Ni-Pt-Ge-RICH FREMDLINGE: INDICATORS OF A TURBULENT EARLY SOLAR NEBULA

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One of the oddest aspects of CAIs is the presence of Fremdlinge — complex aggregates of refractory metal alloys and volatile oxides and sulfides. In a series of recent studies of Fremdlinge we have provided evidence that (1) they are not isotopically anomalous and presumably formed in the solar nebula, (2) they were formed as solid objects before any of the major phases in CAIs, (3) processes involved in their formation, prior to incorporation in CAIs, included oxidation and reduction both at high and low temperatures, and (4) their phase assemblages and reaction textures place strict constraints on the maximum temperatures and cooling rates during CAI formation (Armstrong *et al.*, 1984, 1985a, 1985b; Hutcheon *et al.*, 1985).

In this study we examine a particularly unusual subset of Fremdlinge — those extremely rich in Ni and poor in Fe. We have identified a number of such objects in CAIs from the Allende and Bali meteorites. These Fremdlinge are typically composed of Fe-poor, Ni-Pt-rich metal, Os-Ru and Pt-Ir blebs, Ni sulfides (commonly Ni_3S_2) and phosphates, and do not contain Fe-bearing phases, such as FeS and magnetite, commonly found in other Fremdlinge. They are remarkable in containing large concentrations of volatile siderophiles, such as Ge and Sn (also, cf. El Goresy, 1978; Wark and Lovering, 1978). These Fremdlinge range in size from ~ 10-40 μm, and are composed mainly of discrete 1-10 μm grains. The Pt content of the Ni-rich metal ranges from 3-25%, and Ge varies from ~ 0.2-3%. Ge is concentrated in two sulfides — up to about 0.5% in Ni_3S_2 and at a level of about 17% in an unidentified, lathlike phase of approximate composition Ni_5GeS (found in a number of Fremdlinge from the Bali meteorite). Typical compositions are given in Tables 1 and 2.

Table 1
Fremdlinge Ge1, Allende Egg-3

	NiPt	OsRu	Ni_3S_2
Ni	72.7	5.3	71.9
Co	4.4	0.3	0.5
Fe	10.0	1.2	0.3
Pt	7.2	—	0.5
Ir	3.4	13.8	—
Os	—	36.4	—
Ru	—	40.4	—
S	—	—	26.6

Table 2
Fremdlinge Ge2, Bali Kur-1

	NiPt	Ni_5GeS
Ni	60.8	72.5
Co	6.0	1.0
Fe	9.0	0.9
Pt	21.7	0.4
Ge	1.7	17.2
Sn	0.1	0.2
Te	—	0.1

Data in el. wt.%

Ni-Ge-rich Fremdlinge must have formed either by alteration of preexisting Fremdlinge in the CAIs or by reactions before incorporation into CAIs. Some Ni-enriched Fremdlinge appear to have formed by *in-situ*, disruptive alteration involving sulfidization of preexisting Fremdlinge in CAIs (Armstrong *et al.*, 1984, 1985a); however, the Ni-Pt-Ge-rich objects described in this study show no such textural evidence. Moreover, alteration after incorporation in CAIs requires a source and concentration mechanism to produce the high levels of Ge which are at least two to three orders of magnitude above those found in typical Fremdlinge or CAI phases. These Fremdlinge are more likely formed from alteration of proto-Fremdlinge by back reactions in the solar nebula — losing Fe under oxidizing conditions at moderate T and gaining Ge, Sn and Te under reducing conditions at lower T. The coexistence of volatiles, such as Ge, Sn, Te and Ni_3S_2, with refractory phases, such as OsRu, underscores the complexity of the several stages of chemistry that must have preceded formation of CAIs. These phases could not have formed in a single condensation sequence and must have involved either aggregation or transfer of preexisting grains from regions of the solar nebula having considerably different temperatures and oxygen fugacities.

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BE-10 CONTENTS OF APOLLO 17 DOUBLE DRIVE TUBE 74002/1

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As part of a study of ^{10}Be production rate systematics in extraterrestrial material we have measured the ^{10}Be contents of nine samples from the Apollo 17 double drive tube 74002/1. Material taken 5 cm or more from the top of the tube probably lay undisturbed on the moon for the last 10 Ma (Eugster *et al.*, 1981). Calculations by Reedy (1984); and published data (Nishiizumi *et al.*, 1984, 1985; Finkel *et al.*, 1971; Wahlen *et al.*, 1972) suggested that samples from 74002/1 would span a range of depths suitable for observing the key features expected for the ^{10}Be production rate profile: a small maximum near 30 g/cm^2 and an exponential decrease at greater depths.

Experimental — We measured ^{10}Be by accelerator mass spectrometry in two sets of experiments, (1) at Rutgers U. (Moniot *et al.*, 1982; Tuniz *et al.*, 1984a) and (2) at U. Pennsylvania (Klein *et al.*, 1982). For the latter we added 200 μg of Be as a first spike, removed co-extracted iron by anion exchange, and extracted Be without the use of EDTA. Yields for samples reported here ranged from 80-98%. We checked the reliability of our ^{10}Be standard by comparing it to the one prepared by K. Nishiizumi, U. California at San Diego. The ^{10}Be/^{9}Be ratios of the two standards agreed to within $1 \pm 5\%$.

Results — The ^{10}Be measurements from Rutgers U. and U. Pennsylvania are in fair agreement. Those from the U. Pennsylvania have smaller uncertainties because of the greater output and stability of that accelerator's particle source. The ^{10}Be contents range from about 9 dpm/kg at depths of 10 and 100 g/cm^2 to about 14 dpm/kg near 30-40 g/cm^2. At depths between 20 and 70 g/cm^2 the ^{10}Be contents of the 74002/1 samples exceed those obtained for the Apollo 15 drill core (Nishiizumi *et al.*, 1984) by ~ 30%. At shallower and greater depths the two sets of results are in accord. The Apollo 15 core suffered disturbances to a depth of about 30 g/cm^2 which may explain some of the differences between the two profiles. The values we obtain between 10 and 50 g/cm^2 are consistent with measurements