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Organized by M. STREEL, Paleontology, University of Liège and M.J.M. BLESS, Natuurhistorisch Museum Maastricht

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MICROORGANISMS IN THE MALAGARASIAN SHALES FROM THE KAVUMWE (EASTERN MOSSO, BURUNDI)

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The palynological study of shaly levels with microflora from the Kavumwe Group enables us to recognize approximately twenty species of palynomorphs. These make a correlation with B IIc (Bushimaie Group in Kasaï, Zaïre) possible and more generally with the basis of Upper Riphean (Scandinavia, East European Platform, Siberia, . . .).

The Kavumwe Group as well as Groups of Bushimaie (Zaïre), Bukoban (Tanzania) belongs to the Katangian and is located in the Malagarasian of Upper Riphean age.

The stratigraphical position of this Group in the Malagarasian Supergroup is discussed.

EXTENSION DE LA ZONE METAMORPHIQUE SUIVANT UN AXE NORD-SUD DANS LA PARTIE OCCIDENTALE DES ARDENNES

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Depuis plus d'un demi siècle, les études consacrées au métamorphisme des terrains paléozoïques de la partie occidentale des Ardennes n'ont apporté que peu de modifications au tracer des limites des "zones métamorphiques" (au sens géographique du terme) reconnues par Corin (1930, 1931). L'utilisation du paramètre de la cristallinité des complexes micacés (ou des illites s.l.) nous a permis de préciser davantage l'extension de la "zone métamorphique" (au sens zonéographique du terme) suivant un axe nord-sud.

La détermination de la cristallinité des complexes micacés le long d'une transversale joignant Namur (au nord) à Marbehan (au sud) révèle, tout d'abord, que la zone métamorphique occupe, au niveau de la surface de dénudation actuelle, toute l'aire paléozoïque située au sud de la limite Siegenien-Gedinnien du bord sud du synclinorium de Dinant.
Au nord de cette limite, la détermination de la cristallinité des complexes micacés dans les séries stratigraphiques recoupées par les sondages de Porcheresse et de Wépion indique que la zone métamorphique, qui est atteinte avec les séries du Dévonien moyen, s'étend sous l'aire paléozoïque des synclinoria de Dinant et de Namur.

CORIN, F. (1930). Le métamorphisme de l'Ardenne. Ann. Soc. géol. Belg., Bull., 54 : 99-115.

CORIN, F. (1931). Coup d'oeil sur la zone métamorphique de Paliseul. Bull. Soc. belge Géol. Paléont. Hydrol., 48 : 451-473.

FLUID INCLUSION STUDY

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The fluid inclusion technique allows composition, salinity and density determination of the mineralizing fluid. It can, sometimes, give way to an estimation of the P-T conditions of formation.

Two problems are now treated :

1. the Pb Zn Ba F ore deposits from Belgium : Meuse-Vesdre (North district) and Sud Dinant (South district);
2. the relations between quartz veins and metamorphism or magmatism in the Ardenne (Rocroi-Serpont-Stavelot massives and metamorphic area of Bastogne).

PERMIAN STRATIGRAPHY IN THE CAMPINE BASIN

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In the northeastern part of the Campine basin, the Westphalian coal measures are overlain by a Permo-Triassic sequence dominated by red-coloured sediments and attributed to the Buntsandstein formation. However in the central part of this area (between Bree and Opglabbeek) a grey coloured calcareous sequence attributed to the Zechstein is preserved, traversed by four cored and partly logged boreholes. The Zechstein strata slowly thin from north to south (30 m in borehole 169, 18 m in borehole KS 25) but remain remarkably constant in facies. They consist of dolomitic silty marls alternating with more sandy straticulations and contain an abundant though poorly diversified mollusc fauna and rare dispersed though well preserved plant remains. At the base a thin often inconspicuous basal conglomerate marks the contact with the Westphalian. The upper limit remains unclear : the grey-red colour change apparently crosses lithostratigraphic correlation lines, otherwise facies changes seem gradual.

Pollen assemblages obtained from borehole KB 169 (between 1064 m and 1069 m) contain numerous striated grains (*Striatisaccus* type) which are characteristic of Permian strata up to the Vetlugian stage in the Lower Triassic. *Klausipollenites schaubergeri* which is often observed, is typical of the Upper Permian (Thuringian stage). The samples also contain specimens belonging to the *Lueckisporites* palynodemes and more precisely *L. virkkiae* (normes Ac and Bc). According to Visscher (1971, fig. 19), they are indicative of the transition Zechstein/Lower Buntsandstein.

In borehole KB 172, the palynological data allow the same conclusion. Moreover, the study of the associated macroflora reinforces these results. Numerous fragments of conifers, leafy twigs and isolated needles, are representative of the genera *Ullmania (U. bronnii* and *U. frumentaria) Pseudovoltzia (P. heterophylla)* and *Quadrocladus (Q. solmsii* and *Q. orobiformis);*

they all are regarded as restricted to the Upper Permian (Zechstein facies). On the other hand these remains are found together with bark fragments of *Pleuromeia* a Lycopod typical for the Lower Buntsandstein. This unusual association points to the transitional character of this flora.

VISSCHER, H. (1971). The Permian and Triassic of the Kingscourt Outlier, Ireland, Geological Survey of Ireland, spec. p. 1.

EROSION SURFACES AND NEOTECTONICS ON THE HAUTES FAGNES PLATEAU

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The reconstruction of Cretaceous and Paleogene erosion surfaces on the Hautes Fagnes plateau and the NW-Eifel shows irregularities in their profiles, whose origin is certainly to be found in tectonic deformations taking place after the elaboration of the surfaces, i.e. during Neogene and Quaternary times.

Two types of irregularities are visible : at first, a longitudinal, SW-NE oriented upwarping moving the Baraque Michel massif and the eastern part of the Hautes Fagnes crest. This upwarping involves the development of flexures deforming the erosion surfaces north and south of the Baraque Michel massif. On the other hand, transverse irregularities disturb the surfaces in a SE-NW direction; they are associated with other remarkable morphological features. They witness thus for major zones of radial fracturation, active during Neogene and Quaternary times on the Cambrian massif of Stavelot.

These are to be connected with the SE-NW radial fault system, determining the opening of the Lower Rhine Embayment. It is however the first time that such a Cenozoic activity of fractures belonging to this system is observed on the Paleozoic massif. We have moreover to emphasize that this activity is limited onto the Cambrian, and doesn't affect the Lower Devonian shales of the Eifel syncline, which show a tectonically incompetent behaviour.

Finally, the disposition of the radial faults on the Hautes Fagnes plateau and the updoming of the Baraque Michel indicates that this epeirogenic movement took place after the reactivation of the faults.

A NEW EVENT-STRATIGRAPHICAL MARKER BED IN THE UPPERMOST DEVONIAN OF THE ARDENNO-RHENISH MASSIF

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A new ferruginous ooid-bearing limestone bed is described from the uppermost Famennian in the Denée borehole, near Maredsous (Dinant Synclinorium).

This pseudo-oolitic ironstone (level V) consists of a 19 cm-thick medium-grey bioclastic grainstone/rudstone with densely-packed, non-sorted ferruginized allochems (50-60°/o bioclasts) and heterogenous intraclasts (Fe-intrasparrudite). The grainstone itself is embedded in finely-laminated and bioturbated, micaceous siltstone, interlayered with silty mudstone.

Microfacies analysis points to either slowed accumulation of coarse bioclastic material in the zone of constant winnowing, or to a settling from turbid surficial clouds in a highly turbulent environment.

This new "oolitic ironstone" level (V) shows some good similarities with level IV, which is associated with a transgressive lag deposit or a mineralized hardground at the very base of the Souverain-Pré Formation (Dinant and Vesdre Synclinoria) (Dreesen, 1982). Biometric analysis of the spore florae from the enveloping mudstones indicated the presence of the D/E step limit within the *S. lepidophytus* Zone. This limit is situated at or just below the base of the Etroeungt Limestone in the Ourthe and Hoyoux Valleys (Northern border of Dinant Synclinorium). Thus according to palynological data, level V is situated near the top of the LV Sporezone (Higgs & Streel, 1984) or at the PLm/PLsl transition (sensu Paproth & Streel, 1971).

A particular event deposit occurs at exactly the same (bio)stratigraphical level within the Rheinisches Schiefergebirge, near Dillenburg (Dill Syncline).

Here, the so-called "Jungoberdevonischer Bombenschalstein" represents an excellent marker bed at the very base of the greenish grey shales and sandstones of the Wocklum Stufe (do VI). This volcanic bomb level is a heterogenous lithological complex (2-25 m) comprising spilitic volcanic bombs, pillow lavas, tuffs, and subordinated exoclastic boulders of Upper Devonian cephalopod or reef limestones, and ironstones.

The youngest conodonts collected from the enclosed limestone boulders indicated a Lower *praesulcata* Zone (or top of former Middle *costatus* Zone). Moreover, palynological analysis of the enveloping shales indicated that a 25 m "Bombenschalstein" sequence at Langenaubach (near Dillenburg) is included within the upper part of the LV Sporezone (Somers & Streel, 1978), or more precisely, that is inserted between shales bearing respectively C and E biometric spore zones.

This remarkable synchronism of extremely different event deposits from widely-spaced localities, is not a coincidence, but rather the result of strongly interdepending tectono-sedimentary processes, which have been episodically triggered by synsedimentary tectonic movements along deep-seated transversal faults or block faults crosscutting the Ardenno-Rhenish Massif.

DREESEN, R. (1982). Storm-generated oolitic ironstones of the Famennian (Fa1b-Fa2a) in the Vesdre and Dinant Synclinoria (Upper Devonian), Belgium. Ann. Soc. géol. Belg., 105 : 105-129.

HIGGS, K. & STREEL, M. (1984). Spore stratigraphy at the Devonian-Carboniferous boundary at the Northern "Rheinisches Schiefergebirge", Germany. Cour. Forsch.-Inst. Senckenberg, 67 : 157-179.

PAPROTH, E. & STREEL, M. (1971). Corrélations biostratigraphiques près de la limite Dévonien/Carbonifère entre les facies littoraux ardennais et les facies bathyaux rhénans. Congr. Colloques Univ. Liège, 55 : 365-398, Liège.

SOMERS, Y. & STREEL, M. (1978). Spores du sommet du Dévonien à Langenaubach (Synclinal de la Dill, RFA). Relations entre la conservation des spores, le pouvoir réflecteur de la vitrinite et des intrusions diabasiques. Annales des Mines de Belgiques, 7-8 : 147-154.

THE WESTPHALIAN C-D STRATA IN THE NORTHEASTERN CAMPINE POSSIBILITIES FOR SEAM TO SEAM CORRELATIONS

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The Westphalian C-D strata in the northeastern Campine represent a sequence characterised by a monotonous coal-mudstone-sandstone cyclic alternation of fluviatile origin, dominated in the upper part by coarse-grained sandstone (Neeroeteren Sandstone Member). They reach a thickness of at least 1150 m, limited at the base by the Maurage-Aegir marine horizon (Westphalian B-C limit) and truncated at the top by an unconformity of Campanian or Lower Triassic to Upper Permian age.

These strata have been explored recently by a series of cored boreholes covering an area of ± 250 km^2. Borehole geophysical logs actually are available for 6 boreholes only, covering a sequence of ± 1000 m.

Within this sequence rapid lateral changes in depositional environment and ever recurring facies conditions prevent detailed correlations. Nevertheless exact seam to seam correlations are essential for identifying potentially mineable coal seams and hence for assessing the recoverable coal reserves where upon any new mine planning is necessarily based.

The basic framework for the stratigraphical subdivision is provided by biostratigraphical zonations and by tonstein correlations, as presented in a review of the Silesian (Paproth *et al.*, 1983).

No marine incursions are known within the Westphalian C-D sequence of the northeastern Campine. Tonstein beds are more frequent and prove very useful as they may be indentified unequivocally and traced over long distances and thus make the link between different coal basins. Campine tonstein studies and identifications are carried out by Dr. K. Burger (Ruhrkohle, Essen) and B. Delcambre (UCL). A comprehensive review of Campine tonstein occurrences actually is in preparation.

Biostratigraphical zonations equally allow interregional correlations. Although fossil groups of continental origin may evolve less rapidly than their marine counterparts and closely follow facies wanderings within the paralic sediment sequences, assemblage zones may be recognised and utilised for local correlations and facies reconstructions as well. The GS-SF miospore assemblage limit, marking the base of the epibole of *Torispora securis* always occurs in the coal seam group overlying the Nibelung tonsteins. Megaspore and macroflora assemblages are studied by P. Pierart (Mons) and E. Houllebergths (KUL) respectively.

The first appearance of *Neuropteris ovata,* defined as the Westphalian C-D stage boundary, is hard to establish within a sequence of very simular forms and is also very diachronous due to the increasing distribution of inhospitable environments but ranges downwards into the Walkure coal seam group of the German classification (Ph. D. thesis, E. Houllebergths). For this reason *N. ovata* has little practical value. Furthermore the presumed Westphalian C-D stage boundary slightly precedes tne onset of the Neeroeteren Sandstone which proves a useful though somewhat unconformable lithostratigraphic limit. A new proposal for marking the Westphalian C-D stage boundary would be most welcome.

The fauna associations (mainly mollusc and ostracode) are studied by E. Paproth (GLANW-Krefeld) and M. Bless (Nat. Hist. Mus. Maastricht) respectively. A marine-influenced horizon, characterised by the ostracode *Geisina* has been observed in three boreholes. Apparently the habitat most favourable for *Geisina* is slightly diachronous between these borehole sites. Since the *Geisina* horizon just precedes the important and widely recognised lower Nibelung tonstein horizon at about the middle of the Westphalian C sequence. it may also support a subdivision of this stage at these levels.

However the most precious tools for detailed seam-to-seam correlations within the stratigraphic framework already established are provided by the borehole geophysical logs. Although these logs only reflect the lithological composition of the strata, they amazingly allow ever far reaching interregional comparisons based on cycles of coal seam groups and intervening sandstones. Once a standard log suite has been established - which was only possible through the cooperation of Dr. A. Schuster (Neuenhaus) and D. Schmitz (WBK, Bochum) - very rapid visual correlations may be made between adjoining boreholes, even based on a single gamma-ray log. This constitutes the major advantage of this method which should be continuously controlled by other stratigraphical information. In this way it was possible to estimate the throw along faults and to validate some correlations proposed by ir. J. Tricot (N.V. K.S.). Nevertheless these correlations are limited to sedimentary features of some extent : not every single bed but rather characteristic sandstone bodies, thick coal seams or composite seams will be related.

All these methods lead to basic interregional correlations and allow detailed local correlations, at least of most thicker and laterally persistent coal seams.

PAPROTH, E., DUSAR, M., *et al.* (1983). Bio- and lithostratigraphic subdivisions of the Silesian in Belgium, a review. Ann. Soc. géol. Belg., 106 : 185-283.

UPPER CRETACEOUS TO EARLY TERTIARY DEPOSITS (SANTONIAN-PALEOCENE) IN NORTHEASTERN BELGIUM AND SOUTH LIMBURG (THE NETHERLANDS) WITH REFERENCE TO THE CAMPANIAN-MAASTRICHTIAN

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Upper Cretaceous and Early Tertiary deposits in Northeastern Belgium and South Limburg have been studied by four different methods : bioclast assemblages, benthic and planktonic foraminifer assemblages, ostracode assemblages and petrophysical borehole logs. A rather detailed correlation of the strata has been established. Bioclast and ostracode assemblages suggest that the basal portion of the Maastricht Formation (Valkenburg Member) is the ecostratigraphical equivalent of the upper portion of the Gulpen Formation (characterized by part of the foraminifer zone A'-middle and the zone A'-upper) seems to be the ecostratigraphic equivalent of the lower portion of the Gulpen Formation (Zeven Wegen Member).

In the eastern Campine, a silty to sandy, frequently glauconiferous marl in between the Vaals and Maastricht Formations (here called the Pre-Valkenburg Strata) seems to be the ecostratigraphic equivalent of the Gulpen Formation.

These ecostratigraphic correlations match the petrophysical borehole log correlations. These suggest that the lateral and vertical distribution of foraminifer assemblages (both benthic and planktonic) is more influenced by changes in the paleoenvironmental conditions than was accepted in the previous literature.

INVESTIGATIONS OF THE UPPER CARBONIFEROUS IN THE NETHERLANDS

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Investigations of the Upper Carboniferous in the Netherlands have been focussed upon three main areas :

a. southern part of south Limburg (north of the abandoned mines).
b. northern part of Limburg (Peel area).
c. eastern part of Gelderland/Overijssel (Achterhoek/Twente).

In 1984 the first phase of these investigations has been finished in south Limburg and the Peel area, whereas the reconnaissance in the Achterhoek is still going on.

Results of the studies in south Limburg so far :
three wells were drilled on different tectonic blocks, mainly penetrating Westphalian C strata. Only Kemperkoul-1 penetrates the Upper Westphalian B. Coal reserves were estimated for one tectonic block : the eastern Douvergenhout block. Coal reserves down to a depth of 1500 m of layers with 50 cm or more pure coal amount 600 my tons. The reserves down to a depth of 1200 m of layers with 80 cm or more pure coal amount over 200 my tons in the Douvergenhoutvleugel.

The long known coalification trend in south Limburg-increase of the volatile matter content towards the north - has not been confirmed in the investigated area. An opposite trend has been observed north of the mining area in various coal seams.

The maximum overburden at the end of the Carboniferous has been estimated on coalpetrographical data. In borehole Kemperkoul-1 (erosion level Upper Westphalian C) the overburden has been 2000-3000 meters. Towards the south the overburden must have been considerably higher, partly because the erosion cuts deeper in the stratigraphic sequence but also because of the increase in rank. The overburden in the Maastricht area has been estimated at 5000 to 6000 metres. No significant changes are found in the coalification gradients so far, which suggests a fairly constant gradient in the area. This subject needs further study, however. The data suggest a much thicker cover during late Westphalian and Stephanian times, than was accepted hitherto. Two solutions are proposed :

1. the Dinant nappes had a much farther northern extension during the late Carboniferous. There present northern limitation is controlled by subsequent erosion;
2. in front of the Dinant nappes a molasse basin developed in which a very thick sequence of Upper Westphalian to Stephanian sediments accumulated. The total thickness of this sequence may have been 2000 to 3000 metres or even more . . .

The three boreholes in south Limburg have been investigated palynologically, both on miospores and megaspores. The palynological information obtained from the Westphalian B of well Kemperkoul-1 appeared to be very scarce.

The rich megaspore-findings appeared not to be very useful for zonation purposes. Westphalian C samples of the three boreholes yielded rich and well-preserved miospore-assemblages, which more or less confirmed the palynological zonation according to Van Wijne and Bless (1974).

Several samples, especially from the Lower and "middle" Westphalian C contained reworked palynomorphs, originally belonging to the Devonian and Lower Carboniferous, which indicates a contemporaneous tectonic activity in the source area, most presumably the Ardenne-Eifel area.

VAN WIJNE, D.H. & BLESS, M.J.M. (1974). The Westphalian of the Netherlands with special reference to miospore assemblages. Geol. en Mijnbouw, 53 (6) : 295-328.

LOWER DEVONIAN PLANT STRATIGRAPHY

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The Lower Devonian macroflora from Belgium is rich and diversified. Numerous quarries and outcrops are scattered along the northern margin of the Dinant Synclinorium, yielding a variety of plant remains.

This work is an attempt to develop a biostratigraphical subdivision of the Lower Devonian Period based on plants.

Palynology has already allowed the recognition of a definite zonation. This zonation is used to give precise time intervals to floral assemblages : Lower Devonian needs a better characterisation than "The age of Psilophytes".

CRITICAL REVIEW IN GEOTECHNICS OF THE XRD ANALYSIS OF CLAYEY MATERIALS AND OF CLAY MINERALS

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In the scope of a doctoral thesis recently undertaken, emphasis is put on four interdependent factors characterizing the XRD analysis of clay mineral assemblages extracted from substrates investigated in parallel for their geotechnical properties :

- to reach a better - fast, complete, accurate - flow-sheet for the preparation (extraction) of several grain-sizes fractions from materials exhibiting peculiar geotechnical properties (such as swelling), and the subsequent XRD identification (qualitative and quantitative) of the occurring clay assemblages (use of specific post-treatments : cationic saturations with solvation with polyalcohols and several heatings);
- to compare the mineralogical properties (swelling) of certain materials before, during and after the civil works have been completed in situ;
- to compare the mineralogical results (by XRD analysis) obtained from samples treated in the laboratory at the standpoint of their geotechnical characteristics;
- to propose a simplified flow-sheet for XRD analysis allowing a quick, complete and the most accurate possible qualitative and quantitative evaluation of the clay assemblages, and consequently to offer the geotechnicians some further appraisal about the meaning of their own tests.

In order to reach these tasks, XRD analyses are actually developed as to compare results obtained after the preparation of the samples in different ways (support, grain-size, wetting conditions). Furtheron a direct visualization of the XRD analysis will be achieved through microscopic investigations (polarizing microscopy, transmission and scanning electronic microscopy). The analyses are applied on Tertiary clayey materials from Belgium and Algeria, and on Upper Carboniferous sands, silts and mudstones from Belgium.

WELL LOGGING INTERPRETATION

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The quantitative interpretation of well logs is difficult owing to

- the large amount of informations (data)
- the variety of borehole conditions
- its realization on *micro-computer* without relying to iterative procedures time-consuming.

The methods applied here are based on Fourier Transforms of signals. The deconvolution by the Geologic Impulse Response (GIR) and the adequate filtering of noise allow to present chemical, true physical and lithological characteristics as a function of depth in the borehole.

The GIR is obtained

- by mathematical knowledge of the equations describing the measured phenomena,
- by an experimental description of the response of a tool to an infinitesimally thin layer of material having particular properties,
- by homomorphic signal processing,

depending of the tool of interest (gamma, sonic, resistivity).

These techniques are applied to carbonate, coal and Pb-Zn sulphide ores prospection. Correlations of logs and subsurface geophysical prospection present a 3-D image of the ore and its geology. Further investigations can led to ore evaluation.

STRATIGRAPHIC SIGNIFICANCE OF UPPER PLEISTOCENE TEPHRA IN BELGIUM

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Three ash-falls are firmly known in Belgium. They occured during the last glaciation.

1. "Laacher See Tuff" erupted from the Laacher See area at about 11.000 y. B.P.; it is characterized by high amount of brown amphibole and titanit.
2. "Eltviller Tuff" erupted by an unknown volcano of the East Eifel between 22.000 and 30.000 y. B.P.; it is characterized by high amount of clinopyroxene and olivine.
3. "Rocourt Tuff" erupted by an unknown volcano of the Eifel between about 70.000 and 50.000 y. B.P.; it is characterized by low amount of enstatite which can be considered as a guide mineral.

Quantitative mineralogical variations were noted within each lobe. Hence correlations were partly puzzling. A theoretical modell of similar mineralogical variations was established using two recent ash-falls : 1) Mount St. Helens, May 18, 1980 eruption; 2) El Chichon March-April, 1982 eruptions.

EFFECTS DUE TO THE PRE- AND POST-TREATMENTS IN THE IDENTIFICATION OF CLAY MINERALS BY X-RAY DIFFRACTION ANALYSIS

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X-Ray Diffraction analysis appears as the paramount, easy reproductible and rapid, method of identification of clay minerals. However before any qualitative (and semi-quantitative) investigation remains the diffcult problem of selecting the appropriate method of preparation of the material. So far one has to stress the lack of any standardization method among all clayscientists and laboratories dealing with the analysis of clay minerals : more than 30 methods have been offered in the literature for more than two decades now, for the separation and extraction of the classic "less-than-two-micron" fraction before the preparation of the material as oriented aggregates. Such a situation is mainly due to the problem of removal of Fe- and Al-hydroxides as well as that of any C-organic contaminants, the occurrence of which contributing to a "masking effect" for the diffraction peaks and to the bad quality of the XR-patterns. As a consequence a tentative standardization of the methods of preparation is in progress after the launching of the problem by the Committee for Standardization Preparation Techniques (SPT) set up by J. Thorez for the A.I.P.E.A (Association Internationale pour l'Etude des Argiles). The very topic of the present work is part of this international programme.

20 samples - mainly of Quaternary and Tertiary ages - have been selected for this purpose, and submitted to 15 pre-treatments among the more "classic" ones published in the literature. Fractions below ı, 2 and 5 microns have been extracted and prepared as oriented aggregates (onto-slide-sedimentation and paste methods) and analysed by XRD. Subsequently the extracted clays have been submitted to various post-treatments (mainly cationic saturations) in order ro reach the most accurate identification of the different clay components occurring in the samples.

Comparison of the XRD patterns of materials submitted to the various pre-treatments demonstrates how deeply, in some cases, any chemical preparation can yield drastic qualitative and quantitative modifications of the original clay assemblages. Modifications of the d-spacings, intensities and shapes of the basal (001) reflections of the clay components are variably induced and refer systemically to qualitative and quantitative changes of the original mineral assemblages. Some components become artificially altered consequently to pre-treatments. Moreover new components may appear which occurrence, relatively to the original assemblage, demonstrates that some "manipulations" of the material lead in practice to some drastic compositional changes which are far from the "in situ" associations of the clay minerals.

The final task of the work in progress is to compare the analytical data provided by the pre-treatments, and to offer a simple, accurate, reproductible flow-sheet for the preparation of the clays and clay minerals before the XRD analysis, as to provide finally the "real" composition of the analysed material.

MINERAL RESOURCES

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A. DRILLING SERVICES

- LOGGING : the laboratory of applied geology works with a private company DIASOL s.a.r.l. and they offer together usual logging services and some special development in particular methods like E.M. multifrequencies logging and gamma spectral analysis. Current methods are applied with two different systems the first one, semi-digital system, for holes up to 400 m including natural gamma, gamma-gamma dual spaced, spontaneous potential, single point resistivity, normal 16" and 64", lateral and some special probes. The other one is a full digital system with multifunctions tools and a capacity up to 2000 m including F.D.S. sonde (natural gamma, dual spaced gamma and caliper), compensated sonic, electrical sonde (sp, spr, 16", 64"), and guard log.

Applications are essentially for quarries and coal, some particular applications are for mineral prospecting.

- COMPUTING to correlate logging and geological description to correlate differents holes for lithological and some qualitative prevision in order to anticipate quarries plan, it helps also to give a previsional 3D perspective of the structure in some particular development plans.

B. PROSPECTION

- LAND with traditional methods for mineral prospecting and some special development in multifrequencies E.M. sounding.

- AIRBORNE in association with a private company U.G.G. we use magnetic, scintillometric and afmag methods. The peculiarity of the system : the use of an ultralight powered machine with an in-board micro-computer to analyse and save the data. Special process as been developed using 20 fourier transform and special filters.

C. NEW APPLICATIONS FOR OLD MINERAL PRODUCTS

- SLATE : we develop a system based on polymere concrete using slates waste and some other refuses of ornamental stones as fillers and reinforcements, we are working for that project with a private company TRANSCAR four years ago. Actually we achieve the pilot plan for its industrial application.

MORPHOLOGIC EVIDENCE OF THE STABILITY OF THE COASTAL AREA IN SOUTHERN LAZIO (ITALY)

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In the limestone coastal areas, the corrosion notches are excellent indicators of quaternary shore-lines. For example, in Southern Lazio, some notch-levels are observed at different heights and measured by levelling.

The best developed notch is contemporaneous with the Euthyrrhenian sea-level (last interglacial period). Its height is on an average of 7.39 m near Gaeta whereas in the eastern parts, at Minturno, it reaches 9.84 m and, in the western area, 9.56 m at Monte Circeo.

These differences of height between areas which are relatively close to each other, can't be explained without a relative post-Tyrrhenian uplift of the Minturno and Monte Circeo areas in comparison with the sector of Gaeta.

On the other hand, the presence near 2.50 m of another notch-level in correlation with neo-tyrrhenian beach-deposits at Monte Circeo and Gaeta, tends to prove the stability of all this coast line since this period and implies that the older shorelines might have been moved by tectonic events between Eu- and Neotyrrhenian.

As to Minturno, the exceptional vertical development of the notches (4.5 m in stead of 1.5 m in the other sectors) is interpreted as a sign of tectonic movement syngenetic with the Tyrrhenian sea-level.
(see also in the same volume : DAI PRA, G. & OZER, A., p. 93-98).

APPLIED MINERALOGRAPHY

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The essential purpose of applied mineralography is to tighten the collaboration between mineralogists and all scientists involved in minerals or rocks valorisation such as metallurgists or better called mineralurgists.

This important sector of the geological sciences is taking more and more place, due to the increasing complexity of the ores, to the unceasing need for a better recovery and to the rising proceeding costs.

Starting from raw material and using different kinds of optical methods, applied mineralography leads to the characterization of the ore from the mineralogical, textural and structural points of vue. These characteristics are very usefull to the mineralurgists because of the fact that they allow to anticipate and thereby to avoid the most accurate treatment problems.

Once the choice of a proceeding technique has been made, on the basis of the preliminary ore-study, the hand in hand work between mineralurgists and mineralogists becomes more intense, with the object of improving the concentrator's results. The binocular lens with a magnification up to 50, will be sufficient where a quick diagnostic is required, but more often reflected (or transmitted) light microscopy will be used for qualitative mineralogy and identification of micro-structures.

This narrow collaboration enriched by chemical informations and published case histories, will support the first economical estimations and perhaps engender a pilot or industrial stage.

At those ultimate stages, applied mineralography remains essential because of the coming out of special recovery problems related to valuable or polluting trace elements. Specific techniques such as Electron Microprobe Analysis are then set to work.

Applied mineralography is also successfully used in the diagnostic of slates, hydrometallurgical residues, composite materials, . . . supporting the research for new applications and future technologies.

PALYNOLOGICAL STUDY OF THE DEEP PORTION OF THE PORCHERESSE-HAVELANGE BOREHOLE

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The Porcheresse-Havelange borehole has been studied by palynostratigraphic (spores) methods. The results are here compared to the geophysical data. Uninterrupted Famennian to Upper Siegenian sequence of rocks was met by the borehole until 4800 m. Further below, four major discontinuities were observed by both methods. The Upper Siegenian rests on Upper Gedinnian by a first fault withdrawing more than 250 m of sediments. This Gedinnian rests on Lower or Middle Siegenian by a second fault. The third one separates the last sediments from Upper Siegenian which in turn rests, by the fourth fault, on metamorphic levels with grenats.

LITHOGEOCHEMICAL INVESTIGATIONS IN THE OMOLON REGION (NE-USSR)

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A detailed sedimentpetrographic research of the Upper Famennian and Tournaisian carbonate deposits of the Omolon region (NE-USSR) enabled us to refine the palinspastic evolution model as proposed by Simakov *et al.*, 1983. Concomitant with this research a lithogeochemical study was carried out involving over 180 representative samples. The following elements were analyzed : Mg, Sr, Na, Zn, Pb, Fe, Mn, K and IR (Insoluble residu). Different types of anomalies were found :

a) anomalies with a local character. These anomalies, which occur in the Perevalny valley (Oder and Nizhnenaled section) seem to be linked to faults. They are characterized only by anomalous Pb-concentrations; the other variables display normal values.

b) anomalies which are related to hypersaline facies intervals. The host strata mainly consist of algal micrites and zebra-limestones. Furthermore semi-continous layers of silicified anhydrite nodules occur. These anomalies are characterized by very high Sr concentrations. Furthermore high Zn, Na and Pb values occur.

c) an important strata-bound anomaly is present near the Famennian-Tournaisian boundary. It was recognized in three sub-regions namely in Elergethkyn-, Perevalny- and Pushok area. In these sub-regions shallow marine carbonates are the host rocks. In the deep marine Uljagan strata this anomaly was not recognized. The anomaly is characterized by high to very high Zn and Mn values. Locally also high Pb concentrations occur. In detail however minor lithogeochemical discrepancies are present.

The recognition of such lithogeochemical anomalies is important. The first anomalies may indicate the neighbourhood of fault-related Pb mineralizations. The second anomalies may be a helpful tool in the characterization of hypersaline sequences. Furthermore, base metal anomalies within such sequences could give rise to proto-ore type deposits. The third anomaly may indicate the presence of a strata-bound Pb-Zn mineralization in the Omolon area. Concerning this anomaly the question still remains if this strata-bound type of anomaly may indicate a kind of event, since similar lithogeochemical features were found elsewhere at the same stratigraphical position.

SIMAKOV, K.V., BLESS, M.J.M. *et al.* (1983). Upper Famennian and Tournaisian deposits of the Omolon region (NE-USSR). Ann. Soc. géol. Belg., 106 : 335-399.

LITHOGEOCHEMISTRY, SEDIMENTOLOGY AND DIAGENESIS OF THE BELLE ROCHE BRECCIA

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The Moliniacian Belle Roche breccia is well exposed in the Vesdre basin and in the Ourthe area. Its lower contact with the Vesdre Dolostone Formation or Sovet Formation is always very sharp, while upwards a gradual transition with the Terwagne limestones is present. The breccia features differ from one locality to another. However, in all studied outcrops the breccia can be subdivided into two parts. In the Vesdre basin the lower part consists of a dolostone breccia, while the upper part is a pure limestone breccia. In the Ourthe area this subdivision is based on the occurrence or absence of certain matrix generations. In the lower breccia unit a recrystallized mud and sparite generation can be recognized, while in the upper part only the last sparite generation occurs. In our opinion the lower breccia part represents the culminating point of the Lower Moliniacian regression, while the overlying breccia unit represents the initial stages of the Middle Moliniacian transgression. In between both at least in the Vesdre basin subareal conditions occurred and are documented by the presence of a dedolomitization crust.

The following features occur within the breccia :

- the fragments are angular; often a puzzle texture is present. Brecciated breccia fragments occur;
- fragment size grades from 0.1 cm to several meters; "floating" semi-continuous beds are present;
- most of the limestone fragments consist of micrite (with or without calcispheres and ostracod debris) and algal micrite. Calcite pseudomorphs after gypsum, anhydrite and possibly habite occur. Furthermore, oömicrite fragments are present. As could be proven by cathodoluminescence at least part of these oolites have an influx origin. The majority of the fragments testify to a restricted shallow sub- to supratidal sedimentation environment;
- pseudomorphs after anhydrite nodules occur as fragments within the breccia. The following types were recognized :
  a) calcite pseudomorphs (with lath-shaped relic of former anhydrite crystals);
  b) quartz pseudomorphs (mainly composed by mega-quartz with lath-shaped anhydrite remnants; locally length slow chalcedony occurs);
  c) idiotopic dolomite pseudomorphs with typical chicken wire texture. These fragments sometimes occur as semi-continuous layers several meters in length.
- dolomicrite fragments, which probably are early-diagenetic in origin occur frequently. Furthermore other dolostone types were distinguished.

Just below the Belle Roche breccia continuous beds of evaporite relics were recognized. In the Vesdre basin calcite pseudomorphs after selenite locally occur, while in the Ourthe area several 20 cm thick beds of calcite pseudomorphs after anhydrite nodules were recognized. These beds were found in different localities. Small scale brecciation sometimes occurs within these beds. The enclosing rocks consist of dolomitized algal mats. These strata are comparable with the sabkha sequences described elsewhere. The underlying dolostones (Sovet and Vesdre Dolostones) were interpreted as reflux dolomites.

Above the Belle Roche breccia at certain localities an alternation between micrite beds (with birdseyes) and dolomitized anhydrite beds was recognized. At certain levels within the Terwagne Formation marsh type sediments are present; here calcite pseudomorphs after anhydrite occur frequently. These feature also points towards restricted hypersaline sedimentation conditions.

With the use of cathodoluminescence it was possible to differentiate several dolomite, vein, stylolite, cement and matrix generations and to reconstruct the diagenetical history. Lithogeochemical data enabled us to refine the model. Especially high Na, Sr and F values were measured within the different phases. Therefore the use of these elements as paleosalinity indicator is confirmed.

THE "PSAMMITES DU CONDROZ" (UPPER FAMENNIAN) : A PALEOGEOGRAPHIC OVERVIEW

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Detailed sedimentologic and lithostratigraphic investigations of the "Psammites du Condroz" in the Dinant synclinorium resulted in a all-scale paleogeographic reconstruction (from decametric subdivisions corresponding to vertical and lateral rhythms, to interlayered and superposed megaenvironments corresponding to the (new) lithostratigraphic units :the Upper Famennian Formations). The latter are particularly diachronous as demonstrated by the micropaleontological grid (cenozones with Spores, Conodonts and Ostracodes) applied for regional correlations of the more than 75 studied quarries and outcrops. General trends of the siliciclastic (regressive) progradation on a shallow-water shelf characterizes the "Psammites du Condroz". 11 sedimentary phases have built up by superposition, lateral and vertical relay and interlayering, the actual sedimentologic and lithostratigraphic framework of the Upper Famennian in the investigated area : a northern depositional area (northern flank of the Dinant synclinorium) characterized through time and space by a sedimentary complex comprising alluvial (deltaic), evaporitic lagoonal and barrier environments, and a southern area in which tidal flats, tempestites and fluxoturbidites have also accumulated rhythmically. The depositional processes involve both external (climatologically and tectonically) and internal (block-tilting and paleohydrodynamic) "stimuli" the results of which have induced the vertical and lateral changes of facies and thickness that presently characterize the whole "Psammites du Condroz" setting.

MATHEMATICAL GEOLOGY

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Geochemical and geophysical prospections are generally very expensive. However, the interpretation of the results is difficult and often, the given conclusions are quite poor.

The mathematical treatment of geological data allows a better valorization of the prospection. For this purpose, the methods employed are based on recent advances in structural analysis : geostatistics, decomposition by Fourier series, study of the power spectrum. More typically, application of adequate filter and deconvolution by the impulse response on the phenomena under study produce a signal free of noise due to the measurement. This signal is then easy to interpretate in terms of geology.

Applications of this theory have already been made successfully on geochemical, magnetic and electromagnetic prospections.

ANALYSIS OF OFFSET-DEPENDENT SEISMIC REFLECTION RESPONSE TO DETECT KARSTIFIED LIMESTONE

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The relationship between reflection amplitude offset dependence and limestone porosity due to fissures and dissolution activity is investigated. The karstified limestones studied are the Lower Carboniferous limestones found at depths between 1.500 m and 2.500 m in Northern Belgium. Surface seismic reflection amplitudes from the interface between the karstified Dinantian limestone and the overlying Namurian shales exhibit strong offset dependence.

Calibration of the shale/limestone surface reflection response, performed by means of borehole measurements consisting of offset VSP, full waveform sonic log and fracture logs. In addition theoretical models were tested to establish a relationship between limestone secondary porosity and the variation of reflection coefficient with angle of incidence. In this paper several examples of reflection responses for different karst distribution will be discussed.

CAMBRIAN ACRITARCHS CORRELATION BETWEEN BELGIUM AND THE BRITISH ISLES

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Recent publications on Cambrian Acritarchs of the northern Hemisphere (Scandinavia and Greenland, Great-Britain and Ireland, United States and Canada) confirm the stratigraphic age assigned (Vanguestaine, 1974) to the Deville and Revin Groups : a Lower Cambrian age for the upper part of the "Devillian", a Middle and Upper Cambrian age for the "Revinian" the lowest portion of the latter being still undifferenciated.

The correlations with the typical Cambrian of Wales are now biostratigraphically supported. The "Devillian" is not the stratigraphic equivalent of the Harlech Grits, the first one being older than the latter.

A part of the middle "Revinian" (Rv4) and the upper "Revinian" are to be correlated with the Dolgelly Beds of the Harlech area.

Correlations with Ireland indicate an approximate equivalence between the Bray and the Deville groups, the Ribband and the whole Revin and Salm Groups.

VANGUESTAINE, M. (1974). Espèces zonales d'Acritarches du Cambro-Trémadocien de Belgique et de l'Ardenne française. Rev. Palaeob. Palyn. 18 : 63-82.

CAMBRIAN AND LOWER ORDOVICIAN IN THE STAVELOT-VENN MASSIF. A MODEL FOR DEPOSITIONAL HISTORY

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Lower Paleozoic basement rocks crop out near the northern front of the Mid-European Variscides in the core of the Stavelot-Venn anticline (Ardenne). Quartzites and phyllitic slates of the Cambrian and graptolite-bearing slates and sandstones of the Lower and Middle Ordovician, which reach together a thickness of more than 3.000 m, were deposited in a broad east-west trending zone of subsidence ("Ardenne Basin").

The sequence starts with quartzites of the Deville formation (according to acritarchs dated as lowermost Cambrian) first deposited near-shore and later in a continuously deepening shelf region. From Middle Cambrian onwards black shales of the Revin formation reflect conditions of an outer shelf or even a deeper basin. They are irregularly interbedded by quartzites derived from nearby shallower neritic areas and deposited on submarine fans. In the Lower Ordovician Salm formation sediments of a prograding delta indicate regression and deposition in shallower environments. At the Revinian-Salmian boundary the petrographical composition shows important changes in relation to the source area.

THE INFLUENCE OF THE BRABANT MASSIF TO THE TECTONICS OF THE AACHEN-ERKELENZ COAL-DISTRICT

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Detailed tectonic investigations within the three isolated parts of the Aachen-Erkelenz Coal-District (Erkelenzer Revier, Wurm-Revier, Inde-Revier) prove an influence of the caledonic Brabant Massif to the hercynian tectonics of this area*).

This is observable by changes of the strike of fold-axes, which turn from a south-western north-eastern strike in the western part of the area to a more northerly directed strike in the eastern part.

The intensity of folding decreases very quickly from south-east to north-west within the investigated area. It is connected with important overthrusts (Aachener Überschiebung, Venn-Überschiebung and others) which are regarded as to be initiated by the development of folds of the hercynian orogeny and which were involved in the continuous folding-process. This development of these overthrusts is analogous to that of the "folded" overthrusts of the Ruhr-Carboniferous.

It is very likely that this development of folding and overthrust-tectonics in the Aachen area is caused by an accumulation of pressure during the hercynian orogeny on the southern edge of the consolidated bloc of the Brabant Massif.

Moreover, within the Wurm-District and the adjacent Dutch South-Limburg-District south-east north-west striking ruptures separate blocs of different folding. Thus these faults are assumed to be elder than the hercynian folding probably tracing structures of the deeper underground. The strike of theses faults is remarkably parallel to that of the lineamentic borders of the Brabant Massif. Therefore these ruptures might have been active already before the hercynian orogeny faulting the eastern edge of the Brabant Massif.

All these features loose their intensity towards the east, so the southern border of the Brabant Massif is assumed to be situated within the investigated area and might coincide with the Central-Graben-Lineament whose development can be traced back at least to an remarkable axes-depression of the hercynian folding.

* WREDE, V. (in print). Tiefentektonik des Aachen-Erkelenzer Steinkohlenrevieres. *In :* Tiefentektonik westdeutscher Steinkohlenlagerstätten, Band 2; Krefeld (Geol. Landesamt NW).

CONODONT EVOLUTION AND RELATION TO GLOBAL EVENTS (UPPER PALEOZOIC)

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Evolution of Conodonts in the Upper Paleozoic was frequently punctuated by more or less short-term episodes of crises during which development stagnated by virtue of reduced diversity or extinction. Some of these crises seem to have lasted for several million years, others can be documented as short-term or even abrupt. Low-diversity episodes in the Devonian were (1) in the Pragian before the entrance of the rapidly developing genus *Polygnathus,* and (2) in the Givetian *varcus*-Zone which was followed by one of the greatest outburst of new Conodont taxa (e.g. *Ancyrodella, Ancyrognathus, Schmidtognathus, Palmatolepis, Mesotaxis, Klapperina*).

At the change from Frasnian to Famennian many of the pelagic genera became extinct rather abruptly at or near the top of the uppermost *gigas*-Zone. This crisis of Conodonts is concident with one of the most conspicuous mass extinction of Invertebrate faunas. It was characterized by the persistence of only one species of the most significant Upper Devonian Conodont genus *Palmatolepis* and terminated at the top of the Middle *triangularis*-Zone. By a new evolutive thrust the well-known profusion of late Upper Devonian *Palmatolepis* species was brought forth.

At the Devonian/Carboniferous boundary another short-term crisis was characterized by the extinction of all species of *Palmatolepis* as well as many typical other Upper Devonian platform species. It was also followed by a rapid radiative development of new taxa like *Siphonodella* species and certain *Pseudopolygnathus* species etc., and by the instalment of *Bactrognathodidae* and *Idiognathodontidae.*

In the Lower Visean *texanus*-Zone, another low-diversity, near-extinction crisis occured, after which the earlier known high-diversity among Conodonts never recurred. From that point on, Conodont evolution tumbled from crisis to crisis with diversity increases only regionally with the exception of a worldwide radiative phase at the base of the Upper Carboniferous (*Adetognathus, Idiognathodus,* etc.). The near-extinction in the Lower Permian only was the beginning of the final extinction at the top of the Triassic.

Correlation of some Conodont crises with physical events seems obvious. Does Conodont evolution follow the pattern event/extinction - radiation - gradualistic evolution - event/ extinction ?