ELEMENTAL COMPOSITION OF ASTEROID ITOKAWA BY HAYABUSA XRF SPECTROMETRY. T. Okada[1,3], K. Shirai[1], Y. Yamamoto[1], T. Arai[1,3], K. Ogawa[1,4], T. Inoue[1,2], and M. Kato[1,2,4], [1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan. okada@planeta.sci.isas.jaxa.jp, [2]University of Tokyo, Hongo, Tokyo 113-0033, Japan., [3]Graduate University for Advanced Studies, Sagamihara, Kanagawa 229-8510, Japan, [4] Tokyo Institute of Technology, Ookayama, Tokyo 152-8550, Japan.

Major elemental composition of the near-Earth asteroid 25143 Itokawa was investigated through X-ray spectrometry using the CCD-based X-ray spectrometer, XRS, onboard Hayabusa. Quantitative elemental analysis of Mg, Al, and Si, and qualitative analysis of Ca and Fe indicates that the surface of Itokawa has chondritic composition and that LL- or L-chondrites are most likely, but H-chondrites or primitive achondrites cannot be rejected.

Introduction:

Hayabusa is a Japanese engineering explorer to demonstrate new technologies for sample return from asteroids [1], but it still has a high scientific significance including remote observations of the asteroid during the rendezvous phase as well as sample return of the asteroid surface material [2].

The target asteroid is a near-earth asteroid 25143 Itokawa. Preliminary results of the asteroid remote observations were already reported [2-6]. Surface material of the asteroid is more like an ordinary chondrite meteorites by supporting the X-ray results of Mg/Si and Al/Si elemental ratios [4], and olivine to pyroxene abundance ratio derived from 1 micron band analysis by NIRS (Near-Infrared Spectrometer) [3].

In this study, further analysis after the preliminary results is presented and discussed.

XRS:

The XRS is one of the remote observation instruments onboard Hayabusa for major elemental analysis of Itokawa by measuring X-rays off the uppermost surface of the asteroid[7]. Remote X-ray fluorescence or XRF technique is an application of a well established XRF method in the laboratory but the excitation source is solar X-rays. It has been proven by the Apollo missions to determine major elemental composition of the surface of atmosphere-free planets.

The XRS[7] is based on charge-coupled device (CCD), whose energy resolution (160eV@5.9KeV) is much higher when cooled than that of the conventional proportional counters used by the Apollo 15 & 16 and the NEAR Shoemaker missions[8, 9]. In addition, it has a standard sample plate aboard to concurrently calibrate X-rays excited by the Sun. Since the intensities and spectral profiles of solar X-rays changes time to time, this compared analysis by using the standard sample for real-time calibration has much improved the accuracy of elemental analysis.

The observed data, readout signals from CCD, are processed by using the programmable gate-arrays and the onboard computer of the XRS electronics. X-rays are effectively extracted as X-ray events. They are judged for its grades by split pattern on the CCD pixels such as single pixel event, left-side split, right-side split, or other multi-split events. Only the X-ray events of selected types of grades are analyzed into histogram with the pulse height for each CCD chip[10].

Remote XRF Spectrometry of Itokawa:

During the rendezvous phase, the XRS remotely performed XRF spectrometry of the surface of Itokawa. In this study, we used the data obtained during the decent for the first touchdown on 19 November 2005, since that time is the most desirable condition because of relatively high solar activity for X-ray excitation and low altitude to fill the 3.5 x 3.5 degrees field of view of the XRS by the asteroid surface.

During the rendezvous phase, solar activity was usually faint enough not to determine major elemental composition precisely for each X-ray histogram produced by the XRS. But sometimes relatively enhanced solar condition occurred and those enhancements lasted for a few to several tens of minutes. We integrated the spectra at each of those periods to improve signal to background ratios. After integration of 5 spectra and summation of energy channels at higher energy, X-ray line spectra at the energy of Ca-Kα and Fe-Kα were detected apparently over the continuum background level.

We believe those spectra are the X-ray fluorescence of Ca and Fe. We estimated the upper and lower limits of elemental ratios of Ca/Si and Fe/Si by comparing the X-ray intensities at energy characteristic of each element off the asteroid and the standard sample. With large uncertainty due to low signal to background ratios, we got the results of elemental ratios Ca/Si = 0.09 ± 0.04 , Fe/Si = 1.0 ± 0.5, respectively. In this study, only a single site was analyzed so far for the five elemental ratios. The site is located at the rough terrain near Yoshinodai boulder, it seems likely that the asteroid is homogeneous in composition, at least at the spatial resolution of XRS observations [3, 4].

Elemental composition of Itokawa:
We estimated the surface elemental ratios of Ca/Si and Fe/Si, other than Mg/Si and Al/Si. We compared them with the elemental ratios of stony and stony iron meteorites as possible candidate materials of S(IV)-class asteroid.

Figure 1A plots Ca/Si vs. Mg/Si for meteorites and the solid and dashed ellipsoids reveal the limitation within 1 and 2 sigma of possible composition of Itokawa, respectively. Despite of large uncertainty, ordinary chondrite meteorites are consistent within the error. Figure 1B is the similar plots as Figure 1A, but for Fe/Si vs. Mg/Si. This time Itokawa is more like an LL- or L-chondrites rather than H-chondrites.

Further detailed studies are necessary, but the results show that the composition of Itokawa is more like an LL- or L-chondrites than any other types but a little alteration by a bit of melting could not be ruled out.

Acknowledgments:
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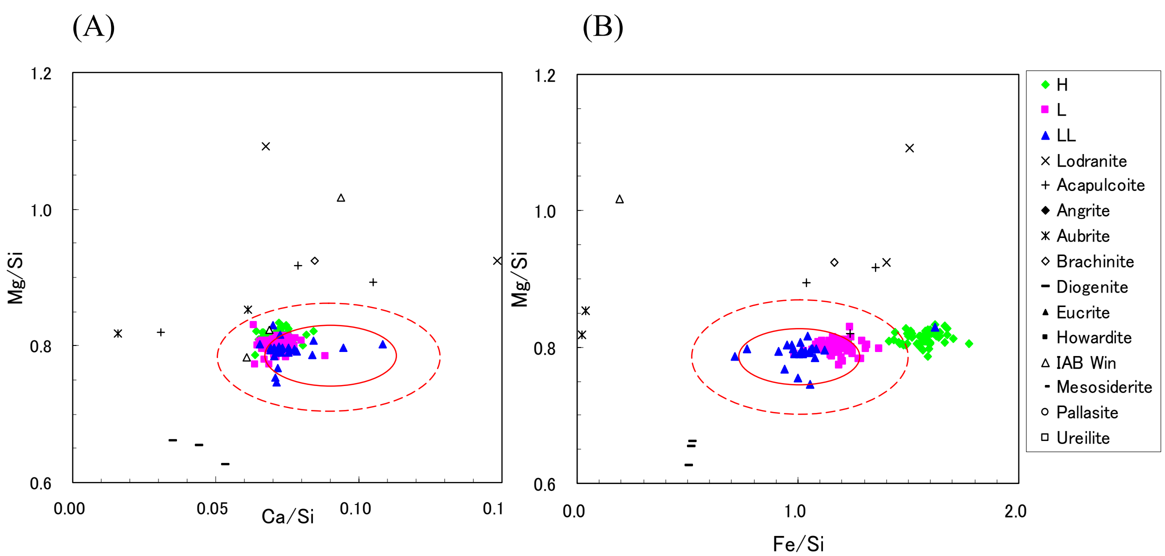

Fig.1 Estimation of Major elemental composition ratios of the Asteroid 25143 Itokawa is compared with plots of stony and stony iron meteorites as the candidate materials of S(IV)-class asteroid. The solid and dashed ellipsoid reveal 1 and 2 sigma uncertainty for Mg/SI and limitations of the upper and lower limit Ca/Si or Fe/SI. In the left hand, Ca/Si vs. Mg/Si are shown (A). Despite of large uncertainty, ordinary chondrite meteorites are consistent within the error. In the right hand, Fe/Si vs. Mg/Si are shown (B). Also with large uncertainty, LL- or L-chondrites are more likely in elemental ratios.