HF-W CHRONOLOGY OF THE BRENHAM PALLASITE. Y. Homma[1] and T. Iizuka[1], [1]Department of Earth and Planetary Science, the University of Tokyo.

Introduction: Pallasites are stony-iron meteorites consisting mainly of olivine and FeNi metal. Some relations with iron meteorites are pointed out for pallasites, implying that pallasites represent the core-mantle boundaries of their parent bodies [e.g. 1]. Therefore, pallasites potentially provide a unique opportunity to study core formation and core-mantle interaction on planetesimals. Further, chronological investigations of pallasites make it possible to decide the timescales of differentiation and crystallization of the planetesimals.

There are a few high-precision chronological studies on pallasites. The ages of olivine in pallasites were determined by the Al-Mg and Mn-Cr systems [2, 3]. The results indicated very early olivine crystallization ages of 1.27 Myrs and ~2.5 – 4 Myrs from the CAI formation. In addition, the Hf-W chronology was applied to pallasite metals [4]. The results revealed that there is a quite large variation in ε^{182}W among Main-Group pallasites and that some of the ε^{182}W values correspond to model ages apparently older than the CAIs, which is contradictory to the currently accepted model for planetary formation. More recently, it has been shown that apparent ε^{182}W variations can be produced by nucleosynthetic anomaly in the early solar system and neutron capture within meteorites. The nucleosynthetic anomaly would make the correlated variation between ^{182}W/^{184}W and ^{183}W/^{184}W, whereas the neutron capture effect would dominantly change ^{182}W/^{184}W for metal samples [5]. Thus, these effects can be corrected by measuring ^{183}W/^{184}W and ^{196}Pt/^{195}Pt ratios, respectively [6]. In this study, the Hf-W chronology was applied to the Brenham main group pallasite. We evaluate the nucleosynthetic and neutron capture effects by combined W and Pt isotopic analyses. Based on the results, we discuss the Hf-W age of the Brenham pallasite and its implications for the origin of main group pallasites.

Sample and Methods: The meteorite used in this study is the Brenham pallasite. The cosmic exposure age of this meteorite has been estimated as 156 Myrs [7]. Since it has an enormous mass of about four tons (the Meteoritical bulletin), degree of the neutron capture effect would be variable among different fractions of Brenham, thereby requiring combined W and Pt isotopic analyses on single fractions.

Brenham was crushed in an agate mortar, and then metal was separated from olivine and troilite by a hand magnet. The separated metal fractions were dissolved by aqua regia, followed by evaporation with 6 M HCl and re-dissolution in 1 M HF. A part of aqua regia was saved for Pt isotopic measurement. Both W and Pt separations were done using AG1-X8 based on the separation methods described by previous studies [6, 8].

The W and Pt isotopic measurements were performed on a Thermo Fisher Scientific Neptune plus multi-collector ICP-MS equipped with a CETAC Aridus II desolvating nebulizer system at the University of Tokyo. The attached sampler and skimmer cones were a nickel-Jet and X for W, and a nickel-normal & H for Pt. NIST SRM 3163 and NIST SRM 3140 standard solutions were used as W and Pt standards, respectively. Instrumental mass bias was corrected relative to ^{186}W/^{184}W = 0.92763 for W isotopes and either ^{198}Pt/^{195}Pt = 0.2145 or ^{196}Pt/^{195}Pt = 0.7464 for Pt isotopes.

Results and Discussion: The results of W isotopic analysis of Brenham metal are shown in figure 1. The metal fractions yielded ε^{182}W values of -3.43 ± 0.15 and -3.85 ± 0.21 relative to the standard solution. These values are within the range of previously reported variable ε^{182}W values for main group pallasite metals [4]. The obtained ε^{183}W values are identical to the standard value within analytical uncertainty, indicating no nucleosynthetic anomaly in the Brenham.

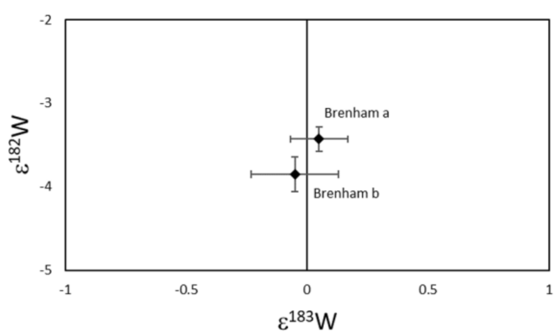

Figure 1. W isotopic data for two fraction of Brenham metal.

The Pt isotope measurement was carried out on one of the two metal fractions analyzed for W isotopes, which is labeled "Brenham b" in figure 1. The resultant Pt isotope ratios were ε^{196}Pt (8/5) = 0.45 ± 0.15, ε^{194}Pt (6/5) = 0.86 ± 0.20, and ε^{194}Pt (8/5) = 0.42 ± 0.15, where (6/5) and (8/5) denote mass bias correction based on measured ^{196}Pt/^{195}Pt and ^{198}Pt/^{195}Pt, respectively. The ε^{194}Pt (6/5) and ε^{194}Pt (8/5) values apparently deviate from the correlated variation between ε^{194}Pt (6/5) and ε^{194}Pt (8/5) expected for the nucleosynthetic effect, indicating that the positive ^{196}Pt anomaly represents the neutron capture effect on the Brenham metal.

As only one metal fraction has been analyzed for Pt isotopes so far, the relationship between $\varepsilon^{182}W$ and $\varepsilon^{196}Pt$ in Brenham metal cannot be defined yet. For correction of the neutron capture effect, therefore, we apply the reported correlation slope for iron meteorites which is -1.32 ± 0.11 [6, 9] (figure 2). While the uncorrected $\varepsilon^{182}W$ value yielded the model age of -2.6 ± 1.7 Myrs, which is apparently older than CAIs, the corrected $\varepsilon^{182}W$ value of -3.26 ± 0.29 corresponds to the model age of 2.0 ± 2.9 Myrs after the CAI formation. The substantial shift of the model age after the correction indicates that the effect of neutron capture is significant in pallasites, implying that the previously reported $\varepsilon^{182}W$ values lower than CAIs [4] would originate in the neutron capture effect.

The Hf-W model age of Brenham is consistent with the olivine Al-Mg and Mn-Cr ages of main group pallasites [2, 3]. Furthermore, the gained Hf-W model age of the Brenham metal is coincident with the Hf-W model ages of magmatic irons, while it is older than those of non-magmatic irons [6, 10] (figure 3). The finding implies that the main group pallasites are of magmatic origin rather than impact origin.

The obtained $\varepsilon^{183}W$ value gives a clue to the origin of Brenham. It has been shown that iron meteorites exhibit dichotomy in $\varepsilon^{183}W$ value and Mo isotopic composition, the latter of which has been identified between carbonaceous and non-carbonaceous chondrites [11]. The $\varepsilon^{183}W$ value of Brenham corresponds with 'non-carbonaceous' iron meteorite groups such as IIIAB irons. This indicates that the parent body of main group pallasites had accreted in the inner solar system.

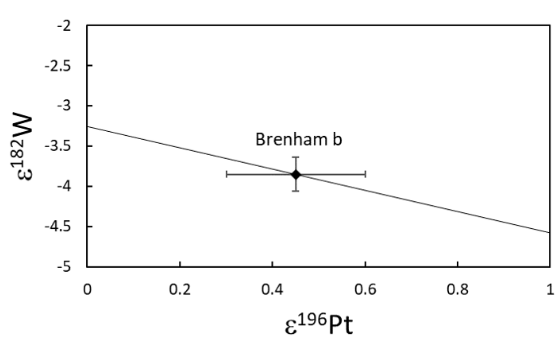

Figure 2. Plot of $\varepsilon^{182}W$ v.s. $\varepsilon^{196}Pt$ for the Brenham metal. The solid line represents the slope of a regression line for W and Pt isotopic analyses of iron meteorites (-1.32 ± 0.11 [6, 9]), which was applied to the correction of the neutron capture effect.

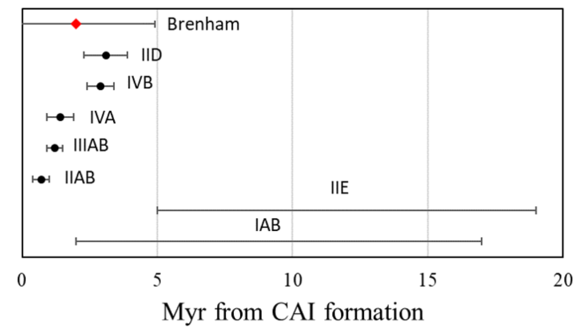

Figure 3. Hf-W age comparison between the Brenham metal and iron meteorites. The model age of Brenham corresponds with those of magmatic irons rather than non-magmatic irons [6, 10].

References: [1] Clayton R. N. and Mayeda T. K. (1996) *GCA*, *60*, 1999-2017. [2] Baker J. A. et al. (2012) *GCA*, *77*, 415-431. [3] McKibbin S. J. et al. (2016) *Geochem. Persp. Let.*, *2*, 68-77. [4] Quitté G. et al. (2005) *GCA*, *69*, 1321-1332. [5] Kleine T. and Walker R. J. (2017) *Annu. Rev. Earth Planet. Sci*, *45*, 389-417. [6] Kruijer T. S. et al. (2013) *EPSL*, *361*, 162-172. [7] Honda M. et al. (2002) *MPS*, *37*, 1711-1728. [8] Breton T. and Quitté G. (2014) *JAAS*, *29*, 2284-2293. [9] Kruijer T. S. (2014) *Science*, *344*, 1150-1154. [10] Markowski A. et al. (2006) *EPSL*, *242*, 1-15. [11] Kruijer T. S. et al. (2017) *PNAS*, *114*, 6712-6716.