(b) Chromium Partition between Ilmenite and Garnet

Examination of Tables 1, 3 and 4 shows that coexisting garnet and ilmenite have similar contents of Cr_2O_3 (weight %) in both the synthesized assemblages and in those of natural garnet-ilmenite asociations. Comparison of $(100\ Cr/R^{VI})_{garnet}$ vs $(100\ Cr/R^{VI})_{ilmenite}$ ($R^{VI} = Ti + Al + Cr + Fe^{+++}$) reveals a wide spread of Cr content in natural garnet-ilmenite paragenesis and preference by Cr^{+++} for the six-fold co-ordination sites in garnet. The synthesized mineral pairs are similar to the more Cr-rich of the natural assemblages but the Wesselten garnet peridotite WSSl is exceptionally high in Cr-content. The coexisting ilmenite/garnet analyses from a zoned garnet from Mir pipe (Sobolev *et al.*, 1974) are anomalous in that Cr^{+++} shows preference for ilmenite-haematite$_{ss}$ sites rather than garnet sites—this exceptional behavior may be directly linked to the very high Fe_2O_3 content (>20%) of these particular ilmenites. The ilmenites with highest Cr_2O_3-contents occur within compositional zones of the garnet containing 4.7–4.0% Cr_2O_3 together with coexisting inclusions of chromite (V. S. Sobolev *et al.*, 1972; N. V. Sobolev *et al.*, 1974). Further evidence of the relationship between Cr_2O_3 and Fe_2O_3 content in ilmenite is provided by the secondary ilmenite within alteration zones of the Wesselton peridotite (Table 3). Ilmenite containing 10.4% Fe_2O_3 and coexisting with chromite, contains 8.6% Cr_2O_3 and is in addition a much more magnesian (12.2% MgO) ilmenite than the Fe_2O_3 and Cr_2O_3-rich ilmenites from zoned garnet in the Mir pipe.

Conclusions

In garnet+ilmenite parageneses, the TiO_2 content of garnet appears to be proportional to temperature of equilibration. The synthesized garnet/ilmenite pairs presented support this conclusion over the temperature range 950° C to 1100° C and the similarity of TiO_2 contents of natural and synthesized garnets (Tables 2 and 3) argues for similar temperatures of equilibration for most natural ilmenite-bearing peridotite assemblages. The most TiO_2-rich natural garnet (2.38% TiO_2, Ponomarenko *et al.*, 1971) known from ilmenite-bearing peridotite of Yakutia contains high temperature, sub-calcic clinopyroxene ($100\ Ca/Ca+Mg = 30$) and on the data presented here implies equilibration temperatures above 1150°.

The synthesized ilmenites from pyrolite and basanite compositions demonstrate that very low f_{O_2} conditions are normally present under the experimental procedures using the piston cylinder apparatus. In particular, f_{O_2} conditions are very close to these under which natural ilmenites coexisting with diamond were formed. Other natural ilmenites from peridotite xenoliths contain a small range of Fe_2O_3 contents, implying a small range of f_{O_2} conditions in the source region. Ilmenites with considerably higher Fe_2O_3 contents occur as secondary products in peridotite xenoliths and as discrete crystals within kimberlite breccias. The higher f_{O_2} conditions implied by these ilmenites probably reflect rapidly changing conditions during transport and eruption of the kimberlitic magma. We infer that mantle-derived ilmenite may be used as a sensitive indicator of f_{O_2} conditions within the mantle and furthermore that f_{O_2} conditions close to the magnetite-haematite oxygen buffer are too high, and inappropriate for experiments aimed at highly undersaturated magma genesis. In contrast, experimental conditions of equilibrium

with graphite (system C—H—O) or close to the Ni—NiO oxygen buffer are appropriate for upper mantle conditions.

The distribution of iron and magnesium between coexisting garnet and ilmenite ($K_{D(Fe^{++},Mg)}^{ilm\text{-}ga}$) appears to be a relatively insensitive function of temperature of equilibration but may increase with increasing pressure at constant temperature. The partition coefficient ($K_{D(Fe^{++},Mg)}^{ilm\text{-}cpx}$) offers more promise as a temperature-dependent variable of use in estimation of conditions of equilibration of natural ilmenite-bearing assemblages. However, the f_{O_2}-dependent substitution of Fe_2O_3 in ilmenite markedly affects Cr_2O_3 solubility relationships and may affect Fe^{++}/Mg partition relation relationships. Natural ilmenites show sufficient variation in major and minor element composition to warrant further study and initiation of experimental projects specifically designed to investigate ilmenite solid solutions under controlled physical conditions.

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