ACCRETION AND COOLING HISTORY OF THE IIIAB IRON METEORITE PARENT BODY. M. Matthes[1], M. Fischer-Gödde[1], T. S. Kruijer[1], I. Leya[2] and T. Kleine[1], [1]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany, [2]Space Research and Planetology, University of Bern, Bern, Switzerland (max.matthes@uni-muenster.de).

Introduction: Magmatic iron meteorites are interpreted as fragments of the metal cores from differentiated planetesimals. On the basis of their chemical composition, they are subdivided into several groups, each representing a distinct parent body [1]. Of these, group IIIAB is the largest and one of the best studied groups. IIIAB irons diplay a wide range of chemical compositions with Ir contents varying by three orders of magnitude. Not only are these chemical variations consistent with crystal-liquid partitioning during fractional crystallization of a metallic melt, they also indicate that almost the entire fractional crystallization sequence of their parental core has been sampled [2].

The chronology of IIIAB iron meteorites has been investigated using different short- and long-lived chronometers, including the ^{182}Hf-^{182}W, ^{53}Mn-^{53}Cr and ^{187}Re-^{187}Os systems [9,12,14]. Collectively, the results of these studies show that the IIIAB parent body accreted and differentiated with ~1 Ma after CAI formation, followed by rapid crystallization and cooling within another few Ma. Additional constraints on the cooling history are provided by metallographic cooling rates. These are consistent with rapid cooling but also vary by a factor of 6 among different IIIAB irons [11]. The large variation in cooling rates has lead to the idea that the mantle of the IIIAB parent body has been removed by impact, facilitating rapid and variable cooling of the IIIAB core.

To better constrain the cooling history of the IIIAB iron meteorite parent body, we applied the short-lived ^{107}Pd-^{107}Ag system ($t_{1/2}$ = 6.5 Ma) to a suite of IIIAB irons, including early- and late-crystallized samples. The Pd-Ag system is ideally suited to determine cooling ages of iron meteorites, because precise Pd-Ag isochrons can be obtained due to the very different Pd/Ag ratios of metal and sulphides [3-6]. However, internal Pd-Ag isochrons are only available for a few iron meteorites and until now no systematic study has been performed in which a suite of irons representing the entire core of a given body were dated.

Samples and analytical methods: The IIIAB irons investigated for this study are Boxhole, Cape York (Agpalilik), Grant and Henbury. The Ir contents of these samples vary by a factor of ~300 and thus cover most of the fractional crystallization sequence of the IIIAB core. The methods for sample dissolution, chemical separation and isotope measurements are described in a companion abstract [15]. The Ag isotope data for samples are reported in ε^{107}Ag as the parts per 10,000 deviations from the mean ^{107}Ag/^{109}Ag obtained for measurements of bracketing runs of the NIST 978a Ag standard. The Pt isotope composition of each sample was also determined [7], to correct for the effects of secondary neutron capture on Ag isotopes [16].

Results: With the exception of Cape York and two specimens of Grant, all samples exhibit well-resolved Pt isotope anomalies, indicating significant neutron capture effects. Nevertheless, after correction for these effects on ε^{107}Ag, Pd-Ag isochrons are obtained for the investigated irons (Fig. 1). The initial ^{107}Pd/^{108}Pd inferred from the isochrons are indistinguishable for the four IIIAB irons and correspond to Pd-Ag ages between ~3 and ~5 Ma (mean: 3.8±1.6 Ma) relative to an inferred solar system initial ^{107}Pd/^{108}Pd of $(3.1\pm0.5)\times10^{-5}$. The latter is slightly higher than reported in [6], based on a Pd-Ag isochron and Pb-Pb age [8] for the IVA iron Muonionalusta. The higher value used here results from the correction of the reported Pb-Pb age for U isotope variations [10], resulting in an U-corrected Pb-Pb age of Muonionalusta of 4564.4±0.3 Ma.

The data for Muonionalusta can also be used to calculate 'absolute' Pd-Ag ages, which range from 4565.1±1.7 for Henbury to 4562.9±2.4 for Boxhole. The age of 4563.7±1.7 Ma for Grant is in very good agreement with an ^{53}Mn-^{53}Cr age of 4563.6±0.7 Ma for sarcopside from Grant [9] (calculated relative to the angrite D'Orbigny).

Discussion: The Pd-Ag ages indicate that the IIIAB metal core cooled below the Pd-Ag closure temperature of ~830°C [9] at ~4 Ma after CAI formation. Formation of the IIIAB core took place at ~1.2 Ma after CAI formation, as indicated by Hf-W chronometry [12]. Assuming that the core was surrounded by an insulating mantle, crust and regolith, such rapid cooling would indicate a small parent body with a radius of ~13 km (calculated using the model of [13]). Our own thermal modeling shows that both the Hf-W and Pd-Ag age constraints are consistent with such a small parent body, if this body accreted at ~0.35 Ma after CAI formation (Fig. 2). The thermal modeling also shows that significantly larger bodies would cool below Pd-Ag closure much later than indicated by the Pd-Ag ages for the IIIABs. However, the variations in metallographic cooling rates observed for IIIAB iron meteorites (ranging from 56 to 338 °C/Ma [11]) appear

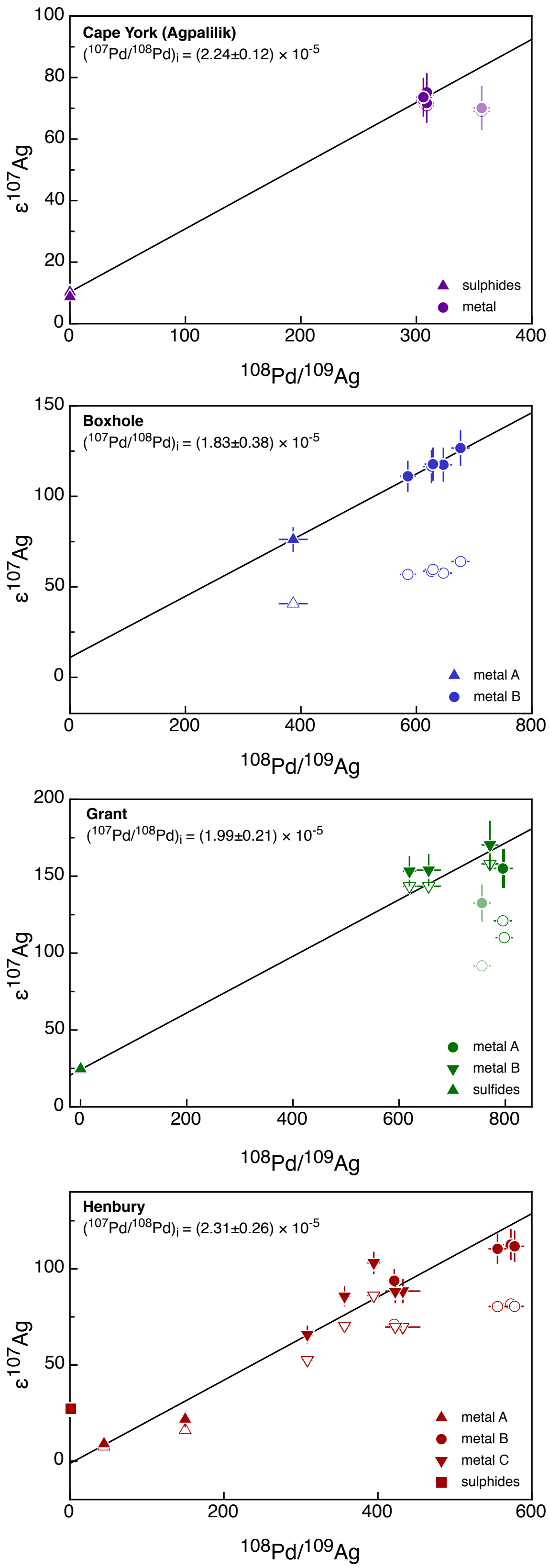

Figure 1. Pd-Ag isochrons for IIIAB iron meteorites. Uncorrected data shown with open, NC-corrected data shown with filled symbols. Regressions calculated using IsoPlot.

inconsistent with cooling of a well-insulated metal core. This is because the high thermal conductivity of Fe metal should lead to an essentially isothermal core [13]. To account for the range in cooling rates, it has been proposed that the insulating mantle of the IIIAB parent body was removed by impact with an equally-sized body, exposing the IIIAB metal core to space [11]. To produce the range of cooling rates it would further be necessary that the IIIAB metal core had a larger radius than that inferred from the Hf-W and Pd-Ag ages, because only then it would be possible to achieve more rapid cooling at the surface and slower cooling in the center. However, Fig. 2 shows that relatively large parent bodies would not cool below Pd-Ag isotope closure at ~4 Ma after CAI formation. Thus, to reconcile a large parent body size with the Pd-Ag cooling age requires that the impact disruption occurred before ~4 Ma after CAI formation, to facilitate the rapid and early cooling required by the Pd-Ag data.

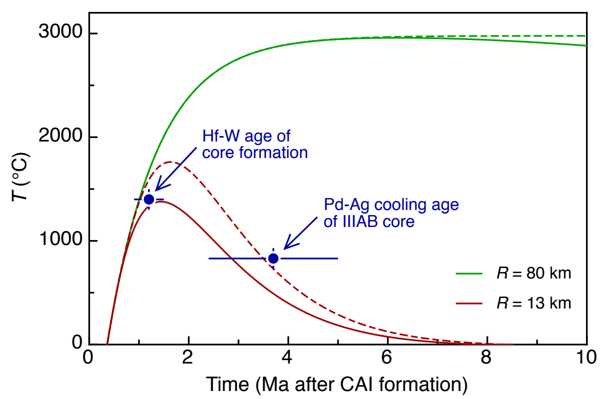

Fig. 2: Time-temperature profiles for an asteroid heated by ^{26}Al decay. Curves are shown for the center (dashed line) and middle of parent bodies with different radii. The Pd-Ag results require a small parent body or, alternatively an early disruption of an initially larger body.

References: [1] Scott, E.R.D. (1972) *GCA*, *36, 1205-1236*. [2] Wasson, J.T. (1999) *GCA*, *63, 2875-2889*. [3] Chen, J.H. and G.J. Wasserburg (1990) *GCA*, *54, 1729-1743*. [4] Carlson, R.W. and E.H. Hauri (2001) *GCA*, *65, 1839-1848*. [5] Woodland, S.J. et al. (2005) *GCA*, *69, 2153-2163*. [6] Horan, M.F. et al. (2012) *EPSL*, *351, 215-222*. [7] Kruijer, T.S. et al. (2013) *EPSL*, *361, 162-172*. [8] Blichert-Toft, J. et al. (2010) *EPSL*, *296, 469-480*. [9] Sugiura, N. and H. Hoshino (2003) *MAPS*, *38, 117-143*. [10] Goldmann, A. et al. (2015) *GCA*, *148, 145-158*. [11] Yang, J. and Goldstein, J.I. (2006) *GCA*, *70,* 3197-3215. [12] Kruijer, T.S. et al. (2014) *Science*, *344, 1150-1154*. [13] Haack, H. et al. (1990) *JGR 95, 5111-5124*. [14] Cook, D.L. et al. (2004) *GCA*, *68, 1413-1431*. [15] Matthes M. et al., this meeting. [16] Leya, I. and J. Masarik (2013) *MAPS*, *48, 665-685*.