Possibility of the whole-mantle circulation: inclusions in chromitite of Luobusa ophiolite, southern Tibet

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Diamonds and unusual mineral asemblages were reported in podiform chromitites of the Luobusa ophiolite, southern Tibet, China (Bai 1993, Bai 2000, Yan 2001). These minerals include (1) native elements (C, Fe, Ni, W, Cu, Zn, Pb, Ag, Au, Ir, Ru, and Cr), (2) alloys (Co-W, Ti-C, Mn-Fe, Al-Fe, Co-Fe, Ag-Au, Fe-Al-La, Ir, Os, Ru, etc), (3) carbides (SiC, CrC), (4) platinium group elements (PGE) and arsenides (As sulfides), (5) silicates (olivine, orthopyroxene, clinopyroxene, amphibole, serpentine, chlorite, uvarovite, pyrope, almandine, wollastonite, zircon, apatite, biotite, sphene, rutil, plagioclase, K-feldspar, phlogopite, silimanite, gehlenite, quartz and octahedral olivine (possible pseduomorph after ringwoodite), (6) oxide (corundum and chromite), (7) carbonates, (8) minerals with unusual compositons (silicon rutil, silicon magnesium spinel etc). Especialy, the first occurrence of the terrestrial ringwoodite was reported (Robinson et al. 2001). The ringwoodite is polymorph of olivine under ultra high pressure, depth over than 510km in mantle. Therfore, mineral inclusions of podiform chromitite in Luobusa ophiolite would provide the important infomation of deeper part of the mantle of the earth.

Mg# and Cr# of chromites (chromian spinel) in the chromitites are very high, 76-80 and 54-81 respectively. Mg# of olivines in chromitite were extremely high (94.5-98.5), due to Mg-Fe exchange between olivine and chromite under the subsolidus condition. But, there are two specific groups of the olivines in the chromitites on Fo value versus NiO contents diagram; high and low NiO olivines. High Ni olivines have about 0.7-1.3% in NiO and about 97.2-98.5 in Mg#. Low Ni olivines have about 0.4-0.6% in NiO, and about 94.6-98.1 in Mg#. This cannot be explained by Ni-Fe exchange between olivine and chromite and suggests the high NiO olivines primarily contained high NiO content.

Zircons were also obtained from the mineral separation of chromitites in Luobusa. U-Pb dating of these zircons by LA-ICP-MS yielded two different ages. One group has relatively younger age 205Ma-534Ma, which plots on a concordia line. Another group has older age 1460-1822Ma, which plots off the concordia line. A discordia line obtained from the zircons with ages of 1460-1822Ma yielded two ages; igneous age about 2055Ma and metamorphic age about 268Ma, which is consistent to younger age of zircons. In additon, cathode luminescence images of these zircons indicate that the older zircons have clear oscillatory zoning, whereas the younger zircons show apparent homogeneous overgrowth.

Luobusa ophiolite has been recognized as fragment of Tethys oceanic crust formed in Cretaceous (100-120Ma)(Allegre et al. 1984). But the age of given by zircons in chromitites is much older than that of ophiolite. So these zircons were probably originated from recycling crustal materials convected through upper mantle. Then high NiO content in the olivines may indicate that these olivines originated from mantle transition zone and/or much deeper mantle. Accoding to high-pressure experimental study of olivine (Gudmundur et al. 1998), wadsleyite can contain high NiO content more than 2%. Disvcovery of ultra high pressure minerals of diamond and ringwoodite, and reductional minerals of native elements and carbides from suggests that chromitite in Luobusa ophiolite originated from deeper part of the mantle. Diamond is stable over 150km deeper in mantle, and octahedral olivine of the pseduomorph after ringwoodite is stable over 510km deep. Furthermore, native elements, alloy, PGE, and carbide in the chromitites indicate very reductional environment. Such in very reductional environment is likely deeper part of mantle, especialy core-mantle boundary.

The presence of unusually older zircons, ultra high-pressure minerals, native elements, alloy, and PGE implies material circulation in whole mantle, among crust, deeper mantle and core.