TRACE ELEMENT DISTRIBUTION IN MINERALS FROM A SILICATE INCLUSION IN THE CADDO IAB-IRON METEORITE; H. Palme[1], I. D. Hutcheon[2], A. K. Kennedy[2], Y. J. Sheng[2] and B. Spettel[1]. [1]MPI f. Chemie, Saarstrasse 23 6500 Mainz, Germany; [2]Div. Geol. & Planet. Sci., Caltech, Pasadena, CA 91125.

The Caddo IAB-iron meteorite was found in 1987 and is classified as a IAB-iron meteorite with silicate inclusions (1).

A 4x5x0.4 cm slice, available for investigation, consisted primarily of silicate with minor metal. A 280 mg silicate sample was separated for bulk analysis by INAA and from another part of the fragment a thin section was prepared.

Major minerals in silicate inclusions are olivine (Fa_{3-4}), orthopyroxene ($En_{91.6}$ $Fs_{6.4}$ Wo_2), clinopyroxene (En_{43} Fs_3 Wo_{54}), and plagioclase (An_{17} Ab_{80} Or_3). Minor constituents are apatite, chromite, troilite and metal. The inclusion is coarse grained with crystal sizes from 0.1 to 3 mm. The overall texture resembles a hetero-adcumulate rock with rounded to anhedral olivine, irregular plagioclase and anhedral orthopyroxene grains with 120° triple junctions indicating extensive recrystallization, characteristic of metamorphic rocks. Point counting on the thin section gave a modal content of 37% ol, 35% cpx, 6% opx, 8% plag, 11% me+sul and <2% apatite. An unusually high content of cpx is also evident from the bulk analysis, which shows 3.5 to 4 xCI REE and Ca (Table 1), corresponding to about 20% cpx. The bulk sample also has a significant Eu-anomaly, similar to the cpx separates. The major and trace element composition of the minerals are, in most cases, homogeneous with no systematic variations in composition throughout the section.

Ion microprobe analyses of REE, Sc, V and several other trace elements were performed in ol, cpx, opx, plag and apatite using PANURGE. The distribution of REE in various minerals of the inclusion are shown in the Figure. The results are very similar to REE contents determined by INAA in single mineral grains of silicate inclusions in the Landes IAB-iron meteorite (2). A major difference with Landes is the low content of heavy REE in plagioclase (0.013 ppm Yb in Caddo plag vs. 0.116 ppm in Landes plag). This may reflect a different cooling history for Caddo, as in this type of inclusion plagioclase is the last mineral to crystallize or the first to melt (3). The REE contents of apatite are much lower than typical values for apatites in ordinary chondrites, angrites and shergottites (4-6), suggesting secondary formation of apatite during cooling by oxidation of metallic phosphorus or schreibersite. The primary occurrence of apatite as intergrowth with metal is consistent with this model. In both Landes and Caddo silicate inclusions, phosphates are not important as REE-carriers.

The equilibration temperature, calculated from the enstatite-diopside solvus and based on preliminary cpx and opx analyses, is 1040°C (7). Olivines are zoned in Ca from 115 ppm in the center to 60 ppm at the rim (ion probe data). Temperatures derived from the center analysis are 607°C and those at the rim 530°C (8). Because diffusion of Ca in olivine is much faster than in px, ol equilibrates with cpx to lower temperatures. The gradual decrease in Ca contents can be used to determine cooling rates (9). A similar zoning profile was found for Ni, with 2.6 ppm in the center and 1.4 ppm at the rim of one olivine crystal. The exchange of Ni between ol and metal is temperature dependent (10). A preliminary calculation gives temperatures of 635°C at the center and 513°C at the rim assuming 7% Ni in the metal (a corresponding analysis is in progress), very similar to the temperatures derived from Ca .

Silicate inclusions in IAB-iron meteorites and in the chemically and mineralogically similar winonaites (11) document the result of extensive thermal metamorphism inside a planetary body at temperatures of around 1000°C. Any relicts of pre-accretionary processes are completely erased, including the presence of chondrules. The content of volatile elements such as Zn, S, and also the rare gases, including ^{129}Xe (12), is higher than in ordinary chondrites despite higher metamorphic

temperatures, probably reflecting greater burial depth inside a planetesimal. Differencies in texture and mineral composition among these meteorites reflect variations in their cooling history. Zonation of Ca in olivine allows to independently determine cooling rates in the temperature range of 650 and 450°C. These data are essential in establishing the size and the cooling history of early formed planetesimals.

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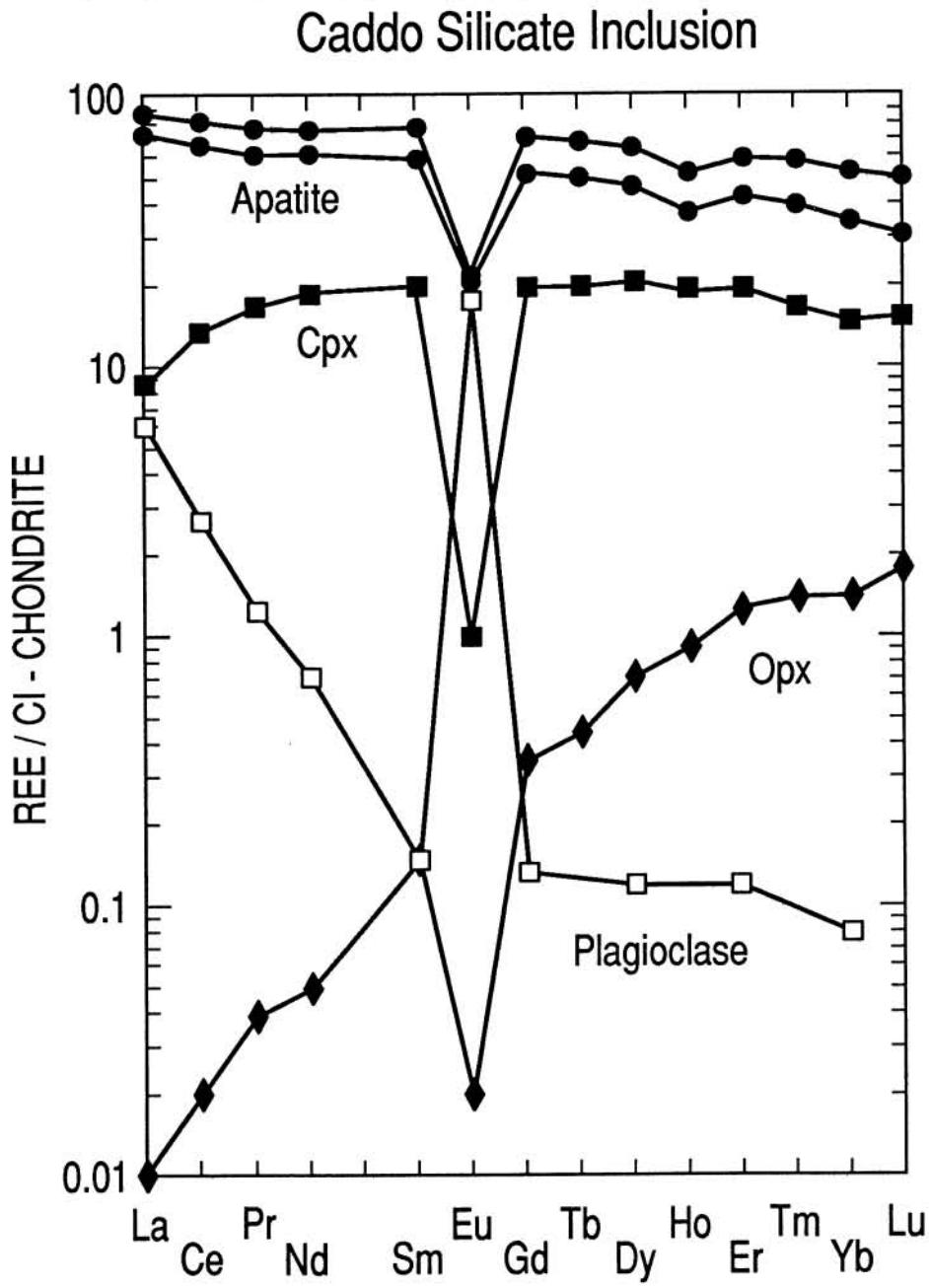

Table 1: Bulk composition of a silicate inclusion in Caddo

		s.d. %
%		
Ca	3.4	8
Fe	13.79	3
ppm		
Na	8120	3
K	530	8
Sc	14.4	3
Cr	2640	4
Mn	2215	3
Co	498	3
Ni	12300	4
Zn	170	10
Ga	10.5	8
As	1.59	7
Se	5.93	6
Br	1.81	9
Ru	0.72	15
Sb	0.068	20
La	0.64	6
Ce	1.9	20
Sm	0.704	5
Eu	0.16	8
Tb	0.16	11
Dy	0.81	15
Ho	0.2	15
Yb	0.55	5
Lu	0.077	10
Hf	0.47	6
Re	0.03	20
Os	0.38	11
Ir	0.324	3
Au	0.164	3
Th	<0.07	
U	<0.2	

s.d.-standard deviation
data by INAA