MEASUREMENT OF PGEs, Re, Mo, W AND Au IN METEORITIC Fe-Ni METAL. M. I. Petaev[1,2] and S. B. Jacobsen[2], [1]Harvard-Smithsonian Center for Astrophysics, 60 Garden St, Cambridge, MA 02138, USA; [2]Department of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02139, USA.

Introduction: The concentrations of Ni, Ga, Ge, and Ir are typically used to assign an iron meteorite to one of the chemical groups [cf., 1-3]. The improvements in analytical techniques, mainly INAA, and the systematic study of a large number of iron meteorites resulted in the development of an extensive database on their chemical compositions [4] which has been used in deciphering the origins of iron meteorites. Other sources of high-quality data for trace elements are isotopic studies of iron meteorites [5-7]. The quality of the analytical data varies depending upon the time and technique used to acquire the data.

Recently [8] we have initiated a study aiming to model the trace element behavior during the early stages of planetary evolution together with the isotopic evolution of both long-lived (*e.g.*, Re-Pt-Os) and extinct (*e.g.*, Pd-Ag, and Hf-W) isotope systems. For the purpose of this study we needed high quality elemental and isotopic data on Mo, Re, Os, Pt, Pd, Ag, W, and other siderophiles. Data on some of these (Os, Re, Pd, Ag) are already available in literature, but on others (Mo, Ru, Rh, Pt, W) they are either of low quality or even missing for many samples of interest. To create a consistent database for our project, we started analyzing a series of iron meteorites for PGEs, Mo, Re, W, and other trace elements using our LA-ICP-MS system.

Several research groups [9-11] have already used the LA-ICP-MS techniques to measure concentrations of trace elements in iron meteorites, but essentially no data other than on the kamacite/plessite distribution coefficients have been reported so far.

Samples and Methods: The 266-nm laser ablation system (NewWave-Merchantek UP266) interfaced to the VG-PQ2+ ICP-MS in addition to the JEOL SuperProbe 733 were used to measure chemical compositions of kamacite and plessite in the Arispe (IC), Bennett County (IIA), Grant (IIIB), Cape of Good Hope (IVB), Cape York (IIIA), Carbo (IID), Chinga (IVB An), Coahuila (IIA), Duchesne (IVA), Gibeon (IVA), Henbury (IIIA), Mundrabilla (IIICD An), Negrillos (IIA), Odessa (IA), Sikhote-Alin (IIB), and Toluca (IA) irons and in the Divnoe primitive achondrite. Before making the LA-ICP-MS measurements, all octahedrites were lightly etched with 0.5% Nital to reveal kamacite bands and plessite fields. Pure metals and Fe,Ni alloys served as the EMPA standards; the LA-ICP-MS standards were the iron meteorites Filomena (IIA) and Hoba (IVB). The chemical compositions of Filomena and Hoba are from [5,6,7,11].

Prior to the LA-ICP-MS experiments, all meteorites were analyzed for Fe, Ni, Co, Cr, S, and P by DBA (50 µm spots). The typical deviations from the reported concentrations of Ni were within the range of 0.1–0.3 wt. %.

The LA-ICP-MS measurements were performed at the laser repetition rate of 20 Hz and energy output of 65 % (10 – 11 J/cm^2); Ar carrier, auxiliary, cool, and N_2 gases flow at 0.6-0.8/1.0/13.5/0.08 L/min. All spectra were acquired using a time-resolved analyses procedure; typically 30 time slices (10-11 for the background and the rest for the signal) were collected over the total acquision time of 60 sec. A monitor standard was analyzed before and after each sample including reference standards. At least three consecutive experiments were performed on each phase in all meteorites and standards.

In the LA-ICP-MS analyses we measured the following isotopes: ^{61}Ni, ^{95}Mo, ^{101}Ru, ^{102}Ru, ^{103}Rh, ^{105}Pd, ^{106}Pd, ^{108}Pd, ^{182}W, ^{184}W, ^{185}Re, ^{187}Re, ^{189}Os, ^{192}Os, ^{193}Ir, ^{195}Pt. Ni was used as an internal standard. The analyses of individual spots (≥40 µm) and line scans are essentially the same. In this study we used 160-µm spots to enhance the count rates of the less abundant elements as well as to achieve better averaging of heterogeneous plessite fields. In the dry plasma used for laser ablation, oxide production is low and therefore metal-oxide interferences are in general negligible, but Ni-, Cu-, and Zn-argide interferences on the LPGEs can be considerable. The Ru, Rh, and Pd data were corrected for the argide interferences using the method described in [12]. The elemental concentrations were calculated according to the reduction procedure described in [13].

Bulk compositions of octahedritic meteorites were calculated from the measured concentrations of trace elements in kamacite and plessite whose abundances were estimated from the mass-balance of Ni: $X_{kam} = (Ni_{ple}-Ni_{bulk})/(Ni_{ple}-Ni_{kam})$ and $X_{ple} = 1-X_{kam}$. Bulk concentrations of Ni are from [14]. This approach ignores troilite (which is depleted in siderophile elements) as well as the small amounts of schreibersite. Another potential source of uncertainties lies in the chemical heterogeneity of plessite fields which typically show M-shaped zoning in Ni, Co, and trace elements [11]. Because the high-Ni and PGE-rich taenite bands of a plessite field constitute a volumetrically small portion of a field, we analyzed the central portions of plessite fields as representative samples of plessite.

Results: Table 1 and Figs. 1-4 report concentrations of trace elements in selected meteorites which have been previously analyzed by other techniques. The whole set of data obtained in this study is reported and discussed in the accompanying abstract [8].

The chemical analyses of Coahuila obtained over the course of this study (Table 1) show excellent reproducibility for all elements as well as a good agreement with literature data (Fig. 1).

Fig. 2 shows that the Pd concentrations measured by us are in very good agreement with the isotope dilution data [6,7]. Small deviations of Cape York and Gibeon are certainly due to the well known heterogeneity among individual specimens of these huge meteorite showers.

Figs. 3 and 4 compare our Re and Os data for Bennett County, Cape York, Coahuila, Duchesne, Gibeon, Henbury, Negrillos, Sikhote-Alin, and Odessa with those measured by isotope dilution [5]. Again, the match is excellent for all meteorites except for higher values in Negrillos (~9 % in Re and ~ 6 % in Os) and Bennett County (~ 5% in Re).

Conclusion: The good match between the LA-ICP-MS and isotope dilution data, not only for homogeneous hexahedrites and ataxites but for heterogeneous octahedrites, clearly shows that our LA-ICP-MS system can be successfully used for analyses of iron meteorites. It also proves the validity of our approach to calculating bulk compositions of Fe,Ni metal of iron meteorites from chemical compositions of kamacite and plessite.

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Table 1. Concentrations of trace elements (ppm) in Coahuila.

Date	Mo	Ru	Rh	Pd	W	Re	Os	Ir	Pt	Au
13-Dec-02	6.45	20.25	3.08	1.55	2.87	1.28	9.61	15.58	26.31	0.539
16-Dec-02	6.79	19.19	2.97	1.54	3.05	1.19	9.22	15.56	26.26	0.513
17-Dec-02	6.93	20.88	3.23	1.74	2.91	1.29	10.08	16.62	27.37	0.444
26-Dec-02	6.81	21.41	2.94	1.62	2.96	1.22	9.66	15.98	25.37	0.477
27-Dec-02	6.88	19.22	2.91	1.60	2.83	1.13	9.60	15.54	24.90	0.470
Average	6.77	20.19	3.02	1.61	2.93	1.22	9.63	15.86	26.04	0.489
1-σ	0.19	0.99	0.13	0.08	0.09	0.06	0.30	0.46	0.96	0.037
%Dev	3	5	4	5	3	5	3	3	4	8

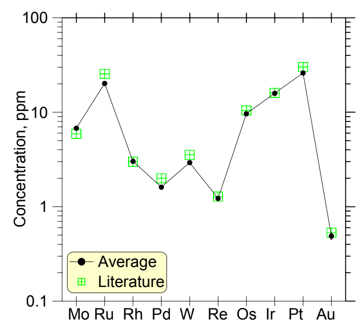

Fig. 1. Trace elements in Coahuila.

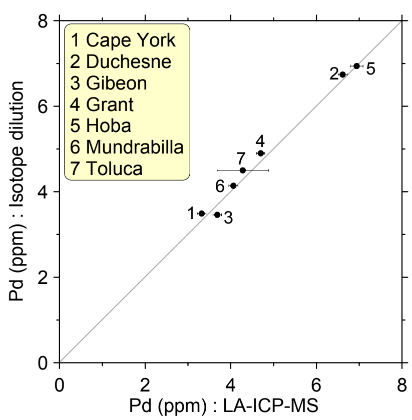

Fig. 2. Pd concentrations in selected meteorites measured by LA-ICP-MS (this study) and isotope dilution [6,7]. Experimental uncertainties are 1 σ.

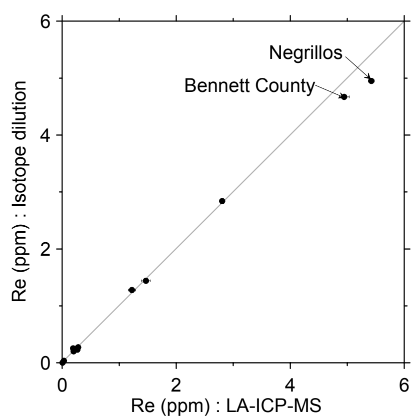

Fig. 3. Re concentrations in selected meteorites measured by LA-ICP-MS (this study) and isotope dilution [5]. Experimental uncertainties are 1 σ.

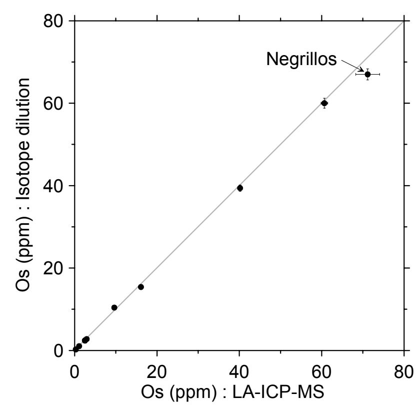

Fig. 4. Os concentrations in selected meteorites measured by LA-ICP-MS (this study) and isotope dilution [5]. Experimental uncertainties are 1 σ.