NI ISOTOPIC COMPOSITIONS IN TERRESTRIAL AND METEORITIC SAMPLES,
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Since the discovery of oxygen anomalies in the Allende meteorite [1], isotopic anomalies for various elements have been found and several theoretical approaches were proposed to explain these anomalies. However, the data base for these anomalies is still very limited and, therefore, generally consistent theoretical interpretations are not yet possible. Of particular importance is the investigation of the isotopic compositions of the iron group elements because the theoretical studies for nucleosynthesis show a sensitive dependence on temperature and proton-neutron ratio for production of these nuclides. If isotopic variations of iron peak region elements such as Ti, V, Cr, Fe, Ni, Cu or Zn exist, isotopic studies of these elements would provide important information and constraints for the theories of nucleosynthesis and the history of the early solar system. Morand et al. [2] and Birck et al. [3] reported Ni and Cr isotopic compositions in meteoritic samples and found no significant isotopic variations. On the other hand, Niederer et al. [4] and Niemeyer and Lugmair [NL] [5] established that isotopically anomalous Ti is ubiquitous in Allende inclusions, similar to what has been observed for O. In conjunction with the dominant 50Ti excesses in normal Allende inclusions [NL] discussed existing models involving neutron-rich, quasi-equilibrium conditions in the interior of a star and pointed out that isotopic anomalies of similar magnitude could be expected for 48Ca, 54Cr, 58Fe, 64Ni and 66Zn. Thus it is important to investigate the isotopic abundances of these elements in samples which have anomalous Ti. For this reason, we started the development of high purity chemical and mass spectrometric procedures which permit the precise measurements of Ni isotopic abundances in natural samples. A second important reason for Ni isotopic measurements is the possible detection of traces of the short-lived extinct nuclide 60Fe whose half-life, according to newest considerations, could be as long as 10^7y [6], and thus would be important as planetary heat-source and nucleochronometer. We present here the initial results from our study of Ni isotopic compositions for terrestrial rock JB-1 and matrices of the Allende and Khohar meteorites.

For the separation of Ni from natural samples, we adopted a cation exchange column procedure using 1N HCl followed by solvent extraction. Chemical yields of more than 80% are routinely obtained. Ni blank determined for the total procedure is ~2ng which mostly stems from the organic reagents (dimethylglyoxime, citric acid). The mass spectrometer used for the results reported here was the LJMS-1 instrument. The samples were loaded on v-shaped Re filaments which were first covered with a silica-gel sponge. After gentle drying, Ni was oxidized at 2A for a few seconds. Ni was measured as the metal species. 4pg samples yielded stable ion currents of 5 x 10^-12 of 58Ni for over 12hours. The mass range between 52 and 70 was monitored for each sample before measurement with the electron multiplier. A satellite peak at mass 58.04 was usually observed. However, this peak is easily resolved from 58Ni. Other masses which might interfere with the Ni isotopes are Fe+, KF+, CaF+, CaO+, TiO+ and Zn+. For Fe+, KF+, CaF+ and Zn+, we found that the interferences were negligible (<<10^-4). CaF+ can be monitored with 40CaF+ at A=59. No significant interferences were observed for 61Ni and 62Ni below ~280°C. TiO+ can be monitored with 47TiO+ at A=63, but 48TiO+ is ten times larger than 47TiO+, making it difficult to estimate the amount of interference at A=64. However, we did not observe any temperature dependent change of the relative abundance of 64Ni up to 1300-1350°C, or any signals on A=63 besides a small hydrocarbon below ~1300°C. Thus, we conclude that TiO+ interferences are negligible.
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below 1300°C. Therefore, all samples were measured at filament temperatures below 1300°C, usually in the range 1200±1280°C.

The results of 18 standard runs of normals prepared from high purity Ni metal are shown in Fig. 1. The mean of these measurements are 61/60=0.043274 ± 6, 62/60=0.137481 ± 10 and 64/60=0.034706 ± 6 normalized to the NBS value of 58/60=2.6164 where the errors are 2σm. Non-linear mass dependent fractionation effects were observed ranging up to 7ε-units in 64/58. With the application of the exponential law for fractionation correction [7], these mass dependent residual effects were eliminated. The 61/60 and 62/60 ratios agree well with the values of Morand et al. [2], whereas our value for 64/60 is 3.3% higher.

In order to permit the detection of possible variations in 60Ni, we renormalized all our data to 62/58=0.052545 which is calculated from our 62/60 value, yielding 60/58=0.382200 ± 12, 61/58=0.016541 ± 3 and 64/58=0.013265 ± 3. From Fig. 1, it can be seen that isotopic variations for 4μg samples could be resolved at present at a level of 2, 10 and 10ε-units for 60/58, 61/58 and 64/58 respectively. Work is under way to investigate modifications of the loading procedure to improve the current sensitivity and precision. Fig. 2 shows initial results for terrestrial and meteoritic samples. All values for terrestrial basalt JB-1 agree with the standard within error limits. The first meteoritic samples (i.e. matrices) were chosen in part because of their relatively high Ni content. These matrix samples were not pure and contained 10% to 20% of chondrules and inclusions. Three measurements so far for the Allende (C3V) and Kharo (L3) meteorites show no significant isotopic anomalies. Investigations for the Allende inclusions and other meteorite samples which show Ni anomalies are in progress.

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