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TECTONO-METAMORPHIC CONTENT OF A RUBY MINE LOCATED IN THE MUZAF- FARABAD DISTRICT, AZAD KASHMIR (NE PAKISTAN).

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ABSTRACT.- The Pakistan Kashmir like the whole Himalayan Range is affected by the pressure of the Indian Continent through the North and undergoes an important tectonic and metamorphic activity.

The main characters of such a context are firstly a tectonic pile composed of four major elements which are from the South to the North : the Subhimalaya, the lesser Himalaya, the Higher Himalaya and the Kohistan Sequence. These four elements are respectively separated by three main thrust zones dipping towards the North : the Main Boundary Thrust, the Main Central Thrust, and the Indus Suture. The most obvious structure is a bending of geological lineaments (Hazara-Kashmir-Syntaxis) around a central core and the eastern continuation of that syntaxial structure in the upper tectonic elements (Nanga Parbat-Syntaxis) and in the collision margin (Indus Suture). The Lesser Himalaya itself is constituted by a pile of thrust units characterized by an increase in age and metamorphic grade towards the North of these units.

At first, a mapping was carried out in August 1992 at *Nangimali*, where a ruby-bearing marble is exploited. That marble is associated with other lithologies which are mainly amphibolites and metapelites.

The mapped field covers an area of approximately 3 km² with an altitude ranging from 3700 to 4260 meters.

After mapping and sampling of the area, petrological and petrogenetical analysis were undertaken. The thin-section study under petrographic microscope confirmed the amphibolite facies and allowed to determine the different paragenetic assemblages.

Chemical analyses on appropriate minerals have been carried out using an electronic microprobe. The results of these analyses were treated by the *Minfile*² software and afterwards by the *PTt Metamorphic Path*³ software. The latter is used for the thermodynamics calculations in order to obtain an estimation of the pressure-temperature conditions undergone by the sampled rocks.

Temperatures obtained with thermometric couples Garnet-Biotite and Garnet-Hornblende are comprised between 500°C and 600°C. The barometers used are the assemblages Grt-Plg-Bt-Qz, Grt-Plg-Bt-Mus, Grt-Plg-Mus-Qz. They have given pressures between 8.5 Kb and 9.5 Kb or 9.5 Kb and 10 Kb, depending on the calibration used.

The field campaign was carried out in collaboration with P. Pleuger; a specific sampling of marbles regard to silicate lithologies subsequently allowed an individual study of both rock series. The work achieved in the scope of that dissertation concerns mainly the silicate lithologies i.e. amphibolites, micaschists and quartzites.

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3. Franck S. and S.M. Peacock, *Program Manual and Computer Exercises for the Calculation of Metamorphic Phase Equilibria. Pressure-Temperature-time paths and thermal evolution of orogenic belts.*

A STUDY OF THE NEOTECTONIC MOVEMENTS IN THE RUSIZI PLAIN

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ABSTRACT.- The Northern Tanganyika basin (Rusizi Plain), forms a part of the western branch of the East African Rift system. The purpose of this study was to make a contribution to the complicated structure of the Tanganyika basin, because the recent faults are related to the rift.

First of all, satellite images (Landsat TM) were analysed. These brought in lineaments, which were actually just lines. A supplementary study of aerial photographs was necessary to give a meaning to these lineaments. From physiographic features, like topographic differences or influences of rivers, a fault could be demonstrated or not. On the basis of literature a geological value could be given to our observations. It delivered information about the exact location of the faults, about the geometry of the faults (strike-slip, normal or inverse movement) and about the age of these faults. It was also possible to relate our observations with data from previous works. Afterwards, this information of different sources could be processed with a Geographic Information System (GIS). The output was an integrated computer map, which helped to interpret the observations.

On the map, two main directions of lineaments could be distinguished clearly. These orientations are symetric, with respect to the NS direction of the plain, namely N30°W and N30°E. Indications of subvertical faults could be found on the aerial photographs :

- a) the eastward tilting of the sediment surface in the mini-grabens, the fault escarpment directed to the west could sometimes be observed on the aerial photographs;
- b) the formation of abandoned meanders, ox-bow lakes and wet depressions as a result of the cut off of a river by a fault.

A stress model that could explain these two dominant directions is the conjugated shear model, that includes a compressive movement along the NS axis (1) and an extensive one along the NE axis (3). It is important to mention here that north of the study area (namely the Kivu rift) and south of the study region (namely the Malawi rift) evidences of a compressive motion along a NS direction already exist. The suggested stress model results in the formation of faults along two directions, which form an angle of 60°, similar to those in the study area.

This model possibly fits in the framework of the complicated Tanganyika basin, because the northern part of this depression is an extensive basin. The western border is more active than the eastern one, that leads to the theory of the half-graben morphology. The sediment surfaces are tilted to the west.

The two principal directions are also present in the basement, which suggest a reactivation of Precambrian faults during Cenozoic times.

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PALEONTOLOGICAL STUDY OF THE NEERREPEN SANDS

(GHOST STRUCTURES, ICHNO- AND MICRO-FOSSILS IN THE TUNGRIAN 1 D)

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ABSTRACT.- For a long time the Neerrepén Sands were considered as more or less unfossiliferous. Few authors only mentioned the occurrence of limonitized rests of molluscs. One of them, Van Den Broeck and Rutot mentioned a recognisable positive impression of an oyster, probably of *Cubitostrea ventilabrum*, a frequent species in the Grimmertingen Sands. Glibert and de Heinzelin postulated that Grimmertingen Sands and Neerrepén Sands belong to the same marine cycle and that the Grimmertingen Sands-faune continues in the Neerrepén Sands. Buurman and Langeraar discovered near Valkenburg (NL-Limburg) impressions of bivalves in the Neerrepén Sands. One of them *Hilberia stettinensis* had never been found in the

Grimmertingen Sands. I discovered a large quantity of impressions in the Neerrepn Sands occurring in the Francart quarry (Tongeren-Belgium). The most frequent species *Palliolium hausmanni hausmanni*, had never been found previously in both Sands.

The profile of the Neerrepn sands shows at the base an infralittoral character. To the top, the littoral character becomes larger. On the top of the Neerrepn Sands the Neerrepn Soil was formed in a dunal environment. During the formation of this soil there were several migrations causing the fossilisation.

Out of the micropaleontological study it was possible to classify The Neerrepn Sands in the Upper-Eocene and not in the Oligocene, like it was done till now.

Of the fourteen macrofossils encountered, twelve were found never before in the Neerrepn Sands. Two of them *Palliolium hausmanni hausmanni* and *Chlamys (flexopecten) weinheimensis* were never mentioned in the Grimmertingen Sands. So the fauna of the Grimmertingen Sands differs really from the fauna of the Neerrepn Sands. Before, *Palliolium hausmanni hausmanni* was considered as a guidefossil for the Eochattian and *Hilberia stettinensis* as a guidefossil for the Rupelian. According to my investigation, their ranges should be enlarged, and we can conclude that macro-fossils are bad guidefossils.

Finally, out of the larger size of *Palliolium hausmanni hausmanni* (larger than in the Upper-Oligocene) we can say that the Neerrepn Sands were deposited in a cold environment. The occurrence of the genus *Arctica* and the find of a lot of *Pinus*-pollen in the sediment prove this conclusion. The freeze-dow structures found in the Neerrepn soil prove that the soil was formed in a climat with at least one cold season too.

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GEOCHEMISTRY OF HYDROTHERMAL DEPOSITS FROM THE GUAYMAS BASIN, GULF OF CALIFORNIA.

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ABSTRACT.- The mineralogy and geochemistry of ten black smoker samples from the Guaymas Basin were studied in order to evaluate the role of sediments in hydrothermal processes at "sediment-covered" oceanic ridge segments.

The Guaymas samples are enriched in anhydrite, calcite and barite, but are depleted in sulfides compared to samples taken from sediment-free rifts. Pyrrhotite is the dominant sulfide mineral, which point to very low oxygen fugacities. The strongly reducing conditions presumably reflect the presence of abundant organic material in the sediments.

Minor and trace elements were determined by X-Ray fluorescence (XRF) and neutron activation analysis (NAA). The results were compared with data from sediment-free hydrothermal systems at EPR 13°N (1) and Lau Basin (2). Surprisingly, concentration levels and patterns of most elements were analogous in the three rift systems. It is an indication that the geochemistry of most elements is not greatly influenced by the presence of the sediment cover.

The lanthanide elements (REE) were analyzed by a NAA procedure involving two radiochemical separation steps. Results could be compared with a REE data set for samples from the Southern Explorer Ridge (3). The REE patterns from both rift segments are characterized by a hydrothermal signature : enrichment of the light REE, positive Eu-anomaly depletion of heavy REE. However, this signature is more pronounced in the Guaymas samples, suggesting that the sediment cover is a supplementary source of light REE and a sink for heavy REE.

The uniformity of *relative* REE patterns for Guaymas samples with mineral parageneses formed at quite variable temperature has two implications. Firstly, REE exchange between the hydrothermal fluid and the sulfate/carbonate phases did not greatly affect the REE patterns. Secondly, the REE fractionation in the hydrothermal fluid is not temperature dependent.

The highest absolute REE concentrations were observed in barite-rich smokers which have been formed at low (< 130°C) temperature. It leads to the conclusion that temperature greatly determines the overall REE scavenging rate from hydrothermal fluids.

The REE analysis of barite-rich samples might be an interesting indirect way to deduce the REE signature of the hydrothermal fluid.

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SEDIMENTOLOGY AND DIAGENESIS OF THE WESTPHALIAN A AND B STRATA IN THE CAMPINE BASIN. (PEER BOREHOLE, BELGIUM),

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ABSTRACT.- Sandstones, shales and coal of the Westphalian A & B extend from 875 - 1348 meter in the cored interval of the Peer borehole, Campine Basin, NE Belgium. Detailed examination of sedimentological features suggest that the Westphalian A & B strata were deposited on an upper delta plain. Deposition was dominated by crevassing into interdistributary bays and lakes. Systematic variation in sedimentation can be detected, pointing out that the basin progressed more inland during this period.

Three main stages of diagenesis can be distinguished : a pre-compactional stage, compaction and a post-compactional stage. Pre-compactional diagenesis is conditioned by infiltration of meteoric water circulating in the deltaic system. Early diagenetic cements are siderite (cement or nodules), pyrite, fine crystalline kaolinite and quartz resulting from feldspar dissolution. Compaction lead to different fracturation phases in the sandstones, later cemented by post-compactional cements. Post-compactional cementation consists of ferroan dolomite, dolomite and ferroan calcite in veins and kaolinite, quartz and ankerite in both veins and sandstone matrix. All post-compactional cements show distinct dissolution features reflecting the changing alkalinity of the formation water. Kaolinite showed a systematic variation in dissolution along the borehole, proving the presence of meteoric condition during asturian erosion.

Ferroan dolomite ($18O = 0.0$ to $+0.5$ PDB) is partly derived from underlying Namurian fluids (-8 SMOW), type 1 vein ankerite ($18O = 0.6$ to $+1.4$ PDB), type 2 vein ankerite ($18O = -2.8$ to $+3.1$ PDB) and ferroan calcite ($18O + 4$ PDB) precipitated during increasing water rock interaction and CH₄ production leading to a pore water composition of -3.4 to 2.8 SMOW. Kaolinite precipitated during decarboxylation reactions of organic acids, in dissolution voids within ankerite. Modelling fluid expulsion from, nearby mudstones and coalbeds was possible using vitrinite reflectance data and detailed burial history of the area. A geothermal gradient of $62^{\circ}C/km$ during first burial (maximum depth : 2300 meter) was calculated using these two constraints. The calculated expulsion was used to determine the chemical conditions in which the different cements precipitated and is in agreement with the above geochemical data and the observed paragenetic sequence.

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CONTRIBUTION A L'ANALYSE METAL-LOGENIQUE ET STRUCTURALE DES GISEMENTS DE SAN MATIAS ET CAPILLANI, POTOSI, BOLIVIE

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RESUME.- Des analyses paragenétiques et structurales des filons minéralisés, d'âge supposé Tertiaire, de San Matias et Capillani (Potosi, Bolivie) ont été menées de front afin de préciser les liens entre les phases de minéralisations primaires (Pb-Zn-Ag) et les déformations tectoniques).

Pour ce faire, une campagne de terrain eu lieu en août-septembre 1992, suivie d'une analyse structurale et minéralogique sur lames minces et sections polies.

Une évolution unique et continue, fut reconnue dans ces gisements du secteur sud de la Cordillère orientale. Au sein de celle-ci, deux phases majeures de déformations et de minéralisations ont été mises en évidence. Ces phases correspondent, d'un point de vue tectonique, aux positions successives de l'axe de contrainte principale en rotation sénestre (E-W à N-S) et d'un point de vue métallogénique, à la formation progressive du minerai. Celui-ci passe d'une cristallisation zincifère à plombifère, et enfin argentifère dans un stade ultérieur.

(1) La première phase se caractérise par des cisaillements dextres, pendant lesquels la sphalérite et l'essentiel de la gangue de quartz et sidérite ont cristallisé à la faveur de failles NE-SW à NNE-SSW en réouverture par transtension.

(2) Lors de la deuxième phase, en cisaillements sénestre, la galène a cristallisé dans des caissons prismatiques en ouverture suivant des fractures NNE-SSW prises en relais par des segments courts N-S.

Enfin, il a été reconnu une troisième phase de minéralisation de sulfosels tardifs (tétrahédrite argentifère, bournonite, et famatinite), et des structures post-minéralisation des failles sénestres N-S responsables du décrochement des filons.

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STUDY OF THE MORPHOLOGY AND SEDIMENT DYNAMICS OF THE CENTRAL PART OF THE GOOTEBANK, SOUTHERN NORTH SEA

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ABSTRACT.- The main objective of this study was to make a detailed submarine cartographic analysis of the morphology of the central part of the Gootebank. This sandbank is located at 22 km of the Belgian coast and is part of the Western Zeeland Ridges.

To accomplish this aim two geosonic surveys were carried out with the help of the oceanographic vessel "Belgica". By making use of an accurate navigation and positionings systems, an echosounder and a sidescan sonar, two bedform maps were drawn on a scale of 1/5000.

Although the topography of the Gootebank is not very pronounced, the sandbank is superimposed by flow transverse bedforms that can be classified as small, medium, large and very large dunes. Most of these bedforms, including the sandbank, are characterized by a stoss and a lee slope. The smaller dunes are oriented perpendicularly to the axis of the bank while the larger ones display an offset of 20° with the smaller bedforms.

Residual sediment transport directions were deduced from the strike and the steep slope of the bedforms. As the strike of the smaller dunes is completely perpendicular to the peak tidal currents, these were used to deduce the net sediment transport direction. During the first campaign the geometric characteristics of the smaller dunes indicate a residual transport towards the SW which corresponds with the direction of the peak ebb current. However the results of the second campaign reveal a transport towards the NE which is the direction of the peak flood current. These opposite results can only be explained by taking into account external factors such as meteorological conditions.

During the first campaign sixty bottom samples were collected with a Van Veen sampler. Several grain-size parameters were calculated and their geographical distribution visualized.

Finally, the areal distribution of the grain-size parameters mean, sorting and skewness were also used to assess the applicability of the McLaren sediment transport trend towards the southern swale whereby the sediment becomes finer, better sorted and more positively skewed. In the southern swale, the sediment trend analysis shows a residual movement towards the SW which is in agreement with the bedform analysis, but on the bank itself there is a clear offset between both methods. The transversal grain-size differentiation is explained by a deviation of the peak ebb tidal current towards the crest mainly due to bottom friction. The coarser deposits on the northern flank are induced by an upslope increase in current speed.

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