

# The status report of the sample acceptance in

## Astromaterials Science Research Group

(地球外物質研究グループにおける試料受入れ状況)

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### ABSTRACT

Astromaterials Science Research Group (ASRG) is the group which started in JAXA/ISAS in July, 2015 and is the organization which researches mainly "extraterrestrial materials". The curatorial works for Hayabusa returned sample and acceptance preparations for Hayabusa-2 returned sample are mainly performed in this group, mainly. Furthermore, the group members organized the consortium studies of the Hayabusa returned samples. The consortia are the research groups organized by ASRG of JAXA in order to obtain the scientific information as much as possible from the particles which are difficult to be distributed to international announcement of opportunities (AOs) because of their rare features in composition, mineralogy, structure or size. And now, eight consortium studies are ongoing as follows; (1) largest (>300 mm) particle in the Hayabusa returned samples, (2) particle including NaCl, (3) particle mainly consisting of FeS, (4) particles including phosphates, (5) particles including Ca-Mg-Na phase, (6) a particle including Fe-S-Ni phase, (7) a silica-containing particle, (8) an agglutinate grain.

# 地球外物質研究グループ

## Astromaterials Science Research Group

On July 1st, the Astromaterials Science Research Group was organized in JAXA.

- The new organization which research mainly "astromaterials"
- The research objects are, mainly, returned samples of Itokawa by Hayabusa, returned samples of 1999JU3 by Hayabusa 2, and returned samples of martian satellites by Phobos/Deimos sample return mission. Also, the group will obtain and analyze the return samples of "OSIRIS-REx mission" which will launch next year by NASA.



<http://hayabusao.isas.jaxa.jp/curation/index.html>

# 地球外物質研究グループ

## Astromaterials Science Research Group

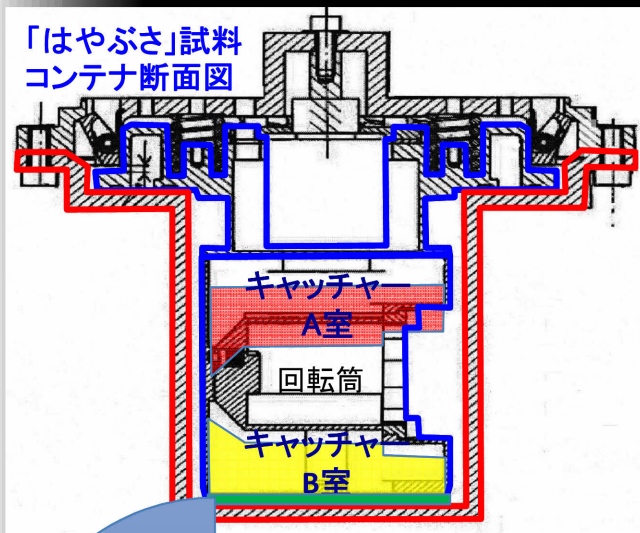
- Curatorial work for Hayabusa returned samples
  - description, allocation, storage, catalogue preparation, global discovery of returned samples, outreach, facility maintenance, contamination control, engineering development, sample investigation, etc.
- Acceptance preparations for Hayabusa 2 returned samples
  - Specifications consideration of the clean room and the clean chamber
    - Preparations for the facility to receive the returned sample without terrestrial contamination, and to put the whole aspect
  - Plan of initial description
    - Discussion for the procedure to description of the samples without destruction and contamination
  - Consideration for sample transportation
    - Discussion of sample transportation in cooperation with co-investigators without terrestrial contamination
  - Construction of sample database
    - Construction and operation of the catalogue database system of the returned sample
- Research for the meteorites / geochemical samples
- *Acceptance preparations for future sample return missions*
  - OSIRIS-REx
  - mars satellites sample return mission



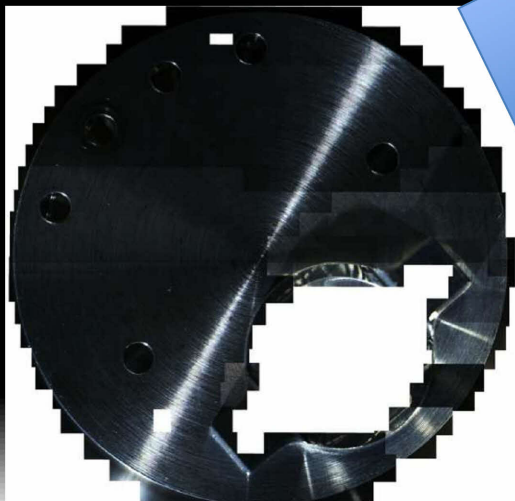
# Specification development of Hayabusa 2 Curation facilities at JAXA

- The committee members
  - M. Abe, T. Okada, T. Yada, M. Uesugi, Y. Karouji, A. Nakato, M. Hashiguchi, T. Matsumoto, K. Kumagai, H. Sawada, K. Sakamoto (JAXA)
  - M. Ito, N. Tomioka, Y. Takano (JAMSTEC)
  - A. Yamaguchi, N. Imae (NIPR)
  - T. Ohigashi (IMS)
  - K. Uesugi (JASRI)
  - A. Kouchi, S. Tachibana (Hokkaido Univ.)
  - T. Nakamura (Tohoku Univ.)
  - Y. Kebukawa (Yokohama National Univ.)
  - H. Yabuta, K. Hashizume (Osaka Univ.)
  - T. Noguchi, R. Okazaki, H. Naraoka (Kyushu Univ.)
  - T. Kunihiro (Okayama Univ.)
  - Y. N. Miura (Univ. of Tokyo)
  - K. Nakamura-Messenger (NAXA)

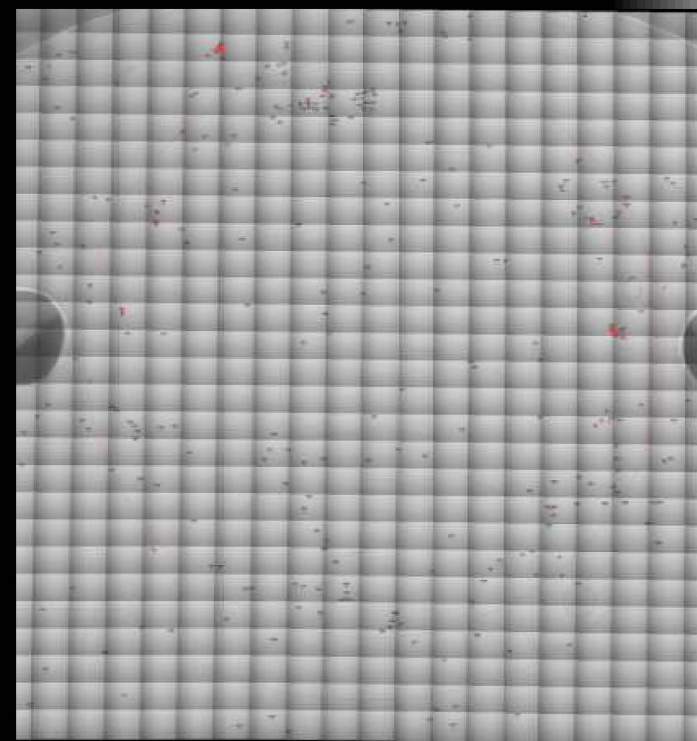
# The initial description for the cover of room B



the cover of  
room B



SEM  
observation,  
directly



SEM mapping

SEM mosaic image of the cover.  
The ability for particle distinction  
in this way improved markedly

# Progress of the description for room B cover

Revised in July 29, 2015

Category	Total	Percentage	Allocatable
1+2	429	23.7%	158
3 (carbon)	165	9.1%	
4 (artificial)	1199	66.3%	
others	16	0.9%	
total	1809		

# The number of particles of allocated

- Preliminary examination : 69
  - 1<sup>st</sup> round : 57
  - 2<sup>nd</sup> round : 6
  - Category 3 : 6
- International AO : 108
  - 1<sup>st</sup> round (2012) : 60
  - 2<sup>nd</sup> round (2013) : 48
  - 3<sup>rd</sup> round (2015) : 49 (in progress)
- NASA : 25
  - 1<sup>st</sup> round (2012) : 15
  - 2<sup>nd</sup> round (2013) : 10
  - 3<sup>rd</sup> round (2015) : 5 (in progress)
- JAXA : 35個
  - Outreach : 3個
  - JAXA : 12
  - Consortium studies : 20



# Progress of international AO researches

- 1<sup>st</sup> AO (2012)(17 themes, 60 particles)

11 papers

Nakashima et al. (2013) EPSL, Noguchi et al. (2014) MAPS, Noguchi et al. (2014) EPS, Mikouchi et al. (2014) EPS, Langenhorst et al. (2014) EPS, Keller et al. (2014) EPS, Thompson et al. (2014) EPS, Harries and Langenhorst (2014) EPS, Keller and Berger (2014) EPS, Langenhorst et al. (2014) EPS, Kitajima et al. (2015) EPS

Presentation for conferences: 50 titles

- 2<sup>nd</sup> AO (2013)(15 themes, 48 particles)

Submitted papers: 3 titles

# 3<sup>rd</sup> International AO

- 3<sup>rd</sup> AO (2015)
  - Open call for proposals were started in January
  - Open call for proposals were closed in March.
  - The examination committee was held in May.
  - 16 proposals were applied, and 12 themes were accepted.
  - Allocated samples are 49 particles.
  - Themes; Organics, shock textures, space weathering, chronologies, etc.

# Consortium Studies

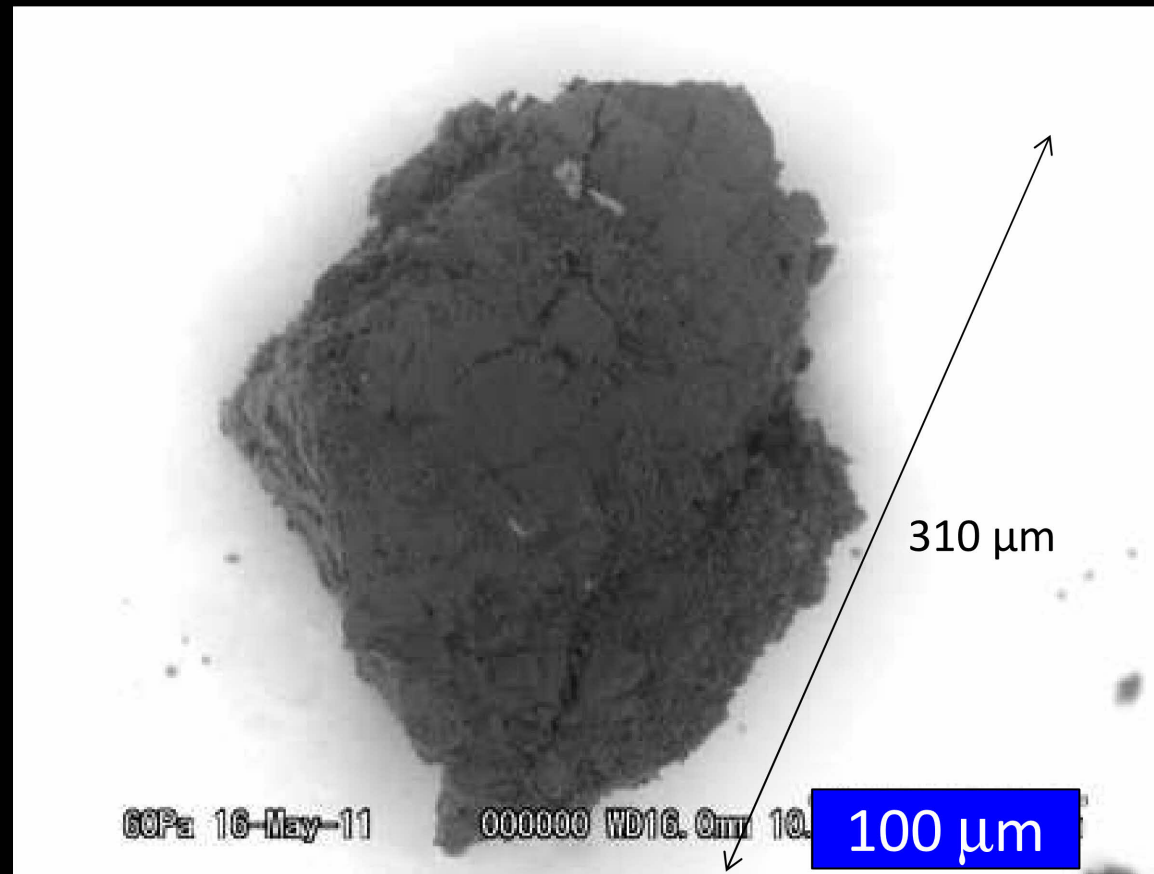
**It is difficult to distribute for international AOs the particles with rare characteristics in composition, mineralogy, structure, or size, although those samples should maintain scientifically important informations.**

Therefore, Astromaterials Science Research Group of JAXA decided to organize the consortium studies for these particles in order to obtain the scientific information as much as possible.

- All consortia were disclosed, and open call for proposals from all researchers who were interested for these particles.
- In 2013, the research proposals were accepted for four themes.
- In 2015, the consortium studies of four themes start newly, and are accepting research proposals.

# Consortium study (1)

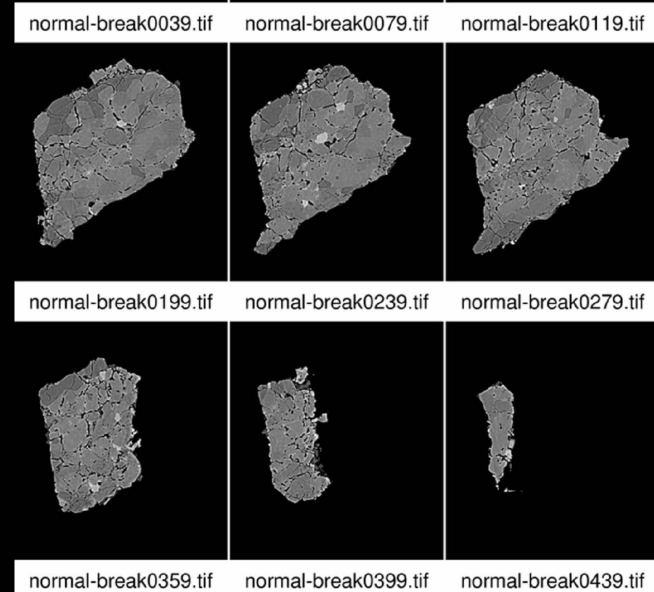
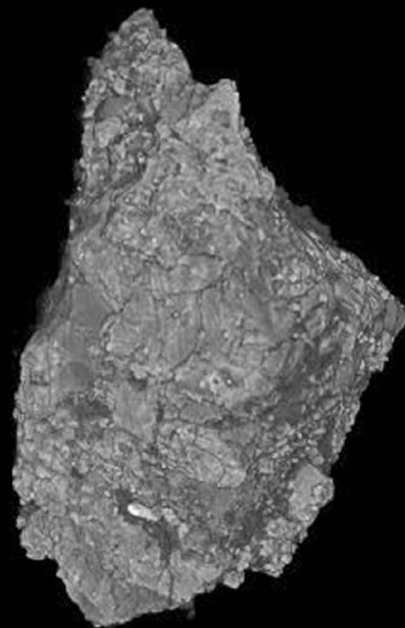
## Largest particle



Largest ( $> 300 \mu\text{m}$ ) particle in the Hayabusa returned samples so far.  
This particle is studied for Ar-Ar dating, cosmic-ray produced nuclides analysis and space weathering.



# RA-QD02-0136-01(CT)

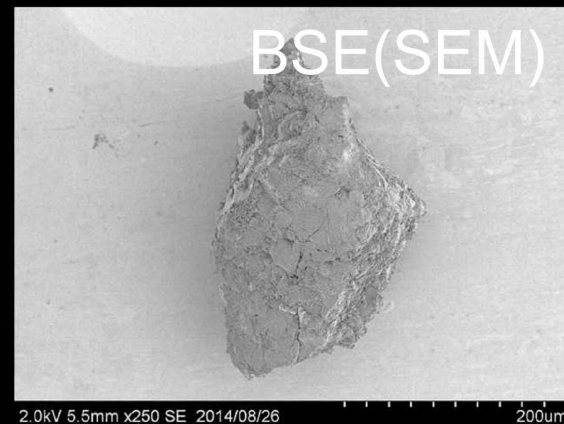


Void

Pyroxene

Plagioclase

BSE(SEM)

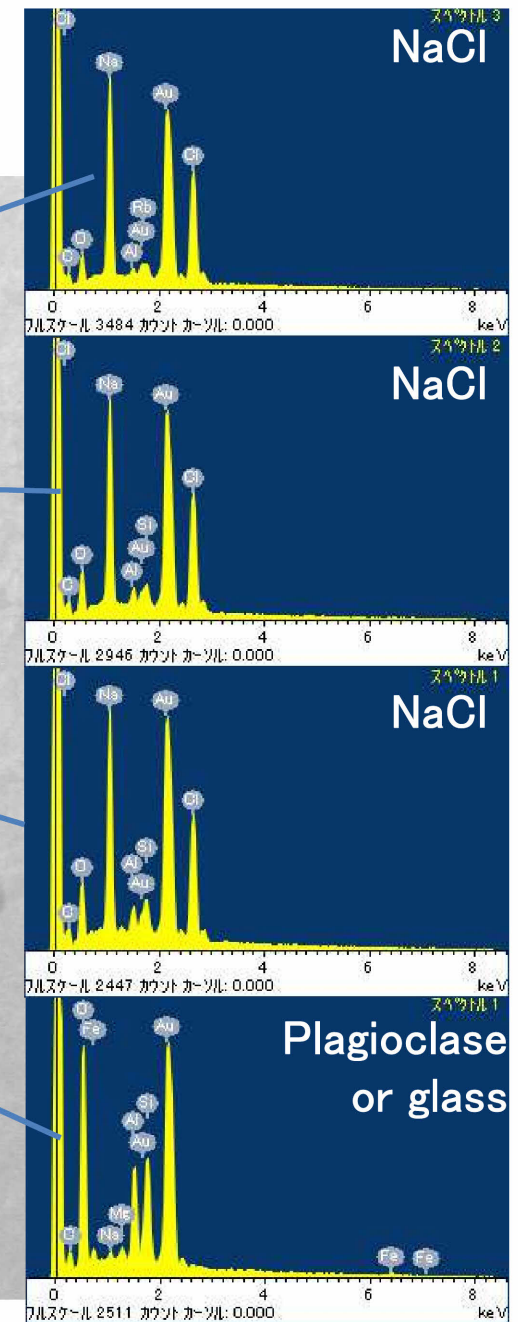
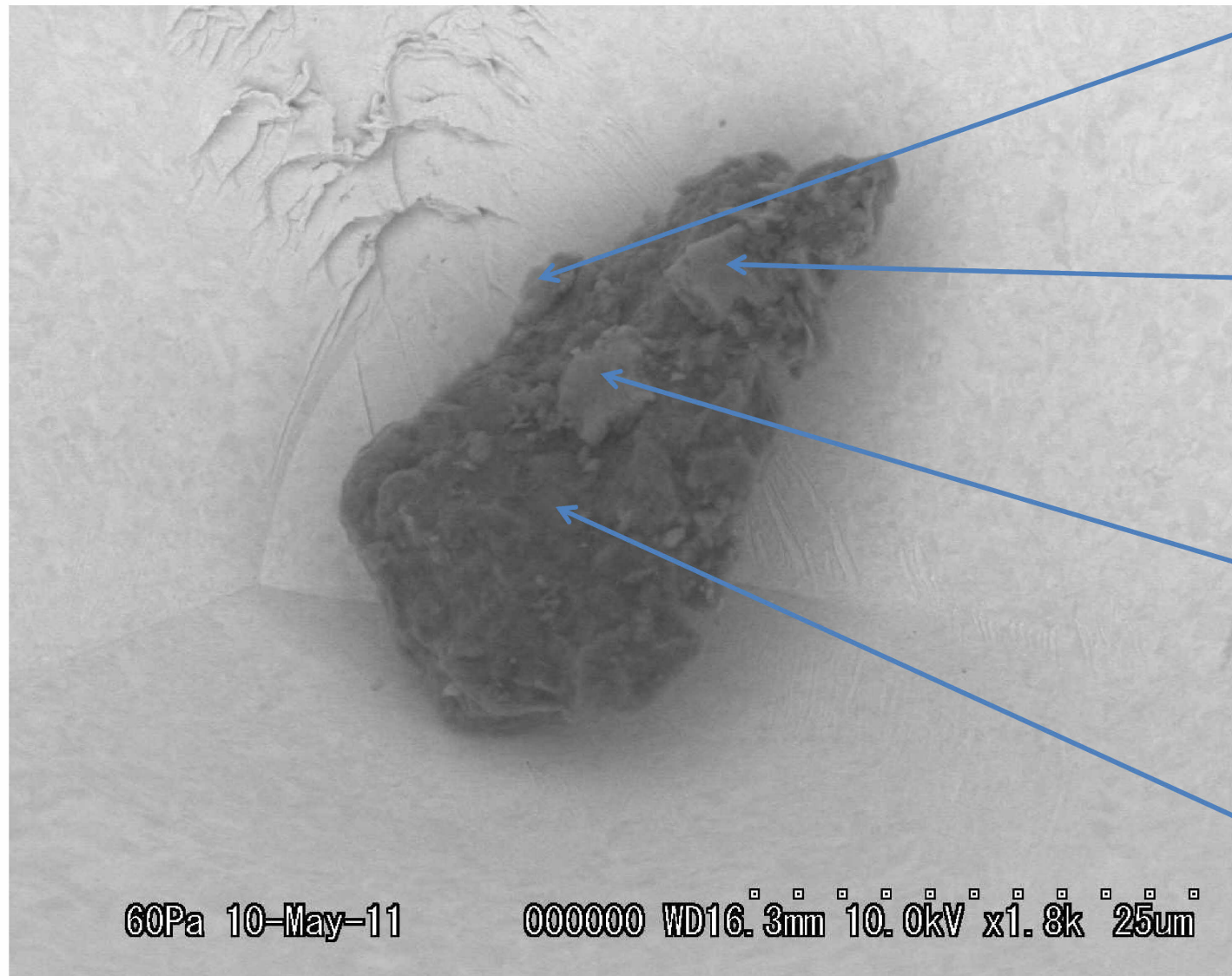


Size : 256.5 µm x 184.2µm x 136.5 µm

Volume : 2.777 µm<sup>3</sup>

Weight : 9.440 µg

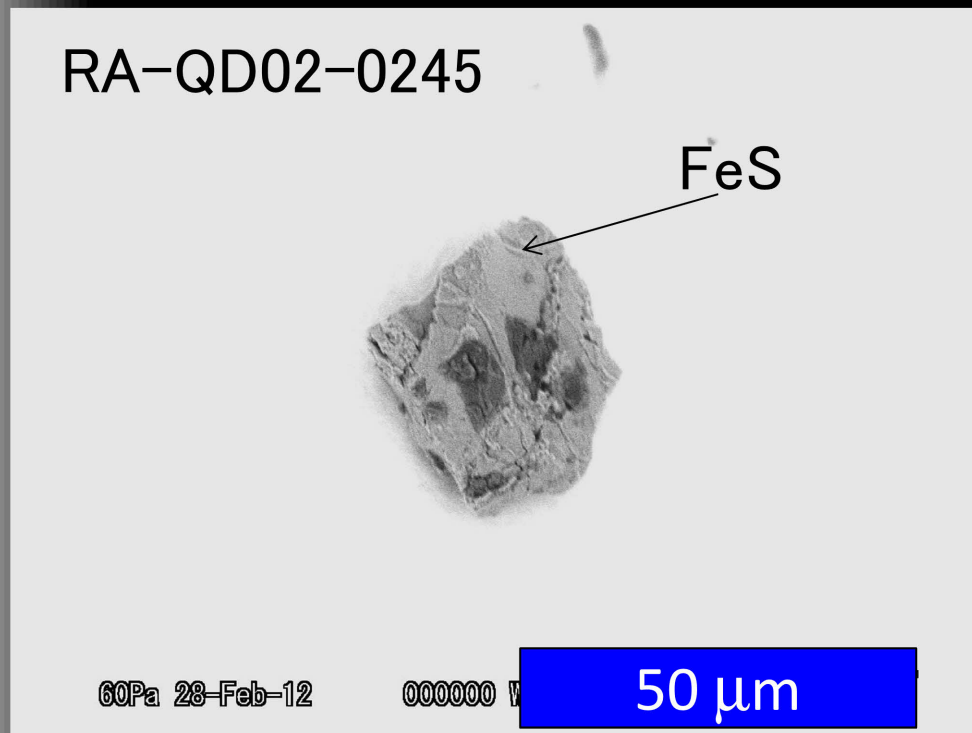
## Consortium study (2) Particle including NaCl



Size: 40μm

# Consortium study (3)

## FeS particle



X-ray CT without atmosphere and resin  
Karouji, Uesug, Tsuchiyama



SEM observation  
Tsuchiyama, Matsumoto



Making of the ultra-thin sections  
Uesughi



INAA (main mass) and/or  
LA-ICP-MS  
Karouji, Ebihara, Shirai, Sekimoto,  
Yamaguchi

TEM observation (ultra-thin sections)  
Noguchi, Keller

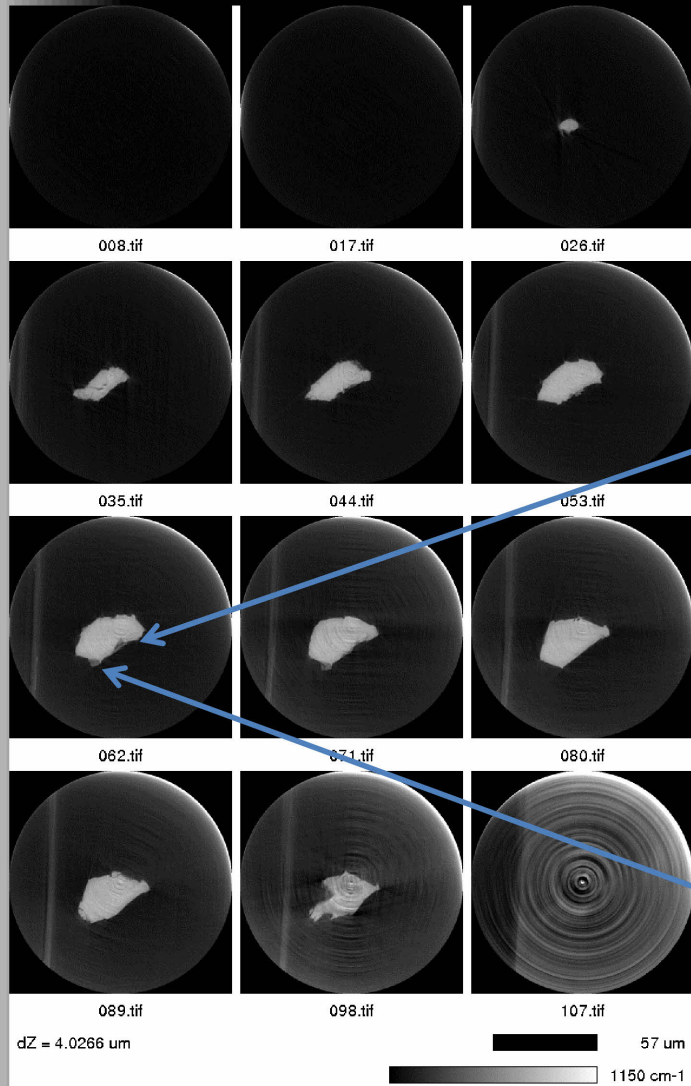
The only particle mainly consisting of FeS so far.  
This particle is studied for siderophile and/or chalcophile element composition and space weathering.



# Consortium Study (3)

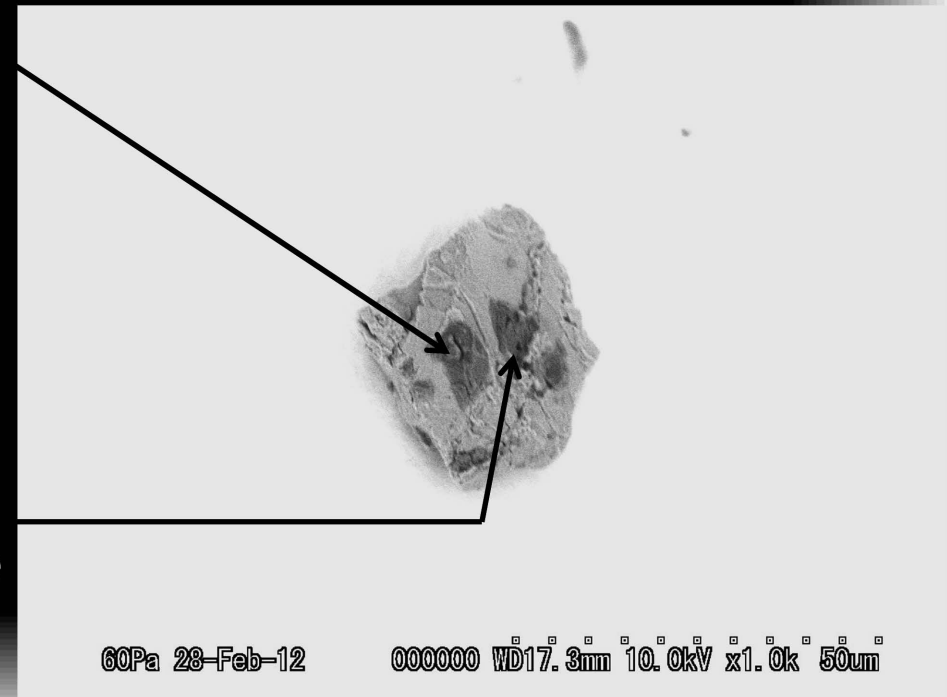
## FeS particle

CT image of the RA-QD02-0245. The olivine and the pyroxene were not embedded in FeS, but were small pieces attached on FeS surface.



olivine

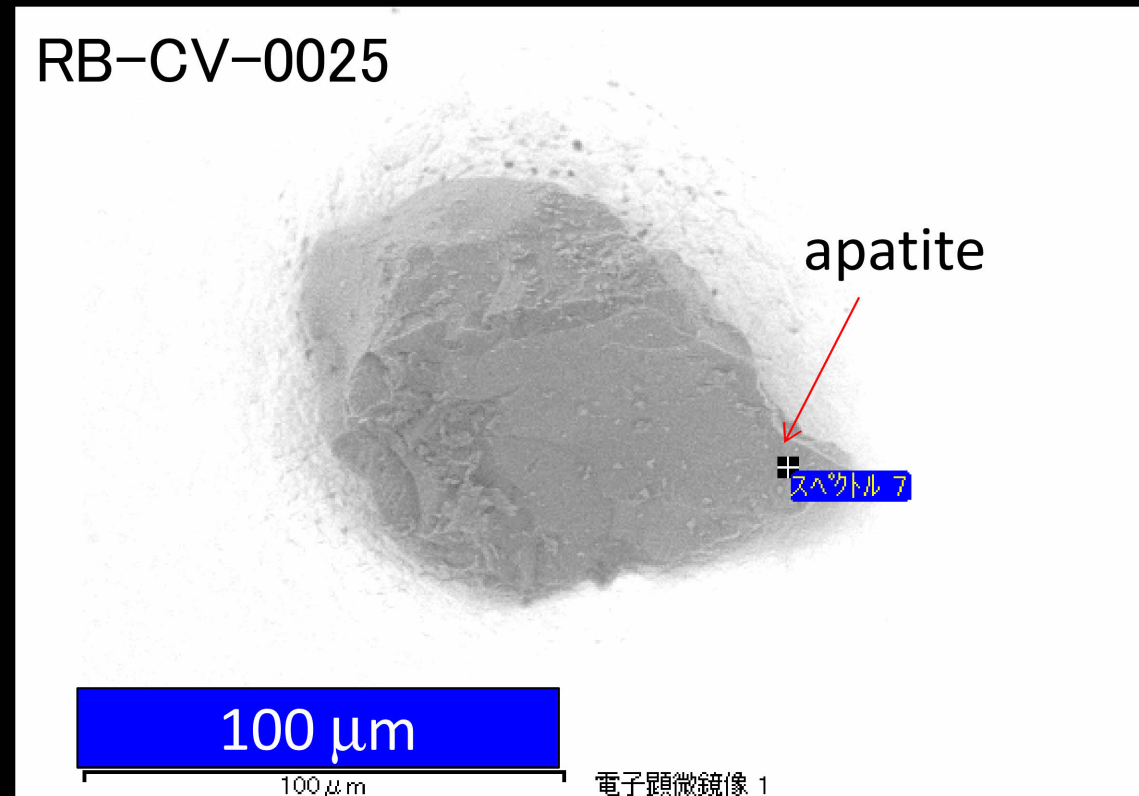
pyroxene





# Consortium Study (4)

## Phosphate-bearing particle



Six particles containing phosphate mineral were found by the initial description so far. These particles are suitable for a chronology study of asteroid Itokawa by the U-Pb isotope analysis.

# Consortium Study (4)

## Phosphate-bearing particle

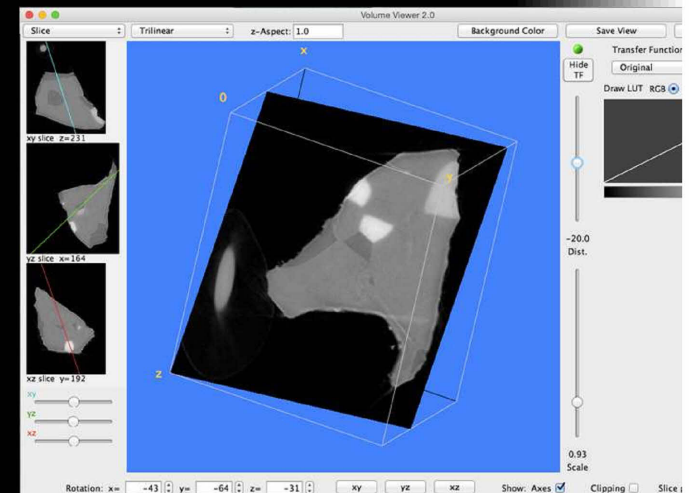
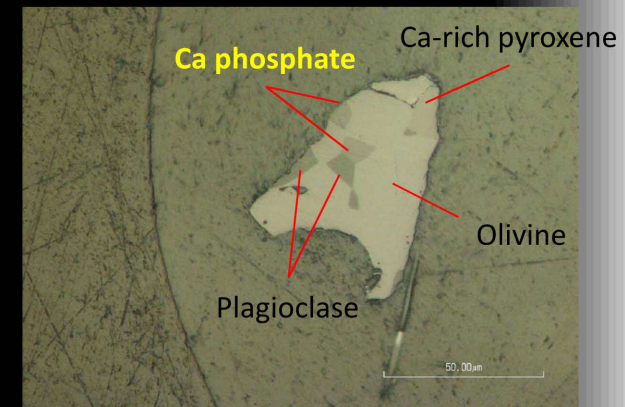
- X-ray CT
  - Karouji, Uesugi, Tsuchiyama

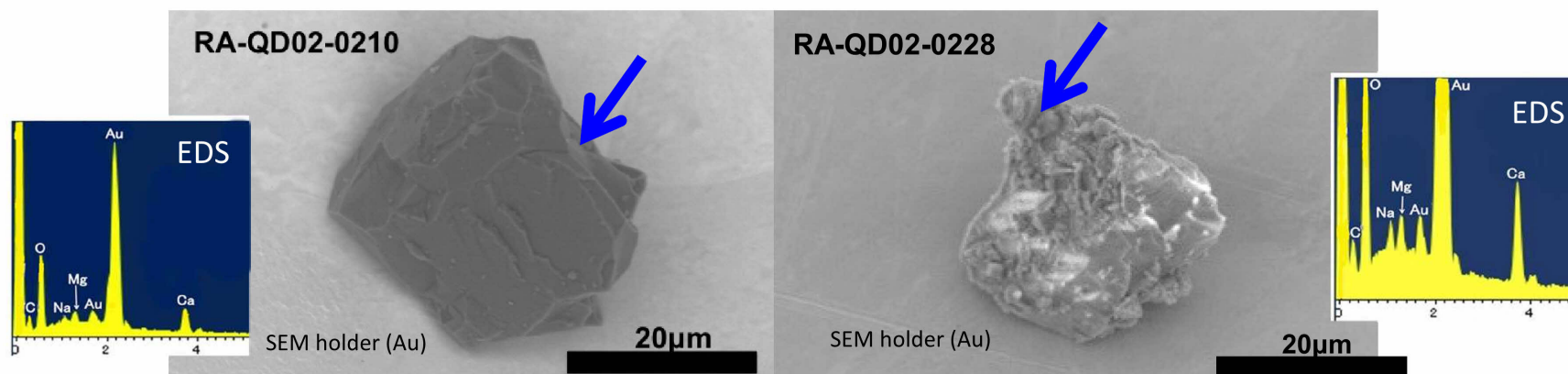


- Polishing down
  - Nakamura, Tsuchiyama



- U-Pb dating by SIMS
  - Terada, Sano



**【Particle information】**

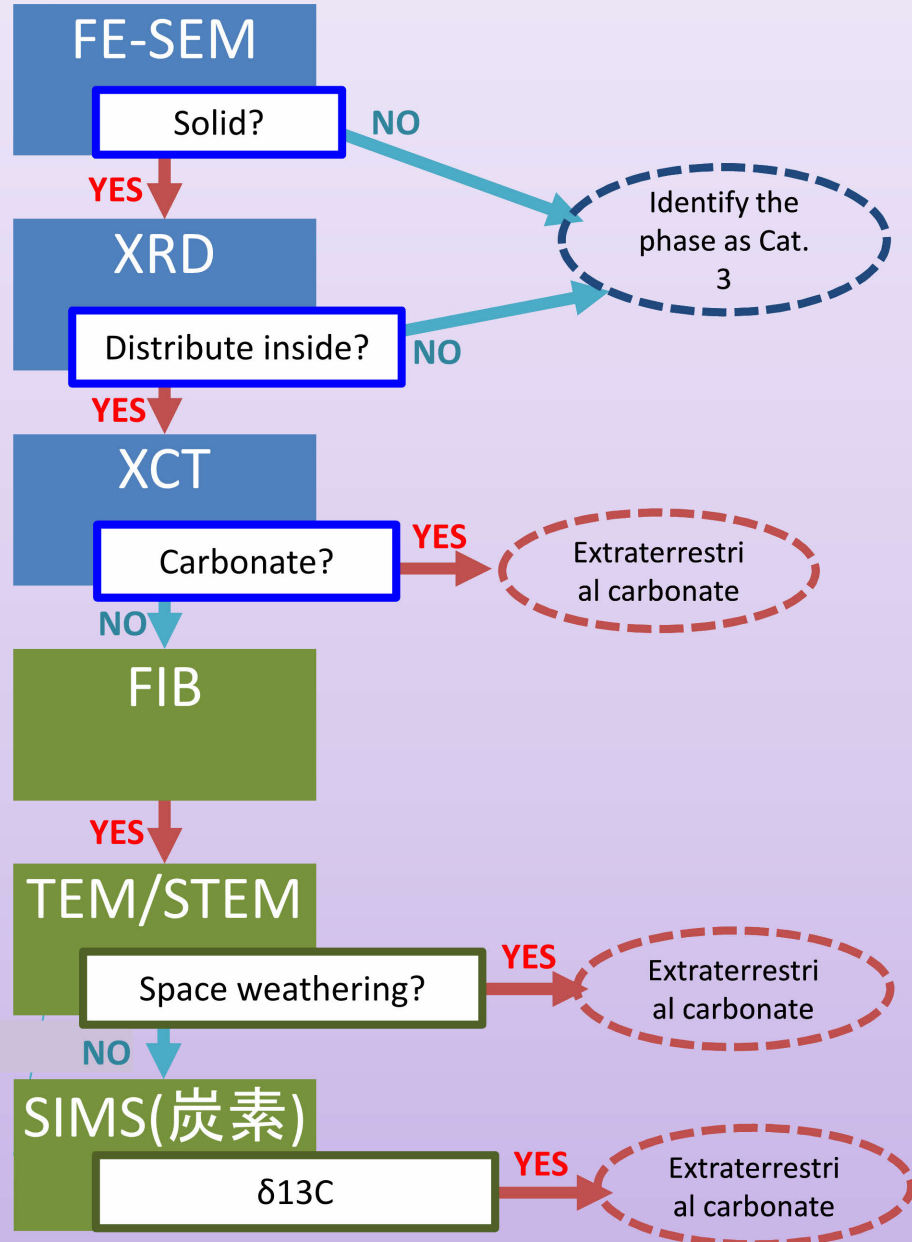
- 37µm (RA-QD02-0210) and 32µm (RA-QD02-0228) in size
- Both particles are mainly consist of olivine, high-Ca pyroxene, and plagioclase.
- **Ca-Mg-Na phases** (3-5µm) are on the particle surface.

Since no other Itokawa sample contains the Ca-Mg-Na phase, these particles that may indicate a new variety of Itokawa surface materials are rare and valuable.

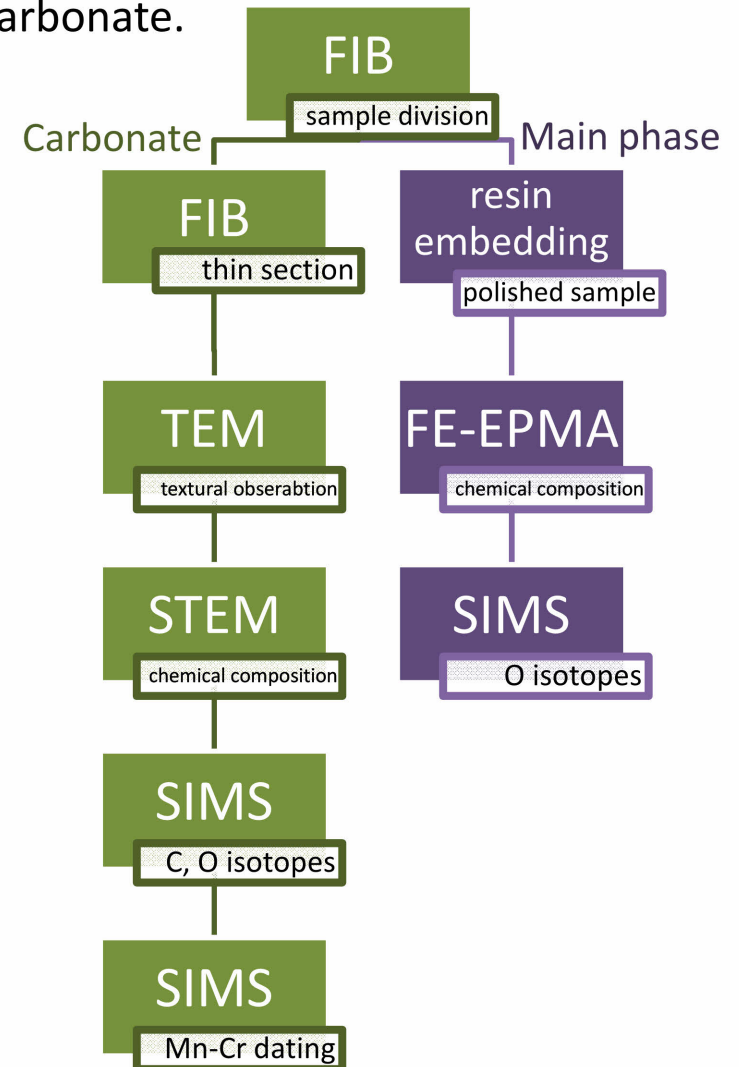
To identify the phase, SEM, XCT, and XRD will be performed. In the case that the phase is extraterrestrial carbonate, it might be formed by aqueous alteration. If the phase was the organic matter, detailed characterization is required.

Presence of carbonate indicates that carbonaceous chondrite-like material distributes on the Itokawa surface. It reflects that these minerals might be evidence of implantation from C-type asteroid to the S-type asteroid.

Determine the Ca-Na-Mg whether the phase is contaminant or extraterrestrial carbonate.



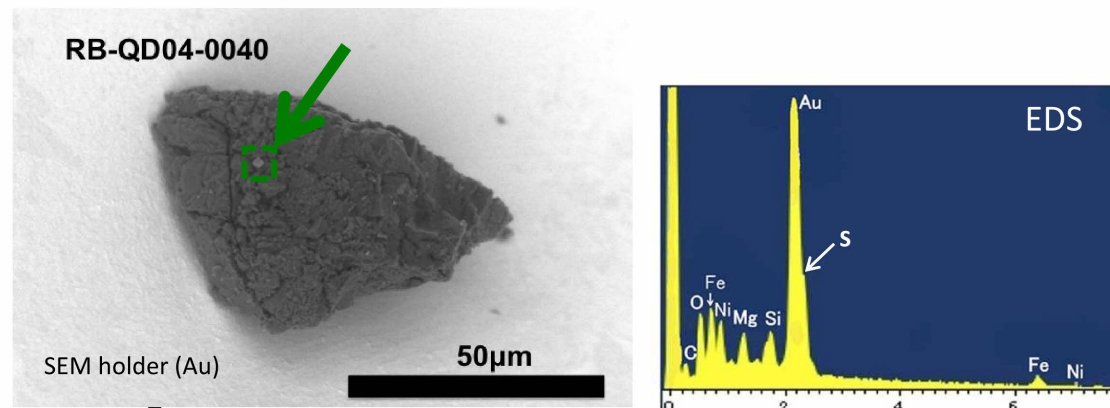
In the case that the phase is **carbonate**, following analysis and observation will be required to understand the formation process of carbonate.





## Consortium study (6)

## A particle including Fe-S-Ni phase



### 【Particle information】

- 74μm in size
- This particle is mainly consists of olivine and plagioclase
- Fe-S-Ni phase (5μm) is on the particle surface.

Since no other Itokawa sample contains the Fe-S-Ni phase, these particles that may indicate a new variety of Itokawa surface materials are rare and valuable.

Our motivation of this consortium study is to identify mineralogy of the Fe-S-Ni phase. After determination of internal structure obtained by XCT, the phase is characterized by XRD. STEM observation will be performed for the detail observation, especially the coexisting minerals. If this phase was the pentlandite single crystal, it can be the first discovery of the aqueous alteration product from the Hayabusa samples.

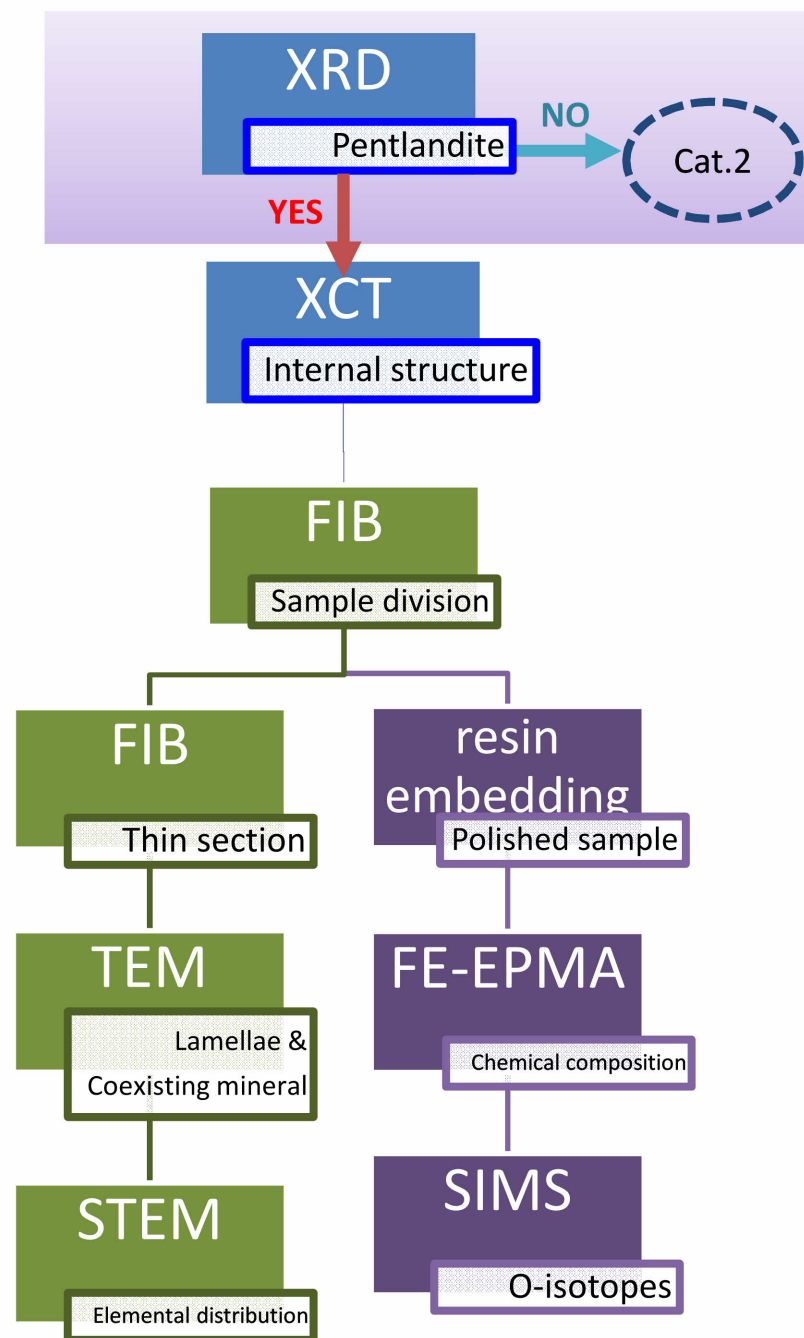
Presence of pentlandite indicates that carbonaceous chondrite-like material distributes on the Itokawa surface. It reflects that these minerals might be evidence of implantation from C-type asteroid to the S-type asteroid.

## 【Research Plan】

Identify the Fe-S-Ni phase and obtain the detailed information

In the case that the phase is identified as pentlandite, the formation process of pentlandite will be understood based on the elemental distribution and the coexisting mineral.

- ✓ Pentlandite coexisting with troilite: Rapid cooling of impact melt
  - Impact History of Itokawa based on temperature and shock pressure.
- ✓ Pentlandite as lamellae in pyrrhotite: Thermal metamorphism of Fe-Ni-S assemblage
  - Thermal History of Itokawa parent body according to temperature and cooling rate.
- ✓ Pentlandite having the elemental zoning of Ni:
  - Aqueous Alteration Product of troilite



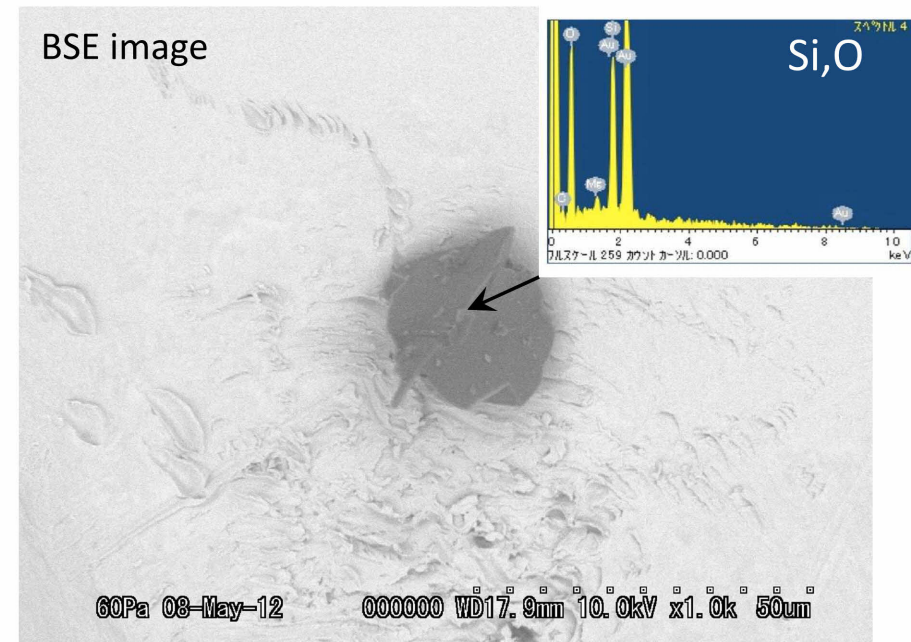
## Consortium study (7) Silica-containing particle

**Particle:** RB-QD04-0069

**Phase:** silica, ol, hpx, lpx, pl

**Size:** 33  $\mu\text{m}$

- So far, this is the only particle containing silica with other silicate minerals among catalogued Hayabusa-returned samples.
- Silica is widespread in ordinary chondrites, but is rare (usually  $< \sim 1$  vol%)

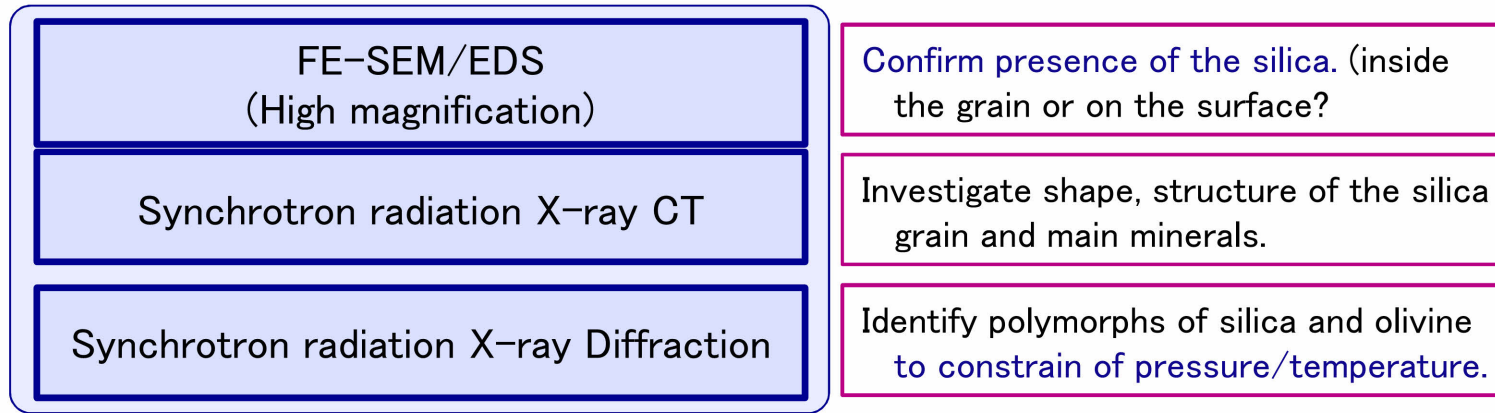


Silica forms many polymorphs under high/low pressure and temperature conditions. Thus, investigation of the particle can give **constraint of the pressure and temperature of shock metamorphism on asteroid Itokawa and/or its parent body.**

We plan several analyses to obtain mineralogical, crystallographic, and isotopic signature of the particle, particularly the silica mainly.

# Research plan

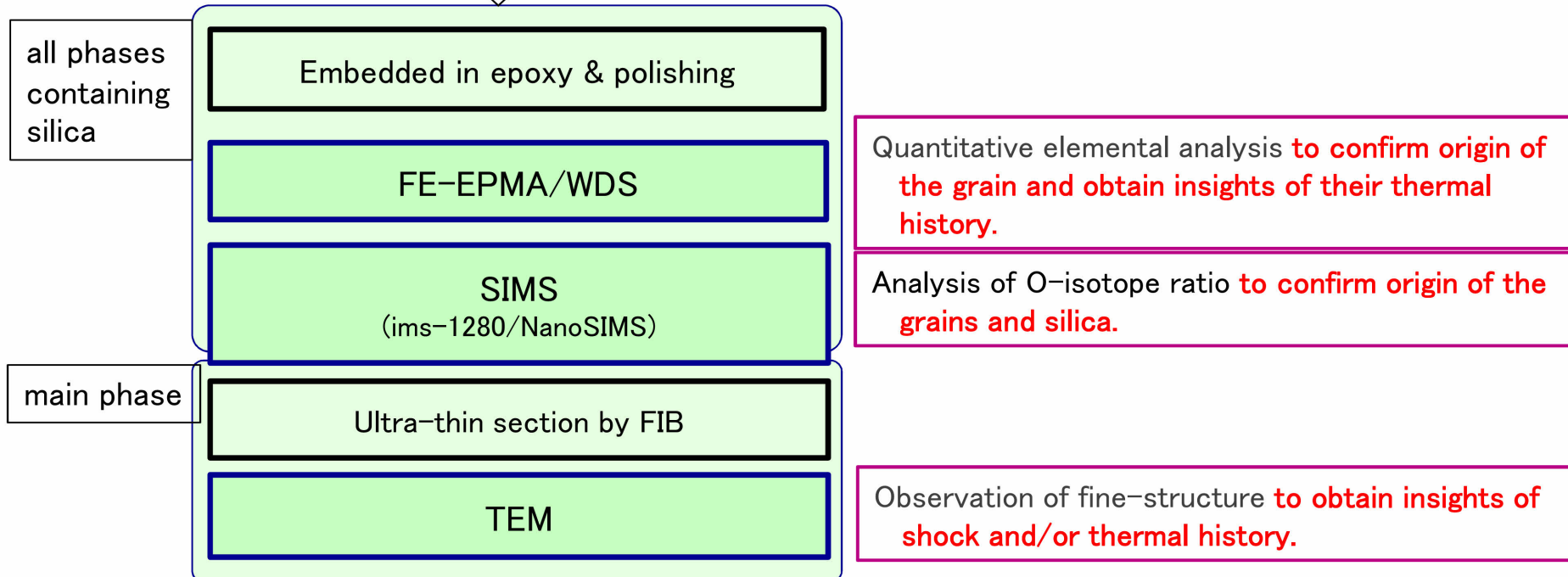
## Non-destructive analyses



FIB

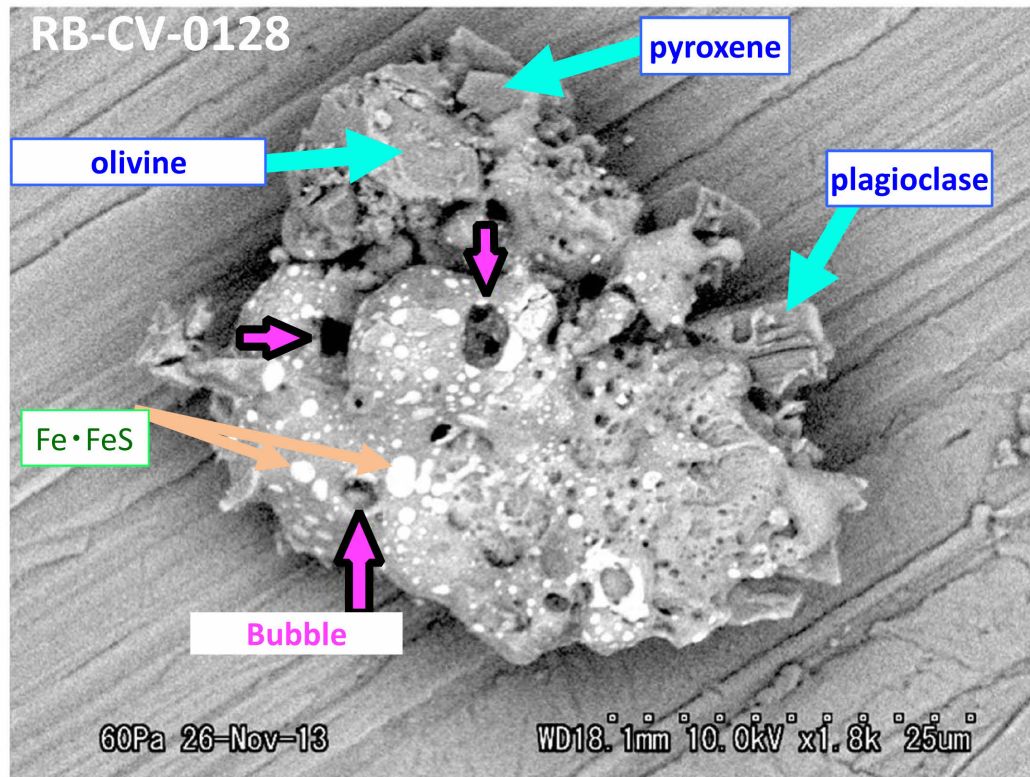


## Destructive analyses

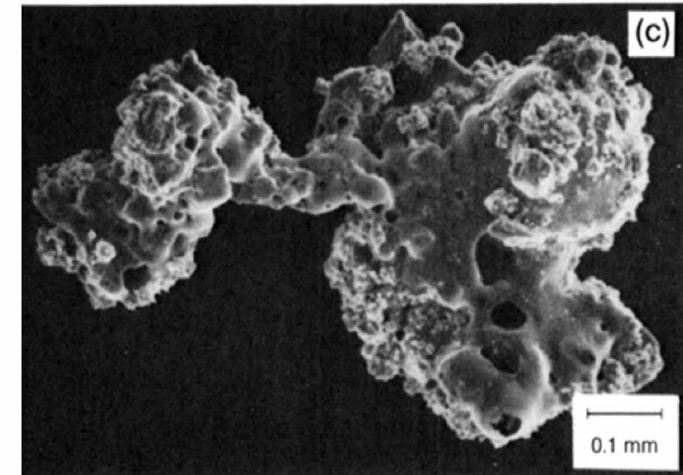




## Consortium study (8) Agglutinate grain(RB-CV-0128)

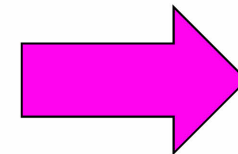


Lunar agglutinate



Lunar agglutinates are considered to be formed by melting and mixing of regolith particles induced by micrometeoritic bombardment into the lunar regolith (Heiken et al., 1991)

- Most part of RB-CV-0128 has rounded **molten shape**.
- **Vesicles** and submicron-sized grains of **Fe** and **FeS** are common throughout the molten surfaces.
- Fractured olivine, pyroxene, and plagioclase grains are attached to the molten surfaces.

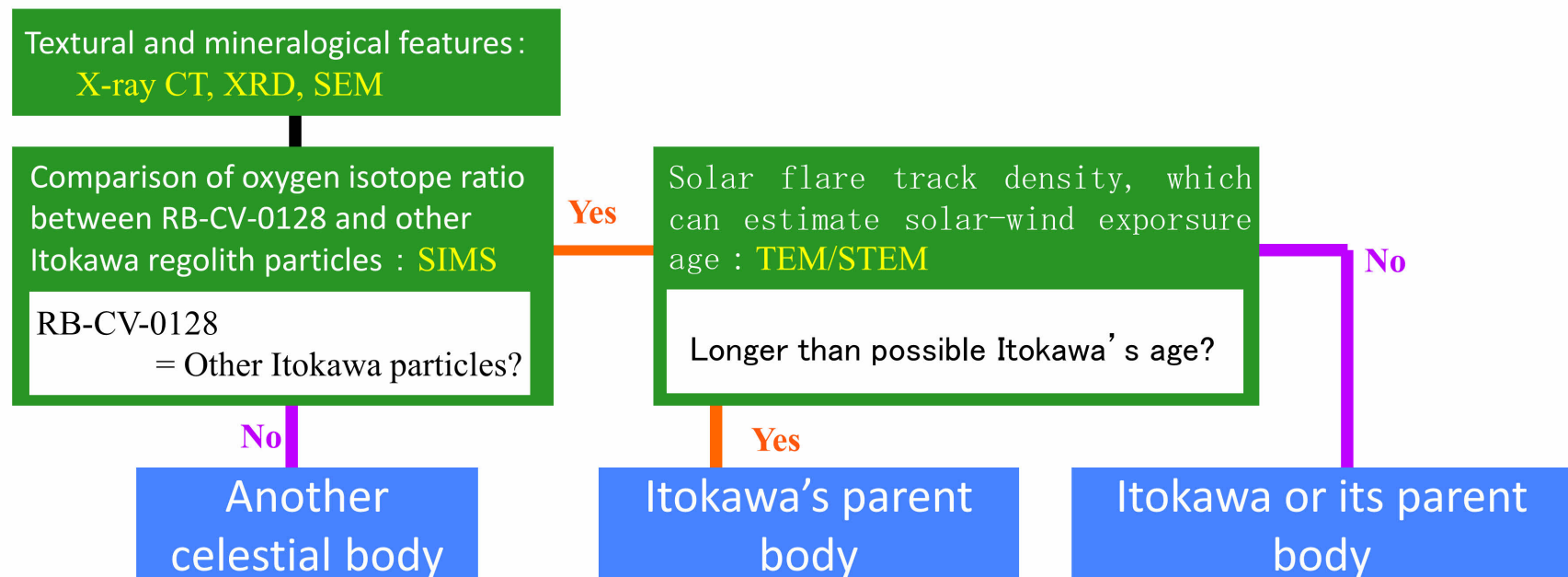


These characteristics are quite similar to lunar **agglutinates**

## Research plan

Agglutinate like object **has not been found in ordinary chondrites** so far (Noble et al. 2011). Despite that, RB-CV-0128 was found in Hayabusa-returned samples those much less than 1 mg in total mass. To understand the difference between LL chondrites and Itokawa regolith particles, we focus on **the origin of the particle**.

## Methods



# Summary

- Astromaterials Science Research Group which started in JAXA in July, 2015 and is the organization which researches mainly “extraterrestrial materials”.
- The studies of the Hayabusa returned samples advances in the international AOs, and the number of papers and presentations at the conferences are increasing.
- Samples are distributed for studies accepted in the 3rd international AO newly.
- The direct SEM observation of the room B cover is carried out.
- At present, 622 particles of Hayabusa returned sample are listed on the catalogue with data of initial description.
- Now, eight consortium studies are ongoing.



## 3<sup>rd</sup> Symposium of Solar System Materials

*You are all invited to participate the international science symposium of Itokawa origin and solar system evolution!*

### Date:

- 18-20 November 2015

### Venue:

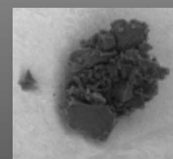
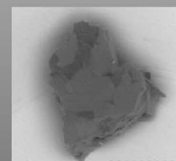
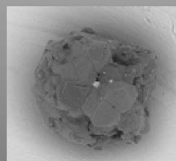
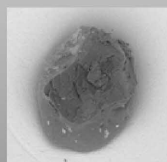
- JAXA Sagami-hara Campus, Japan

<http://www.isas.jaxa.jp/e/about/center/sagami/access.shtml>

### Topics:

- Results from Hayabusa sample analysis
- New insights from solar system material analysis
- Curation of extraterrestrial samples
- Missions to pristine small bodies
- Prospect of solar system evolution by theoretical, observational and experimental studies
- Technique and methodology of sample analysis
- Other related studies

### Hayabusa



### Important Dates:

- Call for abstract 17 July 2015
- Abstract submission due 14 August 2015
- Meeting period 18-20 November 2015
- Proceedings due 28 February 2016

### Registration:

- Anybody interested in these topics is welcomed.
- Registration fee is **free!**

### SOC:

Masaki Fujimoto (ISAS/JAXA), Kouchi Akira (Hokkaido Univ), Kevin Righter (NASA/JSC), Caroline Smith (Natural History Museum, UK), Shogo Tachibana (Hokkaido Univ)

### LOC:

- Astromaterials Science Research Group, Extraterrestrial Sample Curation Team, ISAS/JAXA (Masanao Abe, Tatsuaki Okada, Toru Yada, Masayuki Uesugi, Yuzuru Karouji, Aiko Nakato, Minako Hashiguchi, Toru Matsumoto, Kazuya Kumagai)

Contact: [curator@planeta.sci.isas.jaxa.jp](mailto:curator@planeta.sci.isas.jaxa.jp)

<http://hayabusao.isas.jaxa.jp/symposium/>

### Potential Speakers:

Kevin Righter (NASA/JSC), Saku Tsuneta (ISAS/JAXA)  
Caroline Smith (Natural History Museum, UK)  
Shogo Tachibana (Hokkaido Univ.), Masaki Fujimoto (ISAS/JAXA)

### Invited speakers

Harold C. Connolly Jr. (CUNY), Hideyasu Kojima (NIPR)  
Cecile Engrand (CNRS, Univ. Paris-Sud)

### Pls of selected proposals in 2<sup>nd</sup> Intl AO

Fabrice Cipriani, Wataru Fujiya, Arnold Gucsik, Monica Grady,  
Mutsumi Komatsu, Kunihiyo Nishiizumi, Ryam Ogliore,  
Akira Tsuchiyama, Hisayoshi Yurimoto



**Hayabusa2**