COMMENT ON "CRYSTALLIZATION TREND OF CHROMIAN SPINEL IN SOME ALKALI BASALTS AND CALC-ALKALI ANDESITES FROM JAPANESE ISLAND"

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Nagao et al. (1980) concluded that "it is rather inadequate to compare the depth of crystallization of magma in different provinces in terms of the \( \text{Al}_2\text{O}_3 \) content of spinel".

Nevertheless, comparison of their own data with those from different provinces shows that the \( \text{Al}_2\text{O}_3 \) content of spinel is potentially an adequate tool in estimating the depth of crystallization of magma.

Chrome-spinel may be a useful petrogenetic indicator, because it shows a wide compositional range and is therefore particularly sensitive to variables such as the temperature, pressure, bulk composition, and oxygen fugacity of its parental magma.

Nagao et al. (1980) analysed spinels in the Misasa alkali basalts and the Chokai calc-alkali andesites, and found that both spinels are the most aluminous yet reported from the island arc volcanic rocks. Their observations and data are very interesting and important, but they do not say so. They also seem to have overlooked certain aspects that have been fully discussed by our papers (Shiraki et al., 1977; 1979b) and some previous investigators. As a result they have been led to the misleading conclusion that "it is rather inadequate to compare the depth of crystallization of magma at early stage in different provinces to each other merely in terms of the \( \text{Al}_2\text{O}_3 \) content of spinel". We would like to show here that the data they presented are indisputably convinced of usefulness of spinel chemistry in petrogenetic studies, with a brief discussion on the main factors controlling the spinel chemistry.

Nagao et al. (1980) seem to have underestimated the effects of pressure on \( \text{Al}_2\text{O}_3 \) content of spinel, concluding that the \( \text{Al}_2\text{O}_3 \) content of spinel is controlled mainly by the \( \text{Al}_2\text{O}_3 \) content of host magma. Certainly the composition of host magma is of primary importance. It is difficult, however, to explain the large difference in \( \text{Al}_2\text{O}_3 \) content found in natural spinels in terms of the host magma composition alone. As Shiraki et al. (1977) discussed previously, spinels in basalts have generally less \( \text{Al}_2\text{O}_3 \) than those in the lherzolite nodules included in basalts, though basalts are distinctly richer in \( \text{Al}_2\text{O}_3 \) than lherzolites. Furthermore, the \( \text{Al}_2\text{O}_3 \) content of spinel in basalt and andesite shows a large variation ranging from 49.2% in a chromian spinel in an

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abyssal tholeiite to less than 5% in chromites in boninites, as compared with a relatively small range in host rock Al$_2$O$_3$ content of 19.0% in the plagioclase-phyric basalt to 11% in the boninites (Sigurdsson, 1977; Shiraki et al., 1979a). Experimental studies (e.g., Green et al., 1972; Kushiro, 1972) have established that Al$_2$O$_3$ is favoured in spinel than in plagioclase with increasing pressure. It is plausible to attribute the excess Al$_2$O$_3$ in spinel over the compositional dependence of host rock to the pressure effects.

The relation of Al$_2$O$_3$ content between spinel and host rock should be treated with caution, because the large difference in crystallization stage and sinking velocity between spinel and plagioclase can lead to ambiguity regarding the Al$_2$O$_3$ relationships between spinel and its host magma. In general, primitive MgO-rich basalts crystallizing early spinels have less Al$_2$O$_3$ than differentiated plagioclase-rich basalts (e.g., Kushiro, 1973; Bender et al., 1978).

We discussed the effects of the silicate melt structure on spinel composition and considered that the solubility of Cr$^{3+}$ in melt decreases with increasing SiO$_2$ and decreasing H$_2$O contents (Shiraki et al., 1979b). Empirically we also showed that the Cr/Al ratio of spinel tends to increase with increasing SiO$_2$ content of the host rock. Nagao et al. (1980; p. 52) claimed that "this relation does not always hold for in other provinces," because the Cr/Al ratios of spinels from the silica-saturated and -under-

<table>
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<th>Table 1. Compositions of spinels and their host rocks.</th>
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<td><strong>Locality</strong></td>
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<tr>
<td>SiO$_2$</td>
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<td>TiO$_2$</td>
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<td>Al$_2$O$_3$</td>
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<td>Cr$_2$O$_3$</td>
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<tr>
<td>P$_2$O$_5$</td>
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<td>Cr/(Cr+Al)</td>
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1. Average of 2 Kamejiri basalts (Nagao et al., 1980).
1a. Al-rich spinel from Kamejiri basalt (KB2-c).
1b. Cr-rich spinel from Kamejiri basalt (KB2-a).
2a. Spinel from 2.
3a. Spinel from 3.
4. Hornblende spessartite (2109), Kasuga (Suzuki and Shiraki, 1980).
4a. Spinel from 4.
4b. Cr-rich spinel from spessartite, Kasuga.
5. Olivine andesite, Arita (Seno, 1980).
5a. Spinel included in megacryst olivine from 5.
5b. Spinel included in phenocryst olivine from 5.
saturated rocks are overlapped. Inspection of their Figs. 4a and 4b clearly shows, however, a tendency to high Cr/Al of spinel from the silica-saturated rocks. Sigurdsson and Schilling (1976) suggested high pressure origin for the high-Al spinels plotted near the Al corner on their Fig. 4a.

In Table 1 are compared the spinels from the Misasa basalts and the Chokai andesites with spinels from similar rocks in bulk composition to minimize the compositional effects.

The basalt from the Paleogene Setogawa group is olivine-hypersthene normative and consists of phenocrysts of dominant plagioclase and subordinate olivine set in a groundmass of augite, plagioclase, and altered fine-grained material, probably glass (Ohashi, in preparation). The analysed spinel is a euhedral crystal about 0.05 mm in size in the groundmass. In the Kamejiri basalt series of the Misasa basalts there seem two types of spinels, Cr-rich and Al-rich (Nagao et al., 1980). The Cr-rich spinel from the Kamejiri basalts (Table 1, 1b) is similar in Cr/Al ratio to the spinel from the Setogawa olivine tholeiite (Table 1, 2a), but the Al-rich spinel from the Kamejiri basalts (Table 1, 1a) has distinctly lower Cr/Al ratio than the Setogawa spinel. Assuming the same Cr/Al ratio in both host rocks, it is possible that the Al-rich spinel from the Kamejiri basalts may have crystallized at higher pressure than the Setogawa spinel. This inference is consistent with Nagao's (1978) conclusion from the presence of orthopyroxene that some of the Kamejiri basalts started crystallization at relatively high pressure.

The high-Al nature of spinel from the Chokai hornblende-bearing andesites (Table 1, 3a) is of particular interest. We have shown that the magnesian andesites are characterized by spinels having low Al and high Cr contents (Shiraki et al., 1977; Shiraki and Kuroda, 1977; Suzuki and Shiraki, 1980; Shiraki et al., 1980). The Chokai spinels form a marked exception to this general rule. Similar high-Al spinels in andesites were found to be enclosed in the pargasite rich in octahedral Al from the Kasuga spessartites (Table 1, 4a) and in the megacryst olivine with low CaO content in an olivine andesite from the Setouchi volcanic rocks (Table 1, 5a). Those high-Al spinels accompany the dominant high-Cr spinels (Table 1, 4b and 5b), which show no evidence for high pressure crystallization. On the other hand, for both the pargasite and the megacryst olivine enclosing the high-Al spinels there is clear evidence that they have been carried up from a considerable depth. On this basis Suzuki and Shiraki (1980) and Seno (1980) suggested that the high-Al spinels have crystallized at higher pressure than the high-Cr spinels. It may be inferred that the Chokai high-Al spinels coexisting with pargasite have crystallized at high pressure.

In conclusion we sustain that the use of spinels as geobarometers in magmas of a restricted compositional range seems a promising prospect.

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“日本列島のニ・三のアルカリ玄武岩、カルクアルカリ安山岩のクロムスピネルの結晶作用経路”についてのコメント

白木 敬一・大橋不三男・黒田 直

永尾ほか（1980）は表記論文において、“スピネルの Al₂O₃ 量だけで、スピネルが結晶作用をはじめた深さを推定したり、他地質のそれと比較するのは不適当である”と結論した。しかしながら彼等のデータを他と比較することによって、スピネルの Al₂O₃ 量は、スピネルが結晶作用をはじめた深さを推定する適当な指標となり得る可能性を秘めていることが示される。