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CRUSTAL THINNING POSSIBLY RELATED TO LATE PALEOZOIC UPDOMING : EVIDENCE FROM TWO NEAR EASTERN MEGASTRUCTURES

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SUMMARY

An examination of published interpretation of seismic refraction profiles in Jordan and in Saudi Arabia, shows some localized thinning of the crust. The locality of these changes coincides with the sloping flanks of the Helez geanticline in Jordan and the Riyadh geanticline in Saudi Arabia, both of which are known to have formed in the Late Paleozoic. The observed spatial coincidence suggests a possible Late Paleozoic date for the mantle updoming, possibly in connection with crustal thinning.

RESUME

L'examen d'interprétations publiées de profils de réfraction sismiques en Jordanie et en Arabie Saoudite révèle certains amincissements localisés de la croûte. Les sites de ces réductions d'épaisseur coïncident avec les flancs du géanticlinal Hélez en Jordanie et celui de Riyadh en Arabie Saoudite, tous deux connus pour avoir été édifiés au Paléozoïque supérieur. Cette coïncidence spatiale suggère que l'"updoming" du manteau date du Paléozoïque supérieur peut être en relation avec un amincissement de la croûte.

KEY WORDS

Israel, Jordan, Saudi Arabia, Helez, Riyadh, geanticline, Late Paleozoic, Seismic refraction, Moho, crustal thinning.

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1. INTRODUCTION

During the Paleozoic many cratonic areas of the Afro-Arabian landmass were tectonically dominated by epeirogenic motion over considerable vertical ranges, producing a pattern of swells, or flat-domed geanticlines, several hundred km in diameter. Most of these geanticlines were eroded and reburied before the end of the Paleozoic, although some have retained their Paleozoic structural configuration beneath younger sedimentary sequences. Others, mainly those near the cratonic margin, were affected by subsequent rifting which resulted in structural inversion of terrains in the crestal area. Late Paleozoic structures of these kinds (the Helez and Riyadh geanticlines - Fig. 1) have been described in the Near East where their age and regional dimensions were established on stratigraphical grounds and on the basis of field relations (Gvirtzman & Weissbrod, 1984 ; Weissbrod & Gvirtzman, 1988 ; Gvirtzman *et al.*, 1988). Similar structures, interpreted somewhat differently, were described from North Africa (Sander, 1968 ; Klitzsch, 1970 ; Bellini & Massa, 1980).

The evolution of some African swells (Hoggar, Tibesti, Darfur) has been discussed by Brown & Girdler (1980), Bermingham *et al.* (1983), Neugebauer (1983) and Turcotte & Emerman (1983). Proposed mechanisms include lithospheric thinning under the crestal area, accompanied or followed by uprising of low-density mantle material. This mechanism, however, is based mostly on theoretical modelling using gravimetric data. Such a deep-seated crustal process involving increased heat flow, was assumed by Weissbrod *et al.* (1989) for the evolution of the Helez and analogous structures in the Near East and North Africa.

The annealing of fission tracks in zircon grains from Late Precambrian arkoses, sampled in boreholes in southern Israel, points to a supracritical heating event, unwarranted by depth of burial. Resetting of the radiometric clock in these and other sediments coincides uniformly with the Late Paleozoic uplifting and truncation of the Helez geanticline (Feinstein *et al.*, 1988 ; Weissbrod &

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Gvirtzman, 1988). So far, no other geophysical evidence was reported, that may bear on crustal processes associated with this geanticline.

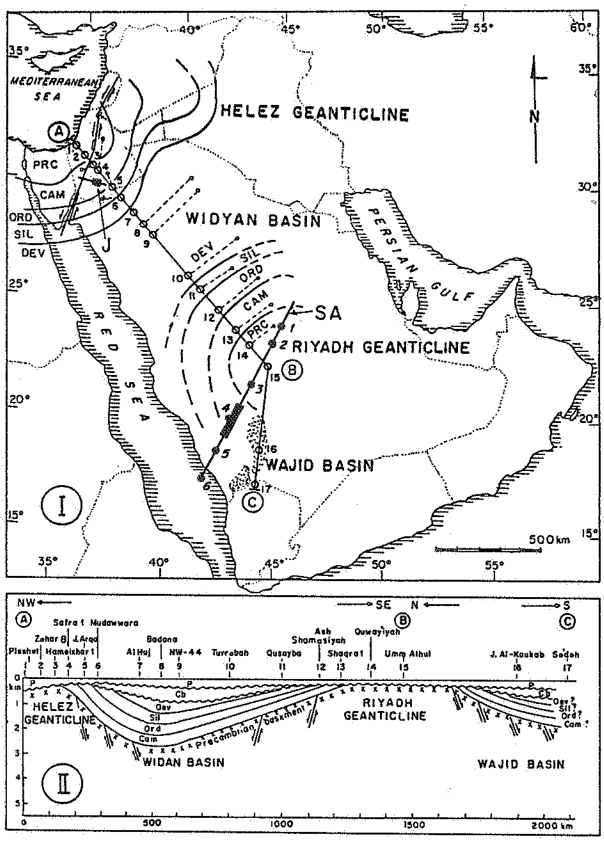

Figure 1. :

I - Schematic outlines of the Helez and Riyadh geanticlines as expressed on the reconstructed sub-Carboniferous erosion surface (modified after Weissbrod and Gvirtzmann, 1988 ; Gvirtzman *et al.*, 1988) and location of seismic refraction profiles in Jordan (J) and Saudi Arabia (SA). Thickened sections refer to boxed areas on Fig. 2.

II - Schematic stratigraphic section A-B-C along the Helez and Riyadh geanticlines and the Widyan and Wajid basins (data points 1 to 17 are projected).

2. PUBLISHED DATA FROM SEISMIC REFRACTION MEASUREMENTS

Lately, results from several deep seismic refraction surveys in the Near East have been published, yielding information on crustal structure along profiles that include sections of the Late Paleozoic geanticlines (Fig. 1). El-Isa *et al.* (1987) have published interpreted refraction profiles in southern Jordan along the southeast-dipping flank of the Helez geanticline (section J on Fig. 1 ; Fig. 2). Another seismic refraction profile, from the crestal area of the Riyadh geanticline south-southwestards to the Red Sea Rift, was run in 1978 by the U.S. Geological Survey (Blank *et al.*, 1979). Ten alternative interpretations of this profile, suggested by various authors, have been summarized by Mooney & Prodehl (1984). Three of these, SA 1-3, are presented in Fig. 2.

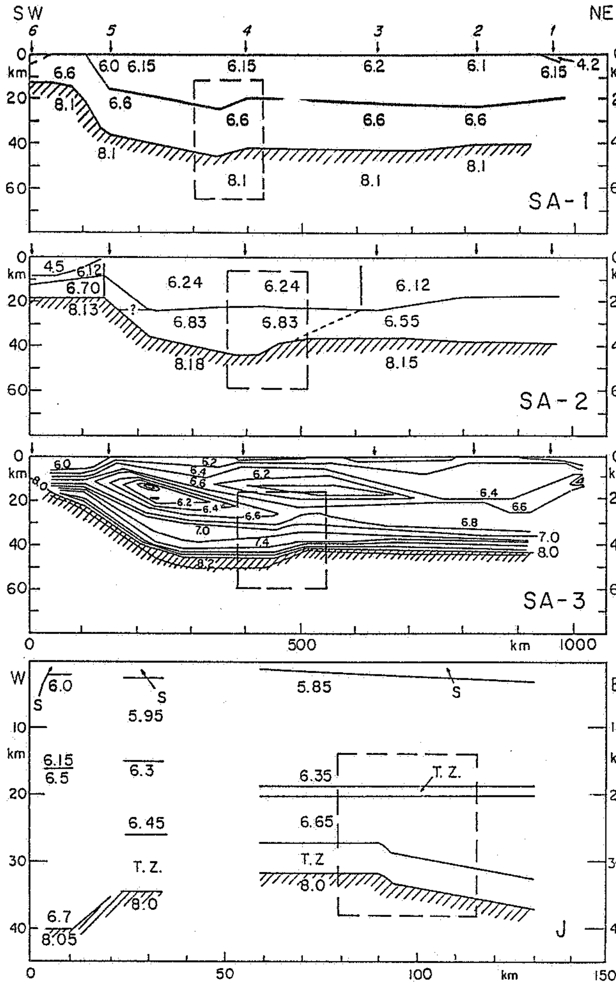

Figure 2. : Seismic refraction profiles in southwestern Saudia Arabia (SA-1 interpreted by Ginzburg, 1984 ; SA-2 by Gettings, 1984 ; SA-3 by Prodehl, 1984) and southern Jordan (J after El-Isa *et al.*, 1987). Boxed areas show notable thinning of crust over short distances. Rapid thinning on the left side of the profiles is related to Late Cenozoic Red Sea rifting and Dead Sea transform.

3. DISCUSSION

For both regions the seismic stratigraphic models show, beside notable crustal thinning related to the Cenozoic Red Sea Rift and Dead Sea transform, another conspicuous transition from thick to thin crust. This transition occurs at those sections of the profile that correspond to transition from flank to crestal areas of the Late Paleozoic geanticlines. The trend is most clearly expressed by a steepening of the Moho (6.8 km/sec - 8.1 km/sec velocity interface) and of the modelled intracrustal boundaries, (Fig. 2 - boxed areas), rising some 5 km over a distance of about 100 km in the Saudi Arabian profile and 5-6 km over about 50 km in the Jordanian section. The cause for the change in crustal thickness is attributed by Gettings (1984) to lateral differences in crust composition. Nevertheless, the areal coincidence of the crustal thinning with the flank areas of the two Late Paleozoic megastructures clearly suggests a link between the crustal thinning and the dome-forming mechanism.

Updoming, as is implied by all presented models, involved upbulging of the crust/mantle boundary, with expectedly parallel increase of heat flow, and possible material contributions from the upper mantle. Post-Paleozoic epeirogenic fluctuations, though affecting the elevation of the sediment/basement boundary, need not have involved corresponding changes in crustal thickness or Moho depth. Even if they did, vertical changes were evidently of lesser magnitudes, incapable of obliterating the remanent bulge of the crust/mantle boundary - a fossil feature of Late Paleozoic times.

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