HF-W DATING OF MAIN-GROUP PALLASITES. Y. Homma[1], T. Iizuka[1] and A. Ishikawa[2], [1]Department of Earth and Planetary Science, the University of Tokyo. [2]Department of Earth and Planetary Science, Tokyo Institute of Technology.

Introduction: Pallasites are stony-iron meteorites consisting mainly of olivine and FeNi metal. Classically, pallasites have been thought to represent the core-mantle boundary of their parent body in response to some relations with iron meteorites, such as IIIAB irons, which are representative of the core [e.g. 1]. Though, several reports indicate that the origin of pallasites is much shallower than the core-mantle boundary [e.g. 2] and further suggest impact mixing as the formation process of pallasites. Chronological investigations of pallasites may give us clues to this problem. It is known that magmatic iron meteorites exhibit older Hf-W model ages compared to irons of impact origin [3][4].

There are a few high-precision chronological studies on pallasites. The Al-Mg dating of olivine yielded a model age of 1.27 Myrs after the CAI formation [5]. The Mn-Cr dating was also attempted to olivine and chromite [6][7], but the data revealed secondary disturbance of the isotope system [7]. Previous Hf-W study reported that metal W compositions of pallasites show a large variation [8]. Some of them even have a lower $^{182}W/^{184}W$ values than the CAIs, which correspond to the model ages older than the CAIs. More recently, it has been shown that apparent $\varepsilon^{182}W$ variations can be produced both by nucleosynthetic anomaly in the early solar system and by neutron capture within meteorites. The nucleosynthetic anomaly would make a correlated variation between $\varepsilon^{182}W$ and $\varepsilon^{183}W$, whereas the neutron capture effect would dominantly change $\varepsilon^{182}W$ [9]. The neutron capture effect can be corrected by measuring Pt isotopes [3]. In order to obtain accurate Hf-W model ages from pallasite FeNi metals, in this study we carried out combined W and Pt isotopic analysis. Based on the results, we discuss the origin of main group pallasites.

Sample and Methods: The meteorites used in this study are Brahin, Esquel, Imilac and Seymchan Main-Group pallasites. The cosmic exposure ages of these meteorites are variable, ranging from 11 to 108 Myrs [e.g. 10]. Thus, various degrees of neutron capture effect are expected. Imilac has a higher $\Delta^{17}O$ value compared to the other pallasites, suggesting that there are plural parent bodies for Main-Group pallasites [11].

Samples were crushed in an agate mortar, and metal was separated from olivine and troilite by a ferrite magnet. 500 mg to 1 g of metal fractions were dissolved by reverse aqua regia. In order to remove inclusions in the metal fractions, the dissolved samples were centrifuged and the supernatant were collected for further steps. At this time, 10 % of the supernatants were saved for Pt isotopic measurement and the rest were used for W isotopic measurement. The aliquots for W isotopic measurement were dried up and re-dissolved with 6 M HCl – 1 M HF. The aliquots were finally dissolved with 0.5 M HCl – 0.5 M HF. The aliquots for Pt isotopic measurement were processed for Os removal using solvent extraction with CCl_4. After eliminating CCl_4 completely by $HClO_4$ and H_2O_2, the aliquots were dried up and re-dissolved with 1 M HCl – 0.1 % Br water. Both W and Pt separation were done using anionic resin AG1-X8 based on the separation methods of previous studies [3][12].

The W and Pt isotopic measurements were performed on an 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 and H for Pt. The samples were bracketed with NIST SRM 3163 and 3140 for W and Pt, respectively. Instrumental mass bias was corrected relative to $^{186}W/^{184}W = 0.92767$ 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 isotope analyses of pallasite metals are shown in figure 1. The $\varepsilon^{182}W$ values are within the range of previously reported variable $\varepsilon^{182}W$ values for Main-Group pallasites [8]. The $\varepsilon^{183}W$ values are identical to the standard value within analytical uncertainty, indicating little nucleosynthetic anomaly in the Main-Group pallasites.

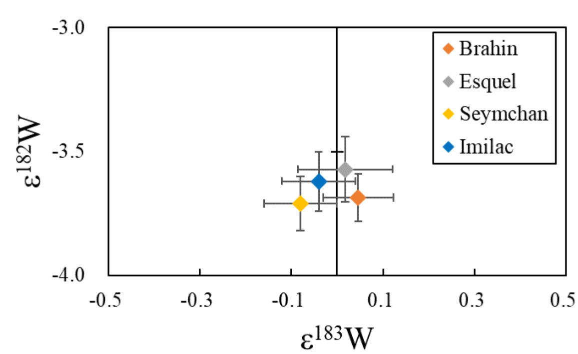

Figure 1. W isotopic data for pallasite metal.

The $\varepsilon^{194}Pt$ (6/5) and $\varepsilon^{194}Pt$ (8/5) values, where (6/5) and (8/5) denote mass bias correction based on measured $^{196}Pt/^{195}Pt$ and $^{198}Pt/^{195}Pt$ respectively, deviated from the correlated variation expected for the nucleosynthetic effect. The ε^{196}Pt (8/5) values show positive anomalies, except for that of Esquel, which has the least cosmic exposure age. These results indicate the neutron capture effect in the pallasite metals. The effect of neutron capture on ^{182}W/^{184}W was corrected using Pt isotopes in figure 2. Since the data distribution is not large enough to obtain a precise regression line, we applied the reported correction slope for iron meteorites (-1.32 ± 0.11) [3][13] to correct the effect of neutron capture on ε^{182}W values of pallasites.

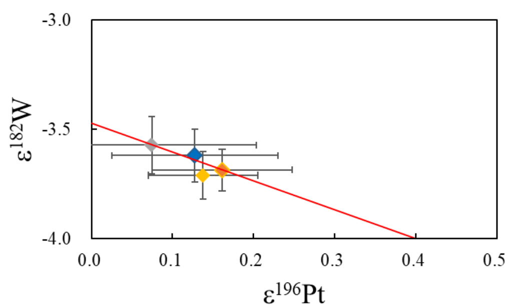

Figure 2. Plot of ε^{182}W v.s. ε^{196}Pt for the four pallasite metals. The solid line represent the slope of the regression line for W and Pt isotopic data for iron meteorites [3][13], which was applied to the correction of the neutron capture effect. For simplicity, only the correction line for Brahin is shown in the figure.

The ε^{182}W values of pallasites corrected for the neutron capture effect range from -3.53 ± 0.14 to -3.45 ± 0.18, which are identical within uncertainty. The ε^{182}W values correspond to the model W ages of -0.30 ± 1.43 to 0.31 ± 1.74 Myrs after the CAI formation.

Figure 3 shows an age comparison between the model W ages of individual pallasites and the reported model Al-Mg age of pallasites. The obtained model W ages of pallasites are coincident with the olivine Al-Mg age of main group pallasites [5]. The model W ages of pallasites are older than iron meteorites of impact origin (e.g. Canyon Diablo, IAB : 11.3 ± 6.1 Myrs) [4] and identical to the crystallization age of magmatic irons [3]. These results support the view that Main-Group pallasites represent the core-mantle boundary, rather than the impact products.

The ε^{183}W values give a clue to the origin of the pallasite parent bodies. It has been reported that iron meteorites exhibit dichotomy in ε^{183}W value and Mo isotopic composition, the latter of which has been identified between carbonaceous and non-carbonaceous chondrites [14]. The obtained ε^{183}W values of the pallasite metals corresponds with the "non-carbonaceous" iron meteorite group such as IIIAB irons. This indicates that the parent bodies of Main Group pallasites had accreted in the inner solar system.

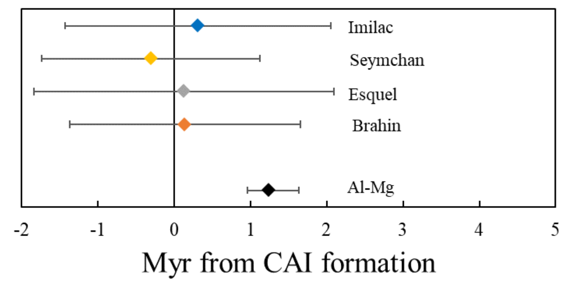

Figure 3. The age comparison between the model Hf-W ages of pallasites measured in this study and the reported model Al-Mg age of pallasites [5].

References: [1] Clayton R. N. and Mayeda T. K. (1996) *GCA*, *60*, 1999-2017. [2] Yang J. et al. (2010) *GCA*, *74*, 4471-4492. [3] Kruijer T. S. et al. (2013) *EPSL*, *361*, 162-172. [4] Markowski A. et al. (2006) *EPSL*, *242*, 1-15. [5] Baker J. A. et al. (2012) *GCA*, *77*, 415-431. [6] Hsu W. (2005) *Geochem. J.*, *39*, 311-316. [7] McKibbin S. J. et al. (2016) *Geochem. Persp. Let.*, *2*, 68-77. [8] Quitté G. et al. (2005) *GCA*, *69*, 1321-1332. [9] Kleine T. and Walker R. J. (2017) *Annu. Rev. Earth Planet. Sci.*, *45*, 389-417. [10] Honda M. et al. (2002) *MPS*, *37*, 1711-1728. [11] Ali A. et al. (2018) *MPS*, *53*, 1223-1237. [12] Breton T. and Quitté G. (2014) *JAAS*, *29*, 2284-2293. [13] Kruijer T. S. et al. (2014) *Science*, *344*, 1150-1154. [14] Kruijer T. S. et al. (2017) *PNAS*, *114*, 6712-6716.