New trace elements and isotopic data on Oman volcanics

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Trace elements and isotopic compositions of Oman volcanics were and still are a clue to understand the context of genesis of this ophiolite. Several teams have worked on these lavas (Pallister *et al.*, Alabaster *et al.*, Ernewein *et al.*, Beurrier *et al.*) in the beginning of the 80s. They did not reach the same conclusions, and their classifications were also conflictual to some degree: if the definition of a lowermost unit of spectacular tholeiitic pillows and flows ('Geotimes' = V1 *pro parte*) and of an uppermost late andesitic flow ('Salahi' = V3), is unambiguous, the identification and interpretation in terms of timing and geodynamic setting of lava units with transitional field and petrographic characters ('Alley, Lasai, Cpx-phyric' = V2 *pro parte*) is more problematic. Previous authors disagree also on the interpretation of subtle trace element characters in terms of back arc versus ocean ridge setting.

In this study we have performed new trace element measurements (ICP-MS, UMR 5563, Toulouse) and some preliminary Nd isotopic compositions (TIMS, XRF, MPI für Chemie, Mainz) on the different Oman volcanics and we have tried to define some critical geochemical parameters that allow us to classify the different lavas in terms of sources and processes. In order to compare with previous work, we have used Albaster *et al.* (1982) classification scheme that is based on objective lithological characters with no *a priori* on the lava stratigraphy (like in the case of V1,2,3 of Ernewein *et al.*, 1988).

Many trace element diagrams can be used to characterize the different types of lavas. We have plotted on Fig. 1 Nd = f(Y) and La/Yb N = f(La N) (Fig. 2) to test the combined effects of sources, melting and crystallization. It appears clearly that three different types of lavas can be isolated in terms of trace element signatures: one with normal MORB characteristics, one which is showing a strong depletion in trace element concentrations associated with a slight decrease in the La/Yb N ratio and one which is out the global trend defined by the previous ones, i.e. enriched in *LREE*.

Concerning the relationships with the field defined units, we observe the following systematics: the enriched lavas all belong to Salahi unit confirming the conclusions of field studies. Continental contamination is suggested by trace element data and confirmed by preliminary Nd data. Most Geotimes lavas present normal compositions, apart from two samples that plot in the depleted field, although in the less depleted part of this field. The Alley lavas present the most extreme depletion, plotting in the depleted part of the depleted field. Part of Lasai plot with Geotimes in normal MORB field, but two samples show rather depleted characters, intermediate between the depleted Geotimes and the Alley.

It is worth to mention that the range of composition within each group (depleted and normal) can be explained by combined effects of melting versus crystallization. However, concerning the relationships between the two groups, it is unlikely, that a same explanation is valid: first because extreme degrees of fractionation should be invoked (90%), inconsistent with major element data, secondly because it would not account for the gap between the two groups. Considering the range of trace element concentrations, all these lavas cannot derive from a unique source and it cannot be possible

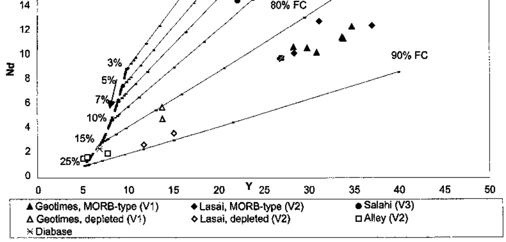

FIG. 1. Nd = f(Y) for the different types of lavas. A simple model of fractional melting versus fractional crystallization is superimposed on the data.

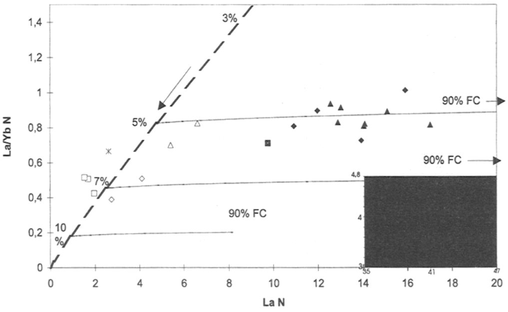

FIG. 2. La/Yb = f(La) chondrite normalysed. Symbols as in Fig. 1. The composition of the liquids in the same melting/crystallization model are superimposed on the figure.

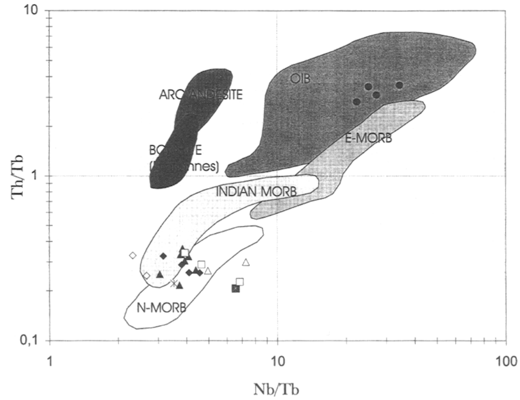

FIG. 3. Th/Tb = f(Nb/Tb). Symbols as in Fig. 1. The Oman lava compositions are compared to basalt signatures in different geodynamic settings.

to explain the depleted or normal characteristics of all these lavas by a simple model of partial melting versus fractional crystallization.

A fundamental observation is that the stratigraphic relationships between the normal and depleted volcanics are not simple (with the depleted overlying the normal lavas), as concluded by previous workers: in two locations we have found pillow lavas with depleted trace element signatures overlain by lavas flows with normal trace element signatures. This simple observation means that these two different types of volcanism are intimately associated.

The major argument which was used by previous authors to associate Geotimes (V1) to the normal ridge event and Alley-Lasai (V2) to some later process related to subduction or emplacement cannot be used anymore. None of these lavas present any evidence of a subduction component participating to their genesis. In Fig. 3, both depleted and enriched lavas fall within the MORB field, with a slightly increase in Th/Tb, leading the compositions into the Indian MORB field. It is worth to mention that the less depleted lavas (Alley) present the higher Nb/Tb ratios, which is the opposite effect that what can be expected for an intra-oceanic subduction volcanism.

These geochemical characteristics coupled with field evidence lead us to propose a new model for the genesis of the depleted and normal lavas series. In a previous study we have shown that depleted lavas in equilibrium with some opx-rich gabbronorite cumulates in the Maqsad area can result from hydrated melting of a depleted lithosphere induced by a new diapiric pulse below an oceanic spreading center (Benoit *et al.*, 1998). In such a model depleted and normal melts can be produced simultaneously. This scenario accounts for the interlayering of depleted and normal lavas reported in the present study and implies that the depleted lavas can be the extrusive equivalent of the opx-rich gabbronorites found in the mantle section of Maqsad. This hypothesis is supported by the *REE* compositions of calculated equilibrium liquids with these gabbronorites, which are similar to the depleted lavas compositions. Preliminary Nd isotopic data measured on the lavas series also confirm that both normal and depleted lavas derived from a pure mantle source.

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