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Rifting and Its Geological Environment [Abstract Only and Discussion]

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Rifting and its geological environment

[Abstract only]

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The ancient geographical, climatic and oceanographic setting that existed at the time of the initial rifting apart of Pangaea and the creation of the Atlantic Ocean can be partly reconstructed from an investigation of rock outcrops in the Atlas Mountains of the kingdom of Morocco and by geophysical exploration and drilling of the continential margin of eastern North America and northwest Africa. Where recognized, the passage from 'rifting' to 'drifting' seems to have been rather distinct, coinciding with the onset of a rapid collapse of the continental edge and the first accretion of a gabbroic and basaltic type oceanic floor. For the first few million years, lavas were extruded into a highly arid sub-aerial environment and onto desiccated playa lakes. A high rate of subsidence allowed more than one kilometre of salt to accumulate in narrow basins of the Atlantic lying well below sea level of the then neighbouring Tethys Ocean.

The progressive widening of the juvenile Atlantic is registered by low-amplitude linear magnetic anomalies within the so-called 'Quiet Zone' and by an exponentially decreasing rate of subsidence of the continental edge recorded by the accumulation of coastal plain deposits, sea-marginal evaporites, carbonate platforms and barrier reefs.

Discussion

P. Wurster (*Geologisches Institut, Universität Bonn, Bonn, Germany*). My comments on Mr Ryan's stimulating ideas and pictures on rifting are based on field work in Morocco since 1975. It was carried out by a group of geologists from the University of Bonn as part of the Deep Sea Drilling Project sponsored by Deutsche Forschungsgemeinschaft. Our contributions, are intended to demonstrate the necessity of carefully coordinated onshore surveys, suited to interprete the deep sea activities from different aspects. For a palaeoenvironmental synthesis, geological mapping, survey of field sections, and elaboration of stratigraphical columns are indispensible. Creation and further development of a passive continental margin is intimately linked with tectonic events and the supply of sediments from adjacent widespread platform areas far behind the coast lines. The structural evolution of any region involves the whole geological environment and history, and it should not be explained by nothing else but sea floor spreading and plate tectonics. It seems to be dangerous to pick up special observations and samples from quite different places to feed a theoretical model.

In some general aspects we share Mr Ryan's views:

(1) All along the whole Atlantic borders Morocco and the High Atlas indeed show the best exposures of Mesozoic formations. The area is therefore well selected.

(2) Key sections in the Agadir region provide complete stratigraphical sequences for immediate onshore observations.

(3) The Atlas Triassic includes coarse clastics, red beds, and covering basalt flows. The thick sequences were deposited in a sharply bounded graben area. This structures formed, indeed, by initial rifting connected to the first breaking up of the Atlantic furrow.

(4) Jurassic and Cretaceous transgressions of the Atlantic are well defined and worked out by French and Moroccan scientists as well as by our group. They caused deposition of shallow marine sediments, separated by littoral zones from terrestrial deposits.

On the other hand our extended field work led us to a distinct conception of structural evolution, palaeogeography and palaeoenvironment of the High Atlas region. We started by compiling and sampling 30 complete sections of lower and mid-Cretaceous, situated at distances of 10–50 km between Agadir, Ouarzazate, Beni Mellal and Safi. Investigations of sediments, geochemistry and palaeomagnetism are in progress (Behrens *et al.* 1978). Results obtained so far by Stets & Wurster (1977, 1978) show that the Atlas region was a trough subsiding continuously from Triassic to mid-Cretaceous. As the African shelf board tilted more quickly, the sea invaded into the sinking Atlas Trough, and formed a persisting funnel-shaped Atlas Gulf. Interfingering shallow marine facies, and gradual shifting of litoral zones during repeated transgressions and regressions exclude rapid crustal movements beyond doubt. Even the syngenetic faults bordering and cutting the subsiding Atlas Trough during Cretaceous have formed by very slow movements. Those which bounded the former Triassic graben structure and persist in time and place throughout the Mesozoic are just the same. Therefore we postulate a narrow Mesozoic Atlas Rift subsiding slowly and continuously. It started simultaneously as a sidebranch when the Atlantic furrow began to open, but the rifting activity in the High Atlas faded away slowly and died out after the Turonian. During all that time of slow subsidence, the rift never reached the stage of real drift furrow, used for further extension or even for ocean floor forming. After the main Atlantic fractures found their nordic paths, the Atlas Rift lost its potential importance as a possible pathway of continental division, and thus became inactive. Later on, the rift was involved in the orogenetic processes of the Mediterranean, and the central part was lifted up. Former marginal faults of the rift were reversed, leading to thrust development.

These results lead us to disagree with essential statements of Mr Ryan:

(1) So far we could not find any trace of his once postulated Atlas transform fault. If it ever existed, it should be proved in the field.

(2) Evaporation and desiccation of deep Triassic basins, and a sudden invasion by deep water facies of a Jurassic ocean, contradict factual evidence; this seems to be a relapse to catastrophism. Mesozoic sequences of the narrow Atlas–Graben and of the broad Sahara basin are quite similar in facies. They are both formed in consequence of slow continuous subsidence and wide extended epicontinental sedimentation under homogenous conditions.

(3) Magmatism within the Mesozoic record or beneath the High Atlas range is doubtless connected to rifting, but has never resulted in forming new ocean floor or crust by spreading activities.

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