ABSTRACT

The general systematics of Mg - Fe exchange equilibrium between orthopyroxene and chrome spinel has been considered in terms of the orthopyroxene end members $MgSiO_3$ and $FeSiO_3$ and the chrome spinel end members $MgCr_2O_4$, $MgAl_2O_4$, $MgFe_2O_4$, $FeCr_2O_4$, $FeAl_2O_4$ and Fe_3O_4. Using available or retrieved thermodynamic parameters: Gibbs energy, entropy and volume of these components and an ideal mixing on site activity - composition relations, four potential geothermometers, based on orthopyroxene - chrome spinel equilibrium, have been tested on an independently and multiply PT - sensed orthopyroxenite of the Red Mountain ultramafics of New Zealand. It appears that the reaction : $FeSiO_3 + MgCr_2O_4 = MgSiO_3 + FeCr_2O_4$ can be used as a dependable geothermometer for high magnesian orthopyroxene and chromium - rich spinel. This thermometer and a new barometer based on the reaction : $MgAl_2SiO_6$ (in orthopyroxene) = $MgAl_2O_4$ (in chrome spinel) + SiO_2 (in melt) have been applied to nine orthopyroxene - chrome spinel assemblages from the Sukinda orthopyroxenite. The equilibration temperatures calculated separately for the chrome spinel core and rim compositions average to 1047°C for the core and 819°C for the rim. The equilibration pressures, determined at a silica activity of 0.3, average to 20.8 kbar for the chrome spinel core and 32.9 kbar for the chrome spinel rim. An assumption of increased silica activity from core to rim, following progressive differentiation of the melt and simultaneous cooling, leads to nearly same core and rim pressures. The estimated depth of equilibration is between 65 km and 100 km for a silica activity around 0.3.

General considerations of orthopyroxene - chrome spinel liquidus relations suggest that the magnesian orthopyroxene and Cr - rich spinel of the Sukinda orthopyroxenite crystallized as

a stable, cotectic pair at the early stage of a basic magma and cooled uniformly over the entire orthopyroxenite band. Geological mapping of the 6 km long and 300 m wide orthopyroxenite band has shown that the band occupies a position near the core of a regional syncline and its field relations and petrography suggest that the orthopyroxenite was forcefully emplaced in a nearly solid state and was later folded along with the other units of the Sukinda ultramafic body. The integrated evidence, from mapping, field relations, petrography and equilibrium thermodynamic analysis of mineral compositions, therefore points to origin of the orthopyroxenite through fractional crystallization of a basic magma in the spinel peridotite field of the upper mantle and its subsequent tectonic transport to a high crustal level.