



Tertiary structure of the Jbel Sirwa region (Anti-Atlas Mountains, Morocco)

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The Anti-Atlas is a mountainous region located in the southern foreland area of the High Atlas Mountains. Upper Proterozoic and Paleozoic rocks dominate in outcrop, slightly deformed during the Variscan orogeny. Post-Variscan (Mesozoic and Cenozoic) rocks are found in localized areas of the Anti-Atlas, mainly in its northern boundary.

The present topographic height of the Anti-Atlas is over 1500 m in extensive parts of it, and over 2000 m in several places, reaching the Proterozoic rocks 2500 m in the Jbel Sagho and Jbel Sirwa regions. Such topographic elevations indicate that these areas have been uplifted recently. Late Cenozoic phonolitic volcanism took place in the Jbel Sagho and Jbel Sirwa, mostly in the latter one, where the Jbel Sirwa volcano reaches 3304 m.

Two Tertiary foreland basins separate the High Atlas from the Anti-Atlas: the Warzazat basin South of the central High Atlas, and the Souss basin South of the western High Atlas. Both basins display an overall synclinal structure, with hinge-lines plunging up to the elevated Jbel Sirwa region (2°E in the Mesozoic rocks in the western part of the Warzazat basin).

Between these basins, the Jbel Sirwa region has only a thin veneer of Mesozoic and

Neogene sedimentary rocks. The structure of these rocks has been analyzed by means of contour maps of its present height and geological sections. Upper Cretaceous rocks (and locally Permo-Triassic rocks) are preserved in isolated outcrops along the continuation of the hinge-line of both basins, joining their Mesozoic substratum. The elevation of these Upper Cretaceous rocks vary from 1300 m in the Warzazat basin (in the E) to 2375 m in the Jbel Sirwa area (in the center), and then down to 900 m in the eastern boundary of the Souss basin (to the W). Hectometric to kilometric thrusts and folds oriented N-S to E-W affect also the Upper Cretaceous rocks. South of the area containing Mesozoic rocks, Neogene sedimentary (Aït Kandoula Fm, formerly called "Pontian") and volcanic rocks are present, spreading south from the Warzazat basin to beyond the Jbel Sirwa, to the S. The elevation of the Neogene rocks shows a similar pattern to that of the Upper Cretaceous ones. They vary from 1200 m in the Warzazat basin border to 2400 m in the Jbel Sirwa, to 1500 m SW of this mountain and 900 m in the western edge of the Souss basin. This distribution points to a connection between the Warzazat and Souss basins during the Aït Kandoula deposition: currently there is a gap of 20 km between the Neogene ("Pontian") rocks in the Souss basin and the western outcrops of the Aït Kandoula Fm in the Sirwa region, and this gap is coincident with the deeply downcut Assif-n-Tfnout.

An E-W, N-dipping, high-angle reverse fault of decakilometric extent cuts the Neogene rocks south of the Jbel Sirwa, producing an uplifting of 500 m of its northern block (the Anti-Atlas Major Fault, Choubert & Marçais, 1952). Other kilometric-scale reverse faults have been observed involving Neogene rocks. All these structures reactivate Variscan or even older structures.

The overall structure of the area can be summarized as follows: 1) A broad anticline oriented NNW-SSE, of about 120 km of wavelength, deforms the Upper Cretaceous and Neogene rocks of the Sirwa region. 2) The uplifting at the core of the anticline is about 1500 m (by comparing the present height of the Neogene rocks in the Jbel Sirwa area and in the center of the Warzazat basin). 3) The Tertiary reactivation of the E-W Anti-Atlas Major Fault seems to be coeval to the anticline, as the latter is only located in the uplifted northern block of the fault. 4) The shortening produced by the fold is less than 1%.