PGE Abundance in Chromitites of the Northern Samail Ophiolite, Oman

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Introduction

The Samail ophiolite, Oman, is one of the best exposed fragments of oceanic lithosphere in the world, and contains a large number of podiform-type chromitite bodies. The Oman ophiolite is considered as the PGE-poor ophiolite by Prichard et al. (1996). However, Ahmed and Arai (2001) found a high PGE chromitite body which contains about 2 ppm total PGE, and suggested the PGE mineralization in the chromitite body. Although the chromitite has an enrichment of IPGE, their interpretation as the PGE mineralization in the Samail ophiolite has invited general interests. We have examined PGE concentrations of several major chromite deposits in the Samail ophiolite, especially in the northern part of that, to evaluate the potentiality of the PGE mineralization.

Regional Geology

The Samail ophiolite occurs in northern part of Oman, and is approximately 400 km long by 100 km wide (Fig. 1). It extends further north into the UAE. The mantle part and crust-mantle transition zone contain a large number of chromitite bodies. Major chromitite bodies have been found by the BRGM survey teams for the 1:250,000 scale geological mapping project of the Directorate Generals of Minerals, Oman. 43 chromite deposits in the Samail ophiolite are found to have the tonnage larger than 10,000 tonnes of ore. Among those, ten deposits have resources larger than 25,000 tonnes of Cr metal (Michel, 1993). Chromite deposits are mainly present in two areas, northern area (around Wadi Rajmi) and southeastern area (Samail-Maqsad block). Occurrences of platinum group minerals are described in chromitites from both areas (Auge, 1986; Ogasawara et al., 1999; Ahmed and Arai, 2001). The minerals are typically laurite and other minerals of IPGE (Ir, Os, and Ru) mineral group.

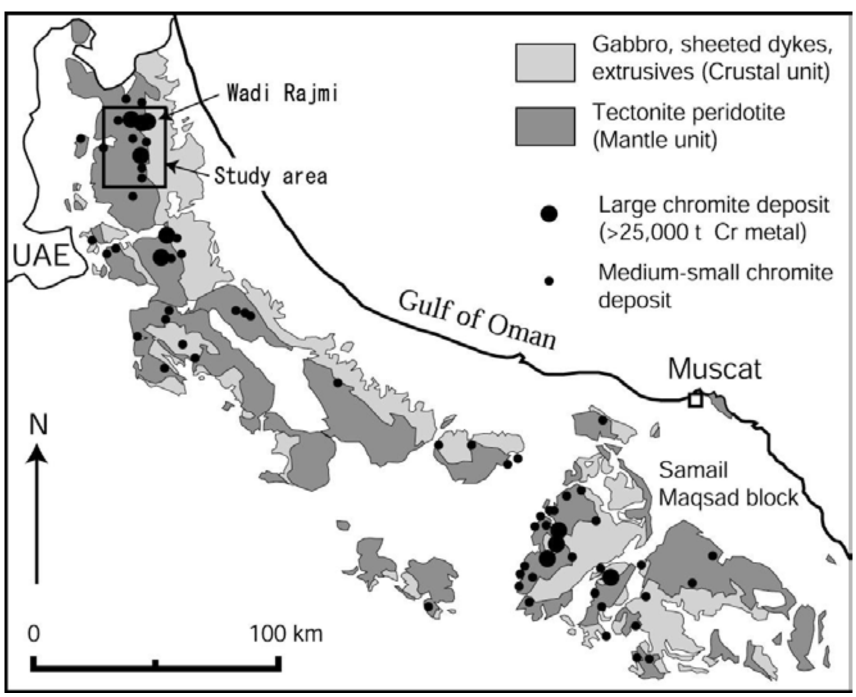

__Figure 1.__ Distribution of chromite deposits in the Samail ophiolite, Oman. Location and size classification of chromite deposits are from Michel (1993).

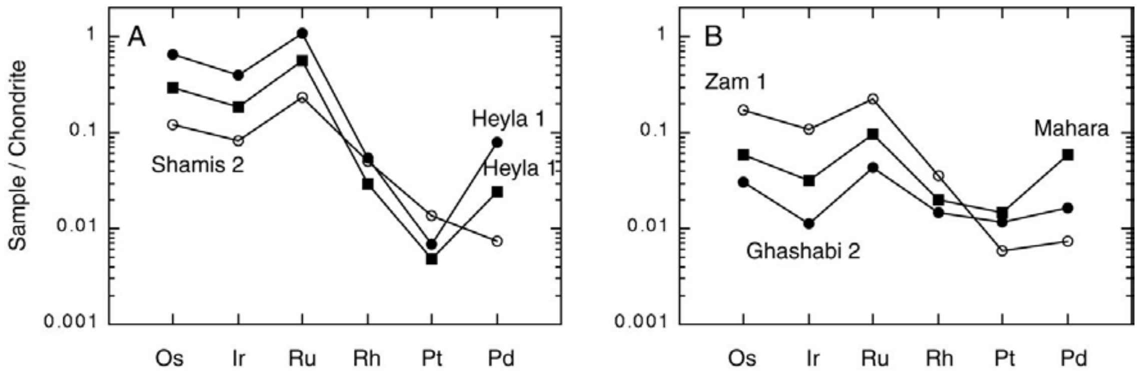

Figure 2. *Chondrite normalized plot of PGE for representative chromitites from the northern Samail ophiolite. Labels are name of chromite deposits.*

Page et al. (1982) analyzed PGE concentrations of 30 chromitites from the Samail ophiolite. The results indicated that chromitites in the northern part has higher PGE than those in the southern part, though analytical results have relatively poor detection limits compared to analytical results of recent studies. Auge (1986) evaluated the PGE data of Page et al. (1982) and unpublished results, and suggested low PGE characteristics of the chromitites from the Samail ophiolite. Leblanc (1991) summarized distribution of PGE in the ophiolites, using data from the Samail ophiolite and others. Accurate PGE abundances have been presented by Prichard et al. (1996) for 13 chromitites from various localities in the Samail ophiolite. The samples are all from northern and central parts of the Samail ophiolite. Ogasawara et al. (1999) presented PGE concentrations of chromitites from southern part of the Samail-Maqsad block.

Samples and Analytical Methods

Eight chromite deposits have been evaluated by present study. Those are Zam 1, Zam 2, Shamis 1, Shamis 2, Heyla 1, Mahara, and Ghashabi 2 from northern part, and a deposit in the central Samail-Maqsad block. 28 chromitite samples and 9 host ultramafic rocks were examined. Samples were analyzed by Ni sulphide fire assay with ICP-MS finish. Precision and accuracy of the analytical results have been monitored with international standards SARM7b (South Africa) and GPt-5 (chromitite, China). Chemical compositions of minerals in chromitites have been examined with electron probe X-ray micro-analyzers.

PGE Abundance of Chromitites

Chromitites from the Oman ophiolite have a typical chondrite normalized PGE pattern of ophiolitic chromitites, enriched in IPGE and depleted in PPGE (Fig. 2). Ru concentrations in the chromitite samples are mostly in the range between 50 to 200 ppb. However, Ru values in the chromitites from the Hayla 1 are 400 and 750ppb and are highest in the samples analyzed. Os and Ir values are also systematically high in the samples with high Ru value. Total PGE values range from 33 to 1380 ppb. Ahmed and Arai (2001) found high PGE abundance in the chromitite up to 2 ppm as total. The total PGE concentrations of chromitites from Hayla 1 (670 and 1380 ppb) are closed to the value of Ahmed and Arai (2001). Though, those samples are enriched in IPGE without enrichment of Pt and Pd.

Table 1. *Avarage PGE concentrations and estimated total metal weights of chromite deposits in the Samail ophiolite.*

	N	Os	Ir	Ru	Rh	Pt	Pd	Total
Northern part	35	46.0	32.9	111.9	6.3	9.4	7.8	214.3
Samail-Maqsad block	18	15.6	16.4	48.8	3.9	5.4	5.8	96.0
Samail ophiolite	54	36.6	28.3	92.9	5.6	8.0	7.0	178.3
Total metal (kg)		94	73	239	14	20	18	458

N: numbers of data to calculate average value. Concentations in ppb. Total metal is calculated with average PGE concentrations of chromitites in the Samail ophiolite and total tonnage of chromite deposits. Total tonnage of chromite ore for the calculation is 2.57 M tonnes (Michel, 1993).

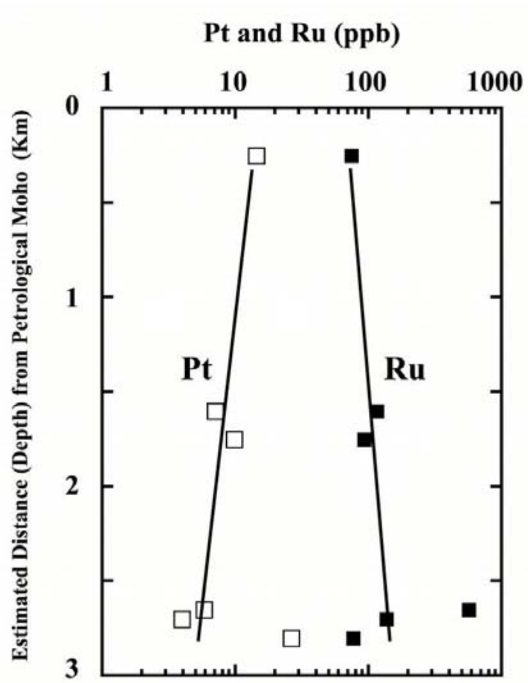

Figure 3*. Variation of average Ru and Pt abundances for chromite deposits in the northern Samail ophiolite with estimated stratigraphic distance (depth) from lithological Moho. Solid lines indicate possible trend of Ru and Pt with depth.*

In the study area, chromite deposits with high total PGE abundances are present in the deeper level of the mantle sequence, i.e., high PGE in high in Hayla 1, Zam 1, and Shamis 2. Average PGE concentrations for each chromite deposit are plotted with estimated depth (stratigraphic distance) from the lithological Moho on Fig. 3. Fig. 3 indicates that Ru concentrations in the chromitites increase with distance from Moho, deep in the mantle. On the other hand, Pt might be decrease with the distance from Moho. Similar diagrams have been constructed by Page et al. (1982). They concluded that Ru in the chromitites increases with depth, till around 4km from the lithological Moho, and then decreases again in the further deeper part. Results of the present study also support this conclusion. This relationship may explain high concentration of IPGE in the chromitites in the deeper section of in the Wadi Hilti by Ahmed and Arai (2001). The difference of PGE concentrations in chromitites could be resulted by the depth of chromitite formation, i.e., high IPGE in chromitites formed at relatively deeper part of the mantle.

An average PGE concentration of chromitites from the Samail ophiolite is calculated with 54 PGE data by Prichard et al. (1996), Ogasawara et al. (1999), and present study, and are presented in Table 1. The average value indicates that Samail ophiolite is characterized as low PGE abundance in the chromitites, as suggested by Prichard et al. (1996). Pt and Pd values are low at about 7ppb. Average concentration of total PGE in the chromitites from the northern Samail ophiolite is 214ppb (Table 1). It is higher than the value of Samail-Maqsad block (96ppb). This result may indicate that chromitites in the Samail-Maqsad block were formed in relatively shallow part of mantle sequence of the ophiolite.

Evaluation of PGE Resources Potentiality of the Chromitites in the Samail Ophiolite

One of the objectives of this study is to evaluate the PGE resources potentiality of the chromitites in the Samail ophiolite, since Ahmed and Arai (2001) emphasized the PGE mineralization in chromitites from deeper part of mantle sequence. Although we found relatively high PGE concentrations in the Hayla 1 chromite deposit, the size of the Hayla 1 deposit is not large. Thus, the economical significance of the deposit for PGE is limited. Furthermore, high IPGE with low PPGE abundance in the chromitites will not encourage to be potential PGE resources.

As we have calculated average concentrations of PGE for chromite deposits of the Samail ophiolite, total PGE contained in the chromitites of the Samail ophiolite can be estimated. The tonnage of chromite deposits has been evaluated by various survey of Directorate General of Minerals, Oman. As the exposure of the Samail ophiolite is extremely well, it is considered that most of major chromitite outcrops have been identified by detail geological survey at the scale of 1:250,000 and 1:100,000 mapping. The total resources of chromitites has been calculated as about 2,500,000 tonnes of ore (Michel, 1993). Assuming all the chromitites has been processed and possible to separate all PGE, the amount of the total PGE can be calculated with the average PGE abundance and chromitite tonnages (Table 1). Although the estimated amounts of total PGE in the chromitites of the Samail ophiolite has only the significance for geochemical modeling, the figure will provide limitation of maximum PGE metals in the chromitites of the Samail ophiolite. Even all the PGE metals have been recovered from the chromitites, only 0.5 tonnes of PGE metals can be obtained. Estimated amounts of Pd and Pt are very small, at about 20kg each. When we assume the total

PGE concentration as 2ppm, which is similar level to the concentration indicated by Ahmed and Arai (2001), total PGE from the chromite deposits in the Samail ophiolite is not exceed 5 tonnes. Thus the level of PGE concentration of chromitites in the Samail ophiolite obtained by present study and previous studies indicate not favor to considered the chromitite deposits as potential PGE resources. Buchanan (1988) suggested that ophiolitic chromitites are generally less attractive targets for PGE compared with other types, as the relatively restricted size of potential ore bodies, together with the depleted levels of Pd, Pt, and Rh. Our evaluation also supports this conclusion.

Summary

New PGE concentration data of chromitites from the Samail ophiolite, mainly from northern part of that, have been obtained to evaluate the PGE potentiality of the chromitites. The results support the conclusion by Prichard et al. (1996), indicating that the Samail ophiolite can be characterized as low-PGE ophiolite. PGE concentrations of the chromitites are related to structural position of the chromite deposit in the mantle. Although, slightly high IPGE concentrations have been found in some of the chromitites in the Samail ophiolite, our evaluation does not support the high potentiality of the PGE mineralization in the chromitite of the Samail ophiolite.

Acknowledgements

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References

Ahmed, A.H., and Arai, S., 2001, Petrology and origin of chromitite deposits in the mantle section of the northern Oman ophiolite: evidence from platinum-group elements mineralization: Abstract of International Conference Geology of Oman, p.6.

Auge, T., 1986, Platinum-group-mineral inclusions in chromitites from the Oman ophiolite: Bull. Mineral., v. 109, p. 301-304.

Buchanan, D.L., 1988, Platinum-group element exploration: Elsevier, Amsterdam, p.p. 185.

Leblanc, M., 1991, Platinum-group elements and gold in ophiolitic complexes: distribution and fractionation from mantle to oceanic floor: in Tj. Peters et al., eds. Ophiolite genesis and evolution of the oceanic lithosphere, Ministry of Petroleum and Minerals, Oman, p.231-260.

Michel, J.C., 1993, Mineral occurrence and metallogenic map of the Sultanate of Oman, at scale 1:1,000,000 with Explanatory Notes, Directorate General of Minerals, Oman, pp.40.

Ogasawara, M., Allawatia, H.N., and Nakagawa, M., 1999, Chromitite in the Samail-Maqsad area in the Oman ophiolite and abundance of Platinum Group Elements. Abstracts of 2001 Scientific Meeting of Japanese Association of Mineralogists, Petrologists, and Economic Geologists, p.177.

Page, N.J., Pallister, J.S., Brown, M.A., Smewing, J.D., and Haffty, J., 1982, Palladium, platinum, rhodium, iridium, and ruthenium in chromite-rich rocks from the Samail ophiolite, Oman: Canadian Mineralogist, v. 20, p. 537-548.

Prichard, H.M., Load, R.A., and Neary, C.R., 1996, A model to explain the occurrence of platinum- and palladium- rich ophiolite complexes: Journal of the Geological Society, London, v. 153, p. 323-328.