PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

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The existence of transform faults in the Red Sea depression

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(This contribution was written before the Discussion Meeting which the author could not attend)

Girdler (1968, pp. 1102–1105) has suggested that transform faults may exist in the Red Sea depression. A possible left-handed transform fault, trending at 050°, and centred on 19° N 39° E was plotted (Girdler 1968, fig. 1). This is supposed to offset the axial trough, and run on to the land, where it is shown displacing the 'marginal structure lines' and the Mesozoic and Tertiary sedimentary/Basement Complex contact by about 50 km.

Girdler (1968) cites Sykes (in *History of the Earth's crust*, Nasa, Symposium) as providing supporting first motion evidence of transform movement along this proposed fault. However Isaacs, Sykes & Oliver (1968, fig. 5) show a left-handed transform 'earthquake mechanism' bearing 020° for a centre associated with the axial trough at 17° N, 40° 30′ E. Because of the proximity of these centres, the 30° difference in trend, and the scarcity of Red Sea earthquake data, the question arises are Girdler and Isaacs *et al.* dealing with the same centres? More data and an explanation are required as there are few places in the world where undisputed transform faults have been described from the land and sea. Girdler's proposed transform fault is therefore extremely important both from a local Red Sea and a global structural view.

Laughton (1965) has shown that the fractures zone cutting the Gulf of Aden ridge do not continue onto the land. Mohr (1967, fig. 1), however, described possible transform faults on the land offsetting the Wonjii fault belt in Afar, Ethiopia; but in 1968 he referred to these and *transcurrent* faults, indicating a left-handed motion for the northernmost, near Massawa, and a right-handed motion for those displacing the Ethiopian boundary structure, the Salt Plain and Afar. The western boundary fault of the Danakil Horst is marked also as a left-handed shear, immediately northwest of the Wonjii fault belt.

Girdler's transform fault is shown as running ashore in the Tokar Delta, southeast of Port Sudan on the African side, and near Al Lith on the Arabian side. The available Sudan Geological Survey Map, Scale 1:4 000 000 is generalized and is little help, but field and aerial photo studies do not show evidence of a major structural disturbance displacing the Mesozoic-Tertiary Sediment/Basement Complex contact by 50 km in the Tokar area. Also on the Arabian side in the Al Lith area no such fault is plotted on the U.S.G.S.–Aramco 1:2 000 000 and 1:500 000 maps. This evidence makes it highly unlikely that a transform fault of the strike and length suggested by Girdler exists. No doubt transform faults occur in the Red Sea Depression as their existence is implicit in acceptance of continental separation. This is now generally accepted as having been taking place on a *limited* scale since the Miocene (Vine 1967; Girdler 1968; Whiteman 1968).†

Evidence of transcurrent movements on the land may help in spotting the locations and directions of such structures in the sea and between Ras Abu Shagara and Marsa Salak (21° N

† Since this contribution was written Tramontini & Davies (1969) have suggested that separation at latitude 23° N is greater than 130 km.

37° E approx.) about 300 km northwest of the Tokar Delta, three independent groups of geologists have suggested that transcurrent movements may have been taking place (Whiteman, in press).

Ras Abu Shagara and Maghersum Island are thought to be separated by a fault zone which trends from the southern tip of Ras Abu Shagara to a point just north of Mohammed Qôl, where it probably continues along the khor which drains down to Mohammed Qôl (Willis *et al.* 1961; Carella & Scarpa 1962; personal observations). The bearing of this proposed fault zone here called the Mohammed Qôl structure is approximately 050°.

Conspicuous magnetic and gravity anomalies occur along the line of this fault. Carella & Scarpa (1962) think that it is a transverse fault, but their map does not shown any displacement in the western Dungunab Bay area. Willis *et al.* (1961) have plotted right-handed shifts of the synclincal axis of Dungunab Bay and the synclinal axis which occurs west of Mukawwar Island. However, they do not show a shift of the Mesozoic and Tertiary/Basement contact.

Sestini (1965) plotted a fault a little to south of the Mohammed Qôl structure, which displaces the Mesozoic and Tertiary/Basement contact by about 9.6 km. Willis *et al.* (1961) also plotted three faults in this zone trending at 065°, and the southernmost shifts the Mesozoic and Tertiary contact by at least 8 km. The movement appears to be *right-handed*. An east–west trending fault is thought to run through Marsa Salak (Willis *et al.* 1961; Sestini 1965). It is not possible because of lack of photocover to be certain whether the Mesozoic and Tertiary/Basement contact has been displaced, but the occurrence of the Basement complex group due north of the Abu Imama and Maghersum outcrops, near Khor Ballobab may indicate a small displacement. These structures have not been walked out on the ground, but have been plotted mainly from distinctive displacements of outcrops on aerial photographs.

The Mohammed Qôl structure is particularly interesting because of its association with conspicuous gravity and magnetic anomalies. Clearly all are worthy of further investigation, because if they are 'tear' faults then they alter the currently accepted structural style for the central Red Sea depression, and may be associated with transform movements in the mantle and crust.

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