RE-ESTIMATION OF ELEMENTAL COMPOSITION OF ASTEROID 25143 ITOKAWA USING HAYABUSA XRS WITH UPDATED POSITION AND ATTITUDE DATA. T. Arai[1], T. Okada[1], K. Shirai[1], Y. Yamamoto[1], K. Ogawa[1,2], M, Kato[1-3], [1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan. (arai@planeta.sci.isas.jaxa.jp), [2]Department of Earth and Planetary Sciences, Tokyo Institute of Technology. [3]Department of Earth and Planetary Science, University of Tokyo.

Introduction: X-ray fluorescence spectrometry of near-earth asteroid 25143 Itokawa has been conducted using the XRS instrument onboard Hayabusa in 2005. This study re-estimated the surface elemental composition with more detail analysis of the XRS data than in the initial report [1], with using newly prepared ancillary data sets as well as the precise analysis of response functions of the instrument. Therefore, increased number of data were used to allow us analysis of higher-Z elements such as S, Ca, and Fe, in addition to Mg, Al, and Si.

Hayabusa Mission: Hayabusa is a Japanese asteroid explorer, aiming at technology demonstration of electric propulsion system for asteroid rendezvous with small mass budget, optical navigation for one meter-order precision operation at 300 million km away from the earth, sample collection at microgravity, and hyper speed direct reentry from interplanetary orbit. However, the mission also has great significance in science of the target asteroid as a primitive body in the solar system. Hayabusa conducted the remote observation during rendezvous of the asteroid, and descent to the surface for sample collection, and now it is on the way back to the Earth.

Near-earth asteroid 25143 Itokawa: The target asteroid, 25143 Itokawa (1998SF36), is classified as S(IV)-class, rotates about 12.1 hours in retrograde direction. The asteroid has about 550m long elongated shape and shows intermediate thermal inertia between rocks and soils. The asteroid was explored by Hayabusa and now found that it has a low density of 1.9 g/cc, or high porosity of about 40%, maybe a rubble-pile. It also has rocky or brecciated surfaces. There are few craters found, which means relatively young surface age by crater population, probably several to 10 million years old [2].

XRS data re-analysis with Ancillary Data: One of the most important science objectives of the Hayabusa mission is to classify, or at least constrain, the surface material into the meteorite types. A meteorite-asetroid connection for S(IV)-class is important to make sure the relation between most observed class of asteroid in space and most found type of meteorite.

The initial report of the XRS analysis shows major elemental ratios of Mg/Si and Al/Si are more like an ordinary chondrite meteorites than any other types [1]. At that time, the dataset of the position of the spacecraft to the asteroid center as well as the attitude of the spacecraft was still under preparation. The Hayabusa spacecraft suffered from the attitude control due to failure of two reaction wheels before reaching the home position, several km sunward from the asteroid. Pointing directions of almost all the data during the rendezvous phase are diverse so that only the data during touchdown could be used before the preparation of ancillary data.

Instrumental Performance Updated: In the laboratory experiment conducted for the flight model, we derived the response function for the output data when X-ray photon enters into the CCD detector. It is basially assumed as Gaussian function but with an escape peak, Si-Ka excitation, as well as the continuum tail for lower energy.

Background Considerations: With the ancillary data of the position and attitude of the spacecraft, we can obtain the portion of the asteroid surface and the background space in the field of view of the XRS. Averaged cosmic X-ray backgrounds are constructed with the data not pointing to the asteroid. We assumed the CXB contribution to the portion of the backgrounds in FOV. Instrumental noises are also considered, which appeared all the time.

Re-Estimation of Composition: We examined the data for all through the redevous phase and selected the data under the condition that 1) Signal to background rations beyond a critical value at the energy of 1-2 KeV, 2) large portion of the FOV is occupied by the asteroid surface, 3) The standard sample is in the sunlit condition, 4) LIDAR data is normally detected its altitude, 5) no remarkable instrumental noise is found.

Only a few percent of data is applicable to the analysis, since very low signal to background data due to the very faint solar activity during the rendezvous period in 2005.

We then obtained the X-ray spectra for the X-rays off the standard sample and off the asteroid surface. The solar X-ray spectrum has been re-constructed using the data of X-rays off the standard sample. In this study, MEKAL model is used for the function and the two sets of higher (10-25 MK) and lower (4-10 MK) temperature component are summed. For the simple compared method of analysis, the element of low abundance in the standard sample is not able to be determined. Therefore, this implies the importance on reconstruction of solar X-rays.

Then we obtained the X-ray spectrum off the asteroid surface by fundamental parameter method with assumption of surface composition. After considered with the response functions, we compared the obtained spectra with the observation.

Then we obtained the elemental composition for the asteroid surface. We re-estimated the composition of Mg/Si, Al/Si, S/Si, Ca/Si, and Fe/Si, in spite of large errors for some elemental ratios.

The result shows that the composition is consistent with that of ordinary chondrites, other candidates cannot be ruled out. Heavily igneous material or hily althered material are unlikely. Metallic iron enriched materials are also unlikely since the Fe/Si is not high enough for accounting for iron meteorites or stony iron meteorites. The composition of major elements is not varied around the asteroid surface. This indicates that the asteroid is considered to be compositionally homogeneous.

For the sulfur content, almost equal to or a little bit of depletion was found. This implies that sulfur is relatively depleted, which suggests the relatively younger surface age than in the asteroid 433 Eros. Probably, space weathering process happens by microimpacts or ion sputtering, and the surface materials are vaporized. Sulfur will be lost to space even faster than other elements, but the case of Itokawa is only a small decrease. Therefore, the relatively small portion of sulfur has been lost so far.

Concluding Remarks: We have re-estimated the surface elemental composition of asteroid 25143 Itokawa, an S(VI)-class asteroid. The composition is more like an ordinary chondrite meteorites, but any other types cannot be ruled out if the types are only rejected with a composition out of more than 3 sigma errors

Sulfur content shows the asteroid is almost primordial or only a small portion altered. Asteroid Eros shows more depletion for S/Si. Probably, the difference occurrs due to the relatively yound surface age of Itokawa, maybe less than 10 million years after Itokawa formation.

Iron content shows the typical iron or stony iron meteorites are unlikely to account for the compostion. This means that the S(IV)-class asteroids may be like an ordinary chondrite meteorites, in spite of the surface spectroscopy with similarity to stony asteroid meteorites.

References:

[1] Okada T. et al. (2006) Science 312, 1338-1341.

[2] Fujiwara, A. et al. (2006) Science 312, 1331-1334.

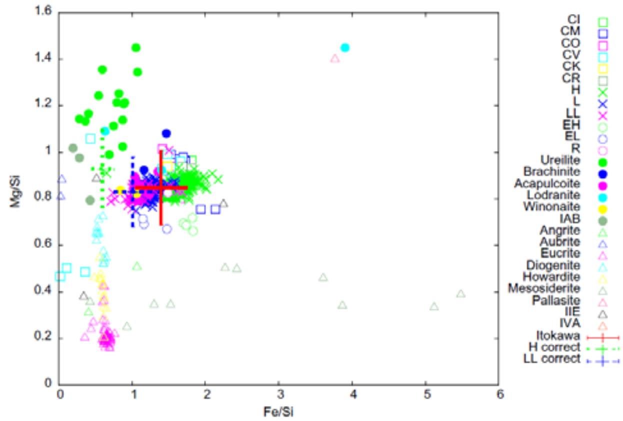

Figure 1: Mg/Si vs. Fe/Si. Itokawa is more like an ordinary meteorites, especially when mineral mixing effects are considered .

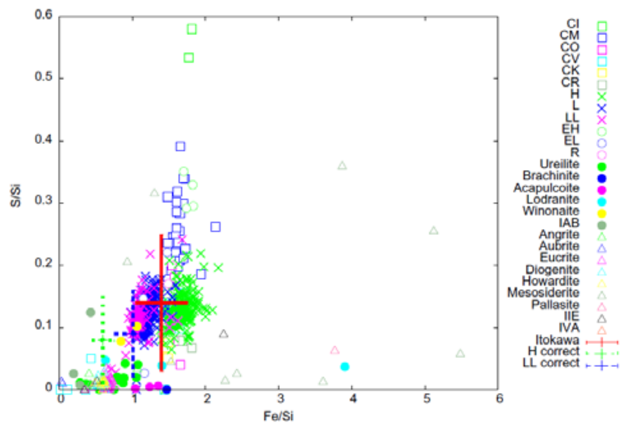

Figure 2: S/Si vs. Fe/Si. Itokawa appears almost primordial or depleted in S by several times, especially when mineral mixing effects are considered .