IN SITU NI ISOTOPIC ANALYSES FOR UREILITIC OLIVINE USING ION PROBE. N. T. Kita[1], S. Togashi[1], S. Terashima[1], Y. Morishita[1], and H. Yurimoto[2], [1]Geological Survey of Japan, 1-1-3 Higashi, Tsukuba, Ibaraki 305, Japan. noriko@gsj.go.jp, [2]Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152, Japan.

Introduction: The ultramafic nature of ureilites limited the chronological information because most of the ureilites do not contain any significant amounts of U-Th, REE, and alkali elements [1]. The search for the ^{60}Ni isotopic anomaly from the decay of short lived nuclide ^{60}Fe (half life of 1.5 Ma) is important for the study of the ureilite early history. The initial (^{60}Fe/^{56}Fe) in the solar system was estimated to be (1.6 ± 0.5) x 10^{-6} from CAI [2]. Earlier work on bulk ureilite analyses by con-ventional method could not find any detectable anomaly [3]. Since the half life of ^{60}Fe is very short, a sample with a high Fe/Ni such as silicates should be analyzed to detect a small isotopic anomaly. The Fe/Ni ratio of 3,000 is required to detect 1 permil anomaly for the material which formed 5 Ma after CAI formation.

In this study, we have developed the technique for the precise Ni isotopic analyses in olivine grains using the ion probe Cameca IMS-1270. In-situ analyses using ion probe has a great advantage of obtaining high Fe/Ni phases in the ureilite by avoiding the thick reduced rim (about 100 µm) which contains reduced iron grains, metallic inclusions and veins in the olivine. The first results on olivine from MET-78008 ureilite are presented. The old U-Pb age of 4.563 ± 0.006 Ga has been obtained for this meteorite [4], so that the sample is a good candidate for detecting an ^{60}Ni isotopic anomaly.

Ion Probe Analyses: Several terrestrial olivines listed in Table 1 were used as standards for the Ni-isotopic and Fe/Ni abundance analyses. The Ni contents in these olivines were in the range of 200-3,000 ppm which were determined by atomic adsorption analyses. Concentrations of Co and Ni in some of the standards were also obtained by INAA. Both ureilite olivine grains and terrestrial standards were mounted in epoxy, polished and Au coated (200 nm). The Cameca IMS-1270 ion probe at the Geological Survey of Japan was used in this study. The O^- primary ion beam (-13kV) was defocused to a 40 µm diameter spot with intensity of 25-30 nA. Secondary ions (+10kV) were measured with mass resolution power of 4,500 and the analyzed area was limited to 20 µm square using the field aperture, which reduced the tailing of the mass spectrum. We did not use ^{58}Ni and ^{64}Ni which have isobaric interference from Fe and Zn. Although the present tuning of the mass spectrometer sacrifices transmission down to 25%, the effect of interference peaks of hydrides and oxides were reduced to less than 10^{-4} even for samples with low Ni contents of less than 100 ppm.

For chemical analyses runs, ^{28}Si, ^{56}Fe, ^{59}Co, and ^{60}Ni were analyzed. The matrix effect according to the Fe content was calibrated using terrestrial standards. We have checked the matrix effect for the different initial energy of secondary ions using terrestrial standards; (1) low energy ions with 25 eV energy window with high mass resolution and (2) high energy ions by applying energy offset of 100 eV with low mass resolution (Fig. 1). Although the matrix effect for the high energy ions are much smaller, it sacrifices more than 95% of the total ions. Since we observed a fairly good linear trend for low energy ions, we chose wide energy window (75 eV) to collect secondary ions with various ion energies. This is also good for isotopic analyses to eliminate a possible isotopic fractionation effect depending on the ion energy. Isotopic analyses runs consist 80 cycles of counting ^{60}Ni for 5 sec, ^{61}Ni for 25 sec, and ^{62}Ni for 8 sec using Electron Multiplier by pulse counting mode with dead time of 14 nsec. Typical counting rate of ^{60}Ni for San Carlos olivine (2,700 ppm Ni) was in the range of (7-14) x 10^4 cps.

Results and Discussion: The fragments of ureilite olivine grains used in this study (0.3-1.2 mm in size) consist of homogeneous core and reduced rim contact with carbon-metallic vein. Thickness of reduced rim is about 100 µm. In this study, only the homogeneous core part was analyzed. Measured ^{59}Co/^{56}Fe and ^{60}Ni/^{56}Fe ratios of different spots did not differ more than 3%, indicating homogeneous composition. The Ni and Co concentrations were calculated to be 70 ppm and 41 ppm, respectively. The calculated ^{56}Fe/^{58}Ni ratio was 3,200, which is much higher than bulk analyses of PCA 82506 ureilite of 190 [3].

The measured isotopic ratios were normalized to the literature value of ^{62}Ni/^{61}Ni = 3.1760 and ^{60}Ni/^{61}Ni = 23.100 [2]. For the isotopic runs, the analytical error (2 sigma mean) of single analysis was in the range of 1 permil for San Carlos olivine, and 3-4 permil for ureilitic olivine. The average of several analyses for standards and the sample are shown in Fig. 2. The result of the 12 analyses on the ureilite olivine indicates ^{60}Ni anomaly of delta(^{60}Ni)= -0.4 ± 1.4 permil, which is normal within an error. Applying ^{56}Fe/^{58}Ni ratio of the sample, the upper limit of ^{60}Fe/^{56}Fe < 1.2 x10^{-7} was obtained. Using this upper limit and the initial abundance ratio of CAI [2], the formation age interval between CAIs and MET-78008 is obtained to be 5.6 ± 0.6 Ma. Although the detection of ^{60}Ni anomaly was unsuccessful, the present result indicates that the ureilite formed at least 5 Ma after the formation of the solar system.

References: [1] Torigoye-Kita et al. (1995) GCA 59, 4087-4091. [2] Birck and Lugmair (1988) EPSL 90, 131-143. [3] Shukolyukov and Lugmair (1993) EPSL 199. 159-166. [4] Torigoye-Kita et al. (1995) GCA 59, 2319-2329.

Table 1. Terrestrial Standards and MET-78008 Olivines

Sample	Fo	Ni ppm	^{60}Ni (cps) for Isotope Analyses
Ichinome-gata	90	3030	
San Carlos	89	2690	70,000 - 140,000
Miyake Island	83-85	600-900	
Fuji	72	800	40,000 - 50,000
Orikabe	60	200	9,000 - 14,000
MET-78008	76	70	3,000 - 5,000

Fig. 1

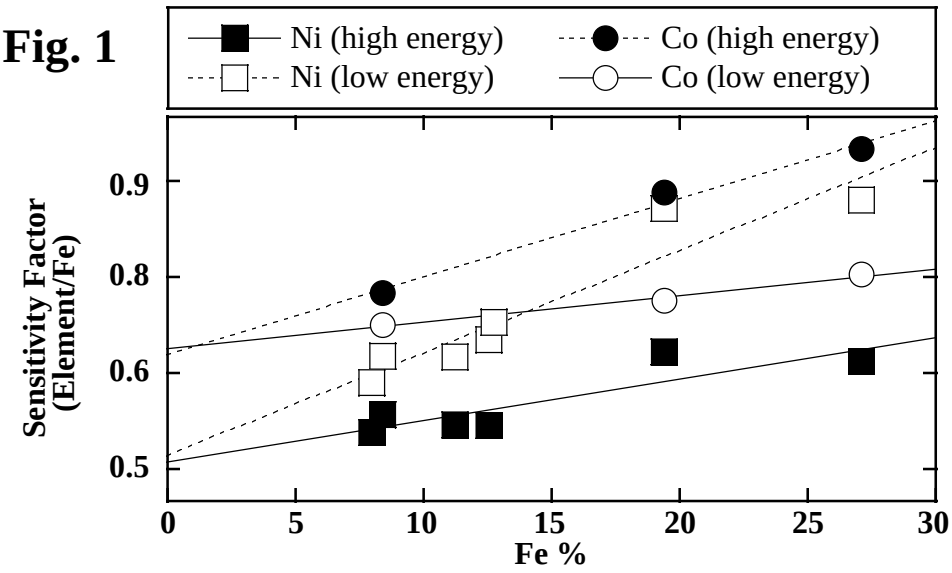
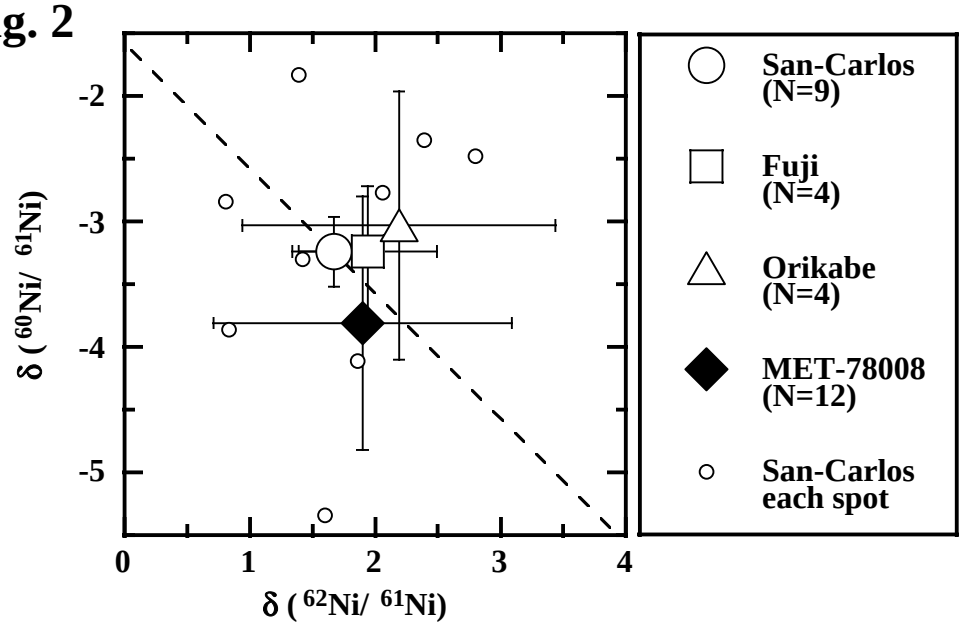
Fig. 2