Lithos 112 (2009) 203–216

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Nature and evolution of the lithospheric mantle beneath the passive margin of East Oman: Evidence from mantle xenoliths sampled by Cenozoic alkaline lavas

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ARTICLE INFO

Article history:
Received 19 September 2008
Accepted 16 February 2009
Available online 5 Marh 2009

Keywords:
Oman
Upper mantle
Xenoliths
Harzburgites
Lherzolites
Trace elements

ABSTRACT

Cenozoic alkaline lavas from the Al Ashkharah area, facing the Indian ocean along the North-East Oman coastline, contain numerous small (<2 cm) mantle xenoliths. They provide a unique opportunity to investigate the nature and evolution of the upper mantle beneath the Oman passive margin, bordering the Owen Basin. All studied xenoliths are porphyroclastic to equigranular spinel lherzolites and harzburgites. They are all devoid of amphibole and phlogopite. The composition of their clinopyroxenes, orthopyroxenes, olivines and spinels indicate that these samples are derived from a typical sub continental lithospheric upper mantle and are quite distinct from the peridotites cropping out in the nearby Oman ophiolite.

The clinopyroxene major element composition record an evolution from fertile lherzolites (Mg#: 89 and Al_2O_3: 7.5 wt.%) to refractory harzburgites (Mg#: 93.5 and Al_2O_3: 2.5 wt.%). The clinopyroxene of most samples are characterised by REE patterns evolving continuously from spoon-shaped to LREE-enriched with almost flat HREE spectra (La_N/Yb_N: 2.5–30; La_N/Sm_N: 3.2–24; Sm_N/Yb_N: 0.25–4.6; Ho_N/Lu_N: 0.88–1.15) and strong negative Ba, Nb, Zr, Hf and Ti anomalies. We propose that these geochemical fingerprints can be accounted for by two processes; (1) a — relatively old (pre-Cenozoic rifting) — decompression melting event characterised by ~1 to a maximum of 13% partial melting and unrelated to the recent (Eocene) tectonic evolution of the Oman margin, followed by (2) metasomatic transformation possibly related to the circulation of alkaline mafic silicate melt displaying geochemical similarities with the host basanites during the Cenozoic rifting event that led to the opening of the Owen basin.

1. Introduction

Mantle xenoliths brought to the surface by alkaline magmas provide a direct access to the petrologic processes conditioning the nature and evolution of the upper mantle (e.g. Gregoire et al., 1997; Coltorti et al., 1999; Gregoire et al., 2000; Delpech et al., 2004). Mantle xenoliths from continental rift systems have been widely studied in the past several decades (e.g. Lenoir et al., 2000; Ionov et al., 2002a,b; Witt-Eickschen et al., 2003). Small (<a few cm), mostly lherzolitic, xenoliths have been recently discovered in alkaline dykes and flows emplaced during Cenozoic times along the Oman passive margin facing the Owen basin (see Gnos and Peters, 2003) but they have not been extensively studied for their trace element geochemistry. Nasir et al. (2006) report bulk rock trace element analyses but, given the small size of the xenoliths, contamination with the host lava cannot be excluded. for example, the marked enrichment in incompatible elements they observed might not be related to mantle processes. The present paper is a complementary study to the one of these authors in terms of analytical procedure: we performed *in situ* (LA-ICP-MS) determinations of the trace element content of clinopyroxene to minimize the risk of contamination by the host alkaline lavas. Moreover, we sampled some localities not studied by Nasir et al. (2006) and the lithological diversity of our collection appears to be more pronounced. The question addressed in the present paper is the nature and composition of the upper mantle beneath the eastern Oman Mountains and how does this mantle compares to sub-oceanic mantle (as represented by peridotites cropping out in the Oman ophiolite) from a nearby area. Our main aim is to decipher if the upper mantle beneath the Oman margin was affected by the melting and/or melt migration processes related to the Cenozoic rifting of the Owen basin. We compare our results to those from the studies of the mantle peridotite xenoliths from Spitsbergen (Ionov et al., 2002a; Gregoire et al., in press) which occur in the same kind of setting (rift-zone) and display close similarities with the xenoliths studied here.

2. Geological setting and sampling

The building and present structure of the Northern Oman mountains result essentially from the obduction of the Oman ophiolite during Maestrichtian times (70–65 Ma) and from a regional uplift that started during the Miocene (Glennie et al., 1974; Coleman, 1981). Our

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0024-4937/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.lithos.2009.02.002

study area is located at the eastern termination of this domain, along a major structural lineament referred to as the Masirah line, a NE–SW trending fault that coincides roughly with the present-day shore line (Moseley, 1969; Smewing et al., 1991). The Masirah line acted as a major transform plate boundary that accommodated the northward drift of the Indian continental block during Cretaceous and Paleocene times (e.g. Royer et al., 2002; Fournier et al., 2008). As a result of the kinematic reorganization that followed the India–Eurasia collision

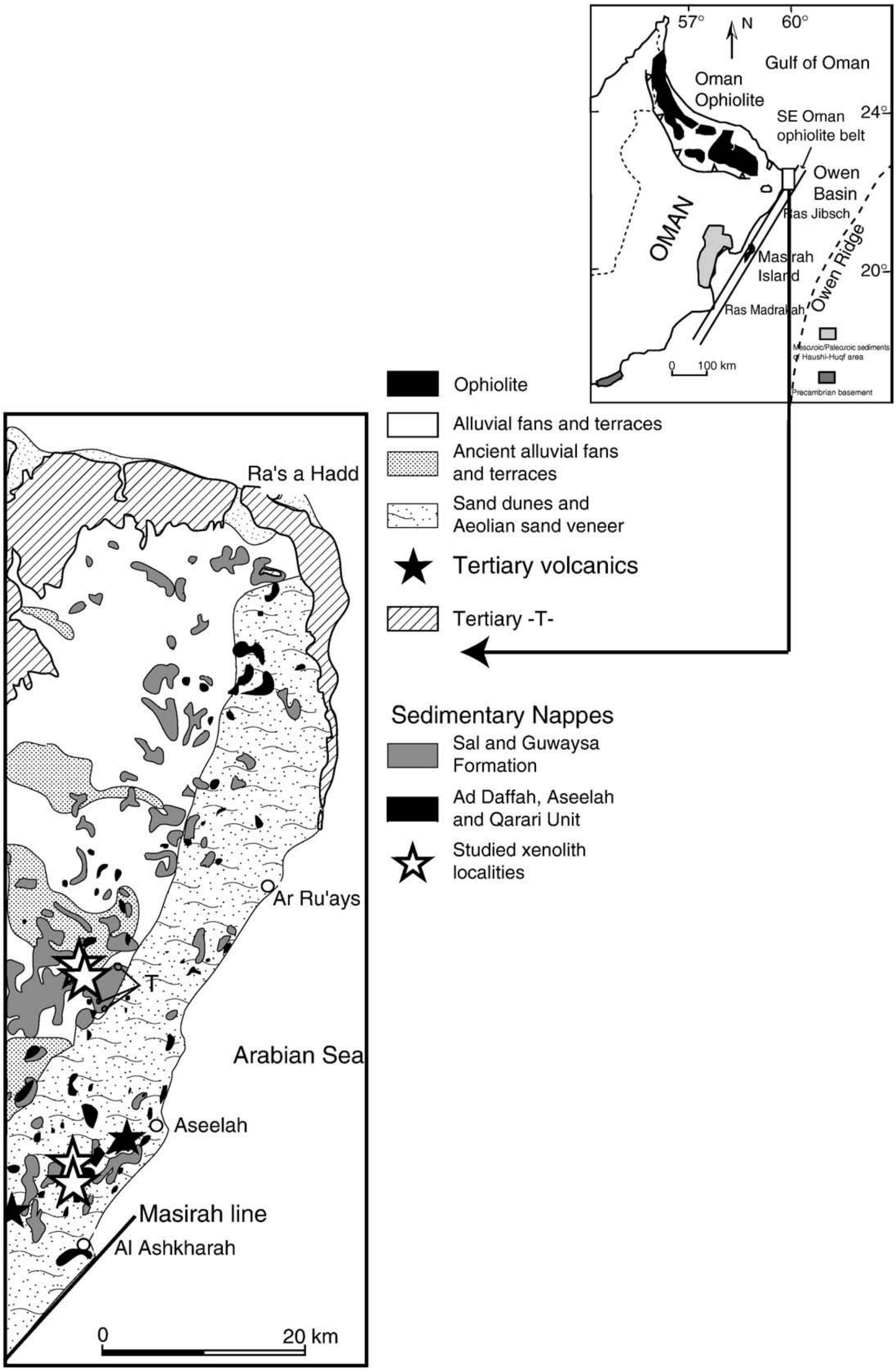

Fig. 1. Location map of the studied area (modified after Smewing et al., 1991 and Gnos and Peters, 2003).