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Evolution of Rifting in Africa

THE recent report by Girdler *et al.*[1] on the rift system of East Africa is of great interest because it presents a crustal model, based on new gravity observations, which suggests an intrusion of low velocity mantle material rising to the base of the sialic crust which underlies the eastern and western rift valleys of East Africa between 3° N and 9° S over an east–west width of about 1,000 km. The crustal model proposed is thus in a general way comparable with the postulated to underlie the worldwide mid-ocean ridge[2] and the Upper Rhinegraben[3]. Studies of seismicity, age of faulting, age of volcanoes and short and long wavelength gravity anomalies are interpreted by the authors as indicating attenuation of the African crustal plate and the early stages of its breakup. The structural behaviour of East Africa is compared with the conveyor belt mechanism of sea floor spreading from mid-ocean ridges as recently reviewed by Vine[4] and rates of movement away from the rift axis of 0·5–2·0 cm yr^{-1} are said to be indicated.

Such high rates of spreading are hard to reconcile with the geological picture of East Africa which is now known in some detail through the many map sheets published by the Geological Surveys of Kenya, Uganda and Tanzania. The terrain is very different from that of the mid-ocean ridges, as judged, for example, from geological mapping in Iceland[5]. Kenya and Tanzania form part of an extensive Pre-Cambrian platform and Caenozoic volcanism is largely limited to a belt parallel to the Gregory Rift Valley which does not (except for two small volcanic centres) extend south of 3° 30′ S. In the Western Rift Valley, the volcanism is limited to two elbows in fault direction and to the junction with the eastern rift at 9° S. Moreover, the volcanic rocks of East Africa are characteristically of alcaline type, whereas those of the mid-ocean ridges are almost entirely of the strongly contrasting tholeiitic type.

The floor of the rift valley itself is much cut by longitudinal faulting, but basement outcropping near the rift margins is not markedly cut by meridional dykes, as would be expected under an east–west tensional stress pattern. Girdler *et al.*[1] do not give the names of the volcanoes used in the computation, nor do they cite any isotope age data in addition to the stratigraphical ages given in the reports of the Geological Survey of Kenya. Many of the volcanoes have been active over quite long periods and, although it is known that the large majority of recent volcanoes and young fault scarps are associated with the relatively narrow rift valley zone, the volcanism had already started here in the late Miocene. On the other hand, activity on Mt Kenya and Kilimanjaro, some distance from the rift, continued into the Pleistocene[6]. Late Pleistocene craters are recorded[7] in the Nyambeni Range north-east of Mt Kenya, and the craters of the Chyulu Range, north of Kilimanjaro, are presumed to be recent[8]. Both these ranges are over 100 km eastwards from the rift margin. It is therefore difficult to see how a general rule that volcanoes are older the farther they are from the rift axis can be established.

Whether the age of faults can be used as a measure of the rate of distension is also doubtful for the following reasons. The exact age of the rift faults in the area included in the computation of spreading rate is difficult to determine, although it is certainly well known that the youngest scarps are associated with the presently active rift valleys. The Gregory Rift Valley, however, fades out into block faulting to the south of 3° S and this factor must complicate the assessment of data for even the most approximate calculation of a spreading rate because there is no central axis. Moreover, it is generally accepted that faults originating at least as far back as the Cretaceous have been reactivated at later dates up to recent. This characteristic of some of the faults of the East African rift system in Tanzania is therefore in sharp contrast to the situation on the mid-ocean ridges where the faulting at the axis affects only recent volcanic rocks. The geophysical information published by Girdler *et al.*[1] is of great value, and will help to explain, for example, the typical uparching of the rift belts which has been regarded as responsible for the rifting[9]; but before quantitative estimates of a spreading rate are accepted, much more must be known about the compatibility of the spreading hypothesis with continental crust geology of East Africa.

It has recently been suggested[10] that certain dislocation zones, with local development of rift valleys[11,12], in the Guiana and West African shields lined up directly with the pre-drift fractures[13]. It is now widely accepted that these fractures later developed by ocean floor spreading into the basins of the present North Atlantic, South Atlantic and the connecting equatorial segment, which suggests that similar mantle structures underly both continental and oceanic segments of these lineaments. It therefore seems that there is a similar type of lineament in both continental and oceanic lithosphere which, in the continental environment, may be affected by arching and consequent limited distension, or, in an oceanic environment, may be a locus of the rise of mantle material accompanied by ocean-floor spreading. Similar considerations apply to the Upper Rhinegraben lineament[3] and have been suggested for the East African rift system[14].

The East African rift lineament meets the spreading mid-ocean rifts of the Red Sea and Gulf of Aden in the Afar triangle, and it is tempting to seek evidence that the African rift is also spreading, particularly in view of the great volcanic outpourings in Ethiopia, although these are dominantly alcaline and not tholeiitic. But the rift valley and the belt of Caenozoic volcanics are on a scale which can be portrayed in detailed geological map sheets, so that verification of spreading, by reference to criteria now accumulated from the ocean floor rifts, should be possible by means of geological relationships[15]. The object of this communication is to indicate that the evidence for spreading at the rates postulated for the Kenya and Tanzania sectors by Girdler *et al.*[1] requires re-examination from the geological point of view because the phenomenon is fundamentally a geological one.

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