MAJOR-ELEMENT COMPOSITIONS AND MINERALOGIES OF SILICATE INCLUSIONS IN IIE IRON METEORITES: IMPACT-INDUCED OR "PLANETARY" DIFFERENTIATION?

Alex Ruzicka[1], Martin Prinz[2], Gregory A. Snyder[1], and Lawrence A. Taylor[1]. [1]Planetary Geosciences Institute, Dept. Geological Sciences, University of Tennessee, Knoxville, TN, 37996. [2]Department of Earth and Planetary Sciences, American Museum of Natural History, New York, New York, 10024.

Silicate inclusions in IIE iron meteorites have O-isotope compositions similar to H-group chondrites [1], textures generally indicative of melting, and major-element compositions that range from broadly chondritic (in Watson and Netschaëvo) [2,3] to highly fractionated (all other IIEs except probably Techado) [e.g., 4-6]. Melting and differentiation may have occurred by (1) impact-melting near the surface of an asteroid [7,8], by (2) normal planetary differentiation, perhaps at the core-mantle boundary of an asteroid [9], or (3) by some combination of impact-melting and planetary differentiation [6,9,10]. The major-element compositions and mineralogies of IIE inclusions can be used to constrain these models. We have focussed on Weekeroo Station as this meteorite contains a variety of fractionated inclusion types. Radiometric and SIMS data for some of these inclusions are presented in companion abstracts [Snyder et al., this volume; Ruzicka et al., this volume].

PETROGRAPHY AND PHASE COMPOSITIONS-- Inclusions in Weekeroo Station are texturally and mineralogically diverse (Table 1). Pyroxene phenocrysts (typically ~100 µm across) in the inclusions are predominantly augite (En_{46-43} Wo_{39-37}) and often contain narrow (<5µm wide) lamellae of orthopyroxene (En_{75-59} $Wo_{1.8-3.1}$). In contrast, inclusion 4 is dominated by a single, coarse (>3-5 mm) grain of orthopyroxene (En_{77} Wo_3). Feldspar in the inclusions is relatively uniform in composition (Ab_{79-83} Or_{3-5}). The composition of glass in inclusions A, 2, and 7 is similar and can be described as a mixture of the feldspar and SiO_2-polymorph (tridymite?) that occurs in the other inclusions.

SIGNIFICANCE OF GLASS-- The presence of glass in some of the inclusions places constraints on the thermal histories of the inclusions. The glass is broadly similar in composition to that of tektites [11]. Annealing experiments on anhydrous tektite compositions indicate that devitrification occurs rapidly (within 10 hours to a few days) between 1000-800°C [11,12]. The tektite data imply that *glass-bearing IIE inclusions cooled from igneous temperatures to 1000°C in 10 hours or less, which is more consistent with a near-surface impact-melt origin than with deep-seated planetary differentiation.* Although it appears that at least the glassy IIE inclusions experienced late-stage impact-melting, this alone does not rule out the possibility that these inclusions were affected by earlier episodes of planetary differentiation.

Table 1. Inclusions in Weekeroo Station (AMNH 2620).

object	predominant mineralogy & texture
A	px set in glass or cryptocrystalline mesostasis
B	px set in albite + SiO_2 mesostasis
1A	fine-grained (<50µm) albite + SiO_2 + FeS
1B	fine-grained (<50µm) albite + SiO_2 + px + FeS
2	glass
4	coarse opx (single xtal) + lesser albite + FeS
6	px set in albite + SiO_2 mesostasis
7	px set in glass

MAJOR-ELEMENT COMPOSITIONS-- The major-element compositions of the inclusions in Weekeroo Station were determined by modal reconstruction. Figs. 1 and 2 show the normative compositions of silicate inclusions in Weekeroo Station (this work) and in a variety of IIE and possibly related iron meteorites (data sources: [2-4,6,7] and unpublished data previously obtained by one of us (MP)). Both diagrams employ the projection scheme used by Longhi [13]. For comparison, Fig. 1 also shows the liquidus equilibria [from 13] most relevant to IIE compositions, and Fig. 2 shows the compositions of melt-pocket-glasses in L-group chondrites [14,15]. Melt-pockets were almost certainly produced by partial-to-complete impact melting of chondrites.

Fig. 1 suggests that *IIE silicates were not produced by simple partial melting of ordinary chondrites*, as compositions do not cluster around peritectic point R.

Fractional crystallization of ordinary chondrite silicate (with melt compositions in Fig. 1 moving from H- and L-group compositions along the dashed lines and ultimately to eutectic point E) is somewhat more promising, as it can produce highly fractionated melts (as well as orthopyroxene cumulates possibly represented by inclusion 4), but even this process has difficulty in accounting for the compositions of many inclusions (e.g., inclusions 7 and 2).

Fig. 2 shows that melt-pocket glasses form a chemical trend that connects the compositions of most IIE silicate inclusions with that of ordinary chondrites. This strongly suggests that *IIE inclusions formed by a more extreme variant of the "impact-differentiation" shown by melt-pockets*. Further support for impact-differentiation, and against normal planetary differentiation, is the absence of an inverse correlation between Mg# and bulk Si and alkali abundances (not shown). Such an inverse correlation is expected for planetary differentiation, but is not observed for either melt-pockets or IIE silicates. Thus, a strong case can be made for the importance of shock-induced differentiation. This is at odds with the conclusions of Keil et. al. [16], who concluded that only trivial amounts of fractionated material are typically produced by impact-melting. However, the data for IIEs do not rule out the possibility of multistage melting events involving planetary differentiation. Moreover, it is uncertain why most IIE meteorites contain only fractionated material, and none of the abundant olivine expected for an H-group precursor.

The data support the idea that IIE silicate inclusions formed by impact-melting, although further study is needed. Impact-induced differentiation of the type required to produce IIE silicates has important implications for planetary processes.

References: [1] Clayton R.N. and Mayeda T.K. (1996) GCA 60, 1999-2117. [2] Olsen E. and Jarosewich E. (1971) Science 174, 583-585. [3] Olsen E. et al. (1994) Meteoritics 29, 200-213. [4] Olsen E. and Jarosewich E. (1970) EPSL 8, 261-266. [5] Prinz M. et al. (1983) LPS XIV, 618-619. [6] Ikeda Y. and Prinz M. (1996) Proc. NIPR 9, 143-173. [7] Rubin A.E. et al. (1986) EPSL 76, 209-226. [8] Wasson J.T. and Wang J. (1986) GCA 50, 725-732. [9] McCoy T.J. (1995) Meteoritics 30, 542-543. [10] Armstrong J.T. et al., (1990) LPS XXI, 22-23. [11] Wosinski J.E. et al. (1967) Science 215, 839-841. [12] Barnes V.E. and Russell R.V. (1966) GCA 30, 143-152. [13] Longhi J. (1991) Am. Mineral. 76, 785-800. [14] Dodd R.T. and Jarosewich E. (1982) EPSL 59, 355-363. [15] Dodd R.T. et al. (1982) EPSL 59, 364-374. [16] Keil K. et al. (1997) M&PS 32, 349-363.

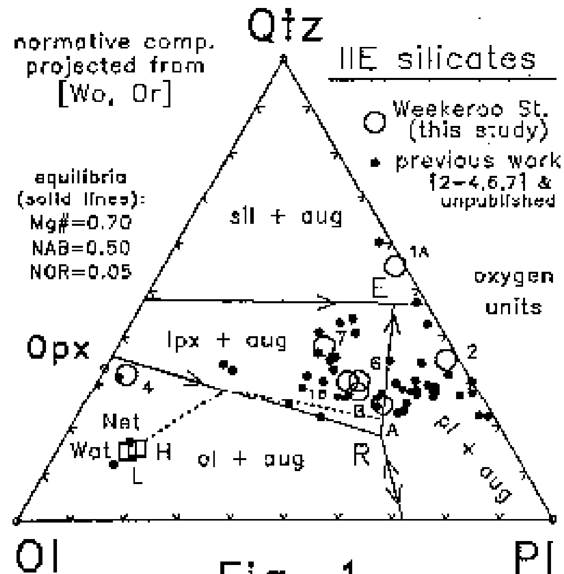

Fig. 1

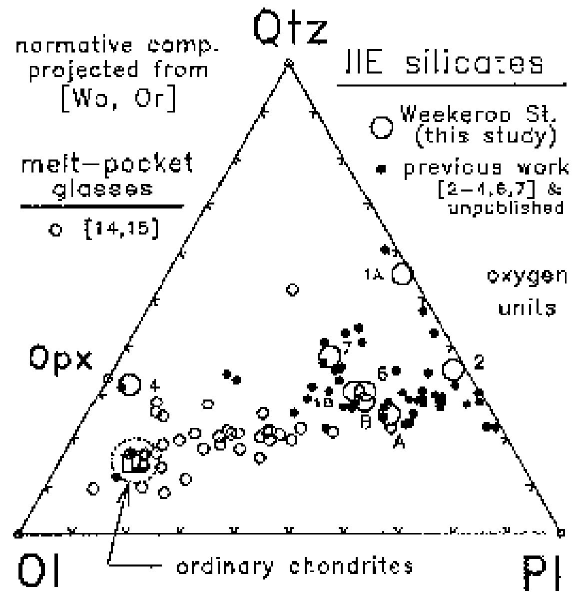

Fig. 2