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GR focus review

The geochemistry and oxidation state of podiform chromitites from the mantle section of the Oman ophiolite: A review

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ABSTRACT

Data are presented for mantle podiform chromitites from eight localities over 350 km strike length of the Oman ophiolite. Chromitite compositions form a continuum from cr# = 0.501 to 0.769, although this conflates a number of different magmatic 'events'. The Oman mantle chromitites record a wide range of $Fe^{3+}/\Sigma Fe$ ratios (as determined by Mössbauer spectroscopy) extending from low values (close to those of MORB) to values higher than currently found in arc magmas and calculated oxygen fugacities for the chromites are about 1.8 log units above the QFM buffer, higher than found in the MORB source. Calculated TiO_2 and Al_2O_3 contents for the parental melts to the Oman chromitites show that they had low TiO_2 contents (0.23–0.96 wt.%) but a range of Al_2O_3 contents (11.8–15.8 wt.%). The variable Al_2O_3 content implies a range of parental magma compositions, probably formed at different temperatures, and the range of TiO_2 compositions indicates that some melts were modified by reaction during their transit through the mantle. The range of compositions observed is not consistent with either a MORB or Arc source but is thought to reflect a range of melts derived from a compositionally evolving source during subduction initiation in a forearc environment.

Contents

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1. Introduction

Chromite forms a large number of small podiform deposits in the mantle section of the Oman ophiolite. Previous studies have attempted to describe in some detail the chemistry of individual occurrences (see for example Ahmed and Arai, 2002; Borisova et al., 2012; Ceuleneer and Nicolas, 1985; Leblanc and Ceuleneer, 1992; Rollinson, 2008; Rollinson and Adetunji, 2013; Schiano et al., 1997). In this study we provide an overview of chromite compositions over the full length of the ophiolite (350 km) based upon a synthesis of new and previously published geochemical data. In addition we report the results of a systematic study of $Fe^{3+}/\Sigma Fe$ in chromites from the Oman ophiolite using Mössbauer spectroscopy. We have recently described in detail chromitites from Wadi Rajmi in the north of Oman and from the Maqsad region in the southern part of the ophiolite (Rollinson, 2008; Rollinson et al., 2012; Rollinson and Adetunji, 2013). Here we present new data for six other podiform chromitite localities from the Oman ophiolite and additional data for Wadi Rajmi. We combine our previously published data and our new data (53 samples) to present a new analysis of the compositional variations and variable oxidation state of the Oman mantle chromitites. We use these data to

- explore the relationships between structural setting and chromite composition
- draw conclusions about the likely mechanisms whereby the chromitites have formed and to
- provide a fuller understanding of the process of oxidation in mantle chromitites.

This review extends the work of Rollinson (2005) inasmuch as that study was based upon the published work of a variety of authors. Here we use a new and self consistent data set obtained by the authors. Our work also complements a recent study by Boudier and Al-Rajhi (in press) who discuss the structural setting of chromitites in the mantle section of the Oman ophiolite.

2. Geological setting

Chromitites have been sampled at eight localities from within the mantle section throughout the ophiolite (Fig. 1) and the details of their occurrence are given in the following paragraphs and summarised in Table 1. The localities are ordered from north to south along the strike of the ophiolite. Distances are quoted as horizontal distance from the Moho perpendicular to the strike but because of the variable dip of the Moho can only loosely be interpreted as 'depths'.

2.1. Wadi Rajmi

Chromitites from Wadi Rajmi can be divided into two groups on the basis of their mineral chemistry and their location with respect to the Moho (Augé, 1987; Rollinson, 2008). Chromitites located within 500 m of the Moho are tabular in form, have cr# in the range of 0.516–0.601. These are similar to chromitites located about 3 km from the Moho which have slightly higher cr# between 0.585 and 0.639. Chromitites from deeper within the mantle section between 5 and 6.5 km are more irregular in form and discordant to the mantle fabric and have cr# between 0.713 and 0.773. The shallow chromitites are associated with gabbroic silicate phases and amphibole may be present. These chromitites are thought to have formed from a parental melt with a MORB-like composition. The deeper chromitites have olivine as the principal interstitial phase and on the basis of their compositions are thought to have formed from a boninitic parental melt. The deep mantle mineral Moissanite was described from the Shamis 2 locality (Fig. 4) by Trumbull et al. (2009). In this study we utilise the data from previous studies (Rollinson, 2008; Rollinson et al., 2012) and include mineral chemical data for four new samples, one from the newly exposed Jabri pit ca 4.4 km from the Moho and three from the previously studied mining camp locality; we also include thirteen new Mössbauer measurements.

2.2. Wadi Fizh

Samples were collected from Wadi Fizh at two localities. The main chromite pit is currently worked and is located about 3 km from the Moho. There the main chromitite body is tabular, about 5 m thick and with a gentle dip north. The host rocks are harzburgite and dunite which are cut through with metre-wide granitic veins. The main chromitite body has no clear dunitic sheath. Sample 05-16 is from the tabular ore and 05-21 from the surrounding scree. A smaller chromitite body was sampled from a disused pit about 4.5 km SE of the main chromitite pit, close to the village of Zaymi. This occurrence is located about 500 m from the Moho. Here the chromitite bodies form narrow dyke-like bodies in dunite, about 20 cm wide, oriented vertically with a NW strike. Sample 05-23 is from a sheared chromitite dyke, whereas 05-24 is unsheared. Akizawa et al. (2012) have described the mantle section from this region and show that the Moho transition zone, the dunitic zone at the crust mantle boundary, is exceptionally thin in this area and is only about 10 m thick.

The samples from the main pit have average cr# = 0.68 and the scree sample 0.501. This difference, whilst unexplained, was also noted by Ahmed and Arai (2002) who recorded a massive ore with cr# = 0.495 and a nodular ore with cr# = 0.647. Chromitites from

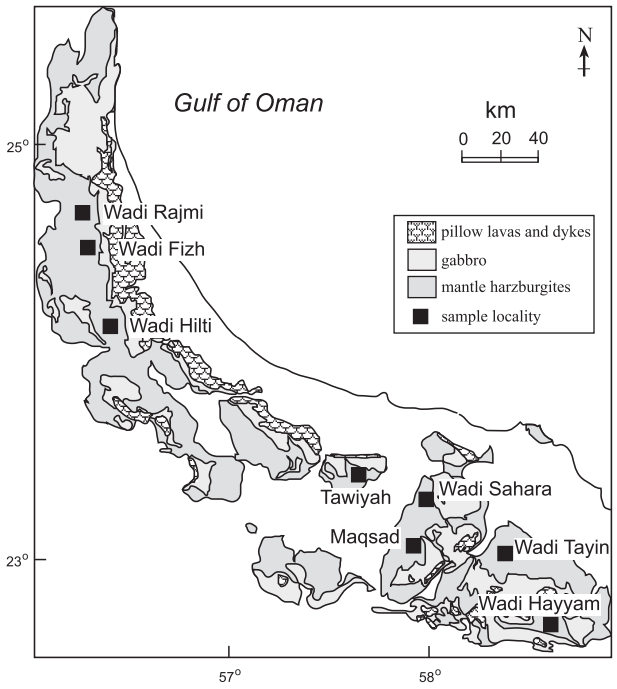

Fig. 1. Geological map of the Oman ophiolite showing the localities studied.