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Conference Reports

Project 233

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Tectonothermal Evolution of the West African Orogens and Circum-Atlantic Terrane Linkages

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Under the auspices of International Geological Correlation Program Project #233 "Terranes in Circum-Atlantic Paleozoic Orogens" (Leaders: J.D. Keppie and R.D. Dallmeyer), a conference was held in Nouakchott, Mauritania from 8-20 December 1987. It was organized jointly by the Department of Geology, University of Georgia, USA; Faculté des Sciences, St. Jerome, Université d'Aix-Marseilles, France; Département de Géologie, University of Dakar, Senegal; Ministère des Mines et de l'Industrie, Mauritanie; Direction des Mines et de la Géologie de Mauritanie.

A group of 71 intrepid geologists made their way to Nouakchott, Mauritania, bedecked in all manner of tropical garb to participate in a once-in-a-lifetime experience. They came from many countries all around the Atlantic: Nigeria, Ghana, Guinea, Senegal, Mauritania, Spain, France, West Germany, Austria, Norway, Sweden, United Kingdom, Eire, Canada, USA, and Mexico.

The conference started with a gracious welcome from the Minister of Mines for Mauritania recorded by the local press and television reporters. The first paper by J. Duncan Keppie was an introductory lecture on terrane analysis. Terrane terminology originated in the Cordillera. Unfortunately, the Cordillera represents a special case in a wide spectrum of accretionary terrane orogens in which such factors as relative motions between terranes may vary from orthogonal to highly oblique, the stage of convergence may vary from simple ocean-continent convergence through magmatic arc-continent collision to continent-continent collision, and this in turn leads to varying degrees of erosion. The deeper the level of erosion, the more the identification of terranes moves from stratigraphic-paleontological-paleomagnetic criteria to metamorphic-structural-petrological-metallogenic-geophysical properties. The Cordillera may represent an end member in the high degree of obliquity of convergence producing exotic terranes, and in the limited amount of erosion. Where terranes originate and are accreted by orthogonal relative motions, neighbouring terranes may have similar geological records and may only be distinguished by the nature of the suture boundary which represents telescoped oceanic lithosphere. In view of these considerations, the definition of a terrane requires modification to allow for the full range of terrane accretionary orogens. Thus, **a terrane is redefined as an area characterized by an internal continuity of geology (included stratigraphy, fauna, structure, metamorphism, igneous petrology, metallogeny, geophysical properties and paleomagnetic record) that is bounded by faults, melanges representing a trench complex, or cryptic suture zones across which neighbouring terranes (i) may have a distinct geological record not explicable by facies changes (*i.e.*, exotic terranes), or (ii) may have a similar geological record (*i.e.*, proximal terranes) that may only be distinguished by the presence of the terrane boundary representing telescoped oceanic lithosphere.**

There followed two papers introducing the geology of North Africa. The first presentation by R. Black reviewed the West African Orogens from Archean through Paleozoic times. G. Rocci followed by reviewing the nature and origin of the Upper Proterozoic Orogens in North Equatorial Africa. The rest

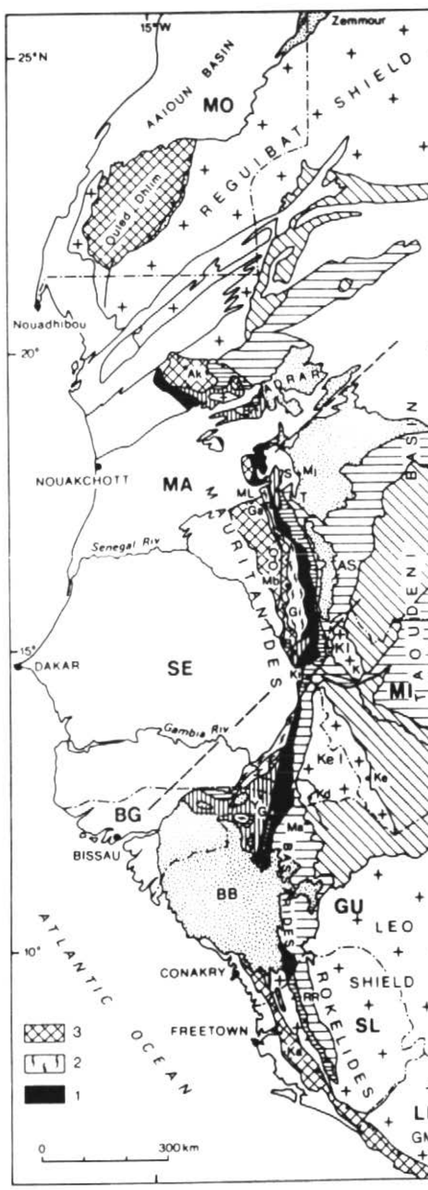

Figure 1 *Preliminary terrane map of the West African Orogens:* ***1****, rift terranes;* ***2****, ensialic arc and host sequences;* ***3****, composite western basement terrane.*

of the first day was filled with a series of papers on the Pharusian-Dahomeyide Orogens starting with an overview by R. Caby. A.M. Boullier and J.M. Bertrand presented data relating to the directions of movement in the Pan-African Trans-Saharan Belt. B.N. Ekwueme reviewed geochronological evidence for the Kibaran Orogeny in West Africa and the *ca.* 675 Ma event in Nigeria, while E.K. Agyei, J. Manu and R.L. Armstrong presented new data for the Dahomeyide Orogen of southern Ghana. Pan-African deformation at Air (Niger) was described by Y. Cosson, A.M. Boullier and G. Rocci in terms of a plate boundary outlined by the presence of ophiolites. A.O. Adjei summarized the geology, structure and tectonics of the Paleozoic Orogens of Ghana, K. Attoh derived the metamorphic pressures and temperatures of garnet-hornblende gneisses in the Dahomeyides of southeastern Ghana and M.A. Rahaman outlined the evolution of the Nigerian Basement Complex.

The second day of the conference was occupied by papers relating to the orogens along the western margin of the West African Craton starting in Morocco and progressing southward. A. Pique presented an overview of the Variscan Terranes in Morocco. C. Bernardin and J. Roussel derived a model for the crustal structure of the Hercynian Meseta and its continental margin based upon gravity data. J. Boulin, M. Bouabdelli and M. El Houicha attempted a paleogeographic and geodynamic model for the Paleozoic belt in the middle of Morrocco. E. Wallbrecher and Y. Bassias documented a Late Pan-African ductile shear zone along the northwestern margin of the West African Craton. This was followed by a review of the Mauritanide Orogen by J.P. Lecorche who, along with J. Roussel, defined basement terranes and sutures in the Mauritanides and Bassarides using geophysics. J.P. Lecorche and R.D. Dallmeyer presented new geochronological data which they integrated into a model for the evolution of the northern and central Mauritanide Orogen. M. Kane characterized the ultramafic-mafic complexes in the central Mauritanides as ophiolitic on the basis of their chemistry. Progressing still farther south, M. Villeneuve reviewed the Pan-African Basseride and Rockelide Orogens. M. Ritz and B. Robineau presented magnetotelluric soundings to identify lithospheric structures in the edge of the West African Craton in eastern Senegal. J.R. Repetski, S.J. Culver and J. Pojeta discussed Early Cambrian microfaunas and their stratigraphic significance from the southwestern Taoudeni Basin. Finally, R. Venkatakrishnan and S.J. Culver presented a model for the Mesozoic breakup of Africa and North America based upon tectonic fabric in Sierra Leone.

The third day of the conference was devoted to the Appalachians starting in the south and progressing northward. J.W. Horton, A.A. Drake and D.W. Rankin provided an overview of terranes in the southern and central Appalachians, then W.A. Thomas and R.D. Dallmeyer gave separate papers on the accreted and suspect terranes in the southern Appalachians. Geophysical data along a crustal transect across the Virginia-Chesapeake Bay region of USA was analyzed by L. Glover, T.L. Pratt and J.K. Costain. D.T. Secor and P.E. Sacks presented structural data interpreted in terms of the relative plate motions during the Alleghenian Orogeny in the southern Appalachians. J.D. Keppie provided an overview of the terranes in the northern Appalachians. Then J.W. Skehan, R.R. Hutchinson, N. Rast and A.M. Hussey outlined the collisional sequence among exotic terranes in southern New England and the Gulf of Maine. D.P. Murray and O.D. Hermes moved toward a viable model for the Alleghenian Orogeny in southeastern New England. R.D. Nance and J.B. Murphy presented the kinematic history of the Bass River Complex in the Avalon Terrane of Nova Scotia. J. Dostal and J.D.

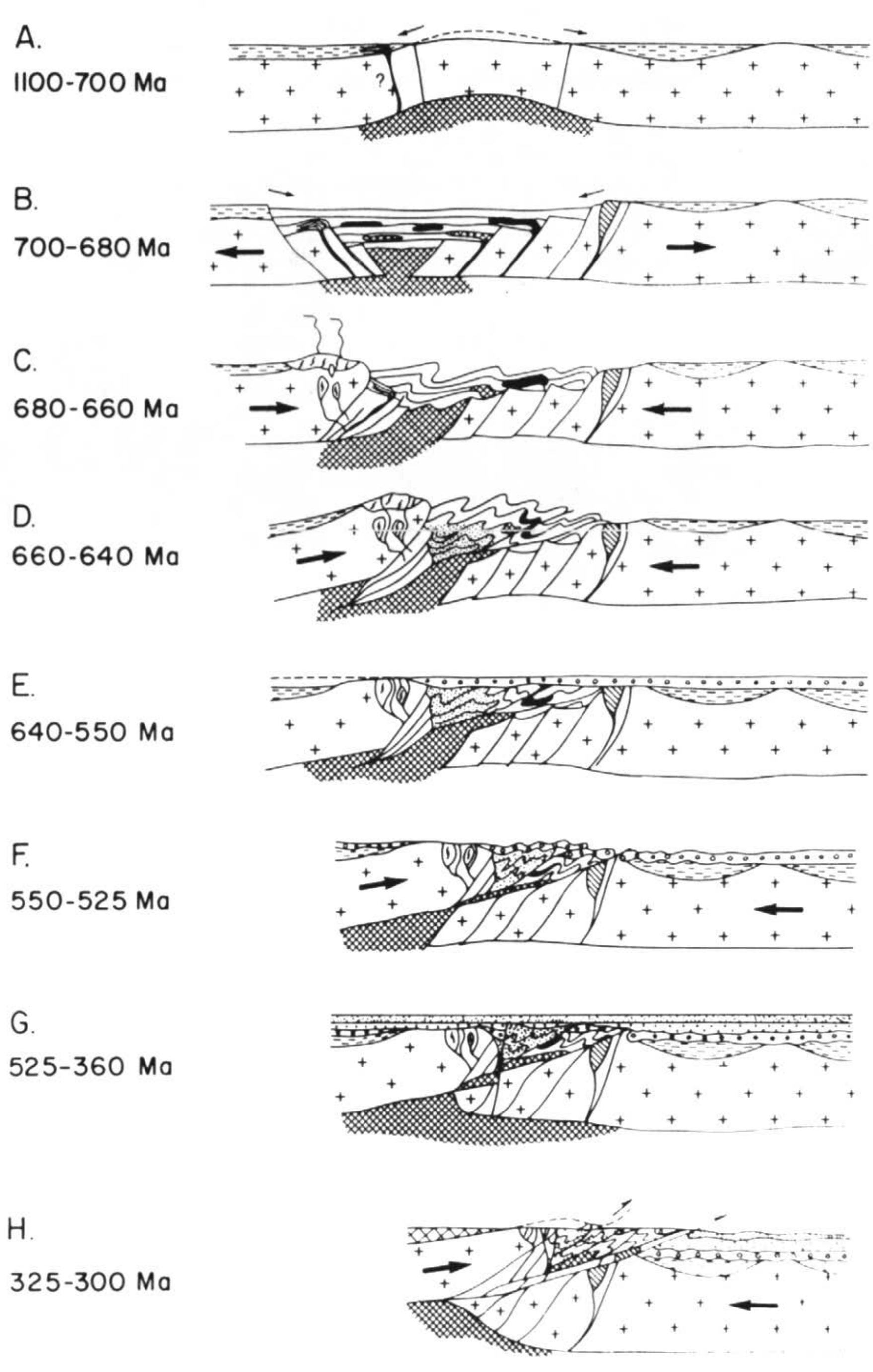

Figure 2 *Geodynamic evolution of the central Mauritanides.*

Keppie reviewed the geochemistry of Late Proterozoic volcanic rocks in the Avalon Terrane of the Northern Appalachians. P.E. Schenk argued for northwest Africa as a source area for the Meguma Terrane of Nova Scotia. The day ended with J.D. Keppie and T.E. Krogh presenting U-Pb data for zircon and sphene in the Meguma Group of Nova Scotia and reviewing possible source areas around the Atlantic.

The last day of the conference started with terranes in Europe, with a side trip into the Caribbean, and ended with Circum-Atlantic terrane correlations. The origin and accretionary history of terranes in the Scandinavian Caledonides was reviewed by D. Roberts. P.G. Andreasson discussed the significance of indigenous and transitional terranes in the Scandinavian Caledonides, while R.D. Dallmeyer, A. Reuter and N. Clauer contrasted Scandian *versus* Finnmarkian terrane accretion in the northernmost Norwegian Caledonides. Terrane linkage in the final stages of the Caledonian Orogeny in Scandinavia was presented by B.A. Sturt and D. Roberts. C.S. Jones analyzed the kinematics of Lower Paleozoic terrane accretion along the Highland Boundary Fault in western Ireland. K. Weber interpreted the Mid-European Variscides in terms of allochthonous terranes and W. Franke reviewed the structural development of the Bohemian Massif. D. Gebauer, I.S. Williams and W. Compston presented geochronological data on detrital minerals in sediments and metasediments from the European Hercynides. Turning to Iberia, R.D. Dallmeyer and A.P. Pieren presented evidence for Late Proterozoic tectonothermal events in SW Iberia and discussed their paleogeographic implications. J.R. Andrews, P. Lake and J.E.A. Marshall analyzed a key terrane beween the NW African and SW European Hercynides, namely, the Iberian Pyrite Belt. P. Castro, C. Quesada and J. Munha described the metamorphic regime in the Beja-Acebuches ophiolite in SW Iberia, and E. Martinez-Garcia outlined the metallogenesis of the Iberian terranes. Then, Paleozoic terranes in the Caribbean region were outlined by M.F. Campa.

In the final session, J.P. Lefort described data supporting Appalachian – West African linkages. R. Caby correlated Precambrian terranes in Benin and Nigeria with those in northeast Brazil. R. Venkatakrishnan and S.J. Culver analyzed the various locations for the northern and southern margins of the Senegal microplate. The Nd isotopic distributions in Iapetus Oceanic biophosphates were related to paleogeographic reconstructions by L.S. Keto, J.E. Repetski and S.B. Jacobsen. The conference ended with a feast hosted by the Director of the Direction des Mines et de la Géologie de Mauritanie.

The conference was followed by a field trip across the central Mauritanide Orogen lead by J.P. Lecorche, R.D. Dallmeyer and O. Dia. Most of the conference participants stayed for the excursion, the logistics of which involved considerable effort for J.P. Lecorche as it involved many 4-wheel drive vehicles with drivers, a water tanker, and food and cooks for 8 days in the desert. The material assistance of the Ministère des Mines et de l'Industrie de Mauritanie and the Direction des Mines et de la Géologie de Mauritanie was greatly appreciated.

The first day was lead by D. Carite and took us eastward some 370 km to our first camp in the sand dunes just east of Magta Lahjar stopping along the way to examine some of the Late Quaternary features. These included the Inchirian shelly sands (40,000-30,000 years old) deposited during a transgressive period. These are overlain by large, NE-trending Ogolian dunes (*ca.* 20,000 years old) fixed by vegetation which grew during the next period with a humid climate (Tchadian Stage: 7,000-10,000 years). Interdune valleys were flooded during the Nouakchottian transgression (4,200-6,800 years) during which marine-lacustrine sediments were deposited. Neolithic artifacts are associated with these sediments. Finally, active, N-trending sand dunes are presently moving across the landscape. An interesting feature observed was the sand fused by lightening strikes, called fugerites.

The rest of the trip was led by J.P. Lecorche and R.D. Dallmeyer and consisted of a traverse across the Mauritanide Orogen. It started in the foreland to the east and progressed westward across the para-autochthonous units, imbricated ophiolitic units, a continental margin rift facies and a poorly exposed calc-alkaline igneous complex in the west. The following sequence of events has been proposed by Dallmeyer and Lecorche (1987, American Journal of Science):

1. Mid-Late Proterozoic (*ca.* 1100-700 Ma) deposition of the West African Supergroup 1, continental sedimentary sequences on crystalline basement of the West African Craton.
2. Late Proterozoic (*ca.* 700-680 Ma) intracontinental rifting leading to the formation of oceanic lithosphere, just preceded (*ca.* 720-700 Ma) by a tectonothermal event in the rift facies.
3. Late Proterozoic (*ca.* 680-640 Ma) convergence producing the western ensialic magmatic arc and imbrication of the oceanic and continental lithosphere during Pan-African 1 orogenesis.
4. Late Proterozoic-Early Cambrian (*ca.* 640-550 Ma) uplift and cooling of the Pan-African I Orogen and deposition of basal tillite and flysch sequences in the foreland.
5. Cambrian (*ca.* 550-525 Ma) Pan-African II deformation and metamorphism which ranges from intense in the Rokelides decreasing in intensity northward in the Bassarides and central Mauritanides and dying out in the northern Mauritanides. At the same time, molasse was deposited in the foreland.
6. Cambrian-Late Devonian (*ca.* 525-360 Ma) deposition of clastic successions in the Taoudeni and Bove basins on the craton.
7. Early Carboniferous (*ca.* 325-300 Ma) Variscan reactivation of the Mauritanide Orogen by folding and thrusting accompanied by variable grades of metamorphism. This was related to the collision of Gondwana and Laurentia which caused further convergence between the western continental block and the West African Craton.
8. Early Permian (*ca.* 300-275 Ma) local ductile deformation along faults bordering the western coastal block during the terminal stages of collision.

The weather was ideal with wind only on the last day which whipped the sand into a veritable fog. The nightly campfires and sleeping out under the stars added to a memorable experience: a chance-of-a-lifetime opportunity. For those unlucky to have missed this chance, a vicarious experience may be acquired by reading the field guide — the first English summary of Mauritanide geology — which may be ordered from R.D. Dallmeyer, Department of Geology, University of Georgia, Athens, Georgia, USA 30602. Copies of the Abstract Volume may also be ordered from the same source.