DISLOCATION SUBSTRUCTURES OF OLIVINE CRYSTALS FROM PALLASITE METEORITES, H.Mori, Department of Mineral Sciences, American Museum of Natural History, New York, N.Y. 10024

I have studied the dislocation substructures of olivine crystals from pallasite meteorites in order to interpret the conditions that existed within the planetary interior in which they formed. Pallasites constitute a relatively rare group of meteorites, but ones which have several remarkable structural and compositional aspects. They consist primarily of two major phases or minerals, olivine and metal. Olivine crystals are large, up to a few cm in diameter and are scattered within the metal. The association of these two dissimilar phases poses a problem or controversy which has existed for many years regarding the origin. Many studies have been conducted to explain their mode of formation[1-6]. However, most of the studies were from a petrological and geochemical point of view. The physical conditions to which the pallasites were subjected have not been well investigated and still remain unresolved. Matsui et al.[7] have studied the dislocation structures of pallasitic olivines. Their study was limited to only a small number of pallasite specimens. In order to derive more universal views on deformational features of pallasitic olivines, I have conducted an optical microscopic observation of the dislocation substructures of the olivine crystals from 21 pallasite meteorites, which can then be used to infer the past thermal and deformational histories of this mineral, and subsequently the planet which contained them.

Sample preparation procedures are as follows: Olivine crystals were extracted from each of the pallasite meteorites studied and were oriented prior to a heating treatment. The orientation was determined with a precession camera. Each oriented crystal was then mounted in an epoxy resin and several slices were cut. Subsequently the slices were heated in air at about 900°C in order to decorate the dislocations in olivine[8]. Thin sections were then made from each of the heated samples and observed with an optical microscope. 21 pallasite samples (Admire, Ahumada, Albin, Brahin, Brenham, Dora, Eagle Station, Esquel, Finmarken, Glorieta Mountain, Huckita, Imilac, Krasnojarsk, Marjalahti, Molong, Mt. Dyrring, Mt. Vernon, Newport, Pavlodar, South Bend, and Springwater) used in this study were from the collection of the American Museum of Natural History. Glide systems, modes of distribution, densities and subboundary spacings were measured in each sample.

The results obtained are as follows: (a) The slip systems were identified as (0kl)[100] and (hk0)[001]. (b) The (100) subboundary is well developed in olivine crystals with an angular shape. The stress levels estimated from the subboundary spacings are several times ten to one hundred bars. (c) Dislocation substructures in olivine crystals with a rounded shape show extensive recovery.

These observations imply that the pallasites have been subjected to two different kinds of deformation events. One kind of deformation event occurred at high temperature and low strain rate within the parent body. The other kind is possibly from tectonic forces or later impact events at low temperature. Klosterman and Buseck[9] showed that pallasitic olivines have a clear correlation between the morphological and deformational features. This study confirmed the correlation. Pallasites with angular olivines appear to have been deformed at high temperature before an olivine-metal mixing event. Rapid cooling from high temperature produced by the mixing event may have prevented the dislocation recovery and olivine-metal grain boundary migration. Pallasites with rounded olivines may have had a similar deformation history to that of pallasites with angular olivines before the olivine-metal mixing events, but slow cooling from the high temperature olivine-metal mixing event may have produced the completely recovered dislocation substructure and rounded olivine shape by the grain boundary migration.

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