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I-Xe Dating of CAI's and Chondrules from CV3 Meteorites

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Carbonaceous chondrites are some of the most primitive and least altered objects in the solar system, and have been widely studied in an attempt to understand processes in the early solar system. The use of short-lived radionuclides to date events such as the formation of chondrules allows us to put a time-scale on those early processes, and will allow us to distinguish between models requiring either nebular or planetary environments for the formation of refractory inclusions (CAIs) and chondrules. Meteorites from the CV carbonaceous chondrite group have experienced different styles of alteration, resulting in the recognition of both 'reduced' (e.g. Vigarano: only minor alteration) and 'oxidised' (e.g. Mokoia: more extensive hydrous alteration; presence of sodalite and phyllosilicates) sub-groups. The alteration may have occurred either on a parent-body (Krot et al., 1998) or in a nebular environment (Bischoff, 1998) or both.

Five chondrules and one CAI from Vigarano, and two chondrules and two CAIs from Mokoia were separated by hand and portions prepared for petrographic and mineralogical study, and future use with other radiometric systems. The remainder of each sample was neutron irradiated (laboratory designation MN12 3.8 x 10^{18}cm^{-2} fast, 9.2 x 10^{18} cm^{-2} thermal) before xenon isotopic analysis using the RELAX instrument (Gilmour, 1994) in conjunction with low-blank laser stepped-heating of the samples.

Chondrules from both Mokoia and Vigarano show little petrological evidence of post-formation alteration. This is in contrast to the CAIs which in Vigarano appear fresh, but in Mokoia show extensive alteration and replacement of the primary mineralogy with sodalite, andradite, hedenbergite and phyllosilicates. A compact type A CAI from Mokoia (sample M2) has an age of between 2 and 3 m.y. later than Shallowater which we interpret as dating the secondary alteration. A type A CAI from Vigarano (sample V5) with an irregular morphology, consisting of unaltered melilite and spinel, gave a well-defined mixing line on a three-isotope plot (see Figure 1). If the iodine rich end member lies on the intercept of the mixing line with the x-axis, then I/^{129}Xe is 0.46 x 10^4 corresponding to an age 14 m.y. earlier than Shallowater. If the iodine rich end member is the lowest observed data point, and we assume that this composition is obtained by mixing planetary xenon with a single iodine component then an age of 8.3 m.y. earlier than Shallowater is obtained (equivalent to a single datum model age) thus the true age of the CAI is constrained to be between 8.3 and 14 m.y. earlier than Shallowater for plausible assumptions about the end-member. One chondrule from Vigarano (sample V3) formed within 2 Ma of Shallowater but a large porphyritic chondrule from Vigarano (sample V4) appears to have been reset much later than the others, some 40 Ma later than Shallowater, and close examination of the section revealed an unusual texture in the mesostasis which may be the result of aqueous alteration.

The early whole-rock I-Xe age of Vigarano may well be due to the CAIs within the rock which have clearly retained some xenon from shortly after their formation between 8.3 and 14 m.y. earlier than Shallowater and are some of the oldest objects dated by I-Xe. CAIs in Mokoia have been extensively altered, and have ages indistinguishable from chondrules in Mokoia suggesting a common parent-body episode 3 m.y. later than closure in Shallowater. These ages are consistent with Mn-Cr dating of fayalite in chondrules from Mokoia which suggested alteration 16 m.y. later than CAI formation in Allende (Hutcheon 1998).

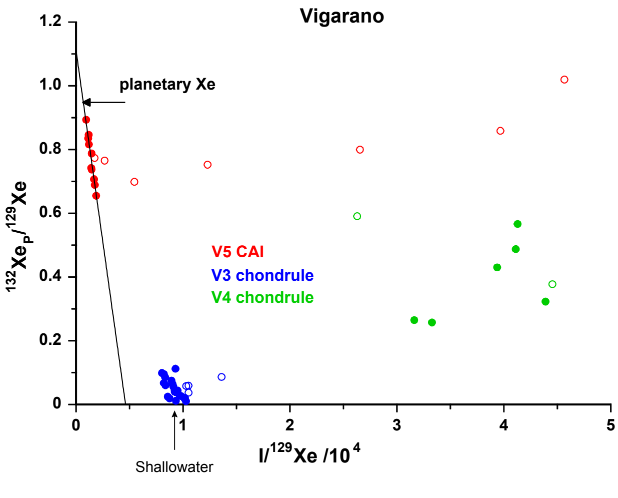

Figure 1: I-Xe data for two chondrules and a CAI from Vigarano. Hollow symbols denote low-temperature gas releases, the solid line is a best fit through the CAI data, and corresponds to an age 14 Ma earlier than Shallowater.

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