Oxidation states of Fe and inclusions in olivine from Esquel pallasite

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Oxidation states of Fe and inclusions in olivine from Esquel pallasite were investigated using ^{57}Fe Mössbauer spectroscopy and electron microprobe analysis (EPMA). The Esquel meteorite is of a main pallasite group (PMG), and consists mainly of olivine and Ni-Fe metal.

The inclusions in the olivine crystals occur in the form of droplets (Type1), subhedral grains (Type2), as symplectic aggregates (Type3) and in the form of needles (Type4). The Type1 inclusions consist of fine Ni-Fe metal, troilite, olivine, and cristobalite or single phases of troilite, Ni-Fe metal and stanfieldite, and are rarely accompanied by chromite, enstatite and/or schreibersite. Type 2 inclusions are composed of very fine Ni-Fe metal and troilite with subhedral cristobalite or enstatite, and chromite. The assemblage of Type3 inclusions is chromite + troilite + enstatite and/or cristobalite. Type4 inclusions are an unknown Ca-Cr-Si-bearing mineral. Types1 and 2 inclusions occur along irregular fractures. The fractures are filled with troilite ± olivine. In the rim of the inclusions and the fractured minerals, troilite and/or Ni-Fe metal are partly altered to FeO(OH).

The average Fo content of olivine from Esquel is 88.3 mol.%. According to the oxidation states of Fe in six olivine grains determined using EPMA method, the average $Fe^{3+}/(Fe^{2+}+Fe^{3+})$ is 5±3 %, suggesting the existence of Fe^{3+} in olivine.

^{57}Fe Mössbauer spectrum of the olivine which were carefully separated to avoid inclusions consists of three doublets assigned to Fe^{2+} at the M2, Fe^{2+} at the M1 and Fe^{3+} at the octahedral sites in the olivine, respectively. The $Fe^{3+}/(Fe^{2+}+Fe^{3+})$ of the olivine is 5±3 %, which is consistent with the result by the EPMA analysis.

Therefore, it is concluded that the olivine from Esquel pallasite contains a small amount of Fe^{3+}. Since secondary inclusions, such as troilite inclusion, might have been formed under the reduced condition, Fe^{3+} in the olivine is regarded to be originally generated in the olivine at the time of formation of the pallasite.

Keywords: oxidation state of Fe, ^{57}Fe Mössbauer spectroscopy, pallasite, olivine, PMG, Esquel