposits. The flat-bedded sand-bodies overlie the Carboniferous unconformably, or they lie upon a well-developed first-order bounding surface; their upper contact to cross-bedded draa center deposits is frequently gradational.

The sedimentary characteristics of the flat-bedded strata and their close genetic association with draa center deposits suggest that they represent basal interdraa deposits and overlying draa plinth deposits.

#### Draa-interdraa dynamics

The recognition of interdraa and draa plinth deposits within the Yellow Sand ridges makes it possible to enlarge considerably the understanding of erg dynamics in the Early Permian desert of NE England. The sequential build-up of the ridges (two superimposed interdraa-plinth-draa center units) suggests that the linear draas experienced an early phase of lateral (or oblique) migration followed by a second phase of

vertical accretion (or downdraa extension at high angles of climb) prior to the Zechstein transgression. This change in draa dynamics probably indicates a change with time of the palaeowind regime.

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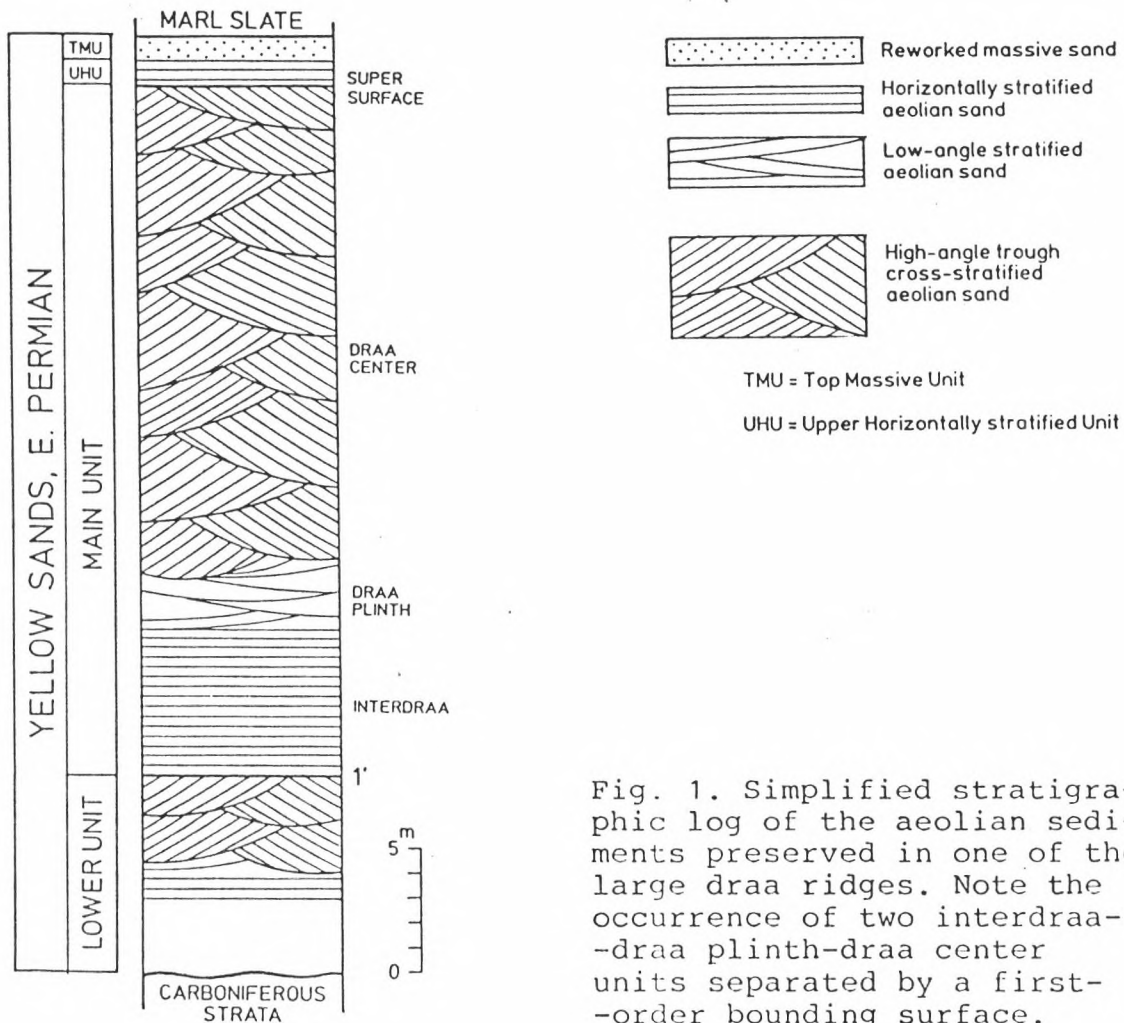


Fig. 1. Simplified stratigraphic log of the aeolian sediments preserved in one of the large draa ridges. Note the occurrence of two interdraa-draa plinth-draa center units separated by a first-order bounding surface.

## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989

Evolution of the Pollica Sandstone Turbidite Basin  
(Cilento Flysch, Southern Appennines)ENNIO COCCO, TOMMASO DE PIPPO & ALESSIO VALENTEDipartimento di Scienze della Terra, Università di Napoli  
ITALY

These notes describe the sedimentological characteristics of the upper portion of the Pollica Formation, a terrigenous sequence located south-west of the Cilento.

Facies analysis and stratigraphic relationship indicate that these sandstone bodies were deposited by gravity flows in a relatively deep marine environment. More specifically, and following the criteria offered by several authors these sandstone bodies can be interpreted as deep-sea fan deposits.

The entire sequence, which is the result of a correlation between three stratigraphic sections, shows a coarsening upward trend with a sudden inversion at the top, less thicker than the previous portion.

The base deposits are represented by the thin bedded turbidites facies, followed by more proximal turbidites characterized by a very parallel bedding and a consistent set of internal sedimentary structures that can be described using the Bouma model ("classic turbidites"). Both are organized prevalently by thickening and coarsening upward cycles. Massive and pebbly sandstones gradually substitute the classic turbidites going upsection until remaining alone, with associated some conglomeratic facies. Above these latter, a thick marl level can be found. These deposits are characterized by an organization of large thinning and fining upward cycles. Another typical evidence is the presence of chaotic facies associated to the most coarsening sediments. The last deposits are again the classic turbidites, arranged by thickening and thinning upward smaller composed cycles.

Each of these portions can be interpreted as the product of a distinct depositional area within a general fan model with a suprafan. It consists of an inner and extensively channelized portion which grades into outer and smoother regions, virtually lacking of channels. In this latter the first thinner bedded sediments were probably deposited. The most proximal turbidites are typical of

suprafan lobes, which are morphological bulges formed at the termini of the braided channels, where the most coarser facies were deposited. The sedimentation of the last portion has occurred in a transitional and/or marginal area at the braided channels and the suprafan lobes.

In conclusion, some indication has been given about certain sedimentary, tectonic and sea-level controls involved in the sedimentation of the Pollica Sandstones, which occurred probably in a "low efficiency fan" along an active margin.

A CHARACTERISTIC SEQUENCE OF DOGGERIAN MICROFACIES  
IN GORSKI KOTAR (WESTERN CROATIA, YUGOSLAVIA)

Vlasta ČOSVIĆ & Vladimir TOMIĆ

Department of Geology and Paleontology, Faculty of Science,  
Soc. revolucije 8, YU-41000 Zagreb

The Middle Jurassic in the region of Gorski kotar (western Croatia, Yugoslavia), is represented by a thick sequence of carbonate rocks. Five different types of microfacies can be distinguished. All of them correspond to the MF-types (Flügel, 1982). They all display the features of shallow water origin, where carbonate bars divided the area of deposition into the zones of agitated water and zones of quieter water. The idealized vertical facies types (Fig. 1) are superimposed and they correspond to different time intervals of the Doggerian.

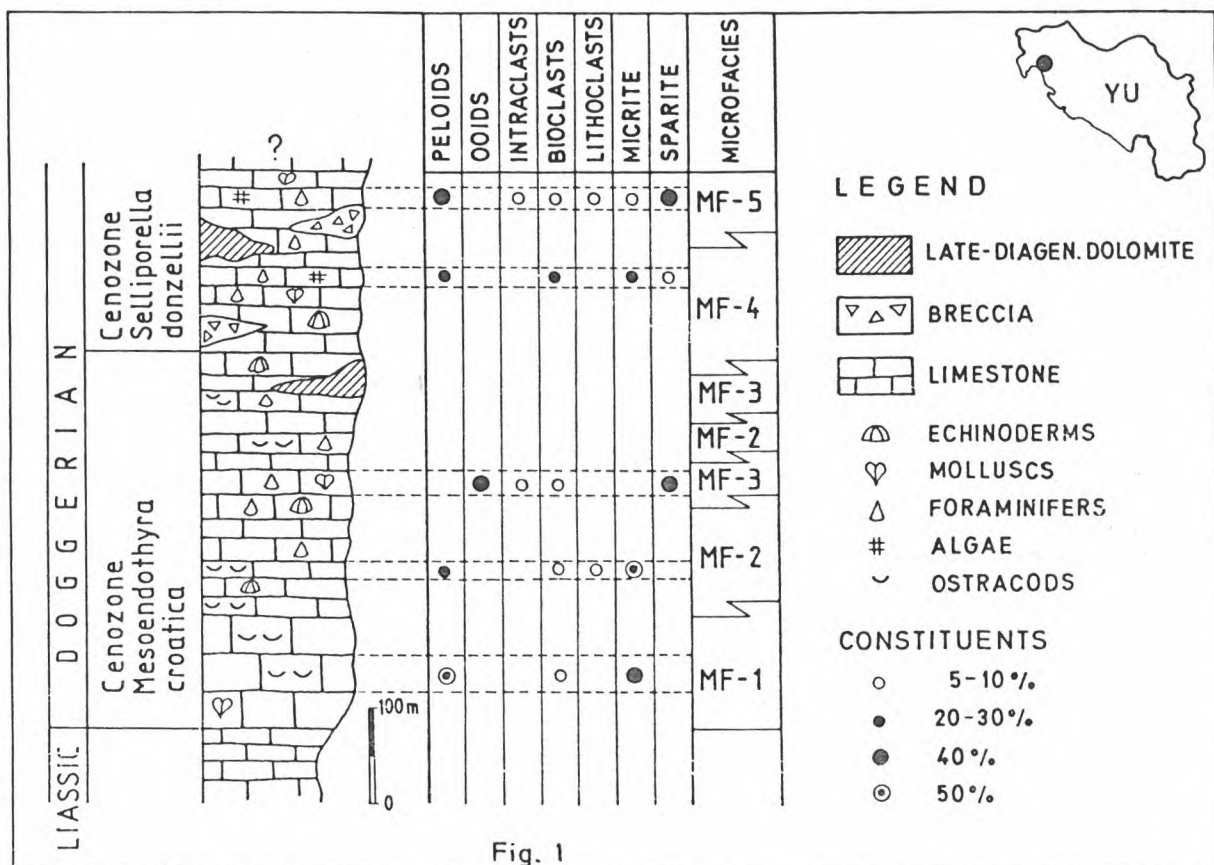


Fig. 1

THE PELLET-MUD FACIES (MF-1) is dominated by peloids. It consists of a monotonous, fossil-poor sequence of rather thick bedded subtidal lagoon limestones.

THE MUD FACIES (MF-2) is homogeneous mudstone to wackestone, with a slightly more diverse fauna of ostracods, molluscs, echinoderms and foraminifers than in the MF-1 facies. It corresponds to a very shallow, slightly agitated water environment, lagoons.

THE OOLITE FACIES (MF-3). Beds are thick, dominantly grainstones, with abundant ooids, formed in moderately to strongly agitated water, on bars.

THE PELOID FACIES (MF-4) contains very abundant and diverse biota, especially foraminifers and algae, in a micritic/sparitic matrix with many peloids. The properties of this MF suggest a deposition in water which was slightly more deeper than the mud environment of facies.

THE SPARITIC PACKSTONE/WACKESTONE FACIES (MF-5). Layers of sediments are up to 40cm thick, comprising peloids, intra-clasts and lithoclasts and scarce foraminifers and skeletal fragments. They were deposited in subtidal-intertidal water environment, probably on shoals.

Dolomites and breccias form sporadic intercalations placed mainly toward the middle and upper part of the described sections.

Two successive bizones are established using local faunal assemblages of foraminifers and dasyclads, although one of the main problems is the scarcity or the lack of index fossils.

The Doggerian of investigated area is represented by carbonate platform sediments deposited in subenvironments which are differentiated with respect to depositional and biotopic conditions of both intertidal and subtidal zones. The sediments with features indicative a completely shallowing trend, have not been found, possibly due to tectonic disturbances of the uppermost part of the sections.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
Maturation modeling and diagenetic histories of Namurian Sandstones,  
East Midlands Basin and Southern North Sea Basin

Greig Cowan  
British Gas PLC, London

Diagenetic processes operating on deeply buried Namurian fluvio-deltaic sandstones from the Southern North Sea basin and on less deeply buried rocks from the East Midlands /Trumfleet Field/ are remarkably similar. Porosity is severely reduced by quartz and carbonate cementation and enhanced by carbonate and feldspar dissolution. Diagenetic modification is so severe that depositional textural criteria have little effect over reservoir properties.

Maturation modeling shows that the Southern North Sea rocks have been buried to at least 4 km whilst the Trumfleet rocks have been buried to only 2 km, however, the maturation modeling also shows that both sediments have passed through similar diagenetic windows during burial and can be used to explain the similar diagenetic histories.

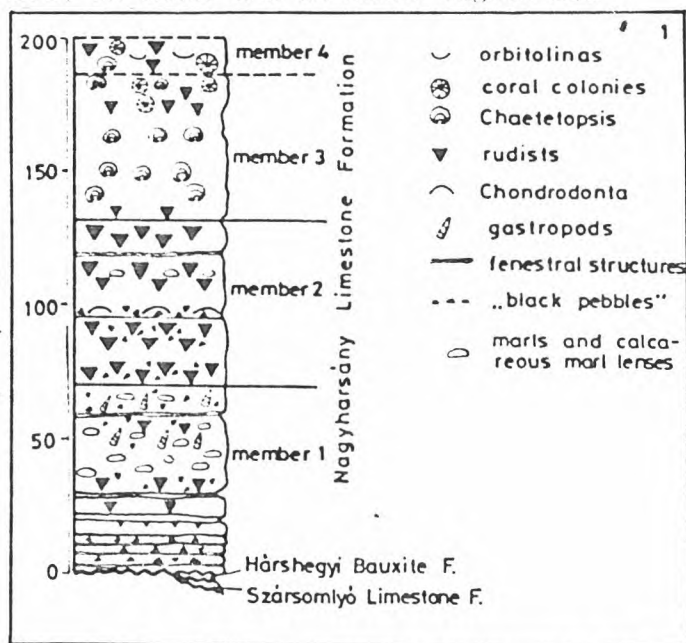
Transgressive urgonian facies with "black pebbles" from the Villány Mts.

G.CSÁSZÁR  
Hungarian Geological Institute  
Budapest

Lower Cretaceous sequence of the Nagyharsány Limestone Formation thickness of which exceeds 200 m in Harsányhegy quarry is surveyed. Lithostratigraphically it is subdivided into four member rank units (Fig.1.) The 70 m thick lower member investigated in thin sections a great variety of texture types has been distinguished as follows: empty micrite (or dismicrite), bioclastic micrite, pelletal micrite, biomicrite, pelmicrite, pelbiomicrite, intramicrite, pelbiomicrosparite, biosparite and intrabiosparite. Based on lithologic characters and its poor fossil content rhythmic change of facies ranging from freshwater to normal marine is detected. Various sedimentary environments are described. The attention is focused on the formation and interpretation of "black pebbles" which are characteristic elements of lofer facies. "Black pebbles" are known to occur in many horizons including normal marine environments. They are supposed to have been formed in ponds with non-agitated water in the supratidal zone but after desiccation during stormy periods they have been transported into the sea. For the paleogeographic reconstruction a block diagram is used in which, among others, an inner and an outer lagoon are proposed.

Figure caption

Fig.1. Simplified lithologic and lithostratigraphic columnar section of the Lower Cretaceous sequence in Harsány-hegy quarry, Nagy-harsány, Villány Mts.



Pannonian sedimentological facies relations  
of the hydrocarbon accumulations within the  
central part of the Pannonian basin.

István CSATÓ

Petroleum Exploration Company

Hungary

The sedimentation cycle started in the Badenian produced 7-8 km thick sequence in the deep depressions of the Pannonian basin up to the Quaternary. Most of the sediments were deposited in the Pannonian s.l. age.

Calcareous marls and marls represent the transition from the Sarmatian to the Pannonian within the deep basins. These beds are overlain by deep-water pelitic sediments. In this sequence, distal turbidites can occur, that are deposited in great mass mainly within deep grabens. The deep-water sediments are covered by delta progradational sequence with downlapping. According to the data available nowadays, the delta filling was built up by three main systems: one of them started from NE, the other from W, and the third (youngest) from NW direction (I.Gajdos). These major trends may vary in some places. Proximal turbidites, delta slope marls, silty marls and delta front regressive sandstones belong to the delta sedimentation. The delta plain association is the uppermost sequence up to the Quaternary.

The delta plain and the distal turbidites have of minor importance from point of view of hydrocarbon reservoir. Associated with the former, trap situations rarely evolve, the latter has bad permeability. The most significant facies are the delta front and the proximal turbidites deposited in the environment of the delta slope base. (Fig.1.)

In the future we have to work out the research method of the non-anticlinal type subtle traps. The different fills may be a large part of the potential subtle traps, that occur in several facies types within the Pannonian basin. For example: slope front fills occur on the concave side of the delta slope (Fig.2.), while walley fills above the local depressions (Fig.3.). These suggest the importance of the sedimentological study of the morphological low environments.

Other perspective subtle traps may be the transitional zones of different facies: pinch-out of proximal turbidites against delta slope marls, individual turbidite lobes, interfingering of distal turbidites with prodelta marls. (Fig.3.)

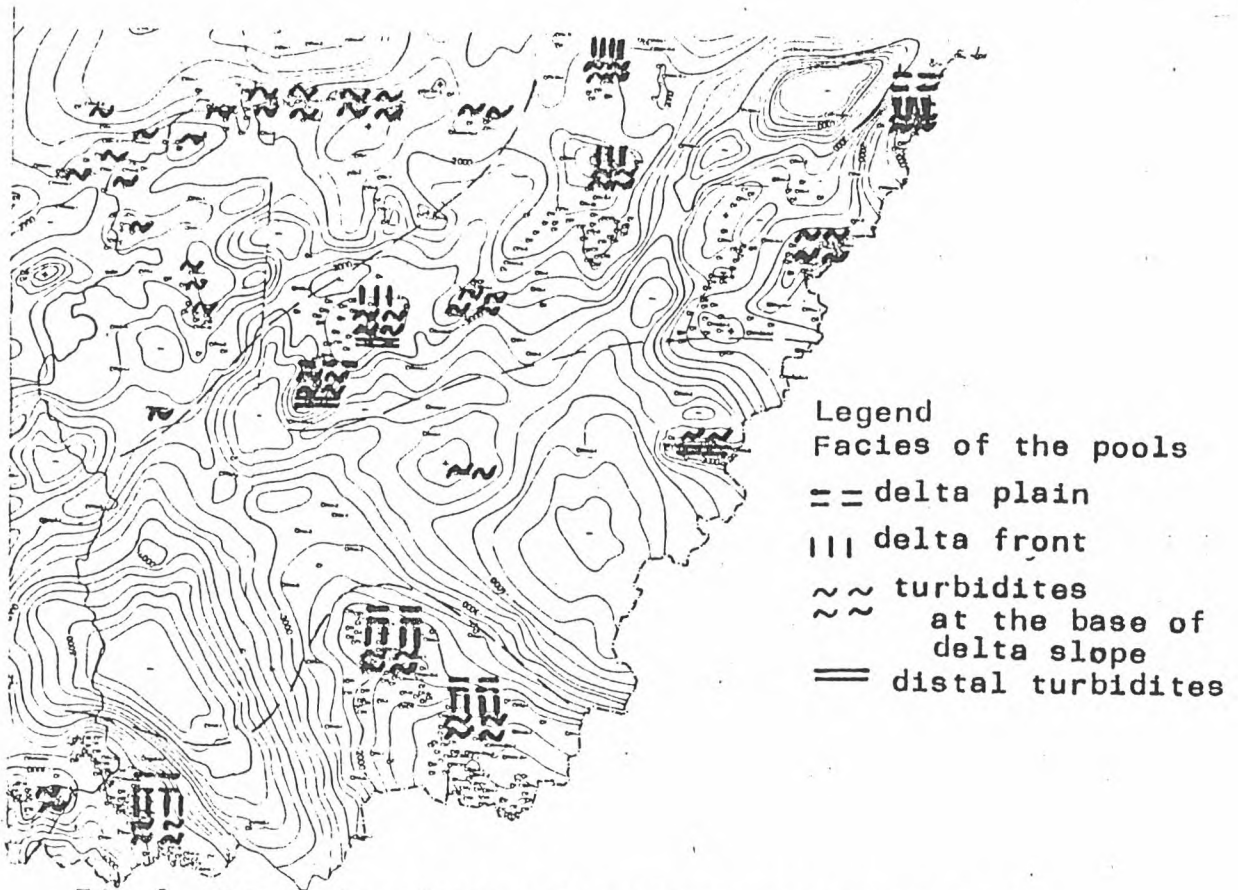


Fig.1. Pannonian facies for the hydrocarbon pools, central Pannonian basin.

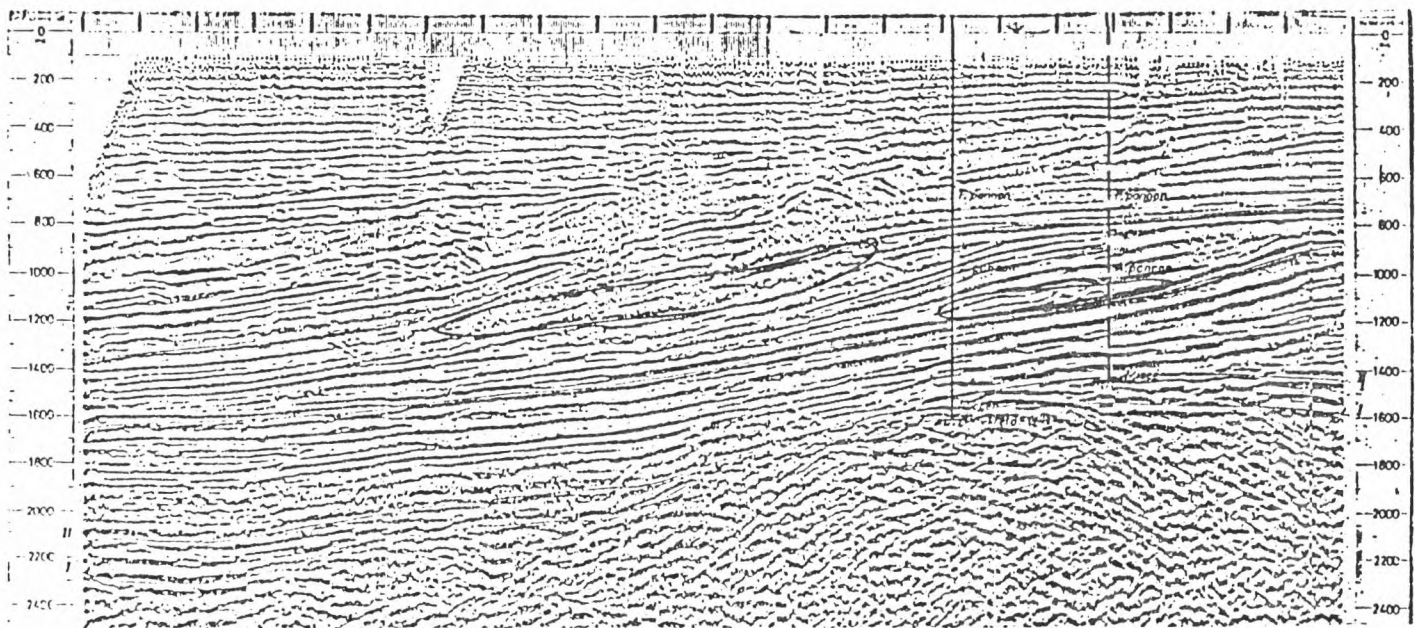


Fig.2. Slope front fills, Nádudvár area

Déva-Dél area  
Facies model diagram for the early Pannonian

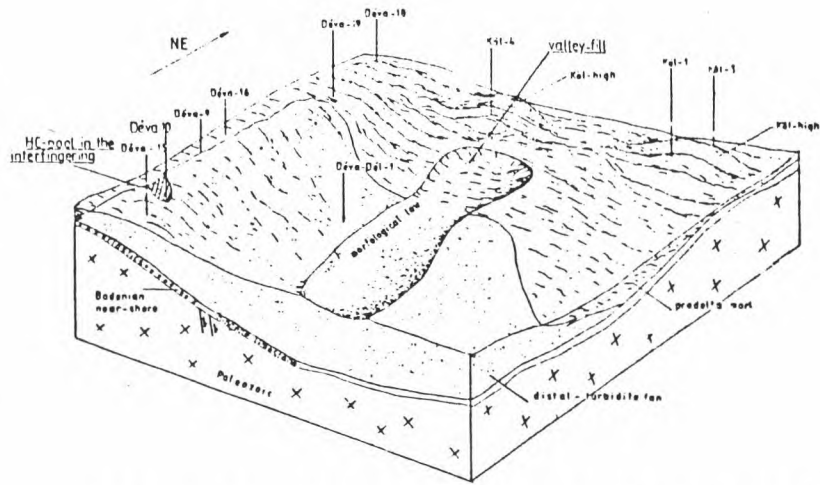


Fig.3. Facies interfingering and valley fill as subtle traps.

TIBOR CSERNY  
Hungarian Geological Institute  
HUNGARY

RUBEN CORRADA  
Geophysical Expedition  
CUBA

Within the framework of the Cuban - Hungarian scientific - technical cooperation seismoacoustic and echographic measurements were performed on the areas of the Lake Balaton covered by deeper than 2 m water, at a local length of 370 km by applying continuous registration.

The investigations were aimed at determination of the thickness of the Lake's loose mud, and at obtaining the geological history of the lake. In the course of the evaluation of the results we compiled the thickness map of the loose mud and seismostratigraphical - tectonic map of the basement, both on scale 1: 50 000.

On the basis of the thickness map the mud is generally 5 m thick. There are elevations in the basement with 1-1.5 m thick mud, while in subsidences it may reach the 8 m. The observed maximum depth was 10 m at the mouth of River Zala inflowing into the lake. Based on the available boreholes and samples taken from them, by applying radiocarbon and palynological dating, the speed of mud accumulation could be calculated as 0,4-0,6 mm/yr. As for the basement on the basis of seismic time section 7 zone sand. within 2 zones five layers were appointed and its depiction accompanied with tectonic elements is the seismostratigraphic - tectonic map of the basement.

The selected zones and layers are partly lithologically differing and on the other hand their conditions of deposition is also different. Geological identification of the zones and layers, on the basis of the already existing and planned boreholes, is the task of the near-future.

10th IAS Regional Meeting on Sedimentology - BUDAPEST, 1989  
The depositional position of the alginite in a basaltic tuff  
maar crater at village Pula (Transdanubian Mountains, West-  
Central Hungary)

Gy. Csirik  
dr. G. Solti  
Hungarian Geological Institute  
Hungary

After the discovery of the alginite deposit at Pula in 1973 (Á. Jám bor-G. Solti, 1973) during 15 years it has become more accurate the knowledge on the formation of the basaltic tuff crater, the depositional position of the alginite and the bentonite deposited in it. The basalt volcano which have had been active  $4.15 \pm 0.17$  million years ago has given rise a maar-type ring-shape crater structure. The first step of the formation of the crater was an explosion of the basalt volcano which has taken place in a lake of Upper Pannonian age 4-5 million years ago resulting in a formation of a soup-plate-shape maar-type ring crater structure. Its side-walls consist of the crossbedded basaltic tuff and the basaltic tuffite. The formations underlying in deep comprise the dolomite of Upper Triassic age and the sediments of Upper Pannonian age. The dispersion of the tuff has taken place in two phases. Between two beds of the tuff there are the intercalations of the clayey marl and the limestone deposited in a lake with sweet fresh water. After the dispersion of the tuff through the channel of the crater the basalt lava has injected from which a bluish black, hard, dense basalt containing scarce porphyritic minerals has formed in 6-8 m of its upper part has had a scoriaceous nature due to the exhalation. The recent studies has determined the accurate size and shape of the crater. The sediments of the Pulai Alginite Formation has deposited above the beds of the vol-

canic matter. The complex with 50 m of thickness can be divided into four parts consist of predominantly the alginite and the bentonite. Its lowermost beds are made of the basalt and the basaltic tuff. The complex of the alginite is overlaid by the sediments of Pleistocene and Holocene age. The sediments of the crater lake has deposited in a shallow water pond characterized oligohaline salinity and pH of 7.6 and 3 o/oo of the maximum value of the salt content. The shallow water has been extremely rich in the coastal plants. The temperature of the water in the sedimentary basin during the virulence of Diatom species was 10-12 °C i.e. the climate has had much warmer moderate character. Based on the climate and the Diatoma species characterizing Pliocene age and the extinction of the species and the radiometric K/Ar age determination date the sediments were formed in the last "sweetening-up" brackish oligohaline stage of Upper Pannonian age. The recent studies allow the investigation of the sediments of the crater in details. The basaltic tuff maar crater has known recently (Egyházaskesző-Várkesző, Gérce-Sitke, Outer- and Inner-Lake of Tihany Penninsula (Lake Balaton)) to locate in pairs. According to our recent opinion the crater at Pula has no the member of the pair. The southern edge of the crater is destroyed and its south-eastern part the alginite is partly eroded. Against the results of the earlier studies the area of the crater is proved to be larger. The maps showing the structure of the basaltic tuff crater the thickness of the sediments underlying the alginite and that of the alginite and that of the sediments overlying the alginite allow the interpretation and the demonstration of the depositional and the destroying processes.

New data on Southern Italy Travertines: textures and depositional environments

BRUNO D'ARGENIO(\*) & VITTORIA FERRERI(\*)

(\*)Dipartimento di Scienze della Terra, Università, Napoli  
ITALY

The textural characteristics of the Italian travertines may be analysed on the base of the primary carbonate incrustation types not taking into account later cementation and porosity variations, as such features appear to be directly related to later diagenetic modifications.

Blue-green algae and bacteria can often play an active role in the primary precipitation of the Southern Italy travertines, as suggested by microscopic characteristics which very often may be similar to a cryptalgal fabric (*sensu* Monty).

The studied travertines may be divided in two great textural groups of clastic and autochthonous travertines, showing gradual transitions among them.

Clastic Travertines consist of rocks that exhibit, on the whole, a particular texture. Their principal components are fragments (arenite to rudite in size) of incrustated vegetables (phytoclats) and, very subordinately small fossils (Ostracods, Molluscs, Characeans). These deposits seldom show sedimentary structures suggesting a typical current transportation; they appear precociously bound by biogenic incrustation, strictly relatable to cryptalgal fabric. Clastic Travertines may contain a variable amount of calcareous-sand matrix, formed of smaller phytoclats, Chara oogonia and "stems", and algal (?) fragments. In the lithotypes supported by a matrix of calcareous sand the incrusting processes and the later cementation are much less developed. On the basis of relative amounts of rudite-sized phytoclats versus calcareous sand content, four groups of clastic lithotypes may be distinguished: Phytoclastic Travertines (sandy fract. 0-10%), Phytoclastic Calcareenites/Calcirudites (sandy fract. 10-50%), Phytoclastic Calcareous Sands (sandy fract. 50-90%) and Calcareous Sands (sandy fract. 90-100%). Other grains, like oncolites, bacterial pisoliths and inorganic pisoliths, may substantially contribute to form clastic travertines. Both inorganic pisoliths and travertine lithoclats may occur as fillings, in channels or karstic conduits.

The Autochthonous Travertines derive from rapid *in situ* incrustations (i.e. the original vegetable component is organically bound during incrustation). On the basis of the incrustation types, three groups of autochthonous lithotypes have been distinguished: Stromatolitic Travertines, Microhermal Travertines and Phytohermal Travertines. Stromatolitic Travertines are laterally continuous, stratiform deposits characterized by discontinuous planar

lamination. The individual laminae, 1 to 5 mm thick, are often separated by sheet-like irregular cavities and derive from incrustated blue-green algae and/or bacteria. Like marine stromatolites they are grouped to form thin (several mm to some cm) intervals. The Stromatolitic Travertines often show a (seasonal?) rhythmicity in the laminae organization which may be related to the variation of one or several environmental parameters. Microhermal and Phytohermal Travertines are mostly made up of incrustated hygrophyle plants (microphytes and macrophytes). For these travertines microscopic characteristics of the incrustations also suggest an active role of Cyanophyta and/or bacteria in the primary precipitation of calcium carbonate. The Microhermal Travertines are made up of tubules ranging from 0,2 to 1 mm in diameter and from 1 to some mm in length, and organized either in very pervious "reticulate" fabrics or in laminae of iso-oriented tubules. In the Phytohermal Travertines, which can be compared with framestones such as defined by Embry and Klovan (1971), the incrustations on hygrophyle plants or mosses form rigid and highly pervious frameworks, with single open spaces sometimes exceeding 10 cm<sup>3</sup>.

Different depositional features (stratification, lamination, orientation of phytostructures, erosional surfaces ect.) may occur in the travertine deposits.

On the basis of the analysis and of the interpretation of either textural features or sedimentary structures, typical associations of lithofacies may be singled out.

The lithofacies associations make up sedimentary bodies whose geometry may be closely related to the morphology of the depositional palaeo-environments.

Obviously, there is not a single genetic model which may be proposed for all the travertine deposits of Southern Italy. However, the individuation of significant natural associations of lithofacies, and of correlative sedimentary environments, allows one to suggest some specific sedimentary models for the studied rocks.

At the present stage of our studies the following lithofacies associations have been distinguished:

1. Calcareous sand with Travertine intercalations (Shallow Lacustrine Facies);
2. Phytoclastic Calcarenite and Phytohermal Travertine (Swamp Facies);
3. Phytoclastic Grainstone and Stromatolitic Travertine (Gentle Slope Facies);
4. Phytoclastic Rudstone, Microhermal and Stromatolitic Travertine (Slope Facies);
5. Micro-phytohermal Travertine (Pool Gradine Facies);
6. Phytohermal Travertine (Waterfall Facies).

"MID CRETACEOUS" REGIONAL UNCONFORMITIES AND RELATED  
BAUXITES/PALEOKARST OF THE MEDITERRANEAN. RESULTS OF  
DISTANT AND PROXIMAL TECTONIC EVENTS?

BRUNO D'ARGENIO  
University of Naples  
Dept. of Geological Sciences  
ITALY

ANDREA MINDSZENTY  
Eötvös L. University  
Dept. of Mineralogy  
HUNGARY

In "Mid Cretaceous" times, more or less simultaneously with the beginnings of the closure of Tethys, we find widespread karst phenomena in several stratigraphic horizons all over the carbonate terrains of the Mediterranean. They may or may not be associated with bauxites and are related to subaerial exposure phases brought about apparently by orogenic/epeirogenic movements and/or by eustatic sea-level drops.

Regarding their main characters and their paleogeographic position they may be divided into the following three groups:

(1) Conformably or paraconformably "intercalated" within carbonate platforms of the southern Tethyan margins (Central Appennines, Apulia, Dinarids, Hellenids). They are characterized by brief stratigraphic gaps, shallow to medium surface karst relief and well-preserved underground cavity-type karstification;

(2) Unconformably developed over deeply eroded, tectonically uplifted areas (Transdanubian Central Range, Northern Calcareous Alps) - likewise of southern Tethyan affiliation, characterized by rather large stratigraphic gaps and pronounced unconformities between the underlying and overlying rocks. Surface karst is of various scale, here and deep-sinkholes are more frequent than in the afore mentioned group. Underground cavity-type karstification is generally less apparent in association with these type of unconformities.

(3) Intercalated within carbonate sequences of the northern (European) "foreland" area (Spain, France, Sardinia, Romania, etc.), characterized by smaller or larger stratigraphic gaps, various degrees of unconformity, and various ratio of underground versus surface karst.

Terrigenous materials (bauxites and/or red clays, paleo-soils) filling cavities and depressions of the karst relief

are supposed to have originated either from thrust slices of the accretionary wedge, from early Alpine nappe piles and from obducted ophiolites (groups 2 and 3) or from wind-blown dust and/or fine pyroclastics produced by distant volcanic activity connected to the deformation of the Peritethyan area (group 1). Of course in both groups the contribution of the weathering products of the underlying carbonates is also a possibility to be counted with.

In the case of (2) and (3) subaerial exposure of the carbonate suites situated relatively close to the actual site of subduction (and later, collision) was obviously brought about by orogenic deformation. Karst phenomena having been formed as a result of this deformation, can be considered as RECORDS of the tectonic uplift (post-tectonic, "PROXIMAL" BAUXITES/PALEOKARST). In case (1) the karstification of so to say "external" platform successions which are situated far from any kind of orogenic tectonism ("DISTAL" BAUXITES/PALEOKARST) is apparently the result of more quiet, epeirogenic movements. In some cases even eustatic sea-level drops could be invoked for as the cause of subaerial exposure of large shallow platform areas. The timing of the paleokarstification events is however in most cases coincident with major phases of tectonic activity taking place in distant, orogenetically active areas. This coincidence strongly suggests that the emersion of the platform areas may reflect - at least in part - the gentle lithospheric bulge brought about by these distant orogenic movements.

## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989

Mobilization and transport of solutes by groundwater, an example: the Iberian chain drainage into the Tertiary Ebro basin (Spain).

DE MIGUEL, J.L.; MARTINEZ, F.J.; SANCHEZ, J.A.; SAN ROMAN, J.  
Dpto. Earth Sciences, Zaragoza University  
50009-Zaragoza (SPAIN).

Some lacustrine systems are characterized by an important chemical deposition; geochemical differentiation and concentration originates highly pure evaporitic deposits (gypsum, halite, glauberite, etc.).

The water is the principal mean of salt transport; the precipitation of salt is the result of different processes, the most important ones are: concentration by evaporation and evaporitic pumping.

In arid and semi-arid climates the main portion of those waters have a subterranean origin, which involves constant flow and relatively high mineralization.

Groundwater flow models in sedimentary basins due to TOTH (1980) show: the different systems of groundwater flow (local, intermediate and regional ones), geochemical evolution of waters and delimitate recharge (infiltration) and discharge areas (humid or lacustrine areas, salt marshes, salt flats, etc.). Groundwater drainage from Iberian Chain into Ebro Depression constitutes an excellent example of Toth's theories application.

Iberian Chain and Ebro Tertiary Depression constitute, in addition to Pyrenees and Catalanian Chain, the four principal geologic units that conformate the northeastern area of Spain.

Iberian Chain constitutes a geologic unit where sedimentary rocks formed along all the ages outcrop; however, there is an areal predominancy of jurassic and cretacic carbonated formations. These carbonated rocks constitute an extense recharge area for groundwater both because of their lithology and topographic situation.

Ebro Tertiary Depression constitutes a big sedimentary basin, whose central zone is filled with gypsum deposits that reach a big expanse and thickness. Nowadays this zone is traversed by Ebro river.

The contact between both geologic units is the principal discharge site for groundwater. If we only consider the central section of this contact (Aragon section), 6 big springs exist on the contact; their total flow is greater than 2.500 l/s. Some common characteristics of these springs are:

- Big and steady flow
- Low tritium content in waters
- High mineralization, greater than 1 g/l (even more than 2 g/l in some cases), and a calcic sulphated chemical composition.
- Relatively high temperatures (22 to 28°C) when comparing them with the atmospheric means temperature (11 to 14°C).
- Similar geologic position of the springs, placed either on the carbonated formations or on their tertiary thin covers (figure)
- Anomalous high conten of silica.

All these characteristics suggest that these springs are regional discharge points -using Toth's terminology, TOTH (1963)-. In the Iberian Chain regional flow is preferably conveyed through the liasic breccias aquifer, so we consider it as the "Iberian Chain regional drainage unit", MARTINEZ et al. (1988).

It has been observed that a part of this groundwater flow is not drained by big springs, those waters pass through the low permeability tertiary formations, SANCHEZ et al. (1987) and arise in a diffuse way in humid areas, salt pools, marshes, etc.

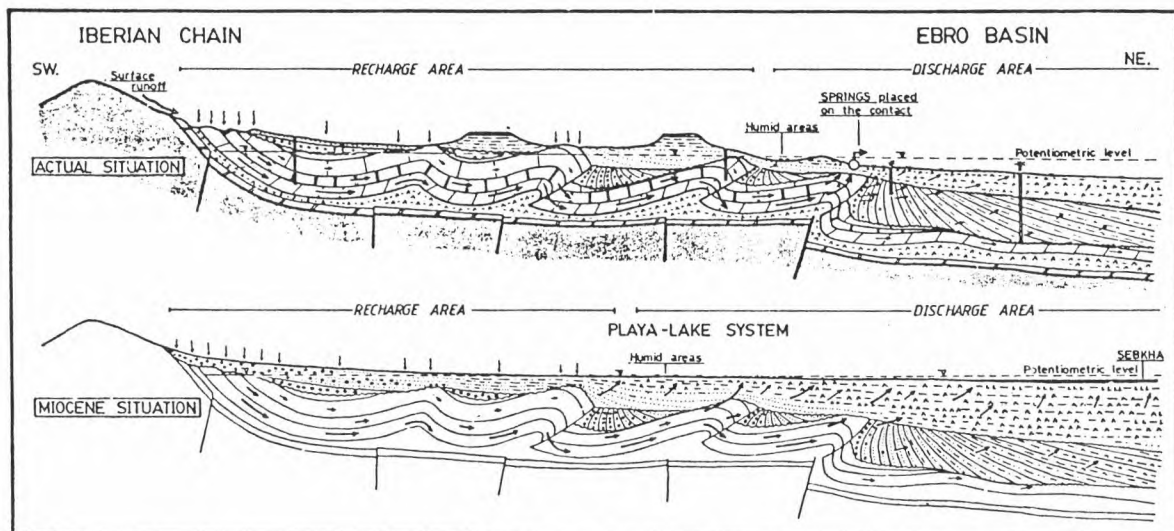
If we take account of both flow and chemical composition of waters of these 6 biggest springs, it is easy to calculate that, at the moment, at least 70.000 tm/year of calcic sulphated are transported from Iberian Chain into Ebro Depression and, by means of Ebro river, to the Mediterranean sea; SANCHEZ et al. (1987).

During the Miocene Ebro Basin was an endorreic depression, so the dissolved salts that were carried by groundwater had to precipitate inside the basin. Considering both gypsum density and present-day discharge rate, a parallelepipedic volume of 50 X 15 km base and 500 m height could be deposited in a 10 million years period only.

Miocene epoch situation is represented in figure ; at that time, groundwater discharge proceeding from the Iberian Chain would not be concentrated in a few big springs but it should be distributed in extensive humid areas or "sebkhas". Those were the places where the evaporitic deposits that we can easily observe now could be formed.

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NEW OBSERVATIONS ON "KEYSTONE VUGS" : THEIR FORMATION AND PRESERVATION IN RECENT BEACHES, AND CONSEQUENCES FOR INTERPRETING ANCIENT SEDIMENTARY DEPOSITS

DEVILLE Quentin, University of Geneva, Department of Geology and Paleontology.

Emery (1945) was the first to systematically described the entrapment of air in beach sand. Dunham (1970) later called the structures produced by air bubbles "keystone vugs" and defined them as follows: "They are as large as 10 grains in diameter and are roughly spherical or lens shaped. The roof of the vug resembles a crude keystone arch". This definition appears to be based on microfacies analysis. Emery, on the other hand, made his observations on Recent beaches. He carefully described vugs and vug morphologies and equally suggested a formation process.

It seems necessary to specify the relation between these studies, the formation mechanisms and the environments where air entrapment occurs.

"Keystone vugs" express themselves as fenestral porosity in sand. The sand is generally fine, well sorted and contains an important interparticle porosity. Open-space structures (meso and megapores: 1 to  $10^4$  mm<sup>3</sup>) may be superimposed on sands of exposed high energy beaches, or on sands of more protected areas such as tidal channel rims.

As stated by Dunham (1970), the swash zone is a favourable place for development of air entrapment in sand. However, it must be specified that only in the uppermost part of the swash zone, when tide reaches its highest level, voids may form and be preserved. There, the two or three last highest and strongest waves cover an area of sand which dried during a tidal cycle. The marine groundwater level is situated a few tens of centimetres below. Wave movement is first rapid and horizontal (1 to 3 m/s), then decreases and finally stops. At that moment, intergranular air is caught between two interfaces: groundwater level below and covering wave on top. If no backwash occurs, the water of the wave penetrates the sediment and fills the intergranular porosity, replacing an air volume by an equivalent water volume. This increases air pressure in the pores (1 to 10 g/cm<sup>2</sup>, depending on initial wave overburden). Part of the air escapes at the wave front. Therefore, the wider the covered area, the more effective is the air entrapment. When water totally penetrates the upper layer of the sediment, pressure reaches its maximum, and sand plus water behave as a dense, and viscous, liquid. In this liquid, air moves and concentrates forming voids: bubbles (shape minimising superficial air pressure) in homogeneous sand, domes or sheets in heterogeneous laminated beach sand, and small tortuous channels (diameter 1 to 4 mm) when air tries to escape to the surface. Percolation continues, and the entire movable water in the upper sand layer flows downward, and only residual and non-movable water is left in the pores. Superficial water pressure holds the particles in position (capillary effect), and internal shear stress may reach 90°. Thus, large structures (1 to 10 cm) such as sand domes can be preserved.

In protected areas, the swash zone is absent. Sea level rises slowly and continuously. The flatter the beach topography, the faster is the covering of the sediment surface by water (10 to 50 cm/s horizontal displacement). Water fills the whole intergranular porosity per descensum. Air can only escape in front of the inundation area or is trapped in the sand and concentrates in bubbles. In some cases, a bubble can escape to the surface when the weight of water and sand covering it, is inferior to its buoyancy. Air entrapment is repeated every tide. Bubble sizes, millimetric at first, can become centimetric after numerous tides.

As in high energy beaches, capillary water permits preservation of the structures at low tide. Porosity in such cavernous sands can reach 60%, and its density comes close to 1 kg/dm<sup>2</sup>.

Consequently, entrapment of air in sand is an overprinted fabric. In both high energy and low energy environments, effect of hydrodynamics is low, and voids are produced basically by water percolating gravitationally through interparticle porosity.

Factors influencing air entrapment in sand are the following: Grain sizes generally range between 0.1 and 0.5 mm. Slope of the uppermost part of the beach must be as flat as possible in order to increase capacity of entrapment. Flooding, temporary or not, of initially dry or slightly humid sand is due to tides, wind-generated waves, oceanic swell and sealevel rise occasioned by low atmospheric pressure conditions. Causes which influence (positively or negatively) the drying of sandy areas are air temperature, relative air humidity, wind and rainfall.

Studies accomplished during the summers of 87 and 88 near Niembro (Asturias, northern Spain) show that air entrapment takes place:

- on exposed beaches at the upper limit of the swash zone, in the uppermost intertidal environment, displaying air bubbles, air sheets, sand domes, channels and, occasionally, their associated blow-holes. -
- on protected beaches (without swash), located in the whole upper intertidal and even in the upper part of lower intertidal, showing air bubbles evolving into cavernous sand constituting a layer of 20 cm or more for mature cavernous sand.
- in both environments, following exceptional events such as equinoctial tides, storms surges, tsunamis, or the addition of several factors influencing sealevel, air entrapment can take place also in the supratidal zone.

During a complete tidal cycle, preservation of air entrapment in exposed beaches is very low. Structures are generally erased by each following tide if the cycle is going towards spring-tide. If the cycle is going towards neap tide, the pore waters retaining the structures evaporate, and, unless early cementation by salt or carbonates occurs, the structures collapse.

On protected beaches, cavernous sand preservation is excellent during the entire tidal cycle. In various places, naturally or experimentally compressed, cavernous sand regenerates very rapidly during half a tidal cycle. Weight of sediment and intergranular porosity are limiting factors for air bubble size and thickness of cavernous sand layer.

If the frequency of events, contributing to air entrapment in sand is the same in both high energy and low energy environments, chances of preservation are reciprocally proportional to exposure of the beaches: protected - well preserved, exposed - hardly preserved.

In conclusion, the most common factor leading to air entrapment is the presence of tides. However, even in continental environments (Emery 1945), if the air-water-sand interactions are comparable to tidal setting, voids may be formed.

DUNHAM R.J.(1970) : Keystone vugs in carbonates beach deposits. AAPG Bulletin, Vol. 45, p. 845.

EMERY K.O.(1945) : Entrapment of air in beach sand. Journal of Sedimentary Petrology, Vol. 15, No 2, p. 39-49, pls 1-3, figs 1-2.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
 THE OXYGEN AND CARBON ISOTOPIC COMPOSITION OF MODERN

RHODOLITHES FROM THE MURTER SEA (MIDDLE ADRIATIC)

Tadej DOLENEC\*, Uroš HERLEC\*, Jože PEZDIC\*\* and Miha MIŠIĆ\*\*\*

Coralline algal nodules and concretions made up mostly of *Lithophilum*, recognized as rhodoliths, are frequently found in a shallow water environment, between 2 and 1 meters, around the islands in the Murter sea (Fig.1.).

Results obtained by X-ray diffractometry and by atomic absorption spectrometry show that they are composed of high magnesian calcite containing 8 to 11 mol % magnesium carbonate which has grown around different nuclei (rock fragments, mollusk shells or shell fragments). As a minor constituent occurs aragonite usually filling the old uniporate conceptacles and some interskeletal cavities.

Isotopic investigations exhibited a large dispersion of  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  of algal calcite and a positive correlation between carbon and oxygen isotope composition. Certain rhodoliths show a gradual enrichment in the light oxygen and carbon isotopes from the inner part to the periphery. The outer parts of these rhodoliths are characterised also by higher magnesium content.

The calculated temperatures of most rhodoliths cover a range from 20°C to 30°C. This temperature range is considered usual for shallow water environment in this area during the summer period.

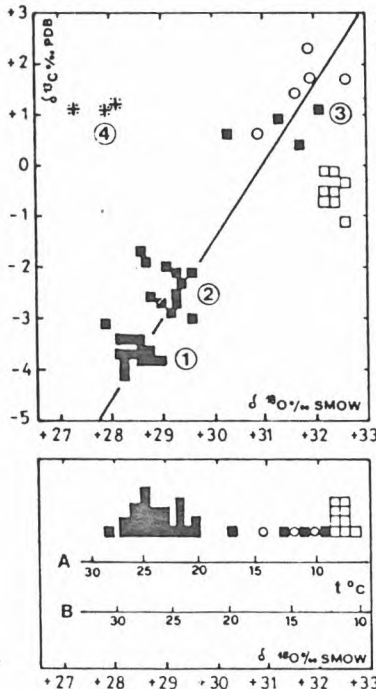
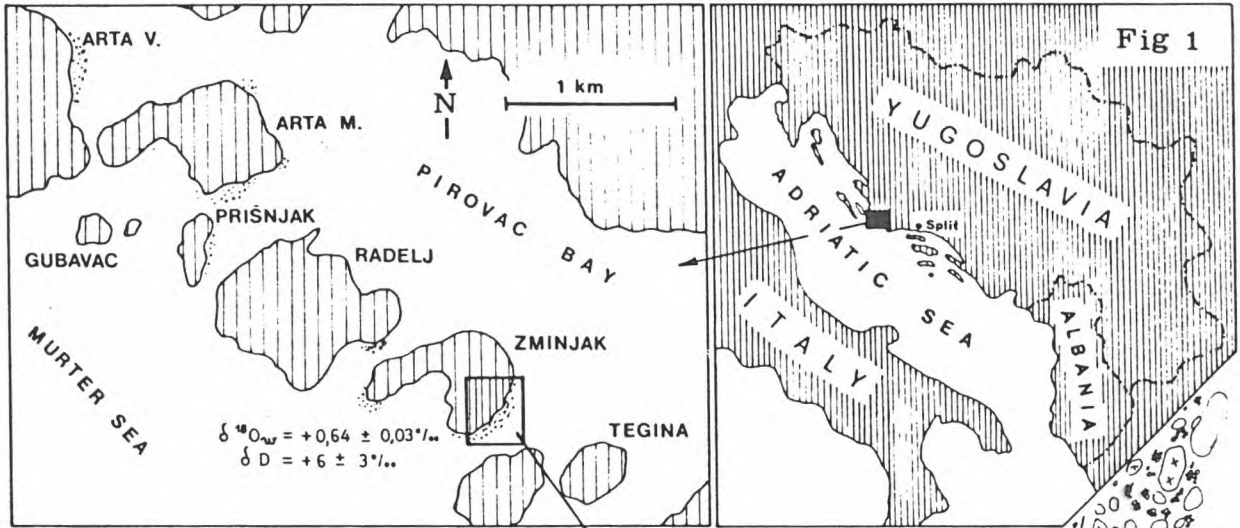
The above - noted dispersion of  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  and the positive correlations between  $\text{C}^{13}$  and  $\text{O}^{18}$  content of investigated rhodoliths may be generally due to a seasonal effect (annual variations of the water temperature are between 12°C and 28°C), as well as to the biological effects.

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\* Institute of Geology and Jozef Stefan Institute, University E.Kardelj, Ljubljana

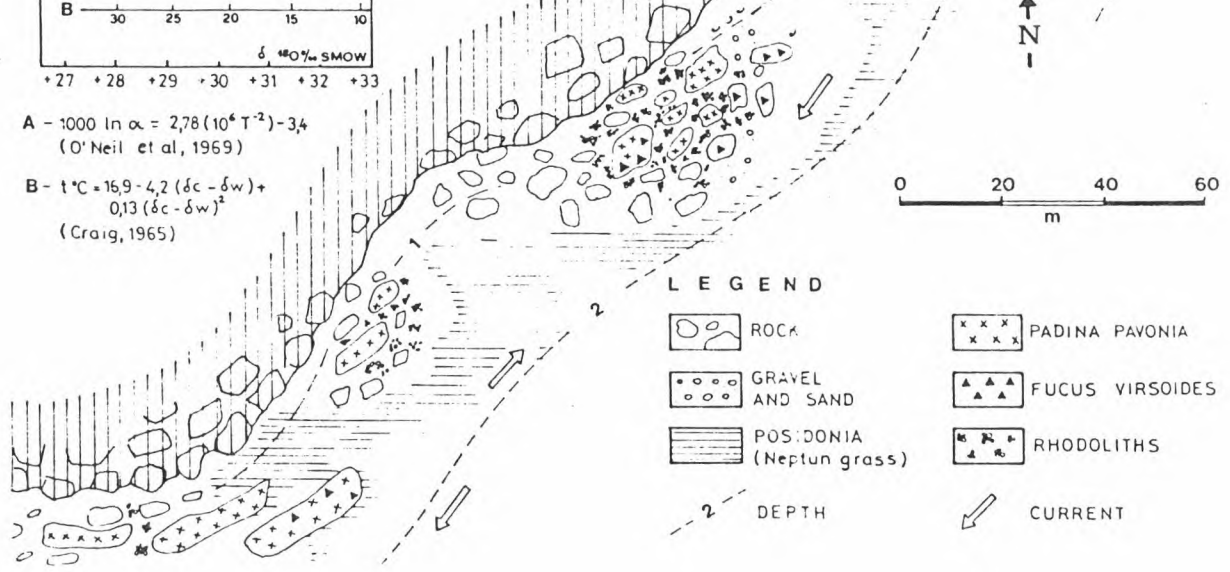
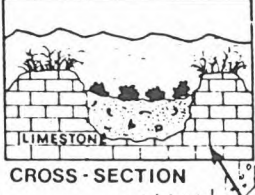
\*\* Jozef Stefan Institute, University E.Kardelj, Ljubljana

\*\*\* Geological Survey Ljubljana, Ljubljana



A -  $1000 \ln \alpha = 2,78 (10^6 T^{-2}) - 3,4$   
(O'Neil et al, 1969)

B -  $t^{\circ}C = 16,9 - 4,2 (\delta c - \delta w) + 0,13 (\delta c - \delta w)^2$   
(Craig, 1965)



On the peculiarities of lamination in the near-shore marine sedimentary strata

YURI DOLOTOV

Department of Oceanology, Atmospheric  
Physics and Geography USSR Academy of  
Sciences  
USSR

Based on the results of detailed stationary natural works carried out in the modern shallow-water sand coasts of the Baltic and Black sea areas and taking into consideration the literary data, the author distinguishes 3 dynamic relief-forming and depositional sedimentary environments (zones) in the nearshore marine area. In each zone there are the sedimentary strata definite textural features caused by common energy of the dynamic environments, by the predominant hydrodynamic factor action.

For the external zone of the wave transformation (the most deep-water ones) is characteristically as follows: the influence on sediment mainly of different type currents action (of unidirectional flat water flows) and significant episodic action of the most severe storms; mainly smoothed bottom surface with small ripples, and larger storm relief-forms arise only episodically. The zone is characterized by thin low-angle (or horizontal) and small-scale rippled (trough) cross-lamination, and specific laminae caused by severe storm regime action (cross-stratification of different type).

For the middle zone of the wave-intensive deformation and destruction is characteristically as follows: action mainly of the oscillatory wave-motions, presence of the large relief-forms (submarine bars and troughs, dunes and sand waves), experiencing intensive migration, of typical districts of plane bed. The zone is characterized by complex alternation of various lamination types (horizontal or gentle

dipping planar stratification, small- and large-scale trough cross-lamination), with short laminae sets and frequent erosional features (discontinuity surfaces).

For upper zone of the swash and backwash is characterized as follows: action mainly of the flat translatory water-flow, presence of the surface usually with general seaward inclination, often with the beach ridges. The zone is characterized by large-scale diagonal cross-lamination, consistent long sets of thin planar gentle seaward dipping parallel laminae, often of lens-shaped and wedge-shaped type.

In ancient sedimentary strata of nearshore marine origin the spreading of the deposits belonging to the three distinguished dynamic zones (environments) depends on the preservation potential of the relief-forms and deposits in these zones, and its highest value is in the deepest and the least dynamical external zone and essentially less is in the others. And on this reason, based on the statistical data, deposits of the first ones mainly become stable geological formations. Ancient deposits of the middle and the upper zones are not always distinguished, and it is conditioned by intensity and recurrence of the reformation process of such relief-forms and deposits, by removal and superimposition of these forms one another.

Fairly frequent finding of the storm formations in the ancient sedimentary rocks depends on high preservation potential of these relief-forms and deposits: they are not subjected to any changes for long time under conditions of the more weak hydrodynamic regimes action.

Geodynamic approach to Neogene palaeogeography of Carpathian region.

Edward G. DONGAROV, Yuriy G. NAMESTNIKOV,

VNIIzarubezhgeologia, USSR.

1. Carpathian region is characterised by horizontal displacements of big amplitudes, overthrusts and strike-slip faults. These were manifested mostly in Neogene, thus the reconstruction of palaeogeographic situations has to be made with geodynamic approach.

2. This approach has become realisable in recent time because, firstly, the plate tectonics concept has been developed into scientific theory. Secondly there are many results of different investigations of Carpathian region available now which allow the geodynamic approach. These results are: (a) litho-facial investigations; in particular, we have compiled a series of stage-by-stage litho-palaeogeographic maps of the region in 1:1000 000; these regional maps along with detailed investigations' data allow revealing areas where genetically different sediments lie in close contact (NE Hungary, Transylvania etc). Explanation of their position in modern plan view is possible only with geodynamic approach; (b) data on overthrusts and faults, mainly on strike-slips, which indicate the surfaces of interaction of microcontinents and blocks,

direction and amplitude of horizontal displacements;(c)palaeomagnetic data which indicate direction and character of displacements;(d)data on magmatism which indicate the time and character of interaction of microcontinents and blocks;some other data.

3. Basing on these results we have compiled a series of stage-by-stage palaeogeographic palynspastic maps in 1:1000000.

4. Analysis of these maps leads to the following general conclusions. The Neogene history of the region is divided into two periodes: Egerian-Karpathian and Badenian-Romanian..

At the Karpathian/Badenian boundary fusion of microcontinents and blocks occured. This resulted in the beginning of formation of the present structure of inner Carpathian region. Before this boundary horizontal displacements had big amplitudes over the whole territory of the region. These displacements might be much bigger than vertical ones. Area of Carpathian region was bigger too. Inside this region there existed vast Inner Carpathian sea. A number of straits linked this sea with the outer Carpathian basins and with Tethys. Different facies were formed on the shelves of the sea and in intermediary areas. After the regional compression the sea dissapeared. Sediments of basinal area were thrust under margins of microcontinents or weathered out. Sediments of different genesis of the sea marginal parts were placed close to each other.

5. Reconstruction of palaeosedimentary environments with geodynamic approach open new perspectives in search for potentially hydrocarbon bearing rocks.

Estimation of drift rates on accreted and eroded beaches  
by fluorescent sand, Nile Delta coast (Egypt)

NABIL EL-FISHAWI and ABDELMONEIM BADR

Institute of Coastal Research

EGYPT

ABSTRACT

Fluorescent sand grains were used to predict the sediment movement quantitatively and qualitatively. This approach was necessitated by the release and sampling methods utilized. The present study was performed at Burullus area to investigate the sediment movement on natural beaches, near man-made structures and through the silted part of the Burullus outlet. The eastern side of the Burullus area subjects to severe erosion where the sea advanced more than 200 m since 1935. On the other hand, accretion became a general phenomena on the western side due to construction of a jetty.

The estimated velocity for sand grains in motion ranges between 1.59 m/min and 2.38 m/min. Such low velocities indicate that the bulk of the sand load travels at a much slower rates along the coast. West of Burullus outlet, the drift rate was estimated to be  $0.92-1.20 \times 10^6 \text{ m}^3/\text{yr}$  where continued accretion was found at the up-drift side of the jetty. At the eastern side and where the waves attack the foot of the coastal dunes, high drift rate was occurred and estimated to be  $2.1 \times 10^6 \text{ m}^3/\text{yr}$ . The amount of offshore drift estimated  $1.2 \times 10^6 \text{ m}^3/\text{yr}$  is responsible for severe erosion on the coastal dune area.

A significant portion of the sediments in motion and estimated  $0.37 \times 10^6 \text{ m}^3/\text{yr}$  is directed from the eastern tip of the outlet to the west and resulting siltation of the outlet and creating difficulties to the navigation.

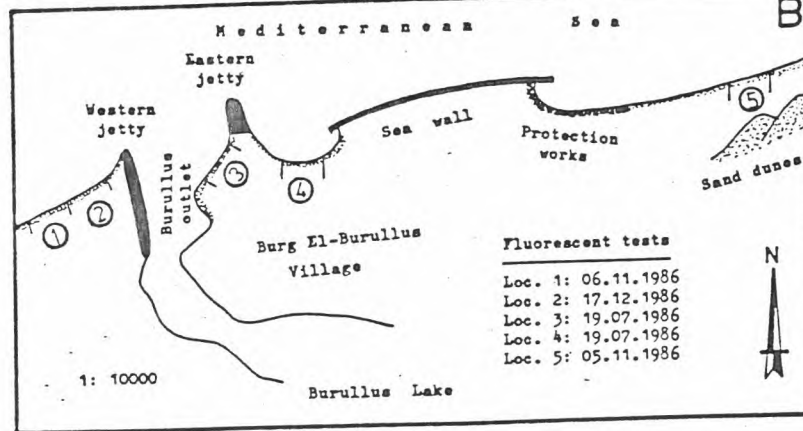
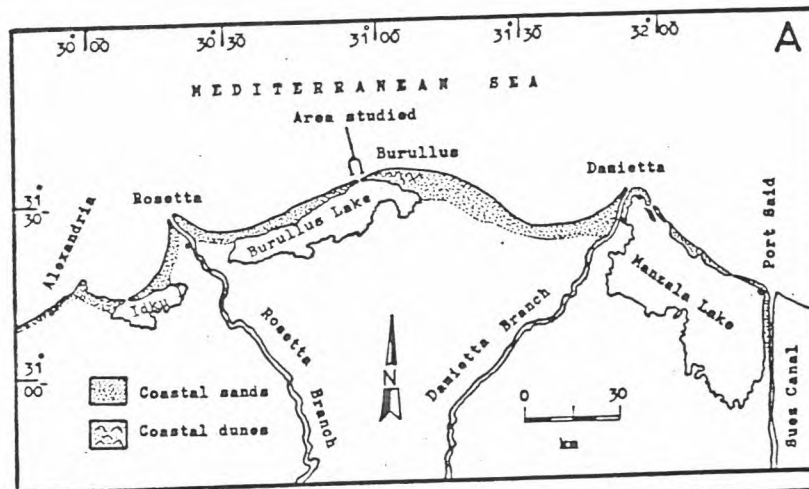


Fig. 1: A- Location map for the Nile Delta coast.  
 B- Studied area. Numbers indicate locations for tracer test beaches.

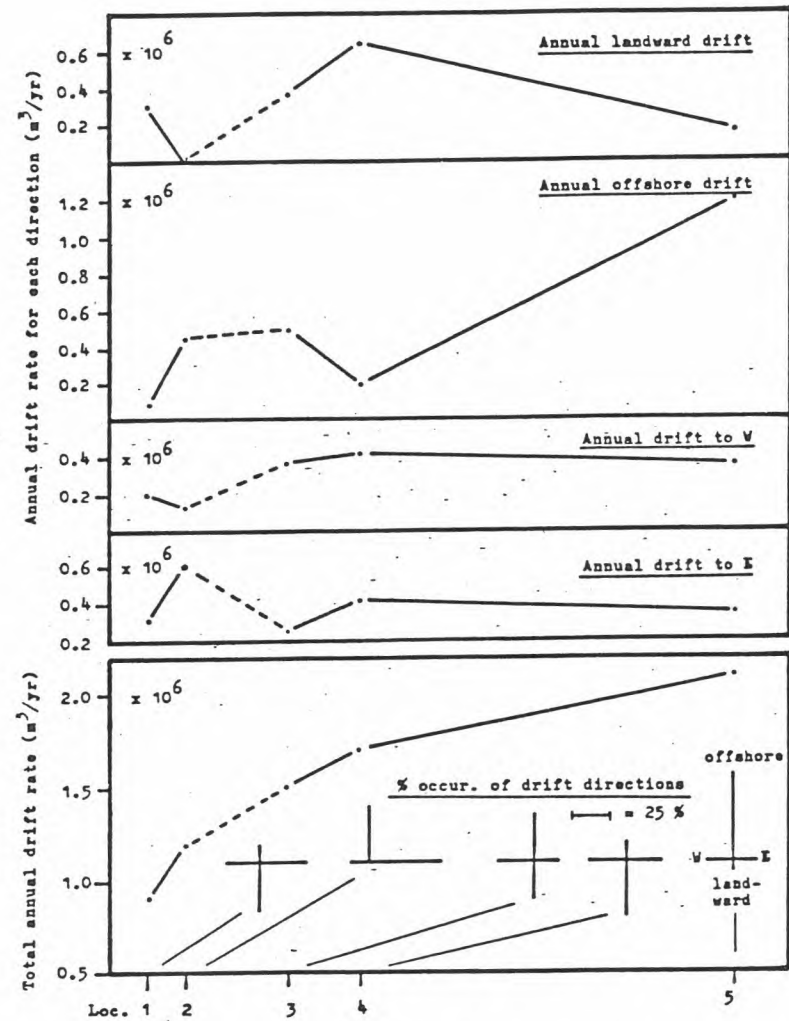


Fig. 2: The annual rate of sediment movement along Burullus coast.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
PLATFORM-MARGIN COLLAPSE AND SLOPE RETREAT, MID-TRIASSIC,  
GUIZHOU, CHINA

PAUL ENOS  
University of Kansas  
USA

WEI JIAYONG  
Guizhou Regional  
Geological Survey  
PRC

YAN YANGJI  
Chengdu Institute of  
Geology and Mineral  
Resources  
PRC

The Middle Triassic (Anisian) facies transition from the stable Yangtze platform southward into the subsiding Nanpanjiang (Youjiang) basin, at Qingyan, Guizhou Province, PRC, indicate an unusual pattern of slope retreat. The lateral facies succession comprises stromatolitic dolomites on the platform; a narrow band of massive, coarse-grained dolomite at the platform margin; intertonguing of dark, laminated lime mudstone with bioclastic turbidites, exotic blocks, and olistoliths at the basin margin that grade basinward into periplatform lime mudstone and finally into terrigenous mudrock and thin-bedded siltstone. The platform margin was evidently buried by terrigenous clastics late in the Anisian when the basinal facies overstepped the platform margin.

The map pattern of the transition reflects a slight net backstepping of the margin prior to the burial of the platform. Slight backstepping of the margin with intermittent minor progradation of the periplatform carbonates is in distinct contrast to the typical pattern of platform-margin retreat through episodic major stepbacks that punctuate periods of upbuilding. The size and local abundance of olistoliths and blocks in basin-margin deposits indicate that backstepping was caused by episodic collapse of lithified blocks at the platform margin. The blocks preserve algal framestones and bindstones with abundant small *Stromatactis* vugs, the only record of bioherms at the platform margin preserved through destructive dolomitization.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

Depositional Systems and Heavy Mineral Suites in the  
Barreme Foreland Basin, Haute-Provence, France

MARTIN EVANS\*  
Department of Earth Sciences  
University of Liverpool  
Liverpool L69 3BX  
UNITED KINGDOM.

MARIA MANGE-RAJETZKY  
Department of Earth Sciences  
University of Oxford  
Oxford OX1 3PR  
UNITED KINGDOM.

Sedimentary successions of foreland basins provide a record of the unroofing history of their adjacent fold-thrust belts. Shortening in the mountain belt gives rise to time-varying provenance, as successively deeper crustal levels are brought to surface and eroded. The sequential analysis of heavy mineral assemblages from each stratigraphic unit of the foreland basin fill enables evaluation of the lithology and tectonic evolution of the hinterland source terrains from which they were derived. This petrographic technique, when combined with other petrological, sedimentary facies and structural data, can be used to constrain the timing of uplift and erosion of source terrains, and permits reconstruction of the dynamic palaeodrainage patterns which characterise foreland basins.

The geological setting of the Barreme basin makes it particularly suitable for an integrated study of structural, sedimentological and heavy mineral data. It is a thrust-sheet-top basin, located in the external zones of the SW Alps in Haute-Provence. The basin fill ranges from late Eocene (Priabonian) to late Oligocene (Chattian) in age. Ten lithostratigraphic units are recognised within the basin, each with a characteristic heavy mineral assemblage. These assemblages become increasingly more complex upwards in the stratigraphic column, reflecting the influence of time-varying source lithology. In particular, the basin records a provenance transition from local sedimentary cover, andesitic arc and foreland basement sources, towards the predominance of material shed from the rising Alpine mountain chain to the east.

The Barreme basin contains a transgressive-regressive sedimentary fill, showing an overall transition from shallow marine to continental alluvial and lacustrine sedimentation. The earliest transgressive sediments, the Calcaires Nummulitiques, are characterised by the presence of two contrasting heavy mineral suites. A zircon-tourmaline dominated suite, derived from local sedimentary sources, occurs with a clinopyroxene-hornblende-euhedral biotite assemblage shed from an andesitic arc. The overlying Marnes Bleues mudstones, which record a deepening of the foreland basin, are associated with four clastic members, each with a distinctive heavy mineral signature.

The Gres de Ville member, comprising storm-generated and turbidite-like sandstones, represents the first significant input of sand-grade material into the Marnes Bleues basin. The grain morphology of the staurolite-tourmaline-apatite-garnet assemblage suggests both first cycle and reworked sedimentary material derived from the Permian cover of the Maures-Esterel massif. Conglomeratic submarine channel deposits, the La Poste member, are intercalated towards the top of the Marnes Bleues. They record the first appearance of a blue sodic amphibole, clinopyroxene and orthopyroxene assemblage of Alpine ophiolite-blueschist provenance. This assemblage is highly significant, indicating the unroofing of deep crustal levels brought to surface by thrusting. The latest stages of the marine basin are marked by regressive shoreline sequences. Coarse-grained Gilbert-type deltas, the St. Lions member, were located in the north of the basin. These are dominated by volcanoclastic heavy minerals, with abundant hornblendes of ferro-hastingsitic composition, associated with minor blue sodic amphibole derived from Alpine terrains located to the NE. In contrast, a fine-grained progradational shoreface sequence in the southern part of the basin, the Gres de Senes member, received detritus from the Maures-Esterel foreland basement massif.

The succeeding Oligocene continental sediments demonstrate an initial phase of multiple provenance, followed by a trend towards predominance of Alpine material. Stampian alluvial red-beds, the Molasse Rouge, include material derived from older sediments which were ultimately sourced from high rank metamorphics. Cannibalisation of underlying marine sediments is signalled by rounded hornblendes together with etched pyroxenes and sphenes. In addition, first cycle Alpine material increases in quantity and diversity, characterised by common serpentine, epidote, blue sodic amphibole and lawsonite. The overlying Chattian lacustrine strata, the Serie Saumon and Serie Grise, continue the trend of increasing diversity of heavy minerals with Alpine affinities. The fluvial Gres Verts, the youngest formation preserved in the basin, is typified by predominance of Alpine detritus, with negligible contribution from local sources. Abundant ophiolite-derived serpentine, enstatite, diallage, augite and chrome spinel is associated with high pressure-index blue sodic amphibole, lawsonite, sodic pyroxene, pumpellyite and epidote. These assemblages indicate the onset of a major episode of thrust sheet uplift and unroofing. The presence of rhodinite-derived vesuvianite and grossularite garnet suggests provenance from the Embrun-Ubaye nappe.

\* present address: BP Exploration,  
Britannic House,  
Moor Lane,  
London EC2Y 9BU,  
UNITED KINGDOM.

Heavy minerals and trace elements in the Palaeozoic  
of Thuringia (GDR)

FRITZ FALK, KNUT HAHNE  
Academy of Sciences,  
Central Institute for  
Physics of the Earth  
GERMAN DEMOCRATIC REPUBLIC

In the course of complex sedimentological investigations in the Palaeozoic sequence of the Thuringian Slate Mts. (Saxothuringian zone of the Variscan orogene) the heavy mineral content of psammitic beds and the geochemistry of pelitic rocks were examined.

Among the heavy minerals such of the stable fraction are most abundant. Zircon, tourmaline, and rutile make more than 90-95 % of non-opaque minerals. In spite of this monotonous composition it is possible to characterize the various psammitic levels and to distinguish them from each other. Characteristic features are the ZTR ratio, the presence of typical minor components (garnet, xenotime), and the appearance of the zircon populations (morphology and internal structure). In the stratigraphic column the ZTR ratio changes in the following way: Very high and high portions of zircon at the base of the Cambrian (95 %) and in the lowermost Ordovician (75-85 %), a sharp cut nearly between Tremadocian and Arenigian (less than 50 % zircon with corresponding high contents of rutile and tourmaline), and again increasing of zircon in Upper Devonian.

The geochemistry of the intercalated slates reflects similar proportions:

- The content of Zr increases upward from the Upper Proterozoic and reaches (together with Rb) a first maximum in Tremadocian slates.
- In Arenigian slates the content of Zr is very low.
- A second maximum of Zr is found in Upper Devonian (here together with a Ti maximum - up to 2 %).

The heavy mineral and geochemical data support our knowledge about palaeogeography, magmatic activity, and about lithology of the source area. The sedimentation in Cambrian and lowermost Ordovician is connected with processes of reworking acid crust materials in a near-shore shelf environment (especially in Tremadocian with acid volcanism). The cut between Tremadocian and Arenigian reflects strong changes in the source material with enrichment of basaltophil elements (Ni, Sc, Fe, Ti). Erosion of deeper crustal sections or an opening entrance of oceanic compositional components to the area of sedimentation may be the reasons. In Upper Devonian basic volcanism produces higher values for Ti; also unrounded crystals of zircon show the erosion of fresh magmatic material.

A quick and easy method for obtaining carbon (inorganic and organic) and sulphur contents of mudrocks ?

KARL FEISTNER  
Department of Earth Sciences  
CAMBRIDGE UNIVERSITY  
ENGLAND

The carbon and sulphur contents of mudrocks are regularly measured due to the large amount of information that such measurements can convey.

The organic carbon content is an indication of source rock potential and, together with sulphur content, may be related to the depositional environment (Berner & Raiswell, 1984) or even the thermal maturity of the mudrock (Raiswell & Berner, 1987).

The inorganic carbon content will consist of shell material and/or authigenic minerals. Following microscopic examination to determine the proportions of these two components, the authigenic carbonate content may be related to organic diagenetic reactions (Curtis, 1987) and used in depth of precipitation estimates following a porosity occlusion model (Raiswell, 1971).

The total sulphur content of mudrocks may be assumed to be equivalent to the pyrite content (Raiswell & Berner, 1986). This is then an indication of the amount of sulphate reduction that has occurred in the sediment and may also be used with the organic carbon content as stated above. The pyrite content also provides one of the values required to calculate the "Degree of Pyritization" of the mudrock which may also be used as a

palaeoenvironmental indicator of bottom-water oxygenation (Raiswell et al., 1988).

Traditionally measurement of sulphur content is by wet chemical methods and is consequently very time consuming. Carbon content has been measured in many different ways, many subject to systematic error or also very time consuming (Froelich, 1980).

This paper reports on the results of using a Carlo Erba Elemental Analyzer 1106 to measure carbon and sulphur contents of mudrocks. Only powdering and acid treatment (to separate organic and inorganic carbon) are required and the machine can run automatically at a rate in excess of one sample every ten minutes, making it an ideal tool for this routine analysis.

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## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

## In situ testing in sedimentology

IMRE FEJES - GÁBOR CSERNUSSI

Eötvös Loránd Geophysical Institute

HUNGARY

This poster presents the engineering geophysical sounding equipment developed in the Eötvös Loránd Geophysical Institute of Hungary. The hydraulic device which is fixed to the ground by anchor bolts pushes down drillpipes into the sedimentary layers. At the lower end of the pipes is a conic pressure measuring head. In addition to cone pressure different nuclear measurements are carried out within the pipe. Thus the method might be called penetro-logging. Combined use of measured parameters allows detection of sedimentological and soil mechanical boundaries in unconsolidated sediments.

Measured parameters are directly proportional to the in situ plasticity and bearing capacity of sediments /cone pressure/, and provide information on grain size distribution, clay content, density and porosity /data obtained by nuclear tools and filtration probe/.

A great amount of data was collected in the Pannonian Basin. Besides processing interpretation of data was also carried out by computer, based on geological control. Results are demonstrated by three-dimensional diagrams of simple sediments, organogenous sediments and bauxites.

After this general information on the engineering geophysical sounding equipment and basis of geological interpretation application possibilities are demonstrated by case histories taken from geological-geophysical surveys, mining exploration, civil and geotechnical engineering.

**Fornells Bay (Northern Menorca, Spain): An Example of Restricted Sedimentation in a Temperate Carbonate Shelf.#**

J.J. FORNOS (\*) - V. FORTEZA (\*\*) - C. JAUME (\*) - A. MARTINEZ-TABERNER (\*\*).

(\*) Dept. Ciències de la Terra. Univ. Illes Balears.

(\*\*) Dept. Biologia i C.S.

Ctra. Valldemossa, km. 7.5, 07071 Palma de Mallorca.

SPAIN

Cala Fornells is a restricted bay located in the northern part of Menorca Island. Its surface area is about 4 Km<sup>2</sup>, with an elongated shape. The maximum length lies perpendicular to the coast line and reaches 4.37 Km. Maximum width is 1.5 Km and is located in the innermost part of the bay. The mouth of the bay is a narrow passage, only 300 m wide. The bathymetry shows a narrow longitudinal central depression with a North-South orientation and a maximum depth of 20 m deep at the entrance to the bay.

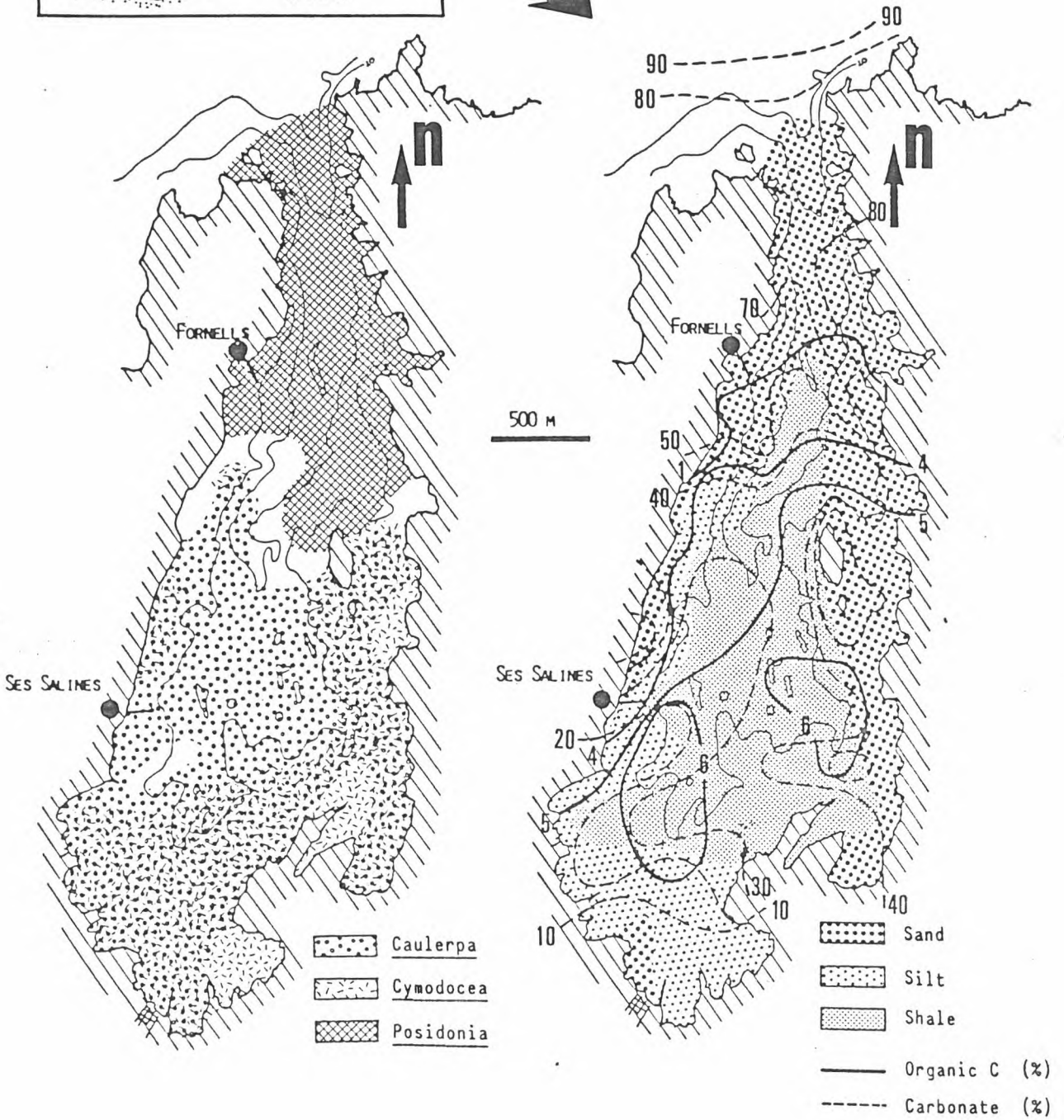
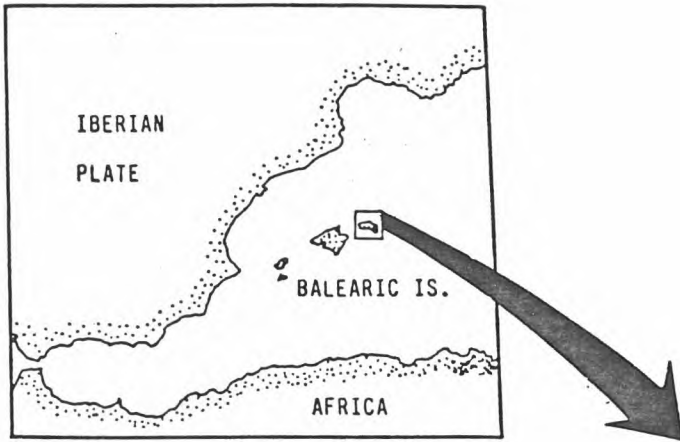
Ecosystem production, terrigenous input and bathymetry are the main controls of the sedimentary facies.

The principal ecosystems are directly related with the bathymetry. Deeper zones out of the bay are dominated by maërl. Their influence is pointed out by the high content of red algae debris present in the entrance to the bay. Posidonia oceanica covers areas between 10 and 30 m depth. Its production is the principal source of the carbonate sediment. It is mainly formed by epiphyte debris. Caulerpa prolifera and Cymodocea nodosa cover shallow zones between 0 and 10 m depth. Cymodocea nodosa is predominant in the shallowest zones (see figure). Other phytobenthonic species present are Acetabularia mediterranea, Halimeda tuna, Udotea sp., Codium fragile, Rytiphloea tictorea and Peyssonnelia sp.

The textural analysis of the sediments shows an increase of the finest fractions in the innermost parts of the bay. Sand-size sediments are predominant (60-80%) in the deeper zones of the bay where the presence of organic carbon is the lowest (0.5%). The finest sands, silts and shales, of terrigenous procedence, increase towards the innermost part of the bay, as well as the percentage of volatil solids and organic contents (4-6%). There is a close relationship between the low percentages of the finest fractions and the contents of organic matter, as well as the presence of the phytobenthonic communities.

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# This work has been partly supported by CAICYT Project "CARBAL" No. 3210/83 and DGICYT Project "TANIT" No. PB87-0812.



Relationship between facies development, conodont stratigraphy and colour alteration indices of conodonts in the Elbingerode Reef Complex, Harz Mountains (Devonian/Lower Carboniferous), G.D.R.

ARNOLD FUCHS  
Bollbrügger Weg 37  
Goldberg, DDR - 2862  
G.D.R.

The Elbingerode Reef Complex (ERC) is situated within the Rheno-Hercynian zone of the Central European Variscan Belt. It developed as an atoll-like structure on an isolated submarine volcanic rise. The onset of the reef growth took place within the Upper varcus Zone of the conodont zonation (Middle Devonian), after the genesis of the iron-ore bed. The atoll-like structure of the reef is expressed by the conodont distribution and the facies pattern. From the varcus- to the asymmetricus Zone (Middle Devonian) a seaward exposed reef talus (fore-reef environment) surrounded the lagoon (back-reef environment). During the asymmetricus-, the Anc. triangularis- and the gigas Zone (Upper Devonian) exclusively fore-reef limestones (Iberg facies) deposited covering the older sediments.

The conodont-lacking back-reef facies is characterized by the predominance of laminated mudstones and grainstones with pellets. Additionally wack- and packstones appear. The conodont-bearing fore-reef limestones consist of pack- and rudstones with occasional float- and wackstone intercalations. The onion-peel structure of the fore-reef limestones of the ERC reflect the transgressive character of the reef ("drowned reef"). Corresponding to the worldwide death of the Devonian reefs, the development of this reefal complex stopped during the Upper gigas Zone. Reef growth, however, did not end synchronously in the ERC.

The reefal deposits are overlain by pelagic post-reef limestones without a significant stratigraphic gap. These strata accumulated from the *Pa. triangularis* Zone to the *anchoralis* Zone (Famennian, Lower Carboniferous). They frequently contain mixed conodont faunas. With respect to their age and lithology these are preserved in several types of neptunian dykes and infillings of pockets within the reefal carbonates (brachiopode limestones, laminated red and grey micritic limestones, allodapic limestones and microbreccia).

The conodonts from the fore-reef limestones, from most of the pelagic post-reef limestones and from most of the iron-ore bed show CAI values between 4 and 5. They reflect the influence of the Variscan orogeny. Some conodonts in the iron-ore bed and of the mixed conodont faunas show higher CAI values (5 - 6). These are attributed to local thermal events.

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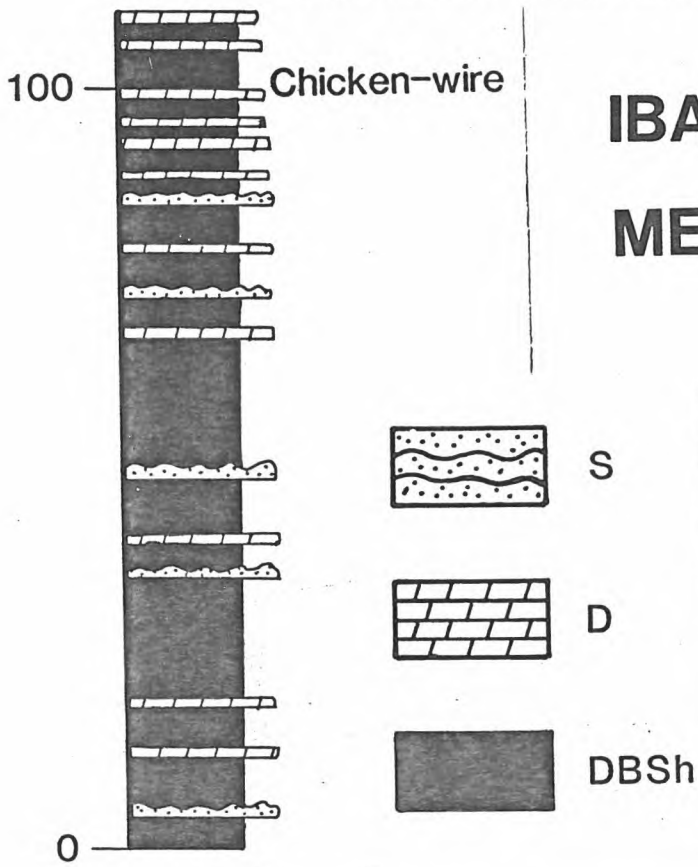
The Lower Wealden Sediments of Bilbao suggest a Lacustrine/Evaporitic Environment (Lower Cretaceous, Basque-Cantabrian Region, Northern Spain)

F. GARCIA-GARMILLA, J. AROSTEGUI & J.M. HERRERO  
Dpto. Mineralogía y Petrología. UPV/EHU. 48080-Bilbao (Spain)

Wealden sedimentary pile (Villaro Fm.) in Biscay Province (Northern Spain) has about 1.100 m. of thickness. It is composed mainly by organic-rich black shales bearing fresh and brackish-water representatives (*Cercomya*, *Corbula*, *Paraglauconia*, *Ilyocypris*). Nevertheless there are five sandy episodes arranged in the same thickening-coarsening sequences denoting sand-bar progradation phenomena and mechanisms. A marine-related lacustrine setting with fluvial-controlled deltaic lobes associated has been suggested for the Villaro Fm. sediments. However, a very characteristic episode is located at the lower part of the Villaro Fm. In fact, the Ibarretxe Member shows particular lithological and textural features. It consists on grey and sometimes-carbonate black shales (DBSh facies in fig. 2), algal-laminated microcrystalline limestones and high-calcitized dolomites with chicken-wire structures (D facies in fig. 2). Fine- to very fine-grained sandstones (S facies in fig. 2) with symmetrical ripples are intercalated in the finest lithologies. The study on thin section shows partially-calcitized gypsum precursors and pyrite crystals indicative of early diagenetic stages under reducing conditions. More or less calcitized gypsum appears as pseudodiapiric nodules about 8 mm. in diameter (fig. 1), but they can reach to 4 cm. (fig. 3). The petrologic and sedimentologic features of the Ibarretxe Member lead us to think in a very restricted lacustrine environment with sporadic dessication events causing evaporitic deposits.



Fig. 1.- Thin section aspect of calcitized pseudodiapiric nodules. Sometimes relict gypsum precursors can be seen.



# IBARRETXE MEMBER

Fig. 2.- Stratigraphic section of the Ibarretxe Member (more than 100 m. of thickness) showing the different facies of the unit. Chicken-wire structures are located at the top.

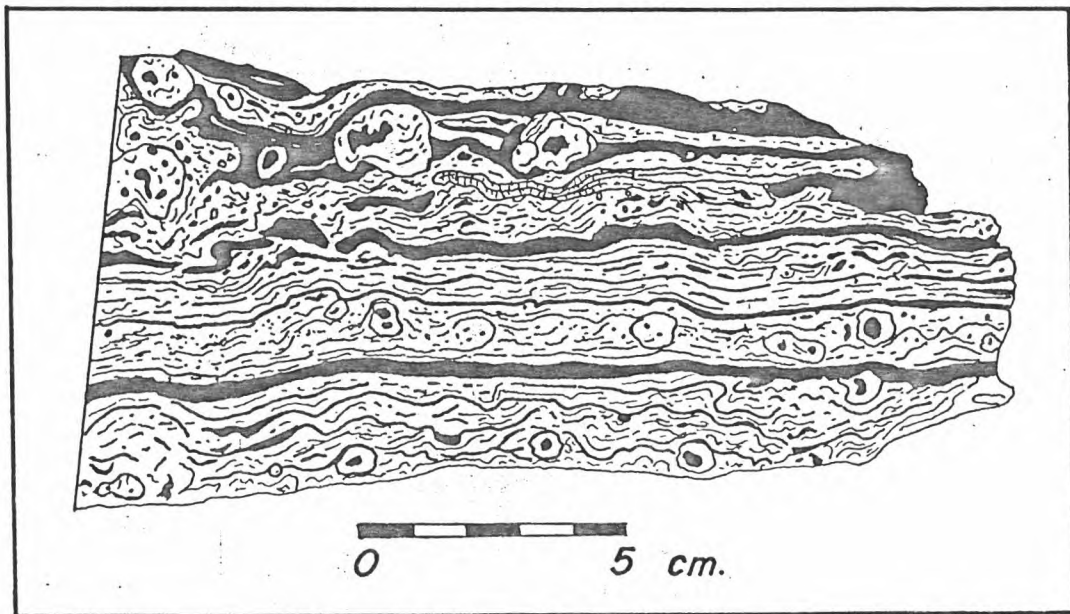


Fig. 3.- A hand-sample showing algal-laminated mudstone facies and calcitized nodules of as much as 4 cm. in diameter.

## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

Lower Cretaceous Fluvio-Lacustrine Systems in Burgos  
(Basque-Cantabrian Region, Northern Spain)

F. GARCIA-GARMILLA\* &amp; J.M. BADILLO-LARRIETA\*\*

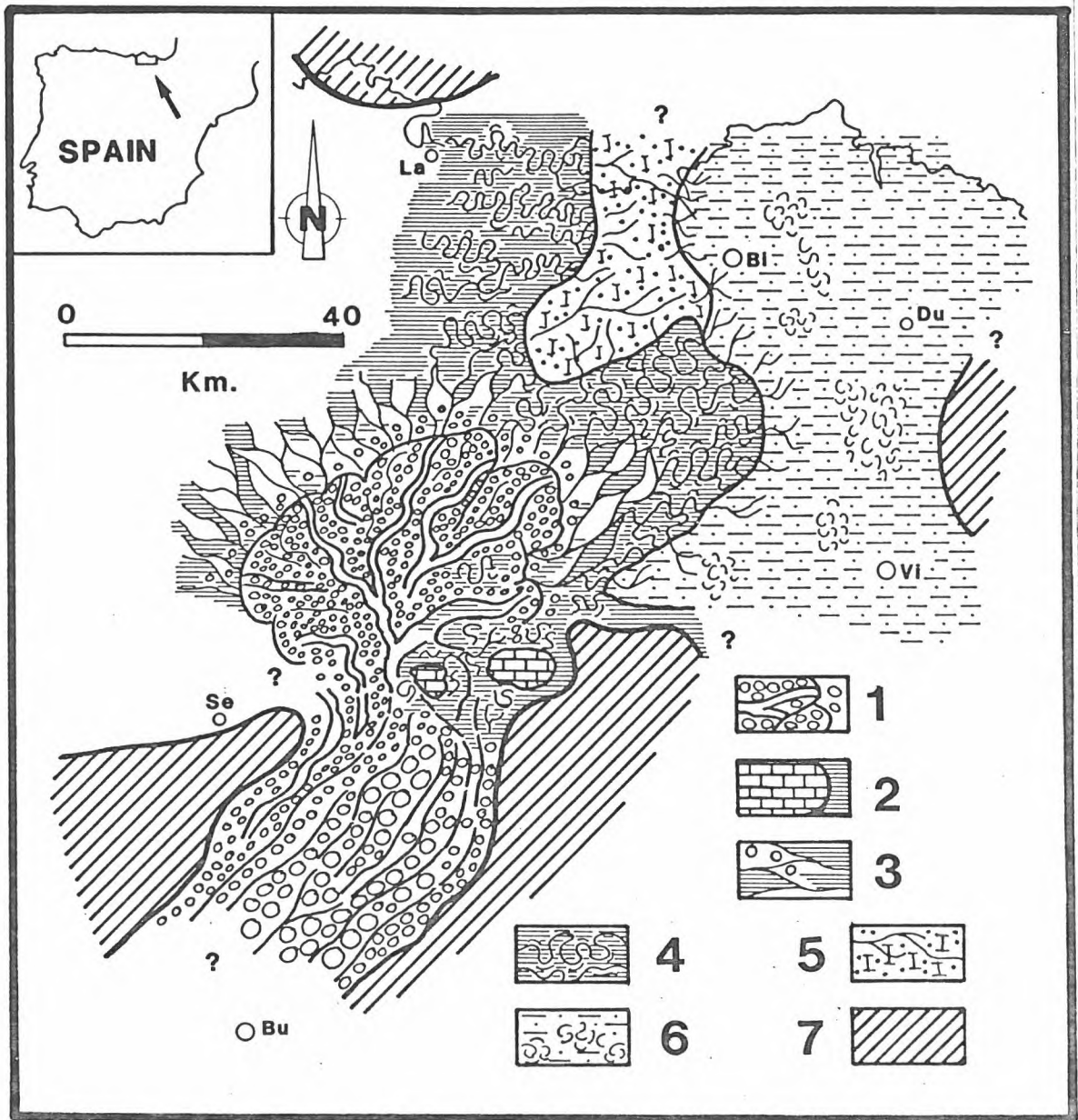
\* Dpto. Mineralogía y Petrología. UPV/EHU. 48080-Bilbao (Spain)

\*\* Dpto. Estratigrafía, Geodinámica y Paleontología. UPV/EHU. 48080-Bilbao (Spain)

Our work deals on the characterization of facies and petrologic aspects of the Pino de Bureba and La Lastra Formations (Wealden of Northern Burgos). The first of them lies discordantly upon Jurassic marine carbonates or basal Cretaceous carbonates and rudites. It is composed by yellow or red-coloured conglomerates, microconglomerates, sandstones and mudstones, which are arranged in thickening-coarsening sequences of 1.5-10 m. thick. The last of them is exceptional (more than 50 m. thick). The conglomerates are polymictic: siliceous and calcareous, the former consisting on quartzites, chert and melanocratic schists, and the latter having probably a jurassic provenance. The more frequent facies association sequence is L-St, Sp-Gm, Gp, Gt. These facies features together with the lack of marine fossils lead us to think in a continental depositional environment for the Pino de Bureba Fm., possibly a prograding alluvial-fan system from proximal fringe subenvironments to nucleus zone, the latter represented by very coarse Gm, Gp and Gt facies. The areal variations of the Pino de Bureba Fm. in the studied zone are conspicuous. The diminution in grain-size and the increase of the (sandstone + lutite)/conglomerate ratio at the N and NW of the type-area (see the figure) suggest the more distal environments towards the N and NW of the Pino de Bureba sector.

On the other hand, the La Lastra Fm. is only outcropped in two areas: at NE of Pino de Bureba village and closely near to Barcina de Los Montes village. In both sectors this unit shows very similar facies features. It is composed by an alternance of oncolithic microcrystalline limestones and reddish shales in strata of 30-90 cm. of individual thickness. The presence of fresh-water ostracods and several species of charophytes suggests a possible lacustrine environment in lateral relationship with the Pino de Bureba Fm. The identified oncolithi types are: C (lamellae in subconcentric growths), R (irregular growths and polylobulate shapes) and I (with ruptures and truncations of the lamellae).

Finally, it's remarkable the lateral equivalence of the alluvial/fluvio-lacustrine systems of Northern Burgos with the tidal/subtidal complexes in the Biscay Province (see the figure) during the lowermost Aptian age. The style of the lateral changes of facies suggests the beginning of the Aptian marine transgression along the northern sector. At the final it was extended to the W (Cantabria) and S-SW (Burgos).



Paleogeographic reconstruction of the E Cantabria/Biscay/N Burgos sector for the lowermost Aptian age. 1: fluvial/alluvial-fan, 2: lacustrine, 3: braided rivers, 4: meandering rivers, 5: tidal-flat, 6: subtidal, 7: non-deposit areas. La: Laredo, Bi: Bilbao, Du: Durango, Vi: Vitoria, Se: Sedano, Bu: Burgos (data of RAMIREZ DEL POZO y AGUILAR, 1972; GARCIA GARMILLA y BADILLO, 1986; GARCIA GARMILLA, 1987).

Event sedimentation in the Zechstein Platy Dolomite tidal flat complex of the Łeba Elevation /N Poland/

ANDRZEJ GASIEWICZ

Państwowy Instytut Geologiczny

POLAND

The Zechstein /Upper Permian/ Platy Dolomite sequence up to 45 m thick developed in N Poland. During slightly tendency to deepening of the Platy Dolomite sea a wide /30-40 km/ carbonate platform tidally dominated and attached to the land developed.

Very poorly bioturbated and microbially influenced Platy Dolomite series consisting of biolaminoids /mainly/, stromatolites and stromatolite-like beds developed in tidal regime is abundantly intercalated by usually thin /5-15 cm thick/ rather laterally discontinuous event layers.

Occasionally occurring close to the land, thicker /up to few metres thick/ usually poorly sorted and normally or inversely graded, medium- to coarse-sized rudstones often represent multiphase deposition. However event sedimentation in the Platy Dolomite tidal flat complex is mainly expressed by coquina and biodetrite layers, especially frequent /up to eight separate intercalations per 1 m of core/, and sometimes graded, in lower part of the series. These beds are dominated by unusually density bivalve shells of one species *Liebea squamosa* /Sow./ and often accompanied by foram, bryozoan and gastropod remains. The latter skeletons sometimes form separate event packstones. Relatively common constituents of these higher energy layers are fragments of algae /*Algites* and *Calcinema*/. The coquina and biodetrite beds usually represent one-phase accumulates. Event layers: often start with a sharp contact at the base and variously fragmented skeletons, show gradual decrease upwards both in shell content

and size in a carbonate mud matrix and on horizontal surfaces elongated fragments exhibit two-directional orientation, sometimes demonstrate distinct streaks or laminae of different-sized material and winnowing features.

The pattern of these deposits indicates either storm surges or strong spring tides with water energy and grain supply limiting a distance of transport and skeletons concentration. These phenomena induced the initial erosion of bottom sediments and grading, streaking and lamination of high energy accumulates. The repeated storm-fair weather conditions gave such condensed layers of event induced deposits. The thick rudstones resulted partly from debris flow and originated as a consequence of repetitive phases of waning high-energy /storm/ current flows. The finer skeletal beds resulted mainly from current winnowing during one-phase storm events.

Relative abundance of an accident layers in the lower part of the Platy Dolomite sequence indicates a broad, open to the sea tidal flats and a form of homoclinal ramp of the carbonate platform. Development of distinct morphologically barrier system in the upper part of the Platy Dolomite limited access of high energy events on the inner platform area. Due of it the event deposits occurred rarely there.

Recent carbonate cementation of beach and marine  
sediments in the Bulgarian Black Sea shelf

VALENTIN M. GEORGIEV

Geological Institute, Bulgarian Academy of Sciences  
BULGARIA

Recent (Upper Holocene) sands cemented by early diagenetic carbonate cements are established in the nearshore zone of the Bulgarian Black Sea shelf. Three main types of lithified sands are distinguished: I. Thin layers of cemented sand situated in the backshore of the beach, usually near an adjacent cliff in ancient carbonate rocks; II. Narrow ridges of massive plates and blocks of lithified sands, usually situated at water depths 0.5-4 m along some big beaches; III. Thin layers or crusts of cemented sands localized on the surface or within the body of some submarine accumulative forms (at depths more than 10 m), showing no direct lithodynamic connection with the adjacent beach.

The lithified sediments are studied by means of optical and scanning electron microscopy. Pure substance of the carbonate cements is separated by ultrasonic desintegration and is analyzed with XRD for determination of the carbonate minerals; the isotopic composition of the cements is determined by mass-spectrometric analysis (Table 1).

According to their carbonate content and the mineralogical composition of the detrital grains, the lithified sediments vary from carbonate sandstones to biocalcarenitic sandstones or even biocalcarenites. The carbonate cements in the lithified sands of the first type are usually represented by meniscus blocky calcite cement or by dentate calcite cement with clearly negative values of  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ , which are characteristic for carbonates, precipitated subaerially from meteoric waters. The cements in the lithified sands of the second type are composed of Mg-calcite, precipitated in

Table 1. - Mineralogical and isotopic composition of the carbonate cements

Occurrence	Type	XRD data		$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
		mineral	mol% $\text{MgCO}_3$		
Obzor beach	I	calcite	5	- 5.9	- 5.8
Lozenets beach	I	calcite	3	- 9.0	- 6.6
Shkorpilovtzi	II	Mg-calc.	13	+ 1.3	- 2.5
Tchimovo bank	II	Mg-calc.	12	+ 1.1 + 0.9	- 2.0 - 2.4
Alepu beach	II	Mg-calc.	13	+ 1.1 + 1.1	- 2.4 - 2.7
Oasis beach	II	Mg-calc.	13	+ 0.9 + 0.5	- 2.9 - 2.8
Koketrays bank	III	Mg-calc.	12	+ 2.0	- 4.4
Stomoplo sands	III	calcite	4	-	-
		Mg-calc.	13	-	-

in two generations: 1/ even rim micritic or subsparitic cement and 2/ intergranular micritic cement. According their structural characteristics, mineralogy and isotopic composition of the cements, the lithified sands of the second type are similar to the typical beach rock, which is characteristic for the tropical tidal seas. The lithified sands of the third type are usually cemented by intergranular micritic cement composed of Mg-calcite. The isotopic composition of this cement clearly indicates its marine origin. In an other case lithified sands are observed, which are cemented by two cement generations: 1/ meniscus subsparitic calcite cement (precipitated subaerially from meteoric waters) and 2/ intergranular "encrustation" micritic Mg-calcite cement (precipitated from marine waters).

The established data prove that the process of formation of early diagenetic Mg-calcite cements is also typical for a tideless sea with lower salinity and a moderate climate like the Black Sea.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
**SEDIMENTOLOGY AND GEOCHEMISTRY OF SEDIMENTARY  
FACIES IN A CRETACEOUS TETHYAN PHOSPHORITE GIANT:  
COMPARISONS WITH MODERN ENVIRONMENTS**

**CRAIG R. GLENN**

**Geologisches Institut, ETH-Zentrum, CH-8092, Zürich, Switzerland**

(Permanent address: University of Hawaii, Department of Geology and Geophysics, Honolulu, HI 96822, USA)

Late Cretaceous epicontinental phosphorites, porcelanites/cherts, organic-carbon-rich shales, glauconitic sandstones and bioclastic and fine-grained carbonate rocks of the Duwi group in Egypt are examined in terms of their overall depositional and diagenetic framework. Two main depositional realms are interpreted for the development of these facies: (1) a hemipelagic environment accompanying initial stages of marine transgression and conducive to the formation of organic-carbon-rich shales and biosiliceous sediments, and (2) a relatively high-energy depositional regime accompanying second-order sea level fall during which deltas advanced, glauconites were reworked seaward from more near-shore sites of authigenic precipitation, and shallow brackish oyster banks became periodically exposed to episodes of fresh water diagenesis, thereby promoting dolomitization and solution-collapse phenomena in associated cherts (Fig. 1). Phosphorites (>18% P<sub>2</sub>O<sub>5</sub>) are found throughout the sequence and are viewed as the result of current winnowing and reconcentration of authigenic grains initially precipitated in associated reducing shales and biosiliceous sediments. In eastern Egypt the phosphorites form winnowed lag layers, some of which may have been redeposited down slope in structural lows. In the west, these sands were concentrated into giant phosphorite sand waves built by tidal and storm reworking of penecontemporaneously deposited phosphatic muds during late Campanian marine transgression.

Carbon isotopic results substantiate interpretations from modern Peru margin deposits for limitation of phosphate mineral precipitation with depth in sediments as a result of lattice poisoning. Carbonate fluorapatite (CFA) growth in Peru margin sediments is confined to shallow levels in the sediments and rates of CFA growth in these sediments decrease in association with decreasing pore-water  $\delta^{13}\text{C}_{\text{TDC}}$  compositions and exponentially downward increasing pore-water TDC, alkalinity, and  $\text{CO}_3^{2-}$  concentrations. In addition, the general relationship of increasing carbonate substitution and decreasing  $\delta^{13}\text{C}$  values for Peru CFA also imply that increases in carbonate and accompanying charge-balancing substitutions in the CFA lattice are forced by increases in the carbonate content in pore waters, and that above a certain  $\text{CO}_3^{2-}/\text{PO}_4^{3-}$  activity ratio structural inhomogeneities in the lattice prevent further CFA growth. Unlike the Peru margin occurrences which are viewed to be chiefly confined to pore waters undergoing suboxic diagenesis ( $\delta^{13}\text{C}_{\text{CFA}} = 0$  to  $-5\text{‰}$ ), relatively light carbon isotope values for Egyptian phosphorite and shale CFA ( $\delta^{13}\text{C}_{\text{CFA}} = 3$  to  $-11\text{‰}$ ) suggest precipitation in pore waters undergoing sulfate reduction and thus more advanced stages of organic matter degradation. Assuming that the  $\delta^{13}\text{C}$  composition of the CFA accurately reflect the proportion of dissolved carbonate-ion in the pore waters of both settings, these results suggest that the pore water carbonate-ion production in the Egyptian setting was less effective in poisoning CFA growth rates relative to that which occurs in the sediments off Peru. This was probably a consequence of decreased CFA solubility under higher bottom water temperatures on the Egyptian shelf and decreased  $\text{CO}_3^{2-}/\text{PO}_4^{3-}$  activity ratios as a consequence of interstitial dissolution of fish debris and/or phosphorus desorption from detrital iron phases. The iron reduced in this process becomes available for incorporation in glauconites in oxic-suboxic environments while it may be precipitated as pyrite in more reduced sediments.

*(continued)*

This study suggests a model for the common coexistence of glauconites and phosphorites in the geologic record. Although upwelling is often advocated as the source of phosphorus for nearly all phosphorite deposits, Tethyan occurrences may have been strongly influenced by fluviably-derived phosphorus borne on particulates and desorbed from these compounds upon flocculation and/or iron reduction in anoxic or dysaerobic bottom waters or pore waters. Evidence from a variety of sources suggests that the continental hinterland to the south in Egypt and possibly much of North Africa was deeply weathered and that the region was humid and supplied abundant fluvial influx of phosphorus and iron to the basin. While factors controlling the phosphorus flux of modern rivers and estuaries are not well understood, extrapolation of estimates of the total flux of soluble inorganic phosphorus from the modern Amazon estuary suggest a nutrient supply sufficient to account for more than 4000 times the estimated phosphorus reserves of Egypt (3 billion metric tons of phosphate rock), and nearly 1800 times the estimated reserves of Egypt, Israel, Jordan, Syria and Turkey combined! Thus, it is possible that many of the black shale-glaucanite-phosphorite-porcelanite/chert associations found along southern Tethys owe their origin largely to deep lateritic weathering across vast regions of the North African craton in Late Cretaceous to Eocene times.

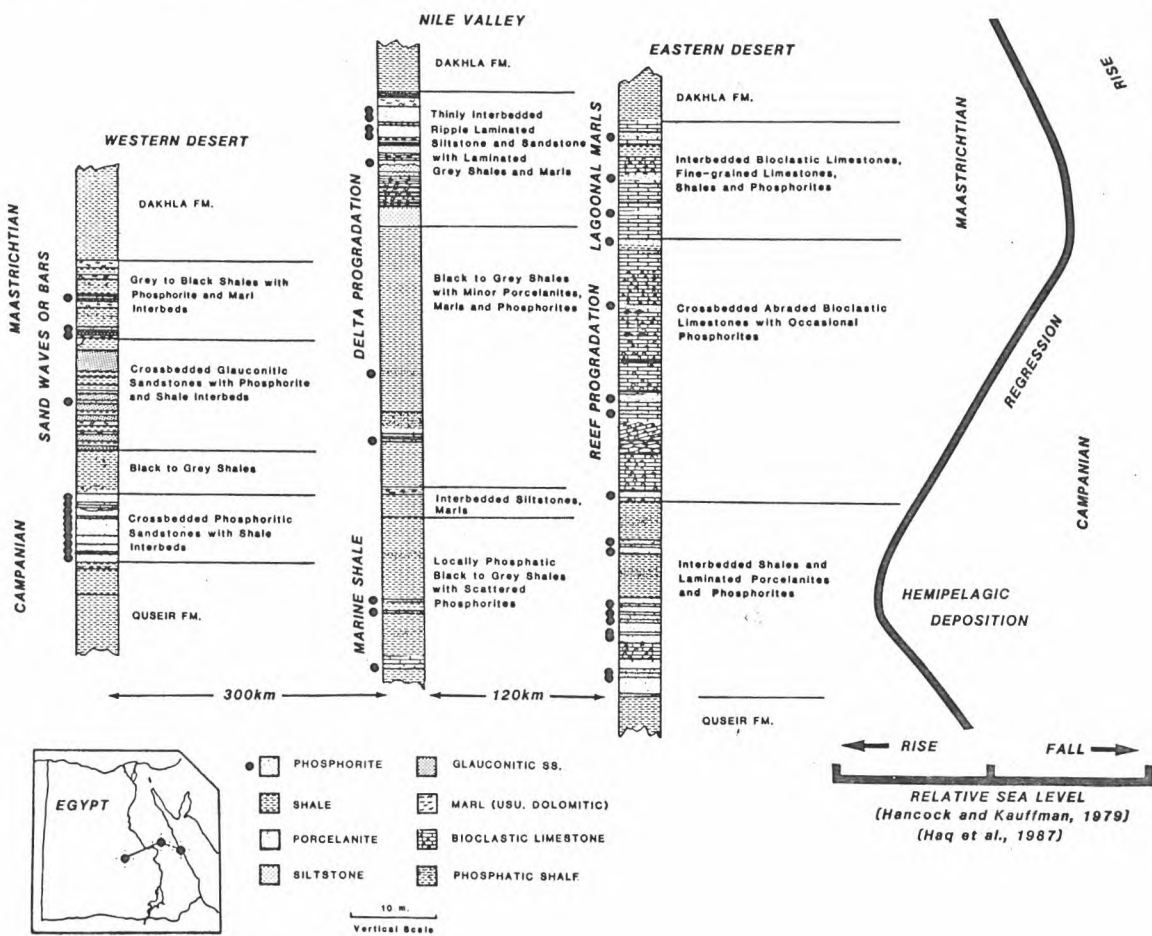


FIG. 1. Summary correlation diagram across central phosphorite belt in Egypt. Note difference in approximate placement of Campanian/Maastrichtian boundary for Eastern and Western deserts. The Western Desert is stratigraphically condensed relative to other localities. The upper Quseir Fm (U. Campanian) in the Nile region is included as part of the Duwi group.

Stages of Upper Triassic carbonate platform development on the Tethys shelf

JÁNOS HAAS

Central Office of Geology

HUNGARY

In the Transdanubian Central Range in Hungary Upper Triassic platform carbonates of 2-2,5 km thick can be observed along a 200 km long profile essentially perpendicular to the strike of the facies zones.

Taking into account space and time relationship of the lithostratigraphical units litho- and biofacies features of Lofer cyclicity and aspects of early diagenetic dolomitization main stages of the carbonate platform evolution can be summarize as follows:

1. Stage of basin upfilling (Fig.1.a.)

Nivellation of the sea bottom was completed upto the Upper Carnian by upfilling of the basins with terrigenous material and redeposited clastic carbonates as well as by progradation of the banks.

2. Shallow lagoonal stage (Fig.1.b.)

On the levelled bottom after a sea level drop shallow lagoon came into being, very sensitive to the sea level fluctuation. At the high sea levels it was inundated but during periods of low sea level it became tidal flat as well as sabkha environment. (Upper Carnian - Lower Norian)

3. Platform stage (Fig.1.c.)

In the next evolutionary stage biogene buildups were formed along the shelf margin and in its background the environment differentiated. During the low sea levels deeper situated areas remained below the intertidal zone, but prevailing part of the platform reached the intertidal and than the supratidal zone (Middle part of the Norian).

4. Bank stage (Fig.1.d.)

In the Upper Norian due to formation of the "Kössen Basin" in the southwestern part of the Central Range the platform transformed into bank. On the top of the bank pattern of sedimentation did not altered significantly.

5. Stage of disintegration of the carbonate platform (Fig.1.e.)

In the latest Triassic disintegration of the platform was commenced, but in the southwestern part of the Central Range it took place only in the Lower Jurassic.

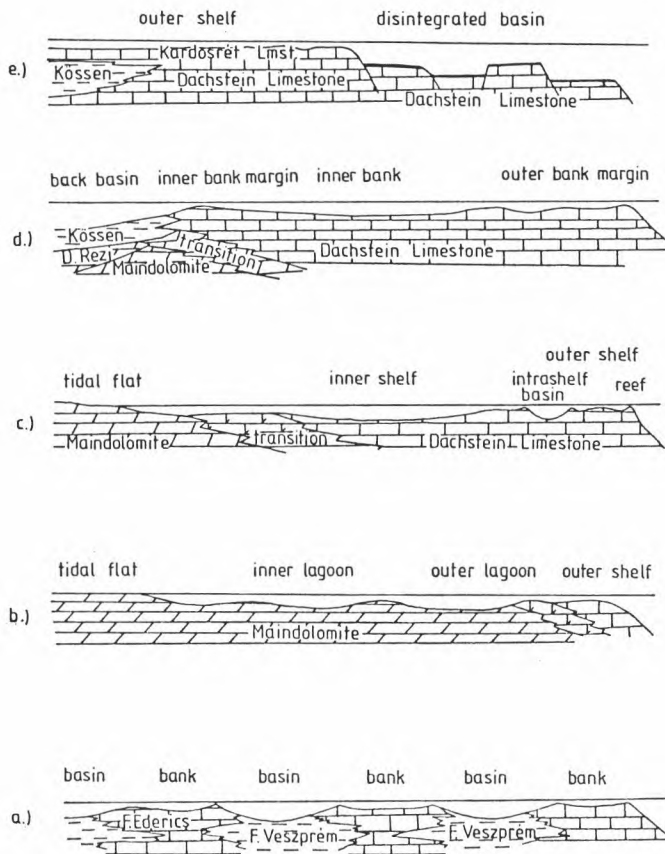


Fig. 1.

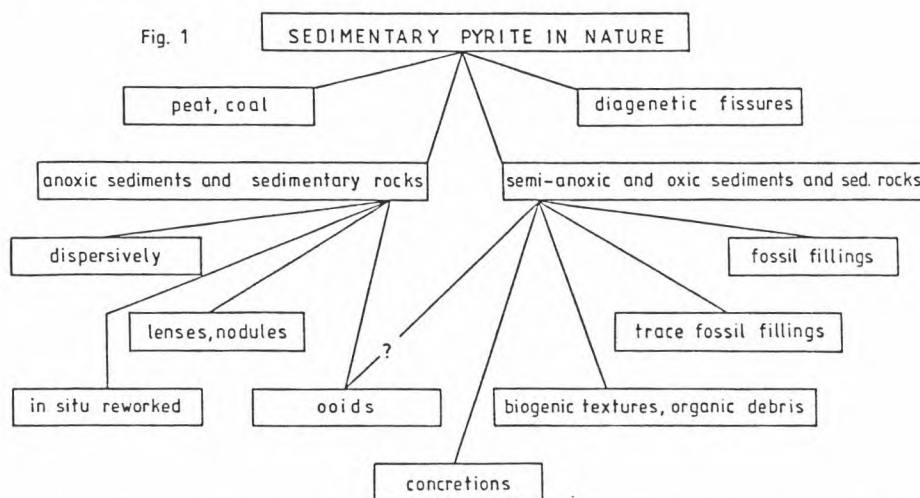
TAMÁS HÁMOR

Hungarian Geological Institute; 1142 Budapest POB 106.

HUNGARY

Sedimentary pyrite is the most characteristic authigenic mineral phase in organic-rich, fine-grained sediments and sedimentary rocks. Based on the macro- and microscopic investigations of sixty Cainozoic-Mesozoic samples and the study of literature, new classification of sedimentary pyrites' occurrences and morphology are proposed.

Authigenic pyrites are reported from various kinds of rocks (shales, sandstones, marls, bauxites, etc.) and from different sedimentary environments (deep sea, littoral seas, fjords brackish swamps, freshwater lakes, euxinic basins, etc.). The classification shown on Fig.1 is therefore in the order of the slightly different genesis.



Sedimentary pyrites can be divided into three main morphological groups-framboidal, euhedral and equant (Fig.2). Framboids are more or less spheroidal crystalaggregates 5-100  $\mu\text{m}$  in diameter which consist of discrete pyrite microcrystallites with no matrix material. Euhedral pyrites are isolated pyrite microcrystals 0,1-10,0  $\mu\text{m}$  in size, generally occurring together with framboids. Their size and crystal habit are similar to those

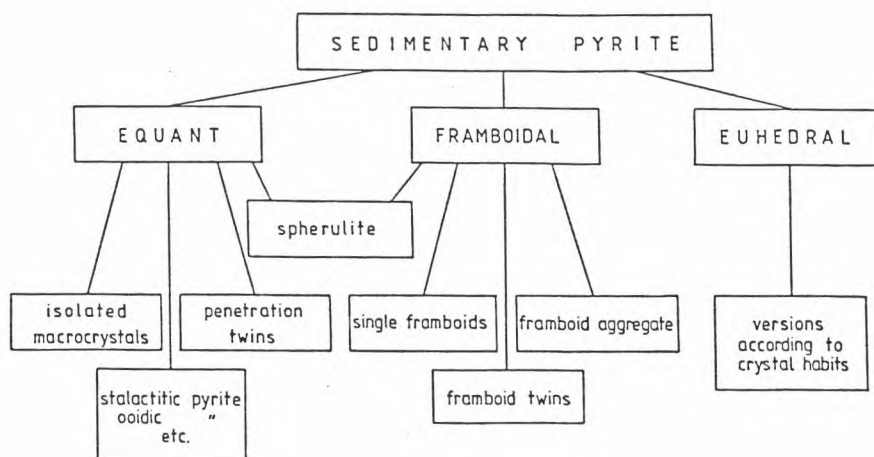


Fig. 2 Morphological classification of sedimentary pyrite

of crystals forming frambooids. Equant pyrites are relatively big (20  $\mu\text{m}$ -2,0 cm) and usually twinned macrocrystals with well-developed faces and crystal anomalies such as natural etches, polysynthetic zone etc.

Frambooidal pyrite is formed slowly through an iron monosulphide phase during the early stage of diagenesis when sufficient iron and sulphate are supplied. During a later stage of diagenesis in a pore system with a restricted connection to the overlying seawater euhedral pyrite is to be formed by the so-called "surface-controlled growth", precipitating at least partly, from a solution without monosulphides.

The large, equant pyrite crystals are formed by a "diffusion-controlled growth" and precipitate directly from abundant solutions provided by continuous diffusion or pore water flow in porous sediments by pushing aside the enclosing sediment. In case of "regular" diagenesis the general sequence of precipitation is frambooidal to euhedral to equant (e.g. in spherulites, concretions) but there are also exceptions.

The most common crystal forms are octahedron, cube, pyritohedron and their combination. On the one hand this is an order of decreasing frequency of occurrence and on the other an increasing degree of supersaturation of the primary solution. Octahedral pyrite formation is more frequent in anoxic-pelitic, typically low pH environments, while the generally coarser cubic crystals are found in alkaline, carbonate-rich sedimentary rocks. Pyritohedrons are usually associated with slightly metamorphosed sediments or with host-rocks of sulphate evaporites.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Diagenesis and fluorescence patterns in the Nagyharsány Limestone  
Formation (Barremian-Aptian) from drill-holes (S-Hungary)

ADORJÁN HORVÁTH  
Eötvös Loránd University  
Budapest, HUNGARY

On the southern part of the Danube-Tisza Interfluve the hydrocarbon-exploring drillings have opened up sequences of the Cretaceous Nagyharsány Limestone Formation (Barremian-Aptian) in 1000-3500m depth in the structural continuation of the Villány Mountains (Transdanubia).

The rock consists of grayish calcarenite and calcilutite. Its facies is shallow-marine, and it contains rich fauna. Several near-surface marine and fresh-water diagenetic features can be recognized: early isopachous fibrous cement, micritization, leaching of grains, collapse of micrite envelopes, syntaxial cement on Echinoderm grains. The formation was not earlier deeply buried as after the Miocene epoch, after the beginning of the formation of the Pannonian Basin.

Characteristic features are in the deep-burial zone: partial brecciation, at least two generations of vein-filling calcite and the different types of solution phenomena, accordingly to the textures, and associated with dolomite and calcite.

The fluorescence of one part of the samples helps both in the recognition of the (burial) texture and in the interpretation of the hydrocarbon migration in these rocks.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Fluorescence in deep-buried Mesozoic carbonates, S-Hungary

ADORJÁN HORVÁTH  
Eötvös Loránd University  
Budapest, HUNGARY

Several core samples of the Mesozoic carbonate sequences from the hydrocarbon-exploring drillings on the Danube-Tisza Interfluvium show fluorescence. They are samples from the 1000-3500m deep basement. Under the microscope, the samples can be best investigated by the blue-light fluorescence (excitation filter BG12, blue; barrier filter G249, orange).

The investigated formations are:

1. Middle Triassic dolomites
2. different Jurassic limestones
3. Lower Cretaceous limestones

The matrix of the dolomites does not show fluorescence, it is connected with veins and cements of brecciated parts. In the younger rocks two main types of fluorescence can be found: in a few cases, the matrix is fluorescent, and the neomorph parts are not. In other cases nothing but the veins show fluorescence, and the matrix does not.

These features can be connected supposedly with the degree of the thermal maturation and oil migration in the formations.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Near-surface and burial diagenesis of Mesozoic carbonates in some  
hydrocarbon-exploring drillings from S-Hungary as revealed by  
fluorescence microscopy and fluid inclusion studies

ADORJÁN HORVÁTH & FERENC MOLNÁR  
Eötvös Loránd University  
Budapest, HUNGARY

The studied carbonates are Anisian dolomite (Forráskút Fkút-2. drilling) and Barremian-Aptian limestone (Ruzsa R-14., Kiskunmajsa Kkm-D-10., Üllés Ü-33. drillings). The formations are now at about 3000m depth.

In the dolomite, a poorly preserved original texture can be identified, the final dolomitization is of burial diagenetic origin, and of high-temperature type. The limestone shows several marine and fresh-water phreatic diagenetic features, and during its burial, two generations of calcite veins and solution features with dolomite and calcite have developed.

The Anisian dolomite does not show fluorescence, whereas in the limestone, the first generation of calcite and the dolomite connected with solution are fluorescent.

The fluid inclusion studies were carried out in the Anisian dolomite on one of the latest quartz veins and in the limestone from the second generation of vein-filling calcite.

The paleotemperature conditions of the migrating fluids were determined on the basis of the fluid inclusion studies. According to the paleotemperature data, the paleogeothermal gradient was higher, than the recent. The paleofluids were mainly of  $\text{NaCl-CaCl}_2\text{-H}_2\text{O}$  types with 3-15 NaCl equiv. wt% concentrations. The early anadiagenetic fluids were probably of low-concentration type and in some cases of  $\text{NaCl-NaHCO}_3\text{-H}_2\text{O}$  type. Also traces of paleohydrothermal activity were

detected, which probably generated the latest dolomitization connected with solution.

According to the fluorescence microscopic and fluid inclusion data the studied Mesozoic carbonate sequences have already passed through the main oil-generation phases.

10TH IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
 SEDIMENTOLOGY OF THE EO-OLIGOCENE LAYERS IN NORTHWEST BELGIUM  
 Patric JACOBS & Erwin SEVENS  
 Renard Centre of Marine Geology, Geological Institute, State University of  
 Gent, Krijgslaan 281, S8, B-9000 GENT, Belgium

**1. GENERAL FEATURES**

A regional revision of the Eo-Oligocene lithostratigraphy in Northwest Belgium (P. JACOBS, 1975, 1978), resulted in a proposal for a new lithostratigraphical column, subdivided in the following way :

Zelzate Formation	Watervliet Member
	Bassevelde Member
Kallo Formation	Onderdijke-Adegem Member
	Buisputten Member
	Zomergem Member
	Onderdale Member
	Ursel Member
	Asse Member
	Wemmel Member

These Eo-Oligocene transitional layers occur in the northwestern part of Belgium. Thickness reaches up to 80-100 m maximum and decreases to the south and the east.

**2. SEDIMENTOLOGY OF THE EO-OLIGOCENE LAYERS**

All information was gathered from boreholes. Variations in grain size enabled correlation between the different study areas. Sedimentary petrography and clay mineralogy revealed further information.

The Eo-Oligocene sedimentation starts with the Wemmel Member, at the base a glauconitic, calcareous fine sand with shell debris. On the contact with the underlying lithostratigraphical unit, small rounded fossiliferous calcarenite pebbles occur, together with quartz grains and shell debris. With a gradual transition, the base of the Wemmel Member passes into a calcareous glauconitic heavy clay with shell debris, and sand spots.

The base of the Asse Member is characterized by a greensand (the so-called "bande noire"). The bulk of the sediment consists of a heavy clay, with pyrite concretions, shell debris and a high glauconite content. The granular glauconite particles occur either dispersed in the clay matrix or concentrated in thin dark or pale green lenses and spots.

With a gradual transition, characterized by the loss of glauconite, the Asse Member passes into the Ursel Member, a homogeneous heavy clay with pyrite concretions and rare sandy spots.

An alternation of homogeneous glauconitic medium fine to fine sand and heavy clay with pyrite concretions and sporadically containing fine sand is subdivided in successively the Onderdale (sand), Zomergem (clay), Buisputten (sand) and the Onderdijke-Adegem (clay) Member.

The upper Member, the Onderdijke-Adegem Member may be lacking to the southeast, probably due to an erosional phase before the deposition of the

next Formation. The sedimentation in the Kallo Formation ends at the top with several thin peaty layers and perforations filled with peaty sand. The base of the Zelzate Formation is characterized by a thin broken flint and white quartz pebbles bed. In the basal part of the Bassevelde Member, fine shell debris occur. The bulk of the sediment is a silty medium fine to fine sand, glauconitic, with pyrite concretions and sporadically containing friable arenite concretions and sandy clay layers of 10 cm thickness. The Bassevelde Member passes gradually into the Watervliet Member, a glauconitic sandy clay, consisting of an alternation of 3 to 5 m thick sandy clay, clay and glauconitic clayey fine sand layers. Pyrite concretions are absent.

### 3. INTERPRETATION

Sediment-genetic interpretation is principally based on general features and interpretation of granulometric data by use of grain size parameters in various combinations. Environmental analysis by use of only grain size parameters is to be considered as partial and limited in its applications. Heavy mineral composition and clay mineralogy were also taken into account. At the base of the Formation of Kallo, sediment of the underlying lithostratigraphical unit is reworked. Gradually, the tidal flat sedimentation depositing the Wemmel Sands, changes into an open mud shelf sedimentation of the Asse and Ursel clay deposition. During the Asse and Wemmel Member deposition, circumstances must have been favourable to the formation of glauconite. The large quantities may have served as an important source for the formation of detrital glauconite or glauconitic minerals, which formed by addition of mica, swelling minerals of the nontronite type, frequently occurring in all younger lithostratigraphic units.

The cyclic variation of the younger sand and clay members of the Kallo Formation is probably indicating a rhythmical shifting between an open mud shelf sedimentation and a tidal flat sedimentation.

After the deposition of the Onderdijke-Adegem Member the cyclic sedimentation is interrupted. The thin peaty layers, perforated by burrowing organisms, at the top of the Formation of Kallo are indicating an emersion period.

The boundary between the Kallo Formation and the Zelzate Formation is characterized by a sedimentary hiatus. A thin flint bed and white quartz pebbles at the base of the Zelzate Formation are witnesses of an old erosion surface. During the deposition of the Zelzate Formation, a tidal flat regime was again installed.

The Eo-Oligocene boundary in Northwest Belgium is characterized in general by very low sedimentation rates and by non-deposition periods, with a sedimentation environment probably shifting in a rhythmical way between an open mud shelf and a tidal flat.

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Diagenesis and recrystallization of the Devonian reef limestone of the Elbingerode Complex, Harz Mountains (GDR)

JANSSEN, Ch. and PAECH, H.-J.

ACADEMY OF SCIENCES OF THE GDR,  
CENTRAL INSTITUTE FOR PHYSICS OF THE EARTH

The Elbingerode reef build-up is an atoll-like structure within the Blankenburg Fold Zone of the Harz Mts. It rests on an isolated submarine volcanic ridge formed in Eifelian time. Subsequently in Givetian time the volcanic seamount were occupied by reef forming organisms. In the main phase of reef growth (pre-rotundiloba interval to asymmetricus zone cf. FUCHS 1987) a central lagoon (back-reef environment) and a seaward exposed reef talus (fore-reef environment) surrounding the lagoon can be distinguished (RUCHHOLZ & WELLER 1988). Starting with the asymmetricus zone lagoonal carbonates were covered by fore-reef limestones. The following nodular limestone deposition indicates the end of the reef growth at the turn Frasnian - Famennian.

In spite of the strong internal deformation, the diagenetic patterns of the limestones and their temporal sequence are recognizable (FRIEDEL & JANSSEN 1988).

The early diagenesis has involved both marine and meteoric processes. Early marine diagenetic processes are indicated especially by micritization, radiaxial fibrous cement and relics of micrite cement. On the other hand the observed drusy mosaic cement, dog tooth cement, syntaxial rim cement, gravitational and meniscus cement, secondary leaching and crystal silt may be interpreted as hints for the presence of freshwater diagenetic conditions.

The carbonate sequences were deformed during the Variscan tectogenesis. Moderate-wavy fold structures associated with cleavage and thrusting are developed (JANSSEN et al. 1988). All sedimentary and diagenetic patterns were over-

printed by dynamic recrystallization processes. Subsequent grain growth due to static recrystallization is caused by annealing (contact metamorphism) along the contact zones of Lower Permian dikes (Mittelharzer Gänge).

During dynamic and static recrystallization processes the behaviour of sedimentary and diagenetic patterns differs strongly:

Sediments were not altered by dynamic recrystallization. At some places fingrained sediments show a flow behaviour caused by grain-boundary sliding (particulate flow). During sustained annealing (static recrystallization) the average grain size increases homogeneously (continuous grain growth). But local adjacent to static recrystallized grains remains of unchanged sediments occur.

The deformation of sparite leads to grain-size reduction by rotation of subgrain boundaries (rotation recrystallization) during dynamic recrystallization. At places of high stress concentration (twin- or grain-boundaries) dislocation-free nuclei form and grow at the expense of the deformed grains due to strain induced grain boundary migration (migration recrystallization). During the primary recrystallization (as part of the static recrystallization) the formation of nuclei and the migration of boundaries were continued at a level of higher intensity than during the dynamic recrystallization. Immediately adjacent to the contact zones of Permian dykes, the primary recrystallized structures were overprinted by grain growth (continuous grain growth). Recrystallized biogenic structures show features of facsimile recrystallization.

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10th IAS REGIONAL MEETING ON SEDIMENTOLOGY--BUDAPEST , 1989  
SEDIMENTARY FACIES AND MINERAL DEPOSITS IN NORTH XINJIANG, CHINA

Jiang Na-yan  
Nanjing Institute of Geology and Palaeontology,  
Academia Sinica

Based on the study of depositional characteristics, the rocks of Carboniferous in North Xinjiang can be divided into three main sedimentary facies, namely, the platform-type facies, the trough-type facies and the slope-type facies. The platform-type facies consists of typical shallow water carbonate rocks with some clastic rocks. There are a lot of typical sedimentary structure of shallow water in them such as wave mark, fenestral structure, bioturbation, vadose structure and so on. The platform-type facies may be subdivided into four subfacies, namely, platform-margin subfacies, open platform subfacies, restricted platform subfacies, and lagoon subfacies. The rocks of platform-type facies would have had a good property of source and reservoir for oil and gas, if no metamorphism had taken place in them. The restricted platform facies and lagoon facies often contain gypsum and other sedimentary ore deposits. Bauxite deposits are also related to the platform-type facies, because its environment is relatively wide and shallow, especially relatively stable, it would become a wide, stable eroded land surface i.e., the environment of bauxite-forming deposits. The trough-type and the slope type facies consist mainly of terrigenous matter with a little carbonate matter. They may be respectively divided into several subfacies. An abundance of Au, Ag, Cu, Pb, Zn and other metal deposits are well developed in them, because they are distributed in an unstable area of tectonic structure, where the action of fault and magma is very active, hence a good mineralogical condition.

Comparative sedimentological study of karst bauxite in the  
Halimba area, Hungary

ERIKA JUHÁSZ , GYÖRGY BÁRDOSSY<sup>+</sup>

Hungarian Geological Institute

+ Consulting geologist, Budapest

The stratiform bauxite deposit of the Halimba basin in the Transdanubian Central Range, is situated on the slightly karstified surface of the Upper Triassic dolostones and limestones, and is covered by Senonian and/or Eocene beds. The formation of this deposit was in close connection with sedimentation during the Senonian and Eocene cycles. The bauxite, sedimented within the Senonian cycle, shows characteristics of a fluvial environment. Due to uplifting during the pre-Gosau phase of the Alpine orogeny the weathering products developed on the surface of different rocks in the southern part of the Transdanubian Central Range. These lateritic materials were eroded and transported by stream water, and deposited in the karstic basins as fluvial bauxite sediments.

Based mainly on sedimentological analyses, the following facies-types have been identified:

- Point bar facies - deposited from braided channel. Its structure is characterised by arcuate microlaminae, strings and cross-stratification; relatively coarse bauxite intraclasts and oolites by flow separation. The texture is bauxite-wackestone or packstone .
- Bed-load facies - coarse grained, unsorted intraclasts with smaller amount of oolites; its texture is bauxite packstone.

- Flood plain facies - a mixture of different, moderately sorted materials with planar lamination or as unlaminated sediments occasionally with graded bedding. Its texture is oolitic and/or intraclastic bauxite-wackestone and/or packstone.

- Flood basin facies - well sorted, fine grained, planar laminated, mostly oolitic bauxite-mudstone.

- Paludal facies - pale or gray bauxite mudstone, rich in organic remnants. The bauxite and the other weathering products were transported by stream water from SE (present day direction!) into the Halimba basin, which was one of the subbasins of the Transdanubian Central Range. By the end of the bauxite transportation coal-swamp environment developed in the Halimba basin, and was followed by non bauxitic coarse clastic sedimentation.

The Senonian bauxite deposit has been partially eroded in the period between the Cretaceous and the Eocene. During the Early Eocene some bauxite was formed by weathering and this has been mixed with the reworked Senonian bauxite. After short-distance transportation this mixed bauxitic material sedimented on the eroded surface of the Senonian bauxite and on the Upper Triassic dolostone. Between the two bauxite deposits there is a thin paludal layer containing pollen grains, which indicates the Early Eocene age of the second bauxite sedimentation process in this area.

The sedimentological study of the two bauxite horizons contributed to a better understanding of the above outlined processes;

Sedimentological characteristics of the Neogene  
sequences in SW Transdanubium, Hungary

GYÖRGYI K. JUHÁSZ  
Hungarian Hydrocarbon Institute  
Hungary

KÁROLY SZENTGYÖRGYI  
Hungarian Hydrocarbon Institute  
Hungary

The Zala-Délibalaton Neogene Basin is situated in SW Hungary and represents a morphologically subdivided sedimentary basin. The depth of two deepest depressions of the basin can exceed 6-7000 m on the southwestern part of it. Sedimentation started in the middle Miocene and was essentially unbroken concerning almost the whole basin. The morphological and paleogeographical-depositional conditions were in close connection. The upper Karpathian sedimentation represents a reduced salinity water schlier complex. The marine deposits of the Badenian sequence can be divided into three lithofacial units, depending on water depth, direction of accumulation and distance from the shoreline. In the deeper part of the basin Badenian is represented by molasse-type sediments, while in the eastern part by epicontinental carbonates and a carbonate - pelitic unit. In the upper Badenian and Sarmatian a regressive sedimentation occurred. The boundaries of the lithofacial units was gradually displaced, the water depth and salinity was reduced. The Pannonian deposits settled on the Miocene uninterruptedly. In the deep zones a great mass of turbidite accumulation occurred, while pelitic sedimentation on the margins, on the eastern flanks. After this a delta system reached the basin from the W and NW, and prograded towards the SE, overlapping all the previous units. The deposits of the delta system are widespread all over the basin. The Neogene sequence was terminated by a fluvial-lacustrine sedimentation.

10<sup>th</sup> IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
Evolution of disintegrated material during formation  
of Quaternary continental deposits in the western part  
of the USSR

GINUTIS JUOZAPAVIČIUS

Lithuanian Geological Research  
and Survey Institute - USSR

A considerable influence on the structure and composition of Quaternary deposits have peculiarities of the rocks in the recharge area, partly those of the glacier bed. The following typical areas with distinctive differences can be distinguished: 1) the area of the Baltic shield, where the glacier was fed only by the products of disintegration of eruptive and metamorphic rocks, partly by the crust of rock weathering; 2) the area of the East-European plain where Quaternary deposits having slight thickness are underlain by comparatively hard carbonate rocks of the Palaeozoic and are enriched by them; 3) the areas where Quaternary deposits underlay more like mature terrigenous Prequaternary rocks, or in which the direct influence of bed rocks is not felt because of heavy Quaternary cover. The analysis of granulometric and material composition has showed both the way of evolution of fragmental material in every area and evident differences among the mentioned factors of deposits having the same genesis but belonging to different areas.

The characteristics of the structure of the moraine material are traced in all sandy deposits of glaciofluvial and alluvial genesis, more distinctly - in intraglacial and marginal sands, less distinctly - in periglacial and alluvial sands. Only during the formation of sandy deposits in the open sea-shore areas or in limnoglacial basins

considerable changes of granulometric composition of source rocks take place. Under a short-term reworking of sandy massives in the postglacial period one can see a connection with source rocks according to the distribution of the modal fractions only. According to the character of rudaceous material in every area three groups of deposits are recognized: 1) kames and marginal glaciofluvial ranges (most badly sorted); 2) channel flows (eskers, sandurs, glaciofluvial, postglacial rivers); 3) glaciofluvial deltas. The peculiarities of fine disintegrated material of moraine-bearing ice determined mainly the structure of clay sediments irrespective of genesis.

Mineral - petrographic composition of Quaternary deposits is mainly determined by composition of subjacent Quaternary rocks and the crust of rock weathering. For the first time in Pleistocene an increasing degree of differentiation of disintegrated material is forming the sands of oligomictic composition only during their formation in some parts of river valleys and in periglacial basins, on the sea shore area and eolian reworking of deposits - even the sands of approximate quartz composition. The following line of an increasing differentiation of mineral composition of disintegrated deposits can be made up: moraines - kames - eskers - glaciofluvial deltas - sandurs - marginal glaciofluvial ridges - glaciofluvial terraces - alluvium-limnoglacial basins - dunes.

A comparatively short - term process of glacial and glaciofluvial sedimentation, low temperatures, good mechanical differentiation and sorting of disintegrated material suppress the proceeded geochemical processes. Only after the postglacial period Mn, Ni, Cu, Ca, Mg and carbon dioxide, which is connected with these elements, become more active.

Processes and conditions of formation of sediments  
on the Pacific margin of Kamchatka

EVGENIA KARNYUSHINA, GENNADI CHOCHIYA,  
Moscow State University  
USSR

Processes of Late Cenozoic and recent sedimentation in forearc and post-arc basins of the Pacific margin of Kamchatka (PMK) show simultaneous sedimentation of pyroclastic, tethrogenous, terrigenous and biogenic diatomic material. These processes caused formation of three main volcanogenous-sedimentary complexes - tuffaceous (tethroid), tuff-terrigenous and tuffite-diatomic. In the post-arc Okhotsk-Kamchatka basin the all mentioned complexes are widely spread. In the fore-arc basins - South Okhotsk, Central and Eastern-Kamchatka terrigenous accumulations are subordinate.

Volcanogenous-sedimentary complexes of the PMK were formed on the shelf within the continental slope and the foot of the slope. Sediments of the inner shelf are presented by hydrogenous accumulations forming spits, bars, underwater channel banks and offshore bars. Facies series of these sediments is limited from the side of the continent by paralic tuff-terrigenous coal-bearing formations and from the side of the outer shelf by finer terrigenous-tuffite-diatomic sediments. In the Okhotsk-Kamchatka basin lenticular sandy bodies of cyclic Late-Miocenic coal-bearing deposits were formed on a wide shelf plain. Middle-Miocenic formations are also productive in the zone of facies replacement of clastic accumulations of the inner shelf to mixed terrigenous-tuffite-siliceous deposits of its out part.

In depressions and terraces of the continental slope and at its foot the mixing of heterogenous materials increases. During formation of granites represented by collapsing and land sliding deposits redistribution of the material of sediments takes place during breakaway and flowing of their semi-fluid masses under the effect of seismic shocks and failure of slopes by underwater canyons. In the composition of recent sediments of this type on the continental margin of eastern

Kamchatka sandy-aleurite tethroid material and aleuropelite diatomic components form intrusion and brecciation structures during mixing. Similar structures but of smaller scales are observed in sediments of rock and mud flow. Accumulative bodies of the described part of the PMK are represented by different-scale blocks, linearly elongated ridges and hills at scarp feet and by large bars of proximal and middle parts of detrital cones.

The main features of the composition and morphology of geological bodies originated in sedimentogenesis remained at the following stage of lithogenesis which makes it possible to use signs of genetic types of sediments for prediction of presence of oil and gas of the PMK.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
Precambrian organogenic carbonate buildups of Siberia

EVGENY KHABAROV

Institute of geology and geophysics  
Novosibirsk, USSR

Precambrian is the time of mass development of stromatolitic organogenic buildups various in form, size and structure forming a frame of thick (hundreds of metres) specific Precambrian carbonate reefs formations.

In Siberia Riphean-Vendian carbonate thicknesses with numerous stromatolitic buildups take shape mainly on the of the Siberian platform and geosynclinal-folded systems surrounding it. Two main types of reefs formations: intracratonic and marginal cratonic.

Plate-like form, broad distribution on the area and rhythmical structure are characteristic for intracratonic formations. Organogenic buildups both simple (bioherms, bioherm beds, differentiated biostromes) and complex (bioherm and bioherm-biostrome complexes) alternate in the section with oolite-pisolite-intraclast grainstone-packstones and recrystallized in some degree by micrites (dolmicrites) and also with terrigenous rocks. Characteristic is the broad distribution on the area of organogenic buildups and practically full absence of lateral "reef" zonality. They were formed on large areas of intracraton shallow water Precambrian basins with slow base downwarping, weakly expressed paleorelief and practically complete compensation of the base subsidence by sedimentation.

Marginal-craton reefs formations are traced along the south and western margins of the Siberian platform and are linear-elongated bodies which stretch for hundreds of kilometres (for example, Chenchinskaya formation - for 650 km). In their structure the specific lateral "reef" zonality re-

lated to linearity in the distribution of the largest and complex reef-like structures, is established. The following lithological complexes are established in the direction from the open basin to the coast line: 1) fore-reef (mainly gravitational carbonate deposits with separate bioherms in the upper parts of the slopes); 2) reef (intricately built complexes from mound-like stromatolithic bioherms with oolite-pisolite-intraclast grainstones-packstones and micrites of interbioherm depressions and tide-low tide channels); 3) back-reef (grainstones with separate bioherms formed in shallow water, sometimes sub-aerial environments with the active hydrodynamical regime); 4) lagoon-shelf (rythmically built thicknesses composed of rock sequences of different class, e.g. stromatolithic limestone - grainstone - micritic limestone). These formations appeared on the shelves of marginal seas mainly in Riphean. The reef-like buildups, larger and more complicated in their structure, were developed on the shelf margins on the boundary of shallow water and deep sea basins.

Thus, numerous different stromatolithic buildups were formed on the territory of Siberia in Precambrian. The margins of the Siberian craton are the areas of development of thick extended reef-like Precambrian structures similar to assymetrical reef Phanerozoic complexes.

WESTERN BOUNDARY UNDERCURRENT AND DEEP WATER FACIES OFF NOVA SCOTIAN CONTINENTAL MARGIN, CANADA

NAZRUL I. KHANDAKER (DEPT. OF GEOLOGICAL & ATMOSPHERIC SCIENCES, IOWA STATE UNIVERSITY, AMES, IOWA 50011 USA) AND ROBERT G. SUTTON (141 FURLONG ROAD, ROCHESTER, NEW YORK 14623 USA)

The present work mainly deals with the sedimentological investigations of sixty-six core samples (Holocene-Wisconsinan) from the Nova Scotian Continental Margin, Canada. These cores consist mostly of silty lutite with subordinate silt and sand, and range from continental shelf/slope break to abyssal plain setting. Most of the cores have been thought to be the product of both turbidity and contour current transport. One problem that presently exists is how to distinguish contourites from turbidites using only core data.

Statistical analyses of the textural and compositional data of the deep-sea sediment cores (Holocene-Wisconsinan) off Nova Scotian Continental Margin helped to establish textural and compositional characteristics of turbidite and contourite facies. Textural and bedding aspects were the most successful variables in this context. Among the compositional parameters, percentages of stained quartz, sedimentary clasts, forams, blue hornblende, tourmaline, and glauconite provided means for clearly discriminating contourites from turbidites. The use of statistically significant textural parameters as an aid in characterizing suspected contourites was also fruitful. Use of these permitted identification of certain beds of uncertain origin as contourites. In contrast with this, the same textural attributes were not useful in recognizing the sediments of doubtful turbidite origin. The sediment group identified as possibly of turbidite origin might actually be an assemblage of proximal and distal turbidites or a mixture of turbidites and hemipelagites, as evidenced from higher silt fraction (38 percent). In addition, the lower continental rise off Nova Scotia is influenced by periods of high and low velocity near-bottom currents. During low velocity conditions, biogenic reworking of sediments by an active benthic infauna predominates in the area (Yingst & Aller, 1982). The resultant contourite muds are highly bioturbated and have relatively high contents of calcium carbonate (10-35 percent) and organic carbon (0.2-1.5 percent). Furthermore, montmorillonite appears in significant amounts only in the contourite facies and increases downslope suggesting northerly source and transport by the Western Boundary Undercurrent. It provides further documentation that during Wisconsin interstades and during most of the Holocene, the sedimentation in the Nova Scotian Continental Margin was controlled by the deep-flowing Western Boundary Undercurrent.

Two types of contourites having differing morphological signatures are recognized following Stow's (1982) criteria. These include: a muddy type deposited from suspension and a sandy type that has been winnowed and partly transported as bed load. Sandy contourites occur as thin, irregular, bioturbated, muddy lag deposits with a mixed, broken, iron-stained, biogenic and terrigenous composition. Muddy contourites are homogeneous, bioturbated, and the sediments consist of mixed biogenic, and terrigenous material. The resultant muddy contourites have relatively high contents of calcium carbonate and organic carbon. The dispersed sand fraction is composed largely of broken biogenic debris and rarely cross-laminated; these may be concentrated in irregular layers as a result of bottom-water winnowing as suggested also for biogenic lag deposits of the Western Mediterranean (Rupke and Stanley, 1974). Of particular interest is the close positive correlation between the frequency of sandy contourite generation and episodes of sea-level; the sandy contourites apparently correspond to episodes of low sea-level.

Most of the textural and compositional attributes of contourites remained unchanged with increasing water depths. This observation suggests that a deep flowing, low velocity (15-35 cm/sec), continuous contour current (well-below seasonal pycnocline) does not change much with increasing depth. Instead, it is influenced by local submarine irregularities and proximal sediment input from seamounts and abyssal hills (Khandaker and Sutton, 1986). On the otherhand, textural and compositional characteristics of turbidites seemed to show slight response to increasing water depths. Since rapid velocity fluctuations occur in a turbidity flow, a difference in the ultimate sediment character can be envisioned. Size segregation and density sorting of materials were very pronounced in contourites. These two aspects are well-reflected in the low ratios of sand versus silt and of high density versus low density minerals. Such a preferential size segregation and density sorting is evidently absent in turbidites. The present study strongly demonstrates the dominant role of bottom-water current in controlling the resultant deep-water sedimentary facies in this part of northwest Atlantic.

RECENT AND ANCIENT ANALOGUES OF COASTAL SABKHAS FROM THE RED SEA  
MARGINAL AREA

EZZAT KHEDR, A.W. FELESTEEN, K. ABUL-MAJD, AND K. IBRAHEEM\*  
Aswan Faculty of Sciences, Assiut University, and \* Regional  
Planning of Aswan, Egypt.

Basin analyses of the Red Sea continental margin sequence between the Sudanese border and southern Egypt (350 Km distance) have unraveled identical stratigraphical units and distinctive isochronous facies. The sedimentary sequence 230 m thick, comprises 12 vertical units ranging in age between middle-Miocene and the present; rests on the African shield with offlap structure in somewhat elongate shelf platform (Fig. A). The sequence has been formed under two successive cycles of transgression and regression comprising eight 3rd-order cycles of regional sea-level fluctuation implying six horizons of ancient sabkhas. The main characters of these sabkhas are, (1) bioclastic wackestone base, sometimes gravelly sand, both are cemented by gypsum-anhydrite (G.A) and dolomite minerals, (2) fine clastic subhorizon including several bands of, desiccated-cracked dolomitic and/or anhydritic cryptalgal laminite, and G.A, (3) plates of anhydrite, (4) sequence of greenish grey shale and coalesced nodules of G.A forming lenses overlying G.A meshwork.

Inspection of recent sabkhas in six sites along the coastal area has indicated their occurrence within the main discharge cirques of dry valleys, opposite to curved beaches of bays and small lagoons. Investigation of Core samples, and pits and trenches across the coastal plane ( 3 to 30 Km in width ) has indicated that, the Holocene sediments of lagoonal and fluvial origin are laid over erosional surface and are extended between two built-up of stromatolgal reefs belonging to Pliocene and Pleistocene ages. Morphology of the sabkha surface (Fig. B) and idealized sequences of supratidal and intertidal zones are described. Interrelationships between the superficial realms of stromatolitic oncolites, algal mats, and salt tolerant plants in one hand, and the subsurface occurrence of evaporite minerals as well as horizontal gradation of mineral species are assessed.

Detailed studies including point-counting, mineralogy, and chemical analyses of the recent and ancient sabkhas has led to the development of a sedimentologic model (Fig. C to F). This model supports the hydrologic model of McKenzie et al (1980) and is able to propose answers to the questions regarding origin and evolution of: layered anhydrite nodules (Fig. D), dolomitized algal mat horizons (Fig. E), coalesced nodules and lenses of G.A. (Fig. F), Meshwork of G.A (Fig. F), transparent gypsum sheets, (Fig. G), cryptalgal laminites of G.A, and a bed of G.A lacking soluble salts (Fig. H).

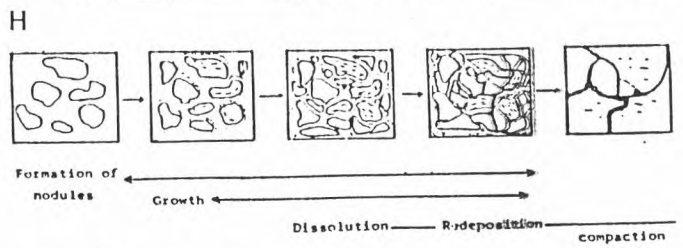
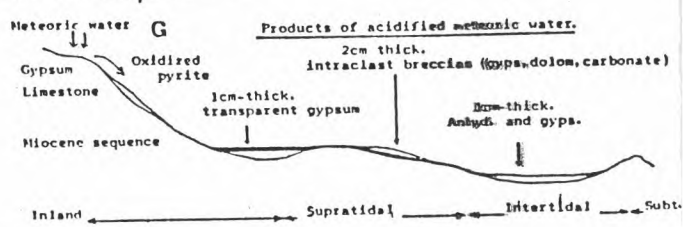
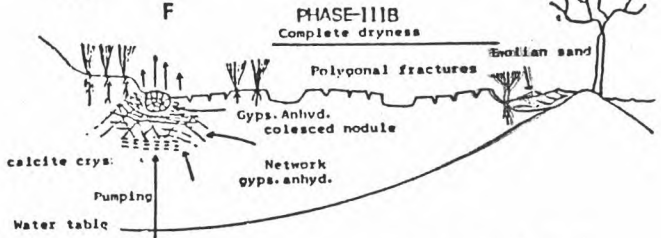
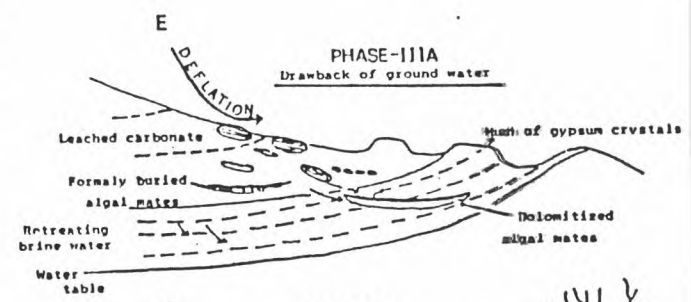
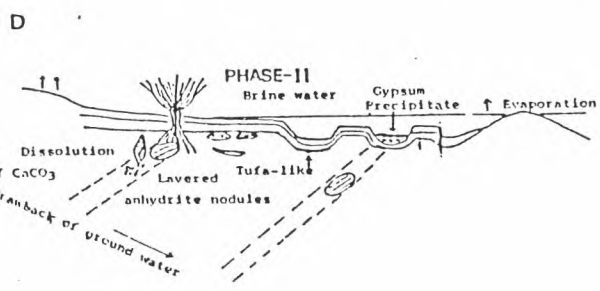
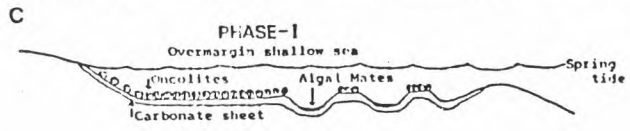
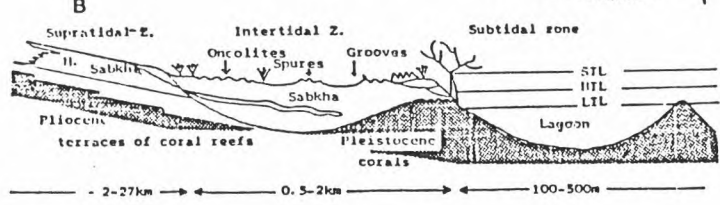
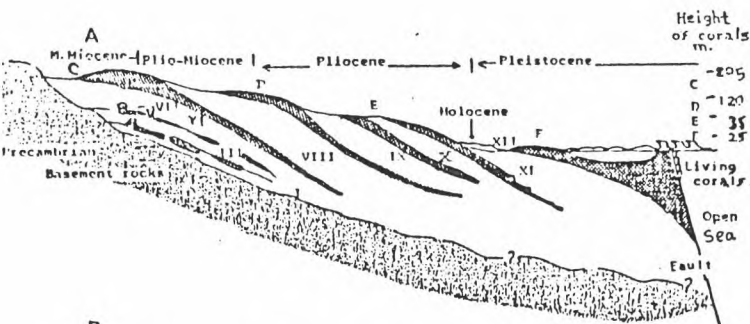


Fig. (A), Stratigraphic cross section in the Red sea continental margin showing offlap structure of different formations and elevation of coral reefs over sea level. Units I to IV= Gebel El-Russas Formation. Units V to VII =Gypsum Fm. VIII=Samh Fm. Units IX and X = Gaber and Tuiba Fm's, equivalent to Ras Benas Fm. Unit X = Ras Ranga Fm., and unit XII = the Holocene sediments including Recent Sabkhas. A to E are dolomitized coral reefs and algal limestone, F = Pleistocene calcareous reefs.

Fig. (B) Cross section in the coastal area showing morphology of the coastal zones relative to tide levels. LTL= low tide level, HTL = high tide level, STL = spring tide level

Fig's ( C to F ) A model of the formation of coastal evaporative minerals during spring tide (phase-I) and the following drawback of brine ground water (phase II & III-A) and the consequent complete dryness (phase III-B).

Fig. (G) Co-existence of evaporitic crusts and oxidized surfaces pyrite deposits in the Red Sea calcareous provinces.

Fig. (H) Schematic diagram illustrating the possible consequence of continuous formation, growth, dissolution-redeposition, and compaction upon recent anhydrite nodules and its fossil G.A analogues.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY, BUDAPEST, 1989.  
Loessoide sandy silts in the Senta - Kikinda area (Yugoslavia)

Dragan KOPRIVICA  
Geoinstitut  
YUGOSLAVIA

Based on numerous macro and microfauna, sedimentological analyses, calcimetry and DT analyses performed in loessoide, sandy silt, their mutual characteristics have been recognized on the whole investigated area, that can be applied on the broad region of the Panonian basin.

The frequent presence of water molusca (mainly gastropods) and ostracods characterizes swamp-lacustrine and fluvial-flooded environment.

The great number of granulometric analyses confirms the dominant participation of silt component. In sandy silts the participation of silt amounts 81 - 87,5%, and in loessoide silt 91 - 95%. Clay component is almost always less than 1%. The rest belongs to sandy fraction (according to Folk). In sandy fraction the most abundant particles are from 0,1 - 0,2 mm, and in silt fraction ranges from 0,02 - 0,005 mm and in less quantity from 0,05 - 0,02 mm.

Calcimetric analyses reveal a high content of  $\text{CaCO}_3$  and it ranges most frequently in the interval from 17 to 29%, what is not characteristic for other Quaternary sediments, except loess.

All DT analyses from loessoide sediments regularly show the presence of dolomite (Table 1). The presence of dolomite is also regular in loess.

The permanent presence of  $\text{MgCa}(\text{CO}_3)_2$  and  $\text{CaCO}_3$  as well as waters fossil fauna indicate that the deposition of these sediments was in stillwater on which surfaces eolian material was flown, identical to those from that loess was formed in Bačka.

Loessoide sediments could be distinguished on the whole area of "varoška" terrace ( $t_2$ ) on the both sides of Tisa (Fig. 1), both on Yugoslav and Hungarian side of Panonian depression (Fig. 3 and 4).

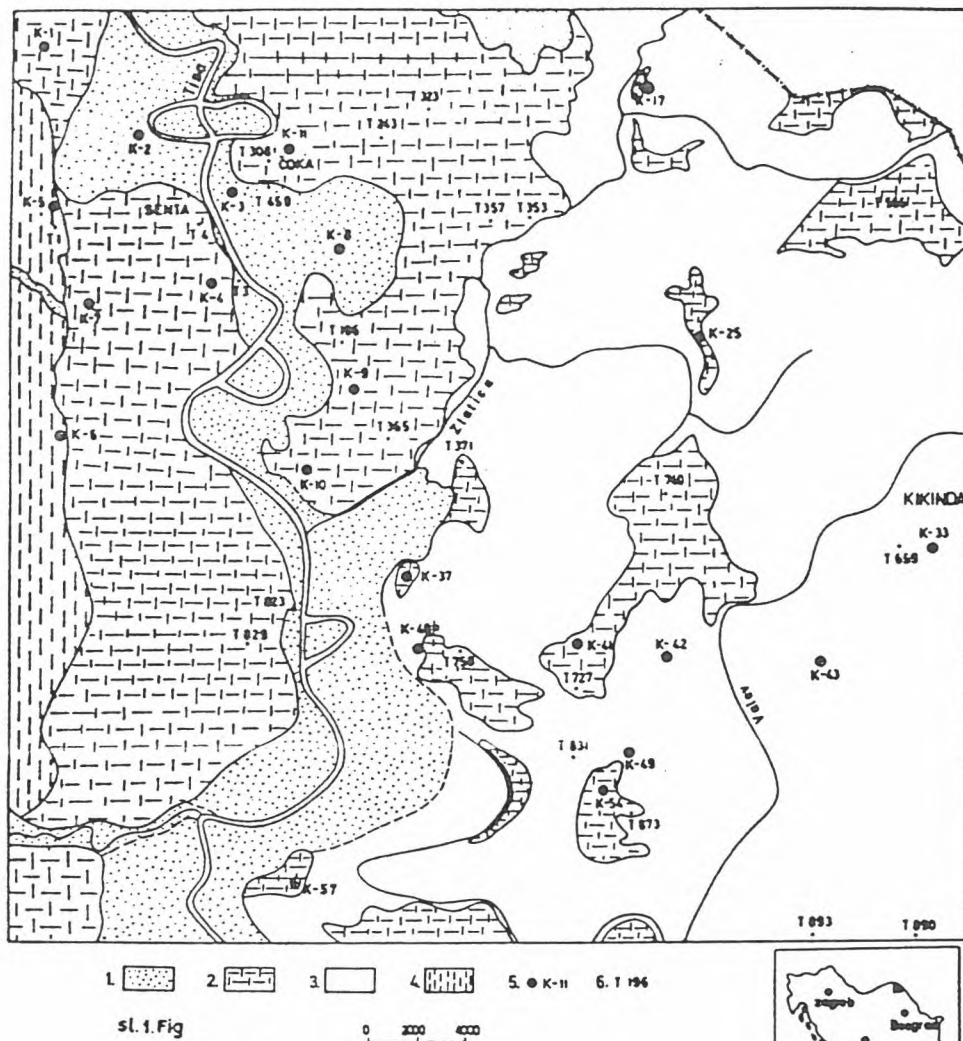


Fig. 1. The sketch map of loessoide deposits /sheet Kikinda/: 1. Tisa flood terraces: silts and sandy silts, 2. loessoide sandy silts, 3. silts and sands of Würm, 4. loess of Würm: sandy silts, 5. exploratory drill-hole, 6. sample site.

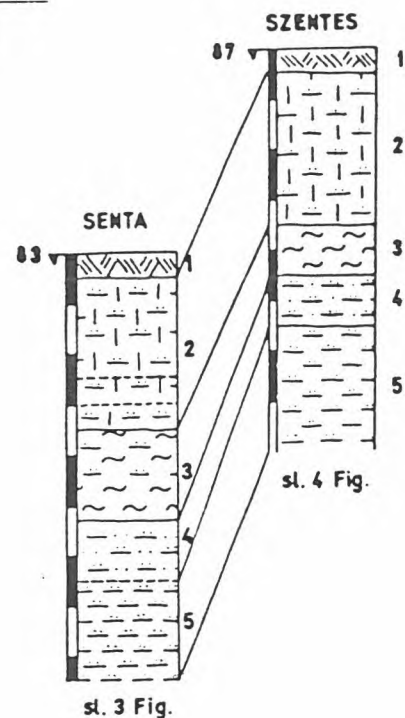


Fig. 3. Section near Senta: 1. soil layer - chernoze, 2. loessoid sandy silt with 23,6%  $\text{CaCO}_3$ , 3. silty clay, 4. sandy silt, 5. silt rich in concretions.

Fig. 4. Section of the brick factory near Szentes: 1. soil layer - chernoze, 2. suffusion loess with 25%  $\text{CaCO}_3$ , 3. fluvial clay, 4. silt, 5. fine silt similar to loess /B. Molnar, oral communication, 1986/.

Early stage in the formation of ferro-manganese nodules in the outer Bulgarian Black Sea shelf

EMANUIL KOŽUHAROV, VALENTIN GEORGIEV

Geological Institute, Bulgarian Academy of Sciences  
BULGARIA

Ferro-manganese nodules in the recent sediments of the Black Sea are known since the end of the last century from the works of N.I. Andrussov in Crimea shelf. During the last decades detailed studies have been carried out in the Kalamitian nodules field in the NW shelf of the Black Sea. Later, ferro-manganese nodules have been found in the Romanian and Bulgarian Black Sea shelf.

Our studies cover the two boundary regions of the Bulgarian shelf where the nodules develop in the form of crusts and encrustations on shell material from the surface layer of the recent sediments. The nodules occur in the depth interval 65-118 m with maximal development between 75 and 90 m. They are rare below the 100 m isobath. The ferro-manganese crusts are of brown-black to rusty-brown colour. In most cases they are thin and rarely reach up to several mm in thickness. A two layer structure is commonly observed: lower (basal) black layer and upper (surface) brown-red layer.

Scanning electron microscope studies reveal colomorphic microtexture and average thickness of the crusts 5-15 microns. The mineral composition, apart from amorphous phases of Fe-Mn hydroxides, includes vernadite proven by XRD and DTA. Chemogenic Mn-carbonate - Ca-kutnahorite also occurs.

SEM and qualitative EDS analysis established manganese composition of the basal layer and iron composition of the surface one. According to chemical data the Mn/Fe ratio in the two-layer crusts is up to 2 but increases when the basal

layer dominates. The nodules are concentrators of heavy metals with particular affinity to nickel and cobalt.

The above described nodules correspond mostly to the innermost layers of the nodules studied in other parts of the Black Sea and are understood as initial stages in the formation of Fe-Mn nodules. Their specific location (along the shelf margin) and the weak terrigenous sedimentation are favourable conditions for chemogenic deposition of Fe, Mn and some heavy metals. The source of the mobile forms of these elements is the boundary zone between the  $O_2$  and  $H_2S$  layers in the water body of the basin. The formation of established geochemical anomalies in the recent deep-sea sediments from the upper part of the continental slope and the rudimentary formation of Fe-Mn nodules and chemogenic manganese carbonates on the shelf edge reflects the influence of this geochemical boundary on the recent processes of sedimentation.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST,  
1989

Engineering geological mapping of sedimentary rocks in  
settlements having cellars

ERZSÉBET KÓVÁRINÉ GULYÁS  
Consulting Engineering  
HUNGARY

In Hungary as in most countries of the world, the geological feature of strata near the surface are quite varied. Generally young sediments dominate mainly palaeogene, neogene or younger than those.

There are many vineyards on the slopes of hills. The inhabitants utilized the favourable conditions from the beginning and produced a lot of cellars for stocking casks.

In the past cellars were situated on the edges of settlements, but at the moment many of them can be found in the centre because of the advanced urbanization. This changed position is the reason of arising new problems.

The buildings built above the cellars, hazardous breaking down of attached public utilities, the dynamic effect of the increasing traffic, these all can have bad influence on the condition of geological formations surrounding cellars.

Under Szentendre -one of our touristic centre near Budapest- a real cellar network can be found in Miocene tuff. The speeding up of rock weathering by antropogene

effects leads to decrease of the solidity to 25-30% of original.

Other Hungarian towns like Szekszárd and Nagymaros cellars are in loess. There the danger is hidden in the structure of loess. It is very sensitive to dynamic effects of the heavy traffic and to water infiltration from the surface.

There are small settlements of North - Hungary like Noszvaj, Novaj and Ostoros where lack of sewerage or making too big cellars in the Oligocene clay causes damages.

We show examples of suitable engineering geological map series of these settlements.

Evolution of the "Badstubbreccia" in the Carboniferous  
of Nötsch (Eastern Alps, Austria)

KARL KRÄINER  
Institut für Geologie und Paläontologie  
Innsbruck, Austria

The "Badstubbreccia" is part of the Carboniferous of Nötsch, a small occurrence of mainly submarine clastic sediments. The Carboniferous of Nötsch (Carinthia, Austria) is situated immediately N of the Periadriatic Line, between the Granite Complex of Nötsch and the Gailtal Crystalline in the S and Permotriassic sediments of the Drau Range in the N and E (all being Upper Austroalpine elements).

The Carboniferous of Nötsch is surrounded by faults. In general, it is a sequence of submarine polymict conglomerates, sandstones (greywackes), siltstones and thick, fossiliferous shales with some thin carbonaceous layers intercalated. Fossils, esp. brachiopods and trilobites, indicate Visean - Namurian age.

Interstratified within this sequence is a more than 300m thick amphibolite-breccia, the so-called "Badstubbreccia".

During the past the origin of this breccia was interpreted differently by various authors: as diabase, sedimentary breccia, volcanic breccia, mylonitic-tectonic breccia and metamorphic oceanfloor basalts.

From structural and textural features of the breccia and from its fossil content in the upper, conglomeratic part (brachiopods, crinoids, plant fossils) a sedimentary origin is proved.

The Badstubbreccia (grain sizes in most cases below 15cm) is dominantly composed of amphibolite clasts (more than 80%) and some metamorphic and carbonate clasts, the latter containing conodonts of Visean age (SCHÖNLAUB 1985), indicating that the breccia is younger, most likely of uppermost Visean age. Due to their texture and mineralogical composition different types of amphibolite clasts have been distinguished. But all the different amphibolite clasts are of very uniform chemical composition (tholeiitic basalts) and seem to be derived from the same source.

The sandy groundmass of the breccia consists of detrital amphiboles, plagioclases, alkalifeldspars, some quartz and epidote (mostly derived from

amphibolites, some quartz and feldspars from other metamorphic rocks).

At a few places the breccia is cemented by calcite.

The Badstubbreccia is interpreted as proximal, submarine debris flows and turbidites, formed at an active margin probably during lateral movements along the Periadriatic Line. It seems that the Periadriatic Line was active already during Visean/Namurian (?transform fault).

Reference:

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10 TH IAS REGIONAL MEETING ON SEDIMENTOLOGY

BUDAPEST, 1989

THE INFLUENCE OF TECTONICS AND CLIMATE ON THE STRUCTURE  
OF CARBONATE FORMATIONS

Vitaly G. Kuznetsov

MOSCOW GUBKIN OIL AND GAS INSTITUTE

U S S R

The inner structure of carbonate formations is defined by the character of cyclic recurrence of section and by peculiarities of lateral changes of rock layers associations. The cyclite structure of the humid and arid platform formations are principally of the same type and characterized by directed decrease from the foundation to the top of cyclite of the quantity of the clay substance, by hiatuses in top. Limestone prevail absolutely in humid depositions, sometimes argillaceous but the material sedimentation mechanism is practically biogenic. A set of rocks in arid formations is much bigger ; limestones, dolomites, rock salts; the ways of sedimentation are biogenic and chemogenic and at that the latter prevails. In other words rocks composition differences are determined by climate. Structure and composition of humid formations by area are quite stable but changes are stipulated by tectonic causes. Arid formations have sharply asymmetric structure. In proximal parts there prevail limestones and the section is rather homogeneous in distal ones a set of rocks is substantially more diverse, but the section is more differentiated. These changes are sti-

pulated by paleographic and above all climatic causes. Sections of deposits of cyncline regions are more dismembered, they have more cyclites but less capacity, usuall without hiatuses in the top cyclites. There can be seen deposits of "eventfull sedimentation". These features are determined by tectonics and at that by stipulated relief basin of sedimentation.

BUDAPEST, 1989

ORGANIC BUILD-UPS OF THE LOWER CAMBRIAN OF THE SOUTH OF  
THE SIBERIAN PLATFORM

V.G.Kuznetsov, O.V.Postnikova, L.N. Ilyukhin

MOSCOW GUBKIN OIL AND GAS INSTITUTE

U S S R

The Lower Cambrian organic build-ups mean the initial stage reef-forming and therefore they have a number of peculiarities. They are characterized by biocoenosis of organisms breedformer, where blue-green algae dominate (renalcis, epiphyton and others), and there appear archaeocyatha. The variety of structural genetic types of breeds (microfacies) is relatively small. Build-ups consist of polyphite, archaeocyatha, epiphyton, marcovella limestones; about 20% accounts for crystal limestones and dolomites. The dolomite content is lower comparing to the whole deposition bulk and at that dolomites are dominantly secondary. Build-ups are of vast spaces, low capacity, low hight and fairly gentle slopes; this determines practically absence of detrital traces. Most build-ups set in a frame huge shallow areas and settled on the boundary with shallow and relatively deep sea. This stipulates their structure, morphological, lithologic and facies asymmetry.

Sedimentary Facies Character of Phosphorus - Bearing System of the Doushantuo Formation and Distribution Regularities of Phosphorite Deposits in Yichang, China

Liang Chuanmao  
Department of Geology  
China University of Geosciences  
Beijing, China

Abstract

The Yichang phosphorite deposits, lies the South China, is one of important phosphorite deposits in China. The deposits occur in the Doushantuo Formation of the Upper Sinian. The author suggest that the lithofacies related to the phosphorite deposits in the Yichang area belong to a sedimentary assemblage of barrier island system on the basis of analysis of sedimentary facies. The phosphorus content in the assemblage is relatively high, but the deposits of commercial value is chiefly located in the barrier island facies of the assemblage.

The sedimentary assemblage of the barrier island system includes four main sedimentary units. From the bottom to the top of the assemblage they are respectively:

Unit 1, the shoreline carbonate tidal flat sediment, is mainly composed of carbonate mudstone, algal carbonate and a few terrigenous mudstone, with minor ripple marks, mud cracks and exhibition "bird's eye structure", representing a relatively lower energy tidal flat environment.

Unit 2, the lagoonal sediment, consists dominantly of black mudstone with well developed lamination and nodular of pyrite, occasionally interbedded with carbonate and phosphate containing a few gypsum. The lithofacies character indicate a half-closed environment with standing water.

Unit 3, the barrier island sediment, is a unit containing commercial phosphorite ore body. It consists chiefly of interclastic ( gravel-sized, sand-size and silt-size ), oolitic phosphorites and carbonates, well sorted and rounded, with well developed inclined and parallel bedding as well as wave marks. Undoubtedly, it represents a high energy environment and the interclastic phosphorite was washed, winnowed, sorted and redeposited.

Unit 4, the shallow sea shelf sediment, mostly comprises micrite with horizontal bedding and wave bedding, some times containing minor siliceous nodular, representing a shelf environment.

The sequence from the tidal flat, lagoonal facies through the barrier island to the shallow sea shelf facies indicate a regrading sedimentation in the Doushantuo period. Each unit

in the assemblage of barrier island system migrated landward during the regrading sedimentation. As the result of migration of barrier island containing the phosphorite deposits, the main phosphorite beds were developed from the southern part to the northern part of the area on the basis of reconstruction of the paleogeography in the Doushantuo period. It is reasonable that the northern part of this area can be regarded as a new potential area of phosphorite deposits to be found in the future.

The rate change of sea level rising fast to relatively slow after the Nantuo ice age probably plays a key role in forming the barrier island system.

P.S.

The figures and plates will be presented with my article at the meeting.

Depositional models  
of the Polish Carpathian Flysch coarse clastics  
(Cretaceous - Miocene)

STANISŁAW LESZCZYŃSKI  
Jagiellonian University, Kraków  
POLAND

The Polish Carpathian Flysch is in the main built of siliciclastic deposits. The coarse clastics (conglomerates, sandstones) represent all facies of Pickering et al. (1986). Most common are sandstones occurring in organised sand-mud couplets (facies of the group C2), less common are disorganized sands (facies B1.1), disorganized pebbly sands (facies A1.4) and normally graded pebbly sands (facies A2.7). Other facies are subordinate, although their participation changes both vertically and laterally.

Detailed analysis allows to classify the coarse clastics into 8 groups differing in texture, structure and/or origin:

- Group PC, comprising beds of paraconglomerates; debris flow deposits;
- Group CL, comprising conglomerate beds; gravelly high-density turbidites or density-modified grain flow deposits;
- Group CS, comprising conglomerate-sandstone-(shale) beds commencing with a conglomerate layer more than 30 cm thick, that includes over 20 % of a bed thickness and contains clasts larger than 10 mm in diameter; gravelly high-density turbidites;
- Group PS, comprising beds of pebbly sandstones; pebbly sand high-density turbidites or fluidized flow deposits;
- Group PSS, comprising pebbly sandstone-sandstone-(shale) beds commencing sometimes with a conglomerate layer up to 30 cm thick, that includes up to 20 % of a bed thickness and contains little admixture of clasts larger than 10 mm in diameter; pebbly sand high-density turbidites;
- Group S, comprising beds of essentially non-laminated sandstones devoid of gravel admixtures; fluidized flow deposits or sandy high-density turbidites;
- Group SS, comprising thick beds of essentially non-laminated sandstones devoid of gravel admixtures and passing to shales; sandy high-density turbidites;
- Group FS, comprising beds of fully laminated, medium, fine-grained sandstones usually passing to shales; low-density turbidites.

Of the eight distinguished groups most common are those of the FS, SS, S, PSS and PS groups. The last four groups together with the CSS and CL groups represent so called fluxoturbidites. For each group an ideal (model) bed was generated (Fig. 1). The divided groups refer to the widely accepted depositional models of sediment gravity flows of Lowe (1982), however, beds of the CS and PSS groups do not fully follow the Lowe's models.

The difference is interpreted here as conditioned by very uneven (rugged) morphology of bottom of the Polish Carpathian Flysch sedimentary basins, its high mobility as well as by low gradients of slopes surrounding the basins.

It is proposed to add the ideal (model) bed of the group SS to the existing models of the high-density turbidites. The hitherto existing models did not reflect such beds sufficiently.

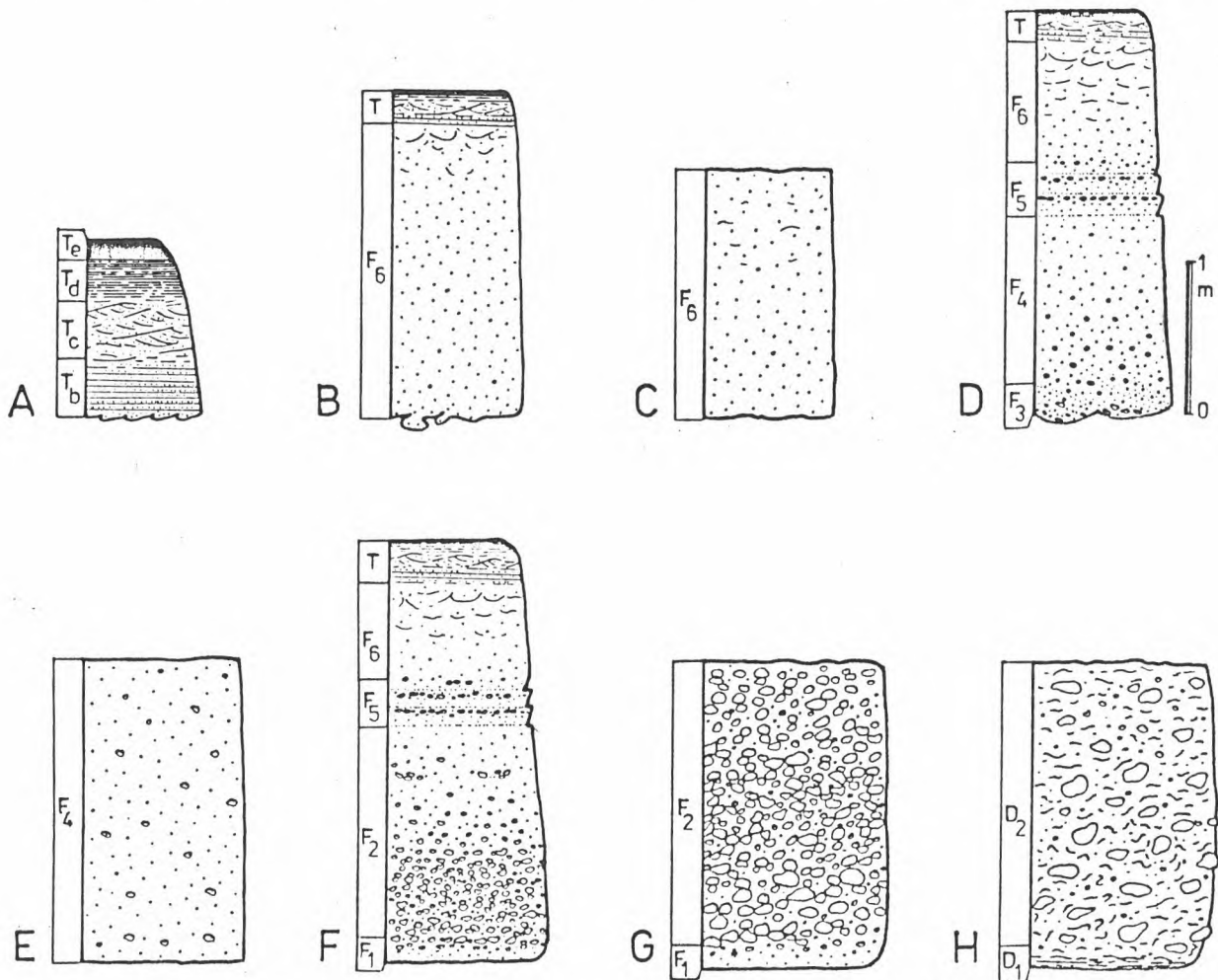


Fig. 1. Ideal beds for the groups: FS (A), SS (B), S (C), PSS (D), PS (E), CS (F), CL (G), PC (H). Other explanations in text

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Tempestites in Lower Palaeozoic shelf deposits of Thuringia  
(GDR)

HARALD LÜTZNER  
Academy of Sciences,  
Central Institute for  
Physics of the Earth  
GERMAN DEMOCRATIC REPUBLIC

The Lower Palaeozoic in the Saxothuringian zone of the Variscan orogene in Thuringia mainly consists of quartzites and slates. Shelf deposits predominate during Cambrian and Ordovician. During this period the dispersion of sand and coarse silt over the shelf was dominated by storm-controlled processes. Sandy deposits of the Goldisthal (?Cambrian), Frauenbach (Tremadocian) and Phycodes Formations (Tremadocian-Arenigian) show varying types of hummocky cross stratification in connection with mud pebbles, redeposited silts and graded layers.

Microfacies analysis displays a series of facies types ranging from unbedded still water mudstones through muddy siltstones of low energy environments up to high-energy well sorted sands. Statistics of the types are useful to trace palaeogeographic trends. The facies types are in part arranged in characteristic sequences which are interpreted to reflect storm events under different palaeobathymetric conditions. In a sedimentary model of the Phycodes Formation the following palaeobathymetric zones are distinguished: (a) deposition dominated by direct storm wave impact with amalgamated and single-event tempestites, (b) deposition dominated by proximal wave-generated currents and small-scale tempestites, (c) deposition under distal wave-generated currents,

(d) stillwater deposition with events of oscillation and deposition from suspended mud clouds (graded layers),  
(e) stillwater sedimentation without current-related structures. The palaeobathymetric development from deep to shallow water conditions is indicated conformably by sedimentary structures and trace fossil communities.

The Sphere of Storm Action, the Distributional Area of storm Deposits and the Possibility to Take Tempestites as Isochrnic Surface in Geological Time

Ma Yongsheng

China University of Geosciences

China

Modern studies on typhoon and other storm weather process indicate that one storm event can affect a large area of ocean, especially the shallow water region and the coastal waters. The average distance from the "eye of the storm" to its outer brim is about 300-500 kilometers. Take typhoon No.8006(Northwest Pacific) for example, during the 10 days action, its affected region is about 3.54-5.90million Km<sup>2</sup> which includes the most part of the coastal waters of China Japan, Philippines and Korea. By the way, the average maximum speed of 1179 times of typhoon in northwest Pacific region is about 36.51m/s. Such violent water movement events which last for a very short time(averagly about 7-9days)act on such huge area, it must leave/must have left very very deep brands in modern/ancient deposits.

The distributional area of modern /ancient storm deposits varies in different scale. The Safety Valve belt of skeletal banks (southeast of Miami, Florida) is about 3-4km broad and 8-9km in length, the German Bay is about 1,173km<sup>2</sup>(after T. Aigner, 1985) and the major part of Hongzhou Bay(southeast China)is covered with fine sand & mud storm deposits. While the carbonate tempestites of Cambrian-Ordovician covered the east part of North China and the south part of north east China(fig.1). Another ancient storm depositional system has been established in South German Basin(Middle Triassic) (T.Aigner). The other studies on storm deposition in modern and ancient time show that tempestites can occur in small region, they also can cover huge areas (even in an intercottinental scale.

The carbonate storm deposits of the late Cambrian in north China represents a large shallow epicontinental sea. The carbonate tempestites characteristics of the Changshan Formation( $G_3$ ) show no or little difference from Changbai, Beijing, Taiyuan to Xuzhou. This consistence provides us the possibility to take the tempestite layers as isochronic surfaces in large or small area--this is a very useful tool to make stratigraphic correlation more correct and easier because they formed during much shorter times in geological history, it also can be used to trace ore beds.

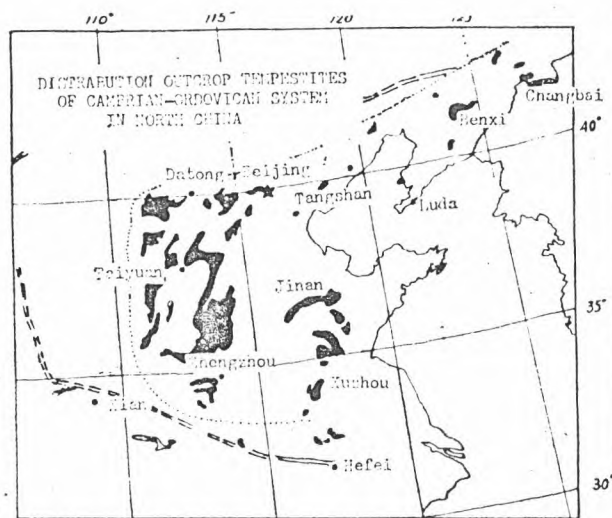


Fig.1. Distrabution map outcrop tempestites of Cambrian-Ordovician system in North China.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

SEDIMENTARY AND PEDOLOGICAL FEATURES ON MICROTIDAL SEQUENCES IN LIMESTONES: AN EXAMPLE IN UPPER CRETACEOUS OF PREBETIC RANGES (SE SPAIN).

Javier MARTÍN-CHIVELET  
Rocío GIMÉNEZ

Instituto de Geología Económica, C.S.I.C., Madrid.  
SPAIN

The uppermost Cretaceous (Senonian) of the external prebetic zone, in Murcia province, is made up by a thick serie (80-100m) of shallow marine limestones. Detailed stratigraphic descriptions of these may be found in previous works (MARTÍN-CHIVELET, 1988). These limestones are composed of well stratified decimetric levels, which are the result of a very uniform sedimentation during a stage of great stability in the external Prebetic area.

The purpose of this contribution is to show the main sedimentary characteristics of these marine limestones, its pedologic features superimposed, and their genetic implications.

A lot of different facies have been described. They form shallowing upwards sequences (in the sense of JAMES, 1979) (Fig. 1). All of them represent the progradation of marsh/swamp environmental conditions over shallow marine deposits (I and II types) or over restricted areas or ponds sediments (III and IV types). Black pebbles occurs in most of the facies described. Under supratidal marsh/swamp conditions, early diagenetic and pedogenic proceses take place and transform the original textures. The transit between lightly modified marine facies and well developed hipercalcimorphic soil (in the sense of FREYTET & PLAZIAT, 1982) is gradual. These processes take place within lightly cemented substrate. Alteration zones are usually restricted to the last 0.2-0.5m of each level. The most representative features of these paleosols are:

- Internal sediment ("vadose silt")
- Microkarst
- Meniscus and gravitational cements
- Coated grains ("vadoids")
- Root marks
- Microcodium (corn cob and lamellar colonies, but also reworked prisms in calcarenites)
- Alveolar texture
- Nodulization
- Incipient marmorization
- Cutans
- Dessication cracks (curved and skew planes included)

The presence of both supratidal and subtidal deposits, the lack of well developed intertidal terms in all sequences and the development of

soils on marine deposits strongly suggests some paleoenvironmental conditions:

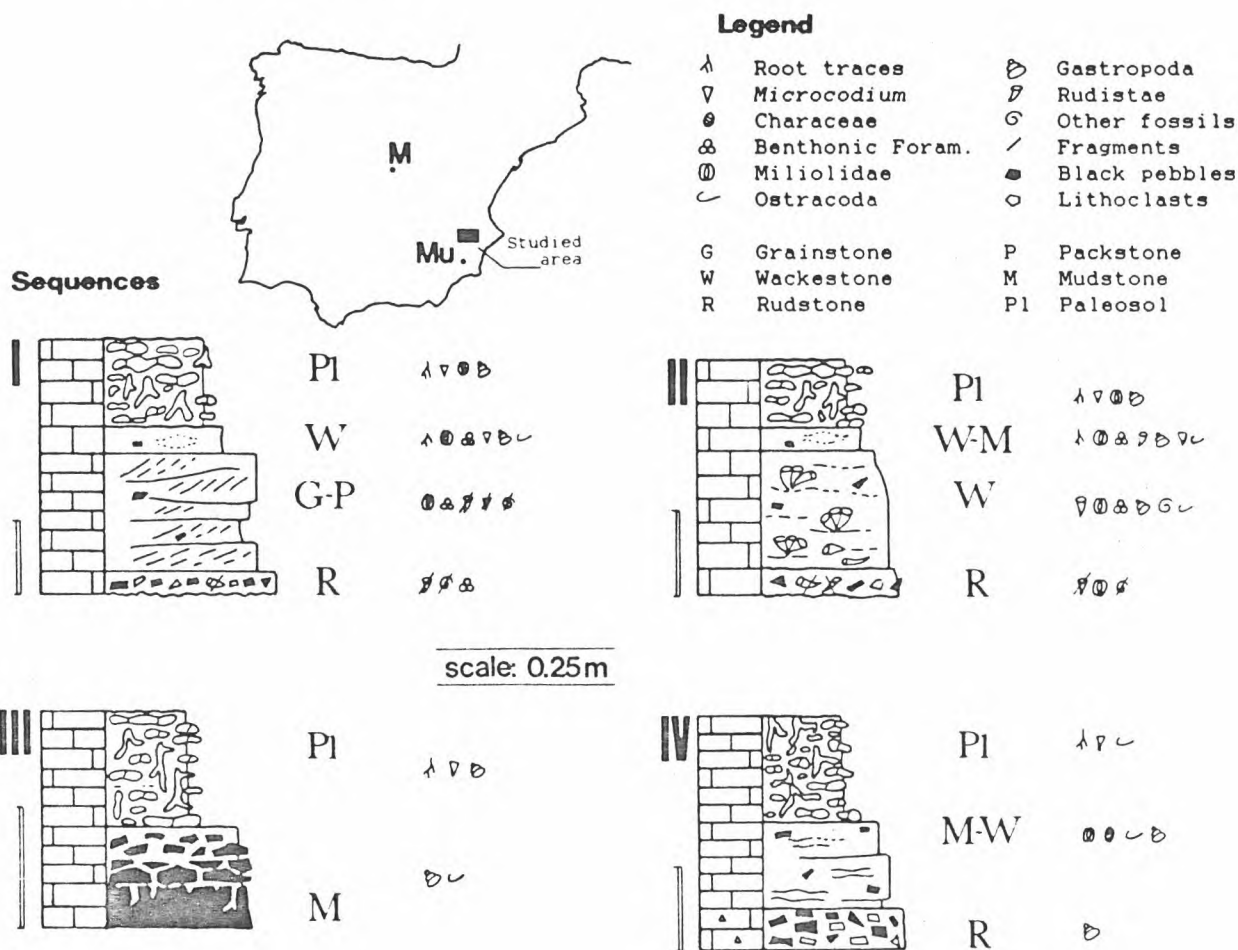
Very reduced diurnal tidality in this part of the Betic basin.  
Humid climate (at least seasonally)

Comparable microtidal sequences are described in recent sediments, in the Florida bay, where the tidal influence is notably reduced (BATHURST, 1971).

This work is a contribution to the PB033101 project of the Dirección General de Investigación Científica y Técnica.

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Recognition of Estuarine Deposits in the Geological Record

J. R. MCLEAN  
Shell Research, Rijswijk  
THE NETHERLANDS

Estuaries are major repositories of sand on modern coastal plains, and are beginning to be recognized more frequently in the subsurface, where they may be major hydrocarbon reservoirs. Estuaries form when relative sea level rise exceeds sedimentation rate and a river valley is drowned. The most prominent examples occur when 1) a lowering of sea level produces increased fluvial gradients leading to erosion and entrenchment of rivers, followed by 2) a rise of sea level causing lowered gradients, deposition of coarse clastic load and back filling of the river valley during transgression. The vertical sequence produced typically has a scoured base and an overall increase in marine influence upward.

Depositional processes and products vary, depending on the relative energy levels of river, wind and tidal input but, in most cases, the combined products of reversing tidal flow and the dilution of salinity by fluvial influx leave a diagnostic signature. Features of tidal influence are often ubiquitous and include: 1) abundant mud beds and laminae draping large and small sand bedforms (wavy and flaser bedding), and occurring as relatively thick beds on point bars; 2) herringbone crossbedding; 3) tidal bundles; 4) mud couplets; and 5) pinstripe bedding. Criteria of fluvial influence include: 1) an ichnological suite controlled by salinity variations, manifested by usually low diversity of burrow types and often by low numbers as well, although the latter can vary greatly locally; and 2) syneresis cracks. Individual lines of evidence alone do not characterize the estuarine deposit; a combination of sequence, tidal features and fluvial features is essential.

Examples from outcrop and subsurface in Canada illustrate the diagnostic features and some of the possible variations. Published global sea level curves can be used as a preliminary guide to those parts of the geological record in which extensive estuarine deposits may occur.

Lower Permian Lacustrine succession, Anthracosia Shales, North-Sudetic Basin, SW Poland.

Krzysztof MASTALERZ  
Wrocław University  
POLAND

The Variscan orogeny resulted in the development of numerous sedimentary basins in central Europe. The North-Sudetic Basin originated in the Stephanian and lasted during the Autunian as an intramontane graben bordered by tectonically active margins. The basin infill is characterized by large-scale fining-up fluvial-lacustrine cyclothems. The Anthracosia Shales form over a 40-m thick horizon of lacustrine facies capping the fining-up cyclothem of the Swierzawa Formation /Lower Autunian/. Interactions between clastic input, lake regime, and biota resulted in several facies which reflect the successive phases of lake development.

Ripple-cross-laminated, reddish-brown sandstones and siltstones with solitary trough-cross sets and abundant mud-chip lags are believed to represent an onshore sand-flat facies. Deposits are organized into small-scale coarsening-up cycles with bioturbated tops. Weak bimodality of ripple-lamination suggests occasional wave reworking. A sedimentary area originally occupied by a fluvial channel belt was gradually changed into the fluvially-influenced onshore zone of expanding lake.

Lacustrine nearshore facies consist predominantly of pale-green sandstones and siltstones. Both current and wave ripples are found in this sequence. Mud ripples are associated with raindrop imprinted and mudcracked surfaces. The abundant evidence of surface exposure points to frequent lake level fluctuations. Stacked, coarsening-up cycles with hummocky-cross-stratified and/or rooted tops suggest the development of vegetated nearshore bars.

Grey, highly-bioturbated muddy sediments within the middle

part of the nearshore sequence were accumulated in a nearshore-offshore transitional zone. These deposits are succeeded by a packet of redeposited sediments which are related to slope failures at the fronts of active fan deltas.

Organic-rich black shales and a few limestone layers displaying tiny parallel or wispy lamination and stromatolitic structures represent lacustrine offshore facies. The sediments are extremely rich in animal and plant remains. These deposits reflect a period of the maximum extent of the Anthracosia Lake. Algae/bacteria blooms enhanced temporarily carbonate precipitation. The eutrophization of lake waters was accompanied by reducing conditions in bottom muds. The occurrence of thin sulphate laminae suggests temporary hard-water conditions while chert laminae in stromatolitic structures are related to hot spring activity.

Greenish, silty-clayey sediments with very thin sandy-silty  $T_{ac}$  and  $T_{abc}$  sequences represent deltaic facies. Thicker, normally-graded sandy laminae become more abundant upwards. Tool marks are common on the soles. This coarsening/thickening-up sequence signifies the phase of the Anthracosia Lake regression. This process resulted from an intense progradation of an active deltaic/alluvial system due to the tectonic uplift of basin margins. Delta slope underflow sediments were successively replaced by channelized conglomeratic/sandy facies of fluvial origin.

The development of lacustrine facies has been controlled by both intra- and extrabasinal factors. The thick, compound, transgressive portion of the lacustrine succession resulted from internally-controlled, slow and long-lasting transgression, when the basin was attaining a quasi-equilibrium between subsidence and sedimentation. The thin regressive portion /deltaic facies/ is related to externally-controlled rapid regression.

Depositional environment of the coal seams of the  
Wałbrzych Formation, Intrasudetic Basin, SW Poland

MARIA MASTALERZ  
Wrocław University  
POLAND

The Wałbrzych Formation constitutes the earliest coal-bearing unit in the Intrasudetic Basin. It comprises upward-fining cycles built of conglomerates, sandstones, mudstones, and coal seams. The thickness of the formation is in a range of 200 - 300 m, while stratigraphically this unit corresponds to the Namurian A.

Optical studies of the coal have revealed that there is a tendency of a decreasing-upward amount of vitrinite, while the amount of exinite and mineral matter increases in this direction. This and some other features of macerals suggest that organic matter was deposited in increasingly humid conditions. Autocyclic mechanisms of an alluvial environment contributed to subsidence and the compaction of fresh sediments were responsible for the drowning of a depositional surface.

The conditions in peat-bogs became more variable towards the top of the formation. The 680 coal seam represents only telmatic forest moor, the 678 - telmatic forest moor and limno-telmatic forest moor. All coal facies but a terrestrial one are represented in the 672 and 664/665 seams. This variability was caused by the difference in the facies distribution of a pre-peat environment as well as differential compaction and subsidence.

There is the relationship between coal seams and surrounding clastic sediments. In the 669 seam, the increase in coarse clastics amount below the seam is associated with the decrease in coal thickness, while in the 672 seam the increase in coal clastics is accompanied by the increase in coal thickness. The seams underlying sandstones are relatively thinner than those occurring under fine-grained sediments.

Moderate and variable ash content and the occurrence of clastic, mostly clay, partings suggest conditions typical of groundwater and surface dominated swamps and, together with low sulphur content indicate pH a little higher than 4 during peat deposition.

Foreset beds on a Neopleistocene fluvioglacial  
Gilbert-type body, eastern Poland.

Krzysztof MASTALERZ  
Wrocław University  
POLAND

Small Gilbert-type deltoid bodies occur within the Neopleistocene fluvioglacial sequences of eastern Poland. They usually reach a few tens of metres in radius and up to 4-8 m in thickness. Foreset bed dips vary from 10 to 50°; the latter being an effect of post-depositional processes.

Most of the foreset strata are sandy and/or gravelly; the silty ones are found subordinately. The beds reach usually several cm in thickness. They show irregular undulations in parallel-to-flow sections and rarely they are planar. Bed dips tend to diminish both down-dip and distally in a foreset.

Some of the foreset strata are graded /normally, inversely, or inverse-to-normally/ while others show distinct lamination /ripple-cross, parallel/. Ungraded, backflow rippled, contorted, and pebble-thick gravelly layers are less common. The structures reflect the different processes operating on a foreset slope, which include slope failures, sand avalanching, tractional transport and deposition, flow separation and backflow activity, and suspension fallout.

The steeply-dipping, graded and contorted beds of a proximal foreset portion are distally replaced by the gently dipping laminated ones often with backflow ripples downslope. Silty laminae tend to be more frequent distally and they thicken downslope. These tendencies reflect the transition from predominant mass deposition in a proximal portion to bed-load with an increasing role of suspended load in a distal foreset strata. A small-scale cyclicity has been detected in foreset bed sequences by means of Markov chain method.

Rotliegendes sedimentary basins in the Sudetes (SW Poland):  
structural, sedimentary and climatic evolution

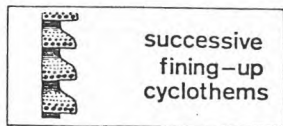
Krzysztof Mastalerz, Jurand Wojewoda  
Institute of Geological Sciences, Wrocław University  
Poland

Rotliegendes deposits in the Sudetes occur in two NW-SE trending synclinal depressions - in the Intrasudetic and North Sudetic basins. The basins are separated from the adjacent areas by faults which were already active when the basins were filled. The intrabasinal tectonic units form a series of grabens and horsts elongated parallel to the main basin axes. The basins started into existence as large accumulation areas in the Early Carboniferous (ISB) and Stephanian (NSB). During the Stephanian and Early Permian the Sudetes were characterized by basin-and range-type style of geodynamic activity, sedimentation, and topography. The most important factors which influenced the basin infills and facies patterns were the rate and style of basin floor subsidence and of sediment supply.

Allocyclic mechanism. During the Stephanian and Autunian three major events of rapid subsidence caused the rejuvenation of Sudetic landscape, which led to intense accumulation of coarse grained alluvial material along the basin margins. During these early alluvial phases the north-western parts of both basins were levelled and occupied by vast alluvial braidplains. At the same time the southeastern parts of the basins were topographically more diversified due to the existence of several smaller subbasins (alluvial valleys, elongated braided distributary systems). The subsidence events alternated with periods of "normal rate" permanent subsidence. Then, the landscape was levelled successively and the basins were filled with fluvial sediments. During these fluvial phases the axial zones of the basins were dominated by river systems with the prevailing direction of transport generally toward WNW. The continuous filling of the basins under a relatively slow subsidence rate resulted in worse drainage conditions and, eventually, resulted in the formation of lakes. The short living lakes developed in various places at different times, however, during the Autunian three distinct lacustrine phases resulted in thick sequences of lake sediments. Such a scheme of repeated basin evolution from alluvial to lacustrine environment is reflected by three asymmetric and fining upward cyclothems. These large scale features of the basin filling successions are allocyclic, i.e. they were initiated and partly controlled by extra-basinal factors.

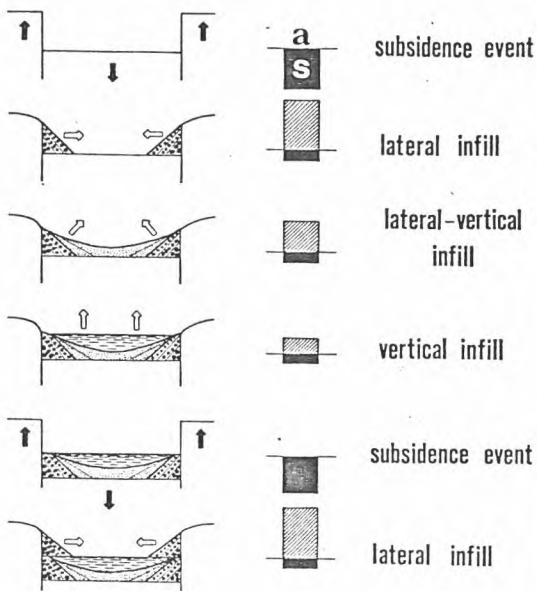
Autocyclic mechanism. The lacustrine sediments in both basins contain several symmetric, transgressive-regressive sequences. These reflect an autocyclic mechanism of lakes evolution, which seems to be characteristic for some intramontane basins. The main factor controlling lake shore progradation, as well as water retention and lake transgression is the basin slope inclination. If the slope inclination is higher than a critical angle, then the lake regression takes place. If the slope inclination decreases due mainly to basin filling, then the volume of retained water increases and lake floods the basin.

**Climatic evolution.** The Stephanian to Zechstein sedimentary sequences in the Sudetic basins reveal a long lasting climatic control, and continuous change of warm climate from wet to arid. Lacustrine sediments appear to be especially good palaeoclimatological indicators. An amount and degree of preservation of organic matter within lacustrine horizons gradually decrease up the Stephanian-Saxonian succession. This trend also concerns the sediments deposited under highly anoxic conditions. It suggests that the climatic conditions for plant vegetation got systematically worse. The Upper Saxonian fanglomerates display features typical of arid alluvial fans including the caliche horizons more numerous and better preserved up sequence.



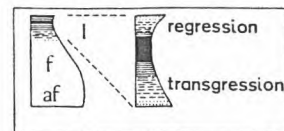
successive fining-up cyclothem

WHY?!

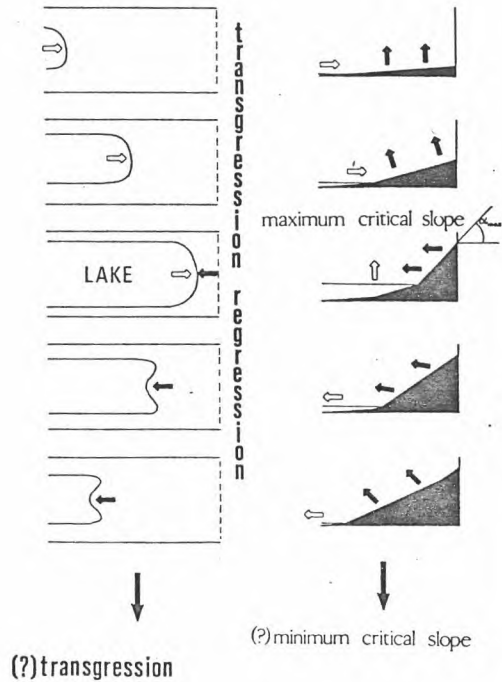


a - accumulation rate  
S - subsidence rate

ALLOCYCLIC MECHANISM



WHY?!



(?) transgression

(?) minimum critical slope

AUTOCYCLIC MECHANISM

Upper Precambrian sulphates of the Siberian Platform

GENNADIY MERZLYAKOV  
Institute of Geology and Geophysics  
USSR

Upper Precambrian evaporites occur in five regions of the Siberian Platform. The section with mostly thickness of the sulphate beds and members is in the southwestern part of the Anabara anteklise. Gypsum occur of the Starorechenskaya suite of the Vendian age (the uppermost of Upper Proterozoic). Gypsum beds and members are in the middle part of the suite and make up more than 50% of its sequence. The gypsum occur amongst dolomite and clay dolomite. The gypsum is white or pinkish grey, dolomites are brown grey. Somewhere calcite grains cementation by fine-grained gypsum aggregates.

We fail to outline the boundary of the evaporite basin. We may only suppose that the central part of the basin was situated approximately at the middle flow of the Kotui River.

The second region where the sulphate rocks Precambrian age occur is not far from Norilsk. Here the sulphates occur in Polbanskaya suite of the Vendian age. Gypsum and anhydrite interbeds with dolomites, clay limestones and marls.

The third region is the southwestern part of the Siberian Platform. Here gypsum and anhydrite occur in the section of the Kuyumbinskaya suite (Kamovsky Arch) and Ostrovnaya suite (Enisei Ridge). Sulphates interbeds and lenses occur in grey or motley dolomites. The distribution area of sulphate rocks

is difficult to establish as they are intersected in single wells.

In Angara-Lena and Nepsko-Botuobinsky regions beds of gypsum and anhydrite<sup>✓</sup> are known too. They occur in Danilovskaya and Iktehskaya suites. A Precambrian age of these suites is now conventional.

In Yudomian carbonates of Aldan region inclusions and lenses of gypsum and anhydrite occur. Precambrian age of these deposits is also debatable.

Evaporite inclusions in the form of pseudomorphs after halite are known in Kyutingdinskaya suite developed on the Olenyok uplift. The stratigraphic position this suite is correspond to the lower part of Upper Proterozoic. Pseudomorphs after halite are confined to carbonate and terrigenous carbonate beds. The pseudomorphs can not be a reliable indication of evaporite sedimentation. Halite crystals may be formed on the stage of early diagenesis.

All the mentioned beds and members of sulphate are confined to the formations, similar to Paleozoic ones in their composition. The facies sequence looks like Paleozoic one too. Upper Precambrian sulphates of the Siberian Platform are bounded up with normal marine deposits. They are likely to be formed in separate zones inside shallow water marine basins. Evaporite environments could appear in relatively isolated areas in carbonate plateau.

NEW TRENDS IN KARST BAUXITE GEOLOGY

ANDREA MINDSZENTY  
Eötvös L. University  
Dept. of Mineralogy  
HUNGARY

Rooted in earlier isolated attempts of NICOLAS, VALETON, D'ARGENIO, BÁRDOSSY, SINKOVEC, ÖZLÜ, COMBES and others, recently a new concept of karst bauxite geology is emerging and gains ground more and more in "bauxite-countries" of South-Central Europe. The essence of this new concept lies in its SEDIMENTOLOGICAL approach: Bauxites previously considered to be just mineral raw materials are being treated now as ordinary fine-grained clastic sediments.

It has been recognized that there may be important paleoenvironmental information coded not only in their mineralogy (as it was recognized already by VALETON, COMBES, KOMLÓSSY, ETC.) but also in their texture, structure, and the karst morphology they are associated with.

Based on this the LITHOFACIES concept of karst bauxites has been elaborated by dividing them into the following main groups:

(a) "VADOSE" (characterized by equally oxidized nature of both matrix and ooids/intraclasts; predominant hematite and/or goethite as primary iron minerals accompanied by gibbsite and/or boehmite);

(b) "PHREATIC" (characterized by less oxidized, often pale deferrificated matrix, sometimes accompanied by likewise deferrificated ooids/intraclasts; goethite, siderite and/or pyrite as main iron minerals; chlorite may or may not occur and the alumina mineral is generally boehmite and/or non-metamorphic diaspore)

Within each of these groups subdivision according to the predominantly autochthonous or allochthonous nature of the sediment is possible.

AUTOCHTHONY is generally indicated by in situ segregational or accretional ooids, (the outermost crusts of which show a gradual transition towards the surrounding matrix) and by the more or less regular grade pattern of the deposits. Non-spherical grains are mainly intraclasts in this group. ALLOCHTHONY on the other hand is shown by a generally high diversity of ooids/pisoids and clastic grains (which all have abrupt contacts toward the surrounding matrix); the presence of bauxite pebbles and by the capriciously changing grade of the ore within the deposits. Among non-spherical grains frequently also non-bauxitic extraclasts occur in this group.

Different terminology was worked out for the two groups. The one used to describe predominantly autochthonous deposits is focussed to early diagenetic phenomena and adapted several terms from pedology whereas the other one - used when describing allochthonous deposits - is essentially a modified version of Dunham's terminology for carbonates amalgamated with Folks system for clastic sediments (JUHÁSZ).

Systematic study of bauxite deposits overlying various types of karst topography and displaying different lithofacies characteristics suggests that there is a correlation between bauxite-lithofacies and the underlying karst relief: in most cases bauxites associated with a highly dissected karst relief, are "vadose" by their lithofacies, and show predominantly autochthonous or paraautochthonous (sensu BONTES) textures, whereas bauxites filling a shallow karst topography frequently show "phreatic" characteristics, and very often display a considerable allochtony.

Since, with tropical climate granted, both lithofacies and karst topography are essentially dependent on the actual position of the deposits above the paleo-groundwater-table; lithofacies studies of bauxites, when coupled with careful morphological analysis of the associated karst, may reveal the details of the paleomorphology of bauxitiferous regions at the time of the accumulation of bauxites.

Accordingly the following two principal MORPHOFACIES can be distinguished:

- a) LOW-LEVEL bauxites, characterized by shallow karst relief, phreatic diagenesis, and a considerable allochtony and
- (b) HIGH-LEVEL bauxites underlain by a highly dissected, deep karst morphology and characterized by vadose diagenesis and a considerable autochtony.

With this in mind it has been envisaged that in the case of regional bauxitiferous unconformities the relative altitude of larger crustal segments may be inferred by looking systematically at the litho- and morphofacies of the bauxites.

In addition to all these, by their silt size extraclasts bauxites may give us some information about the paleogeology of the widest surroundings of their site of accumulation, too.

SEDIMENTOLOGY AND DEPOSITIONAL ENVIRONMENT OF THE  
CSABPUSZTA BAUXITE (PALEOCENE/EOCENE) IN THE BAKONY MTS  
(HUNGARY)

MINDSZENTY, A<sup>+</sup>-SZINTAI, M.<sup>++</sup>-TOTH, K.<sup>++</sup>-SZANTNER, F.<sup>++</sup>-NAGY, T.<sup>++</sup>-GELLAI  
M.-BAROSS, G.

<sup>+</sup>Eötvös L. University, Dept. of Mineralogy, Budapest, HUNGARY  
<sup>++</sup>Bauxite Prospecting Co., Balatonalmádi, HUNGARY

Sedimentological evidence (based on textural study of the Csabpuszta bauxite) strongly suggests that the deposit represents an independent Eocene bauxitization period. Lithological criteria to distinguish the Eocene bauxites from the Senonian ones occurring in the same area are (1) the predominantly pelitomorph texture of the Eocene bauxites as opposed to their oolitic Senonian counterparts and (2) their rather variegated micromineralogical suite as opposed to the monotonous micro-extraclast association of the Senonian bauxites.

They are considered to be the weathering products of older Mesozoic rocks probably mixed with air-born dust and fine pyroclastic material deposited on a low-level karst terrain under vadose conditions.

As to the origin of the micro-extraclasts, all available evidence points to the possibility that during the Eocene bauxitization period already higher-grade metamorphic, continental crust-type material was exposed somewhere in the distant backgrounds, whereas the extraclasts of the Senonian bauxites reflect a much lower grade metamorphism in the backgrounds, alongwith the predominance of a calc-alkaline igneous rock suite.

Lateral and vertical lithofacies variations suggest a gently undulating relief in the depressions of which at the end of the bauxitization period the depositional environment changed from vadose to phreatic.

Facies distribution of the immediate cover when confronted with the lithofacies of the underlying bauxite revealed an interesting "anomaly": at some places the depositional environment reflected by the immediate cover was exactly the opposite what would have been expected on the basis of the lithofacies and thickness of the underlying bauxite. (Sites which behaved like paleotopographic "highs" during the bauxitization period, "suddenly" became depressions at

the beginnings of the Middle Eocene and had been covered by lignitiferous strata. At other places bauxites, reflecting a paleotopographic "high" by their lithofacies, accordingly became covered only at later stages of the Eocene transgression and by limestones reflecting a more open marine environment). Since the areal distribution of the anomalous sites shows a more or less pronounced linear arrangement, we concluded that this anomaly was an indication of the Middle Eocene transgression having been introduced by differential subsidence of probably tectonic control.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
 JURASSIC KARSTIC BAUXITES IN THE SUBBETIC OF SOUTHERN SPAIN

MOLINA, J.M.; RUIZ-ORTIZ, P.A. and VERA, J.A.  
 Dpto. Estratigrafía y Paleontología. Univ.de Granada. Spain.

In the Subbetic Zone (fig.1), small bodies of bauxites related to Jurassic paleokarst occur. The main bauxite orebody and related paleokarst are found north (about 7 km) of Zarzadilla de Totana in the Murcia region. Another outcrop of Al and Fe-rich materials in the Tornajo hill, 16 km west of the above has also been analyzed.

The bauxite bodies and Al,Fe-rich materials fill karstic cavities in shallow marine limestones and epigenetic dolostones of Early Liassic age (Gavilan Fm.). The Jurassic section shows a stratigraphic gap lacking Middle-Late Liassic and Dogger deposits. The Malm consists of nodular limestones (Upper Ammonitico Rosso Fm.), capping a Jurassic section deposited in pelagic swells. Two kinds of alumina-rich rocks have been distinguished: 1) bauxites and bauxitic clays and 2) collapse breccias with irregular clasts

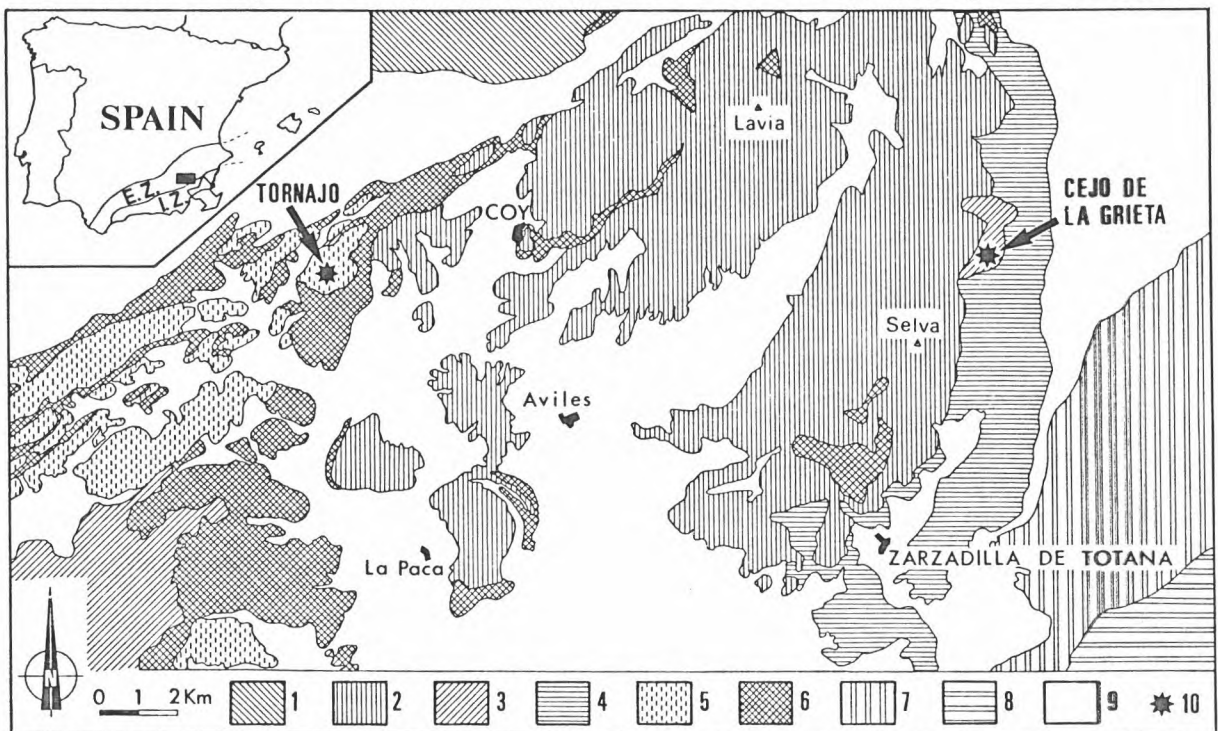


Fig.1. Location map of the study area. Subbetic (1: External. 2: Middle. 3: Internal). 4: Cretaceous and Tertiary materials 5: Tectonic megabreccia of the Crevillente Fault Zone. 6: Triassic of the Subbetic Units. 7: Tertiary of Espuña-Rio Pliego related to Malaguide Units. 8: Internal Zones (Malaguide Units) 9: Postorogenic Neogene and Quaternary. 10: Studied outcrops. Inset map: E.Z. (External Zones) and I.Z. (Internal Zones) of the Betic Cordillera.

of Liassic limestones and dolostones and bauxite matrix. Red, rose and violet colours prevail. Texturally they are mainly composed of a homogenous matrix (pelitomorphic texture, Bardossy, 1982), but pisolitic and grainy textures also occur. Gibbsite and Boehmite are the alumina minerals present and they are always associated with Kaolinite and Hematites. In Zarzadilla de Totana bauxites, where the only mined bauxite orebody (Cejo de la Grieta) of southern Spain is found, the total  $Al_2O_3$  and  $Fe_2O_3$  content ranges from 10 to 67% with common values from 40 to 60%. The  $Al_2O_3/Fe_2O_3$  ratio shows often high values but in some samples  $Fe_2O_3$  is higher than the  $Al_2O_3$  content. However in the Tornajo outcrops no real bauxite occurs as the samples have a  $Al_2O_3$  content not higher than 10% and usually with similar amounts of  $Fe_2O_3$  (from 2 to 17%). These Al,Fe-rich materials of the Tornajo outcrops show red colours and an argillaceous appearance.

The contact between the Liassic limestones and dolostones and the upperlying Ammonitico Rosso facies is a stratigraphic break of regional extent; Domerian to Lower Oxfordian deposits are absent (about 40 m.y. are lacking). Actually it is a paleokarst surface with a middle to strong karstification (Bardossy, 1982; Vera *et al.*, 1988). The bauxites and Al,Fe-rich materials fill seemingly isolated karstic cavities in the Liassic carbonates, but they are vertically related to paleokarst sinkholes and cavities. In the Cejo de la Grieta outcrop no bauxite material occurs lower than 35 m below the paleokarst surface. Therefore we are dealing with karstic bauxites coming from the meteorization and pedogenesis of the Liassic carbonates. The low Al content of the Liassic limestones and dolostones points out the meteorization of a very great volume of these deposits in carbonate islands upto 150 km far of the continental areas, according to the more recent palaeogeographic reconstructions for the Jurassic of the southern Iberian plate margin (Vera *et al.*, 1988). Nevertheless the increase of the Al to ore grade could also be due to other processes such as the accumulation of chemically mature aeolian dust (Brimhall *et al.*, 1988) derived elsewhere from soils, volcanic ash or other volcanic materials. In the Subbetic Zone, basic volcanic rocks occur in the Liassic and Middle Jurassic, and mainly intercalated in the series of the Middle Subbetic, which were deposited in areas palaeogeographically adjacent to the pelagic swells.

These bauxite orebodies are of mediterranean type (Bardossy, 1982) and are similar to those described in other alpine mediterranean realms.

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Moderne lacustrine carbonate depositional environments in the Danube-Tisza Interfluve

Béla Molnár and József Fényes  
"Attila József University"  
Department of Geology and Paleontology  
HUNGARY

In Danube-Tisza interfluvial wind-blown area /and in Kiskunság National Park/ was study in the last two decade about 30-40 lakes and here are carbonate sediments often encountered. The depressions are usually filled by natron lakes recharged from meteoric waters and groundwater seeping towards the depressions of the lakes. Percolating through the windblown sands forming the base of the lakes and containing also carbonates, the groundwater dissolves a considerable quantity of cations, so that the groundwater reaching the lake will introduce into it a high amount of dissolved solids and salts of deversified chemical composition. As a result of summer evaporation, frequently lasting as long as several weeks, and of the high temperature and the CO<sub>2</sub>-extracting action of the plants, a water of high selt concentration and heavily alkaline is produced.

With autumnal rainfalls the lakewater is added to by great quantities of fresh water, which decreases the salinity and the amount of Na<sup>+</sup> and K<sup>+</sup> competing in being precipitated, but which increases the Mg/Ca ratio of the lakewater. Since the Mg/Ca ratio in the water of the lakes is usually between 7 and 12, it is calcite of high magnesium content requiring less energy that is precipitated as primary mineral from the lakewater with additional rise of the Mg/Ca ratio of the remaining pore water it will be transformed into dolomite as a result of early diagenesis. We often found in the dolomit minerales 1-5 % iron content. In some cases the Mg/Ca ratio is higher than 12 so it is allowed of form magnesite. These minerals we identified with X-ray, Derivatographical and IR spectroscopical methods. High ion concentration and high Mg/Ca ratio will provoke a rapid crystallization, so that dolomicrite will be produced. The pores of the harder dolomites of the Danube-Tisza Interfluve are already partly filled and the infill consists, unlike the dolomicrite precipitating from the

solution, of calcisparite produced by a slow crystallization due to a Mg/Ca ratio lower than that of the earlier pore waters and to the smaller  $Mg^{2+}$  content. The fact that the pore water is characterized by a lower Mg/Ca ratio and a lower  $Mg^{2+}$  content compared to the original solution seems to be due to  $Mg^{2+}$  consumed in the course of the formation of early diagenetic dolomites.  $Mg^{2+}$  in the pore waters, however, is invariably present in smaller amount, as evidenced by fibrous, drusy calcite crystals precipitated perpendicularly to the pore wall and elongated according to the c-axis.

In terms of origin, composition, diagenesis and lithification, four members can be distinguished within the sections of hypersaline lacustrine dolomite and dolomite-chalk. The lower three members, i.e. the dolomites, are characterized by FAIRBRIDGE's anadiagenesis, the upper one, i.e. the dolomite-chalk, by syndiagenesis. In this latter lithification is a very important factor within the diagenetic process. Among the diagenetic physical processes described by CHILINGAR et al. it is desiccation and shrinkage, among the physico-chemical ones, it is cementation that plays the principal role.

The formation of voids, their shapes and infilling, the chemical and mineralogical composition of the material filling the voids and its crystal forms are also dependent on these processes and may vary accordingly. In terms of CHOQUETTE-PRAY's genetic classification, the voids belong to the group of voids formed in the eogenetic zone including fabric-selective or interparticle, solutionaffected and shelter voids. Shrinkage voids also belong to this group, but they may be both fabric-selective or not. Additional types are represented by the gas voids and pores, in many cases of geopetal structure, within gastropod shells.

## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989

The open lacustrine facies of Villarroja Pliocene basin (La Rioja province, N of Spain)\*

MUÑOZ, A.; PEREZ, A.; VILLENA, J.  
Stratigraphy Area. Zaragoza University  
SPAIN

Villarroja basin is placed in the SE of La Rioja (North of Spain) in a zone called "Tectonized Fringe" (I.G.M.E. 1982) affected for some tectonic structures that have directions from NW-SE to E-W. This zone separates both Cameros Mountains (Noroccidental sector of the Iberian Chain) and Tertiary Ebro Depression.

It is a little basin (6 km long and 2 km wide) filled by continental sediments (BRINKMANN, 1957) corresponding to alluvial fan and lacustrine systems (fig. 1). They have been dated by VILLALTA (1952) as Upper Pliocene (Lower Villafranchian) by means of mammals.

The next facies in the lacustrine deposits are distinguished:

Laminated lutite and marl facies: These are dark grey to white coloured facies with  $\text{CO}_3\text{Ca}$  contents from 26 to 58 percent. They are disposed in tabular layers, 0.05 to 2.5 meters thick, presenting a well marked milimetric lamination which is caused by the different grey shades. These layers have a high ostracod and charophyte remains content and a lower one of little gastropods and fish teeth. It must also be pointed up their high organic matter content that confer these facies present a local bituminous appearance.

Laminated limestone facies: These are yellowish white and grey coloured facies; their  $\text{CO}_3\text{Ca}$  contents range between 87 and 98 percent. They present a well developed horizontal lamination formed by milimetric light and darkest bands.

Light coloured sheets are constituted either by an accumulation of ostracods and charophytes stems or by a high amount of little gastropods. In both cases the disposition of the remains is parallel to lamination.

The dark sheets are mainly constituted by micritic mud (mudstone texture). Locally, some very well preserved plant remains may appear inside the sheets.

Detrital coarse grained facies: They are constituted by grey to ochre coloured sandstones that locally include angular clasts (even 20 cm diameter big). They are disposed in tabular and lenticular layers from 5 to 25 cm thick that locally may present horizontal lamination.

The remarkable conservation of lamination, whose characteristics suggest a seasonal origin, and remains of fragile plants in lutite, marl and limestone facies, in addition to bioturbation absence, allow us to interpret these deposits as generated in of a relatively deep lake. In this lake, the appearance of levels with high content of organic matter, evidence repetitive anoxic events.

On the other hand, detrital coarse grained facies which appear inside the last ones could be originated by stream episodes, which were in lateral relation with the lake.

The existence of facies corresponding to deep zones of a lake, in spite of the little size of the basin, would be in a direct relation with its tectonic origin. The basin, of semigraben type, was generated by the distensive movement of a fault that limits it to the south. The filling of the basin is caused by progradation of the alluvial systems over the lacustrine ones.

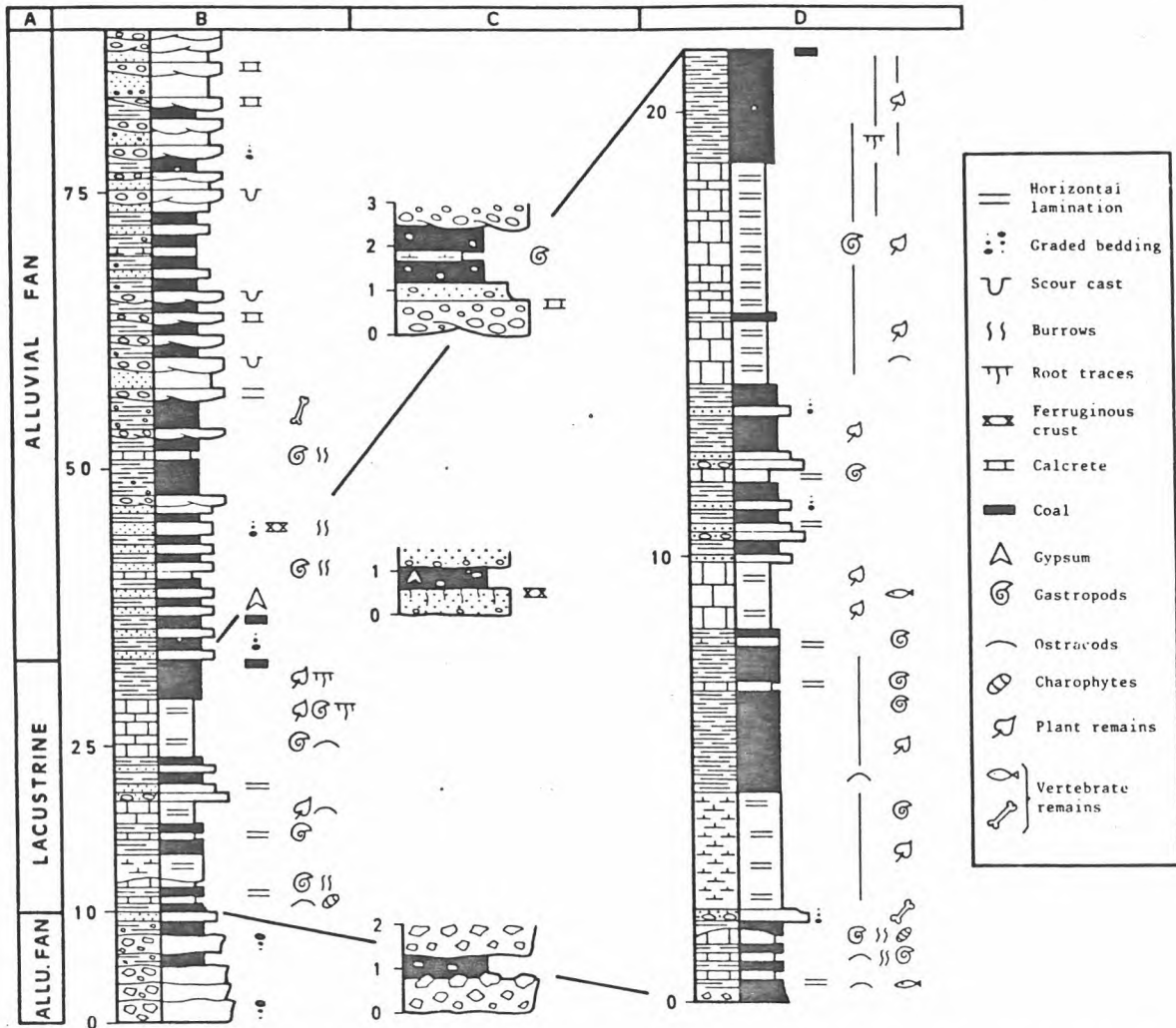


Fig.1: Sedimentological synthesis. A: Sedimentary environment. B: General sedimentological profile. C: Type-sequences of alluvial facies. D: Sedimentological profile of lacustrine facies. Scales in meters.

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Genetic model of bedded cherts in Emine flysch /Bulgaria/

NACHEV IVAN<sup>1</sup>, NACHEV CHAVDAR<sup>2</sup>

<sup>1</sup>Geological Institute, 1113 Sofia, BULGARIA

<sup>2</sup>National Museum Earth and Man, 1421 Sofia, BULGARIA

The Emine mixed flysch /Turonian - Paleocene/ is a repeatedly /2000 m/ and rhythmic /0,10-1,20m/ alternation of micrite or argillaceous limestones /pelagites/ and graywackes, calcareous sandstones, siltstones or clastic limestones /resedimentary rocks/.

In Upper Cretaceous clastic-limestone flysch the cherts are of three morphologic types: 1 - rhythmic bedded cherts; 2 - nodular cherts; 3 - chert lithoclasts in slumps and olistostroms. They are of Coniasian, Santonian and Campanian age.

In the genetic model the micrite limestones with planctonic foraminifers are result by normal hemipelagic sedimentation and the clastic limestones - by resedimentation of turbidite and contourite currents. Siliceous sponge spicules /opal-A/ were a source of  $\text{SiO}_2$ . In clastic limestones they are much and associate with benthonic foraminifers, crinoids, calcareous algae etc. By resedimentation of shelf sediments the sponge spicules were concentrated in the laminite part of turbidite or in the contourite clastic limestones. The diagenetic processes in alkaline conditions and high pH have determinated the dissolution of biogenic opal-A in the sponge spicules and their calcitization. The silica-rich interstitial fluids migrated lateraly. The silicification is process of replacement of calcite biogenic tests, bioclasts and matrix from opal-CT and formation of early diagenetic bedded cherts in beds of clastic limestones. The vertical migration of silica was weak, local and partial. As a result the nodular cherts are formed in beds of micrite limestones.

The morphology and quantity of early diagenetic cherts are correlated with the composition, texture, structure and permeability of the

host-rocks - clastic or micrite limestones. Intraclasts in synsedimentary submarine slumps are indication of early diagenetic origin of the bedded cherts before a full compaction of the sediments. The diagenetic transformation of opal-CT into chalcedony is determined by the origin of the finecrystalline, fibrous to fanlike chalcedony in grain-calcite bioclasts and biogenic tests, mainly in high permeable clastic limestones. In low permeable micrite limestones the chalcedony is found as crypto- to microcrystalline. Calcite rhombs were formed after opal-CT transformation in fan-like chalcedony. Brittle fractures in cherts are filled with calcite. The veins intersect the bedded cherts but they don't pass in the hosted-rocks - clastic or micrite limestones. They are formed after the fan-like chalcedony probably during the late diagenesis.

The early diagenetic silicification took place after the dissolution and calcitization. It was an intensive process which formed causal early diagenetic bedded cherts in clastic limestones and nodular cherts in micrite limestones.

The association between rhythmic bedded cherts and clastic limestones /carbonate turbidites or calcarenites/ is a main empirical regularity. It is connected with early diagenetic origin of cherts.

In Upper Jurassic deposits of the Betic Mountains in South Spain the bedded and nodular cherts are contained in carbonate turbidites /calcarenites/ and pelagic turbidites /biomicrites/. They are comprehended as a result by early diagenetic silicification, with silica derived from the dissolution and calcitization of radiolarians. Turbidite sedimentation favours silicification because rapid burial of the transported siliceous tests prevents silica from the dissolution of the tests passing into overlying sea water. The genetic model shows a relationship between the turbidite sedimentation and an early diagenetic origin for silicification.

The proposed new genetic model shows the relationship between normal pelagic sedimentation, intraclastic resedimentation and an early diagenetic origin for silicification with bedded and nodular cherts in distal thin bedded clastic-limestone flysch.

Triassic-Jurassic boundary formations of South Gemicum  
( Inner West Carpathians )

Annamária NÁDOR  
Hungarian Geological Survey  
H-1142 Népstadion út 14.  
HUNGARY

Sequences in eight outcrops and two boreholes have been investigated. The results follow the conclusions of Grill et al./1984/ and Kovács /1984/ on Triassic facies distribution, discussing history of the region at the Triassic/Jurassic boundary and during Early and Middle Jurassic time.

1. During Early and Middle Norian time the area of basin sedimentation increased, platform sedimentation was restricted to the former inner shelf region of the Silica area /Dachstein Limestone/. In the former outer shelf margin -- which collapsed and subsided in Late Carnian time -- and in the Bódva basin uniform pelagic Hallstatt Limestone was deposited.

2. During Late Norian and Rhaetian time the former pattern persisted, but first indications of a general increase in depth are observed. While the Dachstein reef flourishes on most of the platform, some minor, subsided blocks bear the transitional Szörnyűkút Limestone. The basin receives a clastic influx from the north into a pure pelagic calcareous ooze /Zlambach Marl/. The clastic fraction was transported through channels, "canyons" crossing the Dachstein platform.

3. Frequent breaking in sedimentation is observed at the Triassic/Jurassic boundary. Rarely it can be shown by biostratigraphy /Szörnyűkút - Bleskový Prameň, Bystrický et al. 1973/, but mostly it is shown by a change in sediment type. No unconformity was observed between Triassic and Jurassic strata. The hiatus is related to the uniform subsidence of the region at the end of Triassic, while the northern land got far away. The subsided blocks did not receive sediments until new paths

for sediment influx from land or platform were established. Sediment flux from land might have been trapped into a basin at the shelf margin. Its seaward boundary was formed by a barrier /a Liassic Dachstein type reef/. Autochthonous pelagic sediments were washed away by currents in the starved basin.

4. The Jurassic formations contain only basin sediments. The first of them is the Liassic Hierlatz and/or Adnet Limestone; bioclasts /crinoids/ were washed into the basin from the platform.

5. Depth of the basin increased during Early and Middle Jurassic time. Carbonate sedimentation changed to deposition of Allgau beds containing fine clastics, and displaying resedimentation features: olistoliths, allodapic limestone beds. Appearance of fine clastics is due to the subsidence of the Early Jurassic barrier.

6. No more clastics fluxed into the basin during Middle to Late Jurassic time, which resulted in uniform radiolarite deposition.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
Modern organic-carbon-rich mud deposition of the  
Western Baltic Sea - a conceptual model

R.-O. NIEDERMEYER

Department of Geological Sciences, University of Greifswald,  
GERMAN DEMOCRATIC REPUBLIC

Mud deposition prevailing in the deeper basin areas of the postglacially (Weichselian) formed Baltic Sea occurs for nearly 8.000 years and has started during the Atlantic Stade. Both the very young geological history and the oceanological characteristics (semi-enclosed sea, strong thermohaline water stratification) of the Baltic Sea represent excellent pre-conditions for actualistic sedimentological studies, especially with regard to modern organic-carbon-rich mud formation and early diagenesis. The interdisciplinary synthesis of sedimentologically relevant phenomena needs investigations of both the water body and the sediments which include measurements and determinations of temperature, salinity, oxygen content, suspended matter, sea water and pore water chemistry, sediment chemistry and petrography.

In the present paper an attempt is made to describe and to model the modern mud deposition of the Western Baltic Sea considering the prevailing environmental conditions. It is shown that the depositional conditions and processes occurring within the system sea water/sediment are strongly biogenically affected (e.g. epilimnic carbonate production, pyritization). Coarse mud predominates in the study area, sometimes interbedded with medium mud (bimodal grain size distribution). The mineralogical composition of the mud is rather homogenous. Quartz, feldspars (orthoclase, plagioclase), pyrite, dolomite, gypsum and the clay minerals illite, illite-smectite-mixed-layer (ML), kaolinite and chlorite have been identified by X-ray studies. The following average values of the clay mineral con-

tent were obtained: 42.4 % illite, 40.6 % illite-smectite-ML, 12.8 % kaolinite, 4 % chlorite. The average values of total carbonate content amount to 0.7 to 1.2 %, those of organic carbon to 5.0 to 7.5 %.-Pore waters are of the chloride-alkali-type and show increasing calcium depletion with increasing depth. The Ma/Ca-ratio, which is important for early diagenetic dolomite formation, exceeds 3. The sedimentary environment is characterised by oxic to locally suboxic (or anoxic) conditions.

With regard to the potential of accumulation of organic-carbon-rich sediments the "productivity type" is derived as the characteristic sedimentary environment (see Fig.). Further to the Eastern Baltic Sea (for example, Gotland Basin) the "stagnation type" seems to be more characteristic.

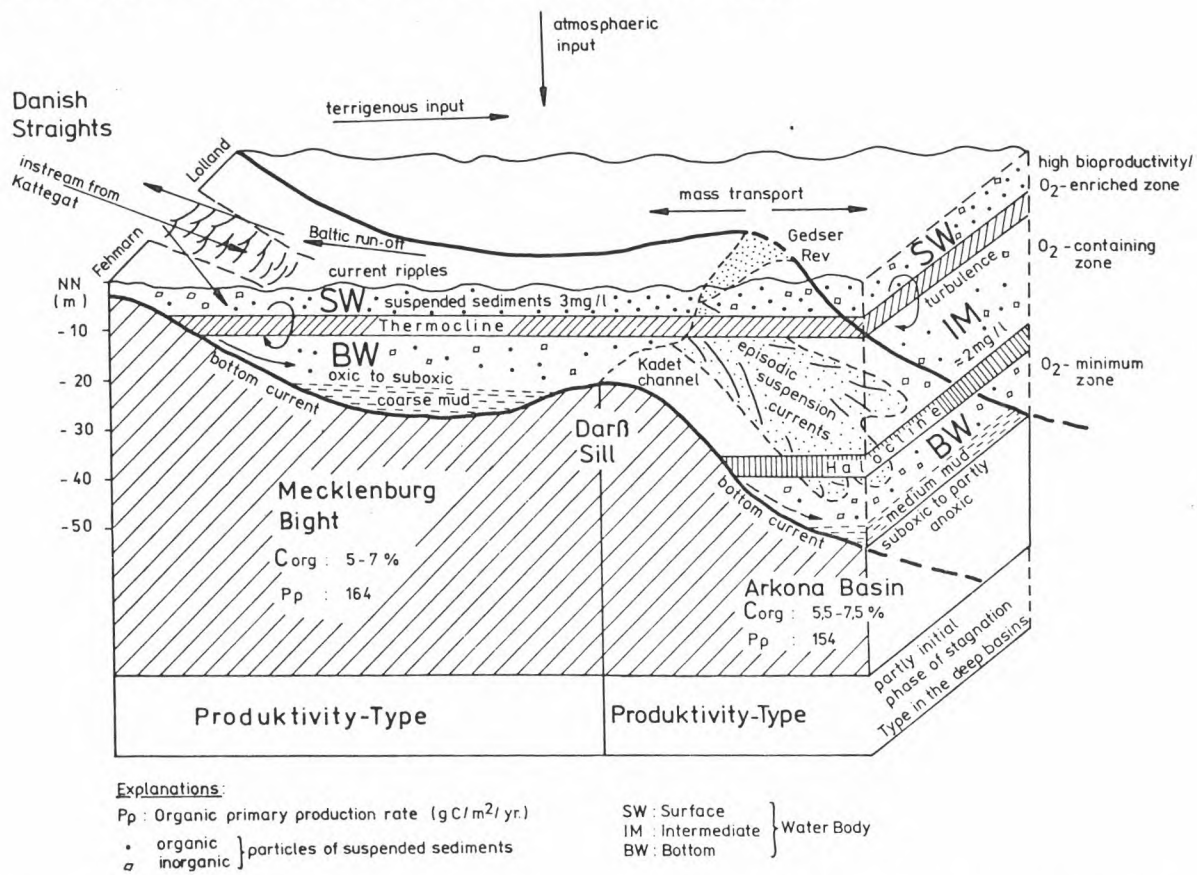


Fig.: General sedimentary (conceptual) model of two mud-forming basins of the Western Baltic Sea (Mecklenburg Bight, Arkona basin) separated by a sill area (Darss-Sill)

Washover fan, brackish bay sedimentation, and bivalve mass mortality caused by toxic dinoflagellate blooms in the Berriasian-Valanginian of Bornholm, Denmark

Nanna Noe-Nygaard and Finn Surlyk  
Institute of Historical Geology and Palaeontology, and the Geological Survey of Greenland, Copenhagen, Denmark

The Robbedale and Jydegård Formations (Berriasian-Valanginian) of the Danish island of Bornholm represent a 100 m thick vertical sequence from shoreface, foreshore and beach sands of a high-energy coast through backbarrier flat, bay margin pond and distal washover fan sand and clay, to fluvial sands. Thin bay-margin clay beds contain monospecific assemblages of the bivalve Neomiodon angulata and the gastropod Viviparus cariniferus and polyspecific assemblages of Viviparus and juvenile bivalves. The three assemblage types were all formed by mass mortality. The N. angulata assemblage resulted from seasonal toxic dinoflagellate blooms, the V. cariniferus assemblage from desiccation of shallow ponds, and the polyspecific assemblage from storm washover. The longevity of the backbarrier-bay system (c. 10 Myr), thickness (100 m) of the bay deposits and apparently stacked nature of the facies belts suggest a relatively stationary position of the individual subenvironments, with only minor progradation. This reflects strong tectonic control of the depositional system during an important phase of synsedimentary block faulting and wrenching along the Tornquist Zone. The importance of washover fan sands in the backbarrier deposits, and the lack of tidal indications in the whole sequence, suggest a microtidal regime. A system of migrating mud banks formed in shallow water on the landward side of the barrier. The bay waters varied from almost fresh to brackish, and anoxic conditions commonly occurred at the bottom. As a general scenario it is envisaged that longshore currents redistributed bedload from a major delta and formed an extensive NW-SE barrier-spit which partly enclosed a major to the NE. The barrier was deposited on the backbarrier flat made up of the subaerial parts of coalescent washover fans. Enormous amounts of suspension load from the delta travelled further along the barrier to be deposited in the lee-side bay.

Sedimentation, volcanism and ore's formation  
during the Permian in the Northern Pamirs

NOVIKOV V.P., SUPRYCHEV V.V.

Institute of Geology AN Tadjik SSR  
USSR

During the Permian period the Northern Pamirs joined to the active margin of the Laurasian continent. Thus, the section of the Permian sediments of this region, with the thickness of 3000-4500 m, characterise the Northern eugeosynclinal branch of the Paleotethys.

Two acts of volcanic activity are fixed in Darvaz-Zaalaish tectonic zone of the Northern Pamirs: the Early Permian (Sakmarsk-Jakhtashian) and Late Permian (Cubergandin-Murgabian). The submarine andesite-basaltic volcanism is connected with the first activity act. For the second act subcontinental rhyodacite-andesitic volcanism is very typical. At the intervals of the eruptive manifestations there gathered the terrigenous-carbonate (Asselian), argillo-carbonate-reefs (Bolorian) and evaporite-argillo-carbonate (Middian-Julfian) sediments.

The Early Permian volcanism is characterised by a Fe-Ti specialization and accompanied by the sedimentation of the grey pyroclastic sediments and lavas (500-600 m thickness), enriched by titanium minerals. The products of the Late Permian volcanism are characterised by a sodic specialization and a high copper background. During the second volcanic activity act the pyroclastic red Iolliharian series was sedimented, with the thickness nearly 1800 m. Its lowest half shows tuffs and tuffites interbedded with the rare trachyande-

sitobasalts. The upper one shows volcano-terrigenous rocks and the tuffits, which are have a continental (alluvial-proluvial) genesis. The roof of the series is accompanied by the grey alluvial-deltaic and gulf-lagoonian terrigenous and carbonato-argillaceous sediments with the mineralization of the "copper sandstons" type (chalcosine, bornite). The copper mineralization is synchronous with the sedimentation and formed by means of the influences of the hydrothermal - volcanic fluids on the bottom sediments. Formation of zeolites (laumontite) of the lowest part of the Iolliharian series is connected with the post-volcanic processes in the tuffs and tuffits masses. Formation of the zeolites are close connected with the hydrothermal decomposition of the vitroclastic rock's component.

The red Iolliharian series overlies by the evaporite-argillaceous multicolored depositional complex (Chapsai series). This complex consists of the intercalation of gypsum, common salt and rare lenses of humic coals. The volcanic influence on these sediments is hardly felt, but sometimes there appears some admixture of dacite piroclastic material.

The described set of the Upper Permian piroclastic sedimental series characterises the large part of the Afghan-Pamir-Kunlun province and is a due sequence of the continental and lagoon-coastal-marine formations, typical for Late Paleozoic copper-, evaporite and coal accumulation belts.

**TITLE : Sedimentary processes on the submarine flanks of a volcano (Piton de La Fournaise, Reunion Island). Preliminary results of a sidescan sonar cruise.**

**AUTHORS:** G. OLLIER\*, P. COCHONAT\*, J. F. LENAT\*\*, B. SAVOYE\*, P. BACHELERY\*\*\*  
P. BOIVIN\*\*, B. CORNAGLIA\*\*\*\*, C. DENIEL\*, P. LABAZUY\*, P. LIPMAN\*\*\*\*\*  
P.VINCENT\*\*, M VOISSET\*

\* Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), centre de Brest BP 70 29263 Plouzané, France

\*\* OPGC, Université de Clermont 2, 5 rue Kessler, 63038 Clermont-Ferrand, France

\*\*\* Laboratoire de Géologie, Université de La Réunion, France

\*\*\*\* Laboratoire de Géophysique Marine, Institut de Physique de Paris, Paris, France

\*\*\*\*\* US Geological Survey, Denver, USA

La Réunion Island is located in the Western Indian ocean, at the southernmost part of the Mascarene Basin, 800 km eastward of Madagascar Island (Fig.1). Due to the modern volcanic activity of the island, numerous onshore geological studies were completed in the past 20 years, providing a significant set of data in the area. Particularly, a morphologic study of the eastern flank of the Piton de la Fournaise volcano, located on the southeastern portion of the island, allowed to identify a huge collapse known as the Grand Brûlé collapse. Recently (1984), a bathymetric survey (Seabeam) showed a 10 km wide submarine corridor with a hummocky seafloor topography continuing offshore the Grand Brûlé slide (Fig. 2).

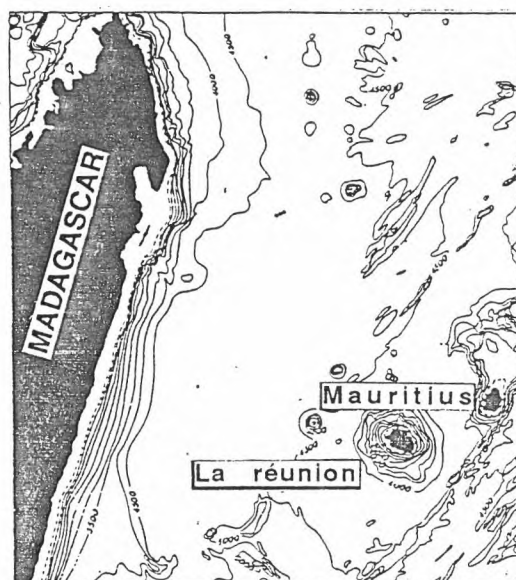


Fig. 1 After Bonneville and al, in press

Last summer a 1500 km<sup>2</sup> area of the offshore continuation of the Piton de la Fournaise structures was surveyed using the Ifremer deep acoustic image system: SAR (système Acoustique Remorqué).

The SAR system allows to map over a 1500 m wide swath with a resolution of 0.3 m in water depth as deep as 6000 m. 930 km of contiguous SAR profiles were completed in the area and the data were processed to built sonar mosaics. Bottom photographs and sampling were collected on selected sonar targets in order to calibrate the acoustic facies.

The objectives of the cruise were to investigate the submarine structures of the active volcano and to study a sedimentary system associated with volcano slope landslides and high energy coastal erosion.

The main finding of the survey is the permanent occurrence of clastic sediments (volcanic sands, gravels and boulders) overlying the volcanic basement or the slumped blocks area. The origin of the clasts is to be searched in the gravitational slides occurring on the aerial volcano flanks as well as in the coast erosion due to the action of waves. The coastal section of the surveyed area is affected by particularly rough sea conditions leading to a rapid deposition of volcanic sands and gravels. The material is spreaded on a very narrow shelf and is rapidly resedimented on the upper slope. Sediment waves of metric scale range are exhibited by the sonograms, in addition, bottom photographs show the existence of centimetric ripples scattered throughout the entire surveyed area.

Finally, the sonar data of the Fournaise cruise suggest that, on the submarine flanks of

a volcano, the sedimentary processes and particularly the gravity events have been largely underestimated until today. A field of giant blocks (hectometric range scale) consisting of subaerial volcanic material was found in the offshore continuation of the Grand Brûlé slide. The blocks are organized in a typical debris avalanche lobe located in the submarine corridor recognized during the 1984 bathymetric survey. The blocks that likely travelled from an apparent aerial breakaway area (Grandes Pentes) are now lying 40 km off the shoreline at a water depth of about 2500 m.

Local gravity effects, related to the existence of sharp topographic structures in the studied area, were also observed during the cruise. This is particularly the case for a volcanic spur which is eroded by numerous like aerial gullies that feed an accumulation area of soft and clastic sedimentary material.

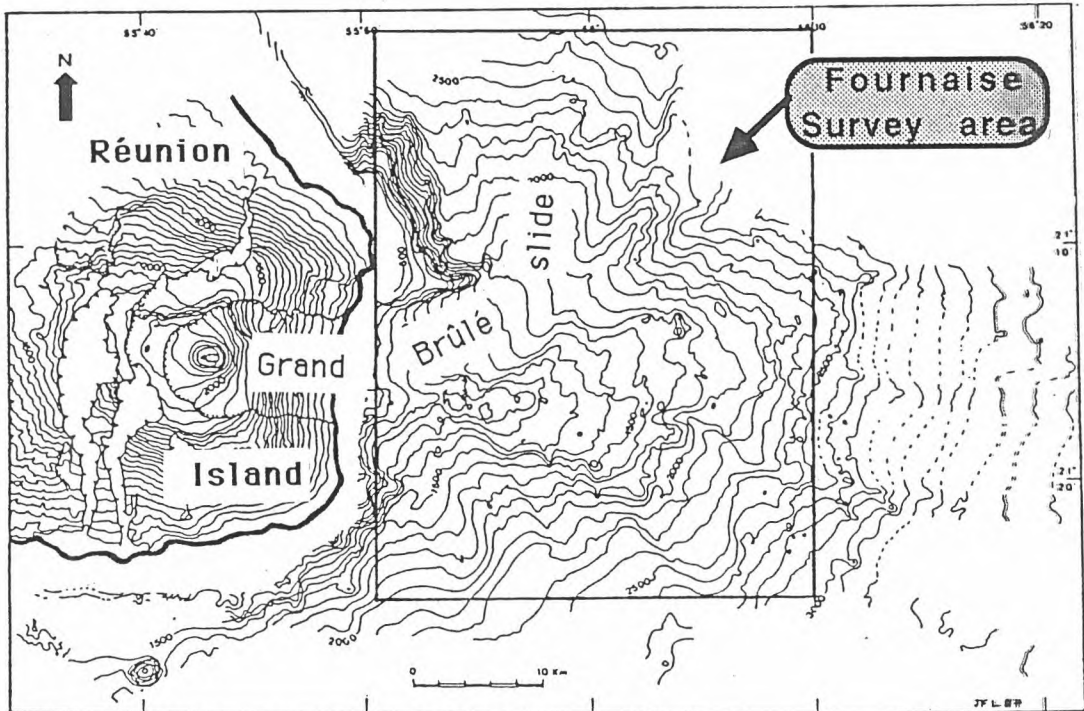


Fig. 2 After JF Lénat, 1987

Recognition of water-table position by means of Fe, Mn-incrustations. A case study in recent and paleofluvial environment

PALINKAŠ A. Ladislav

Faculty of Mining, Geology and Petroleum Engineering,  
University of Zagreb, Pierottijeva 6, 41000 Zagreb, YU

PAVUŠEK Ivanka

Faculty of Biotechnology, University of Zagreb,  
Pierottijeva 6, 41000 Zagreb

Recent discovery of Fe, Mn incrustation in alluvial sediments of the Sava river (Jarun pebble-lake, Zagreb) was impetus for detailed microbiological and geochemical investigation of that appearance as well as search for ancient analogues in Permian braided-river sediments in Žirovski Vrh mountain.

Fe, Mn incrustation appear in gravel-bearing sediments of point bar and channel-fill origin in the Sava river alluvium, covered by flood-plain, fine-grained clastics, after shifting of meandering system to another position.

It is placed in vadose zone, above a fluctuating water-table in coarse-grained sediments. Sharp separation of Fe and Mn (oxide) hydroxides (still disordered, as determined by x-ray) is a consequence of distinctive change in Eh-pH conditions in soil water, percolating downward and carrying iron and manganese organic chelates into well-aerated zone above the water-table.

Microbiological investigation, after inoculation, culturing and examination by incident light microscopy and SEM analysis revealed presence of sheate-forming bacteria.

Similar Fe, Mn enrichment has been observed in Permian,

uranium-bearing sandstones of Žirovski Vrh mountain. A basic sedimentary sequence, which has been related to braided-river facies, starts with paleochannel conglomerates, fining upwardly into sandstones and terminates as mudstones with organic remnants (levee sediments with some paleosol characteristics). The incrustations are in the same position on the profile like in the Sava alluvial deposits. This feature might be applicable in paleohydrological investigation.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
ANISIAN (MIDDLE TRIASSIC) STRATA IN SE PART OF  
AREA BETWEEN DANUBE AND TISZA AND THEIR IMPORTANCE  
AS HYDROCARBON RESERVOIRS  
S. Pap<sup>x</sup>

Westward from the Algyő-Ferencszállás paleogeomorphological ridge the Lower Pannonian deposits become more and more clayey. In the deeper parts of the basin marly deposits of the Dorozsma Marl Formation and Vásárhelyi Marl Formation are getting thicker. The thick pelitic-marly sequence is a good caprock, HC-pools of the area first of all under of them "were formed. In this so called "deepzone" are found 98,75 % of recovered reserves. The most important reservoir-rocks of this deepzone are Middle Triassic, Anisian brecciated dolomites and dolomarls. These formations are reservoirs in 5 cases from 9. Anisian strata contain 32,5 % of reserves of the total area in deepzone.

Here we know 3 facies of Anisian stage:

- type of Móraváros
- type of Ruzsa
- type of Üllés

Above mentioned formations are mostly parts of multiple pools and in some cases they accumulate as stratum-pools. Regard to the content of strata these pools may be saturated-and undersaturated oil-, gas-condensate and gas pools.

The pools or poolparts of Anisian reservoirrocks can be found in the following depths :

Forráskut	3161-3217 m
Üllés	2151-3306 m
Szeged	2584-2715 m
Kiskunmajsa-S-Ruzsa	1798-2106 m
Mórahalom	1278-1312 m

x Kőolajkutató Vállalat (Petroleum Exploration Company)  
H-5000 Szolnok Munkásőr u. 43. - HUNGARY

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
Red-coloured complex of Cenozoic deposits of the Pamir-  
Alai (USSR)

VLADILEN PARAEV

Institute of Geology and Geophysics of the Siberian Branch  
of the USSR Academy of Sciences

USSR

1. The Pamir-Alai is a mountainous country in the Middle Asia bordering on the Kizil-Kum, Hungry steppe and Fergana depression in the west and north-west. In the south within the Soviet territory up till Pyandzha-Amudrya valley. The Alai-Zeravshan-Gissar mountain system, Tajik depression, Darvaz and Pamirs and some other contiguous regions are parts of the Pamir-Alai territory.

2. Paleogene-Quaternary deposits, among which the complex of continental red-coloured formations, is the largest are broadly developed on the Pamir-Alai territory. Mainly rudaceous unsorted debris rocks - pattums - of Oligocene-Miocene age take part in its building. These pattum formations are poly-modal granulometric mixtures. The most of them - conglomerates, conglomerate-breccias, gravel-sand and sand-aleurolite ones. According to the composition of its components they are subdivided into carbonaceous and non-calcareous, volcanoclastic and terrigenous. Volcanogenic rocks occur often among clastic ones. More often these are basaltic, andesite-basaltic and more seldom andesite porphyrites,

3. The red-colored complex is polygene formation. The rock types taking part in its building make up rock-mineral accumulations in the form of independent bodies. They are depositions of fan deposits, deposits of temporary slope fluxes and channels, submontane fans, broad alluvial plains and surface of planation.

Outbreaks of tectonic activity (seismicity, perhaps) under the conditions of dissected topography favoured the formation

and displacement of large rock masses saturated with rudaceous unsorted material. During quiet periods of the tectonic regime, such mature deposits as quartz sandstones were accumulated. Bedlike thick bodies of alluvial deposits are formed in wide river valleys. The processes of impetuous sedimentation are replaced by their contrast is interformation erosional surfaces appear. The same circumstance attended the formation of relatively well sorted small-pebble gravel-conglomerate accumulations of surface of planation

4. The certain space location of the above mentioned complex and its isolation of independent big stage of red-coloured sedimentation in Cenozoic history of the region. This stage began in Oligocene and lasted (about 27 mill. years) without considerable interruptions. It was marked by deposition of thick red bed formations and their broad distribution.

5. The peculiarities of this stage were conditioned by the general tectonic stirring up of mainly ascending movements and rise of mountain structures. The areas occupied by seas reduce. Marine grey-coloured series are replaced by red-coloured terrigenous ones. Depressions and troughs of different type are filled up with rudaceous pattern formations.

Delta plain sequences in the Cretaceous of the West Greenland Basin.

GUNVER KRARUP PEDERSEN,  
Institute of Geology, University of Copenhagen,  
DENMARK.

The deltaic Cretaceous Atane Formation of the West Greenland basin is exposed in up to 600 m high sections characterized by interbedded shale, slightly consolidated sandstone and thin coal seams, which in SW Nûgssuaq constitute coarsening upwards (CU) sequences (Fig. 1, 2-4). Fossil invertebrates are very rare whereas trace fossil may be common. The CU-sequences have been interpreted as mainly non-marine delta plain deposits (Henderson et al. 1976, Shekhar et al. 1982). These authors established a generalized palaeogeographical model according to which increasing marine influence should be expected from SE to NW (left to right in Fig. 1). Fig. 1 exemplifies the depositional environments with the Atane Fm. Log 1 represents the continental flood-plain with fluvial channel deposits (Johannessen & Nielsen 1982, Pedersen & Jeppesen 1988). Log 2 illustrates a vertical stacking of CU-sequences interpreted as reflecting progradation of mouth bars and channels into non-marine interdistributary bays. In log 3 the combination of trace fossils produced by infaunal suspension feeders and wave-generated structures indicates partial marine reworking of the mouth bar deposits. Log 4 exemplifies deposition in marine influenced interdistributary bays where the increasing diversity of trace fossils and the ubiquitous wave-ripples support the general palaeogeographical model.

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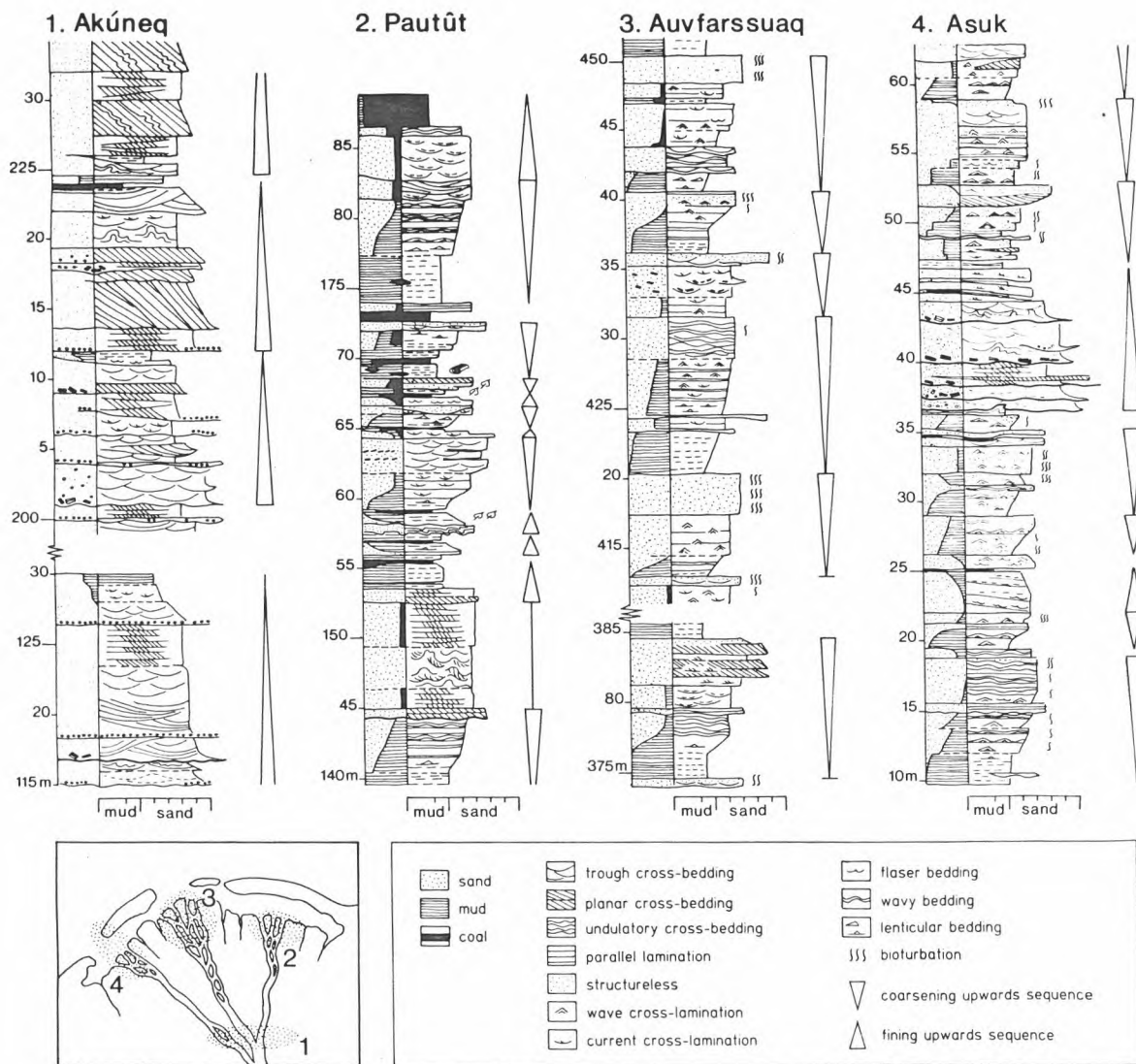


Fig. 1. Four characteristic sections in the Cretaceous Atane Fm., northern Disko and southwest Nûgssuaq, West Greenland. Log 1 shows upward fining sequences of cross-bedded medium-grained sand and subordinate beds of mud or coal. Log 2 shows CU-sequences with a basal shale facies devoid of trace fossils, cross-laminated fine-grained sand erosively overlain by cross-bedded sand and a capping of thin coal seams. Log 3 lacks coal seams and the CU-sequences are terminated by densely burrowed sand with trace fossils characteristic of the *Skolithos* ichnofacies. In log 4 the CU-trends are less pronounced and a prominent facies is heterolithic shale with wave-ripples of sand. Local mottling of the heteroliths is associated with trace fossils of the *Cruziana* ichnofacies. Possible depositional environments are sketched in the inset map.

**10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-  
BUDAPEST, 1989**

Sedimentology Of A Condensed Sequence (Altmann Mb.) and  
Sequence Stratigraphy In The Lower Cretaceous (Drusberg Fm.,  
Helvetic Realm, Switzerland)

JÜRGEN PFEIFFER

Geological Institute

Institute of Technology, Zurich

Switzerland

The presented study is part of a research project, which deals with the paleogeographic development of the southern continental margin of Europe during Cretaceous and Tertiary time.

Main targets are a reconstruction of paleogeography during Late Hauterivian and Barremian, an improvement of biostratigraphic data (ammonites, microfossils) and an apply of the model of sequence stratigraphy to the Drusberg Fm..

The Altmann Mb. is embedded between the Helvetic Siliceous Limestone (HSL, Hauterivian) and the Druberg Mb.(Barremian-Lower Aptian).

The HSL consists of siliceous limestones, biosparites and condensed layers. In the uppermost part normally a coarse bioclastic limestone is developed ("Kieselkalk-Echinodermenbrekzie", KE).

The Altmann Beds present a 0-20m thick sequence of glauconitic, phosphatic condensed layers with a high amount of detrital quartz. The quartz is probably transported by currents parallel to the coast from the Bohemian Massif. Enrichment in fossils (ammonites, belem-nites, oysters, sponges, etc.) is bound to widespread hardgrounds. Unfortunately preservation of fossils commonly is poor. An intense bioturbation is characteristic. In general a sharp boundary to the underlayer with subsolution is developed.

To the top the Altmann Mb. transists to the Drusberg Mb., which consists in the lower part of marls and marly limestones. To the top a gradual transition to bioclastic limestones with a decreasing amount of clay can be observed.

In the terms of sequence stratigraphy the lithological units could be correlated as follows:

KE and Altmann Beds are part of a Transgressive Systems Tract (TST).

The EB is a "basal transgressive lag", due to a relative rise in sea level (amount of rising is larger than the accumulation). Upward the TST is forming a Condensed Section (Altmann Mb.). The boundary between TST and the High Stand Systems Tract (HSST) is the Maximum Flooding Surface. This is represented in the lowermost beds of the Drusberg Mb. The other part of the Drusberg Mb. belongs to a regressive sequence (a slow rise in sea level is correlated with a large amount of sediment transported into the basin).

The complete section could be called a shoaling upward sequence (sensu JAMES 1977).

The global changes in sea level described in the Global Cycle Chart (Vail et al., 1977) cannot be correlated to the conditions in the Helvetic Realm, perhaps due to the large amount of carbonate produced on the shelf.

Neogene seismic and electro facies of the Pannonian Basin

György Pogácsás<sup>\*</sup>, Györgyi Kádár-Juhász<sup>\*\*</sup>, László Lakatos<sup>\*</sup>,  
István Révész<sup>\*\*</sup>, Katalin Ujszászi<sup>\*</sup>, László Várkonyi<sup>\*</sup>,  
Péter Várnai<sup>\*</sup>, Gábor Vakarcs<sup>\*</sup>

<sup>\*</sup> Geophysical Exploration Co. H-1062 Budapest Népköztársaság u.59.

<sup>\*\*</sup> Hungarian Hydrocarbon Institute H-2443 Százhalombatta POB.32.

HUNGARY

Abstract

Neogene stratigraphic and facies framework for the Pannonian Basin were carried out by an integrated interpretation of seismic and well log data. Exploring the reservoir facies some parts of them are of primary importance from the aspect of hydrocarbon accumulation.

As the size and number of the "seismic indication" not yet tested by drilling decreases, the prospecting for subtle traps connected to the stratigraphic and facies anomalies gets more and more into the fore. In case of the subtle traps no such unequivocal criterium similar to the structural closures can be relied upon as in case of the conventional structural traps. With a view to reduce the risk of exploration to a reasonable degree, with regard to the subtle traps, the existence and/or the possibility of existence of all the necessary conditions of hydrocarbon accumulation /trap, reservoir, seal, source rock, timing/ should be ascertained. To determine the above necessary /but not inevitably sufficient/ conditions of hydrocarbon accumulation /trap, reservoir, seal, source rock, timing/, it is essential to determine the stratigraphic and facies aspects of the geological model. Based on seismic and electrofacies pattern the Upper Pliocene-Pliocene Pannonian seismic megasequence was subdivided into basal transgressional, aggradational deep water, progradational delta and aggradational alluvial sediments. The isochronous time-horizons start near the surface at the margin of the Pannonian Basin, cross the Upper and Lower Pannonian boundary and approach the basement in about 100 km distance. Comparing the hiatus represented by seismic unconformities in the basin margin

with euastatic sea level falls of the global sea level change curve of Haq et al /1987/ the accordance was close and systematic. This may refer to the fact that the sea level falls of the Pannonian inland sea happened in the same phase as did the global sea level. The reasons and amplitude of sea level rises and falls identified on the seismic profiles are not exactly clear yet. On the basis of seismic profiles and well logs, it was possible to clearly identify the Pannonian transgressive shelf deposits /transgressive system tracts /TST/ and the progradational highstand system tracts /HST/. Since the age of the hiatus identified on the margin of the Pannonian Basin is the same as that of the global sea level falls /Pogácsás et al in press/ it is possible that in the Pannonian Basin the existence of the lowstand wedge systems tract /LSW/ and the lowstand fan systems tract /LSF/ also should be reckoned with.

**Subaerial crusts, ooids and breccia horizons in Upper Visean of Namur Basin (Belgium): Sedimentology and diagenesis.**

**A. PREAT et Th. DE PUTTER**

Université Libre de Bruxelles, Laboratoires Associés de Géologie, Pétrologie et Géochronologie, C.P. 160, 50, av. F. Roosevelt, B-1050 Brussels (Belgium).

The studied beds are located in the Belgian "V3a" level of the "Grande Brèche", which crops out over a widespread area in the Namur and Dinant Basins and has been recently suggested to be a collapse breccia by Mamet *et al.* (1986). This conclusion, based on several sedimentological arguments is furthermore supported by the lateral equivalence of the "Grande Brèche" with the preserved evaporite beds (700 m of anhydrite) in the Saint-Ghislain borehole (W of Namur Basin). The breccia is massive, 30 to 60 meters in thickness, composed of homogeneous visean limestone blocks embedded in a grey cement and ranging over a large scale in size (a few millimeters to a few meters). Important features are: the presence of metric continuous beds "floating" in stratigraphic position in the breccia, the high concentration of calcite and chert pseudomorphs after evaporites, the presence of dedolomite.

The study of the "Grande Brèche" in Landelies (W of the Namur Basin) has revealed the presence of sabkha cycles of supratidal evaporites.

Presently studied material is composed of pisoid, oncoid and ooid levels lying paraconformably in the breccia and presenting a pluridecametric lateral extension. The sedimentological and diagenetic study of these levels supports the collapse interpretation of Mamet *et al.* (1986). Four main diagenetic stages have been recognized, which are included in a shallowing-upward sequence (regressive event ?).

1-Subtidal quiet semi-restricted marine phreatic phase characterized by a spongiostrome boundstone-bindstone facies (algae, stromatolites, bacteria ?) with a few bioclasts (none of them of open-marine environment) and without any terrigenous material. The decomposition of the mats and the precipitation of gypsum between them follow this first step; an early microspar phase (microspar 1, stagnant marine phreatic) then occurs and the former bindstone facies is progressively transformed into a packstone or grainstone with algal minipeloids (20 to 30  $\mu$ ). Quiet water calcitic ooids with primary radial fabric then precipitate within this peloid facies (Sandberg, 1975 and Davies *et al.*, 1978).

2-Mixing zone is marked by a process of dolomitization and by the extensive dissolution of gypsum. It is important to note that, due to the calcitic nature of the ooids, these latter remain unchanged during this stage. It seems however probable that a loss of  $Mg^{2+}$  takes place without any important textural alteration of the ooids (Sandberg, 1975).

3-Meteoric phreatic phase materialized by the second microspar cement formation (microspar 2, stagnant zone) and the bladed and equigranular cement development in the active zone. The silicification (lutecite) and calcitization of the dissolved gypsum crystals ( microspar or radiaxial fibrous calcite) occur at this moment as does also the dissolution of the few aragonite bioclasts. As for the former phase, the ooids remain stable and unchanged.

4-The fourth phase corresponds to vadose dissolution and produces the typical fenestral fabric. Asymmetric and/or meniscus cements, subaerial crusts, made of radiaxial fibrous cements, form also at this stage. The reverse graded-bedding, so characteristic of many vadose pisolites is not obvious in our material but other features as the grain-supported nature of the substrate, the downward elongation of the pisolites, the association with dolomite, the absence of unconformity,...(Esteban, 1976) tend to confirm the vadose nature of the grains. The contact with oxidizing meteoric waters also induces a process of dedolomitization.

This sequence can be repeated several times during return to subsurface conditions and balance between subsidence and sedimentation.

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10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST,1989  
RASENEISENERZ CONCRETIONS IN LUXEMBOURG, ELUVIAL PRODUCTS OF  
IRON CRUSTS DEVELOPED IN THE MINETTE FORMATION.

P.A.Riezebos,W.G.H.Z. ten Kate, M. de Bruin

In the Grand Duchy of Luxembourg /S.W.Gutland/ ferruginous concretions of various size and shape are found in local surficial loams underlain by Dogger and Lias deposits. The loams are supposed to be principally weathering products of Tertiary age. Two types of iron concretions are distinguished: Bohnerz and Rasenerz. The first is exclusively found in loams overlaying the Bajocian limestone /Dogger/. The second one occurs in more sandy loams on various Liassic sediments, and at topographically lower levels.

In contrast to Bohnerz concretions, Rasenerz specimens have generally an oölitic texture, similar to that of the ironstones of the Minette formation. This is a typical sedimentary facies /Upper Lias-Lower Dogger/ in middle Europe. In Luxembourg this facies is restricted today to a small area near the French border. So, a geomorphological model can be framed, in which the present Rasenerz -bearing loams are explained as erosional remnants of a land surface that for a great part consisted of a crust-covered Minette formation.

To test this model, Minette bulk samples /25/, Rasenerz concretions /30/ and Bohnerz concretions /26/ were subjected to neutron activation analysis /NAA/. From the univariate statistics of 16 out of 36 measured chemical elements, it is inferred that the application of multivariate statistical techniques is not advisable, because of the highly irregular distributions of the individual variables. Dynamic cluster analysis of a screened subset of the NAA output, comprising only 10 elements, indicates that within the total sampled population subgroups are distinguishable. At a certain level of homogeneity these subgroups show an obvious linkage between the Minette ironstone samples

and the majority of the Rasenerz samples. The remaining Rasenerz samples are evidently related to the Bohnerz samples. Correspondance analysis reveals that the variable As characterizes the Bohnerz and about 30% of the Rasenerz samples, and that the Minette and about 70% of the Rasenerz samples are characterized by Co, Cr, Sc and a number of Lanthanides.

Therefore, the present data seems to support the idea that the Rasenerz concretions are for the greater part actually residual fragments of iron crusts, which developed when the Minette formation was near or at the land surface.

**MIOCENE MIXED SHELF DEPOSITS OF MALLORCA ISLAND**

A. RODRIGUEZ-PEREA  
Departament de Ciéncies de la Terra  
Universitat de les Illes Balears  
Palma de Mallorca 07071  
**SPAIN**

During Early Miocene a mixed shelf was developed in the Balearic Islands. It registers a sudden and strong palaeogeographic change from a Paleogene Northwars expansive shelf. Burdigalian to Langhian sediments consist of calcareous turbidites related to the evolution of contractional structures.

Lower Miocene sediments, previously defined as Sant Elm Calcarenitic Formation, were formed by littoral deposits, mainly marine calcarenites. Sedimentation was largely detrital, consisting of calcareous lithoclasts, though bioclastic components are also important. They cover an irregular palaeotopography without any sedimentary polarity definition, and lie unconformably over Mesozoic or locally Paleogene rocks. Their thickness range from zero to tens of meters and its lower contact is usually erosive.

Facies associations change from point to point, even over short distances. Lateral variations lead to many different facies associations. Although littoral sediments are predominant, continental, restricted and open shelf environments are recorded.

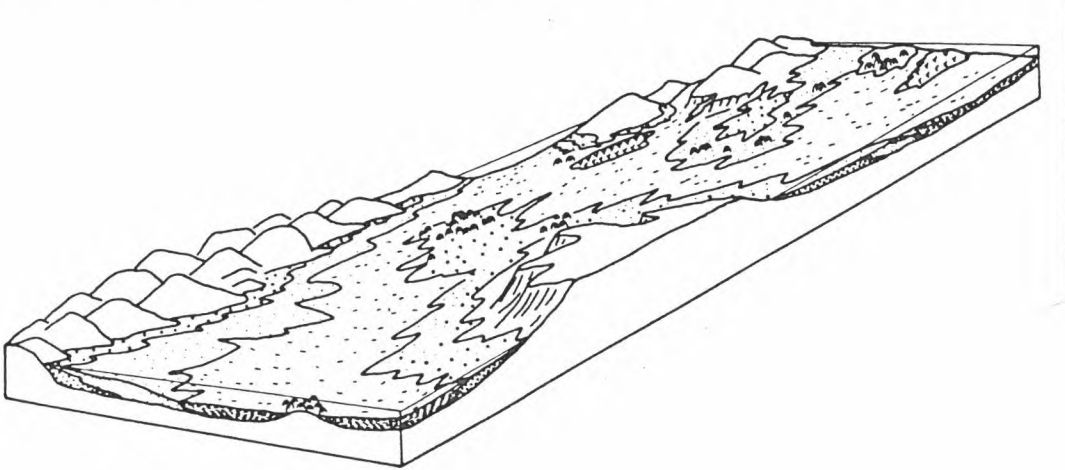
*Continental deposits* are represented by decimetric breccia sequences with red silt matrix. Microcodium structures are present. Clast size range from several centimeters to one meter in proximal areas. Paleosoils develop on top of breccia sequences as well as on top of Mesozoic basement. These facies are considered to be the proximal parts of alluvial fans.

*Littoral sediments* are recorded by several facies associations. Breccias, conglomerates and calcarenites are dominant textures in proximal zones. Bed structures are absent, clasts are heterometric and they reach up to 2 m in diameter. Few bioclast are present in proximal facies. Conglomerates and calcarenites are predominant deposits in most of the areas. Conglomerates are heterometric and subrounded and they form lenticular bodies inside the calcarenites. Calcarenites are the most characteristic facies of this mixed shelf deposits. They are formed by massive, bioturbated calcarenites, that locally show dune cross stratification. Frequently bioclasts are dominant: Bivalvs, Equinoderms (*Schizaster* sp., *Clypeaster* sp. and *Scutella* sp.), Oysters, Coralline Algae and Foraminifera. (*Amphistegina* sp., *Heterostegina* sp., *Miogypsinoidea* sp., *Miogypsina gunteri* COLE, 1938, (DEFRANCE, 1822)). Fish teeth and turtle fragments are also present. Littoral facies associations record proximal and distal fan-deltas as well as fore-shore and shore-face environments.

*Restricted facies association* is formed by sandy calcisiltites containing plant fragments and fresh water limestones. Algal chains of *Rivularia* sp. form limestone layers, while *Elphidium crispum* (LINNEE, 1758) and *Ammonia beccarii* (LINEE, 1758) characterize calcisiltite fauna. Restricted facies were deposited in a paralic environment. A complete flora has been reported. It includes species from both a tropical climate and a temperate one.

*Reefal facies* are reduced in volume and interfinger very rapidly with other littoral deposits. Coral fragments are widespread throughout almost all the outcrops. They become predominant in some localities where a coral rudstone or framestone is present. In some places coral growths are free of terrigenous influence (Santa Ponça, Deia) but frequently they coexisted with terrigenous inputs. In some cases coarse breccias reduce coral species diversity but in others the coral growth was disturbed by fine grained sediment.

*Open shelf facies associations* are mainly formed by calcisiltites. Coralline algal facies are built up by red algae biostromes showing branching habits. *Mesophillum* sp. and *Lithothamnium* form bafflestones while *Lithoporella* sp. shows encrusting habits. Calcarenites and calcisiltites with worm tubes form a fine-grained facies association characterized by the absence of light-related fauna. Calcisiltites with sponges are also characteristic of open shelf sediments. *Craticularia* sp. as well as Briozooan and Cidaris-like echinoids are the main components of this association. Calcarenites and calcisiltites are sometimes rich in Globigerinidae and this association defines the deeper parts of the mixed shelf.



Evidences of volcanic activity of the rhyolitic type has recently been found in several localities of the Serra de Tramuntana. All these facies associations characterize the mixed shelf environments of the Early Miocene of Mallorca. Terrigenous influences greatly vary from point to point, depending on palaeotopography, but the climate was favourable to carbonate production everywhere. Sedimentary polarities could, like the facies or faunal assemblages, change suddenly. An irregular and very changeable sedimentation results from that situation.

The facies distribution shows a non linear coast line. A rugged relief with no regional sedimentary trend characterizes an irregular platform running through emerged lands. Local conditions were very relevant in order to determine what kind of deposits were to be sedimented.

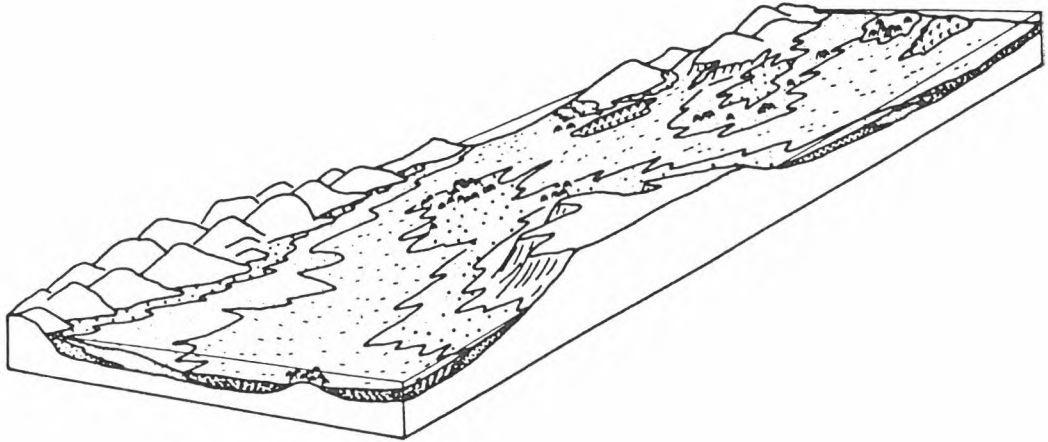
Productive ecosystems were probably dominated by sea-grasses, coralligen and locally by reefs; deeper areas were ruled over by a filtering fauna and planktonic organisms.

Although we can recognize distinctive mixed shelf environments, it is difficult to propose a predictive model for mixed shelves in a non linear coast line and high relief. It might be better to accept that a model simply can not be erected for this type of sedimentary environment. Sedimentation takes place according local palaeotopography, although carbonate production seems a climatic function.

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This work has been partly supported by CAICYT Project No. 3846/79

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Early Cretaceous sedimentary evolution in  
North-Western Bulgaria

NIKOLINA RUSKOVA

Geological Institute of Bulgarian Academy of Sciences  
BULGARIA

The Early Cretaceous is an important stage in the Old-Alpine development of NW Bulgaria. As a result of the almost uninterrupted sedimentation, a huge complex of sediments deposited there. Its great variety in facies as well as in thickness is connected with the development of the Moesian platform, as a main palaeo-structural unit.

Thus, in the beginning of the Early Cretaceous - during the Berriasian-Valanginian - the sedimentary environment appears to be a direct continuation of those of the end of the Tithonian: mainly carbonate rocks deposited in two structural-genetic types divided along the Kozloduj-Kneža line and the Jarlovitsa-Bijalo Pole line. To the north-east of the latter, in the epicontinental part of the basin, these types are the characteristic Kaspičan limestones (with dolomites at the base), whose facial analogue to the north-west of the Jarlovitsa-Bijalo Pole line is the Carbonate Formation in Vidin District. The area between the two lines is a deep-sea part of the shelf, where the pelagic limestones of the Gložene and Salash Formation formed, saturated with calpionelids.

During the Hauterivian the typical platform facies (the Kaspičan and the Carbonate Formation) lose their importance and the pelagic limestones of the Salash Formation (except for the Lom Depression) acquire significance also in the region to the north-east of the Kozloduj-Kneža line. The north-western part, on the contrary, raised and large areas remained above the sea level: above the partly-washed Valanginian base (excepting the R-1 Simeonovo drill for the Lower Aptian)

came the Upper Cretaceous sediments.

The beginning of the Barremian is a direct continuation of the main Hauterivian facies. This refers to the region of the Lom Depression, where the micritic limestones of the Salash Formation completely filled the base of the sections. So, the pelagic environment persevered but in the limestones appeared clayey-clastic material that saturated the sections in the middle and upper levels of the Barremian (Hairredin Formation). The environment appears most deep-sea in the south-eastern part where the sections are filled up with marls (Mramoren Formation).

The sedimentary environment during the Aptian is characterised by a greater heterogeneity. In the central part it inherited the main tendencies from the end of the Barremian because in their base the sections are build up of the sediments of the Hairredin Formation. But in the region to the west, they are lacking. From the middle of the Aptian, however, the central part again began to submerge slowly, and consequently there were deposited mainly clayey sediments (marls and clays), that also filled up the whole part of the Albian. The emmersion episode of the north-western corner is also present, and only for short periods of the Aptian certain parts of it submerged. Synchronically there, just like the carbonate platform (Bahama type) in the Central Fore-Balkan, formed Urgonian sediments - the coral reef of the R-1 Simeonovo or the oölitic limestones at R-1 Bijalo Pole.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989  
Lithology and genesis of late cenozoic sediments in the NE  
part of the Krušné hory Mts. (northern Bohemia)

ELIŠKA RŮŽIČKOVÁ

Institute of geology and geotechnique, Czechoslovak Academy  
of Sciences

CZECHOSLOVAKIA

The late Cenozoic sediments cover the foot of the Krušné hory Mts. and adjacent parts of the Most basin, attaining a relatively great thickness and extent. They have been divided into three principal genetic groups: colluvial, proluvial, fluvial and lacustrine sediments, and criteria for their differentiation and stratigraphic correlation have been established.

The most widely distributed on the slopes of the Krušné hory Mts. are colluvial deposits; their continuous sedimentation since early Pleistocene till the Holocene is evidenced by the presence of fossil soils of interglacial character. Proluvia, which are preserved at a large extent at the foot of the mountain range, derive predominantly from middle to late Pleistocene. Of the same age are fluvial deposits of short streams which occur in the ambient part of the basin together with sediments deposited by the major streams (Ohře and Bílina). Their stratigraphic interpretation has not been performed because only a short sector of the whole drainage system is involved and the development of the river system

was rather complicated here. The occurrences of lacustrine sediments are limited, and they differ one from another due to different time of their origin but chiefly to diverse conditions of the sedimentary environment. The eolian-colluvial sediments are most extensive in the watershed between the Bílina and Ohře.

The criteria of differentiation of individual genetic types are based on the differences in lithology. They are given by the material composition, the association of heavy minerals in particular, representation and ratios of clay mineral contents, the proportion of stable and unstable clasts, their shape and character of their surface, the degree of wearing and on the granularity.

Relative age of the individual genetic groups can be derived from changes in the ratio of stable to unstable clasts and in proportions of heavy minerals. It is also indicated by the ratios of clay minerals, the degree of their crystallinity, and the existence and degree of the crystallinity of Fe hydroxides and oxides.

The Peridinaridic Carbonate Platform evolution  
and old basements

DRAGO SAVIĆ

Institute of Geology, Sachsova 2  
Yu-41.000 Zagreb

Intradaction

A short survey was done on some complex changes connected to the geodynamics mobility accompanied with the forming of simple, old structures - "harde pans" and basins in very differently positions and space sizes too, during the evolutionary changes of the ancient geological times.

The forming of Carbonate Platform and the other occurrences

From region to the region strong changes of various intensity and at various times were connected to the Sallian orogenic phase during the Permian age. Thanks to the uprising movements the new land surfaces were formed varying in morphological forms sizes and time duration. The former old land of a short relief without different erosional bases existed from U. Permian up to the beginning of the Carnian age characterized by the enrichment of chemical processes in situ.

Contrary to that, this land-phase which was short is marked by breccias, clastites and Košna-conglomerates in the other Yugoslav regions and grödner sandstones too inside the Alps. At the W. Serbian region the clastites of M. Permian are transgressive over the older basement, while the land-deposits are at the E. part. Over the U. Permian age the basins are predominantly with carbonate deposition, contrary to the other clastite basins characterized by turbidite flows, gravity sediment flow etc. The next changes were connected by Pphalian phase accompanied with a short emergence inside the ancient ocean contrary to the other parts of that sea characterized by a continuously carbonate-mud sedimentation which is visible today on Velebit mountain and in other parts of N.W. Yugoslavia.

The ocean of L. Triassic age was characterized by a clastic deposition predominantly through the proximal over distal turbidite flows and laminites up to a basinal-pelagic carbonate-mud deposition which were deposited during the Anisian age. Inside the other parts of that Anisian sea were deposited the clastics characterized by various stages of turbidites and other flows accompanied by volcanic-magmatic activity. During the transitional Anisian-Ladinian age an emergence happened contrary to the continuous deposition inside the other basins over various submarine morphological forms of that sea what is visible today in the Petrova Gora region, in Alpa etc. After the short supratidal deposition these old lands were flooded. Inside that whole sea the clastites were deposited accompanied by volcanic and magmatic activity and followed by

the continuously limestone mud deposition during the U. Triassic age too. This did not happen over the new-formed land surfaces during the emergence accompanied by faulting and submarine inflows of tele-thermal solutions (D. Savić, 1985). Next came the clastics and carbonate-mud-clastics deposition during the Carnian age characterized by various stages of turbidites and other flows, channels and so normal basinal deposition. There are well-known basins with coal-occurrences inside the marl and volcanic activity in other parts of the former sea. After that there was the carbonate-mud deposition over the bottom of the global sea characterized by changes from intertidal over short emergences up to the shallow and middle deep subtidal inside the shallow region of that ocean. There are in today's U. Triassic dolomites similar as or same as a Lophorit facies (A. G. Fischer, 1964).

Inside these same sea-regions there is also a carbonate-mud deposition during the Lias, Dogger and Malmian age contrary to the other parts of that ocean by different depositions.

At the beginning of the U. Malmian age strong changes were happening connected to the intercontinental geodynamics mobility. They were forming the basins of chemical-evaporitic precipitation contrary to the other typical clastics deposition and at last some basins of continuous carbonate-mud sedimentation were formed during the Malmian, L. and U. Cretaceous age. Inside the other regions of that ocean the new lands were formed during the emergence connected by the Early Cimmerian phase accompanied by the forming of various basins which existed over the L. Cretaceous age. The Austrian phase was reflected inside some region of the former sea during the Albian-Cenomanian age.

The spacious transgression happened at the beginning of the Senonian age connected to the tectonical phase at various space positions characterized by the different deposition inside the open, closed, over lagoonal and flysch basins. These depositions were finished during the Paleocene when there were strong tectonic changes thanks to which the present setting of Dinaridian was formed.

#### Conclusion

The beginning of the forming of the submarine carbonate platform was connected to the U. Triassic global sea-Tethys ocean with a carbonate mud deposition over the heterogeneous submarine forms of old land basements.

The regional evaporitic basins of the U. Malmian during L. Cretaceous age were formed accompanied by little basins (bosnian) contrary to the continuously carbonate mud deposition over the large and smaller platforms up to the Eocene.

Differentiation of these basins happened over the Peridinaridic, Adriatic and other platforms.

Besides the depositional forms of genesis similar to the debris sheet model (Cook and al., 1972) and other bodies are visible. These bodies are like carpets, with or without fingers, lateral transitions, various aprons etc.

TITLE : **The Submarine Var Canyon (French Riviera) : Detailed Study  
of the Activity of a Modern Canyon.**

AUTHORS : B. SAVOYE\*, P. COCHONAT\*, G. OLLIER\*, G.A. AUFFRET\* and J.F. BOURILLET\*

\*Institut Français de Recherches pour l'Exploitation de la Mer (IFREMER), DERO/GM,  
B.P. 70, 29263 Plouzané, FRANCE.

On October 16, 1979 the coastline of Nice was submerged by waves of several meters in amplitude. In the same time, part of the embankment in front of the international airport disappeared into the sea. A few hours later two submarine telephone cables were broken at a distance of about 80 kms and 110 kms from Nice. In the meanwhile, no earthquake was registered by the nearby Monaco Observatory. The 1979 event was attributed to a submarine slide of unknown origin, that generated a turbidity current in the Var canyon. In the following years several investigations were carried out to evaluate the location and magnitude of the sub-sea disturbance.

The Nice continental margin is characterized by a very narrow shelf and a steep continental slope, thus the 1000 m isobath is reached 5 km seaward the coastline. The continental slope is incised by the Var and Paillon canyons, which are separated by a flat-floored, broad valley. The two canyons join in the broader lower Var canyon, that bends in an E-W direction. About 60 kms from this confluence, the Var canyon turns to the southeast and feeds a small fan.

The modern evolution of the continental slope off Nice began with an erosional phase in the Messinian age. During the Pliocene and part of the Quaternary, a thick detritic cone was built up. The cone was fed by sediments derived from the erosion of the alpine chain and transported by the Var river and the Paillon river. During the Quaternary the sediment supply progressively decreased whereas a phase of erosion with extensive submarine slides and gravity processes (mass-wasting, debris-flows, turbidites...) occurred and is still active today.

In 1986, the Var canyon and the continental slope off Nice were surveyed using the SAR : a new deeply towed high resolution sidescan sonar and 3.5 kHz subbottom profiler package. Later on, a ground-truth operation using the CYANA submersible and Küllenberg cores provided in-situ observations and samples. In 1988, a new cruise provided seismic data.

The head of the Var canyon is located at the coastline and is very steep with a slope gradient of 15 %. Sonar images exhibit a like fluvial morphology and deposits. Such a morphology is thought to be the result from the submarine action of the Var river flows during exceptional swellings.

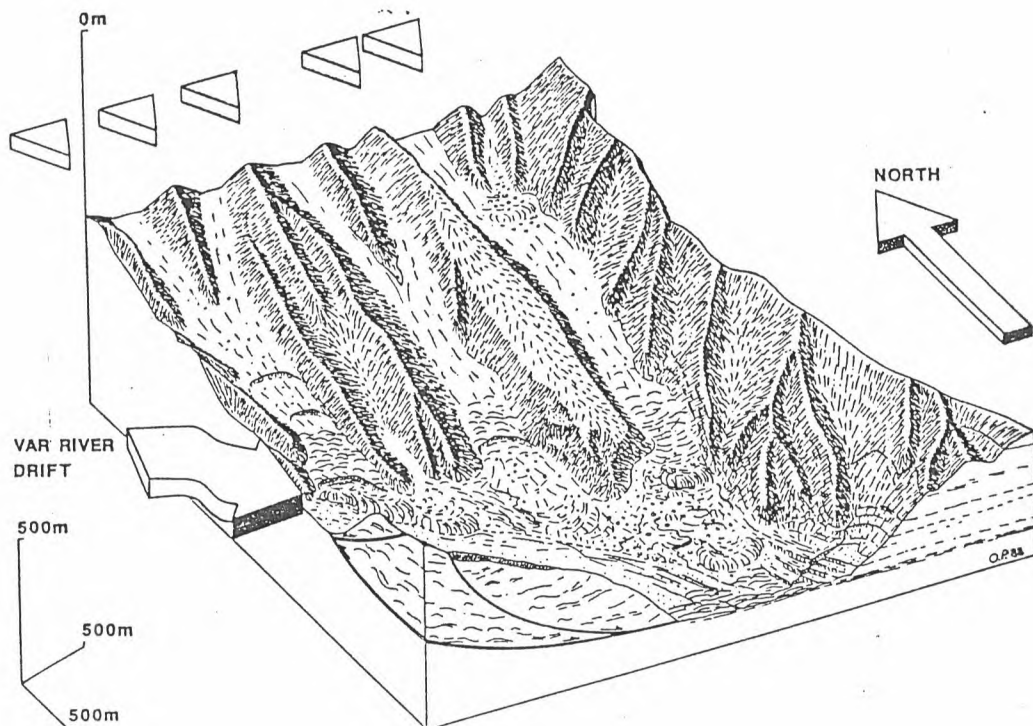
The Var River "delta" is deeply incised by sharp-cut chutes that directly feed the Var canyon (see fig.). Several evidences of sedimentary instabilities were observed during the submersible dives. It suggests that recent failures occurred on very steep slopes offshore the airport.

A giant ripples field lies on the canyon floor extending from the feet of the chutes area to a water depth of 2000 m. The wavelengths of the ripples range between 25 m to 120 m (average of 55 m) and their amplitudes are metric. In the uppermost lower Var canyon, the ripple chords become larger whereas the canyon floor widens and the gradient slope decreases. The submersible observations indicate that the giant ripples are made by well-rounded cobbles or boulders with a diameter up to sixty centimeters. The giant ripples exhibit several features which could be related to near-bottom traction forces. The "A" axes of elongated clasts dip upstream and the "b" axes are

perpendicular to the canyon axis . The clasts preferential orientation would result from rolling, sliding and saltation motion in a highly turbulent, probably high density turbidity current flowing along the Var canyon. Walker's graph applied to a boulder with a mean diameter of 30 cms give a mean flow velocity of 700 to 800 cms/s. One can noticed that the calculated velocity is of same order than those estimated for the 1979 turbidity current.

Downstream the ripple field, the canyon floor looks like a large patchwork of reflective and non reflective areas. It coincides with the channel broadening, a decrease of the gradient slope and the disappearance of the left wall. The initiation of the patchwork pattern could be explained by a change in the hydraulic conditions after which gravity flows intermitently touched and eroded the canyon floor. Going downslope, the reflective areas become less frequent. The lengths of the patches vary from 100 m to 3 km and the non reflective areas (muddy areas) usually correspond to topographic highs.

Beyond the bend of the Var canyon to the south east, sonar images show a very flat uniform and relatively non reflective canyon floor. Graded sands and stratified silts were observed in the lowermost part of the channel system .



GRAVITATIONAL FEATURES AND MASS MOUVEMENTS  
IN THE "BAIE DES ANGES" OFF THE COAST OF NICE

Along the 60 kms of the imaged canyon, wich are entirely upslope from the location where submarine cables were disrupted, there are principally extensive evidences of bottom reworking and local deposition sites. Numerous gravity events have likely taken place in the studied area in the last thousand years, thus it is very difficult to identify the proper imprint of the 1979 event.

The plan view of a modern canyon floor using side scan sonar, submersible and cores allows us to propose an approach of the sedimentary facies associations which contrasts with and complements the usual studies in cross section (seismic) or on land.

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Gypsum crusts formation and "stratigraphy" on weathered building limestones

NICK SCHIAVON

Dept. of Earth Sciences  
University of Cambridge  
Downing Street, CAMBRIDGE CB2 3EQ  
UNITED KINGDOM

Black crust samples, a weathering product of decay on the limestone surface of two famous London monuments, i.e. Westminster Palace and Cathedral, have been collected and examined under SEM, both in secondary and back-scattered mode (BSEM), attached to an EDAX analyser. Mineralogical bulk composition has been determined by X-ray diffractometry. As well documented by literature on building limestone decay (Bernardi et al. 1986), the black crusts are mainly composed by a framework of needle-like and platy gypsum crystals. Minor mineral phases are present and the BSEM investigation interfaced with EDAX has proved particularly useful in their identification for the mineral phases can be easily distinguished by difference in brightness connected with the atomic number of the elements forming the mineral (Z-contrast).

This helps in identifying particles imbedded in the gypsum diagnostically important for recognising the source of the pollutants, namely irregular carbonaceous particles from wood, spherical aluminosilicate glassy particles from coal and spherical carbonaceous particles from oil combustion processes (DelMonte & Sabbioni 1987).

In thicker crusts a "stratigraphy" on the distribution of these

particles can sometimes be seen recording the outward growth of the sulphate crust during historic changes in polluting sources. In U.K., where at least the change from coal to oil can be precisely dated, the thickness of the "stratigraphic intervals" in the crusts may prove useful in determining growth rates both in rural and urban environments.

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Facies differentiation in carbonate rocks during the  
Upper Devonian in the region of Eastern Thuringia  
(G.D.R.)

GERDA SCHIRRMMEISTER

University of Greifswald

G.D.R.

A great diversity of lithotypes which change relatively quickly in horizontal and lateral directions is characteristic of the Upper Devonian carbonate rocks of the Variscan belt. This fact again and again provoked extremely different interpretations. The basis of all sedimentation models is the assumption of a division of the area of sedimentation into swells and basins. Swells may be of different origin and the parts of the basins are believed to have been subsided to various extents.

In order to find out a suitable sedimentation model for the region of Eastern Thuringia we have investigated the various lithotypes especially with the help of microfacies analysis. Two main facies areas can be divided, i.e. pelagic deep sea sedimentation at the slope of the so-called Tiefschwelle and the basin margin (Schwarzburg Anticline) and pelagic shallowwater sedimentation on top of the Tiefschwelle (Berga Anticline). Even within these both regions the sediments show further facies differentiations especially during the lower Upper Devonian. Both areas were distant from the main land. The characteristic lithotype of the deep sea sedimentation is the nodular limestone, which is only partly cemented, whereas in the shallowwater facies the limestones are almost completely cemented and are flaser-like up to massive. An important source of facies differentiation is the interaction between magmatism and carbonate sedimentation.

Concerning the swells the common microfacies type is the pelagic ostracode wackestone. The equivalent layers of the Kellwasserkalk horizons are particularly rich in fossils and are cemented pelletal shell limestones. The area is repeatedly divided by submarine swells. This relief may be due to the basic volcanic accretions and intrusions and influences the sedimentation indirectly, which is characterized by shallowing upward sequences. The direct influence of the magmatic activities leads up to the destruction of preexisting carbonate platforms and produces carbonate breccias with transitions up to spilite amygdaloidal rock (cf. Fig.). Distal influences of the eruptions are in situ brecciation and slumping folding, which can be observed in the carbonate rocks.

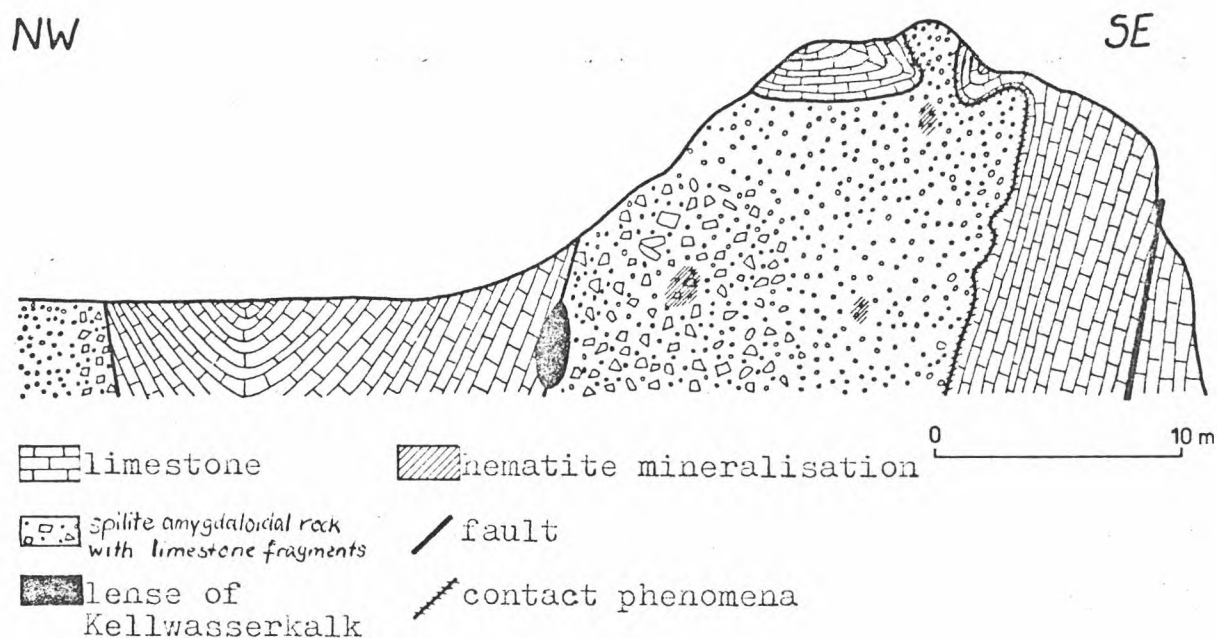


Fig. Profile of an outcrop from the region of Berga Anticline, which shows the interaction between magmatism and carbonate sedimentation.

VLADIMIR SEDLETSKI, ANATOLI BAIKOV, GRIGORI SEMENOV

Rostov State University

USSR

The most intensive halogen sedimentation occurs in the tectonically active zones within the formed textures. The continuing development of these textures influences the distribution of thickness and facies, mineralogical composition of salt-bearing boundaries and often controls the duration of the halogenic process and its completeness. The following phases of tectogenesis even removed in time effect much older salt series and bring about vary reperi-mposed events. It is therefore very important to ascertain some features which would help to determine the character of the tectonic movements with reference to the halogenic deposits i.e. to ascertain presedimental, consedimental and postsedimental character of the deposits.

The sings of presedimental tectonics on the halogen-bearing territory are the following: the tectonic character of the salt-bearing boundaries and the lithology facies complex within them; the uneven thickness change of halogen brought about by block composition of underlying formations i.e. by the tectonic relief of the bed; the correlation of halogenesis and preceding bioherm or reef edifice forming along the big tectonic dislocation.

The consedimental evolution of textures with the reference to the process of halogenesis is reflected in the following features: thicness change of halogen series accompanied change of facies completeness of section and the following rise of both features in the direction of deeper blocks; accumulation of hydrochemical sediments in the part of the postreef province with the reference to the distributive one;

the contents of potassium in the deposits connected with the syngenetic descending movement in productive part of the basin; the presence of halogen deposits in the graben-like textures between the blocks and which are not found in the blocks proper. Usually consedimental tectonics determining the thickness and completeness of the deposits in the salt-bearing basins, is inherited from the preceding period of sedimentation. Therefore presedimental and consedimental tectonics is a single through process in most cases. It takes place before the halogenesis stage, during the halogenesis stage and after this stage.

Reef formations are nonthrough process.

There are some results of the postsedimental tectonics. They are the following: essential broken bedding of primary halogen series often accompanied by the movement of these series right up to salt diapirism and change of the primary structure by the inner flow of salt; washout of salt series right up to its destruction accompanied by exotectonics phenomenon in overlapping series the formation of erosional cut; tectonics dislocation across the halogen series often contains epigenetic mineralisation.

That is why we may conclude that the tectogenesis influences the halogen sedimental process and the later transformation of the halogen series by the scale and the peculiarity, which has a versatile character. It is necessary to study and compare all watched geological factors in each case to restore the complete picture of the tectonics activity within the salt-bearing basin.

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Kaolinite and depositional environments of Jurassic  
deposits in Baltic region

PETRAS SHIMKEVICHIUS,

LILIYA ROTKYTE

Lithuanian Geological Research Institute

LITHUANIAN SSR, USSR

The Jurassic of Baltic region is subdivided into continental and subcontinental terrigenous deposits of pre-Middle Callovian and marine carbonate-terrigenous sediments of Middle Callovian-Volgian stages.

The Jurassic rocks contain clay minerals as follows: kaolinite, illite-micas, montmorillonite, chlorite and irregular mixed-layers illite-montmorillonite minerals. The greatest variations are in the kaolinite content.

The distribution of kaolinite in basins of sedimentation shows directions of supplying them by terrigenous material and its dispersing in basin.

Continental and subcontinental deposits contain a large quantity of kaolinite. The distribution of kaolinite differs in sediments of different suits. Two main supplying provinces of Late Jurassic marine basin are legibly distinguished by distribution of kaolinite.

The gradual decrease of amount of kaolinite up the section starting with the Oxfordian-Kimeridian corresponds to the beginning of sea regression.

In this work the authors for the first time in Baltic region applied model of correlation proposed by R.A. Gygi and F. Persoz (1986). The authors carried out this model of correlation among sections, but it was possible only in Callovian and partly in Oxfordian sections which were previously subdivided into ammonite zones and

contain kaolinite.

The authors chose this model of correlation for the contrary purpose - using correlated profiles to within one ammonite zone to trace lithological and lithofacial simultaneous transitions in the basin of sedimentation in any direction. For this purpose the authors chose to study Middle and Upper Callovian deposits.

On consequence of the beginning of transgression in Middle Callovian the coarse grained sediments - carbonate sands and sandstones-formed basal horizon - the lower ammonite zone of Middle Callovian. This horizon contains large quantities of kaolinite. Later, on the boundary between the lower and upper ammonite zones of Middle Callovian transgression stabilized - there is lithological transition of sandstones to aleurites and even clays in remote parts of basin. Amount of kaolinite decreases. During the Late Middle Callovian sea transgressed with new strength (upper ammonite zone) - again sandstones were deposited, the quantity of kaolinite increases.

On the boundary between Middle and Late Callovian the transgression stopped. At the beginning of Late Callovian (lower ammonite zone) was new not very large advance of sea - sandstones were deposited, further from the coast they transited to aleurites, marls and limestones. During the last part of Late Callovian (upper ammonite zone) marine conditions stabilized, the transgression advanced slowly - only near the coast aleurites are found, meanwhile in deeper parts of basin there are clays and carbonate sediments. The quantity of kaolinite in the upper part of section is more or less permanent, without steep alterations.

Shallowing-upward carbonate sequences in a nontidal,  
pre-evaporite basin /Zechstein Limestone, SW Poland/

Wojciech Sliwiński  
Institute of Geological Sciences, Wrocław University  
Poland

Two, locally three coarsening-upward sequences are distinguished in the Zechstein Limestone in the SE part of the North-Sudetic Basin.

Lithofacies A - consists of sets of thin layers of homogeneous or finely planar-laminated limestones interbedded with marls and/or shales. Texturally, the sediments are mudstones with wackestones. Two kinds of sequences are observed: A1 - limestone - marl/shale and A2 - marl - limestone. The sediments were deposited below a storm wave-base.

Lithofacies B - singular layers of massive round-shaped limestones /mudstones to packstones/ in the marl/shale matrix. The sediments are derived from the ramp gravity flows of partly consolidated material.

Lithofacies C - moderately thick cross-bedded oncolitic and skeletal calcarenites /packstones also wackestones and grainstones/. They filled extensive, flat channels eroded in lithofacies A. Sometimes they also pass gradually to the lithofacies A toward the top of the sequence. Lithofacies C represents episodic sediments connected with deposition in storm channels just below a normal wave-base.

Lithofacies D - thin and singular layers of graded laminates with the laminae of siliciclastic material. The bases of layers are erosive and sharp, undulated or flat. From the bottom of the layer to the top the lamination changes as follow: hummocky cross-lamination, horizontal flat lamination, irregular and discontinuous lamination with water-escape structures. Lithofacies D is the result of the storm events - tempestites.

Lithofacies E - consists of thick and very thick massively bedded, locally cross-stratified oncolitic and oolitic dolomites. Dolomites are fine- to coarse-grained packstones to grainstones. Individual beds have sharp by defined bases. Lithofacies E1 consists of thick oncolithic dolomites steep and irregularly laminated within lithofacies E. Two genetic possibilities are considered: 1 - stabilization of sediment by algae - "embryonic algae-reef"; 2 - formation of diagenetic concretions. Lithofacies E is the result of the barrier development. The paleo-karst filled with terra rossa /TR/ is observed in the top of lithosomes E.

Lithofacies F - thin bedded silty and sandy dolomites with well preserved sedimentary structures. Limpid dolomite and pseudomorphs after sulphates are observed. Trace fossils are numerous. Lithofacies F is interpreted as mud-to-calcareous plain deposits.



Lithology and geochemistry of the lacustrine sediments filling the Pula basalt tuff crater (Upper Pliocene, Hungary) - Implications for paleoenvironment.

GÁBOR SOLTI and ISTVÁN VETŐ<sup>II</sup>  
Hungarian Geological Institute  
HUNGARY

The Pula crater is the first recognised and characteristic example of the maar-type craters produced by the final basaltic volcanism in the Carpathian Basin. The geology of the crater is described by Csirik and Solti (1989, this volume). A lithological-geochemical summary is given here for the lacustrine series penetrated by 39 coreholes. On this basis a reconstruction of the paleoenvironment is carried out.

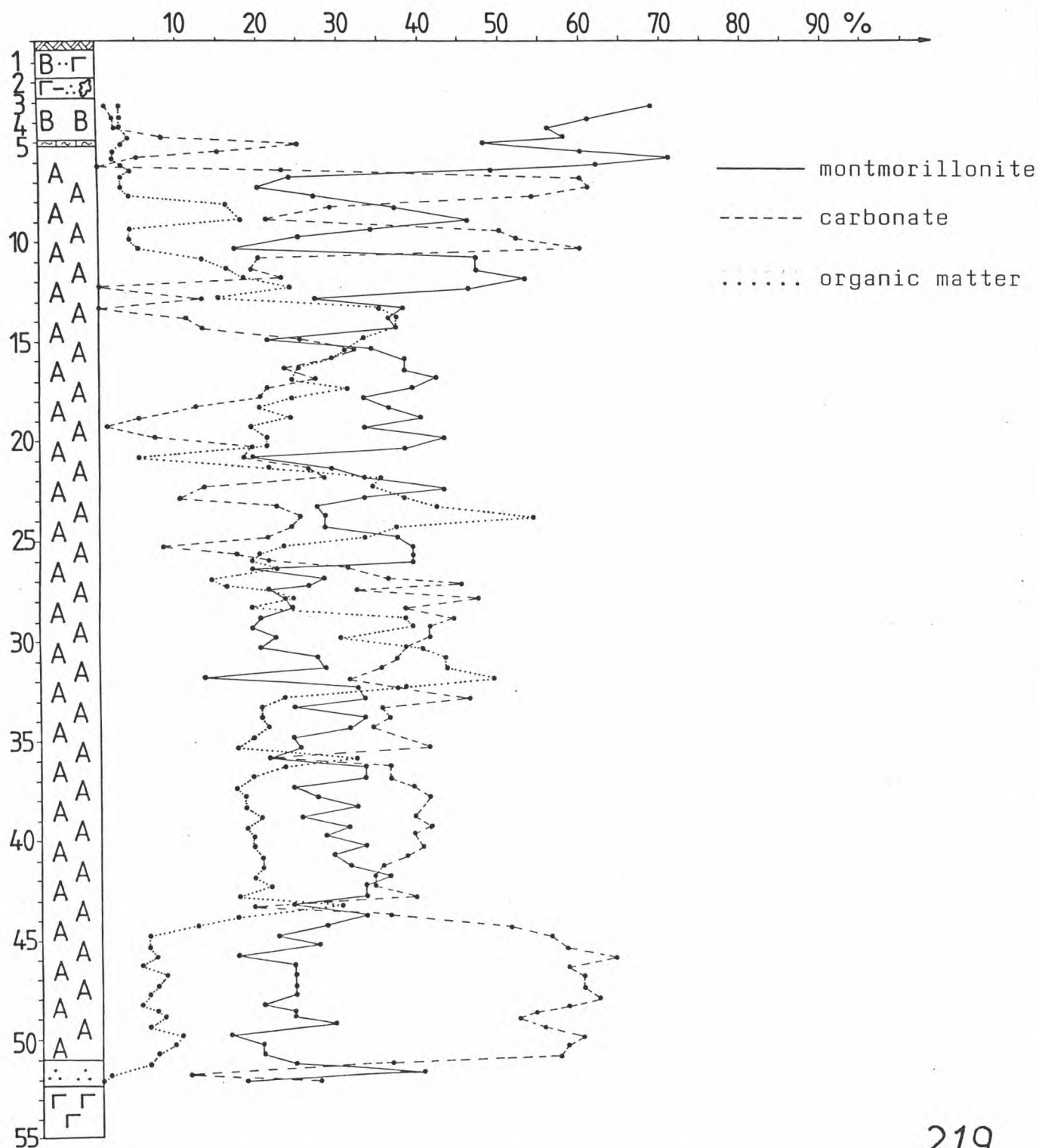
The crater of one km diameter was formed 4.15 My ago, its filling up with lacustrine sediments had a duration of max. 1 My. On the basis of lithologic differences three members can be distinguished in the lacustrine series (Fig. 1.):

- basal coarse-grained volcano-sediments (3 m thick)
- alternation of massive and laminated alginite layers (sediments having algal organic matter as their main component are called alginite here); this member dominates the series (40 m thick)
- alternation of limy and bentonitic layers on the top of the series

The sedimentary series filling up the other maar-type craters in Hungary (Gérce, Várkesző, Egyházaskesző) show very similar lithological build-up, but the thickness data are different. The geochemical characterization of the alginite member is based on X-ray, thermal and chemical (main and minor components) analysis (Rischák G., Földvári M.) of about 100 core samples from the well Put 30. The samples represent 0.5 m thick intervals on an average.

The four basic components of the alginite member are carbonate (mainly aragonite), mixed-layer clay minerals, opal and organic matter. The carbonate/clay mineral ratio decreases upwards, the abundance of organic matter shows cyclic variations (four cycles with 0.1 % and 40 % extrem values)(Fig. 1.). The aragonite precipitated from thermal waters feeding the crater lake. The intensity of thermal water activity decreased with time, meanwhile the rate of material transport from the tuff ring remained relatively unchanged. The cyclic changes of the organic matter abundance reflect the long-term cycles in the planktonic production of the Pula crater lake.

Plot of montmorillonite, carbonate and organic matter content vs depth in the well Put 30 (thermal analysis data of Földvári M.)



The Jurassic series of Central Tunisia: an example of shallow to deep marine carbonate shelf

Mohamed SOUSSI (1), Ali M'RABET (1) and Mohsen RABHI (1,2)

(1) Université de Tunis II, Faculté des Sciences, Département de Géologie, Laboratoire de Sédimentologie et Bassins Sédimentaires, Campus Universitaire, 1060-Tunis, TUNISIE.

(2) Office National des Mines, Service Géologique, 95, Avenue Mohamed V, 1002-Tunis Belvédère, TUNISIE.

The Jurassic series of the N-S Axis in Central Tunisia correspond to four major carbonate sequences.

The first Jurassic sequence (Liassic in part, more than 200 m in thickness) is mostly composed of dolomitized tidalites including dessication breccia, algal laminations and stromatolites, asymmetric (low energy) ooids and pisoids and local evaporite micronodules being dissolved and cemented by dolomite. These facies are rich in mud-cracks and birdseyes being either early cemented or filled by vadose internal sediment. They correspond to a very shallow marine and calm platform having a relatively wide extension and including numerous tidal flats. The upper part of the sequence is enriched in benthonic fossils and even contains ammonites indicating a relative deepening of the marine platform during the Carixian. In addition, the carbonate sedimentation rate decreased as suggested by a submarine hardground at the top of the sequence.

Within or prior to the second Jurassic sequence (Lower-Middle Toarcian, up to 18 m thick) sedimentation, a major tectonic event occurred and the marine platform was dislocated into several depressions (grabens) and highs. In addition, a marine deepening occurred leading to the deposition of transgressive and ammonites-rich marls and laminated mud-wackestones. In the depressed zones, the latter correspond to true black-shales containing up to

3.7% of total organic carbone and thus confirming the existence of the Toarcian Anoxic Event in the Tunisian part of the Southern Tethyan margin.

The third Jurassic sequence (Upper Aalenian-Lower Bajocian to Lower-Middle Bathonian, up to 30 m in thickness) corresponds to a transgressive-regressive sedimentation on the irregular and relatively deep platform inherited since the Toarcian. The Bajocian lower part of the sequence includes iron ooid and pisoid deposits being rich in ammonites while the Bathonian upper part is composed of wackestones containing cephalopods and intercalated with shales. The top of the sequence corresponds to a submarine erosion surface.

The fourth Jurassic sequence (up to 200 m thick) is Upper callovian to Lower Tithonian in age. Its lower part is composed of pack-wackestones rich in ammonites, belemnites and protoglobigerines and locally of debris flow-mud flow deposits rich in cephalopods and exhibiting slump marks. These transgressive facies reflect an outer shelf to slope carbonate sedimentation. The latter became shallower during the Upper Oxfordian as suggested by the overlying oolitic and bioclastic limestones. However, within the Kimmeridgian-Lower Tithonian carbonates which are rich in saccocoma and radiolaria, a renewed marine deepening occurred leading to the installation of an outer shelf carbonate sedimentation.

In sum, the Jurassic carbonate sequences in Central Tunisia have been deposited on a marine platform being initially very shallow and then deeper and dislocated into several depressions and down-faulted zones. their sedimentation has been controlled mostly by tectonic and eustatic factors.

Upper Riphean flysch of the Yenisei Mount  
(south-western margin of the Siberian Platform)

Julius Sovetov & Eugene Butakov

Institute of Geology and Geophysics

Siberian Branch of the USSR Academy of Sciences

USSR

Flysch deposits are situated in the north-east of the Yenisei Mount and make the middle part of the Chingasan series of Upper Riphean (820-700 m.y.). In the sequence of marine terrigenous deposits the flysch is on two stratigraphical levels: in Karyernaya and Chividinskaya suites. Modern "residual basins" of Chingasan stratigraphical level are in Post Cambrian fault-line subsided north-western strike zones. The maximum length of a flysch band is 150 km, the width - 50 km.

A series of marine terrigenous deposits were accumulated after a long gap on the denudated surface of Riphean sedimentary and magmatic formations having suffered folding and metamorphism, and occupies the edge position on the Siberian craton. Chingasanskaya suite is overlapped by shallow marine and continental red-colored deposits of Chapskaya series (Vendian). Its upper stratigraphical horizons make up the basal beds of the Siberian Platform mantle and occur on a very large territory.

The flysch formation is subdivided into three stratigraphical units: the low flysch (Middlekaryernaya), middle diamictite (Lower Chividinskaya) and upper flysch (Upper Chividinskaya). The stratigraphical units ranged relative to each other towards the edges and along the trough.

Middle Karyernaya flysch sequence (300-400 m) has a narrower distribution than Chividinskaya one; up and down along the section it changes into aleurolites of the farthest shelf and then into sandstones of the nearest shelf bars. In Middle Karyernaya flysch the associations (facies) are singled out: I - channels-valleys, II - fans of valley mouths and interchannels parts of slope. Channel facies-valleys-multistoried formation are subdivided into: 1a - grain flow deposits, 1b - debris flow deposits, 1c - turbidites, 1d - overbank channel deposits. 1a deposits make the channel, 1d frame the channel, 1b and 1c were spread along the whole valley. The fan deposits are subdivided into: IIa - middle-small-layered turbi-

dites (zebra). Both types replace the channels laterally and are bound up with different dynamical regime of the flows. Debris and grain flows and turbidity currents of high density ran from the north-east to west-south-west of the slope. The turbidity currents of low density turned mainly to the south-west-south along the basin edge. The vertical facies sequences are divided into two cycles of the fan progradation, the upper cycle is more proximal.

Lower Chividinskaya sequence of boulder-pebble diamictites (0-800 m) occupies mainly the northern part of the basin and consists of the deposits of debris pebble and grain flows. Poorly sorted deposits of debris flows with sand-aleurolite-clayey matrix include debris of different size, well rounded boulders and not rounded blocks from 30 to 200 cm in diameter. Clastic material is local from rocks of Riphean formations of the basement. Conglomerates and horizontally layered sandstones occur in isolated members in different parts of diamictites and make up not more than 10% of the volume. In the north-western part of the region diamictites alternate with tuffs and basalt and trachybasalt lavas wedging out in the distance of the first tens of kilometers; in south-east of the region diamictites are associated only with Upper Chividinsky flysch.

Upper Chividinskaya flysch sequence (300-450 m) consists of alternating large sandstone beds and packets of sandstone, aleurolite and argillite intercalation. Two associations (facies) are singled out: I - upper parts of the valleys, II - low parts of the valley. Association I is subdivided into deposits: Ia - coarse-grained grain flows ( $P_{1-2}$ ), Ib - middle-small-layered turbidites of  $T_{abcde} - T_{bcde}$ , <sup>1</sup> seldom  $T_{cde}$  types. Association II is subdivided into deposits: IIa - fine-grained grain flows ( $P_3$ ), IIb - fine-thin layered turbidites of  $T_{bcde} - T_{cde}$  type; <sup>3</sup> IIc - aleurolites-argillites (hemipelagic). At <sup>2</sup>  $T_{cde}$  the transition in the strike from associations I to II the size of sandstone grains, thickness of grain flows and turbidites decreases; the number of beds and thickness of hemipelagic interval "e" increases. The thickness of beds P changes from some dm to some m (15 m maximum). Abundant foot signs are on beds P and T and show a wide sector of directions to the south-west with the mode south-west  $150^\circ - 180^\circ$ . In the stratigraphic sequence of directions the bedding of sand bodies change in azimuth up to  $60^\circ$ . Detrital material entered the upper part of the trough in the north-west of the region and removed along it from north to south.

Chividinsky elongated flysch basin was formed as the result of oblique extension and breaking of the craton edge and formation of the trough which was filled only by marine deposits. The trough was overlapped by Vendian deposits of the mantle overlying its edges on Prechingasansky basement, after the episode of folding and denudation of a part of the flysch deposits.

Heavy mineral events and tectonostratigraphy: The case study of the Neogene Styrian basin (Austria)

KARL STATTEGGER

Institute of Geology and Paleontology  
Karl-Franzens-University  
Heinrichstraße 26, A-8010 Graz

AUSTRIA

Heavy-mineral analysis is an established method to decipher provenance of clastic sediments. The modeling of lithological end-members from heavy-mineral data is an advanced approach to reconstruct sediment-source relationships in a geodynamic context (Stattegger 1987): Heavy-mineral distributions are mixtures of different minerals depending on the regional distribution of source rocks, transport and diagenetic alteration. The different mixing proportions are referred to lithologically meaningful end-members. These end members mark clearly discernible heavy-mineral events which are used to decipher provenance of clastics in different plate-tectonic settings. Various minerals or mineral types (e.g. geochemical varieties) can be used for that purpose.

A famous example of heavy-mineral based tectonostratigraphy offers the Neogene Styrian basin, situated on the eastern margin of the Alps and continuing into the Pannonian basin. The mainly clastic rocks reach a maximum thickness of 3500 meters. The stratigraphic sequence (early Miocene - late Pliocene) shows repeated changes between garnet- and epidote rich heavy-mineral spectra. A concept of heavy-mineral cycles was developed thereof (Nebert 1983): Such a cycle starts with a garnet event, continues with a garnet-epidote mixing stage and ends with the predominance of epidote. Up to four cycles can be distinguished which do not follow stratigraphic boundaries.

A geodynamic explanation of the cycles is proposed: During the late Alpidic orogenic stage, recurrent heavy mineral events with sudden

changes in the spectrum do occur, reflecting stepwise collisional and succeeding tensional activity in the hinterland in connection with uplift and erosion of metamorphic core complexes. Garnet events are the sedimentary feedback of Neogene transtensional tectonics after the Alpidic collisional orogeny, leading to fragmentation and subsidence of crustal blocks. High relief-energy erodes "fresh" crystalline rocks. More stable tectonic conditions, lower relief and transport energy, intense weathering due to the warm humid climatic conditions are responsible of the enrichment of epidote and the reduction of garnet respectively. More detailed information on changing source areas can be obtained from the study of geochemical variations of garnets and other heavy minerals (Morton 1985).

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**Transgressive - regressive depositional sequences in Upper Pleistocene (Tyrrhenian) coastal sediments of Sardinia, Italy**

ANDRÉ STRASSER, ERIC DAVAUD, PASCAL KINDLER, ROSSANA MARTINI  
Department of Geology and Paleontology, 13, rue des Maraichers  
1211 Geneva  
SWITZERLAND

Coastal sediments of Tyrrhenian (Upper Pleistocene) age occur in many localities along the shores of Sardinia (Ulzega and Ozer, 1980). Ten outcrops along the southern and western coast (Fig. 1) have been studied in detail, and some preliminary results are presented.

Facies comprise siliciclastic grains eroded from the pre-Tyrrhenian substrate, and organic carbonate elements such as bivalve and gastropod shells, echinoids, ostracods, serpulids, foraminifera, calcareous algae, and locally corals. Sedimentary structures are well preserved and imply shoreface, foreshore, backshore and eolian depositional environments. Root traces are locally abundant. Many outcrops are capped by calcrete.

Detailed sequence analysis reveals two major depositional sequences (Fig. 2). Sequence boundary 1 cuts into the pre-Tyrrhenian substrate and implies an important drop of relative sealevel. The overlying conglomerates probably correspond to the transgressive deposits. Shoreface, beach and lagoonal deposits then prograde over the downlap surface. According to the facies succession in some sections (Fig. 2A), this first major sequence may be subdivided into two smaller sequences.

Sequence boundary 2 erodes into the underlying sediments (and locally merges with sequence boundary 1), again suggesting a sealevel fall. The transgressive deposits commonly contain rhodoids and incrustations of red algae. The sequence continues with regressive deposits going from shallow shoreface to beach and eolian.

Diagenesis seems to have occurred in a predominantly freshwater-phreatic setting, as implied by isopacheous, equigranular calcite cements. However, the transgressive deposits are better cemented and display a much reduced porosity, whereas the prograding highstand deposits are very porous and show dissolution of carbonate particles. Aragonite needle cement indicating a marine diagenetic environment was found in only two samples above sequence boundary 2. Pedogenetic influence may lead to mottled micritization.

Dating by U-series and isoleucine epimerization suggests ages of 138'000 and 120'000 years for the first major sequence, and about 90'000 years for the second one (Hearty, 1986). These ages correspond to climatic peaks well documented in the Quaternary record (Shackelton and Opdyke, 1973) and related to Milankovitch orbital forcing. It can therefore be assumed that the sedimentation of the two studied sequences was (at least partly) controlled by glacio-eustatic sealevel fluctuations.

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Fig. 1 Locality map of studied outcrops (arrows).

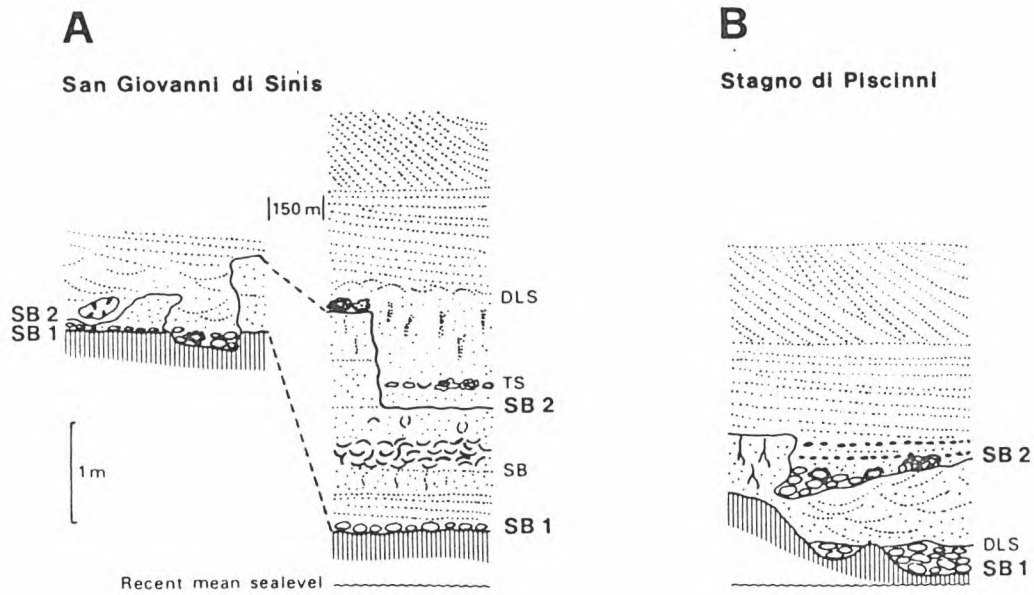


Fig. 2 Two of the studied sections, illustrating the two major depositional sequences. SB: sequence boundary; TS: transgressive surface; DLS: downlap surface; vertical hatching: pre-Tyrrhenian rocks.

A.T. SULTANOV

Higher Institute of Mining and Geology  
Sofia, BULGARIA

The rocky Black Sea coast between Cape Shabla and the village of Tyulenovo is built up of algal stromatolite limestones of Sarmatian age. Columnar stromatolite bodies with circular cross-sectional area have been found in the northern part of the profile. As the result of modern weathering processes these bodies have been greatly karsted, forming typical karrenfelds. Their sectional view shows a concentric-zonal structure. They reach 5 m in diameter. Columnar bodies, up to 2.5 m high, have been found in the southern part. On horizontal plane they are shaped like stripes which can be followed along several tens of meters. The bodies are elongated (up to 3-4 m long), their width generally being about 85 cm (rarely up to 1 m). The long axis of the bodies is oriented perpendicular to the ancient coastal line. The erosion channels between the stromatolite bodies and between the established stripes are filled with biomorphic material consisting of gastropods, foraminifers, bryozoans and shells cemented with small-grained calcite. Flint conglomerate fragments can also be encountered in the channels. The algal laminae are convex and determine the domelike structure of the stromatolite bodies with equally wide tops and bottoms. Their texture is defined by the irregular alternation of dark and light layers, commonly about 2-5 cm thick. Microscopic investigations have shown that the dark layers are composed entirely of filiform algal fragments with micrograined texture. Incrustations of small-grained calcite can be observed only in the pores. The light layers consist of irregularly oriented algal formations thus determining a particular clotted texture. The space between these formations is filled with shells of foraminifers and carbonate detritus cemented with small- to medium-grained calcite. Biomorphic limestones with abundant oncolites, up to 40 cm in diameter, lie over the stromatolite bodies. The morphology and structure of these stromatolite bodies show that they have formed in sublittoral environment during the transgressive development cycle of the Sarmatian Sea.

Shelf sand ridges, banks and sandwave fields from  
the Volgian-Valanginian Raukelv Formation  
Raukelv Formation of Jameson Land, East Greenland

Finn Surlyk and Nanna Noe-Nygaard

Geological Survey of Greenland and Institute for Historical Geology  
and Palaeontology, Copenhagen, Denmark

The coarse-grained sandstones of the Middle Volgian-Valanginian Raukelv Formation of Jameson Land, East Greenland show spectacular examples of large and giant-scale cross-bedding. The giant-scale cross-beds occur as single isolated sets 15-50 m thick, which can be followed over tens of kilometres. The cross-strata are sigmoidal and simple, or compound being internally composed of large-scale trough-shaped cross-beds. The set tops are glauconitized and burrowed by Diplocraterion habichi. Cross-strata may also show glauconite impregnation. Transport direction was towards the east at a right angle to the N-S trending basin axis. A diverse marine fauna of giant-scale bivalves, ammonites and crinoids characterizes the facies. The cross-beds are separated by sheets of tabular to trough cross-bedded co-sets 5-40 m thick. These units can also be followed laterally over tens of kilometres and the top of the co-sets is burrowed and impregnated with glauconite. Transport direction was towards the south or, in rare cases, to the north. A few levels of bioturbated muddy siltstones occur between the coarse-structured sandstone sheets.

Deposition of the Raukelv Formation took place in a system of eastwards migrating sand ridges, which eventually formed wide banks. Ridge building was followed by mainly southwards migration of sandwave fields. The water depth was below fair weather wave base and rate of deposition was slow, reflected by the glauconitized omission surfaces separating the sand sheets.

The new interpretation of the Raukelv Formation as representing relatively deep water shelf sand ridges, banks and sandwave fields allow a total reinterpretation of the correlative lower Hartz Fjeld Formation in Milne Land which was earlier viewed as stacked fan-delta deposits, and of isolated sets of giant-scale cross sets occurring in other Jurassic formations in East Greenland. Finally, the upwards transition over a few metres from the deep-shelf mudstones and turbiditic sandstones of the underlying Hareelv Formation to the Raukelv Formation does not require a sea-level drop of several hundred metres as would have been the case if the latter formation was of fan delta or very shallow marine origin.

**10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST**Sedimentological and Faciological Characteristics of the Senonian  
Pelagic Formation of Hungarian Plain

KÁROLY SZENTGYÖRGYI

Hungarian Hydrocarbon Institute

HUNGARY

Based on the data of hydrocarbon exploration wells the Senonian formations are known in two sedimentary belt in the region of Hungarian Plain. The lateral connections in the certain belts are cleared by the borehole data but the relationship and the palaeogeography of the two sedimentological zones are unknown so far.

The Senonian formations of northern sedimentary and facies belt in the middle part of the Hungarian Plain consist mainly reddish-brown, pelagic marl and calcareous marl with some limestone intercalations. From point of view of sedimentology the Upper Cretaceous sequence represent an independent sedimentary cycle.

The petrologically homogeneous sedimentary complex is known in a narrow zone of SW - NE (locality Izsák, Szolnok, Kisújszállás, Kunmadaras and Nádudvar).

The Upper Cretaceous formations in the middle part of Hungarian Plain facio- logically, lithologically and characteristics of microfacies content are similar with the formations of Carpathian Pieniny Klippen Belt of similar age (so call Puchov-type marl).

The reddish-brown, pelagic foraminifer rich sediments are of Campanian and Maastrichtian stages.

The Senonian sediments known from middle part of Hungarian Plain connect with Upper Cretaceous formations of same age and facies of Transcarpathian and Máramaros Zone.

Middle Cretaceous submarine channel-fill conglomerate  
in the Gerecse Mountains, Hungary

Orsolya SZTANÓ  
Department of Geology, Eötvös University  
H-1088, Budapest, Múzeum krt. 4/a  
HUNGARY

This presentation deals with a conglomeratic unit, named Köszörűkőbánya Conglomerate Member of the Lábatlan Sandstone Formation. The unique outcrop is situated near to Lábatlan. These sediments are known as the uppermost part of Lower Cretaceous coarsening upward clastic sequences of the Gerecse Mountains. The nannoplankton assemblage from the intercalated siltstone layers has proved Late Aptian - Early Albian age.

The alternation of poorly stratified conglomerates, greenish-grey sandstones and grey, laminated siltstones can be seen in the quarry. The stratified, medium-to-coarse grained sandstone is pebbly, sometimes massive. Thin strata of matrix supported, inversely graded conglomerate are also intercalated. Occurrences of solitary cross-bedding of trough or planar type refer to traction currents. In the conglomerate cherty pebbles are dominant, but cobbles and boulders of reefal limestone are abundant as well as large, up to 2m long, intraformational rip-up-clasts of underlying sandstone and siltstone. The clast supported, imbricated and graded conglomerate of channel-fill origin was incised into the underlying siltstone, producing scour marks. The upper conglomerate bed, which consists mainly of limestone pebbles, is excellently graded. Slump structures referring unstable palaeoslope environment also occur.

The angle of imbrication, the mean and the maximum particle size were measured in the field. The angle of a/p/a/i/ type imbrication was plotted on a lower hemisphere stereonet that indicated palaeocurrent direction from NE to SW. Taking the palaeomagnetic data into consideration the palaeodirection must have been from SE to NW.

All these features suggest sedimentation in a channel of an upper (-middle) fan by high-density gravelly and sandy turbidity currents, which resedimented the deposits of the shelf edge.

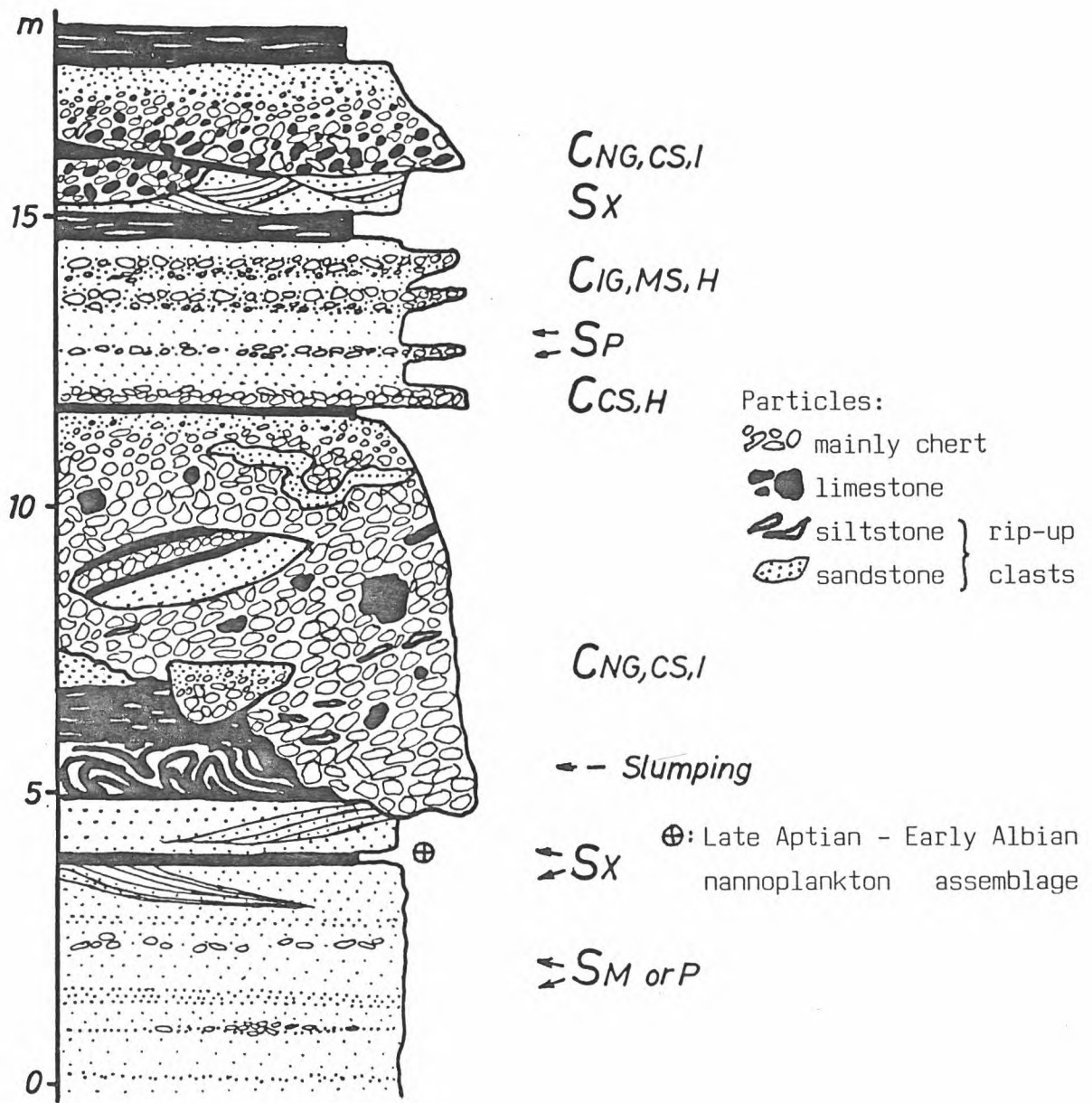


Fig. 1.

Schematic section shows the most important sedimentological and lithological features of Köszörükőbánya Member. C= conglomerate: NG= normal-, IG= inverse graded, CS= clast-, MS= matrix supported, I= imbricated, H= subhorizontal clasts; S= sandstone: P= pebbly, M= massive and X= cross-stratified.

Sand waves in the Early Miocene Pétervására Sandstone,  
northern Hungary

Gábor TARI, Szabolcs LEÉL-ŐSSY and Orsolya SZTANÓ  
Department of Geology, Eötvös University  
H-1088, Budapest, Múzeum krt. 4/a  
HUNGARY

The Pétervására Sandstone Formation (PSF), cropping out over some 1,000 sq km in northern Hungary is of Lower Miocene ( Eggenburgian ) age and ranges in thickness up to 800 m /1/. It is composed of fine- and medium-grained monocrystalline quartz sand which often contains intrabasinally reworked glauconites. Thin silty and calcareous silty intercalations are common as well as mud-clasts, chert pebbles and shell debris. Except for some small pectinids and shark teeth, the lower part of the formation is almost barren of fossils, but the uppermost 100 m is always fossiliferous ( *Ostrea* - *Chlamys* - *Balanus* assemblage ) /1/. Tuffaceous material ( bentonite fragments, redeposited biotites ) is occasionally incorporated into the upper part of the PSF.

The most striking and predominant primary sedimentary structure is the large-scale tabular cross-stratification attaining 8 m in height. The ebb-oriented foresets, dipping northward, indicate a highly asymmetrical tidal influence during deposition /2/. Some of this sand waves show cyclical variation in bundle thickness suggesting diurnal spring-neap tidal periodicity /3,4/. The tide-dominated sedimentary environment is also supported by the frequent occurrence of mud drapes ( 1-5 mm thick ) associated with cross-stratification of smaller scale ( 0.2-0.5 m ).

We speculate that the deposition of sand waves of PSF is related to the world-wide Early Miocene transgression /5/. This eustatic sea-level rise flooded the elongated Alpine foredeep /6/ and as a result, the Tethyan

link become even stronger with the Eoparatethys. The narrow seaway, connecting the peri-Alpine depression with basin of the PSF in the backland area of the uplifting West Carpathians, must be assumed through the Austro-Vienna basin.

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10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989

Sedimentology of the Middle Eocene Szőc Limestone  
Formation of an investigated area in the northern  
Bakony range (Transdanubia, Hungary)

by

Kálmán Tóth

Hungalu Bauxite Prospecting Co. Balatonalmádi HUNGARY

The area in question is located between two Middle Eocene basins in the NE-SW strike zone of the 3-4 km wide Dudar-Bakony-ozslop-Csetény bauxite occurrence.

The sequence of layers in the basins consists of coal bearing complex with clayey marl and foraminiferous (partially Globigerina) marl layers of brackish water in its cover. Although the Eocene layers of the area are almost of limestone facies. The area is well prospected by bore holes (The drilling grid is 50 m on the bauxite deposits). Coal bearing complex occurs locally only, (sometimes not exceeding an area of 250 m<sup>2</sup>), and usually it is setting on bauxite. Bauxite, coal and mostly dolomite and in a smaller part dachstein limestone are the bedrocks of the Szőc Limestone Formation. This formation in this area includes only the horizons of Nummulites perforatus and N.millecaput. Inside this formation several facieses can be separated as follow (Explanation of facieses are after Wilson's standard facieses):

- laminated limestone= shelf lagoon of restricted circulation
- Rotalia or small Nummulites bearing limestone = edge facies of shelf lagoon
- Miliolina limy marl, limestone, Miliolina-Alveolina limestone, Alveolina limestone, bauxitic Miliolina marl, Alveolina limestone with bauxite debris = shelf lagoon of open circulation
- biodetritus limestone = winnowed edge sand and/or foreslope sand
- coral limestone, coral-Lithothamnium limestone =organic

build up.

- Limestone with dolomite debris, limestone with bauxite and dolomite debris, limestone with debris of dachstein limestone, limestone with pebbles of bauxite and dolomite = foreslope and/or abrasion zone
- large Nummulites limestone = open sea shelf

The poster shows the microfacies-types in particular, the arrangement of facieses in space, the circumstances of sedimentation of the self-plateau on the basis of constructed facies-profiles and the morphology of the pre-Eocene terrain.

This morphology, can be determined in absolute value too, as compared it to the "quasi-plain surface" of the relatively well defined limit of almost complete Eocene sequences of Nummulites perforatus and N. millecaput horizons. In areas of non complete sequences, because of their denudation, the relative morphological position can be modelled just by the verification of immediate cover facies of the basement. Depressions are marked by laminated limestone and/or Miliolina limestone, Alveolina limestone, while hillocks by large Nummulites limestone, setting immediately (closely) on the basement.

There is close connection among certain cover facieses and bauxite occurrences. Laminated limestone and partially Rotalia bearing small-size Nummulites limestone are connected with bauxite Miliolina marl, which contains bauxite material in pelitic-aleuritic grain size, are known to be definitely as indicators of the presence of a bauxite -trap.

The facies-analysis method can be practically applied in bauxite prospecting on the basis of its role marking bauxite bearing traps.

Sedimentary Analysis of an Upper Jurassic Calcareous oolite,  
Villány Mts., South-Hungary

ÁKOS TÖRÖK

Budapest Technical University, Dept. Mineralogy and Geology  
H-1521 Budapest, HUNGARY

The calcareous oolite /lower part of Szársomlyó Limestone F./ discordantly overlies the famous Bathonian-Callovian iron-oolitic and stromatolitic layers which contain the rich and well-known ammonite fauna of Villány. On the karstic top of the Upper Jurassic limestone lies bauxite and the Lower-Middle Cretaceous pachyodont limestone. The detailed investigation concentrated on the lower 20m of the Upper Jurassic formation.

The oolitic packstone and grainstone are the typical microfacies types of this rock. The characteristic microfacies elements are the followings:

--Ooids:

1. well rounded tangential micritic ooids with thinly laminated cortices
  - a, with micritic nucleus covered by narrow sparitic and finally the top, wide, micritic rim
  - b, with micritic core without sparitic inner rim
  - c, with homogeneous micritic internal structure
2. irregular micritic ooids with thinly laminated cortices
3. half moon ooids

--Intraclasts: well rounded micritised ones

--Skeletal grains: ostracods, echinoderm fragments and radiolarians are the most frequent.

The fauna shows a duplicity since shallow marine bioclasts as ostracods and coral debris occur together with pelagic organisms as ammonites, belemnites and radiolarians. Brachiopods bivalves and gastropods can be observed sporadically. The macrofossils usually occur in patches which have a close connections with stylolites, calcite veins and brecciation.

The microfacies characters and faunistical evidences indicate the following facies model: the Upper Jurassic calcareous ooids were formed on a platform edge and continuously redeposited towards the foreslope. The transported ooids mixed with the pelagic faunal elements on the slope. The lack of cross bedding /which indicates the oolitic shoals/, the presence of intraclasts and pelagic organisms support this interpretation. We must suppose a very narrow platform margin on which the ooids could cross, and a rather long distance from the source of terrestrial material influx /no quartz nucleus occur/. The autochthonous organic reef of the platform is unknown. The facies has a probable simmilarity to "pelagic ooids"/Jenkyns 1972/.

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10th REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
The role of Bulgarian Black Sea coast's landslides in  
accumulation of heavy minerals

VENDULKA TSVETKOVA-GOLEVA

Geological institute of Bulgarian Academy of Sciences  
BULGARIA

Systematic studies on processes of accumulation of heavy minerals on different types of coast along the Black Sea revealed the specific role of landslide related beach sands as a concentrator of heavy components. This stimulated detailed investigations of landslides terrains in view to explain the nature of this undescribed until now geological phenomenon in the accumulation processes and formation of placer deposits (Tsvetkova-Goleva & Simeonova, 1984).

The studies of different coast sectors cover regime sampling along observation profiles. The sampling within the landslide bodies was done likewise along profiles which cover individual landslide cycles. Core material from preliminary boreholes was quartered and subjected to a complete grain sizing separation.

The problem is studied on the example of Sarafovo landslides (N of Bourgas) which reveal the complete spectrum of phenomenon. They show the following features:

The landslide accumulative sectors of the beach sands show unusually high content of heavy fraction (total of heavy and magnetic fraction). The concentration is 80 - 90 %.

A group of proofs summarizes results of heavy component variations during a 10 years period of observations.

The profiles studied along the whole body of the landslide include individual cycles of the sliding process.

A comparison of two contrastig profiles indicated simila-

rities in the accumulation of the heavy component. It occurs mainly in the initial phases of the sliding process into the brown clays and the content gradually decreases towards the later cycles.

The quantitative differences may be complemented by some qualitative ones which refers to the spectre of composition of heavy minerals, currency, appearance of autogenic ore aggregates of minerals.

The established high concentration of heavy minerals in the sediments of Sarafovo landslides indicated their important role as a source of heavy minerals in the beach sands and in the aquatory

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Triassic (Upper Muschelkalk) reef-mud mounds, Catalan Basin, Spain: early marine diagenesis and dolomitization

MAURICE TUCKER  
Univ. of Durham  
ENGLAND

FRANCESC CALVET  
Univ. of Barcelona  
SPAIN

JIM MARSHALL  
Univ. of Liverpool  
ENGLAND

In the Upper Muschelkalk (Ladinian) of the Catalan Basin, reefal complexes are prominent in the Prades Domain near Tarragona and they are completely dolomitized. Mud mounds developed upon a carbonate ramp in moderate water depths and they evolved into more complex facies mosaics as they grew into shallow water. They range from isolated, circular structures a few 100m across to elongate ridges parallel to the palaeo-strike of the basin. They reach 60m in height and while growing, virtually nothing (0.1m) was deposited in the inter-mound areas. The mound core is composed of massive peloidal skeletal mudstone and wackestone although packstone and even locally grainstone do occur. The mound core, with scattered bioclasts and Tubiphytes passes up into a skeletal-rich reef facies which in places is a framestone-cementstone microfacies. This more reefal facies may also occur on the flank of the mound. Corals, bryozoans, sponges, microbial laminated crusts and calcareous algae are common framebuilders and binders, and molluscs and foraminifera are also present. Peloidal grainstone lenses are common in framestone-bindstone microfacies and fibrous marine cements are conspicuous.

The upper parts of these reefal complexes consist of well-bedded dasyclad grainstones and peritidal stromatolitic, fenestral, intraclastic and pisolitic dolomites. Flank facies are poorly-developed in some reefs whereas in others, much flank progradation has taken place and clinofolds are prominent. Sediments are peloidal, skeletal packstones; dasyclads are common as are corals and crinoids, and lenticular, muddy flank patch reefs are also present.

The reefal complexes were subjected to exposure, limited erosion and karstic dissolution as a result of a major sea-level fall. After the subsequent sea-level rise, a laminated deposit, the Pedra d'Alcover, was deposited in the inter-reef areas, onlapping and then overlapping and burying the reefal-mounds. Hypersalinites periodically existed during deposition of the lower Pedra d'Alcover as evidenced by horizons of replaced evaporites.

The diagenesis of the reefal complexes is noteworthy for the early marine cementation, the meteoric diagenesis in reef-top strata and the dolomitization, which is pervasive. The reef framework facies has two distinctive types of marine cement (both dolomitized): fibrous calcite and botryoidal aragonite.

The fibrous calcite occludes small cavities in the reef framestone and lines larger cavities with isopachous fringes. However, some fibrous calcite cement layers are not isopachous, but show thickness increases into cavity corners and the filling of subcavities off major ones first. Although dolomitized, these columnar crystals preserve all the usual undulose extinction and curved twin plane fabrics of many fibrous calcites. They were probably high Mg calcite originally. Many of the peloids within the reef framework facies could also be precipitates. The botryoidal aragonite forms mamelons with fibres up to 50mm long and they

fill large cavities in the reef framework. They were precipitated after the fibrous calcite and in some instances there is a suggestion of a phase of dissolution before aragonite botryoid precipitation. This could relate to the drawdown which affected the basin, with the aragonite being precipitated when the reef-mounds were submerged again. The mud mound core facies does contain many vugs from evaporite dissolution and coarse dolospar and quartz pseudomorphs after gypsum-anhydrite. There was clearly an early phase of evaporite replacement (not displacement) and this probably took place after the exposure and reflooding of the basin, at a time of hypersaline waters during deposition of the Pedra d'Alcover.

The main phase of pervasive dolomitization was early and near-surface, as shown by compactional fractures cutting the dolomite mosaic and filled by coarse dolospar. The excellent preservation of grains and cements originally of calcite, probably high Mg, and the poor preservation of originally aragonitic skeletons, also support an early event. It is likely that dolomitization took place before the complete exposure of the reefal complexes and the paleokarstification. If the reefal complexes had been limestone when emergent, then much more extensive vuggy porosity would have developed; the mineralogy (HMC and A) would have stabilized to low Mg calcite and subsequent dolomitization would have been very fabric destructive. The dolomicrite of the reef-top laminites could be evaporative, supratidal dolomites, but the mechanism of dolomitization of the reefal complexes as a whole is unclear. Possibilities are: (1) dolomitization by seawater being pumped through the reefal mounds when reef-top peritidal facies were being deposited, (2) brine reflux during reef-top peritidal deposition, or (3) meteoric-marine mixing-zone dolomitization during reefal mound exposure.

Oxygen isotope data from the dolomitized mound core facies and aragonite botryoids have an average  $\delta^{18}\text{O}$  of  $-2.6\text{‰}$ , with most values being in the narrow range of  $-2.1$  to  $-3.3$ . Carbon values are mostly in the range of  $0.7$  to  $2.4$ , with the average being  $1.4\text{‰}$ . This is a typical marine signature. Several analyses give negative values down to  $-3.1$ , suggesting some organic influences. Two analyses of the Pedra d'Alcover average  $\delta^{18}\text{O}$   $-3.8$  and  $\delta^{13}\text{C}$   $-0.7\text{‰}$ . Taking into consideration the  $\delta^{18}\text{O}$  of Triassic seawater and the probability of higher seawater temperatures in the Triassic, the  $\delta^{18}\text{O}$  values of these Muschelkalk dolomites are quite negative and suggest either seawater or mixing-zone dolomitization. For comparison, Keuper marine dolomites of evaporitic origin have  $\delta^{18}\text{O}$  of  $+1.5$  to  $+4$  per mil. Some recrystallization of the Muschelkalk dolomite is a possibility.

These Upper Muschelkalk reefal complexes have been subjected to many phases of early diagenesis: seafloor cementation, emergence and karstification, dolomitization, either by seawater pumping or mixing-zone migration during basin drawdown and local evaporite replacement.

Development of Jurassic carbonate sedimentation in the  
Choč unit, the Tatra Mts., Poland

ALFRED UCHMAN

Jagiellonian University

POLAND

The Choč unit consists of the Anisian - ?Middle Jurassic rocks. Jurassic section is represented by typical Alpine limestones /about 300 m in thickness/, showing mosaic facies changes. There are: peloid limestones with ooids /?Lotharyngian/, zoogenic /Hierlatz type/, crinoidal and cherty limestones /?Lotharyngian - Domerian/, and red pelagic limestones /Middle Jurassic/. Zoogenic limestones consist of crinoidal limestones bearing shallow - water brachiopods and pelecypods shells. Cherty limestones are siliceous crinoidal limestones interbedded with spongiolites.

Gradual passing of the zoogenic limestones through the crinoidal limestones to cherty ones is visible in the same horizon. Red limestones are composed of micrite sediments bearing ?planctonic foraminiferes and locally filaments deposits. Those deposits occur also in neptunic dykes inside the zoogenic limestones.

The character of deposits and faunas suggests that sediments forming the peloid, zoogenic and crinoidal limestones were previously deposited in shallow - marine conditions. Distribution of facies and their thickness suggests that those sediments were transported down, into deeper - marine environment, where the spongiolites were deposited. Shallow - marine sedimentary environments were represented probably by sea - mounts, formed during the Thethys ocean opening, beginning from the end of the Triassic. Sediments were transported down, filling intra - seamounts basins. The upward increasing amount of deeper - water cherty limestones and occurrence of red pelagic limestones, suggest the sinking of this seamounts following a widely known trend in development of the Thethys embraced also the Tatra Mts.

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Depositional geometry of prograding carbonate sands along the upper  
slope of Maiella carbonate platform (Central Italy)

ADAM VECSEI and GREGOR P. EBERLI  
Geological Institute, ETH-Z, CH-8092 Zürich  
SWITZERLAND

During the Late Cretaceous, progressive infilling of the basin adjacent to the Maiella carbonate platform resulted in a change from (1) onlapping carbonate turbidites intercalated with pelagic "Scaglia" deposits and several megabreccia beds to (2) prograding carbonate sands of Maastrichtian age. The wedge-shaped sheet of redeposited carbonates along the upper slope of Maiella platform records the poorly known depositional environment at the platform-basin transition. These carbonate sands were shed from the platform top and deposited in a wedge along the platform margin and the upper slope. Apparently uniform beds reveal a complicated depositional geometry resulting from a combination of migrating channels of variable size and sheetlike sand flows intercalated with large breccias.

Over an area of 10 by 7 km, the sand bodies are continuously exposed along three valley flanks trending approximately perpendicular to the platform margin. The thickness of the carbonate sand sequence ranges from 0 to 150 m at its onlap onto shallow-water rudistid grainstones and biostromes; the thickness increases to about 250 m in 5 km distance from the onlap contacts. The onlap contacts onto the platform are characterized by bed dips up to 45° decreasing to 10° as infilling of the basin continued.

The wedge-shaped sand sequence is subdivided into composite megabeds of 15 m to 30 m thickness. Each megabed itself consists of a series of thinner redeposited beds. The individual beds are arranged as sigmoids, which prograde basinwards downlapping onto the surface of the underlying megabed and show toplap upper terminations. The sigmoids are about 50 m long in dip direction; they dip up to 10° in their foreset parts whereas the megabeds they are forming dip maximally a few degrees. Low-angle cross-bedding is formed at the intersection of prograding sets of sigmoids each measuring up to several 100 m in width. The megabeds are composed of mutually erosive channels and sheetlike sand-flow deposit. The channels occur at all levels within the megabeds; their width ranges from 1 m to several hundreds of meters while their depth reaches only few tens of meters.

They are filled with unsorted coarse sand and pebble-sized angular clasts of mainly rudistid debris and of finer grained, rounded sand clasts. Larger channels additionally contain meter-sized angular boulders eroded from the channel flanks. The channels show multiple infilling events and extensive migration.

The interbedded sand beds show a characteristic distribution of grain size and bed thickness within the sigmoids. The topsets and the upper part of the foresets are composed of normally graded coarse and middle sand derived mainly from the erosion of rudistid platform facies, as well as some orbitoid foraminifera and rounded sand clasts. Beds are 0.2 m to 1 m thick. Unsorted pebbles and sand are found at the base of the foresets, ending downdip with a sharp contact. Below this contact follow the bottomsets, which consists of a 1 cm to 4 cm thin bed of fine sand and silt.

Restricted to the uppermost slope are intercalations within the carbonate sands of breccias, up to 15 m thick and with a limited width varying around 50 m. Besides some rip-up clasts, erosion at the base is minor. The unsorted breccias form a positive relief. The grain size varies from sand to boulders up to 10 m in diameter. The components are blocks of rudistid reefs, shallow-water grainstones and biogenic debris indicating erosion of material from the platform edge.

The wedge of redeposited carbonates at the platform-basin transition of Maiella platform is arranged in apparently uniform megabeds. The internal geometry, however, reveals prograding sigmoids as thick as one megabed. Abundant channeling at all levels indicates that sediment was transported through feeder channels to the front of 15 m to 30 m high, coalescing lobes. Faint grading within the sand beds suggests a process between density-modified grain flow and turbidity flow as transport mechanism. The vast amount of rudistid debris in all grain sizes suggests an intense reworking of the rudist reef material. Large breccias with a positive relief might represent local slumping deposits triggered by platform margin instabilities. The internal geometry of the carbonate sand wedge documents that sheetlike distribution of sands along the upper slope is the result of a network of channels feeding small prograding lobes.

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Morphology of the continental slope and structure  
of Holocene sediments in the Western part of the  
Black Sea

Venelin Velev  
Institute of Oceanology  
Bulgaria

A characteristic feature of the Western part of the Black Sea is the simplified morphologic profile of the basin space which consists of shelf, continental slope, continental uprising and abyssal bottom. There are no "transitional zones" as: barrier island systems, deep sea trenches, abyssal troughs. All this makes the Black Sea a suitable model for studying the basin-fill geometry and the structure of sedimentary units.

The continental shelf in the Western part of the Black Sea is loaded mainly by sediments deposited by the Danube River and the Southern Stream, which is the dominating hydrodynamic agent.

The continental slope takes shape at a depth of 150-200 m and has a generalized morphologic profile of a concave type. Its upper part is steeper and has more or less differentiated topography, which is due to the combined action of erosional, slumping and fault phenomena. The studies that have been carried out for the recent 3 years, including echographic, sparker and geological activities, specified to a considerable extent the existing notion of floor topography and the structure of the Holocene deposits. Over the most part of the continental slope a complicated network of submarine valleys and canyons is developed. By its configuration the continental slope is divided into three regions: Southern, Central and Northern. Secondary slope ridges divide the Southern and the Central regions into smaller area-subregions. The maximum length of the most prominent valleys sometimes is above 50 km. Some valleys are linear, without affluents, so their development is probably predestined by the lineament tectonic. Most frequent are the submarine valleys on the slope between cape Maslen nos and cape Emine. By other hand the segment between villages Obzor and Bliznatsi remains undisturbed by the submarine valleys and canyons.

Continental slope passes into narrow continental rise (on a depth of 1700-1900m), and then - into large and flat basin floor. The Holocene deposits of this region consist of two lithostratigraphic units: nannofossil ooze (I) and sapropelic low-carbonate mud (II). Both units are enriched with organic matter, but sapropelic mud contains up to 3-4 times more organic carbon. The coloured and thin-layered

Holocene sequence allows to observe clearly the texture characteristics of the sediments, which are traced upwards to the edge of the shelf. Linkage with shelf deposits (po- or in organic carbon - 1+2 %) is rarely observed in the space between pre-Holocen relict barriers accumulated on the outer shelf. The quantity of organic carbon in sediments clearly increases downward and in the continental rise it reaches 10-15 and more per cent (by dry weight). By their structural and textural peculiarities the Holocene sediments belongs to several facial areas.

1. Area of predominantly nepheloid deposition. Spread on the upper part of the continental slope; characterized by clinoforn position of the units, pinching out on the accumulative ridges of outer shelf. The structure of sediments is aleuro-pelitic and the texture is unclearly laminated along the whole depositional sequence.

2. Area of mixed (nepheloid-pelagic-mass transport) deposition. In the Holocene profile an alteration of fine-grained delicate laminated and massive or friable layers is observed. The latter are formed of enriched in organic matter and highly fluidized deposits, which are resedimented, moving down the slope under the influence of gravitation. The bottom level of the sequence is always thin-bedded. This area is situated mainly on the upper and central part of the continental slope.

3. Area of predominantly mass flow sedimentation. It is characterized by domination of deposits, which are formed on the account of gravity mass transport: slides, slumps, debris-, grain- and mud-flows sediments. Thus, thick sequences with the appearance of condensed breccia are formed. The thus formed sequences are covered with a nepheloid-layer deposits. The area is spread over the central and lower part of the continental slope.

4. Area of submarine-fan sedimentation. It is located at the mouths of submarine valleys and receive the bulk of sediments by means turbidity currents and gravity mass transport. Unlike the previous area here the normal stratigraphic succession in the sequence is disturbed. The basic part of the sedimentary sequence is represented by debris flow and mud-flow deposits, connected with lithologic material, generated on the shelf (outer shelf) and the continental slope.

Clay mineralogy of genetic types of Hungarian sedimentary  
rocks

ISTVÁN VICZIÁN

Hungarian Geological Institute

HUNGARY

The results of more than 10 thousand X-ray analyses and published data on clay minerals in sedimentary rocks of Hungary were collected. The sedimentary formations were arranged in 7 groups according to their environment of formation:

1. Fossil weathering crusts and soils. From  $T_3$  to  $M_1$  they contain predominantly kaolinite /e.g. Ladinian in Mecsek Mts., clays underlying the Senonian Ajka Coal Formation,  $K_3$  to E bauxites and  $K_3$  to  $M_1$  fire clays in Transdanubia/. Upper Pannonian variegated clays of the Great Hungarian Plain as well as red clays /terra rossa/ are of variable composition containing much smectite and illite.

2. Eolic, periglacial sediments. Q loess, covering wide areas of Hungary is of polymineralic composition depending on the lithology of local source areas. Kaolinite is rare in Hungarian loesses.

3. Sediments of fresh-water lakes and swamps. Coal deposits contain mainly smectite and poorly crystalline kaolinite and their interstratifications /e.g. Senonian Ajka and  $M_1$  Sajó Basin coal deposits/. Diagenesis leads to the transformation into the association illite+illite/smectite+kaolinite /e.g. Liassic coals of Mecsek Mts./.

Upper Pannonian / $Pl_2$ / lacustrine clays and marls contain detrital, well-crystallized illite+chlorite and interstratified illite/smectite.

4. Chemical sediments in lakes. Sediments of Sarmatian / $M_2$ / limnic basins on volcanic terrains of the Tokaj Mts.

include commercially exploited deposits of illite /Füzér-radvány/, bentonite and kaolin /e.g. Rátka/.

5. Fluvial sediments. In deltaic sandstones /O<sub>1</sub>/ of Cserhát Mts. important kaolinitic clay deposits are mined. Clay content of Upper Pannonian /Pl<sub>2</sub>/ fluvial sediments is similar to lacustrine ones.

6. Detrital marine sediments. In many tectonic cycles a sequence from coastal areas to open sea can be observed. Dominant clay minerals of the individual facies zones are kaolinite, illite, smectite, respectively /e.g. J of Mecsek Mts., Oligocene and Miocene cycles in Northern Hungary etc./.

From M<sub>2</sub> to Q kaolinite is less frequent.

7. Neof ormation and chemical sediments in marine basins. In evaporitic sandstones and marls of T<sub>1</sub> in Mecsek Mts. illite, chlorite and corrensite were formed. K<sub>1</sub> basalts in submarine environment have altered to nontronite, saponite and chlorite. Tertiary acid tuffs frequently contain zeolites /e.g. clinoptilolite and mordenite/ and smectite.

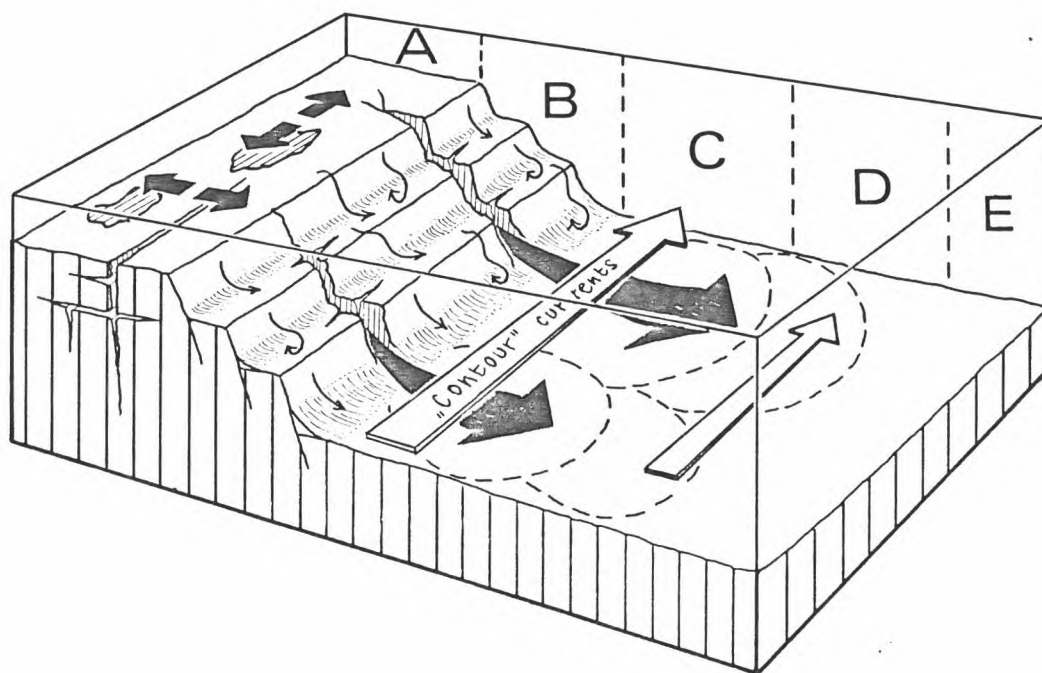
In tectonic zones hydrothermal alteration leads to the formation of well-crystallized kaolinite and dickite /e.g. mobile zones S and W of Lake Balaton/.

Abbreviations: T: Triassic, J: Jurassic, K: Cretaceous, E: Eocene, O: Oligocene, M: Miocene, Pl: Pliocene, Q: Quaternary.

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Fault-scarp controlled carbonate sedimentation in a Tethyan Jurassic seamount  
area (Bakony, Hungary)

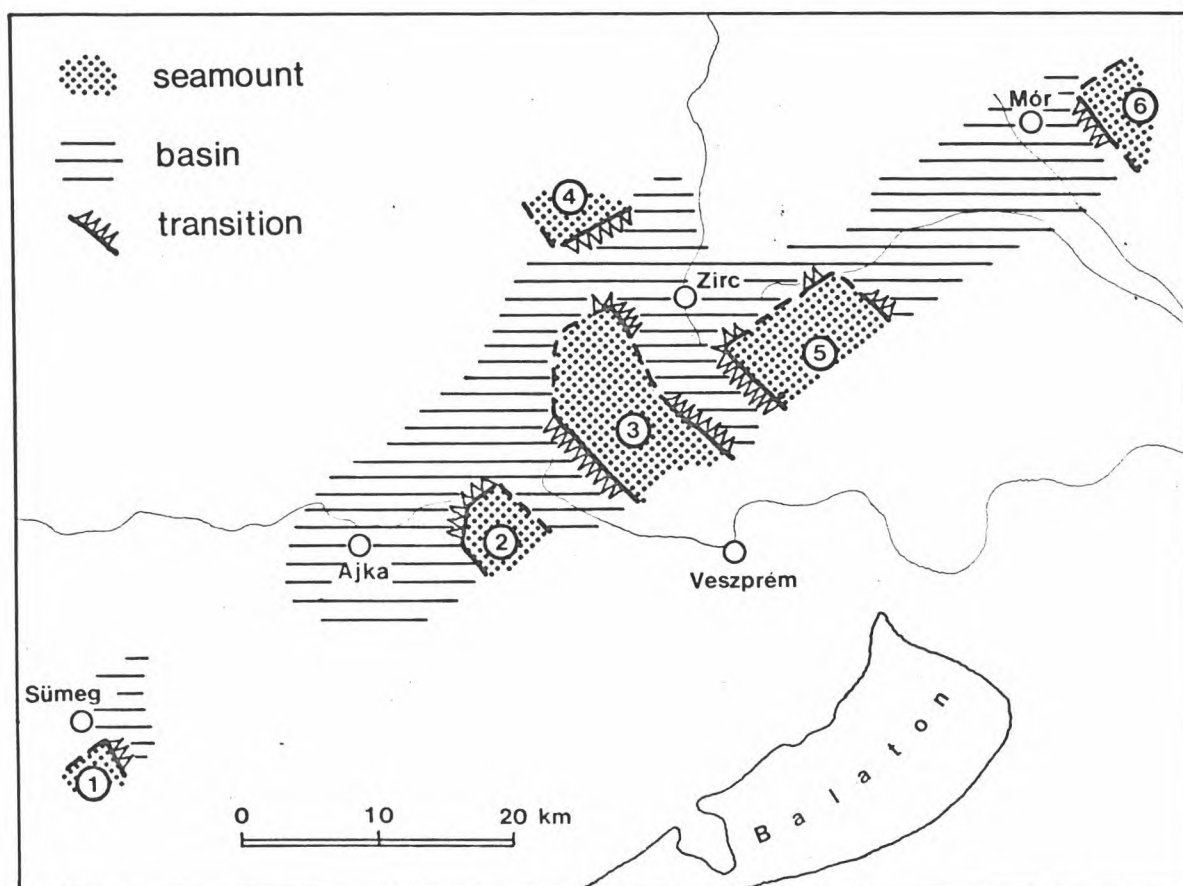
ATTILA VÖRÖS  
Hungarian Natural History Museum  
HUNGARY

In the Bakony area the "Hauptdolomit + Dachsteinkalk" carbonate platform of Norian and Rhaetian times was drowned and became dissected by normal faults in the Hettangian. The tectonic movements and block-faulting were repeated several times during the Jurassic and resulted in a basin-and-seamount bottom topography. The paleogeographical features are well mirrored by the distribution of the various Pliensbachian limestone types. The five main types of limestones correspond to five depositional environments which differed partly in depth and partly in distance from the submarine fault-scarps (Fig. 1):



(A) Red, manganiferous limestones - seamount top, where sediment accumulation was possible only in local depressions or in episodic neptunian dykes. (B) Scarp breccias + "Hierlitz" limestones - seamount slope and foot. The steep escarpment formed by normal faulting was largely non-depositional. Loose blocks of the basement (usually "Dachstein"-type limestone) together with larger shells

and skeletal fragments of organisms which lived on the top or slope were carried down by gravitation and accumulated on the steps or at the foot of the seamount. Occasionally, mass-flows started toward the basin. (C) Crinoidal limestones - transition to basin interior. The peripheral areas of the inter-seamount basins received the proximal (mainly crinoidal) parts of the mass- or grain-flows arriving from the seamounts. "Contour" currents might spread the finer debris over larger areas. (D) Spiculitic cherty limestones and (E) ammonitico rosso limestones - basin interior. The distal parts of the grain-flows were deposited here, frequently interfingered with the pelagic lime muds. Reworking by bioturbation might be strong.



On a tentative Pliensbachian paleogeographic map (drawn on the basis of the above principles)(Fig. 2) six seamounts and an intervening system of basins appear: (1) Mogyorósdomb seamount, (2) Kakastaraj sm., (3) Hajag-Papod sm., (4) Kőrishegy sm., (5) Ámos sm., (6) Vértes sm. This paleogeography remained practically constant up to the end of the Jurassic; repeated tectonic movements along the fault-scarps triggered several major mass-flow events.

## 10th REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989

Basal conglomerates of the Gosau Group (Senonian) of Austria:  
alluvial sedimentation in small rapidly subsiding, fault-bounded basins.

MICHAEL WAGREICH  
Institute of Geology  
University of Vienna  
AUSTRIA

Within the Northern Calcareous Alps the sediments of the Gosau Group (Coniacian to Eocene) unconformably overly eoalpine-deformed Permotriassic to Lower Cretaceous rocks. The sedimentation of the Gosau Group marks a new sedimentary cycle after a major thrust movement within the Northern Calcareous Alps during the mid-Cretaceous. Basal coarse-grained sedimentation is the result of the sedimentary infill of small, rapidly subsiding basins between more stable areas.

The basal sediments of the Gosau Group are mainly alluvial and fan-delta deposits. The alluvial facies can be divided into (1) proximal and distal alluvial fan deposits of cohesive and non-cohesive debris flows, sheet floods and immature braided streams (mainly sheet and longitudinal (bars). (2) "mature" braided stream deposits with sediments mainly of longitudinal and transverse bars and (3) minor lacustrine deposits (clays or marls with freshwater molluscs, sandstones, bioturbated siltstones and coal seams).

Sequences occur at two different scales:

- Fining-upward sequences up to 10 m thick are interpreted as results of "autocyclic" alluvial fan and braided stream processes.
- 10 to 30 m coarsening-upward and coarsening-fining-upward sequences reflect the influence of tectonic movements at basin margin faults, which cause a steepening of the relief and progradation of the coarser fan facies (often debris flows) onto sediments of the lower fan-braided stream environment.

Within the type locality of Gosau (Upper Austria) an elongated, E-W trending basin about 10 to 20 km length and 5 to 10 km width can be reconstructed. Sedimentation rates of 10 to 50 cm in 1000 years could be estimated. Subsidence analyses indicates a first sudden subsidence phase with sedimentation of alluvial conglomerates followed by slow declining subsidence with sedimentation of marine marls. Several arguments point to oblique slip fault movements as the major process of basin initiation.

Within different Gosau basins (e.g. Gosau, Fahrenberg, Woerschach, Lilienfeld) highly variable proportions of debris flow versus waterlaid sediments could be observed within the proximal alluvial fan environment. The occurrences of debris flows seem to be controlled by both source rock composition and the steepness of the local tectonic relief.

Sedimentary evolution and provenance of South Alpine flysches: Palaeotectonic implications.

W. Winkler & D. Bernoulli  
Geological Institute  
ETH-Zürich  
Switzerland

The Lombardian Flysch of the Southern Alps records orogeny, uplift and erosion in the Austroalpine/South Alpine realm of the South-Tethyan margin in Late Cretaceous times. The terrigenous flysch sediments overlie a deepening upward pelagic to hemipelagic sequence of Jurassic to Mid-Cretaceous age deposited on the submerged distal continental margin of the Apulian (Adria) promontory or microplate. They cover the time interval from Late Cenomanian to Campanian. After recession of the turbidite fans in Campanian hemipelagic base of slope sedimentation resumed in Early Maastrichtian.

Sedimentologic and petrographic analysis reveal a variable sedimentary pattern of prograding and recessing fans in time and space. Heavy mineral data indicate two distinct source areas, both situated to the North and Northeast of the E-W trending flysch basin.

The Sarnico Sandstone and Piano di Sirone Formations (Turonian-Early Santonian) represent a prograding fan system and are characterized by a heavy mineral assemblage of mainly apatite, zircon, tourmaline and rutile derived from low grade metamorphic continental crust as exposed in the eastern Southern Alps and in contiguous sections of the Eastern Alps. The heavy mineral association corresponds to that of the coeval Austroalpine flysch formations and the fan progression reflects the peak of uplift along the Austroalpine/South Penninic convergence zone.

The heavy mineral assemblages of the other flysch formations (Flysch rosso, Formazione di Pontida, Varesotto Flysch, Flysch di Bergamo and Coldrerio Flysch) are mainly composed of garnet, staurolite associated with minor kyanite and sillimanite as well as with small amounts of tourmaline, apatite, zircon and minerals of the  $TiO_2$ -group. This indicates a main derivation of the material from amphibolite-grade metamorphic rocks. Variscan medium grade basement rocks today occur in the Strona-Ceneri Zone of the Southern Alps but also in Austroalpine units to the North such as e.g. the Silvretta Nappe. The source area may thus have been situated in the present day Southern Alps or in their northern neighbourhood, now separated from the Southern Alps by the Tertiary Insubric Line. In any case the content of the flysch sequences documents erosion of the km-thick Mesozoic continental margin sequence and exposure of the South-Tethyan Variscan basement during the Late Cretaceous orogeny.

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Sedimentology of Devonian and Carboniferous deposits in the  
Opawskie Mountains, Poland

ANDRZEJ WOJCIK  
Dept. of Geology  
Szttygarka-School of Mines  
27 Stycznia 69  
41-300 Dabrowa Gornicza  
Poland

The Opawskie Mts. are built up the Devonian and Lower Carboniferous deposits /graywackes, conglomerates, silstones, claystones, limestones/. There was a bathymetrically much differentiated basin and shallow water sedimentation prevailed in some parts of the Culm flysch succession.

The claystones and limestones of Devonian age consist of supramature clastics derived from the strongly weathered, flat source area. Deposition was affected by normal traction bottom currents rather than by turbidity currents. The invasion of the Culm facies /graywackes, claystones, conglomerates, silstones/ suddenly contributed rapidly erodes immature clastics from this highly uplifted source area. Afterwards, the sediments became progressively mature throughout the Culm succession until the Upper Carboniferous.

All these sediments were subject to varying metamorphism ranging from anchimetamorphism to the epizonal grade.

Geological characteristics of Silurian deposits in the  
Myszkow-Zawiercie area /Silesia-Cracow region, Poland/

ANDRZEJ WOJCIK

Dept. of Geology

Sztygarka-School of Mines

27 Stycznia 69

41-300 Dabrowa Gornicza

Poland

Paleozoic orogen Silesia-Cracow region two major structural stages: Caledonian and Variscan. The former consists of Cambrian, Ordovician, and Silurian sequences, while the latter of Devonian and Carboniferous ones.

The Silurian deposits in the Myszkow-Zawiercie area representedly claystones, silstones, sandstones and conglomerates. The sequence can be subdivides into Lower and Upper complexes.

The Lower complex /landoverian, Lower Llodlovian/ consists of claystones and siltstones with sandstones intercalations. Its thickness amounts to around 600-800 m. The Upper complex /Middle and Upper Llodlovian/ consists of clay-sand-conglomeratic rocks with predominance of sandstones. The thickness of this a series rocks is probably up to several thousand meters. Sediments originated /Lower complex/ in a deep sea at a little delivery substance. Increase of amount substance is unwaranted of intensive erosion. Upper complex originated in a coastal zona at changing turbulent conditions of sedimentation.

ANDRZEJ WOJCIK

Dept. of Geology

Sztygarka-School of Mines

27 Stycznia 69

41-300 Dabrowa Gornicza

Poland

For rational generalization of information it is necessary to use not only theoretical imaginations, received by intuitive-practical way about the problem, but one should take into account the results of investigation of the branch sciences, which may be useful for the decision of that problem.

Sedimentation processes which are the result of regular impulse. It is argued that the only convincing mechanisms which can provide such a stimulus are linked to the regularities of planetary movement.

A numerical model based on the concept of informational energy is proposed with a view to evaluating the degree of internal organization of the lithological sequences within a stratigraphic unit. The lithic sequences identified in a sufficient number of locations are analysed as coherent systems defined through characteristic lithotypes.

The lithological sequences exhibiting a stochastic behaviour are described through the matrix of the observed transition probabilities. The lithological dependences are checked as chains of events showing a Markovian behaviour.

The lithological transition probabilities are introduced in the calculus of informational energy, characteristic of each studied location.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989

Formation and structure of a lacustrine alongshore bar: Recent example from Turawa Lake, SW Poland

JURAND WOJEWODA

Institute of Geological Sciences, University of Wroclaw  
POLAND

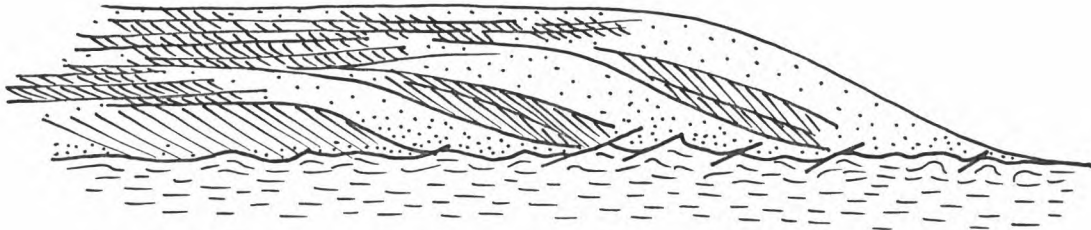
The Turawa Lake is an artificial reservoir which supplies the main waterway in SW Poland - the Odra river. The Turawa dam retents the waters of the Mala Panew river. The lake bottom consists of fluvial, eolian and fluvio-glacial sediments of Quaternary age. The lake surface in the maximum fill state is of an order of 15 km<sup>2</sup>, and the maximum depth reaches 8 - 10 metres

The lake circulation pattern depends strictly on weather conditions, mostly on wave activity and prevailing wind direction. During the fair-weather times, the main flow concentrates along a submerged valley of the ancient Mala Panew river, while the nearshore currents are less important. On the contrary, during the storm events the nearshore circulation is dominant. If the storm inducing winds blow westwards they result in a strong alongshore drift, whose velocity reaches up to 1 m/s. This is the current which significantly controls the nearshore sedimentation and erosion processes especially around two peninsulae - the Rybaczowka and Antonowka ones. Near the dam, the storm wave action causes water piling and results in the offshore flowing, nearbottom compensation undercurrents.

Due to repeated storm events, an alongshore bar has been built to the Rybaczowka peninsula. In 1986, during the low water level time, the bar was emerged and three trenches were made within it. The internal structure of the bar is compound. The dominant sedimentary structures are the large scale foresets of a microdelta type and cosets of climbing ripples. The climb angle of stoss-side sets does not exceed 20°, while that of lee side sets reaches up to 35°. Two prominent systems of first order sedimentary surfaces have been distinguished. The mud-draped and steeply inclined reactivation surfaces were originated during the interstorm fair weather times.

A rate of bar growth has been estimated. During the 1 to 3 days lasting storms, a longitudinal growth was of an order of 3 to 5 metres, while the perpendicular one was usually less than 0.7 meter.

The sandy sediments of the bar overlay lacustrine muds. The boundary surface is abrupt and the overload deformations are typical there.



*Longitudinal section of alongshore lacustrine bar*

### The sedimentary environment of Qarhan Playa in the Qaidam Basin, Northwest China

Yu, Junqing  
Geological Institute  
ETH-Zentrum  
8092 Zürich

Chen, Kezao  
Salt Lake Research,  
Academia Sinica  
Xining, China

Qarhan Playa, extending over an area of 5800 km<sup>2</sup>, is found in the central area of the inland drainage Qaidam Basin, Northern Tibet-Qinghai Plateau. Halite is the predominant deposit averaging 35 meters thick associated with a KCl rich brine. The conventional <sup>14</sup>C dating of total organic matter in sediments indicates that the formation of the halite deposits started around 25'000 years B.P. at Qarhan. Controlled by the climate and local hydrology, Qarhan playa displays sedimentary facies and environmental history briefly summarized as follows:

Firstly, Qarhan Playa has developed from a deeper and fresh water lacustral environment as shown by the existence of a thick lacustrine mud. Subsequently, it shallows upwards from intercalated clay and silt to gypsum- and halite-bearing sediments. The 'Shell Bed' in the eastern palaeoshoreline and its faunal assemblage also give evidence of the existence of a deeper lake with fresh to slightly saline water around 25,000-30,000 years ago (<sup>14</sup>C dating on shells).

Secondly, Pliocene halite-bearing sediments, covering a huge area to the west of Qarhan sourced halite-dominated salts at Qarhan. The climate and the hydrological situation, controlled by river systems emanating from the Kunlun mountain slopes, determined the sedimentary characteristics of the former Qarhan lake.

Thirdly, four progressive sedimentary cycles, beginning with clastic deposits and ending with halite deposits, have been distinguished in the Qarhan sequence. Within each cycle, the halite deposit were mixed with clastic, gypsum and carbonate components in varying amounts. Halite and gypsum crystals are also formed within clastic sediments. Thin silt laminae within halite may be interpreted as the result of wind deflation events as evidenced by the existence of a huge area of Yardan structures (wind-eroded canyon-ridge landform) and strong westerlies. Gypsum either occurs in halite layers as laminae and inclusions or interlayered with clays or muddy silts. Carbonate occurs as cement for clastics or occasionally as thin clastic layers in halite. Clearly, the Qarhan sequence is the result of the interaction of the former saline brine with the following factors: (1) the seasonal fresh water input and suspensions bearing sediments from surrounding mountain areas, and (2) the intense evaporation at Qarhan which exceeds precipitation by 100 times and (3) the transport of wind-borne silts.

Finally, the current salt lakes, Dabusun and Shini salt lakes etc., which surround the playa, are obviously derived from redissolution as evidenced by the "dissolution contact" between salt lake water and sediments with the playa crust. Timing of desiccation of the playa and formation of the "dissolution Lakes" are still in question due to lack of reliable <sup>14</sup>C dating. However, AMS <sup>14</sup>C dating of organic matter and <sup>18</sup>O data from ostracode in nearby Qinghai lake sediments, suggest that the wetter period in northern Tibet-Qinghai Plateau may begin around 11,000 y B.P. and reach the maximum about 10,000 y B.P. This may give a clue to the initiative time for the current salt lakes on the playa.

Sedimentation and Diagenesis in the Villaro Wealden  
(Lower Cretaceous, Basque-Cantabrian Region, Northern Spain)

I. YUSTA, J. AROSTEGUI, F. GARCIA-GARMILLA, J.M. HERRERO & F. VELASCO  
Dpto. Mineralogía y Petrología. UPV/EHU. 48080-Bilbao (Spain)

During the Villaro Fm. time deposition (Berriasian-Barremian), the central sector of the Basque-Cantabrian Region (Bilbao area) experienced an ascertainable subsidence. As a result of this the sediments were accumulated in a considerable and monotonous ensemble up to 1000 m. of thickness. The sedimentary features of this unit reveal the everlasting character of the depositional environment which was the stage of this prolonged event. In fact, the Villaro Fm. is largely composed by organic-rich pyrite-bearing laminated black shales containing scarce fossils; the most part of them, if not all, are fresh- and brackish-water specimens (Cerco-myra, Paraglauconia, Musculus, Pseudoptera). This low-energy environment perhaps was similar to an estuarine (eventually lacustrine) complex. But on the other hand, the well-represented five sandy episodes of the unit are not easy to concile with low-energy settings. Really a fluvial-controlled deltaic system was associated to the lacustrine ambient denoting an increase in the energy of the waters with the consequent developing of deltaic lobes. Indeed the sands in them show tractive structures: planar and through cross-stratification at metrical scale, cross-lamination, hydroplastic folds and symmetrical ripples, the latter representing abandoned facies such as disactivate channels or pools.

With regard to the appraising of the extent of diagenesis of the Villaro Fm., a total amount of 15 pelitic samples have been collected (grey and black shales). These samples are mineralogically very similar. The argillaceous minerals are very abundant reaching to 75%. Quartz is about 20% and the feldspars (albite), pyrite, organic matter and more rarely carbonates are represented in less than 5%.

The X-Ray techniques analysis of the  $< 2\mu\text{m}$ . fraction shows the existence of illite (mica-like) as the most representative mineral (more than 80%). In addition to illite, the illite/smectite interstratifieds ISII type (REYNOLDS & HOWER, 1970; SRODON, 1984) and chlorite, both represented in 10% and 5% respectively, are the unique detected argillaceous minerals.

The plot of the I(001) of the mica-like in the REY & KUBLER diagram (1983) indicate a very closed groupment. This lead us to think in a constant source-area and/or a similar diagenetic action upon all the lutitic samples of the Villaro Fm.

The Kübler index (1968) (width at half height of the 10 Å peak) increases progressively with the burial depth (from 0.52 to 0.80 in °2θ). A possible interpretation for this variation together the peculiar style of the 10 Å peak upper angle tail can be the existence of an interstratified phase mica-paragonite. These results and the very high valour of the vitrinite medium reflectivity in oil (average 4%) in some coal-horizons allow to consider the Villaro Fm. within the ankimetamorphic zone.

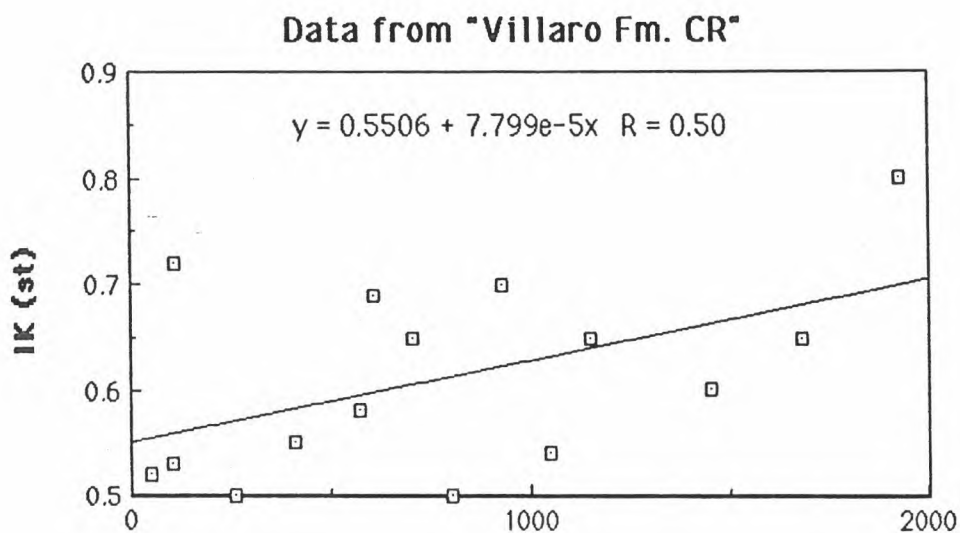
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**Regression line of Kubler index (Illite crystallinity)  
versus relative depth for the Villaro Fm.**

Clay minerals as indicators of phosphorite formation  
of the inland epicontinental seas

YURI ZANIN, KONSTANTIN ZVEREV, EMILIA SOLOTCHINA  
Institute of Geology and Geophysics  
USSR

Different opinions on the relation of phosphorite formation to climates were discussed in the literature - if the genesis of phosphorites is related to epochs of warm or cool climate. The authors studied the climate conditions of phosphorite formation of the inland platform seas by the way of the example of Upper Cretaceous deposits of Enisey-Mouth depression of the northern Siberia. For this aim clay mineral composition (fraction lesser than 0,002 mm) was analyzed.

Phosphate-bearing sandy-silty-clayey rocks of the Turonian, Coniacian, Santonian and Maestrichtian stages and non-phosphatic silty-clayey rocks of the Campanian stage present in the region. Fine-grained material of all phosphate-bearing stages is represented by caolinite and chlorite sometimes with admixture of montmorillonite. All studied samples of these stages content hydrargillite in a small amount. Clay minerals of the rocks of the Campanian stage are represented by montmorillonite with a small amount of chlorite.

It is possible to think, that phosphate-bearing rocks were formed during the intensification of the weathering processes, that was related to the warming and humidization of the climate.

M.A. ZHARKOV

Institute of Geology and Geophysics  
Siberian Branch of the USSR Academy  
of Sciences  
USSR

At present the conceptions that the environments of evaporite sedimentation were invariable during the whole geological history, are widely spread. The evaporite sedimentation took place either in the basins isolated from the open sea or in the (intratidal) near-shore zones, or in the lake continental environment. At the side by side with this, the data available at present suggest about fundamental qualitative changes of environments of evaporite sedimentation in different Phanerozoic epochs.

The history of Phanerozoic evaporite sedimentogenesis is divided into four stages, differing in duration and peculiarities of evaporite basin location characteristic only of them: 1) Vendian-Paleozoic, 2) Triassic-Yurassic, 3) Cretaceous-Paleogene, 4) Neogene-Moderu. Paleogeographic position of evaporite accumulation belts, their amount and extent depended on the areas of continents, their space relations, and also on the sizes and extent of oceans. From one epoch to another the sizes of evaporite basins, their position on continents and relations to the open ocean, location and sizes of intermediate basins and barrier zones were changed. At the same time the composition of saltbearing deposits in evaporite basins was changed.

Similar transformations were occasioned by the fact that in different Phanerozoic epochs appeared very specific environments of evaporite sedimentation, especially on the stage of the formation of easily soluble salts for which separate sedimentation models were suggested.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Sedimentary environment of Lower Muschelkalk (M.Triassic)  
at the basin-central position of Ruedersdorf (GDR)

W.H. Zwenger, Fürstenwalde

The Muschelkalk outcrop of Ruedersdorf near Berlin is unique in the North-German lowland. It is especially interesting because of its paleogeographical position in the centre of the German Basin with influences of the southeastern marine connections to the Tethys (Carpathian and Moravian Gates). There the first marine ingressions occur in the Myophoria beds (Lower Anisian). It is followed by the continuous marine carbonate development of the Wellenkalk. This stage is dominated by a facies of restricted shelf characterised by reduced water circulation, high salinity and low sedimentation rates. The normal sedimentation of this facies belt is represented by micritic limestones and marlstones which were deposited in the upper sublittoral at a depth between 20 and 70m. Episodical particle-limestone sheets (arenites, bioclast- and intraclastrudites) appear in the Wellenkalk as an intrafacies. They are caused exogenously by short phases of increased water turbulences. The peaks of this small-scale cycles are marked by tempestites. The texture of these tempestites and the general frequency of particle-limestone events indicate slow subsidence and the preparation of a submarine rise even in the Wellenkalk stage. This basin-central rise is finally realised at the Schaumkalk stage. It represents an eulittoral facies with bar-like arenite bodies deposited in very shallow agitated water. These grainstones are free of calcareous mud and mainly consist of pseudoolites. The repeated evidence of chlorophycean spores (*Globochaete alpina*) and single parent cells is regarded as an indication of an extensive participation of calcareous algae in the particle formation. Another example is given by the micritic envelopes of some globoid particles caused by cyanophyceae. Long phases of stable eulittoral environment are proved by facial selective hardgrounds connected with Schaumkalk arenites. They form irregularly shaped bodies which are laterally geared to non-cemented sediments. Several developmental stages from firmgrounds to hardgrounds are to be

found in such composite hardground sequences. The "fining downward" type is realized in small-scale cycles as well in mesocycles. The basic sequence of mesocycles begin with mudstones followed by arenite complexes. Hardgrounds and primary sedimentary dolomites in the top regions reflect trends to shallowing upward. To the top of the Schaumkalk stage, the scale of mesocycles become shorter, arenite complexes increase at the expense of calcipelitic slack-water facies. The carbonate megacycle of Lower Muschelkalk is finally replaced by the regressive salinar cycle of Middle Muschelkalk. While the small-scale cycles are mainly controlled by the hydrodynamic system, the supraregional similar trends of mesocycles point to eustatic fluctuations of sealevel. At the basin-central rise of Ruedersdorf, these mechanisms are, in addition, coined by epeirogenic activities.

ABSTRACTS

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## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

Nautile submersible dives on deep-sea pelagic deposits in Northeast Central Pacific nodule mining area. (Preliminary results of Nixonaut cruise).

Cochonat P. for NIXONAUT GROUP (Charles C.\*, Cochonat P.\*\*, Greger B.\*\*\*, Hoffert M.\*\*\*\*, Landuré J.Y.\*\*, Le Drezen E.\*\*, Lemoign T.\*\*, Lenoble J.P.\*\*\*\*\*, Le Suavé R.\*\*, Meunier J.\*\*, Pautot G.\*\*, Regnault J.P.\*\*)

\* Ifremer Toulon France,

\*\* Ifremer Brest France

\*\*\* Preussag Hannover RFA

\*\*\*\* Université Strasbourg France

\*\*\*\*\*Ifremer Paris France

16 dives were completed by Ifremer in the Northeast Central Pacific Ocean at a water depth of about 5000m between the Clarion and Clipperton fracture zones. The regional morphology of the sea bottom is usually described as an abyssal hills landscape. The sedimentary cover deposited on the oligogene oceanic crust created at East Pacific rise, is composed of the Marquesas formation made up of calcareous oozes and the Clipperton oceanic formation (recent pelagic siliceous clays overlapping by unconformity siliceous and calcareous oozes).

The dives were focused on specific targets selected from previous data gathered during bathymetric, coring, photographs, sonar and particularly high resolution seismic profiling surveys. The scientific purposes of the cruise were to get ground truth on the sedimentary environment of nodules area, the nodules distribution and the geotechnical properties of surficial layers by means of a vane shear device manipulated by the mechanical arm of the submersible.

The two main scientific findings of the cruise are:

(1) a revised description of the entire sedimentary sequence and its specific morphology,

(2) the evidence of correlations between geological environment and the shear strength of recent surficial sediments and the nodules distribution.

Above the basalt, the deposits indeed appear to be essentially calcareous up to the hiatus underlined by an Fe/Mg crust below the plio-quadernary pelagic clays. Significant erosional processes related to the dissolution of these thick carbonate facies (50m) occur when calcareous layers following the topography of the basement come at or very closed to the surface.

Consecutively, faulting and slumping may occur to create steep slope observed in cliffs or throughs.

The upper pelagic clays formation previously recognized on acoustic records as a transparent unit was particularly studied. In the investigated area, the lateral variability of in situ measured values of cohesion suggest that different geotechnical facies could exist in the same apparent lithology. This result has to be explained by dynamic sedimentary processes. On the other hand, the nodules distribution and the variability of nodule types appear also related to the sedimentary environment

The results of this cruise will be subsequently used to propose a new interpretation of sedimentary processes in the investigated area.

10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989  
Sedimentology, mineralogy and petromagnetism of Miocene sediments of  
Sokolovska Basin /Czechoslovakia/

A.Cimbalnikova,A.Zeman

Institute of Geology and  
Geotechnics of the Czechoslovak  
Akademy of Sciences /UGG CSAV/  
Prague

On the south east of Krusne Hory Mts. foothill there exists system of three Miocene brown coal basins. Their genesis is connected with a rift valley from the Early Miocene. The central brown coal basin is termed as Sokolovska panev Basin. Its Middle Miocene group of beds is the object of our lecture.

The Middle Miocene group of beds /thickness of 100-120 m/ is termed under *Cypris angusta* Reuss as the Cypris group of beds. The Cypris group of beds is formed by grey mudstones, compound from kaolinite, illite and montmorillonite with admixture of authigene calcite, dolomite, siderite and analcime. The high content of authigene analcime is more in places than 20 %. It may be the evidence of volcanic origin of the Cypris group of beds. The content of rare earths and organic matter were studied also.

The magnetic susceptibility /10.000 - 11.000 x 10<sup>-6</sup> Si/ of part of the Cypris group of beds /20-30 m thickness/ is caused by the highly magnetic mineral of greigite Fe<sub>3</sub>S<sub>4</sub>. The average content of greigite in a magnetic horizont of the Cypris group of beds is 1-2 vol %.

**CARBONATE DYNAMICS IN A DELTAIC COMPLEX FROM THE SOUTHERN PYRENEES. LOWER EOCENE. SPAIN.**

GIMENEZ, J. and CALVET, F.  
University of Barcelona, Spain.

The Pyrenees divide the Iberic Plate from the rest of Europe. They are divided into the Basque-Cantabrian Pyrenees and the Central-Eastern Pyrenees by the Pamplona Fault. The Southern part of the Central-Eastern Pyrenees is made of Lower Thrust Sheets and Upper Thrust Sheets. The southward displacement of the South Pyrenean thrust sheets over a stable, Lower Eocene carbonate platform (Ilerdian times) resulted in the development of the South Pyrenean foreland basin. The thrusts developed in a piggy-back sequence, the Upper Thrust Sheets being the first to be lifted into place. (Figure 1).

The earliest movements of the nappes can be reflected in a deltaic complex during the Cuisian age (this deltaic complex forms the highest part of Sagnari Formation and all the Coronas Formation).

This deltaic complex is mainly made up of siliciclastic sequences and frequent thin carbonate intercalations, and two parts can be distinguished:

a) A lower one is formed by thin, thickening sequences due to very common crevasse events, sparse channelized finning upwards sequences and thin carbonate levels. This part is interpreted as a lower delta plain in origin. (Figure 2).

b) An upper one, formed by red beds, without any carbonate facies, and it's interpreted as an upper delta plain with fluvial influences. (Figure 2)

The carbonate intercalations are often metric in scale, but when all the clastic supply is restricted, there's a great development of the carbonate facies, above 30 m thick, and this carbonate facies packet forms the Upper Carbonate Unit (belonging, also, to the Coronas Formation). (Figure 2).

Into the deltaic complex, the most important developed carbonate facies are: a) Oolitic packstones and grainstones. b) Miliolid-peneroplid-opertobitolites wackstones and packstones. c) Discorbid wackstones and packstones.

These miliolid and discorbid facies are more typical of restricted, marine environments, while the oolitic facies could represent an energetic rise of marine conditions.

The ostracode facies developed in the Upper Carbonate Unit, up to 10 m in thickness, could be explained as deposited in a brackish environment, with a continental influence, because of the great monospecific accumulations, and the relation between ostracodes and carophytes. This environment was separated from more marine conditions by the sea grass accumulations which were able to produce a baffle effect.

Depending on the carbonate facies we could talk about different mechanisms to explain one or another facies deposition:

a) The restricted sea grass, discorbid, ostracode facies, developed at the top of the deltaic sequences can be interpreted as an abandonment deltaic event, with more or less continental water influence, except in the Upper Carbonate Unit, with a regional, total clastic supply restriction.

b) The oolitic facies (with a more widespread distribution), can be thought of as a sudden transgressive event, due to relative sea level rises, not directly connected with the deltaic dynamics.

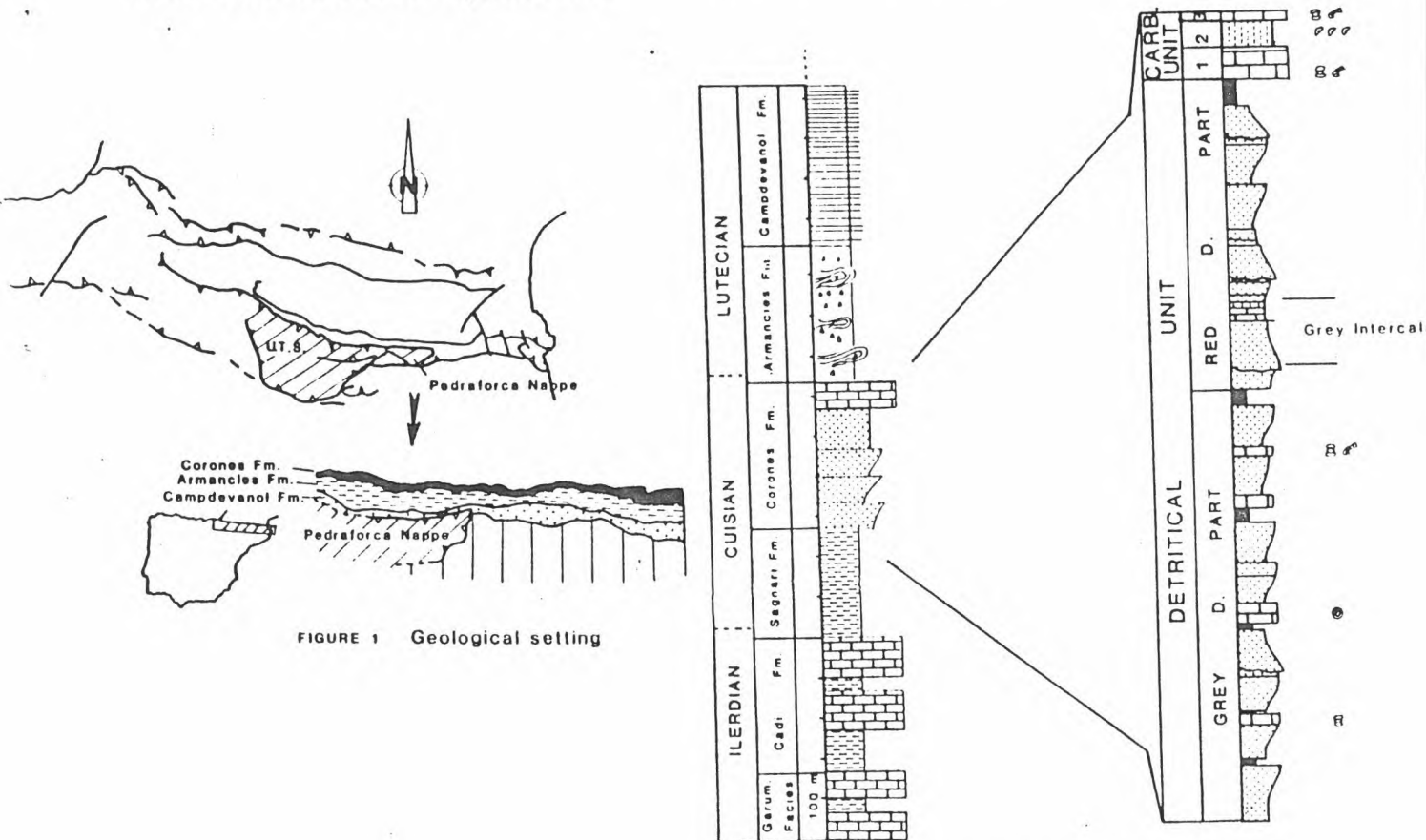


FIGURE 1 Geological setting

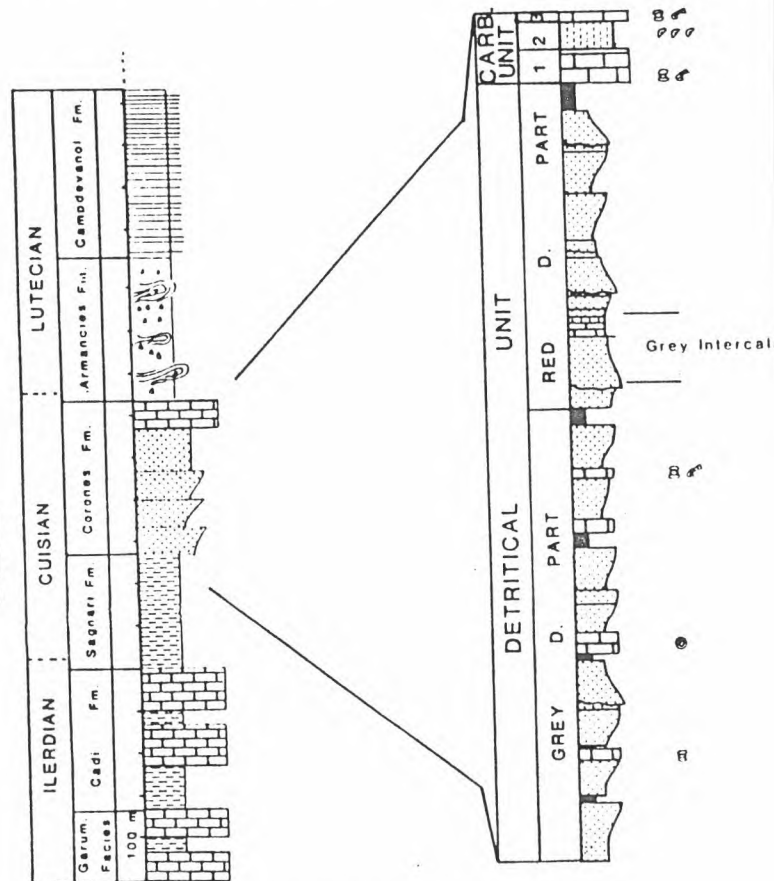


FIGURE 2 Lithostratigraphic scheme

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10<sup>th</sup> REGIONAL MEETING ON SEDIMENTOLOGY I.A.S. BUDAPEST '89

A LOWER CRETACEOUS FLYSCH SEQUENCE IN THE GERECSE MTS.  
/HUNGARY/

B. KRIVÁN

Academical Research Group, Loránd Eötvös University  
Department of Geology, Budapest Muzeum krt. 4/a. H-1088

In the Transdanubian Central Mts. there were two sedimentary basins separated from each other in Lower Cretaceous: the Bakony and the Gerecse Basin. In the Bakony Basin the Lower Cretaceous was represented by limestones and marls. At the same time in the Gerecse Basin /NE of the Transdanubian Central Mts./ took part detrital sedimentation. Here the sedimentation started with deposition of thin calcareous sandstones and limestone breccias /Felsővadács Breccia/ on the rough surface of Lower Tithonian limestone. This Berriasian breccia means the lower member of the Bersek Marl formation, which consists of 100-150 m thick marl, calcareous marl series with interbedded sandstones, siltstones. There are easily recognizable Bouma sequences. The most characteristic is Bouma's  $T_{de}$  base cut-out sequence, in which  $T_d$ , the upper interval of parallel lamination is represented by sandstone seldom siltstone. The pelitic interval,  $T_e$  consists of marls with alternate lime content. The largest exposure of the Lower Cretaceous detrital complex can be found at the quarry of Bersek Hill, where there has been found more than 650 cycles of two parts within a 70 m thick succession.

The deposition of the Bersek Marl /Valangian-Lower Hauterivian/ was followed during Upper Hauterivian-Lower Barremian by coarser detrital sequence called Lábatlan Sandstone formation. The transition from Bersek Marl to Lábatlan Sandstone is continuous. The boundary has been identified at the first thick sandstone layer. There is a transitional zone between the two formations, which is characterized by the continuous decreasing of the lime content upwards and by increasing of the sand quantity. The thickness of the Lábatlan Sand-

stone changes from 50 to 180 m and decreases southwards. The sandstone layers are obviously thicker and coarser upwards at the same time their graded character straightens.

At the Bersek Hill quarry it has been found more than 150 cycles in the sequence. The most typical was Bouma's  $T_{ab}$  but there were also some example for the  $T_{a-c}$  sequence. The lower part of the cycles consists of sandstones which are often graded and a lot of times sandy siltstones.  $T_b$  is represented by fine-grained sandstones which occur in the current lamination intervals too, sandy siltstones, siltstones and marls.

The coarsening was continuous throughout the whole Barremian. Its last product was the Kőszörükőbánya Conglomerate, the final member of Lábatlan Sandstone formation. Formerly it was considered as exclusively Barremian, but according to the latest paleontological investigations it seems to be younger /Upper Aptian-Lower Albian/.

Although formerly the detrital complex was regarded as product of shallow water sedimentation, nowadays the investigations have proved its deep sea origin. The layers of the Lábatlan Sandstone show a lot of flysch features as graded bedding, soil marks, trace fossils etc. The sequence can be considered as product of a prograding submarine fan. Measurements for the statement of the paleotransport direction were made by different ways in different places of the area /imbri - cation, channels, soil marks/.

The data suggest a N, NE /actual/ source area. Paleogeographically the Lower Cretaceous Gerecse Basin might have been surrounded by land to the E, S and N and it should have been filled up by the material derived from a N-NE submarine fan. The Gerecse Basin's relation with the Northern Calcareous Alps hasn't been clearly proved yet.

Sedimentological response on the tectonic development of the Vienne Basin

P. SEIFERT  
ÖMV-AG  
Wien

The Vienna Basin is the northwest part of the Pannonian-Intra-Carpathian basin system, and is situated in the external zone of the Alpine-Carpathian thrust belt.

The tectonic development of the basin occurred in three stages: Stage 1: the first was the extensional fault regime of the Lower Miocene which caused the creation of a basin superimposed on the back of the northwards prograding Alpine-Carpathian nappe system. This basin development represented a southern embayment of the molasse foredeep, lying to the north. Sedimentation started with continental clastics at the beginning of the Eggenburgian /22 My/, followed by a shallow marine shale sequence. The separation of the Paratethys from the Tethys during the Ottnangian /18 My/ resulted in a brackish facies regime and a regression, sediment input was from Alpine-Carpathian southern areas during this time. In the northern part of the basin full marine conditions were established again in the Karpatian /17 My/. Higher sediment input in the southwest caused a widespread extension of limnic-fluvial sediments.

Stage 2.: at the beginning of the Middle Miocene the tectonic movement in the whole region changed to strike-slip translation, resulting in the pull apart stage. The connection to the molasse foredeep in the northwest was interrupted and a large west-east prograding delta system was established.

The maximum extension of marine sedimentation in the Middle Badenian /15 My/ corresponds to a global eustatic sea level high stand. Up to the Sarmatian /12 My/ the environmental conditions changed from shallow marine to brackish.

Stage 3.: the uplift of the Alpine-Carpathian mountain belt during the Late Miocene and Pliocene introduced a vertical tectonic movement in the Vienna Basin. Limnicfluviatile sediments successively filled the Vienna Basin and the shoreline prograded eastwards into Hungary.

COMPLEX GEOCHEMICAL METHOD FOR DETERMINATION OF THERMAL HISTORY

T.Póka  
Laboratory for Geochemical  
Research of the Hungarian  
Academy of Sciences  
Budapest

Improving a complex methodology, the research aimed to contribute to the better understanding of the thermal history of Mesozoic sequences forming the basement of young basins, and to the thermal evolution of different regions, in order to provide data to hydrocarbon prognosis.

The complex geochemical method applied to determine the different stages of maturity is based on vitrinite reflectance, illite crystallinity and bituminological measurements.

Although the differences in results obtained by these methods are sometimes considerable, they can be explained by diverse tectonic-paleogeographic and geochemical conditions and thus, are suitable to reach further conclusions.

The lecture will give the thermal history reconstruction of a Mesozoic sequence in a certain region of the Pannonian Basin, as an example for the complex geochemical investigation.

## 10th IAS REGIONAL MEETING ON SEDIMENTOLOGY - BUDAPEST, 1989

### LOWER PERMIAN COALS OF BRASIL AND QUATERNARY ANALOGS OF CANADA

I. Peter Martini, Department of Land Resource Science, University of Guelph, Guelph, Ont. Canada. N1G 2W1

In Brasil coals are found in the Parana' Basin primarily in the state of Rio Grande do Sul, with other smaller deposits in the states of S. Catarina, Parana' and S. Paulo. They differ slightly in time, with some of the thin seams of the S. Paulo State ranging from pre-Gangamopteris age (possibly upper Carboniferous; M. Mor) to the lowermost Permian (Cerquilho; transitional, pre-Glossopteris flora). All coals of the other states contain Gangamopteris floral associations and are of Lower Permian age. The former are associated with glaciogenic diamict-bearing stratigraphic units (Itarare' Subgroup) and they are interpreted as derived from interglacial organic deposits (fens) developed on upper deltaic floodplains. The latter are all post-glacial, and derive from peatlands evolved in a variety of landscapes, including upper deltaic plains and back-barrier plains associated with prograding and uplifted coastal systems. Some of the most interesting peat-coal forming settings of the coals of the Rio Grande do Sul however, consists of peatlands formed on metamorphic substratum, and in narrow valleys both modified by Permo-carboniferous glaciers. Most of the valley deposits are of limno-thelmatic origin (terrestrialization (growth of peat) of shallow lakes).

The present boreal peatlands constitute good analogs for most of the Brazilian peats. They were both formed primarily in tectonically stable settings, on similar substratum such as glacially molded basements crystalline rocks or glacially modified valleys, as filling of lakes or as deposits of primarily graminaceous organic peatlands (fens) locally treed. The recent-ancient comparison also reveals that: (a) few examples exist of interglacial or interstadial peats-coals; (b) indication of seasonality can be obtained from fossil plant fragments; (c) very rapid, geologically instantaneous, warming has occurred after deglaciation. Peat has flourished under the optimum conditions of wet and cold climate, and thick deposits have developed in the past where slow tectonic subsidence has provided space for the peat to grow; (d) the juxtaposition of peat with sediments of coastal, lacustrine, deltaic origin is coincidental because peat does form until the sedimentological activities of those environments have been greatly reduced or terminated. For instance, no significant peat develops behind active barrier beaches or on boreal marshes. It does however develop when such coastal systems are cut off from the active coastline by uplift or coastal progradation, and are located in inland, sedimentologically inactive, freshwater settings.

Clastic and carbonate sedimentation in an Eocene strike-slip basin at  
Budapest

FODOR, L., KÁZMÉR, M.  
Eötvös University  
Budapest

The Upper Eocene sedimentary basin at Budapest was formed upon a dissected, karstified Triassic surface.

Alluvial and marine plateaus, scarps and basins received coarse clastic and carbonate sediments, transported by braided rivers, long-shore currents, rockfalls, slumps, debris flow, and turbidity currents, respectively.

Uplift and karstification, block tilting and dyke opening, contemporaneous with uninterrupted basin sedimentation nearby, are indicators of a strike-slip regime.

The Buda Hills are part of the Bakony terrane, having been located within the Alps before Oligocene time. This tectonically controlled Upper Eocene sequence may indicate the initial steps of a continental escape along the Periadriatic fault system.



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Honoured Reader,

hearty welcome - from the Oil and Gas Production Company of Hungarian Great Plain -- to the participants of the I A S 10. Regional Conference in Budapest.

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Dr Aladár Pápa  
general manager



10th REGIONAL MEETING ON SEDIMENTOLOGY-BUDAPEST, 1989

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