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Neoproterozoic continental arc volcanism at the northern edge of the Arabian Plate, SE Turkey

Semih Gürsu[a,b,*], Andreas Möller[b], M. Cemal Göncüoglu[c], Serhat Köksal[d], Huriye Demircan[e], Fatma Toksoy Köksal[c], Hüseyin Kozlu[f], Gürsel Sunal[g]

[a] Mugla Sıtkı Koçman University, Department of Geological Engineering, Muğla, Turkey
[b] The University of Kansas, Department of Geology, Lawrence, KS, USA
[c] Middle East Technical University, Department of Geological Engineering, Ankara, Turkey
[d] Middle East Technical University Central Laboratory, Ankara, Turkey
[e] Mineral Research and Exploration General Directorate, Division of Geology, Ankara, Turkey
[f] Turkish Petroleum Corporation (Retired), Ankara, Turkey
[g] Istanbul Technical University, Department of Geology, Istanbul, Turkey

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ABSTRACT

New geochemical, Sr/Nd isotope and zircon U–Pb LA-ICP-MS data from the Derik Volcanics in the Southeast Anatolian Autochthone Belt of Turkey are consistent with an Andean-type Cadomian arc that developed along the northern edge of the Arabian Plate during the Late Neoproterozoic. The Derik Volcanics represent a volcanic complex including andesites, rhyolites and basalts, with volcanoclastic and fluvial sediments. They are unconformably overlain by playa sediments with Early Cambrian ichno-fossils, followed by Middle Cambrian-Silurian shallow marine deposits.

Geochemically, the Derik Volcanics (DV) display transitional-calcalkaline affinities. On Th/Nb–Ti/Zr diagram, DV display negative trends from rhyolites to late to early-stage andesites and mafic dykes, respectively. The REE patterns are highly to moderately fractionated, with $[(La/Yb)_N = 5.20–6.77$ in late-stage andesites, 4.38–10.51 in rhyolites, 2.58–4.65 in the early-stage andesites, and 2.51–4.21 in mafic dykes]. Normalized trace element and REE diagrams display Th, La, Ce, Sm enrichment and depletion of Nb, Ti and Eu as is typical for Andean-type active continental margin igneous rocks. The enrichment of LILE and LREE, combined with depletion of HREE also suggests that the Derik Volcanic rocks were formed in relation with a subduction zone. Negative Eu anomalies $(Eu/Eu)_N$, range from 0.50 to 1.81, indicates fractional crystallization of feldspar. The DV have positive εNd (+0.15 to +4.20) and mean model ages of 1.28 Ga for the early-stage andesites, 1.34 Ga for rhyolites, 1.35 for late-stage andesites, and 1.36 Ga for mafic dykes. The positive $\varepsilon Nd_{(T)}$ data show that DV are product of mantle-derived magmas. Lower $^{143}Nd/^{144}Nd$ isotope ratios than the depleted MORB mantle (DMM) source indicate that the DV may have been contaminated by crustal material during magma genesis. Geochemical modeling shows that all four volcanic rock types may have been formed by different percentages of batch melting of DMM and subducting slab sources.

Zircon LA-ICP-MS data give crystallization ages of 581.4 ± 3.5 Ma ($n = 7$) and 559.2 ± 3.2 Ma ($n = 3$) for the early and late-stage andesitic rocks, as well as ages of 569.6 ± 1.6 Ma ($n = 17$), 571.6 ± 1.9 Ma ($n = 18$), 575.4 ± 4.3 Ma ($n = 6$) for the rhyolites.

The geological and geochemical features together with the new age data suggest that the Derik Volcanics formed along a continental arc in the course of the southward subduction of Prototethys oceanic lithosphere along the northern margin of the Arabian Plate, which is attributed to a late-stage phase of the Cadomian Orogeny of the Pan-African cycle.

1. Introduction

The Arabian Plate (AP), representing one of the minor lithospheric plates, extends about 2600 km in north–south and 3000 km in east–west directions. The AP is tectonically bounded by Dead

* Corresponding author at: Mugla Sıtkı Koçman University, Department of Geological Engineering, Muğla, Turkey. Tel.: +90 252 2113155.
E-mail addresses: semihgursu@mu.edu.tr, semihgursu@yahoo.com (S. Gürsu).

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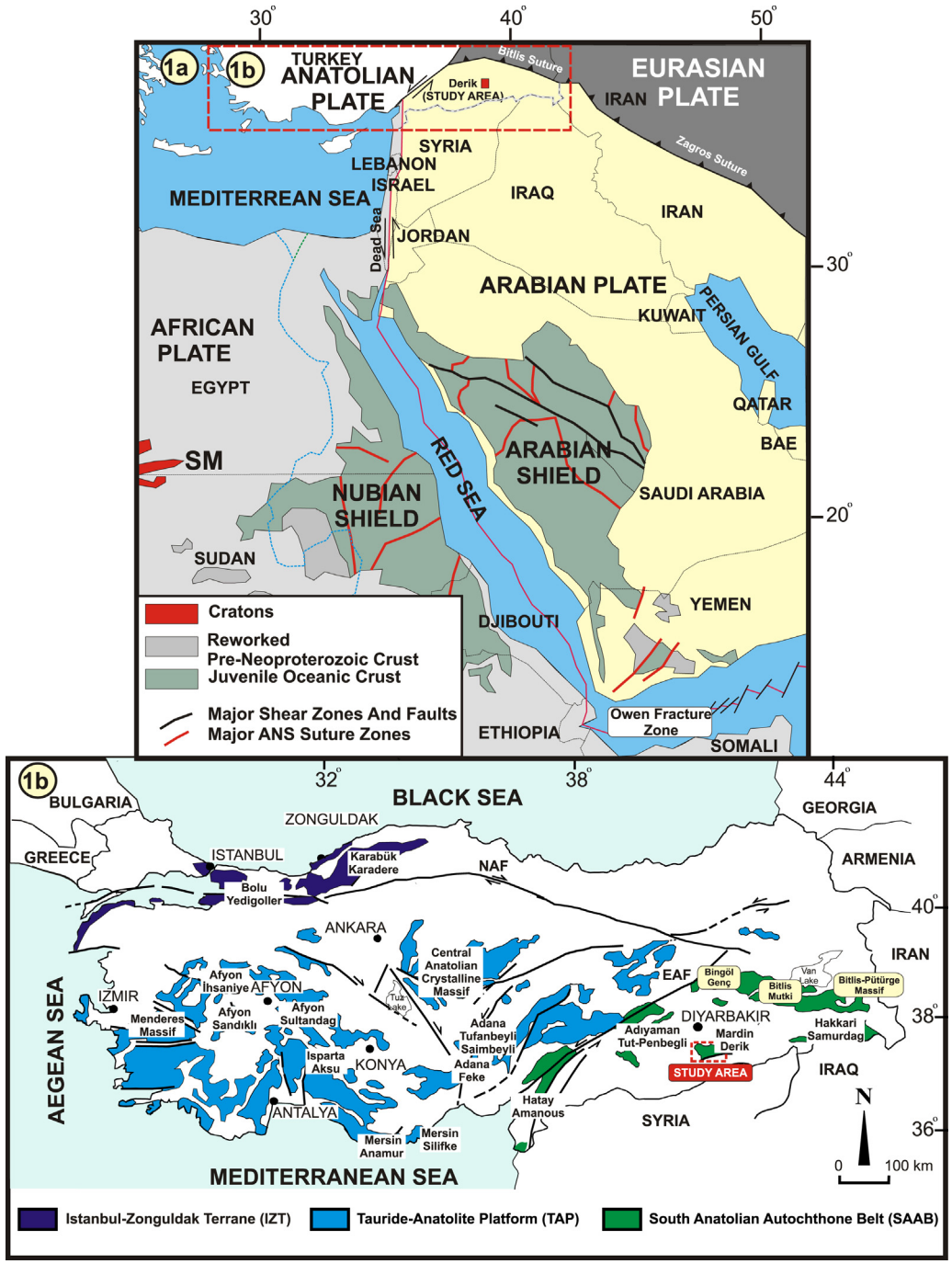

Fig. 1. (a) Geological units of the Arabian-Nubian Shield and the East African Orogeny (EAO) and the location of the study area (modified from Johnson et al., 2011 and Fritz et al., 2013). (b) Main Alpine tectonic units of Turkey (after Göncüoglu, 1997).

Sea transform faults and Red Sea Rifts in the west, the East Anatolian Fault–Bitlis Suture Zones–Zagros Collision zone in the north, the Owen Fracture Zone in the east and the Gulf of Aden Rifts in the south (Stern and Johnson, 2010). Its upper crust comprises of a crystalline Neoproterozoic basement overlain by a Phanerozoic sedimentary sequence. The lower crust of the AP is mainly composed of juvenile Neoproterozoic oceanic crust of the Arabian-Nubian Shield that represents a suture zone after closing of the Mozambique Ocean between the older continental fragments of East and West Gondwana during the 630–550 Ma interval (Stern, 1994; Unrug, 1996; Stern and Johnson, 2010; Fritz et al., 2013). The Arabian shield (AS), representing the eastern portion of the Arabian-Nubian shields of the East African Orogeny, is exposed in the southern margin of the AP (Fig. 1a). Stern and Johnson (2010) proposed that Neoproterozoic basement rocks of the AS were formed as primitive arc systems of the Mozambique Ocean that existed from 870 to 630 Ma. The terminal collision between older crustal blocks of East and West Gondwana occurred between 630 and 600 Ma. Convergence and tectonic escape continued to 600–550 Ma after the closure of the Mozambique Ocean (Stern, 1994; Unrug, 1997; Stern and Johnson, 2010). The Cadomian magmatic arc has been proposed to have formed simultaneously or shortly after the subduction of Proto-tethys Ocean as an Andean-type continental margin along the northern part of the AP (Carter and Tunbridge, 1992; Pickering and Smith, 1995; Göncüoglu, 1997; Keppie et al., 2003). At the Neoproterozoic–Early Cambrian