Apparent I-Xe cooling rates of chondrules compared with silicates from the Colomera iron meteorite. C. M. Hohenberg, A. P. Meshik, O. V. Pravdivtseva Washington University, Physics Department, CB1105, One Brookings Drive, Saint Louis, MO 63130, USA, cmh@wustl.edu.

Introduction: In I-Xe dating, a regular pattern of increasing $^{*129}Xe/^{*128}Xe$ ratio with increasing extraction temperature is often observed. If one makes the crude assumption that the temperatures at which the Xe is extracted in the laboratory is approximately the same as the temperature at which those sites closed 4.6 Ga ago, a (zeroth order) model cooling rate can be found. In order to test and refine this model we can apply the cooling theory of Dodson [1] to those extraction steps approaching the I-Xe isochrons. Using an Arrhenius plot for these temperature fractions, and assuming that an only single phase is involved, the effective diffusion parameters can be estimated (frequency factor and activation energy). From the apparent (zeroth order) cooling rate, the closure temperature can be estimated from the Dodson equation [1]. This model closure temperature can then be compared with the actual laboratory temperature at which the isochron begins. The ratio of the closure temperature and the temperature corresponding to the start of the isochron provides the ratio of the two temperature scales, incorporation and extraction. The actual cooling rate is then given by the apparent (zeroth order) cooling rate times the temperature scale factor.

Figure 1 shows Arrhenius plots for I-Xe data for a silicate inclusion (K-feldspar) from the Colomera iron meteorite [2], and three individual chondrules from Allende. The activation energy found for the Colomera inclusion is 55 Kcal/mol, and the corresponding closure temperature about 400ºC. The change in model I-Xe age for points approaching the isochron, divided by the extraction temperature interval provides the first approximation of the cooling rate, $4 < \Delta T/\Delta t < 16$ ºC/Ma [2]. Since the isochron for the Colomera silicate begins at about 1500ºC, about 3.8xs the estimated closure temperature, the corrected cooling rate should be about 1/4 of this first approximation, or $1 < \Delta T/\Delta t < 4$ ºC/Ma [2].

Previous studies of Allende chondrules also suggest a regular pattern of increasing model I-Xe age as the extraction temperatures approach the isochron [3]. Arrhenius plots of a representative set of these chondrules are also shown in Figure 1. Chondrules 3, 6 and 9 have apparent activation energies of 185, 89 and 174 kCal/mol, respectively, and apparent closure temperatures 900 °C, 700 °C and 900 °C (about 1.3 xs lower than the temperature at which the isochron begins). We interpret this as indication that the laboratory extraction temperature approximates the corresponding temperature in the rate equation. If true, this implies that the apparent $\Delta T/\Delta t$ in approach to the isochron approximately gives the actual cooling rate of these chondrules. Apparent cooling rates for chondrules 3, 6 and 9 are shown in Table 1 as a function of extraction temperature. Included are the temperature fractions approaching the isochron. Lower temperature fractions do not fit the single phase model in the Arrhenius plot, presumably corresponding to lower temperature phases or iodine contamination. Although there is still some scatter, most of these Allende chondrules a surprisingly consistent apparent cooling rate of 50 – 350 ºC/Ma as the isochron is approached.

Whether this rate applies to cooling in the nebula or the Allende parent body, consistency of this apparent cooling rate among these Allende chondrules is suggestive of the latter, and one to two order of magnitude greater that that inferred for K-feldspar inclusions in the Colemera iron meteorite.

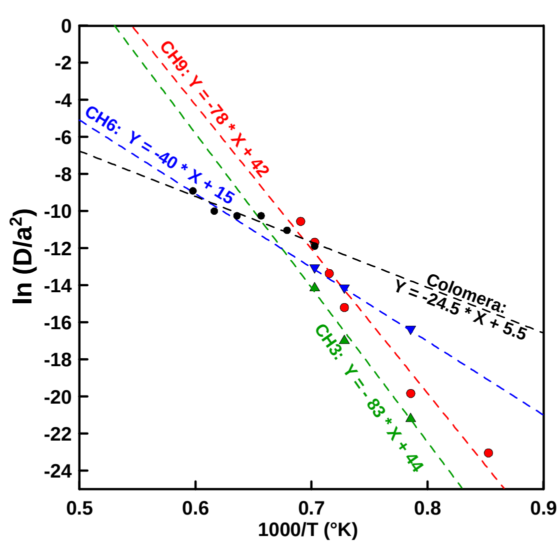

Fig.1 Arrhenius plots (Colomera silicate inclusion and Allende chondrules CH#3, CH#6, CH#9.

Table 1. Model cooling rates for Allende chondrules #3, #6, #9.

T, °C	#3	#6	#9
1200	636	36	41
1300	128	28	67
1325			209
1350	270	94	560
1375			165
1400			70
Average	345	53	185

Acknowledgments: This work supported by NASA grant NAG5-12776.

References: [1] Dodson M. H. (1973) *Contr. Mineral. Petrol.* **40**, 259-274. [2] Pravdivtseva O. V. et al. (2000) ***LPSC XXXI*, #1929**. [3] Swindle T. D. et al. (1983) *GCA* **47**, 2157-2178.