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The Anti-Atlas Pan-African Belt (Morocco): Overview and pending questions

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ABSTRACT

Between the High Atlas and the Saharan platform, the Anti-Atlas of Morocco offers large exposures of Precambrian rocks beneath the moderately folded Paleozoic series. These inliers allow reconstructing a segment of the Pan-African Belt and of its foreland at the northern outskirts of the West African Craton (WAC). From ~885 Ma to ~540 Ma, three periods are recognized in the Pan-African cycle. The Tonian–Cryogenian period ends with the obduction of supra-subduction ophiolite and oceanic arc material at ~640 Ma. The Early Ediacaran period is marked by the development and subsequent closure of a wide marginal basin next to a likely Andean-type arc. The Late Ediacaran period is recorded by subaerial molasse deposits associated with post-collisional high-K calc-alkaline to shoshonitic magmatism. Although a wide consensus has been reached based on the number of new robust datings, several questions still remain pending, which we address taking into account relevant African and European correlations.

1. Introduction

The Precambrian inliers of the Anti-Atlas mountain range (Fig. 1) have been studied for long (Choubert, 1952, 1963; Neltner, 1938). They expose wide outcrops of the Neoproterozoic Pan-African belt and of its Paleoproterozoic foreland (Gasquet et al., 2008 and references therein). Recent studies are numerous and provide a remarkable wealth of structural, geochronological, and geochemical data, as reported below. Despite such a rich documentation, controversies remain on important issues: (i) the evolution of the Neoproterozoic oceanic domain from which the ophiolites and arc units exposed in the suture zone come from (e.g., Triantafyllou et al., 2018); (ii) the discrimination between the post-Eburnian platform cover recently dated to the Late Paleoproterozoic (Ikenne et al., 2017) and the Neoproterozoic passive margin sequence (Leblanc and Moussine-Pouchkine, 1994); (iii) the geodynamic interpretation of the post-obduction magmatism and sedimentation that developed during the Early Ediacaran (Abati et al., 2010; Letsch et al., 2018b); (iv) the nature of the continental block that bounded the oceanic domain to the north (present coordinates) and then collided against the WAC during the Ediacaran; (v) the origin and tectonic framework of the Upper Ediacaran volcanic/sedimentary cover series that overlie unconformably the deformed Pan-African units and immediately predate the Cambrian deposits.

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Our goal is to present a short review of the state of the art in the geology of the Anti-Atlas Pan-African belt, making a point on the five key issues cited above. In the following, the cited ages are U–Pb zircon ages, unless otherwise stated. Table 1 (Supplementary Material) lists the most important U–Pb zircon dates available in each of the Anti-Atlas inliers, generally obtained by SHRIMP or LA–ICP–MS methods.

2. Geological setting

The Anti-Atlas mountain range is a hierarchical, nested range. At the largest scale, the range corresponds to an ENE-trending lithospheric fold cored by Paleozoic and Proterozoic rocks, and whose envelope is made of thin Cretaceous–Neogene strata that form the "hamadas" plateaus in the South, and the Souss and Ouarzazate–Ar-Rachidia basins in the North (Fig. 1). This fold echoed the Atlas compressional orogeny (Frizon de Lamotte et al., 2009), but the Anti-Atlas fold crest elevation was increased by about 1000 m due to the development of a hot mantle anomaly underneath, which also caused the high elevation of the Atlas domain farther to the northeast (Fullea et al., 2010; Missenard et al., 2006). Late Miocene to Quaternary alkaline volcanism occurs above this hot anomaly, well-illustrated in the Anti-Atlas by the Siroua strato-volcano erected on top of the Siroua plateau (Admou and Soulaimani, 2011).

The more internal, but still large-sized part of the range corresponds to the Variscan fold belt. This belt formed at the expense of the thick Paleozoic series deposited on the rifted margin of the West African Craton (WAC; Burkhard et al., 2006; Michard et al., 2010). The Anti-Atlas fold belt is the thick-skinned foreland belt common to the Mauritanide in the west and to the Meseta Paleozoic orogen in the north. Inversion of the faults formed in the Cambrian-Ordovician and Late Devonian rifting events occurred during the Late Carboniferous–Permian (Baidder et al., 2016), and resulted in the uplift of the present-day Precambrian inliers.

Two contrasting groups of inliers are recognized, separated from each other by the Anti-Atlas Major Fault (AAMF; Choubert, 1947). Along the AAMF (Bou Azzer and Siroua inliers) and farther to the northeast (Saghro and Ougnat massifs, Ouzellarh massif of the Marrakech High Atlas, Skoura massif north of Ouarzazate), the Precambrian inliers only display Neoproterozoic terrains. In contrast, those to the southwest of the AAMF only expose Paleoproterozoic terrains that include Eburnian basement rocks and their Upper Paleozoic cover series (see below).

3. The Tonian-Cryogenian pre- to syn-Pan-African times

3.1. Evolution of the oceanic domain

The occurrence of ophiolites in the Bou Azzer and Siroua inliers (Figs. 1 and 2) was introduced by Leblanc (1972) and raised immediately a major interest, not only from a geodynamic point of view, but also because of the particular metallogeny of these rocks. A wealth of structural, petrological, and geochronological studies developed during the last three decades helped to reach a consensus about the major stages of the evolution of the Pan-African oceanic domain. This consensus is summarized as follows, mostly after Blein et al. (2014a), Hefferan et al. (2014) and Triantafyllou et al. (2016, 2018):

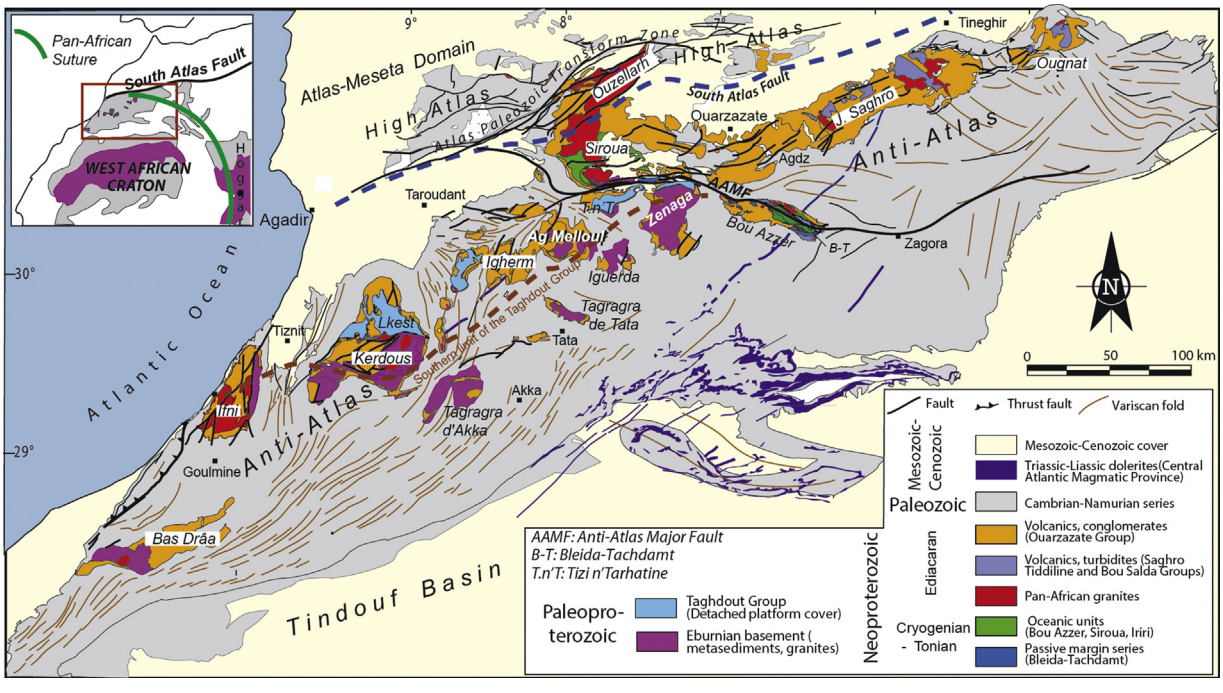

Fig. 1. The Anti-Atlas mountain range, after Gasquet et al. (2008), modified.