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$^{40}Ar/^{39}Ar$ hornblende and biotite geochronology of the Bulfat Igneous Complex, Zagros Suture Zone, NE Iraq: New insights on complexities of Paleogene arc magmatism during closure of the Neotethys Ocean

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ABSTRACT

In NE Iraq, the eastern edge of the Arabian plate is overlain by arc rock allochthons whose genesis and tectonic emplacement were related to the consumption and closure of the Neotethys Ocean. This paper demonstrates the occurrence of unrelated Paleogene arc rocks in two adjacent allochthons. The Bulfat Igneous Complex at Wadi Rashid (NE Iraq) is an intrusion within the *Upper Allochthon* Albian–Cenomanian Gimo–Qandil sequence suprasubduction zone assemblage. A thrust separates this allochthon from the underlying *Lower Allochthon* of the Eocene-Oligocene Walash–Naopurdan volcanic-sedimentary arc rocks. The Bulfat Igneous Complex at Wadi Rashid consists of gabbro and granitic composite intrusions in which components mingle down to a small scale. Textural relationships in the Bulfat Igneous Complex rocks indicate emplacement at high crustal levels with rapid cooling, which is consistent with amphibole geobarometry indicating crystallisation pressures between ~250 and 300 Mpa. Ti-rich igneous pargasite and Ti-rich igneous Fe-biotite from gabbroic and granitic components yielded $^{40}Ar/^{39}Ar$ ages of 39.23 ± 0.21 and 38.87 ± 0.24 Ma respectively. These ages agree within analytical error and suggest coeval emplacement and rapid cooling of mafic and felsic magmas in the Eocene, in an event that was distinct and much younger than the host Albian–Cenomanian rocks. This igneous event was unrelated to formation of Cenozoic rocks in the underlying, tectonically separate, lower allochthon. The trace element signatures of the Wadi Rashi volcanic rocks show volcanic-arc characteristics for the granites and the gabbroic rocks resemble E type MORB. The presence of Eocene arc-related rocks in two allochthons suggests complexity in Paleogene subduction systems, with possibly two subduction zones operating at that time.

1. Introduction

The Zagros Suture Zone in NE Iraq (Kurdistan) is a complex collage of predominantly arc-related rocks formed in the Neotethys Ocean. With ocean closure these arc-related rocks were obducted onto the eastern edge of the Arabian plate as several allochthons (Fig. 1; Aswad et al., 2013; Ali et al., 2012, 2013). Recent studies are highlighting the temporal and lithological complexities of the Kurdistan sector of the Zagros Suture zone, with most importantly the recognition of Cretaceous as well as Cenozoic arc-related allochthons (Ali et al., 2012, accepted). The Kurdistan Cretaceous rocks form a linkage between Tethyan Cretaceous rocks to the south in Iran and Oman, and those to the north in the eastern Mediterranean, and thereby show the presence of active Cretaceous arcs throughout the extent of western Neotethys. In most cases different Zagros Suture Zone Cenozoic and Mesozoic arc assemblages cannot be distinguished in the field, and often any associated sedimentary rocks are not suitable for biostratigraphic constraints (Ali et al., 2013; Aswad and Pashderi, 1984). Furthermore, due to minefields and current conflict, fieldwork has in many instances to be based on rapid appraisal and limited sampling of roadside outcrops. Nonetheless, a growing amount of $^{40}Ar/^{39}Ar$ mineral and U–Pb zircon geochronology is revealing two important periods of arc magmatism; in the Cretaceous (Albian–Cenomanian) and the Paleogene (Eocene–Oligocene; Aswad et al., 2011, 2013; Ali et al., 2013, 2016).

In this paper we report on yet further complexities to these systems — the presence of Eocene arc rocks emplaced into a significantly older Cretaceous intra-oceanic assemblage. This is revealed by the $^{40}Ar/^{39}Ar$ dating of igneous hornblende and igneous biotite from the Bulfat Igneous Complex in Wadi Rashid, 30 km east Qalah Deza City, NE Iraq

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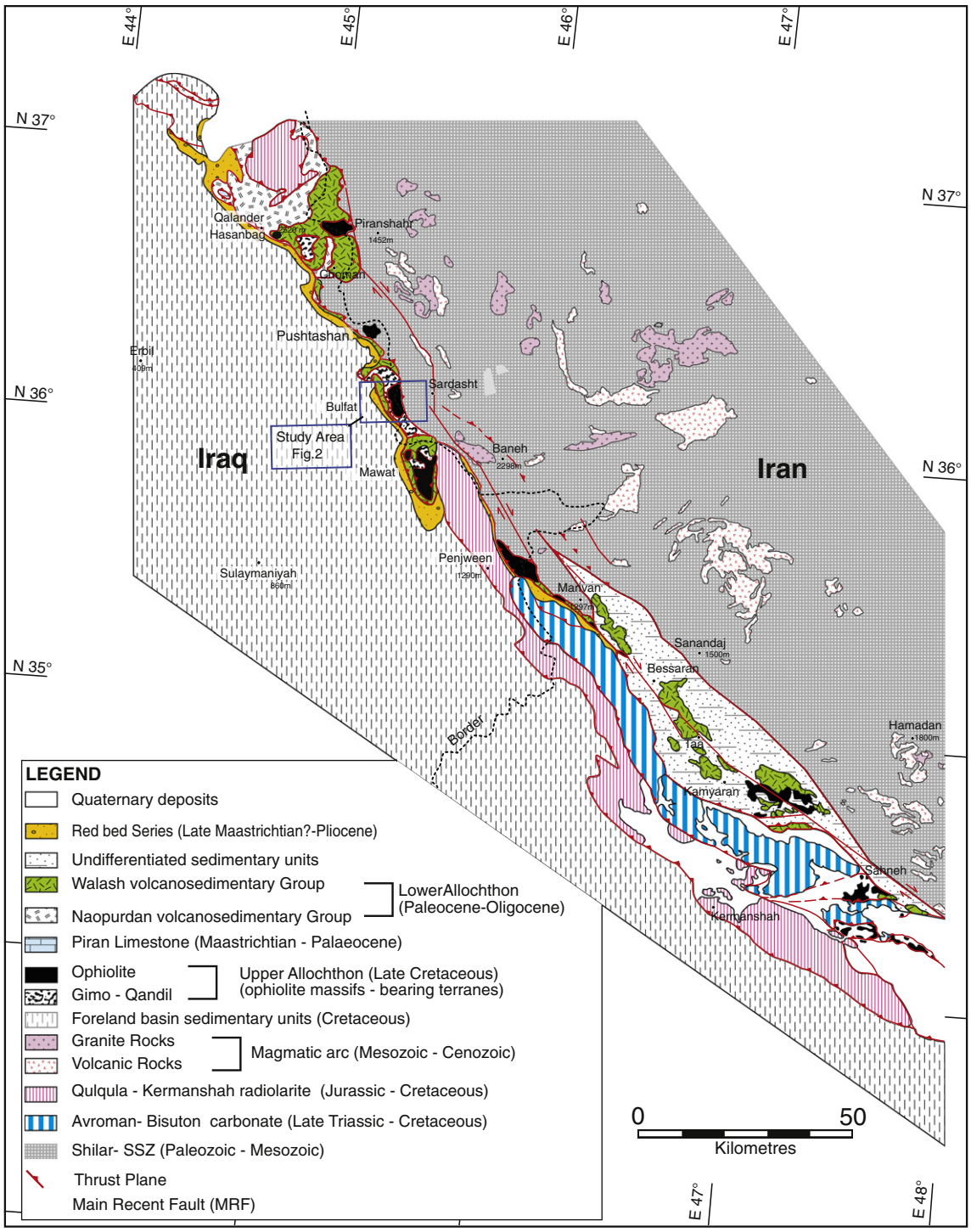

Fig. 1. Geological map of the Zagros suture zone along the Iraq-Iran border, showing the location and tectonic division of the study areas (after Ali et al., 2013).

(Fig. 1). This complex was emplaced into an *Upper Allochthon* consisting of the Albian-Cenomanian *Gimo–Qandil sequence* ophiolite-bearing terrane (Fig. 1; Ali et al., 2012; Jassim et al., 1982). The geochronology presented here demonstrates a Paleogene age for the Bulfat Igneous Complex, *c.* 60 million years younger than the host Gimo-Qadil sequence. However, the age of the Bulfat Igneous Complex agrees within error with that of arc-related rocks in the underlying *Lower Allochthon* of the *Walash–Naopurdan* volcanic-sedimentary assemblage (Ali et al., 2013). Our discovery in Iraq of the presence of unrelated but essentially coeval Paleogene arc magmatism in two separate allochthons points to the complexity of tectonics in the final stages of Neotethys consumption. Our favoured interpretation is that two subduction zones were operating in the Paleogene.

2. Regional geology

The Bulfat Igneous Complex occurs within the NW–SE trending Iraqi Zagros Suture Zone (Figs. 1 and 2; Jassim et al., 2006). Within this zone are the allochthonous Albian–Cenomenian Gimo–Qandil sequence (Upper Allochthon) and the Paleocene–Eocene Walash–Naopurdan volcanic-sedimentary sequence (Lower Allochthon; Aswad et al., 2011; Aziz et al., 2011). The Gimo–Qandil sequence used to be referred