Morphotectonic and active tectonic features in Qalamoon Mountain Chain, Syria, as indicators for crustal shortening in northern Arabian plate

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Introduction

The NNE elongated Qalamoon Mountain Chain lies in central Syria between the NNE oriented Anti Lebanon Mountain Chain and the NE trending Palmyrides. It is built by Lower Jurassic up to Oligocene limestone, marl and chalky limestone (fig 1).

Since Miocene onset northern rims of the Arabian platform located to the south of the Palmyrides basin was subducted and sinisterly strike slipped at the Palmyrides Faulting Belt which bounds the southern rims of the Palmyrides basin (Chaimov & et.al.1990).

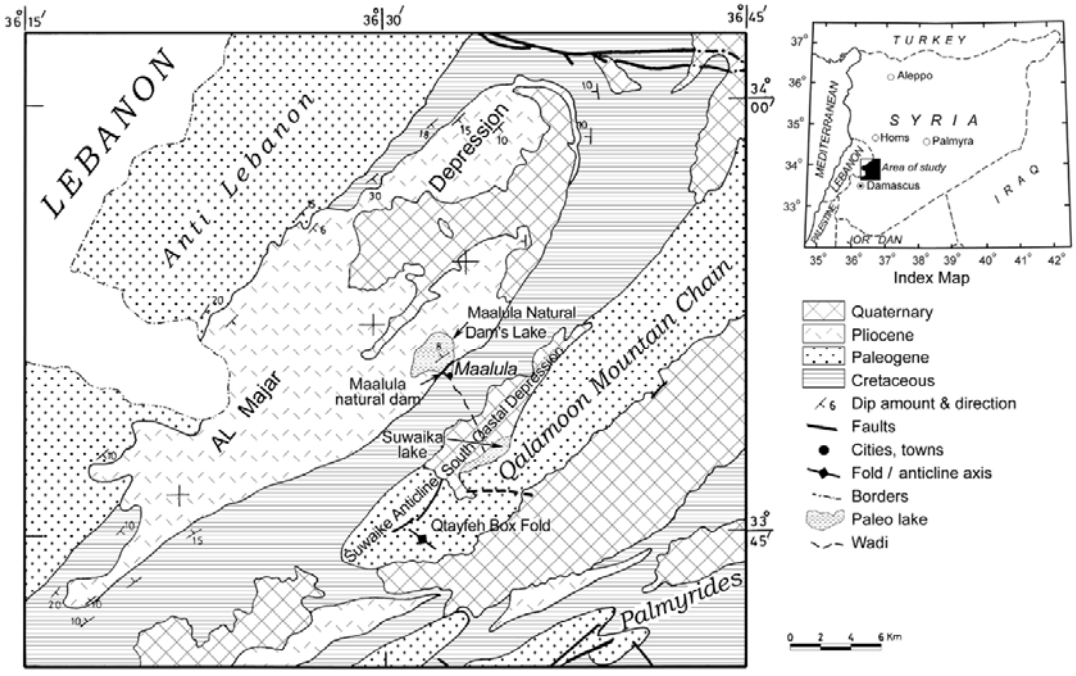

Figure 1. Location and geological map of the area of study.

At Pliocene onset the entire region was uplifted, and thick sediments were folded forming anticlines and confined continental depressions, among which the asymmetric NE-SW elongated Al Majar and Southern Qastal depressions, which were filled by continental Lower Pliocene conglomerate, sandstone and siltstone. During Late Pliocene-Quaternary, vertical tec-

tonic movements associated with further faulting and folding took place load (Ponikarov, 1966, Al Najjar and Layyous 2000, Radwan et al.2001).

Methodology

A Landsat 6 TM imagery has been digitally enhanced for better contrasting, edge sharpening. Lineaments and active tectonic features were delineated. Field morphotectonic evidences were mapped and interpreted. Specific sediments were sampled for dating active tectonic events and deformations. The results were implemented to synthesize an active tectonic scenario.

Discussion

Detailed field mapping in Al Majar Depression disclosed the following observations:

- The Neogene sediments outcropped in Al Majar Depression's central parts attain an elevation of 1800m, exceeding the elevation (1500m) of the enclosing Oligocene limestone cliff (Maalula cliff) which outlines the depression's rims.
- The 630m Pliocene thickness of the continental sediments accumulated in Al Majar depression indicates that the rims of Maalula cliff should have during Miocene and Pliocene an absolute elevation higher than the elevation of the current outcropped Neogene sediments.
- The Q4 conglomerate outcropped to the east of Al Majar Depression is 45° and 52° tilted. It bears in its upper levels boulders of Oligocene compact limestone Maalula cliff while its lower levels are devoid of such.
- Maalula cliff vanishes strikingly near Maalula town with the development of NW oriented parallel gullies cutting deep through its exposed upper surface.
- A box fold incompatible with traditional Plamyrides box folds, with its axis making 45° clockwise angle to their axis, is mapped.
- Most of the southern Palmyrides anticlines are z-shape kinked. This phenomenon becomes more pronounced in the Palmyrides southwestern anticlines.

These observations indicate that the traditional NE-SW direction of max. compression, prevailing during Neogene in the Palmyrides and Anti Lebanon temporally shifted during Quaternary to NE-SW direction.

Accordingly, the following neotectonic-morphologic-paleogeographic scenario for the area was established (fig 2):

- The NW-SE oriented Early-Miocene traditional compression formed the southern Palmyrides anticlines among which Suwaika anticline, which borders the confined Al Majar Depression.
- A continuing NW-SE directed compression since Pliocene onset has gradually narrowed the Palmyrides anticlines, deepened and narrowed enabled Al Majar depression to accommodate more than 630 m thick sediments which overlaid discordantly (5°) the underlying Miocene clastics.
- A general uplifting during Early Quaternary occurred due to a continued NW-SE directed max. compression, hence exposing the area to erosional effects on earlier Miocene and Pliocene sediments. Consequently, small lakes within Al Majar Depression have been formed during Quaternary. One of such lakes is west Maalula lake dammed from the east by the Maalula Oligocene compact limestone cliff, and confined from the west by highly elevated Pliocene terrain (fig 2). The cliff played the role of a natural dam.
- During late Quaternary stages the max. compression converted to NE-SW direction. Such a change is evidenced by:

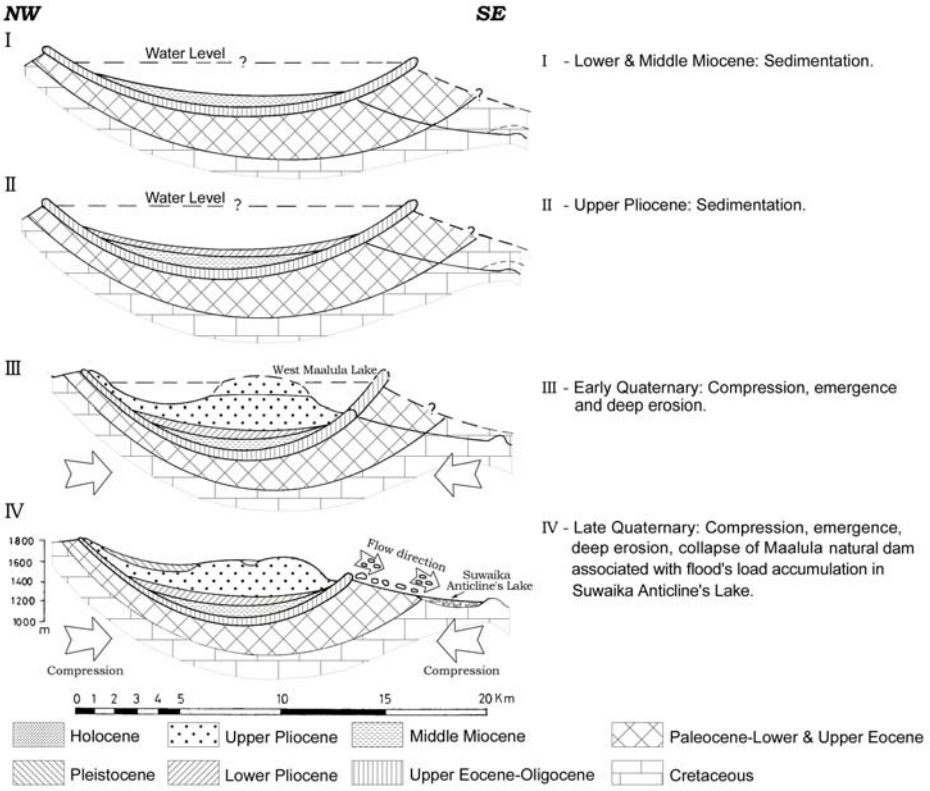

Figure 2. Neotectonic-morphologic-paleogeographic scenario of Al Majar depression explaining the collapse of Maalula natural dam accommodating some shortening.

- An increase in the dip of Maalula cliff at the depression's northeastern and southwestern extremities.
- The presence of an incompatible box fold described above (fig. 1).
- Z-shaped kinking of the southwestern extremities of the NE elongated Suwaika anticline and some of the southern Palmyrides southwestern anticlines (fig. 3).
- The deep cut of percolating water through NW joints that penetrate the exposed northwestern portions of Maalula cliff upper surface. The erosion effect of the surface runoff was far less weaker hence cutting shallower through the cliff upper surface that exposed northeast of Maalula in comparison to its effect on it toward southwest where the cliff is fully eradicated according to the following suggested morphotectonic scenario:
  - The Miocene and Pliocene sediments those overlying Maalula cliff at the southwestern parts of Al Majar Depression have been eroded and vanished more rapidly than those exposed at the depression's northeastern parts hence exposing Maalula cliff to the erosion effect particularly on NW joints for longer time.
  - The depression's southwest parts uplifted relatively higher than its northeastern ones hence exaggerated the erosion effect along the NW surface run off courses eroding gradually the cliff.
  - These courses deepened and widened further due to a continued NW-SE oriented compression during Upper Pleistocene. Mar Sarkis gully, widened to the degree that the Oligocene Maalula natural dam collapsed (fig. 1 & 2). Consequently, Maalula natural dam's lake was suddenly and vigorously evacuated in form of flush flood loaded with boulders, gravels and pebbles of Maaula cliff. This event was dated by ^{14}C as old as 27260+/-200 to 20990+/-120 year b.p.. The flood flowed in Maalula- Ain Al Tineh Wadi and accumulated its load in a small restricted lake confined by the foot slope of Jabal Suwaika anticline and the box fold (fig 1).

- Lacustrine conglomerate, whose components are the erosion products of the adjacent Suwaika anticline's Cenomanian limestone, dolomite and chert only, deposited in Suwaika Lake. After the collapse of Maalula natural dam, the flood's load reached Suwaika lake and new conglomerate bearing huge masses and boulders derived from Maalula cliff, overlain discordantly (7-10°) the former conglomerate. Both conglomerates should be initially horizontal nevertheless, they dip 45° and 52° northeastward pointing to ongoing active tectonic events occurred before and after Maalula natural dam collapse, rising further uplifting Suwaika anticline.

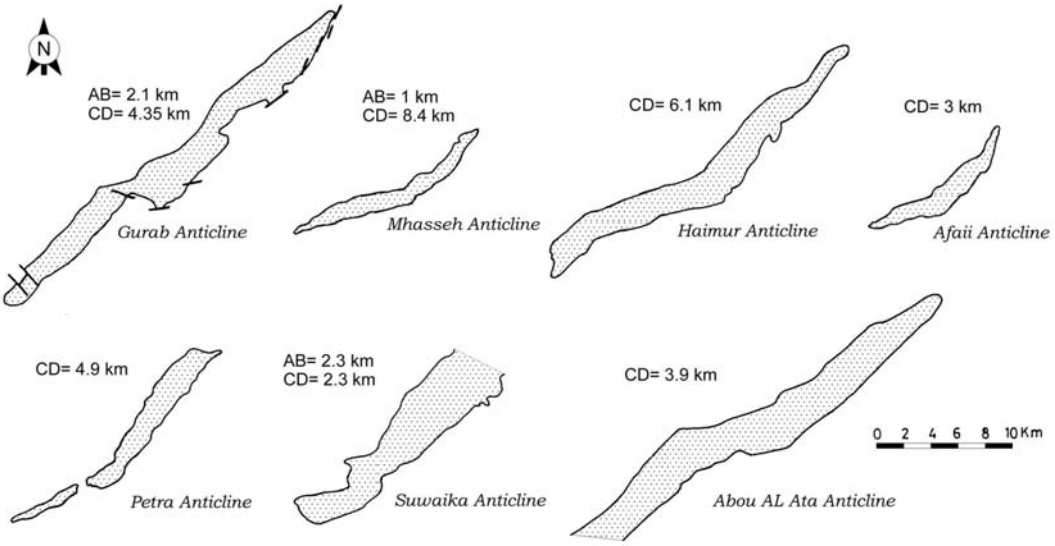

Figure 3. Calculated shortening due to Z-shaped kinking of the southwestern extremities of some NE elongated southern Palmyrides southwestern anticlines.

Conclusions

A NW-SE balanced cross section of Al Majar Depression gave a 17.5% calculated shortening shortening which equals 5.1 km due to neotectonics and active tectonics. The z-shaped kinking of southern Palmyrides anticlines, gave a calculated shortening ranges between 1 and 8.4 km. This may contribute in explaining some of the missing 20 km shortening in Syria estimated by Chaimov et. al. 1990.

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