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Post-Panafrican late Proterozoic basins in the Central Anti-Atlas (Morocco): their influence on the Variscan contractional structures.

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Located South of the High Atlas, in Morocco, The Anti-Atlas is a 700 km-long chain trending NE-SW. In the Central Anti-Atlas region, between Warzazat and Taznakht, the Proterozoic Pan-African basement (X1 to X2-3) crops out in isolated areas (boutonnières), where it is overlaid by late to post Pan-African Upper Proterozoic and Palaeozoic rocks. Late to post Pan-African Upper Proterozoic rocks (X3) have been classically divided into three units (X3i, X3m and X3s) which include volcanic rocks — mainly rhyolites— and continental siliciclastic rocks, the older units intruded by late granites (Choubert, 1952 and Choubert et al., 1970).

Rocks belonging to the upper unit of post Pan-African Upper Proterozoic rocks (X3s) were deposited in basins bounded by faults with a dominant dip-slip normal motion; as a result, this unit have a variable thickness, being locally absent in the uplifted blocks. Uppermost Proterozoic (Adoudounian) and Palaeozoic rocks deposited unconformable on the older rocks in the Anti-Atlas. The Central Anti-Atlas was slightly deformed during the Variscan orogeny by folds and high-angle thrusts. Two areas are selected to study the post Pan-African to Variscan evolution of the area: the Tiwiyyine basin and the Anti-Atlas Major Fault.

Tiwiyyine basin
This basin is delimited by kilometric-scale normal faults. Three of them can be observed in the field: two striking NE-SW (NW and SE boundaries) and one striking NW-SE (SW boundary), while the NE boundary is covered by Cenozoic rocks. The basin fill reaches 725 m and has been divided into three units:
1. X3s1: Coarse conglomerates with basal breccias.
2. X3s2: Laminated dolomites at the base, red pelites and conglomerates.
3. X3s3: Conglomerates with interbedded andesites.
Unit X3s2 passes laterally to the SW to unit X3s1.

The thickness of the basin fill diminishes to the SE. This is specially visible at the basal X3s1 unit. At both sides of the two NE-SW-striking faults, only the upper X3s3 unit is found, while none of the three units is observed SW of the NW-SE- striking fault. The substratum of the X3s unit inside and outside the Tiwiyyine basin is the X3m unit.

Extension along two NW-SE cross-sections is 7.2 % and 8.3 %. Along a section oriented NE-SW the calculated extension is 5.1 %, although only one boundary fault has been taken into account.

During the Variscan orogeny the Tiwiyyine basin underwent a contractional deformation that caused the inversion of the normal faults bounding the basin, and the formation of folds parallel to them. The inversion of the two NE-SW-striking faults caused the substratum of the basin to crop out in their hanging wall. In the SW segment of the basin, the NW-SE fault was not inverted and the base of the Adoudounian still covers the fault. In the hanging wall of this fault a NW striking fold appeared, that beyond the basin becomes a SW-vergent reverse fault. A NW-SE syncline, visible in the Adoudounian rocks, formed to the SW, in the footwall of the fault.

The horizontal shortening along the two NW-SE cross-sections is 14.8 % and 12.7 %. The shortening along the section oriented NE-SW is 2.8 %, although, as stated previously, only one boundary fault has been

taken into account. From these data, horizontal shortening in all directions can be deduced, evidenced by the map recognition of sinusoidal fold traces and three-limb synclines. These patterns are typically the result of synchronous cross-folding with different amounts of shortening in different directions (Gosh and Ramberg, 1968). We interpret these structures to be originated by an unique episode of horizontal constriction.

Anti-Atlas Major Fault

The Anti-Atlas Major Fault (AMF) is a structure inherited from the Panafrican orogeny. It has been proposed even as the Panafrican continental suture (Leblanc, 1976). North of Taznakht the AMF appears as a North-dipping fault that experienced a normal slip during the sedimentation of the X3s unit, as can be deduced from the presence of this unit in its hanging-wall while it is absent in its footwall. Adoudounian and Palaeozoic rocks lie unconformable on both blocks of the fault, but they were affected by part of the normal slip of the AMF, which can be observed along several kilometres, putting in contact Adoudounian rocks in the hanging wall to X2 and X3i in the foot-wall. To the east, the AMF shows a reverse slip at surface, and the Adoudounian rocks of the hanging wall are thrust onto those of the footwall. The minimum Variscan shortening is estimated to be about 9% in a NNE-SSW direction.

Summarizing, the AMF had two episodes of normal slip (one during the sedimentation of X3s and another involving the Palaeozoic rocks), and a late episode of reverse inversion during the Variscan orogeny. The Variscan reverse slip was less than the previous normal one, with only the Adoudounian level, in the eastern part of the sector studied, recuperating the previous downthrowing.

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