Lithos 122 (2011) 122–136

Contents lists available at ScienceDirect

Lithos

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

Triassic alkaline magmatism of the Hawasina Nappes: Post-breakup melting of the Oman lithospheric mantle modified by the Permian Neotethyan Plume

François Chauvet [a,b,*], Henriette Lapierre [b], René C. Maury [c], Delphine Bosch [d], Christophe Basile [b], Joseph Cotten [c], Pierre Brunet [e], Sylvain Campillo [b]

[a] Université des Sciences de Nantes; CNRS-UMR 6112; Laboratoire de Planétologie et Géodynamique de Nantes, 2 rue de la Houssinière, BP 92208, 44322 Nantes Cedex 3, France
[b] Université Joseph Fourier; CNRS-UMR 5025; Laboratoire de Géodynamique des Chaînes Alpines; Observatoire des Sciences de l'Univers de Grenoble, Maison des Géosciences 1381 rue de la Piscine, 38400 Saint Martin d'Hères, France
[c] Université Européenne de Bretagne, Université de Brest; CNRS; UMR 6538 Domaines Océaniques; Institut Universitaire Européen de la Mer, Place N. Copernic, 29280 Plouzané, France
[d] Université de Montpellier II; CNRS; UMR 5243 Géosciences Montpellier, Equipe Manteau-Noyau; Place E. Bataillon, 34095 Montpellier Cedex 05, France
[e] Université Paul Sabatier; CNRS; UMR 5563 Laboratoire Mécanismes de Transfert en Géologie; Observatoire Midi-Pyrénées, 14 avenue E. Belin, 31400 Toulouse, France

ARTICLE INFO

Article history:
Received 24 June 2010
Accepted 13 December 2010
Available online 21 December 2010

Keywords:
Neotethys
Passive margin
Post-breakup magmatism
Triassic
Hawasina
Oman Mountains

ABSTRACT

Middle to Late Triassic lavas were sampled within three tectonostratigraphic groups of the Hawasina Nappes in the Oman Mountains. They are predominantly alkali basalts and trachybasalts, associated with minor sub-alkaline basalts, trachyandesites, trachytes and rhyolites. Their major, trace elements and Nd–Pb isotopic compositions are very similar to those of the Permian plume-related high-Ti basalts which also occur in the Hawasina Nappes. The Triassic lavas derive from low-degree melting of an enriched OIB-type mantle source, characterized by $\varepsilon Nd_i = 0.3–5.3$ and $(^{206}Pb/^{204}Pb)_i = 16.96–19.31$ (for $t = 230$ My). With time, melting depths decreased from the garnet + spinel to the spinel lherzolite facies and the degree of melting increased. The oldest are distinguished from the others by unradiogenic Nd and Pb signatures, with $\varepsilon Nd_i = -4.5$ to -1.2 and $(^{206}Pb/^{204}Pb)_i = 16.35–17.08$, which we attribute to their contamination by Arabo-Nubian lower crust. The lavas likely derived from the Oman lithospheric mantle, the original DMM-HIMU signature of which was overprinted during its pervasive metasomatism by the Permian plume-related melts. We suggest that these lavas were emplaced during post-breakup decompression-triggered melting in the Middle Triassic during global kinematic reorganization of the Tethyan realm.

1. Introduction

Petrologic and geochemical studies of ancient oceanic crust and continental margins can be used to reconstruct the dynamics of past rifting and oceanization processes. The Middle Permian opening of the Neotethyan Ocean (Besse et al., 1998) separated Gondwana from Cimmerian continental blocks (Ricou, 1994; Stampfli and Borel, 2002). It led to the formation of passive continental margins south of the Neotethys Ocean, i.e. on the northern edges of the Australian, Indian, Arabian and African shields. Cretaceous to Neogene convergence between Laurasia and Gondwana (Stampfli and Borel, 2002) then led to the disappearance of Neotethyan oceanic crust. Fragments of its southern margins were incorporated into Alpine collisional belts in the Himalayas, Oman, Zagros, Syria, Cyprus, Turkey and Greece (Coleman, 1981, Fig. 1a).

These inverted margin fragments carry remnants of successive magmatic episodes, which can be used to constrain the formation and development stages of the southern Neotethyan margin. For instance, Middle Permian flood basalts are widespread in NW Indian (Panjal Traps) and Oman (Saih Hatat and Hawasina nappes Fig. 1a). Their plume-related geochemical features suggest that the breakup of Gondwana was associated with the emplacement of an intraplate volcanic province and associated volcanic-type margins (Garzanti et al., 1999; Maury et al., 2003; Lapierre et al., 2004; Chauvet et al., 2008). Younger (post-breakup) volcanic sequences are generally tectonically associated with Tethyan ophiolitic nappes, from the Himalayas to the eastern Mediterranean (Fig. 1a). Within these nappes, volcanic rocks are stratigraphically associated with late Middle to Late Triassic pelagic sediments and/or reef limestones. In the Oman Mountains, these Triassic post-breakup volcanic series have been considered as tectonically inverted intra-oceanic plateaus or seamounts (Glennie et al., 1974; Searle et al., 1980; Searle and Graham, 1982; Robertson and Searle, 1990; Stampfli et al., 1991; Pillevuit, 1993; Pillevuit et al., 1997), as well as their equivalents in the Himalayas (Ahmad et al., 1996; Robertson, 1998; Corfield et al., 1999) and Mediterranean sequences (Syria: Al Riyami and Robertson, 2002;

* Corresponding author. Université des Sciences de Nantes; CNRS-UMR 6112; Laboratoire de Planétologie et Géodynamique de Nantes, 2 rue de la Houssinière, BP 92208, 44322 Nantes Cedex 3, France. Tel.: +33 251125474; fax: +33 251125268.
E-mail address: francois.chauvet@univ-nantes.fr (F. Chauvet).

0024-4937/$ – see front matter
doi:10.1016/j.lithos.2010.12.006

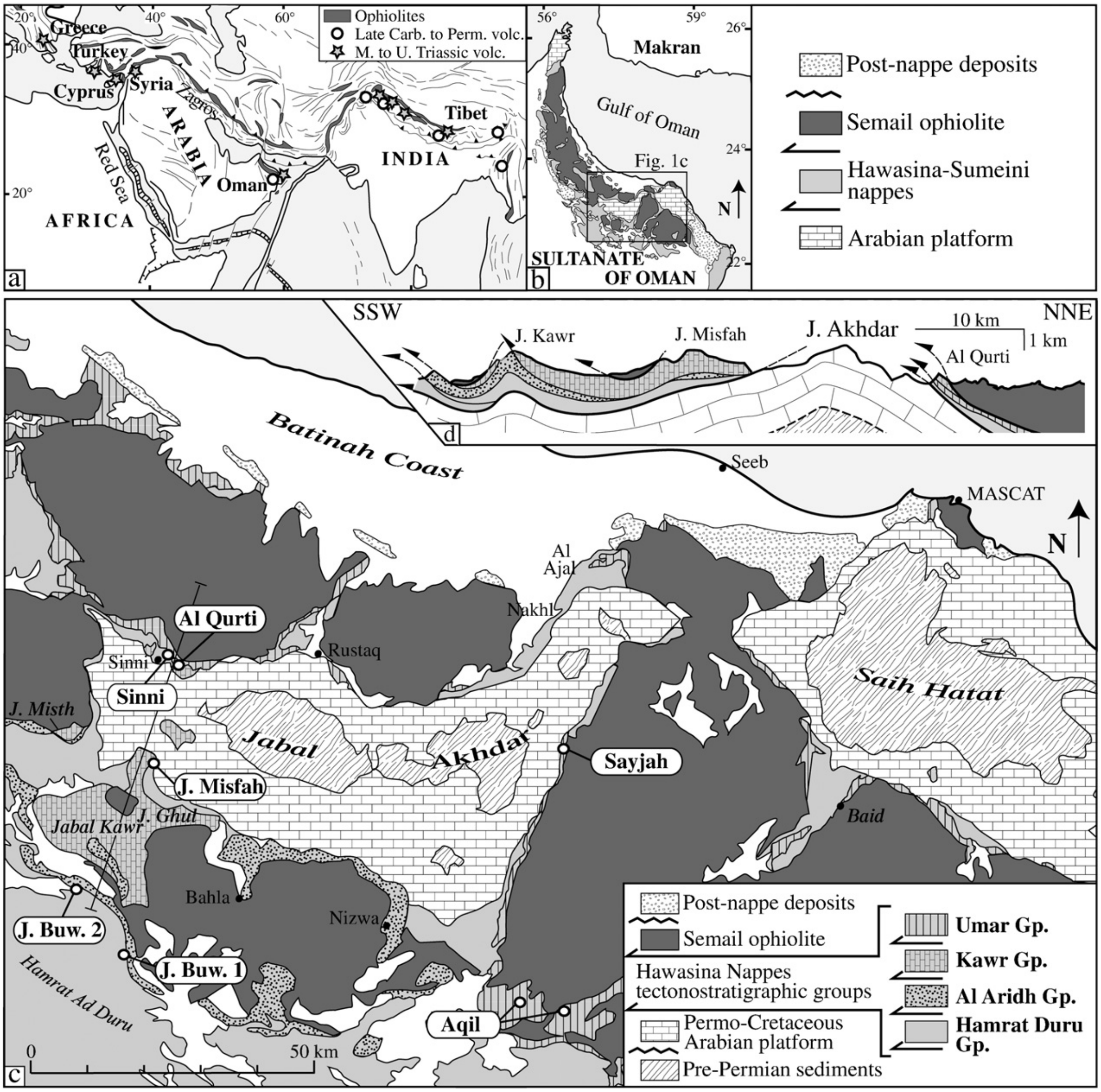

Fig. 1. Geological setting. a) The Tethyan Suture (ophiolites and associated mélanges) after Coleman (1981), with locations of the main late Carboniferous, Permian and Triassic volcanic sequences associated to the Neotethyan margins inverted segments (mainly from Garzanti et al., 1999). b) Simplified geological map of the Oman Mountains and associated main structural units (after Glennie et al., 1974). c) Sampling locations on the geological map of the Hawasina nappes (after Béchennec, 1987 modified by de Wever et al., 1990). Sampling sites coordinates of Sinni: 23°25′4″N–57°09′2″E; Sayjah: 23°11′23″N–57°51′58″E; Aqil: 22°47′8″N–57°48′4″E (Om-45); 22°47′2″N–57°51′3″E (Om-52); 22°47′5″N–57°48′2″E (Om-42); 22°47′9″N–57°48′4″E (Om-48 and -49); Jabal Buwaydah 1: 22°53′6″N–57°05′7″E; Jabal Buwaydah 2: 23°00′8N–57°00′E. d) Regional cross section according to Béchennec (1987).

Cyprus: Lapierre et al., 2007; Chan et al., 2008; Turkey: Maury et al., 2008; and Greece: Monjoie et al., 2008),. Alternatively, the Oman Triassic lavas have been interpreted as remnants of a second rifting episode of the Arabian continental margin (Lippard et al., 1986; Béchennec et al., 1988, 1990, 1991).

A new petrologic and geochemical investigation (major and trace elements and Nd, and Pb isotopes) of Middle to Late Triassic lavas from the allochthonous units of the Oman Mountains allows us to address these two hypotheses.

2. Geological setting

The Arabian continental margin of the Neotethys ocean formed during Permo-Triassic times (Béchennec et al., 1988; Robertson and Searle, 1990). Reconstructions of this margin (Glennie et al., 1974; Béchennec, 1987) suggest the occurrence of a continental platform (Saiq Fm.), a continental slope (Sumeini Group), and basinal environments (Hawasina units). In the Oman Mountains, remnants of several basins are exposed in the Hawasina Nappes, which are sandwiched between the autochthonous Arabian platform and the Semail ophiolitic nappe (Fig. 1b; Bernouilli and Weissert, 1987; Béchennec et al., 1988). They include the Middle Permian (Murghabian) to Late Cretaceous sedimentary and volcanic units.

Béchennec (1987) and Béchennec et al. (1988, 1990, 1993) distinguished four tectonostratigraphic groups within the Hawasina Nappes tectonic pile (Fig. 1c,d). From the base to the top, they are the Hamrat Duru, Al Aridh, Kawr and Umar Groups (Fig. 1d). These groups were emplaced either in proximal (Hamrat Duru) or distal (Umar) pelagic basins, in a trench or slope (Al Aridh) or as an isolated carbonate platform (Kawr). While the Hamrat Duru basin appeared during the Middle Permian major rifting event, the three others (Al Aridh, Kawr and Umar Groups) formed during Middle to Late