Exsolution textures produced by annealing a metal alloy of Fremdlinge composition. A. Bischoff, Institut für Planetologie, Wilhelm-Klemm-Str.10, and Institut für Mineralogie, Corrensstr.24, 4400 Münster, F.R.G.

Fremdlinge are refractory metal-rich aggregates in Ca,Al-rich inclusions. Many Fremdlinge contain cores of NiFe-metal, poikilitically enclosing Os,Ru,Re-rich particles (e.g.[1]). Two constrasting scenarios for the origin of Fremdlinge have been discussed:(1) low T aggregation in the nebula (e.g.[2,3]), with no severe alteration during and after the incorporation into the CAI, or (2) homogenization and reequilibration within a CAI on cooling (e.g.[4,5]). In the first case the Fremdlinge would have preserved original pre-CAI textures and equilibria and in the second case the reequilibration on cooling would require the exsolution of Os,Ru,Re-rich particles in NiFe-metal. This abstract presents the first results of an experimental study on Fremdlinge compositions and supports the findings by [5], who studied the Ni-Ru-system.

Sample preparation. For the annealing experiment an eight element mixture was prepared. The composition of the starting material was based on the bulk composition of Fremdlinge in the Allende CAI A37 [1]. Pure metal powders of Re, Os, Ru, Ir, W, Mo, Fe, and Ni were used (Table 1). The metal mixture was mechanically compacted and loaded on a water-cooled copper plate in the electron furnace. The melting process was performed under a vacuum ($\approx 10^{-5}$ Torr). After quenching in vacuum a large metal spherule was removed from the furnace. During the melting procedure 15.5 wt% of the starting material were lost mainly in form of small spherules that were ejected from the target during the melting process. The sample was cut into several pieces. Before the annealing processes one piece was studied by electron microscopy. The sample was homogeneous even in its center. No variations in composition could be determined. The two annealed aliquots described in this study were heated in quartz glass tubes for one week at 900°C and 1 atm. Glass tubes were evacuated and flushed with Ar-gas for four times. After heating for one week one sample was quenched in air, the other was stepwise cooled to 400°C in 34 days.

In both samples exsolution textures were observed. Differences in the textures and compositions will be described below.

Quenched sample. 4.1 vol% Os-rich particles were exsolved from the alloy. These Os-rich grains are mainly homogeneously distributed throughout the sample (Fig. 1), and probably formed by homogeneous nucleation. Most particles are round and smaller than 2μm in diameter. In some areas they are arranged in chains, and in very restricted areas they have a wormy, elongated appearance. Based on the great difference in the atomic numbers between Fe, Ni, and W, Os, Re, Ru, Mo, Ir, the NiFe-rich matrix appears very heterogeneous in the BSEM-image. Near the Os-rich particles the matrix is depleted in Os, Re etc. causing a much darker image than at greater distances. There is a continuous gradation between areas depleted in refractory metals and those areas in which the nucleation of Os-rich grains had failed (Fig. 1). Some typical analyses of the NiFe-matrix material are listed in Table 1 demonstrating the variations especially in Os due to various distances from the exsolved Os-rich grains. The largest variations were found for W (1.81-5 wt%) resulting in a relatively high mean concentration of 2.45 wt% (Tab. 1). All other metals show very little variations, for example Ru (1.56-2.36 wt%), Ir (5.3-7.6 wt%) and Mo (1.38-2.26 wt%). All Os-rich particles have very similar compositions. The mean composition is listed in Table 1. The exsolved Os-rich grains are enriched in Os, Re, Ru, Mo, and W relative to the NiFe-matrix, while Ir partitioned into both the NiFe-matrix and the exsolved Os-rich nuggets (Table 1).

Stepwise cooled sample. The stepwise-cooled sample contains ≈6.5 vol% Os-rich grains. Most of these grains (≈3μm) are larger than in the quenched sample; however, in addition a population of small grains (<0.5μm) is present that might have formed during the stepwise cooling process. The abundance of elongated, wormy grains is much lower than within the quenched sample. The Os-rich grains have somewhat higher Os- and lower Ir-concentrations compared with the previous sample (Table 2). The NiFe-matrix is very heterogeneous (Fig. 2). During the cooling process sharp boundaries were formed. It appears that these boundaries prevented diffusive equilibration (especially of Os) between neighbouring areas. Each area has a different contents of the heavy refractory metals. In the darker areas around Os-grains 3-6 wt% Os were analyzed, whereas the light regions within the matrix have Os-concentrations of up to ≈10 wt% (Table 2).

Conclusions: This study demonstrates that the Fremdlinge texture (Os-rich grains in NiFe-matrix) can be produced by exsolution. The exsolution process can be best explained during the cooling history of the CAIs. It is also possible that exsolution already occurred in the solar nebula (like the formation of V-magnetite or other volatile-rich phases) prior to the incorporation into the CAI. Information for the latter possibility can be obtained by the study of Fremdlinge from the CAI A37 [1].

[1]Bischoff and Palme, GCA 51, 2733-2748 (1987); [2]El Goresy et al., 9th PLPSC, 1279-1303 (1978); [3]Armstrong et al., GCA 49, 1001-1022 (1985); [4]Wark and Lovering, LPS IX 1214-1216 (1978); [5]Blum et al., 50th Meeting of the Meteoritical Society, Newcastle upon Tyne, 15 (1987).

Table 1: Quenched sample

	1	2	3	4	5	6	7
Fe	25.1	24.6	25.9	25.9	24.3	25.1	6.4
Ni	50.3	49.4	54.7	51.7	49.3	50.8	8.7
Mo	2.81	2.22	2.05	2.08	1.71	1.87	8.2
Ru	1.98	2.31	2.20	1.95	1.59	1.86	7.5
W	2.40	2.12	1.81	2.09	2.03	2.45	6.0
Re	0.91	1.09	1.12	0.90	1.09	0.92	4.6
Os	11.0	11.8	7.5	9.0	10.2	8.5	52.0
Ir	5.5	6.5	5.7	6.7	6.9	6.6	6.7
Total	100.00		100.98		97.12		100.1
		100.04		100.32		98.1	

1:starting composition; 2:mean bulk composition of the annealed sample (normalized to 100%); 3-5: typical analyses of the NiFe-matrix; 6:mean composition of the NiFe-matrix; 7:mean composition of Os-rich particles (normalized to 100%).

Fig.1

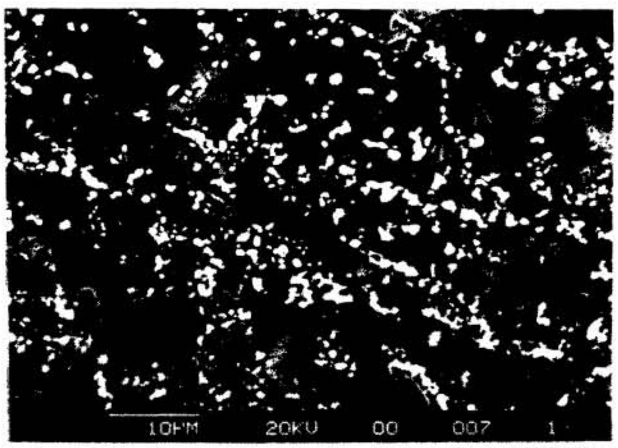

Table 2: Stepwise cooled sample

	1	2	3	4	5	6	7
Fe	26.8	27.3	27.6	26.5	25.9	25.5	5.8
Ni	57.3	57.7	56.0	51.9	53.5	49.7	7.5
Mo	1.65	1.47	1.73	2.00	2.04	2.04	8.7
Ru	1.56	1.50	1.75	2.30	1.91	2.35	8.1
W	1.26	0.98	1.91	2.07	1.98	2.17	5.8
Re	0.87	0.59	0.67	0.74	0.60	0.55	4.8
Os	3.6	5.5	6.3	7.9	8.6	9.4	53.6
Ir	6.2	6.1	7.5	7.1	7.0	7.7	5.7
Total	99.24		103.46		101.53		100.0
		101.14		100.51		99.41	

1-6:typical analyses of the NiFe-matrix (from dark areas (1) to light areas (6); see Fig. 2); 7:mean composition of Os-rich grains (normalized to 100%)

Fig.2