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New Evidence for Horizontal Movement Along the Jordan Rift

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ABSTRACT The Jordan Rift makes the northern segment of the East African-Red Sea-Syrian Rift system in which the opening of the Gulf of Aden and the Red Sea is continuing here as a transcurrent movement. For other geologists, the Jordan Rift is a graben made by vertical tectonics which have been operating on this Rift since the Precambrian times. Their evidence is based on: (1) the distribution and abundance of dykes in the basement, (2) the distribution of Precambrian sediments and (3) the thickness and distribution of the Lower Cambrian Basal conglomerates. Careful field examination of these evidences showed that they are not well founded. Thus, casting more doubt on the weakened graben tectonic hypothesis.

The evolution of Wadi Araba-Jordan Rift (Fig. 1) has been debated for more than a century ago. Tens of papers have been published, and geologists are divided on this issue between those who support horizontal movement along the Rift (Lartet 1869, Quennell 1958, 1983, Freund *et al.* 1970, Hatcher *et al.* (1981) and those who advocate graben (vertical) tectonics (Picard 1943, Wetzel and Morton 1959, Bender 1974a, 1983).

Bender, *op. cit*, in all his publications, was, and still is, defending vertical tectonics for the evolution of this Rift; and as support for this style of graben tectonics, claims that there is a suture line (Weak zone) along it. In other words, the Rift, in his view, has existed as an elongated depression since Precambrian times.

His lines of evidence are:

i. Dykes, in the basement, increase in the vicinity of the Rift and decrease away from it. This is due to the existence of a weak zone along the Rift.

ii. Precambrian or Infracambrian Cambrian sediments, *i.e.*, the Sarmuj conglo-

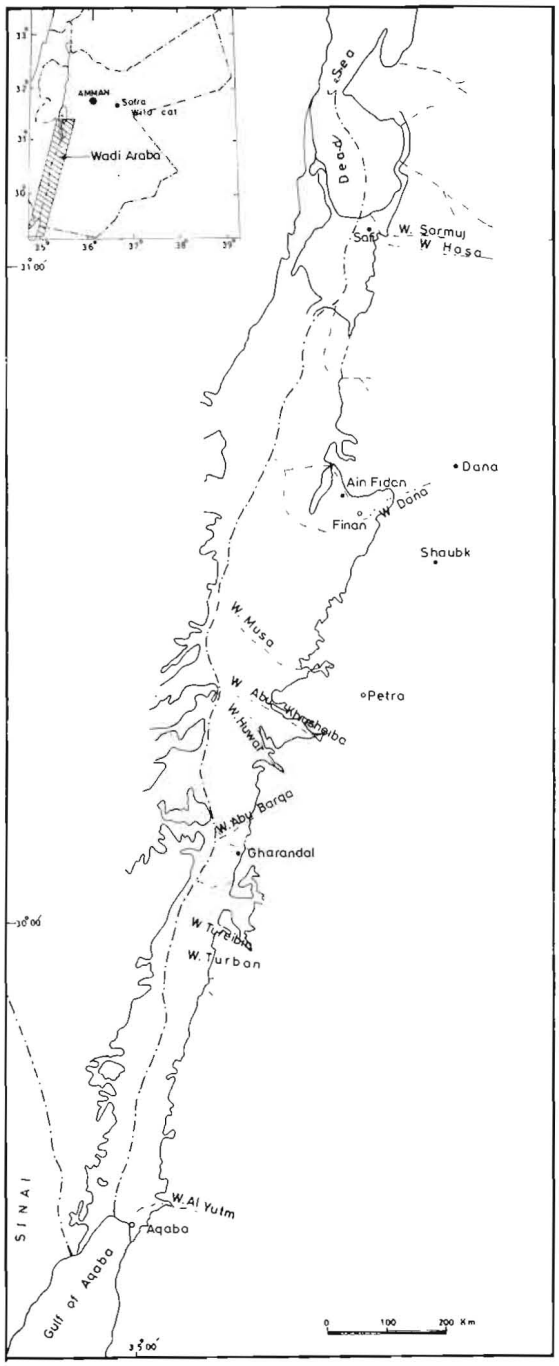

Fig. 1. Location map for Wadi Araba.

merates and the Slate-Graywacke series, occur only in the Rift, thus, documenting an elongated depression along the Rift.

iii. Lower Cambrian Basal Conglomerates occur only along the Rift, especially in its central and northern parts, once more indicating a depression along the Rift.

iv. Middle Cambrian quartzporphyry dykes are rather extensive only along the Rift. Thus, indicating a zone of weakness.

It is the intention of this paper to examine this evidence in the light of new field data.

Stratigraphic Setting of the Basement

The stratigraphy of the outcropping part of the basement in Jordan is rather simple. It is shown in Table 1 and Fig. 2. It should be mentioned that the grey granite of Burdon (1959) is equivalent to the apilite-calcalkali and plagioclase granites of Bender (1974b). The granodiorite occurs as small or large xenoliths in the grey granite. The alkali granite is equivalent to the pink granite of Burdon.

Dykes

Dykes in the basement are of different types and ages. It is not the aim of this paper to discuss the material of the dykes, but rather their distribution and abundance in the various rock types.

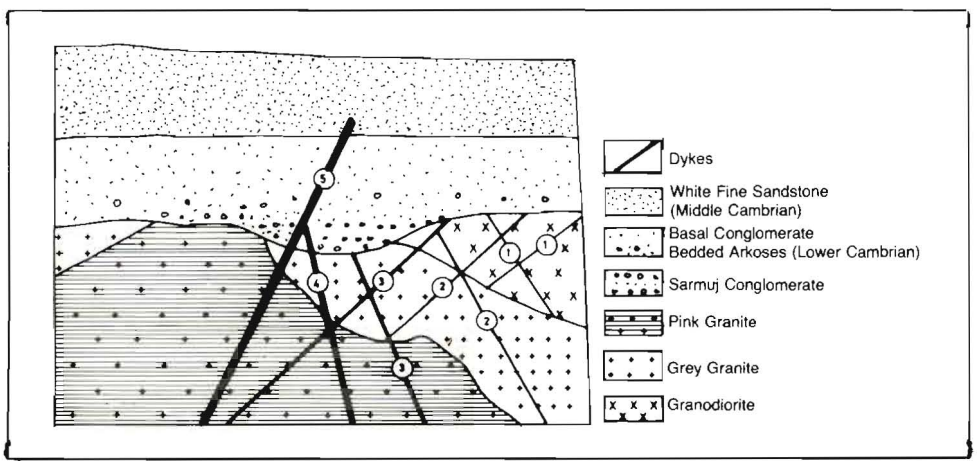

Fig. 2. Sketch diagram showing the stratigraphic phases of the basement, Lower and Middle Cambrian in the Rift area.
1, 2, 3 ... dyking phases.
Note that intensity of dyking increases in older rocks.

Table 1. Stratigraphy of the Jordanian basement.

Burj formation	Middle Cambrian
Quartz porphyry dyking	Middle Cambrian
Basal Conglomerates and Arkoses	Lower Cambrian
Peneplanation and gravelling	
Dyking	
Alkali granite (pink granite)	
Extensive dyking	
Aplitte, calc-alkali and (grey granites) plagioclase granites	Precambrian
Dykine	
Granodiorites	
High grade metamorphic rocks	

Bender, *op. cit.*, claims that dykes increase towards the Rift and vanish or decrease eastwards. Careful field investigation shows that this conclusion is not valid. Three E-W sections were measured across the basement and the dyke to country rock ratio was determined.

1. *West of Fidan-Wadi Dana Section In Northern Wadi Araba*

The country rock is grey granite. It is introduced by various types of dykes making a ratio of more than 40% in both localities (Fig. 3).

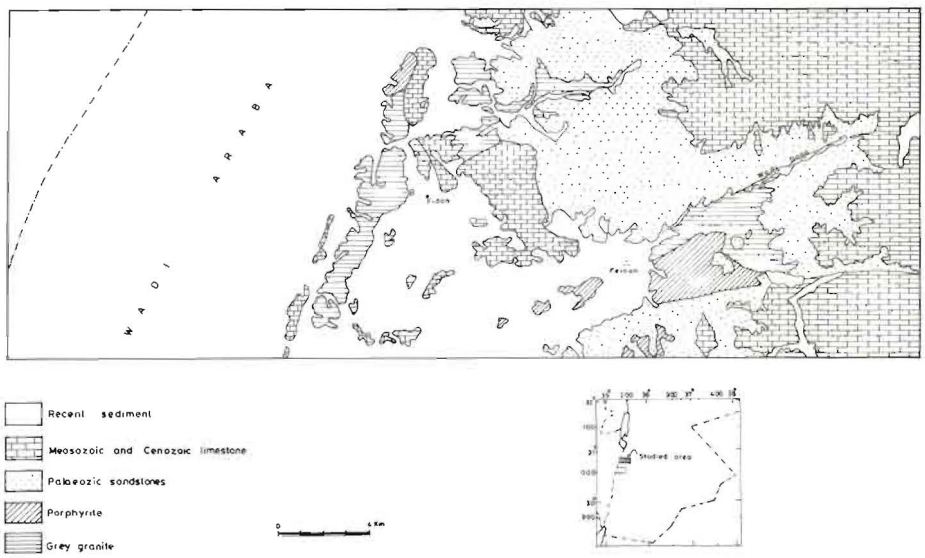

Fig. 3. Geological map of the Fidan-Wadi Dana area, northern Wadi Araba (after Bender 1974b).

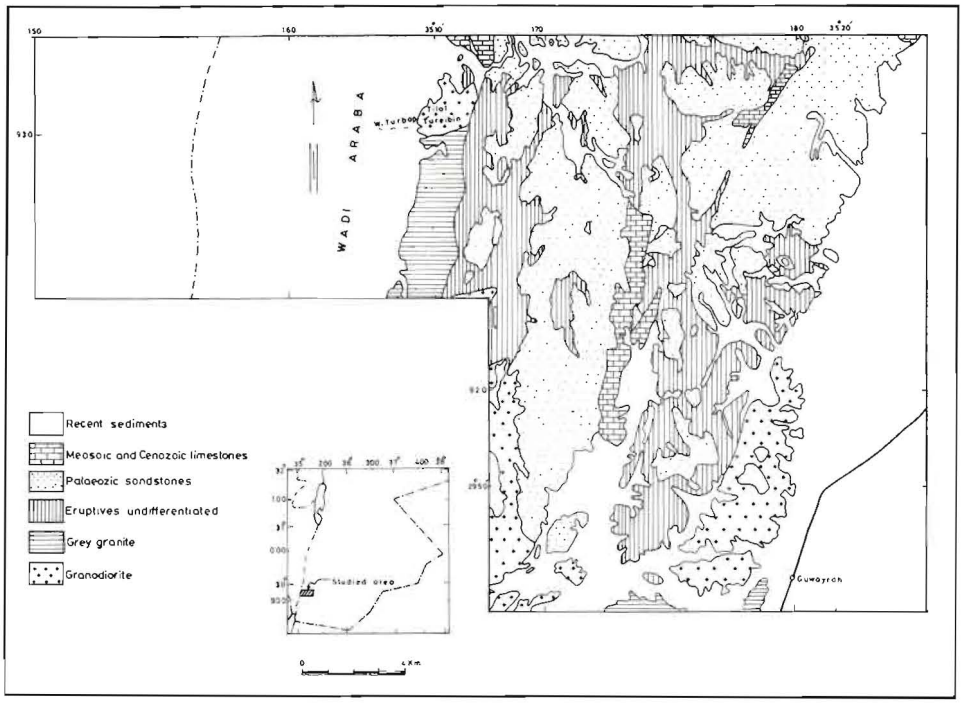

Fig. 4. Geological map of Wadi Turban-Guwayrah Area central W. Waraba (after Bender 1974).

2. *Wadi Turban-NW Guwayrah Section*

There exists what Bender, *op. cit.*, designated as undifferentiated eruptives. They are in fact grey granites as the country rock cut by 40-60% dykes of various types in both localities (Fig. 4). The dykes are more resistant than the grey granite, thus forming ridges while their scree obscures the granite outcrop on either side, a feature difficult to discern in aerial photographs.

3. *Wadi Al Yutm Section*

This is possibly the best section as regards accessibility. Three smaller sections were studied along this wadi; for locality numbers see Fig. 5.

a) *Granodiorite*

Locality	*Ratio of dykes*
1 (W)	10%
2	15%
3 (E)	15%

b) *Grey Granite*

Locality	*Ratio of dykes*
1 (W)	3%
2	10%
3	10%
4	25%
5	10%
6 (E)	10%

c) *Pink Granite*

Locality	*Ratio of dykes*
5 km W of 1	0.5%
4	0.5%
5	1 %
6	1 %

It is concluded that dykes are restricted in their distribution to time events (dyking phases) and thus to rock types of the basement (Table 1) rather than to space. If the same phase of magmatism is considered, the dykes do not decrease or increase in frequency in any direction.

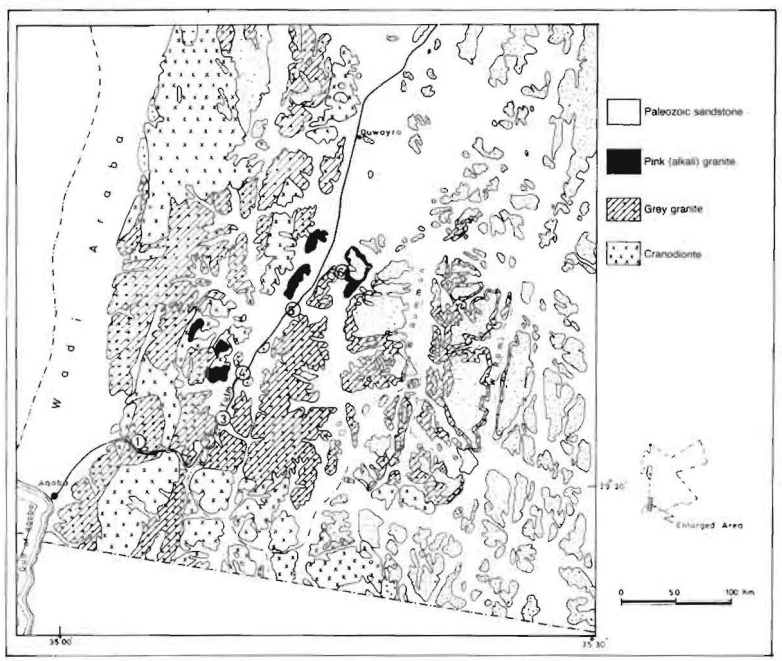

Fig. 5. Geological map of Aqaba area. Numbers 1, 2, 3 ... station where dyke ratios were measured.

Precambrian Sediments

Bender, *op. cit.* claims that the Sarmuj Conglomerates (200 m) and the Slate-Graywacke series (200 m) are distributed only along the Rift zone. Thus, the Rift has been a depression since Precambrian times. This is true in the vicinity of Wadi Araba. But about 420 m of Sarmuj Conglomerate was drilled in the wildcat Safra well some 40 km SE of Amman, this thickness being twice that encountered in Wadi Araba. If more outcrops of the basement are discovered, then possibly still more of this material will be found (Fig. 6). Further south, the Similar Hammamat conglomerates in Sinai and Eastern Egypt crops many tens of kms away from the Gulf of Aqaba and the Red Sea (Said 1962).

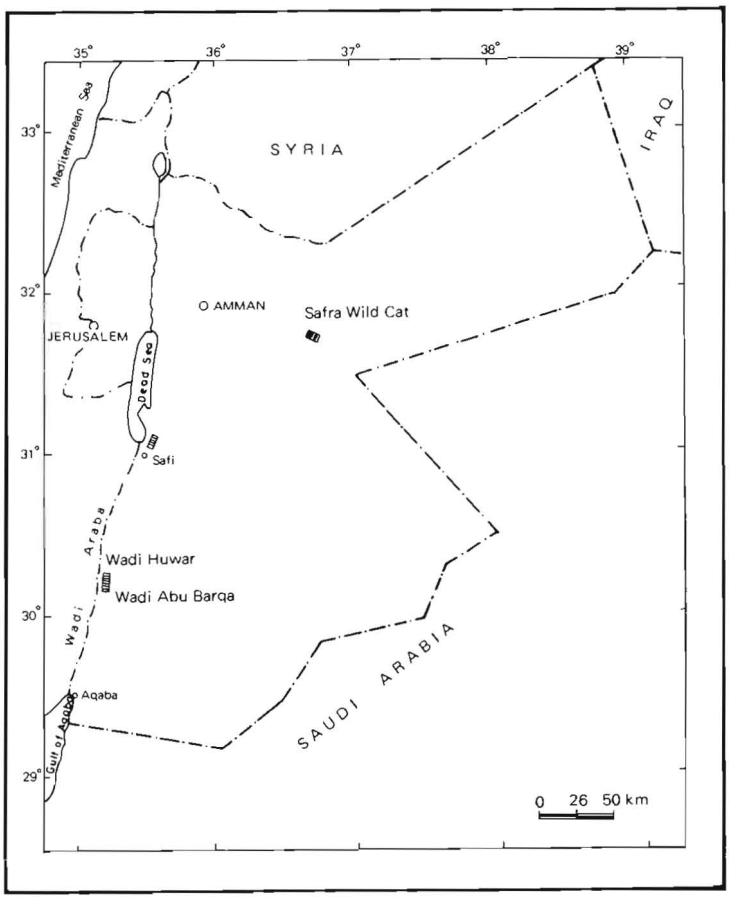

Fig. 6. Distribution of the Precambrian-Infracambrian Sarmuj Conglomerates and Slate and Graywackes (▥).

Lower Cambrian Basal Conglomerates

Using the same argument, Bender claims that these conglomerates are also well distributed and thicken along the Wadi Araba and they are missing away from it.

This formation was examined over a distance of more than 250 km, from Wadi Sarmuj (in the Dead Sea basin) through Wadi Araba, as fas as Wadi Ram east of Aqaba (Fig. 1). It consists of various proportions of pebbles in an arkosic sandstone matrix. Pebbles are predominantly of quartz, but rhyolite, quartz porphyry, granite

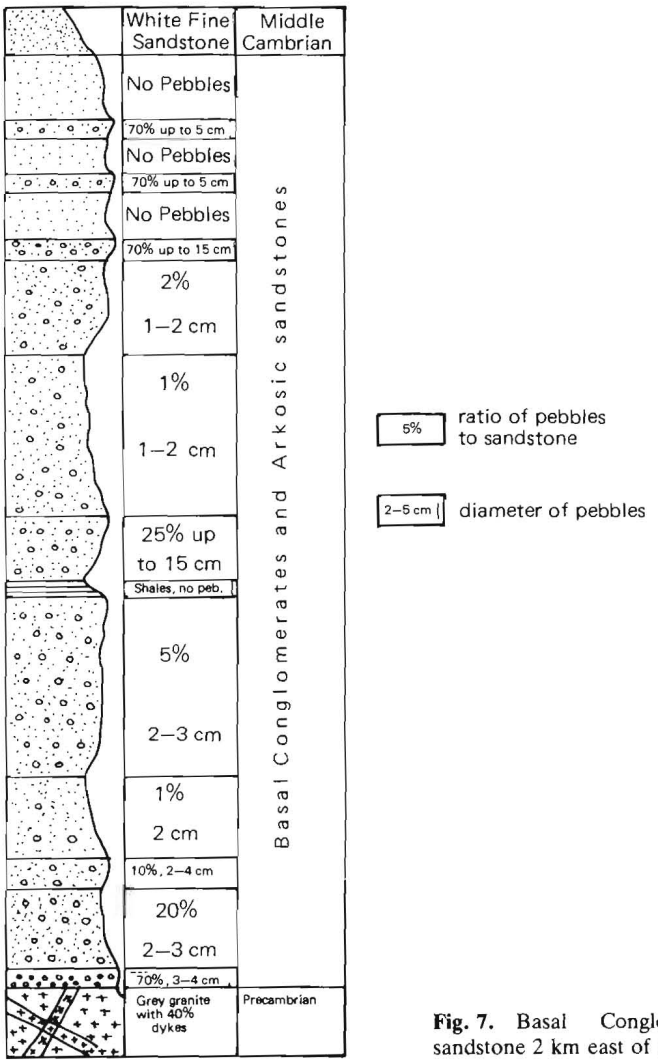

Fig. 7. Basal Conglomerates and Arkosic sandstone 2 km east of NRA campin Wadi Dana.

and sandstones also occur. In the extreme north (Wadi Sarmuj), it has a thickness of 20 m, while in Wadi Dana a section is measured in this formation (Fig. 7) attains a thickness of about 50 m. In Wadis Abu Khusheiba, Abu Qurdhiya and Huwar, the conglomerate is sometimes found but not always, and usually it is far less prominent than in the north (Wadi Dana).

In Wadi Abu Barqa along the Rift it does not occur. In the extreme SE, in Wadi Rumman (away from the Rift), a measured section (Fig. 8) records more than 50 m thickness, very much as that of Wadi Dana. Fig. 9 is a photograph of its base.

Thus, the distribution of this conglomerate is not restricted to the Rift zone. Selley (1972) interpreted the Lower Cambrian Pebbly Sandstones east of

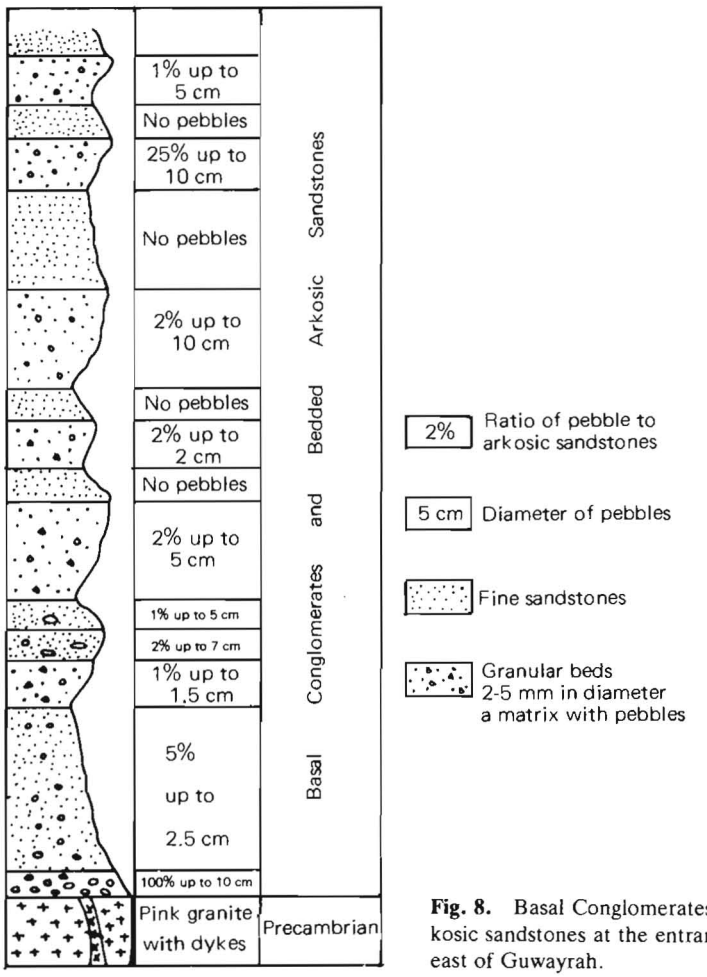

Fig. 8. Basal Conglomerates and the Bedded Arkosic sandstones at the entrance of Wadi Rumman east of Guwayrah.

Fig. 9. Basal Conglomerates in Wadi Rumman east of Guwayrah (Fig. 8), right on the contact with the granite.

Guwayrah as a channel lag deposits in a braided river system, and this is possibly why this facies appears and disappears, rather than being restricted to the postulated Precambrian elongated depression along the Rift.

Quartz-Porphyry Dykes

This phase of dyking intrudes the basement and sometimes formations up to the Middle Cambrian. The dykes are claimed by Bender, *op. cit.* to have intruded been along the Rift zone. Examination of the geological maps of Burdon (1959)

and Bender (1974b) shows that they occur extensively far to the east of the Rift (*e.g.*, 2 km west of Petra). Also, this type of dyke is rather an important type NW of Guwayrah, in the so called undifferentiated eruptives in Bender (1974b). In short, they are rather abundant everywhere in the basement. They are also abundant in Sinai and Eastern Egypt (Said 1962) and in northern Arabia in the equivalent of Jibala Formation (Delfour 1979).

Discussion and Conclusion

The above mentioned data had shown that Bender's data on the Wadi Araba paleosuture is partly or totally in error. It also shows that there have been, possibly, many elongated or non-elongated depressions in the basement. Thus, there is not an inherited weak zone along the Jordan Rift since the Precambrian. Advocates of vertical tectonis has used this paleosuture as one strong evidence to support their hypothesis. In this view, the Jordan Rift has existed since Precambrian times, several hundred million years before plate tectonics started to operate. Subsequently, this Rift is old and has nothing to do with the opening of the Red Sea and the Gulf of Aden in the Mesozoic and Cenozoic.

It is clear, then, that this paper adds an other evidence against the weakened graben tectonics and a new support to the horizontal movement along the Jordan Rift.

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أدلة جديدة على الحركة الأفقية على طول غور الأردن

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يشكل غور الأردن الجزء الشمالي من حفر الانهدام الإفريقي - السورى، حيث أصبحت حركة فتح خليج عدن والبحر الأحمر حركة أفقية على طول غور الأردن. غير ان جيولوجين آخرين يعتقدون بأن هذا الغور قد نشأ بوساطة الحركات التكتونية العمودية التي كانت وما زالت عاملة فيه منذ حقب البريكامبرى. وأدلتهم على ان هذا الغور قد كان موجودا منذ البريكامبرى ترتكز على ما يلي:

١ - توزع القواطع في صخور القاعدة وكمياتها.
٢ - توزع رسوبيات البريكامبرى.
٣ - توزع كونجلوميرات الأساس للكامبرى الاسفل وسمكها.

ولقد اوضحت هذه الدراسة الميدانية الجديدة أن هذه الأدلة مغلوطة جزئياً أو كلية. ومن ثم فإنها تُلقى ظلالا جديدة من الشك على نظرية التكتونية العمودية التي أضعفت أكثر بفعل هذه الأدلة.