THE SEARCH FOR EXTINCT IRON-60 IN IRON METEORITES. S. Mostefaoui[1], G. W. Lugmair[1,2] and P. Hoppe[1]; [1]Max-Planck-Institut für Chemie, J. J. Becher-Weg 27, 55128 Mainz, Germany (E-mail: smail@mpch-mainz.mpg.de). [2] Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0212, USA

Introduction: The search for ^{60}Ni isotopic anomalies produced by the decay of short lived ^{60}Fe ($T_{½}$ = 1.5 Ma) was successful in primitive chondrites and in the eucrite Chervony Kut [1,2,3]. Correlated with the Fe/Ni ratio, ^{60}Ni excesses of up to ~100‰ were found in Semarkona troilite and an inferred initial ^{60}Fe/^{56}Fe of ~10^{-6} was determined [1]. Recent work on iron meteorites, using the Hf-W system showed that the types IIIAB, IVA, IVB, and IC are as primitive as CAIs [4,5]. If this is true, one would expect ^{60}Ni-excesses in iron meteorites as high or higher than previously found, provided that the Fe-Ni system closed at the same time as the Hf-W system. In an attempt to verify such a hypothesis we present here an *in situ* NanoSIMS study of the Fe-Ni system in sulfides from two selected iron meteorites.

Petrography: Optical microscopy studies of polished thin sections of the Henbury IIIAB and Tlacotepec IVB iron meteorites were performed in order to select suitable mineral species for Fe-Ni isotopic measurements with the NanoSIMS. We chose Henbury and Tlacotepec because they were measured in the Hf-W study [H. Palme, pers. comm.]. We have found troilite to be the most suitable mineral because it can have high Fe/Ni ratios, a prerequisite for the detection of ^{60}Ni excesses. Troilite grains with high Fe/Ni ratios were found in both meteorites. In Henbury, except for two large polycrystalline troilite globules (Fig.1a), isolated troilite grains are rare. One small grain with a much higher Fe/Ni ratio than the globules was found (Fig1b). In Tlacotepec, only a few troilite grains (<50µm) were found (Fig.2). We measured 3 grains in Henbury and 4 in Tlacotepec with the NanoSIMS. The selected grains all had Fe/Ni ratios high enough for potential ^{60}Ni excesses to be resolved.

Analytical Technique: The Fe and Ni isotopes in troilite were measured with the Cameca NanoSIMS-50 ion microprobe at the Max-Planck-Institute for Chemistry. Using high current conditions (~ 0.7-1.5nA on the sample surface), a primary ion beam of O^- was focused into spots of 1 to 5 µm in size on the samples. Positive secondary ions of ^{54}Fe, ^{60}Ni, and ^{62}Ni were measured in a multidetection mode at a mass resolution m/Δm of 3000, sufficient to separate isobaric interferences from compounds such as $^{30}Si_2$, ^{44}CaO, and ^{46}TiO. However for ^{62}Ni, despite its peak-to-peak resolution from ^{46}TiO, we found that the tail of ^{46}TiO can contribute to the ^{62}Ni signal. We verified this by measuring ilmenite ($FeTiO_3$) grains with very low Ni contents. Up to 90% of the signal was found to come from the tail of ^{46}TiO. To avoid this potential problem for troilite grains with low Ni contents we verified that ^{46}TiO did not cause any interference .

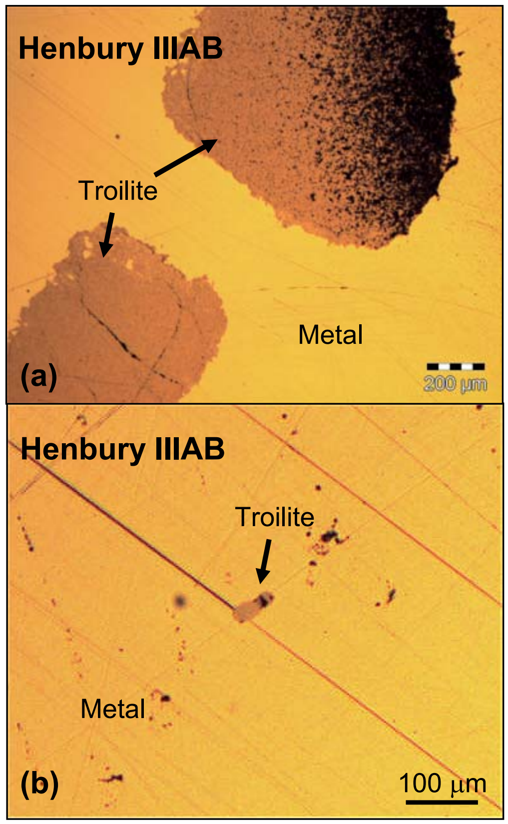

Fig.1: Troilite grains in the Henbury IIIAb iron meteorite selected for the NanoSIMS measurements.

The dynamic background was measured for each mass from the peak center at a mass difference of Δm = -0.1 amu. Contributions from the dynamic background (<0.01cps) to the ^{60}Ni and ^{62}Ni secondary ion signals (typically 100cps and 15cps, respectively) were low. The instrumental mass fractionation for $^{60}Ni/^{62}Ni$ ratios was corrected using Ni-rich metal in the vicinity of the selected troilites. The reproducibility of the $^{60}Ni/^{62}Ni$ measurements on these Ni-rich regions was ≈ 4‰. A synthetic FeS standard was used to determine the sensitivity factor ($\varepsilon(Fe^+)/\varepsilon(Ni^+)$ = 1.7±0.1) for Fe/Ni ratios.

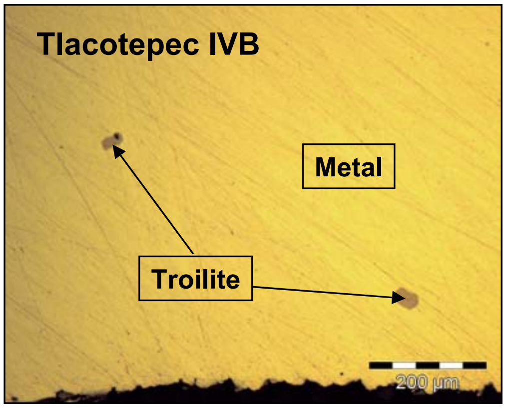

Fig.2: Typical troilite grains in the Tlacotepec IVB iron meteorite selected for measurement.

Results and discussion: Figure 3 displays $\delta^{60}Ni$ values as a function of the $^{56}Fe/^{58}Ni$ ratio in the troilite. The $^{60}Fe/^{56}Fe$ ratio of $1\text{x}10^{-6}$ inferred as the lower limit of the solar system initial [1] is also shown for reference. In Henbury, five measurements on 3 grains were performed. The elemental Fe/Ni ratios vary from ~340 in a troilite globule (Fig.1a) to ~120000 in the troilite grain of Fig.1b. In Tlacotepec, four measurements were done on three grains. The Fe/Ni ratios vary from 2400 to 8600. As clearly shown in Fig.3, no ^{60}Ni excesses are detected in all the troilite grains. All the $\delta^{60}Ni$ values are consistent with zero. The best fit lines through the data points give maximum inferred $^{60}Fe/^{56}Fe$ ratios of $7.5\text{x}10^{-8}$ and $6.8\text{x}10^{-8}$ for Henbury and Tlacotepec troilites, respectively.

The results in Fig.1 show no evidence for live ^{60}Fe in the Henbury and Tlacotepec meteorites. This finding is inconsistent with the Hf-W results, which suggest that iron meteorites and CAIs were formed contemporaneously [4]. Iron meteorites have magmatic origins and their compositions are consistent with crystallization from a melt suggesting that they represent cores of differentiated asteroids [6]. If the Hf-W results are indeed reflecting old ages for iron meteorites [5], then the troilite composition would have been established much later than the segregation of the metallic core. This implies that either the troilite is formed very late after core formation or that the parent body cooled very slowly before reaching the troilite closure temperature. In both cases, a time span of more than ~6 My is necessary between the end of metal segregation and core formation and the closure time of the troilite in order to explain the present upper limits of the $^{60}Fe/^{56}Fe$ ratios in Henbury and Tlacotepec. The silicate counterparts of these iron meteorites would be good candidates for the search of extinct ^{60}Fe because they cooled much faster than the metallic core and could have retained ^{60}Ni excesses. However, there presently are no known candidates among differentiated achondrites that are genetically related to these magmatic iron meteorites.

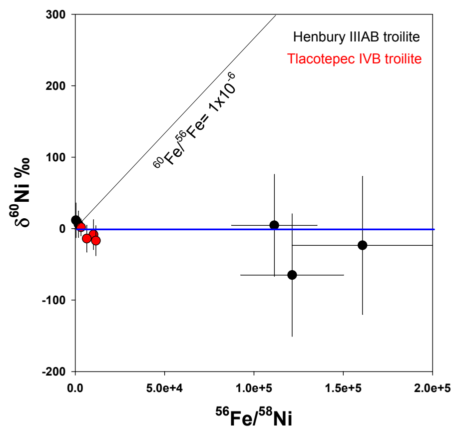

Fig.3: $\delta^{60}Ni$ as a function of $^{56}Fe/^{58}Ni$ for troilite grains in Henbury and Tlacotepec. ^{56}Fe and ^{58}Ni are calculated from measured ^{54}Fe and ^{60}Ni. Errors are 2σ.

Acknowledgements: We thank J. Zipfel for providing us with suitable samples of iron meteorites. We thank E. Gröner for technical assistance and K. P. Jochum for providing us with the synthetic FeS standard.

References: [1] Mostefaoui S. et al. (2004) *Lunar Planet. Sci.* 35, abstract #1271. [2] Tachibana S. and Huss G. R. (2003) *Astrophys. J.,* 588, L41. [3] Shukolyukov A. and Lugmair G. W. (1993) *Science,* 259, 1138. [4] Kleine T. et al. (2004) *Beih. Europ. J. Min.,* 16, 69. [5] Kleine T. et al. (2004) *Amer. Geophys. Un.*, Abstract #P31C-04. [6] Scott E. R. D. and Wasson J. T. (1975) *Rev. Geophys*., 13, 527.