Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 499

Heavy Solar Noble Gases in Meteorites – New Insights into a Unique Archive of Solar Wind

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Introduction

Solar noble gases trapped in lunar and asteroidal regolith samples are a unique long-time archive, allowing us to study the evolution of the outer solar atmosphere. By closed system etching and single-grain analyses it has been shown that Ar, Kr and Xe implanted by the solar wind are retained unfractionated in lunar soils [Wieler et al., 1994]. Almost no data on solar Kr and Xe in meteorites are available so far, because the primordial component, which is mostly situated in carbonaceous phases, compromises the solar signal. A possibility to separate the solar and primordial components is by closed system stepwise etching with HF, which should attack the carbonaceous phases less efficiently than the solar-gas-bearing silicates. Here we present isotopic and elemental ratios of implanted solar Kr and Xe from the regolithic meteorites Fayetteville, Pesyanoe and Acfer111. At the conference data from Noblesville will also be available.

Experimental procedure

We analysed bulk silicate grain-size separates (300-400 mg; 60-100μm) and additionally from Acfer111 a metal fraction. All samples were very gently crushed, sieved and cleaned with ethanol with no further treatment. Pesyanoe was chosen because it appeared to contain no primordial Xe [Kim & Marti, 1992], Fayetteville is one of the most solar-gas-rich chondrites and Acfer111 contains unfractionated light solar noble gases [Pedroni & Begemann, 1994]. Noble gases were extracted by stepwise etching with HF at room temperature in our Au-Pt line connected to a mass spectrometer. This avoids fractionation due to diffusive gas release at high temperatures and allows us to obtain depth profiles of the noble gas composition in the grains. Results: We observed a solar-wind-like isotopic composition of He, Ne and Ar in the first several etch steps in all samples. With progressive etching , the He- and Ne-composition changed to SEP (solar energetic particles). These results will guide our interpretation of the Kr-, Xe-composition and the 36-Ar/84-Kr, 84-Kr/132-Xe ratios. Fayetteville shows in the first steps nearly constant 84-Kr/132-Xe (8.3) and 36-Ar/84-Kr (2870) ratios in the range of lunar values and especially for Ar/Kr in the near of the unfractionated solar value [Andersen & Grevesse, 1989]. However, with progressive etching both ratios decrease and approach primordial (Q) ratios (Figure 1). Nevertheless the separation of solar and primordial gases by HF was successful in the first gentle etch steps. Pesyanoe shows rather constant ratios for most steps, similar to the release patterns of lunar samples. The ratio 84-Kr/132-Xe (6.4) is in-between the highest and lowest lunar value, whereas the 36-Ar/84-Kr value of 1650 is lower than in Fayetteville and lunar samples. At the very end of the etch run small amounts of primordial gases were released. The Ar/Kr and Kr/Xe elemental ratios in lunar samples indicate time-dependent fractionation processes in the solar wind source region according to the FIP (first ionisation potential) effect [Wieler et al., 1995]. The enhancement of Xe relative to Ar and solar abundances in Fayetteville corresponds well with that of recently (~100 Ma) irradiated lunar soils. Xe and Kr data of Pesyanoe suggest an old solar wind irradiation instead, although substantial atmospheric contamination can not yet be fully excluded. Further experiments to check this are planned. 36-Ar/84-Kr and 84-Kr/132-Xe of the metallic and the bulk fraction of Acfer111 are very constant over the whole etch run but the values are significantly lower compared to the other meteorites (84-Kr/132-Xe ~2-3, 36-Ar/84-Kr ~1000). Xe isotopic ratios of both fractions, metallic and bulk silicate, indicate a mixture between primordial and atmospheric gases. In contrast to the other meteorites here Acfer111 is a desert find, which explains high air contamination. The work so far has shown that the etch technique is partly successful to separate solar and primordial Kr and Xe in meteorites, although primordial gases were also released in long etch steps. Another unexpected result is the relatively high amount on primordial gases in metallic grains. The results confirm that gas-rich meteorites are complementary with lunar samples to elucidate the heavy noble gas composition of the ancient solar corpuscular radiation.

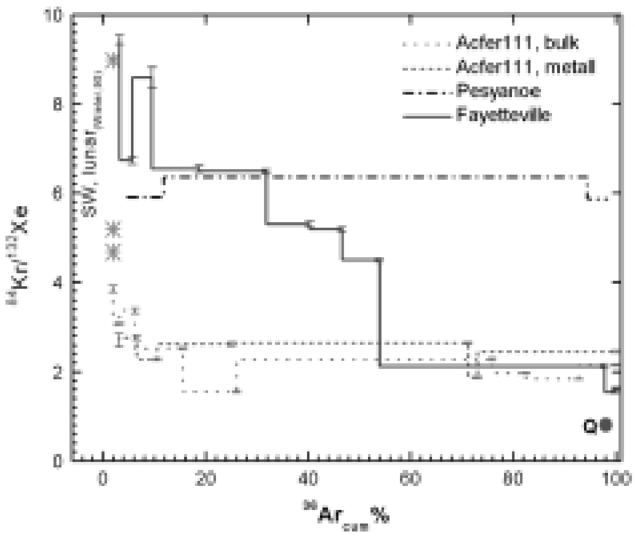

Figure 1: 84-Kr/132-Xe vs. cumulative fraction of 36-Ar for Fayetteville, Pesyanoe and Acfer111 analysed by closed system stepwise etching. 1σ errors are given. Primordial component (Q) Busemann et al., 2000.

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Volume 5(2), 500

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