GEONEWS
The Geological Society of Africa Newsletter

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Cover Picture-Soil profiles on the Angolan Coastline, 100km south of Luanda.

Africa Geonews
THE NEWSLETTER OF THE GEOLOGICAL SOCIETY OF AFRICA
February 2003

Editorial

The past year had been one of activity for the Society. There was the colloquium that was held in Morocco, there was also the IAGOD/Geocongress that was held in Namibia, there was a regional conference in Nairobi on Geohazards and the African Women Geoscientists conference held in Cape Town. All these activities are reported herein.

On behalf of the GSAf council I would also like to thank all our institutional members for the support they are giving to the society. Such support is critical to the activities of the society and for a good working relationship between industry and GSAf. Individual members are also thanked for their support as it them who make majority the members in our society.

It is heartening to see our women folk becoming more involved in geological issues. We wish them very well, and hope that the newly elected office bearers will work hard to make their organisation a strong one.

We would like to encourage our members to become active in the developing of regional IGCP projects. There is currently a very low representation of African projects on the IGCP schedule. IGCP projects are specifically formulated to answer some of the regional questions, such that, with some supplementary funding many geological questions can be answered.

I would like to wish all the members a successful 2003. As we prepare for CAG 20, let us work hard for the good of GSAf.

Benjamin Mapani
Editor.

The 19th Colloquium of African Geology and the post-colloquium Anti-Atlas field trip (El Jadida, Morocco, 19 to 27 March 2002)

Introduction

A better understanding of the geology and mineral potential of Africa is important in the overall context of social and economic development across the continent. Four decades ago, scientists undertaking geological research in Africa decided to hold a meeting to exchange ideas and discuss results. Consequently, in 1964, the “Colloquium of African Geology” (CAG) was born. At the beginning, this meeting was limited to Heads of Departments and selected scientists. Afterwards, growing numbers of participants made this meeting a must for all geologists and students of African geology, so that 500 delegates attended the colloquia in Berlin (1987) and Nancy (1990).

Between 1965 and 1990, CAG was held in Europe, and catered mainly for European scientists and African scientists and students (English- and French-speaking) domiciled in Europe. During this period, CAGs were held in London (1965), Clermont-Ferrand (1969), Leicester (1971), Florence (1973), Leeds (1975), Göttingen (1977), Montpellier (1979), Open University, UK (1981), Tervuren-Brussels (1983), Saint Andrews (1985), Berlin (1987) and Nancy (1990). In 1990, the decision to organize the next CAG in Africa was taken. So in 1993 the well-attended and highly successful 16th CAG was held in Swaziland, but only 45 delegates attended the 17th CAG in Harare, Zimbabwe in 1997.

The Geological Society of Africa then decided to alternate the biennial CAG between Europe and Africa. Thus, at the18th CAG in Graz, Austria where more than 200 scientists attended, the Chouaib Doukkali University at El Jadida Morocco, was elected to organise the 19th CAG in 2002.

Technical sessions in El Jadida (19-22 March)

The 19th CAG took place in March 2002, in the El Jadida Geology Department, with Professor Nasser Ennih as chairman of the organising committee. El Jadida is an attractive seaside resort in western Morocco. The meeting was attended by more than 350 participants from 28 countries (Algeria, Austria, Belgium, Burkina Faso, Canada, Cameroon, Egypt, France, Germany, Holland, Ireland, Italy, Kenya, Mexico, Morocco, Portugal, Romania, Senegal, South Africa, Spain, Switzerland, Tanzania, Tunisia, Uganda, United Kingdom, USA, Zambia and Zimbabwe). Delegates from North Africa were particularly well represented, indicating the positive role that holding the CAG in Africa can play. Following selection, 348 abstracts were published in an attractive abstract volume printed in Belgium.

A broad range of topics and themes were covered in four parallel technical sessions over the four days:

* Record of continental construction and fragmentation in Africa, Geological correlation between Europe and Africa.
* Rift-related structures and magmatic phenomena, Ore deposits and gem minerals, Hydrogeology
* Petroleum Geology and Geophysics, Cover sequences, Stratigraphy and Palaeontology
* Orogenic cycles and related Magmatism, Environmental Geology and Quaternary Geology.

Plenary sessions were set at the beginning of each half-day:

- Anti-Atlas geology: an overview, by Nasser Ennih, El Jadida, Morocco;
- Un nouveau scénario tectonique pour la formation de la chaîne du Rif by Ahmed Challouan, Rabat Morocco;
- Terranes rheology and the Pan-African orogeny in the Tuareg shield (central Sahara) by Jean Paul Liégeois, Tervuren, Belgium;
- Soil quality build-up means durable agriculture and viable environment by Rachid Mrabet, INRA, Settat Morocco;
- Provinces métallogéniques et exploration minière au Maroc by Abdellah Mouttaqi, BRPM, Rabat Morocco;
- Le Plomb au Maroc by Ahmed Wadjinny, Touissit, Morocco;
- Apport des techniques isotopiques à l'étude des ressources en eaux by Lhoucine Bouchaou, Agadir, Morocco;

Isotopic imprint of present and past pollutant lead invasion by Alain Veron, Marseille, France;
- New chances for Carboniferous/Permian biostratigraphic correlations Gondwana – Euramerica by Jörg W. Schneider, Berlin, Germany;
- Post-collision/postorogenic vs. anorogenic alkaline magmatism: the Gondwanan Europe record by Bernard Bonin, Paris, France;
- Utilisation de la carte thématique à la compréhension de l'histoire géologique by Jean Sougy, Marseille, France.

In addition to oral presentations, 76 posters were displayed. Both oral and poster presentations precipitated many animated discussions. The wonderful social events that were organised during the colloquium were typically Moroccan in flavour and highly appreciated.

Anti-Atlas Field excursion (23 to 27th March)

The post-colloquium field excursion to the Palaeoproterozoic-Neoproterozoic Anti-Atlas belt was attended by 28 participants from 10 countries: Belgium (Demaiffe, Laduron, Liégeois), Burkina-Faso (Lompo, Naba), France (Bonin, Burollet, Le Goff, Lerouge, Lescuyer), Germany (Kröner, Schenk, Sommer), Italy (Sacchi), Romania (Berza, Costea, Gabudeanu, Iliescu), South Africa

(Elsenbroek, Ingram, Macey, Master, Thomas), Tanzania (Muhongo), United Kingdom (Bennett), under the able leadership of Nasser Ennih, Abdelilah Fekkak and Ezzoura Errami, from El Jadida.

The Anti-Atlas belt is of particular geotectonic interest, being located along the northern boundary of the West African Craton (WAC) and including some important mineral deposits, some of which are currently mined. The belt has recently been the subject of a series of publications, emanating from different teams, often with different interpretations put forward. In addition, systematic 1: 50 000 scale mapping has recently been carried out on various parts of the belt by various teams, many of whom were represented, so that the excursion generated much discussion. The Anti-Atlas belt is elongated NE-SW and limited to the north by the South Atlas Fault (SAF), a major tectonic still seismically active (Agadir earthquake in 1960) feature extending from Agadir on the coast to Algeria in the East. The SAF separates the Phanerozoic orogenic belts to the north from the Proterozoic belts to the south. The Anti-Atlas is classically separated into two domains by the Anti-Atlas Major Fault (AAMF): 1) a stable Eburnian (c. 2 Ga) domain forming the south-western Anti-Atlas (Ifni, Bas Draa, Kerdous and Ighrem inliers) and the southern part of central Anti-Atlas (Bou-Azzer and Zenaga inliers); 2) a mobile Pan-African domain including the northern part of the central Anti-Atlas (Bou Azzer and Sirwa inliers) and the eastern Anti-Atlas (Saghro (or Sahro) and Ougnat inliers). The AAMF is spatially associated with ophiolitic complexes in the Bou Azzer and Sirwa inliers that have traditionally been considered to represent a Pan-African palaeosuture formed between 600 and 700 Ma. This view has been challenged recently by Ennih and Liégeois (2001, *Precambrian Research*, **112**, 291-304), who considered the actual northern limit of the WAC to be the SAF. This implies that the Pan-African oceanic material is thrust upon, and underlain by, the WAC. Part of the excursion took place in the Zenaga region, an area recently mapped at 1: 50 000 by a South African team (Thomas and co-workers), four of whom participated in the excursion.

The first day was dedicated to the Zenaga inlier around Tazenakht. Here, the Palaeoproterozoic basement (Zenaga Complex) is made up of several peraluminous and calk-alkaline granitoids dated at c.2035 Ma (U-Pb zircon, Thomas *et al*., 2002, *Precambrian Research*, 2002, **118**, 1-57) that intruded Eburnean mica schists, gneisses and migmatites. One outcrop showed a strong foliation with mylonitic to blastomylonitic characteristics and the proximity of the transcurrent AAMF induced warm discussions about the possible Pan-African origin of the fabrics. The second part of the day was taken up with early Neoproterozoic (pre-Pan-African) lithologies: 1) swarms of continental tholeiitic dykes (gabbro, dolerite, trachy-andesite) dated at c. 780 Ma (Rb-Sr) cross-cutting the Zenaga basement. These could be a useful target for palaeomagnetic studies to determine the WAC position at that time; and 2) passive margin sedimentary rocks (Taghdout Group), composed of limestones, quartzites and jaspilites preserving spectacular shallow-water sedimentary features (ripple marks, mudcracks, etc), despite their sub-vertical attitude in the visited area. This succession was deposited in rift basins related to the pre-Pan-African break-up of the northern margin of the WAC. At the end of the day, a Pan-African alkaline granite was briefly seen, cross-cutting the Palaeoproterozoic basement. This granite is related to the post-kinematic Ouarzazate Group rhyolites and ignimbrites (c. 580 Ma) that cover a large part of the Anti-Atlas. The evening and night was spent in a typical Moroccan small hotel that gave a taste of the local cuisine and an opportunity to inspect the newly-available geological maps.

The second day was spent examining the renowned Bou Azzer ophiolite sequence. On the way, the group stopped to look at the transition between rhyolite of the Ouarzazate Group and the overlying Tata Group (sedimentary rocks with trachytic layers), which hosts the Precambrian-Cambrian boundary. Within the Bou-Azzer El Graara inlier, after a presentation at the mine, we inspected a convincing cross-section through the ophiolite comprising dunite, pyroxenite, harzburgite, sheeted dykes (at a distance), trondhjemite (plagiogranite) dykes and larger masses of quartz diorite. Some of the extracted minerals such as the skutterudite (Co, Ni) As_3) were also seen. The Bou-Azzer area consists of tectonic slices of allochthonous ocean crust and fore-arc flysch sedimentary rocks that were well seen in the plain north of the ophiolite (Tidiline/Sarhro Group). Island arc building has been demonstrated between 760 and 740 Ma in the Sirwa inlier, while accretion occurred between 680 and 660 Ma.

The third day was devoted to the Boulmane and Imiter inlier in the Saghro area. At the first section, we examined folded Neoproterozoic Sarhro Group sedimentary rocks and pillow basalts, with structures compatible with thrusting to the south. The depositional setting of these rocks in either a back-arc/ forearc basin or a distal passive margin basin was debated. Lunch was kindly provided by the Imiter silver mine, where major mineralization is associated with the Sarhro Group and Pan-African transcurrent tectonics, even though the source of silver is not known.

The afternoon was devoted to the volcaniclastic rocks and granitoids of the Imiter inlier, the granitoid being mainly of high-K calk-alkaline composition (gabbro, diorite, quartz-diorite, granodiorite, monzodiorite etc), intrusive in the Sarhro Group. Outcrops showed that these high-level granitoids are closely linked temporally to the Ouarzazate Group and its precursor, the Mgouna Group. Rocks of the latter group (~605 Ma?) are crosscut by the granitoids, while Ouarzazate flows and erosion products covered the granitoids. Consistent U-Pb ages of c. 580 Ma from such granitoids, obtained by different teams working in different areas, confirm this - the high-K calc-alkaline volcanics of the Ouarzazate Group have given the same ages (de wall et *al.,* 2001). The thick and extensive Ouarzazate Group was also seen during the excursion where it dominates the Anti-Atlas landscape. The group is made up of volcanic/volcaniclastic and volcano-detrital deposits with several eruption centres recognised. In the Imiter area, the Ouarzazate Group and the granitoids are overlain with a sharp unconformity by middle Cambrian rocks.

On the last day, before returning to Casablanca, a short touristic detour was made to the spectacular Todra Gorges before traversing the Atlas Mountains via the Tichka pass (2200 m) and Marrakech.

What is remarkable about the well-exposed Anti-Atlas belt is the dearth of Pan-African high-grade metamorphic rocks. The Neoproterozoic story starts with continental break-up (780 Ma?), island-arc building (760-740 Ma) and accretion (680-660 Ma), followed by emplacement of largely undeformed, high-level, high-K calc-alkaline and alkaline granitoids and rhyolites (580-560 Ma). Arc accretion and ophiolite emplacement are demonstrated, but no continent-continent collision-related event.

As a direct result of this field excursion, therefore, this interesting situation has led to two new initiatives to elucidate the nature of the boundaries of the WAC.

1) A book in French, "Le craton ouest-africain et ses ceintures de chaînes mobiles" (see below);

2) A proposal for a new IGCP project will be submitted, with the provisional title: "Craton boundaries: the case of the West African Craton". It will be lead by the El Jadida team. The project will aim to correlate the tectonostratigraphic terranes within the WAC; examine the nature of the boundaries between the Palaeoproterozoic, Neoproterozoic and Palaeozoic terranes and the role of shear zones in accretional tectonics; and study the magmatism around continental margins, the thermal evolution and geochronology of key lithologies, and the mineral deposits within and around the craton. Calls for letters of support to accompany the proposal will soon be sent to interested parties in the international community.

Conclusion

CAG19 was a great success due to the large number of participants, the high level of many presentations and ensuing discussions. Additionally, good conference organization and the warm welcome given to delegates by our Moroccan colleagues and from the officials and general population of El Jadida, contributed greatly to this success. Social events, such as the royal lunches under a huge traditional caïdal tent on the campus and the extraordinary, typically Moroccan, gala dinner in an Andalou palace generated a friendly and relaxing ambience. For the lucky delegates able to join the excursion, other facets of Moroccan life in addition to fascinating geology were to be enjoyed. CAG19 demonstrated the important role that such colloquia can play in Africa.

Two major Elsevier publications should result from this conference: 1) a series of short, provocative, high quality articles in English to make up a special issue of the *Journal of African Earth Sciences* ("Key points on African Geology", guest edited by N. Ennih, J.P. Liégeois and R. Thomas); 2) a book in French (still under discussion, but hoped to be the first of a series published in that language and devoted to African geology). The first book will comprise review papers or syntheses and will be entitled "Le craton ouest-africain et ses ceintures de chaînes mobiles" with invited editors B. Bonin, N. Ennih, J. P. Liégeois and J. P. Milési.

The present *GSAf* Council Members and all CAG19 participants enthusiastically approved that the 20th Colloquium on African Geology (CAG 20) will be held during June 2004 in Orléans (France) and organized by the BRGM (Bureau de Recherches Géologiques et Minières).

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GEOLOGICAL SOCIETY OF AFRICA COLLOQUIM OF AFRICAN GEOLOGY

Report on the Geological Society of Africa (*GSAf*) 19th Colloquium of African Geology

The Society's 19th Colloquium of African Geology (CAG19) was held at the Chouaib Doukkali University, El Jadida, Morocco, from 19-22 March 2002 under the high patronnage of king Mohammed VI. The meeting was organised by a hard-working local steering committee led by and comprised largely of staff from the University's Faculty of Sciences. A key feature of the meeting was the friendly atmosphere that prevailed throughout among all the participants.

This was the first time that the colloquium had been held in North Africa. It undoubtedly helped raise the international profile of geosciences in Morocco and was attended by well over 300 participants from some twenty-eight countries. The majority of the African delegates, unsurprisingly, came from the North African countries (Morocco particularly, Algeria and Egypt), reflecting the high costs of travel to Morocco from the rest of the continent. Notwithstanding this, however, the following African countries were also represented: Burkina Faso, Cameroon, Senegal, South Africa, Sudan, Tanzania, Uganda, Zambia and Zimbabwe. In keeping with the philosophy of the colloquia, CAG19 also attracted geoscientists from nine European countries and the USA, all of them working and collaborating actively in the continent to develop our understanding of African geology. Most of the participants came from academia and, to a significantly lesser extent, geological survey organisations and consultants. Direct representation from the international mineral and petroleum industries was disappointing – arguably this was the industries' loss, as the colloquium program and the scientists present offered a wealth of information and expertise that would surely have been of value to exploration geologists engaged in both of these branches of geosciences.

As is customary, the Colloquium focused very much on the science and covered a wide range of topics including continental construction, fragmentation and correlation, mineral, energy and water resources and environmental geology, and the applications of structural geology, stratigraphy, sedimentology, palaeontology and geophysics to these disciplines. Particular emphasis was placed on the evolution of the 2000 million year old West African Craton and its marginal mobile belts (Morocco is positioned on the northern margin of the craton). Presentations were given in English and in French in four parallel sessions except during keynote addresses. There was also a large poster display throughout the meeting.

The local organisers obtained generous local and international sponsorship and support. *GSAf* benefited directly from, and acknowledges with gratitude, the valuable financial assistance it received from the UK Department for International Development (DFID) and from Rio Tinto Mining and Exploration Ltd, UK (the company is operating in Guinea, Zimbabwe and Botswana among others). This sponsorship enabled the Society to bring six participants to the meeting, five of these from sub-Saharan countries.

The meeting provided a valuable opportunity for the nine *GSAf* council members or their representatives present to hold a business meeting and informal discussions. At the end of the colloquium a general meeting accepted the offer of BRGM, France, to host the 20th Colloquium in Orleans, France, in 2004. The next International Conference of the Society, the 13th in the series, is planned for Cairo in 2005. This accords with the policy of rotating these meetings around the continent, the 12th Conference having been held in Cameroon in 2001.

As a result of the Colloquium, the scope and variety of geoscientific activities in Morocco and, indeed, the work being accomplished, often against the odds, throughout the continent, are now better appreciated internationally and many new collaborative links were forged. The Society welcomed over forty new members during the event but new members and supporters are always welcome to join at any time to help *GSAf* advance its aims of furthering the study and applications of geoscience and developing the professional calibre of African geoscientists throughout the continent.

The colloquium was followed by a wide-ranging and fascinating field excursion through the Haut Atlas mountains, an extension of the Alpine fold belt, to the Anti-Atlas zone to the south, and the interface with the northern margin of the West African craton. It is planned to provide a separate account of the excursion, which will be submitted for publication in the IUGS journal Episodes. We hope to be able to feature this article also on the *GSAf* homepage in due course.

John Bennett
April 2002

Geoenvironmental Hazards and Disasters in Africa
Nairobi, Kenya, 01 – 03 July, 2002

Geoenvironmental hazards and disasters in Africa are on the rise both in frequency and intensity with increasing heavy toll in human, economic and ecological terms. The need for cost-effective hazard assessment and mitigation is unarguable especially in countries where the geoenvironmental data base is still limited and rates of rural development are accelerated as part of the move towards poverty alleviation.

The Workshop on Geoenvironmental Hazards and Disasters in Africa was organized and co-sponsored by UNESCO Nairobi Office, Moi University, Africa Geoscience Review, University of Nairobi, Deutscher Akademischer Austauschdienst (DAAD) and the Geological Society of Africa (GSAf).

The objectives of this Workshop were to present the latest scientific understanding of natural and human-driven geoenvironmental hazards and disasters on the African continent; to examine their effects on African societies and lives, assess the effectiveness of available mitigation options, explore possibilities for their improvement as well as contemplate on new measures for disaster management.
One focus of the meeting was to try and evolve a mechanism that would be effective in transmitting the information gathered by the scientific and technical experts to the policy makers and local authorities in the participating nations.

The Workshop was held at the UNESCO Conference Hall in Nairobi on 01 and 02 July, 2002. On 03 July, participants took part in a full day's field excursion to Lake Magadi, about 115 km southwest of Nairobi. This is a unique and fascinating part of the Great Rift Valley where participants observed varied features of environmental and geological interest. The field trip guidebook (see below for how to get a copy) provides a mine of information on the geological evolution of Magadi, the production and extraction of soda ash and environmental problems of the area as well as references. *En route*, the archaeology of the famous prehistoric site of Olorgesaile was seen and illustrated. This site offers an exceptional opportunity for the study of conditions of life during the early part of the Stone Age.

The Workshop attracted a group of over thirty participants from ten countries and comprised university researchers, government ministry officials and NGO representatives, providing a forum for assemblage of discussion and fostering a mutually beneficial exchange of information on major geoenvironmental hazards and disasters in Africa, essential mechanisms, impelling question marks and valuable suggestions for future research.

The Workshop started with an informal get-together where participants took the opportunity to make scientific contacts and meet fellow researchers and policy makers in a bid to develop and strengthen collaborative studies and improve networking in regional monitoring, mitigation and rehabilitation strategies.

The Workshop was officially opened by Professor K. Ole-Karei, deputizing for Professor R.M. Munavu, Vice Chancellor, Moi University whose speech was read on his behalf. In this inaugural address, it was noted that the workshop theme was of major societal importance and that such a distinguished panel of African Earth scientists would succeed in addressing the issues as succintly as possible.

Welcome addresses were also given by Dr. Paul Vitta, Director, UNESCO Nairobi Office, Dr. Thomas Schlueter, Program Specialist in Earth Sciences, UNESCO, Mr. D. Kaniaru, Director, DEPI, UNEP, Prof. C.A. Kogbe, Chair, Africa Geoscience Review, Prof. Isaac O. Nyambok, Vice President, IUGS and Prof. T.C. Davies, Chairman of the Workshop Organizing Committee.

The first session of the scientific program comprised five keynote addresses, presented respectively by, Dr. A. Muma (deputizing for Prof. C.O. Okidi of the World Conservation Union) : “Legal Issues in Disaster Prevention and Management”; Prof. Isaac O. Nyambok : “Coping with Natural Disasters in Africa : The Way Forward”; Dr. T. Schlueter : “The Role of UNESCO’s Earth Sciences Division in Natural Disaster Preparedness and Prevention”; Prof. T.C. Davies : “Reconstruction in the Aftermath of Environmental Catastrophes in African Countries” and Prof. C.A. Kogbe : “Review of Natural Hazards Caused by Volcanic Eruptions in Africa”. The speakers noted *inter alia* that African countries have a primary responsibility to conduct a rigorous audit of the effectiveness or consequential identification of needs of their early warning and preparedness

capabilities and that the conduct of response strategies and capabilities is particularly relevant following any disaster event.

The rest of the scientific programme was covered in sessions that addressed the following themes :

º Seismic and Volcanic Hazards
º Erosion, Landslides and Floods
º Environmental Impact of Mining
º Climate Related Disasters
º Hazard Mapping and Early warning systems
º Prevention and mitigation of disasters
º Monitoring, Reconstruction and Resettlement

In all, 44 papers were submitted prior to the opening of the Workshop. All submitted papers will be subjected to thorough scientific review and those selected including summaries of the discussions, comments and Workshop resolutions will be published in a ‘Special Issue’ of the Journal, Africa Geoscience Review.

During the closing plenary, the following key and critical actions stemming from the summary discussions and conclusions, were proposed by Prof. I.O. Nyambok.

Workshop Resolutions and Recommendations

º In the interest of concerted continental efforts to reduce the adverse effects of natural and other disasters, all African countries have an obligation and responsibility to encourage and support improved early warning practices at national and regional levels.

º Specialized regional and global centres involved in the preparation and dissemination of disaster information provide important links to national early warning systems. The application of their technical capabilities and the utility of their products should be carefully integrated into the needs of the distressed countries.

º In the interest of protecting people from the risk of natural hazard, it is essential that the formulation and presentation of early warnings and preparedness be based on the best available technical and scientific knowledge, free of political distortion or manipulation.

º International bodies, regional and subregional organizations should work to maintain the vital importance of timely exchange and unrestricted access of observed data and exchange information between countries, particularly when hazardous conditions affect neighbouring countries.

º Timely, accurate and reliable warnings should be understood in the context of generally accepted standards, nomenclature, protocols and reporting procedures. Established means of communication should be employed for the dissemination of any information to specific authorities designated in each country.

º Collaboration and coordination are essential between scientific institutions, public authorities, private sector, media and local community leaders in order to ensure that the dissemination of information is accurate, timely, meaningful and can result in appropriate action by an informed population.

º There is an urgent need for networking at the national, regional and international levels in order to promote access to information on geoenvironmental hazards and disasters.

º There is an urgent need for manpower development in the areas of data acquisition, satellite image interpretation, monitoring, hazard mapping and risk assessment techniques as well as in planning and engineering best practice.

º Finally, it was resolved that an NGO, named by the acronym GEOHADA (Geoenvironmental Hazards and Disasters in Africa) be inaugurated, with representatives from each of the countries represented at the Workshop. The mandate of this Organization will be to identify sources of funding to facilitate research and development in the above-mentioned priority areas.

The Workshop was formally closed by one of the UNEP representatives, Dr. James Kamara.

The Organizing Committee of this Workshop is particularly grateful to UNESCO, Moi University, Africa Geoscience Review, DAAD, University of Nairobi and GSAf who generously provided financial and material support that facilitated the attendance of the African participants. We also acknowledge the contribution of the participants, facilitators and their institutions for offering their time and considerable expertise to the successful conduct of the Workshop.

For further details including request for a copy of the field trip guidebook, please contact :

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IAGOD Congress, Namibia, July 26th -31st 2003.

The IAGOD/Geocongress 2002 was held in Windhoek, Namibia from 22nd-26th July 2002. The congress was sponsored by Society for Geology Applied to Mineral Deposits, various corporations and Mining companies and organised by the Geological Societies of South Africa, Namibia and Zambia with co-organisation from IAGOD and Society of Economic Geology. About 300 delegates attended the congress from over 20 countries, including post graduate students, who were sponsored by the organizers. The Geological Society of Africa was well represented. The congress was held at the SAFARI hotel, where 240 papers were presented. The exhibition hall was well attended, close to the poster hall which became a hive of activity as participants eagerly jostled to read the various posters on offer.

Of extreme importance was the participation of the mining industry, geophysical and consulting houses, and Universities from the region. The mining industry also defrayed some of the organizational expenses. The congress made a reasonable profit, which was divided among the three geological societies of South Africa, Namibia and Zambia.

Excursions to world class deposits in the Namib desert where deposits such as Rosh-Pinah and Tsumeb which are largely stratiform Zn-Pb (Cu-Ag) sulphide mineralization and the Zambian copperbelt deposits that are also stratiform Cu-Co deposits were visited.

The Association of African women Geoscientists - 1st biennial conference

CapeTown October 2002-11-14

The first conference of the Association of African Women Geoscientists was held in Cape Town from the 11th to 14yh of October 2002. Key issues discussed at this conference were: The value that women brought to communities by using the geosciences (e.g. clean water supplies, small mining for economic empowerment)
the need for education of people in the use of resources (mineral and non-mineral)

Also the organisation (AAWG) discussed at some length its own objectives in the modern world. The conference was made possible by the support from PetroSA (Ex Soekor/Mossgass) major sponsor, DeBeers, SA, who also presented several poster papers and were represented by their staff geologists, Nozala Investments who sent delegates to attend the conference. Other sponsors were Petroleum Agency SA, Bongani Nkanyuza (an individual), Unesco, DME, Forest Oil, Energy Africa, Anglo Gold, Council for Geoscience, Geological Societies of Africa and South Africa, Tira Holdings and Harmony Gold.

A new executive was chosen with AAWG Council is as follows:
President : Monica Omulo (Kenya/ Tanzania)
Secretary: Agnes Jikelo (South Africa)
Treasurer: Pamela Aboudha (Kenya)
Membership: awaiting information

Feedback supplied by Pamela Naidoo, Natasha Tomlinson, Erica Barton and Welcha Minnie.

OBITUARY: PATRICE PINNA (1947-2002)

Dr Patrice Pinna died on Monday morning, 15 July 2002 at the Oysterbay hospital in Dar Es Salaam, Tanzania. The late Patrice was a staunch member of the Geological Society of Africa (GSAf) and one of the European geologists who worked extensively on the geology of Africa. He knew Africa very well and could happily travel anywhere there without suffering from health problems. He spoke and understood Kiswahili, and other African languages, and as well as Portuguese and English. Patrice was born on 06 June 1947 in Paris (France). He was a son of a Sardinian immigrant whose personality was both rough and tough when necessary but was also very caring, gentle and loving. Thus, Patrice had an open mind, was a free thinker, and a perpetual and tireless fighter for justice.

Patrice obtained an MSc in geology degree from the University of Paris XI (Orsay) in 1970, and in 1974 he graduated from the same university with a doctorate degree, which was based on his 700 km^2 – mapping project of the Caledonides (Norway). After graduation, he attended a military service at Le Mans and worked as a fireman in Paris. He loved this military training because it always reminded him on how his immigrant parents were involved in the fight against the nazi ideology. In 1976, the late Patrice temporarily taught geology and biology at secondary schools in Le Mans and La Flèche then was offered a permanent job at the Geological Survey of France (BRGM). This new employed was the real turning point for the young Patrice. He had to forsake European geology and culture and spend much of his professional life in the African wilderness. I recall the day when we (about thirty geologists from different parts of the world, IGCP 348 in 1994) had to wait for the late Patrice for hours while seated in field vehicles in Arusha (Tanzania) because someone stole all his traveler's cheques. Patrice reported the matter to the police and the nearest national bank but he did not get the expected service. Having a few minutes left before the bank was to be closed, he decided to go and buy bread and a bottle of water, and went back to the bank and sat on the floor demanding the desired service, namely blocking any business transactions using his stolen dollar cheques. He succeeded and joined us for the field excursion!

In 1977-78, Patrice led a Nigerian-French team of geologists working on the mineral deposits of the Benue trough in NE Nigeria. Several publications and maps covering an area of 20,000 km^2 on the scale 1:50,000 were produced. In 19978, he was deployed by BRGM to supervise a core-drilling program in French Guinea. This project was on the Pb-Zn-Cu-Ag mineralization in volcano-sedimentary formations of this country. In 1979, he had an "armchair" geological work perusing the literature on Au-mineralization in the Trans-Amazonian belt of Brazil, Guyana and Venezuela. He also started mapping Belle-Isle-en-Terre area of Brittany (France), which was eventually published in 1985. In a 1979-80, Patrice was given a demanding task of leading a BRGM geological mission to decipher the unknown metallic mineral wealth in Saudi Arabia, especially localization of the Cu-Pb-Zn-Au mineralization in the volcano-sedimentary and plutonic complexes. This exploration program enabled the BRGM team to produce geological maps on the scales 1:10,000 and 1:100,000.

The most outstanding work of Patrice was on the geology of Mozambique (1980-86). This was a very comprehensive geological investigation involving geological and geophysical mapping of the whole of Mozambique. Coal, uranium and REE deposits were discovered and a geological map on the scale of 1:1,000,000 was published in 1987. This six-year mapping project in Mozambique introduced Patrice to the geology of the classical type-area of the Proterozoic Mozambique belt of Arthur Holmes and to the concept of the Pan-African tectono-thermal events of Kennedy. He chose to remain in this type of complex fold belts of Africa for the rest of his life. The mapping in Mozambique was tough due many landmines. The dense bushes and swamps of the remote areas of this country were extremely dangerous because of wild animals and malaria-carrying mosquitoes. Patrice learnt to hunt wild game, which he relished eating and even discovered that some types of snakes are delicacies. His major geological findings from the type-area of Mozambique Belt in Mozambique were published in 1995 in a 59-page research paper in the Precambrian Research. This co-authored paper gave a detailed description of the Mesoproterozoic crustal growth and Neoproterozoic tectonism of this part of the orogenic belt, and its significance in the geodynamic evolution of the supercontinent Gondwana. This is a well-cited paper for those working on the evolution of Rodinia and Gondwana supercontinents. After that tough mapping regime in eastern Africa, Patrice moved to central Africa and worked in Cameroon for three years (1986-89). He led a team of French-Cameroonian geologists to undertake a detailed geological mapping of the Adamaoua Province covering an area over 70,000 km^2. They also worked on Au-base metal mineralization in this area. This work was a foundation stone for his appraisal of the Pan-African geodynamics of central African region. Due to radical changes in the financial policy in BRGM, Patrice had to retreat to the geology and mineral resources of Europe in the period between 1989 and 1992. He undertook small projects in Portugal and France. He also decided to take his employer to court on the issue shrinkage of research funds for geological work in Africa. He won this case and went to start a new project in East Africa.

As from 1992 till his death, Patrice worked on the geology and mineral resources of East Africa. He first worked on the geodynamic and metallogeny of the Archaean Tanzania Craton. His BRGM field was in Kakamega, southwest Kenya. From there, "the flying Pinna", as most East Africans knew him, traversed the whole of this craton in Kenya, Tanzania and Uganda. He also made time to study the Proterozoic fold belts that surround the craton. The BRGM has a lot of geological, geochemical and isotopic data from "the flying Pinna" and his colleagues. At the time of his death, Patrice was finalizing a paper titled, "The Archaean evolution of the

Tanzania Craton (2.93-2.53 Ga): from greenstone/TTG assemblage to an archaic volcanic arc." This manuscript was to be submitted to Precambrian Research journal. As usual, this was to be paper of a minimum of fifty pages!

It was always fascinating to listen to the late Patrice narrating his fieldwork tales. It happened in Cameroon in 1987 when everyone was sound asleep; Patrice went to take bath in the cool waters of the Faro River, which was near their camp. A few minutes later he was confronted by a female hippopotamus with her baby. He did not know what to do, whether to cry for help or to relax and just laugh at the charging hippo. Before he could make a decision on his survival, he was attacked by the angry hippo and had to run away for his safety throwing away all his things, including a wristwatch. The following day he went back to the river and found the hippo, calm and relaxed, near the bank of the river. His crushed watch was buried in sand but was still working. He went into the water for his morning bath. During this fieldwork in Cameroon, his family, including a very young daughter, Cécile, to accompanied him Patrice was a good motor mechanic; he learned these skills when he was a teenager playing around with abandoned vehicles along the streets and garages of Paris. In 2000, while working in a very remote part of the Archaean Tanzania Craton, Patrice and his three field colleagues had to drive the whole night in a rented Suzuki Vitara vehicle which had a broken clutch plate for over 300 km! He was a very energetic and courageous field geologist.

He was a typical field survey geologist who participated in the production of geological maps rather than journal papers. During his lifetime, he collaboratively produced some geological maps for the following countries: Mozambique, Cameroon, Nigeria, French Guiana, Saudi Arabia, Portugal, Norway and France. He published several papers in the Journal of African Earth Sciences and Precambrian Research. He participated in several IGCP projects dealing with the Proterozoic geology and mineral resources of Africa. He was a regular participant of the numerous meetings and conferences that were organized by the Geological Society of Africa. Dr Patrice Pinna had Africa at his heart. We, in Africa and BRGM have lost a very experienced and knowledgeable Precambrian field geologist. He was a genuine and a true friend of Africa. We shall all miss a remarkable and an exceptional character who was in great love of the development of the geology, earth resources and peoples of Africa.

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GEOLOGICAL UPDATES : SHORT PAPER

MISE EN EVIDENCE DE SYSTEMES DELTAIQUES AU COURS DE L'ORDOVICIEN INFERIEUR ET MOYEN DANS LE HAUT ATLAS CENTRAL (MAROC).

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Deltaïc systems during Lower and Middle Ordovician in the central High Atlas (Morocco).

ABRIGED VERSION :

INTRODUCTION : the studied series : Tizi-n-Tichka, and Imini, belong to the structural domain of central High Atlas. These series were signaled by Gigout (1938), and Destombes (1963 ; 1970) . They are called « série à -cône in cône » and were interpreted as a distal shelf dominated by oscillatory currents and storm (Ouanaïmi, 1989) .

This Note reports the results of recent sedimentological analysis in central High-Atlas . With new interpretation.

SITUATIONS : The central High Atlas is limited to the East by the Ouzellagh Massif, to the West by the mesozoïc cover of the central High Atlas, to the North by the Demnat plain, and the South by Ouarzazate plain (fig.1). The studied series are :

- Tizi-n-Tichka attribued to Llanvirn by Gigout (1938), and by Destombes in 1970 (fig.1 & 2) belong to central High Atlas. It's located from a few meters to the col of Tizi-n-Tichka.
- Imini dated to Arénig (Destombes, 1963), is located in a 30 Kms from the West of Ouarzazate.

STRATONOMIC ANALYSIS : The stratonomic analysis of the series Imini (central High Atlas), during Arénig and the serie of Tizi-n-tichka (central High Atlas) during Llanvirn, allows to recognise facies which refer to deltaic environments.

The lithofacies recognised are characterized by the coexistence of wave facies, unidirectionnal current facies , and storm facies, as well as a synsedimentary deformations features. These lithofacies are organised in a coarsenning-upward deltaic sequences :

- The Front delta deposits consists of alternating decimetric coarse to medium sandstones beds and centimetric mudstones beds. The sandstones beds display wave and current cross-bedding, storm facies, and synsedimentary deformations features.
- The prodelta deposits are composed of highly bioturbed mudstones and siltstones.

The paleocurrents measurements analysis (of asymetrical current ripples) indicate transport path from the S.W for the Imini succession during Arenig, and for the Tizi-n-Tichka succession during Llanvirn. These sources of apport provened from emerged lands, who corresponding respectively to actually emplacement of the Ouzellagh Massif, and the Siroua Massif.

CONCLUSIONS : The detailled sedimentological analysis of studied series showed during Arénig in the outcrops of Imini, a wave and storm dominated delta, and during Llanvirn a tide dominated delta in Tizi-n-Tichka.

In Imini the delta show a rise sea-level, followed by a new sea-level fall, traduced by a prodelta deposit. The top of the prodeltaic environment is marKed by an erosive inconformity (Vail et al., 1987).
In Tizi-n-Tichka the delta show two depositional sequences of front delta, the first sequence is prograding in la a muddy-siltstone prodelta, the second in Offshore.

These two deltaic system are very subsidents, and attested by the synsedimentary faults, and glissemnts structure, the instability of the basin during Arénig-Abereidien (Chacrone, 1996).

The emerged lands attested by the paleocurrents measurments during Arénig-Llanvirn are in agreement with the model of Hamoumi (1988) which show the existence of emerged lands in the West of Morocco during Ordovician.

RESUME

L'analyse sédimentologique, et stratonomique des séries ordoviciennes du Haut Atlas central a permis de reconnaître un delta édifié dans une plate forme dominée par les vagues permanentes et les vagues de tempêtes au cours de l'Arénig dans la série de l'Imini et un delta de marée dans la série de Tizi-n-Tichka au Llanvirn. L'étude des paléocourants a montré l'existence de paléoseuils dans le bassin étudié au cours de l'Ordovicien inférieur et moyen, avec des sources d'apport de sédiments de directions S.S.W au N.N.E dans les deux séries étudiées.

Mots clés : Ordovicien, Maroc, Haut Atlas central, deltas, paléocourants, paléoseuils.

ABSTRACT: The sedimentary, and stratonomy studys of the ordovician in the central High Atlas permits to recognize the existance of delta deposits controlled by waves and stroms during Arenig in the Imin area, and a delta deposit controlled by tide during Llanvirn in the Tizi-n-Tichka area.
The paleocurrents study show the existance of paleoseuils in the basin during Arenig/ Llanvirn, with the directions of the main flows, which are S.S.W to N.N.E in the two studied series.
Key words : Ordovician, Morocco, central High Atlas, deltas, paleocurrents, paleoseuils.

INTRODUCTION

Les séries de Tizi-n-Tichka, et de l'Imini, appartiennent au Haut Atlas central (fig. 1). Le Haut Atlas central est un ensemble de boutonnières, qui s'étendent sur une distance de 50 Kms en longueur, et sur une distance de plus de 60 Kms en largeur. Il est limité à l'Est par le massif de l'Ouzellagh, à l'Ouest par la couverture mésozoïque du Haut Atlas central, au Nord par la plaine de Demnat, et au Sud par la plaine de Ourzazate et de Skoura.

La série de Tizi-n-Tichka :

La succession ordovicienne de Tizi-n-Tichka (fig. 1) appartient à une structure monoclinale peu déformée, découpée par des failles normales ou inverses, et par des chevauchements locaux (Ouanaïmi, 1989). Elle affleure à quelques mètres avant le col de Tichka (X=78,60 ; Y=311,10. Feuille de Had Zraqtane au 1/50.000), situé dans la zone axiale du Haut Atlas de Marrackech. La lithostratigraphie de cette série a été établie d'abord par Gigout en 1937, puis par Neltner en 1938, ensuite par Hollard en 1967, et enfin par Destombes en 1971. Destombes a daté la série, grâce aux fossiles déterminés par Willefert S : les Illaenidés.

La succession étudiée de Tizi-n-Tichka qui a une épaisseur de 200m environ, repose par un contact normal sur les niveaux de fer oolithique de la base du Llanvirn. Le sommet de la coupe passe aux pélites du Llandeilo (Destombes, 1971 ; Ouanaïmi, 1989 ; Chacorne, 2000).

La série de l'Imini :

La série de l'Imini (fig. 1) affleure près du village d'Iflilt. Elle appartient à la boutonnière de l'Imini, localisée à une trentaine de kilomètres à l'Ouest de Ouarzazate. La boutonnière de l'Imini est située dans le flanc sud du Haut Atlas central, qui constitue la zone subatlasique méridionale (Destombes, 1963). Elle s'étend sur 14 Kms de long et 2 Kms de large. La boutonnière est traversée par la route de Ouarzazate-Marrakech.

L'Ordovicien dans cette boutonnière est disposé en série monoclinale, puissante, à pendage vers le Nord (Destombes, 1963 ; destombes, 1985). La coupe a été visitée d'abord par Dubois en 1933 (in Destombes, 1963), puis par Neltner en 1938. En 1963, Destombes a réalisé dans la région une étude lithostratigraphique et biostratigraphique. Ouanaïmi en 1989, a décrit les faciès de la base de la série qu'il a appelé (Si1a).

La coupe de l'Imini a une épaisseur d'environ 225m, elle appartient à la formation des Fezouata supérieurs, datées par les Didymograptus gr. Deflexus (Destombes, 1963). Sa base repose sur des argilites gréseuses bioturbées, le sommet est surmonté par les pélites du Llanvirn.

Ce travail présente les résultats d'une analyse sédimentologique détaillée (analyses stratonomiques et mesures de paléocourants) qui a permis de reconstituer les lithofaciès sédimentaires et d'interpréter les milieux de dépôts de ces deux successions. Les lithofaciès reconnus traduisent une sédimentation dans des environnements deltaïques, édifiés dans une plate forme dominée par les vagues permanentes et les vagues de tempêtes (série de l'Imini) ou dans une plate forme dominée par la marée (série de Tizi-n-Tichka).

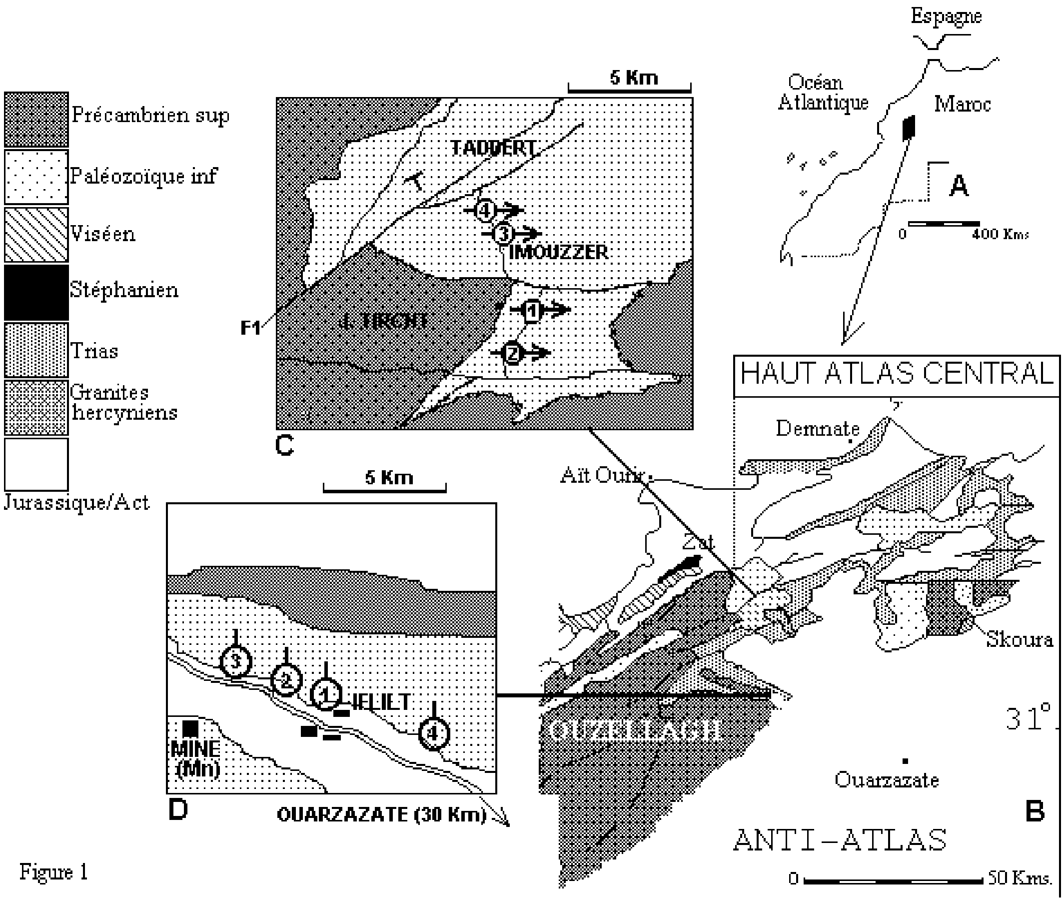


Figure.1 A- Carte du Maroc (Map of Morroco), B- Localisation du Haut Atlas central. *Location of the central ,* C- Boutonnière de Tizi-n-Tichka, D- Boutonnière de l'Imini.

LES LITHOFACIES DE L'ARENIG INFERIEUR :

a- Descriptions

Le lithofaciès IM.1 s'agit d' une séquence élémentaire constituée de deux termes : le terme basal est un niveau conglomératique à galets de quartz. Le niveau sommital est formé d'une amalgame de bancs décimétriques de grès quartzitiques à lamines parallèles regroupées en faisceaux en forme "S", ces faisceaux forment un litage sigmoïdal (Fig. 2).

Le lithofaciès IM.2 est constitué par une alternance de bancs décimétriques de grés fin et d'interbancs pélitiques à épaisseurs centimétriques (Fig. 2). Les bancs ont une base érosive, avec des traces d'affouillement (flûte-casts). La structure interne des bancs montre un faisceaux de lamines obliques de directions opposées, qui se recoupent et forment des limites érosives. Ce litage est le type 7 de la nomenclature de De Raaf *et al.*, (1977). Selon ces auteurs ce litage est typique des rides asymétriques de vague. Le sommet des bancs est modelé par des rides asymétriques à litage parallèle au flanc long, ces rides sont des rides de courant unidirectionnel (Allen, 1968).

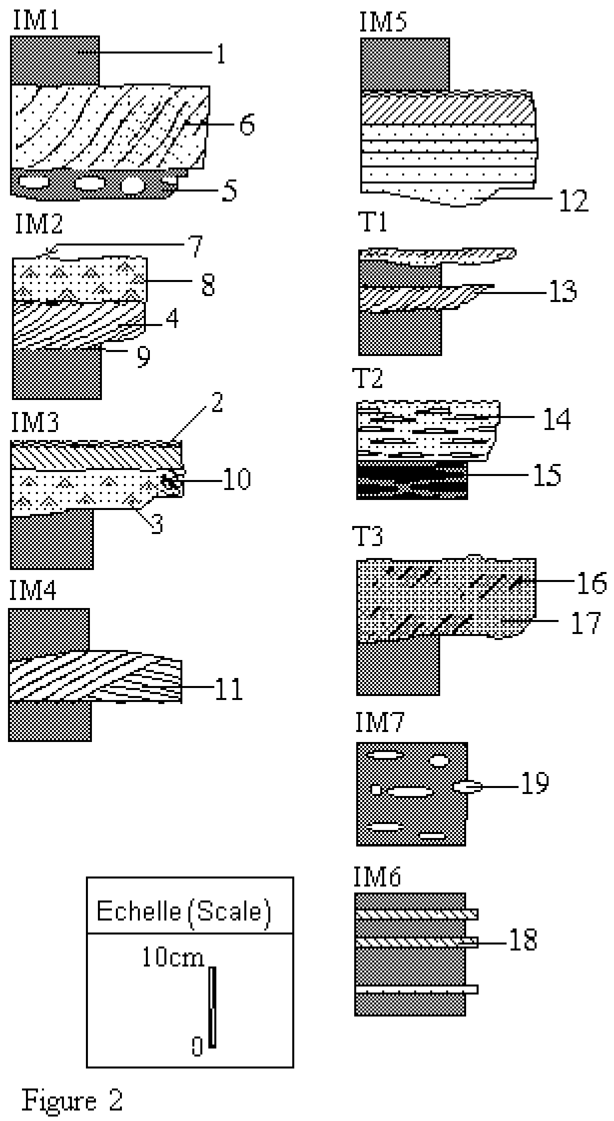
Le lithofaciès IM.3 est constitué par des bancs lenticulaires, centimétriques de gré fin et des interbancs de nature pélitique, d'épaisseur centimétrique (Fig. 2). La base des bancs est érosive et bioturbée. La structure interne des bancs montre à la base des lamines parallèles et ondulées de longueur d'onde centimétrique, ces lamines sont discontinues, ce litage est typique de la vague (De Raaf *et al*., 1977). Le sommet des bancs montre également des lamines obliques parallèles regroupées en faisceaux de même pendage, ces lamines constituent un litage de courant unidirectionnel. Il est à noter parfois dans les bancs, des structures de glissements synsédimentaires. La surface sommitale des bancs est modelée par des rides lingoïdes, caractéristiques de l'écoulement unidirectionnel.

Le lithofaciès IM.4 est formé par l'alternance d'interbancs pélitiques d'épaisseur centimétrique, et de bancs lenticulaires, à grés fins, dont la base et le sommet sont érosifs. L'épaisseur des bancs est décimétrique (Fig. 2). La structure interne des bancs montre un litage oblique en mamelon (Harms, 1975 ; Reineck & Singh, 1980). Le litage en mamelon est disposé sous forme de lamines obliques et parallèles, disposés en faisceaux à directions opposées, les faisceaux ont des contacts tangentiels et érosifs

Le lithofaciès IM.5 est formé de bancs gréseux moyens, d'épaisseur décimétrique, amalgamés, montrant une base érosive avec des figures de charge et des traces de bioturbation (Fig. 2). La structure interne des bancs montre un litage plan surmonté d'un litage oblique de rides de courant unidirectionnel (Allen, 1987 ; Reineck & Singh, 1980). Ces structures sont coiffées au sommet par des rides chevauchantes en phase de type S, A et B (Hunter, 1977 ; Guillocheau, 1983) qui se traduisent sur la surface sommitale des bancs par des rides polygonales.

Le lithofaciès IM.6 montre des bancs silteux fins, centimétriques (Fig. 2). La surface basale des bancs est érosive, la structure interne présente des lamines millimétriques obliques, qui forment le litage des rides de courant unidirectionnel, ce terme est surmonté par des lamines ondulées décimétriques de rides de vague. Ces lamines parfois frustes varient latéralement d'épaisseur. Les bancs silteux s'alternent avec des interbancs métriques d'argilites fortement bioturbées.

Le lithofaciès IM7 est formé de bancs gréso-carbonatés centimétriques, très lenticulaires, qui passent latéralement à des miches gréso-carbonatés et à des sphéroïdes. Ces bancs sont alternés par des interbancs métriques, d'argilites silteuses à rythmites gradées. Lenticulaires. Ce lithofaciès traduit un environnement d'offshore distale (Reineck & Singh, 1980 ; Guillocheau, 1983 ; Hamoumi, 1988).



<u>Figure 2-</u> Les faciès sédimentaires (sedimentary facies)
1- interbanc pélitique ; 2- rides chevauchantes en phase (climbing ripples) ; 3- litage de ride de vague (wavy laminae ripple) ; 4- litage de courant (current cross bedding) ; 5- conglomerat ; 6- litage sigmoidal ; 7- - ride asymetrique de courant (asymetric current-ripple) ; 8- litage oblique de vague (wavy cross-bedding) ; 9- flute cast ; 10- convolute-bedding ; 11- litage oblique en mamelon (hummockey-cross-stratification) ; 12- figure de charge (load-cast) ; 13- tidal bundle ; 14- lamine de vague (wavy laminae) ; 15- flaser bedding ; 16- drapage d'argile (mud drap) ; 17- grès ferrugineux (ferrugineous sandstone) ; 18- strate silteuse (siltstone strata) ; 19- miches gréso-calcaires (nodules).
Graphic Logs for the different sections shown on the map.

<u>b- Interprétations :</u>

Les lithofaciès reconnus dans les successions de l'Imini résultent de l'interférence de trois régimes hydrodynamiques différents :
-un régime de courant unidirectionnel,
-un régime de vagues permanentes attesté par différentes structures définies par De Raaf et al. (1977),
-un régime de vagues de tempêtes attesté par le litage des rides chevauchantes de type A, B et S, et par les rythmites gradées, les sphéroïdes, les grés argileux bioturbés, ainsi que le litage oblique en mamelon (Reineck & Singh, 1980).

Ils traduisent un milieu à hydrodynamisme mixte de type deltaïque. Ce milieu est influencé par l'action des vagues permanentes et des tempêtes, par référence à la systématique des deltas établie par Allen & Mercier (1987) et Bathacharya et al. (1991). De surcroît, le cortège des figures sédimentaires plaide en faveur d'un milieu turbulent (Reineck & Singh, 1980), alors que les convolutes bedding reconnues dans le lithofaciès IM3 représentent des structures syn- à post-dépôt. Elles peuvent être engendrées par plusieurs facteurs :
-un fort taux de sédimentation ,
-un échappement d'eau au cours de la compaction (Postma, 1983),
-une pente faible de 1° est capable d'engendrer des convolutes bedding, ou une tectonique synsédimentaire.
-une activité sismique produite dans le bassin de dépôt (Seilacher, 1984).
L'ensemble des figures et des structures sédimentaires permet d'opter pour un delta édifié dans une plate forme dominée par les vagues permanentes et les vagues de tempête .
Le lithofaciès IM6 est interprété sur la base de :
- la granulométrie très fine du sédiment
- le développement important de l'activité biologique qui traduit un milieu calme et moins enérgitique,
Le fait qu'il surmonte directement le faciès distal de l'offshore, et surmonté par le front de delta, ce lithofaciès indique un milieu deltaïque plus profond que le front de delta. Dans ce milieu, l'action hydrodynamique des courants et des vagues très faible permet le développement des communautés biologiques. Il s'agit d'un milieu de prodelta (Allan & Mercier, 1987).

LES LITHOFACIES DU LLANVIRN :

Ils sont reconnus au Llanvirn de la succession de Tizi-n-Tichka.

a- descriptions :

Le lithofaciès T.1 : Le banc est décimétrique, de nature gréseuse, à grès moyen, et à base et sommet érosifs. l'interbanc est de nature pélitique fortement bioturbée, d'épaisseur centimétrique. L'intérieur des bancs montre un litage formé d'un paquet de lamines millimétriques à inframillimétriques disposées comme suit : la base du faisceau, d'épaisseur décimétrique, est formée de lamines parallèles, ces lamines continuent sur une pente faible (10° environ), pour constituer ainsi un litage oblique. Les lamines obliques deviennent parallèles aux lamines de la base du faisceau. Cette disposition donne une forme en "S". Les limites des faisceaux indiquent parfois des surfaces de réactivation et des drapages d'argiles "Mud draps". Ce type de litage observé à la base des bancs correspond au litage oblique sigmoïdal . Le litage oblique sigmoïdal est interprété comme un ensemble de faisceaux tidaux (Reineck & Singh, 1980, Terwindt, 1981, Nio & Yang, 1991). Les faisceaux se forment à la suite de la migration des mégarides au cours des cycles de marée : flot/jusant (Reineck & Singh, 1980, Terwindt, 1981, Nio & Yang, 1991). Les surfaces de réactivation sont produites par l'action du courant subordonné suite à l'érosion de la partie avale de la mégaride, qui s'est formée lors du courant dominant. Le sommet des bancs montre des lamines obliques et parallèles regroupés dans des faisceaux de même pendage, ces lamines constituent un litage de courant unidirectionnel.

Le lithofaciès T.2 est constitué par l'alternance de bancs gréseux moyens décimétriques, et d'interbancs pélitiques d'épaisseur centimétriques. Les bancs, à limites érosives, montrent dans leur structure interne un litage formé de lamines ondulées parallèles qui varient latéralement d'épaisseur. Le sommet des bancs est constitué de rides chevauchantes en phase de type S, A et B (Hunter, 1977). Les interbancs renferment des structures formées par niveaux silteux montrant des laminations ondulées et discontinues, à longueurs d'ondes centimétriques. Les creux des lamines ondulées sont drapés d'argiles. Ces structures sont des "flasers-bedding" (Reineck & Singh, 1980, Terwindt, 1981, Nio & Yang, 1991).

Le lithofaciès T.3 est identifié au sommet de la série de Tizi-n-Tichka. Il est constitué de bancs gréseux moyens, métriques et lenticulaires. Les bancs montrent un litage ondulé et discontinu et renferment des lentilles ferrugineuses. Les niveaux ferrugineux de ce lithofaciès occupent les surfaces drapées d'argile, et forment des flasers-bedding. La base et le sommet des bancs sont faiblement bioturbés. Ce faciès est celui des grès-quartzitiques à litage madré. Selon Reineck et Singh (1980), la formation des flasers-bedding nécessite une alternance de périodes agitées par les vagues et les courants responsables des dépôts sableux, et de périodes calmes où les silts se déposeront par décantation dans les creux des rides. Ce faciès est rapporté à une dynamique tidale (Reineck & Singh, 1980, Terwindt, 1981, Nio & Yang, 1991). Il est à noter également la présences des rides à flanc long et flanc court sur la surface sommitale de ces bancs gréso-ferrugineux, ces rides asymétriques ont un indice de ride "R.I" élevé (R.I > 15), elles sont définies comme des rides de courant unidirectionnel (Allen, 1968).

Le lithofaciès T.4 montre des bancs silteux centimétriques, alternants avec des interbancs décimétriques d'argile bioturbé.

Le lithofaciès T.5 ressemble au lithofaciès IM7, il est formé d'interbancs métriques, d'argilites silteuses, ces interbancs montrent des faciès de rythmites gradées. Ils sont alternés de bancs gréso-carbonatés lenticulaires, qui passent latéralement à des miches gréso-carbonatées, ou à des sphéroïdes. Les miches sont parfois bioturbées, elles ont jusqu'à 30cm de diamétre. Ce lithofaciès traduit une activité de tempête distale (Reineck & Singh, 1980).

b- Interprétations :

Les lithofaciès T1, T2, et T3 reconnus dans les successions de Tizi-n-Tichka résultent de l'interférence de deux régimes hydrodynamiques différents : le courant unidirectionnel, et les courants de marée.
Les structures sédimentaires qui indiquent l'écoulement unidirectionnel sont représentés par des figures d'affouillement "flûte-casts" et traces d'objets traînés, par des rides asymétriques à indice de ride "R.I" élevé (R.I > 15), par des litages obliques unidirectionnels (Allen, 1968; Guillocheau 83).
Les faciès tel que les "tidal bundles", les "flaser beddings", les "wavy beddings", les drapages d'argiles et les surfaces de réactivation montrent une activité tidale. Ces faciès en association dans un même banc aux figures de glissements synsédimentaires, et aux faciès d'écoulements unidirectionnels, indiquent un delta édifié dans une plate forme dominée par la marée.
Le lithofaciès T4 indique un environnement deltaïque beaucoup plus profond que le front de delta, sa position entre la plate forme distale et le front delta, lui confère un environnement de prodelta.
Le lithofaciès T5, comme IM7 traduit par ses faciès, un environnement d'offshore distale (Guillocheau, 1983 ; Reineck & Singh, 1980).

LES SEQUENCES DE DEPOT :

Les lithofaciès reconnus dans les deux séries étudiées, s'organisent dans des séquences grano et stratocroissantes. Ces séquences sont l'expression de séquences de dépôt d'épaisseur hectométrique et traduisent la migration du système deltaïque au cours de l'ordovicien inférieur et moyen. Les séquences de dépôts sont formées par l'agencement vertical des séquences élémentaires, constituant le plus petit motif répétitif dans le système sédimentaire étudiés (Vail et al., 1987). Les séquences élémentaires dans les deux séries étudiées sont représentés par les lithofaciès mis en évidence.

Les séquences de dépôt du système deltaïque au cours de l'Arénig :
Deux séquences de dépôt sont définies dans la série de l'Imini : S.I.1 et S.I.2. La première est constitué par l'agencement vertical des lithofaciès IM (3,4 ,5,6, 7). Cette séquence, de 160m d'épaisseur environ, commence à la base par un intervalle transgressif (les pélites offshore : IM7 surmontés par le prodelta : IM6) surmonté par un prisme de haut niveau marin (le front delta, formé par l'alternance des lithofaciès IM 3, 4 et 5). La deuxième séquence S.I.2, d'épaisseur d'environ 65m, est formée par l'agencement des lithofaciès IM (1,2,5,6, 7). Elle traduit à la base un intervalle transgressif (les pélites offshore : IM7 suivis par le prodelta : IM6) surmonté par un prisme de haut niveau marin (le front delta, formé par l'alternance des lithofaciès IM 3, 4 et coiffés par le chenal du front delta : IM1).

Les séquences de dépôt du système deltaïque au cours du Llanvirn :

Dans la série de Tizi-n-Tichka, le delta est édifiée dans une plate-forme dominée par la marée, il s'agit de deux séquences de dépôt : S.T.1 et S.T.2 : la première séquence d'environ 150m d'épaisseur commence à la base par un intervalle transgressif (offshore : T5 surmonté d'un prodelta : T4), et au sommet par un prisme de haut niveau marin (front delta : alternance de T1 et T2). La séquence S.T.2, de 50m d'épaisseur environ, montre à la base par un intervalle transgressif (offshore : T5 surmonté d'un prodelta : T4), et au sommet par un prisme de haut niveau marin (front delta : T3).
Les séries étudiées montrent des deltas très subsidents, de 200m d'épaisseur environ, et formés de deux séquences de dépôts, qui traduisent une alternance de grès moyen à grossier du front delta qui prograde sur un matériel silto-argileux prodeltaïque.

La cartographie et Les corrélations latérales entre les séquences de dépôts des deux séries étudiés, a montré des corps sédimentaires lenticulaires hectométriques. La série de l'Imini est bordée au sud par le massif précambrien de siroua, la série de Tizi-n-Tichka est limitée à l'ouest par le Massif de l'Ouzellagh (Ouanaïmi, 1989 ; Hamoumi & Chacrone, 1994 ; Chacrone, 2000).

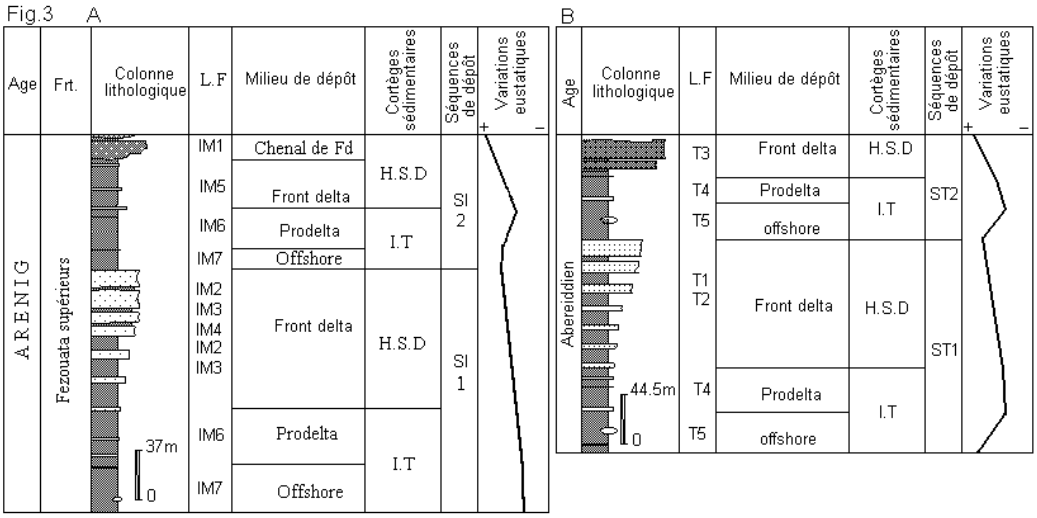


Figure 3- Les séquences deltaïques (delta sequences). A : Imini ; B: Tizi-n-Tichka.
L.F. : Lithofaciès ; Chenal de fd : Chenal de Front delta (front delta chenal); H.S.D : High Stand Deposit ; I.T : Intevalle transgressif.

LES MESURES DES PALEOCOURANTS :
Les mesures des paléocourants effectuées dans les deux successions étudiées permettent de préciser la direction des sources d'apport (Fig.4). Ces mesures effectuées sur les litages obliques unidirectionnels ont montré l'existence au cours de l'Arénig dans la série de l'Imini, une source d'apport de direction S.S.W vers N.N.E, elle correspondrait à l'emplacement actuel du Massif de Siroua. Au cours du Llanvirn, dans la succession de Tizi-n-Tichka, la source d'apport est de direction S.S.W vers N.N.E, cette source d'apport provenait d'un paléoseuil, qui pourrait correspondre à l'emplacement actuel du Massif de l'Ouzellagh. L'existences des terres émergés est prouvée aussi dans la littérature, par l'existences de certaines failles atlasiques cartographiées dans le Massif Ancien du Haut Atlas et qui seraient hérités d'une activité ante cambrienne ; comme c'est le cas de la faille ENE-WSW à E-W d'Ourika-Taddart (Fig. 1) et d'autres failles bordières du Massif précambrien de l'Ouzellagh et le Massif précambrien de Siroua, qui ont soulevé, ces massifs précambriens en paléoseuil depuis le Cambrien ((Proust, 1961 & 1973 ; Ouanaïmi, 1989 ; Ouanaïmi et Petit, 1992 ; Proust et al., 1977). L'existence des paléoseuils est prouvée également grâce aux reconstitutions géométriques des corps sédimentaires qui ont montré à l'aide de la cartographie régionale des boutonnières étudiées (Ouanaïmi, 1989 ; Hamoumi et Chacrone, 1994), la proximité du Massif précambrien de l'Ouzellagh à l'Ouest de Tizi-n-Tichka, et le Massif de Siroua Sud de l'Imini.

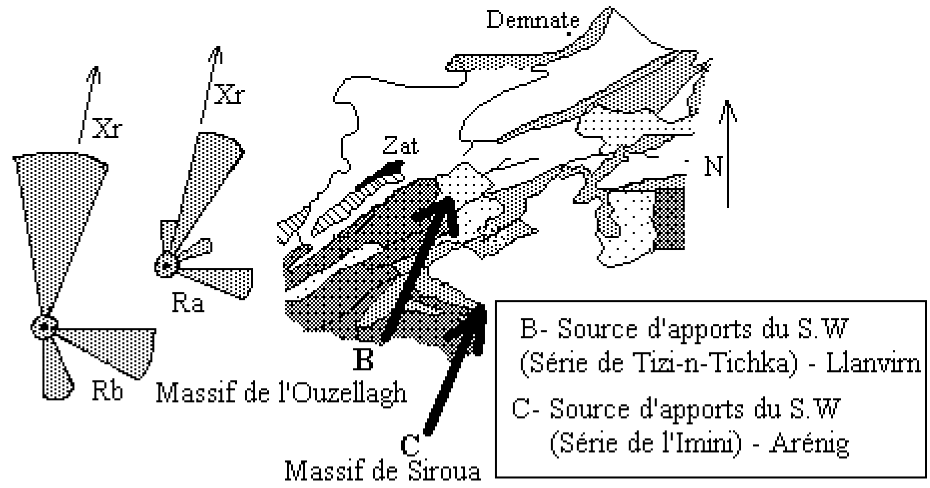


Figure 4. Les diagrammes circulaires et paléogéographie, Ra: Rosace des mesures de paléocourants de Tizi-n-Tichka, Rb : Imini., Xr : Moyenne vectorielle représentant la direction principale du courant (Vector mean flow direction) : 30° pour Imini, 20° pour Tizi-n-Tichka.

CONCLUSIONS

L'analyse sédimentologique détaillée des séries étudiées a montré qu'au cours de l'Arénig dans la série de l'Imini s'est installé un delta édifié dans une plate-forme dominée par les vagues permanentes et les vagues de tempêtes, et l'installation dans la série de Tizi-n-Tichka, au cours du Llanvirn, d'un delta de marée. Ces séries deltaïques sont constituées de 2 séquences de dépôts, elles traduisent une hausse eustatique (prisme de haut niveau marin), liée au dépôt de front delta qui a progradé sur le prodelta et l'offshore (intervalles transgressifs) sous-jacent.

Les mesures des paléocourants, effectuées sur les litages obliques unidirectionnelles ont montré des sources d'apport de direction S.S.W vers N.N.E dans les deux séries étudiées. Ces sources d'apport provenaient de paléoseuils qui correspondraient à l'emplacement actuel du Massif de Siroua au cours de l'Arenig, et au Massif de l'Ouzellagh au cours du Llanvirn. L'existence de terres émergées durant l'Arenig-Llanvirn dans le Haut Atlas confirme les résultats de Hamoumi (1995) qui montrent qu'au Maroc l'Ordovicien s'est développé dans au moins deux bassins, situés dans la marge nord-gondwanienne, et séparés par des terres émergées.

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Légende des figures :

Figure.1 A- Carte du Maroc (Moroccan map), B- Localisation du Haut Atlas central. *Location of the central ,* C- Boutonnière de Tizi-n-Tichka, D- Boutonnière de l'Imini.

Figure 2- Les faciès sédimentaires (sedimentary facies)

1- interbanc pélitique ; 2- rides chevauchantes en phase (climbing ripples) ; 3- litage de ride de vague (wavy laminae ripple) ; 4- litage de courant (current cross bedding) ; 5- conglomerat ; 6- litage sigmoidal ; 7- - ride asymetrique de courant (asymetric current-ripple) ; 8- litage oblique de vague (wavy cross-bedding) ; 9- flute cast ; 10- convolute-bedding ; 11- litage oblique en mamelon (hummockey-cross-stratification) ; 12- figure de charge (load-cast) ; 13- tidal bundle ; 14- lamine de vague (wavy laminae) ; 15- flaser bedding ; 16- drapage d'argile (mud drap) ; 17- grès ferrugineux (ferrugineous sandstone) ; 18- strate silteuse (siltstone strata) ; 19- miches gréso-calcaires (nodules).

Figure 3- Les séquences deltaïques (delta sequences). A : Imini ; B: Tizi-n-Tichka.

L.F. : Lithofaciès ; Chenal de fd : Chenal de Front delta (front delta chenal); H.S.D : High Stand Deposit ; I.T : Intevalle transgressif.

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Forth coming events

1. **Geoindicators and their applications in arid regions 14th-17th April 2003, Workshop organized by the Department of Geology, Assiut University and the Unesco Cairo Office. Contact Prof. Dr. Moustafa M. Youssef Geology Department, Faculty of Science Assiut University, 71615 Assiut-Egypt Fax: 02-088-312564 & 02-088-342708 Tel.: 02-088-411450, E- Mail: myosef@acc.aun.edu.eg OR myosef943@yahoo.com**

2. **IGCP 450 Sediment hosted Base metal deposits of western Gondwana. Field Meeting and Excursion, Lubumbashi, DRC, 14-25 July 2003. Contact Dr. Jacques Cailteux (igcp450lubum@forrestrdc.com. Deadline for submission of papers 30th March 2003.**

3. **IM16 16th Industrial Minerals Congress, Montreal, Canada. April 6-9. Contact address: modriscoll@indmin.com, website www.indmin.com.**
4. **International Symposium on Environmental Chemistry, September 7-11, 2003. Edinburgh, Scotland. Contact address: J.G.Farmer@ed.ac.uk, Fax: 44-131-650-4757**
5. **Mantle Plumes: Physical Processes, Chemical signatutres, Biological effects, Cardiff, Wales, UK. September 10-11, 2003. Contact address: kerra@cf.ac.uk, website : www.geolsoc.org.uk/template.cfm?name=Plumes. Fax: +44-(0)29-2087-4326.**