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APPLICATIONS OF MÖSSBAUER SPECTROSCOPY IN MANTLE PETROLOGY

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Since the Earth's mantle is composed predominantly of minerals that are Fe-bearing solid solutions, Mössbauer spectroscopy (MS) is an essential tool for helping to understand many geochemical and petrological processes that occur at depth. The oxygen fugacity (fO_2) plays an important role in many processes since it influences mineral stability, the volatile species, as well as the rheological and transport properties of minerals. The fO_2 can be estimated through chemical equilibria involving the Fe^{3+} and Fe^{2+}-bearing components in mantle minerals, such as spinel and garnet (WOOD et al., 1990). Thus, a primary task for MS is the accurate determination of the Fe^{3+}-contents in such minerals. Extended Voigt-based fitting (LAGAREC & RANCOURT, 1997) yields a better overall fit for spinel compared to a pure Lorenzian line shape model. For garnet, unequal recoil free fractions for Fe^{3+} and Fe^{2+} need to be accounted for (e.g. WOODLAND & ROSS, 1994). Regional variations and depth profiles in mantle fO_2 can be derived from such data (e.g. WOOD et al., 1990; WOODLAND & KOCH, 2003).

Spectroscopic measurement of $Fe^{3+}/\sum Fe$ in coexisting pyroxenes allows a test of redox equilibrium within the mantle assemblage by comparing cpx-based (LUTH & CANIL, 1993) and spinel-based oxybarometers. Fe^{3+}-partitioning between phases can also be assessed, along with the estimation of whole rock Fe_2O_3 contents in mantle samples. This yields a better understanding of the behaviour of Fe^{3+} at high pressures and temperatures.

Many crystal chemical aspects of mantle phases can also be investigated by MS. For example, ordering of Mg and Fe^{2+} on the M1 and M2 sites in pyroxene can be determined (WOODLAND et al., 1997). In mixed valence phases such as garnet, spinel and the spinelloid polymorphs, MS allows investigation of magnetic properties and site occupancies of Fe^{2+} and Fe^{3+}, and provides information complementary to magnetic susceptibility and XRD measurements.

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