Earth and Planetary Science Letters 393 (2014) 83–93

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

www.elsevier.com/locate/epsl

Early Carboniferous (~357 Ma) crust beneath northern Arabia: Tales from Tell Thannoun (southern Syria)

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ARTICLE INFO

Article history:
Received 5 August 2013
Received in revised form 12 January 2014
Accepted 18 February 2014
Available online 12 March 2014
Editor: T.M. Harrison

Keywords:
Hercynian
U–Pb zircon
xenolith
geochemistry
Sr–Nd–Pb isotopes
Syria

ABSTRACT

Continental crust beneath northern Arabia is deeply buried and poorly known. To advance our knowledge of this crust, we studied 8 xenoliths brought to the surface by Neogene eruptions of Tell Thannoun, S. Syria. The xenolith suite consists of two peridotites, one pyroxenite, four mafic granulites, and one charnockite. The four mafic granulites and charnockite are probably samples of the lower crust, and two mafic granulites gave 2-pyroxene equilibration temperatures of 780–800 °C, which we take to reflect temperatures at the time of formation. Peridotite and pyroxenite gave significantly higher temperatures of ~900 °C, consistent with derivation from the underlying lithospheric mantle. Fe-rich peridotite yielded $T \sim 800$ °C, perhaps representing a cumulate layer in the crust. Three samples spanning the lithologic range of the suite (pyroxenite, mafic granulite, and charnockite) yielded indistinguishable concordant U–Pb zircon ages of ~357 Ma, interpreted to approximate when these magmas crystallized. These igneous rocks are mostly juvenile additions from the mantle, as indicated by low initial $^{87}Sr/^{86}Sr$ (0.70312 to 0.70510) and strongly positive initial εNd(357 Ma) (+4 to +9.5). Nd model ages range from 0.55 to 0.71 Ga. We were unable to unequivocally infer a tectonic setting where these melts formed: convergent margin, rift, or hotspot. These xenoliths differ from those of Jordan and Saudi Arabia to the south in four principal ways: 1) age, being least 200 Ma younger than the presumed Neoproterozoic (533–1000 Ma) crust beneath Jordan and Saudi Arabia; 2) the presence of charnockite; 3) abundance of Fe-rich mafic and ultramafic lithologies; and 4) the presence of sapphirine. Our studies indicate that northern Arabian plate lithosphere contains a significant proportion of juvenile Late Paleozoic crust, the extent of which remains to be elucidated. This discovery helps explain fission track resetting documented for rocks from Israel and provides insights into the nature of Late Paleozoic (Hercynian) deformation that affected Arabia near the Persian Gulf.

1. Introduction

We are interested to better understand the origin and evolution of the continental crust of the Arabian Plate as exemplary of how continental crust forms and evolves. Basement exposures in the Arabian Shield in the southern part of the Plate indicate that this crust mostly formed in Neoproterozoic time, 900–540 Ma (Fig. 1A) (Brew et al., 2001; Stern and Johnson, 2010). It is often assumed that all Arabian continental crust is of similar Neoproterozoic age but this assumption is untested because northern Arabia is deeply buried beneath Phanerozoic sediments. Recent results suggest that the buried crust of N. Arabia has a more complicated history than heretofore imagined.

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http://dx.doi.org/10.1016/j.epsl.2014.02.043
0012-821X/

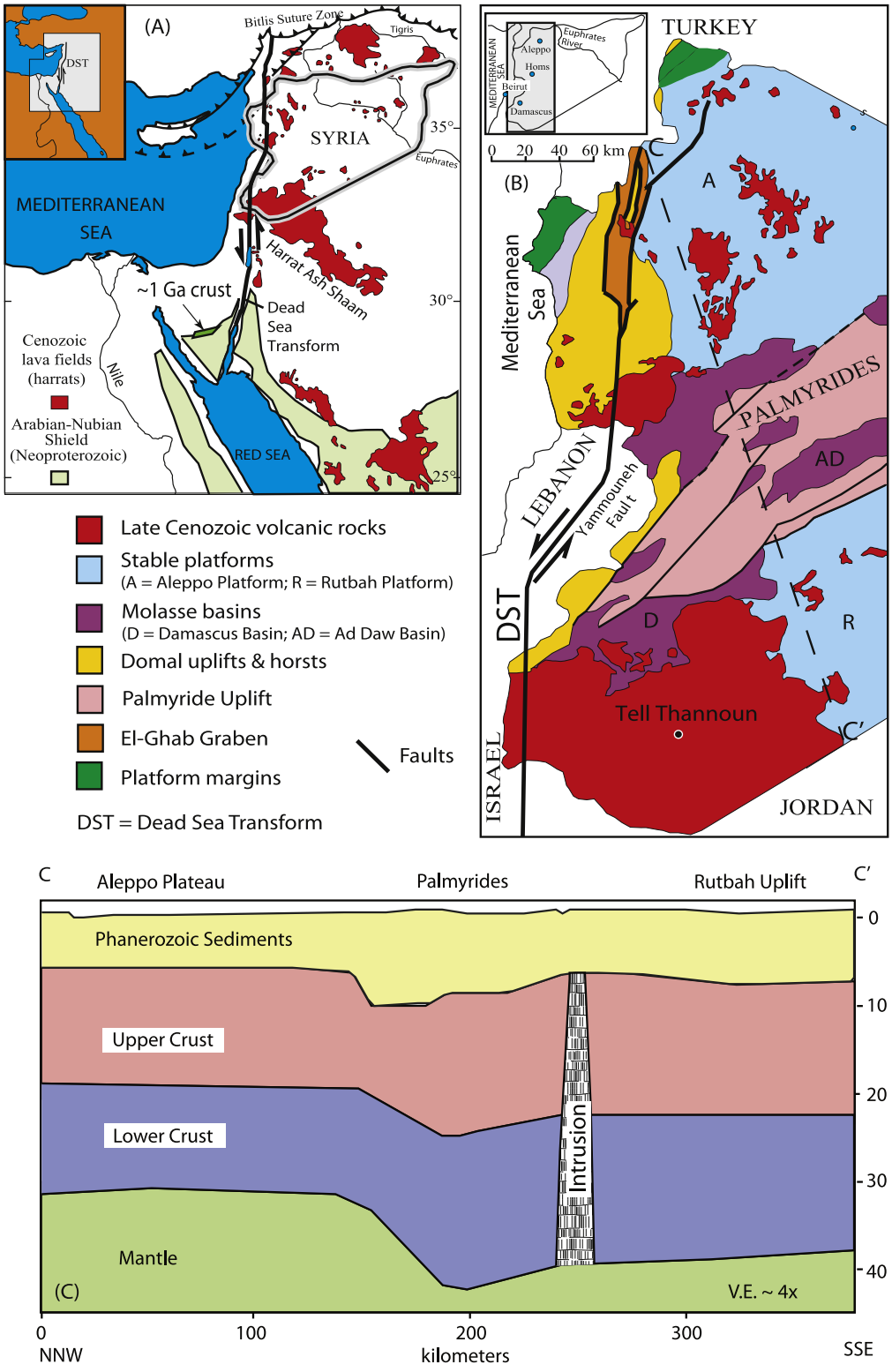

Fig. 1. (A) Main outcrops of Cenozoic volcanic rocks in the northwestern part of the Arabian Plate (modified after Lustrino and Sharkov, 2006). Note the northern limits of exposed basement of the Arabian Shield (light green). (B) Simplified geological sketch map of western Syria (Lustrino and Sharkov, 2006), showing location of crustal profile C–C′. DST = Dead Sea Transform. (C) Crustal profile, modified after gravity model of Brew et al. (2001), further constrained by receiver functions and independent determinations of depth-to-basement.

For example, ~1.0 Ga crust has been documented at the northern limit of the Shield in Sinai (Fig. 1A) (Be'eri-Shlevin et al., 2012) and detrital zircons of this age are abundant in Cambro–Ordovician sandstones from the region (Meinhold et al., 2013), suggesting that Mesoproterozoic crust may be buried beneath thick sediments of northern Arabia (Fig. 1). On the other hand, buried crust may include Phanerozoic material, consistent with the observation that northern Arabia was affected by the Hercynian orogeny in Carboniferous time, possibly reflecting subduction of the Paleotethys and terrane accretion along the northern margin