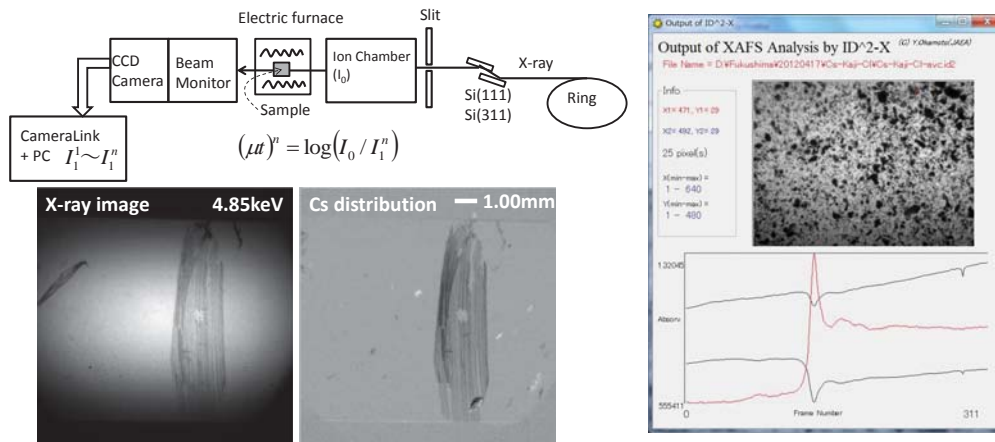


## Interpretation of Cs behaviour in waste reduction process by X-ray imaging and position sensitive XAFS methods



Quantum Beam Science Directorate, JAEA  
Y.Okamoto

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### The aim of this study

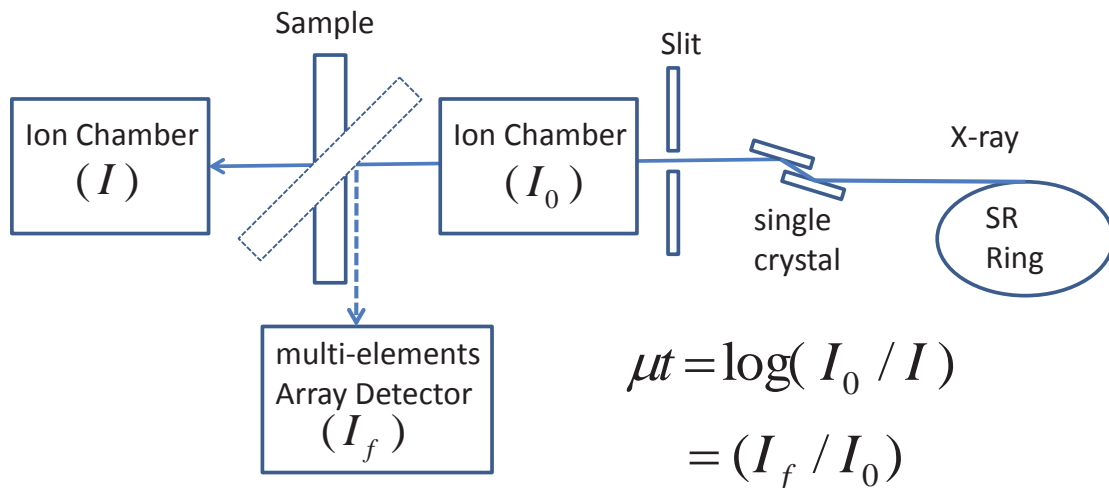
- (1) X-ray imaging observation of soil at heating
- (2) Cs  $L_3$ -edge imaging XAFS analysis in clay mineral/soil
- (3) Imaging XAFS analysis of Cs in flying ash

### Remarkable technique of this study

- (1) XAFS technique with position sensitivity
- (2) In-situ X-ray imaging at heating
- (3) Separation of Cs and Ti in the Cs  $L_3$ -edge XAFS spectra

2

## Layout of the **normal XAFS** measurement

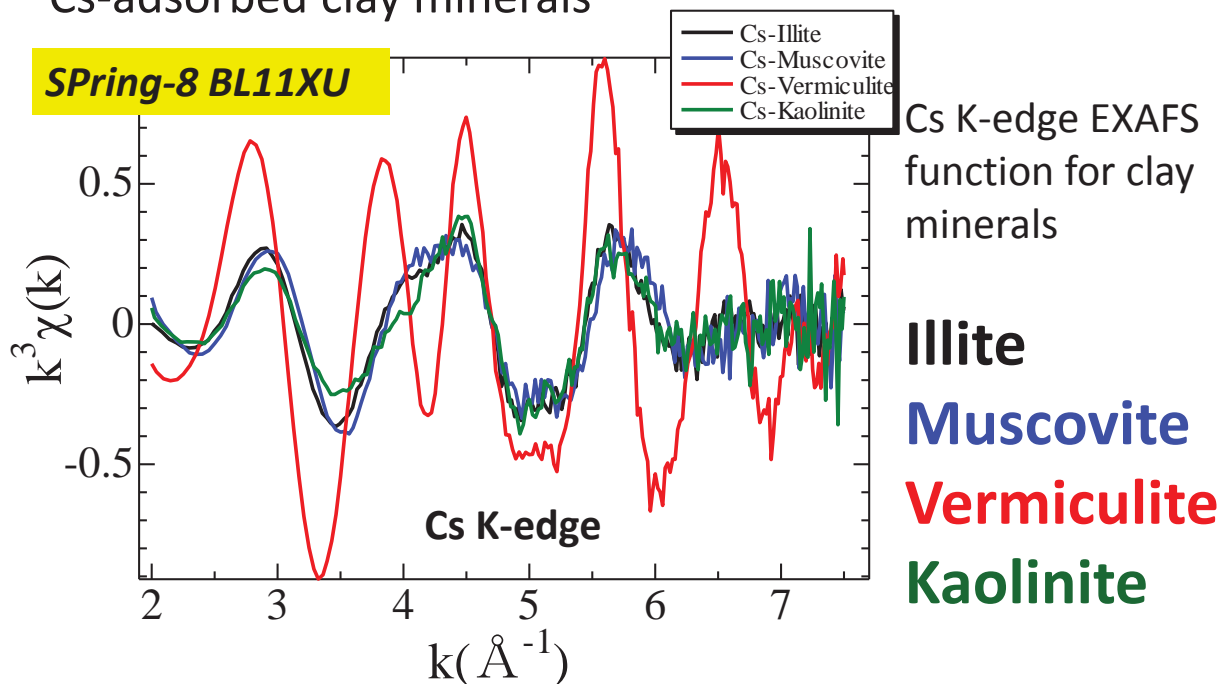


Intensity obtained from the normal XAFS is **an averaged value corresponding to the X-ray beam size**

shaped by the slit. ↗

3

## **Example of normal XAFS** measurements for some Cs-adsorbed clay minerals

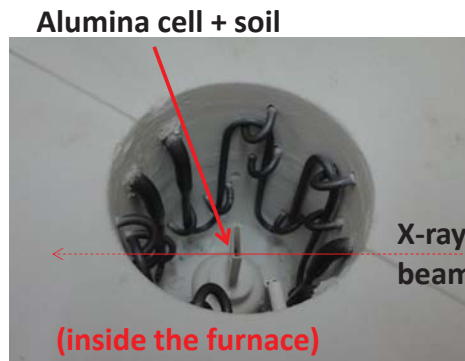
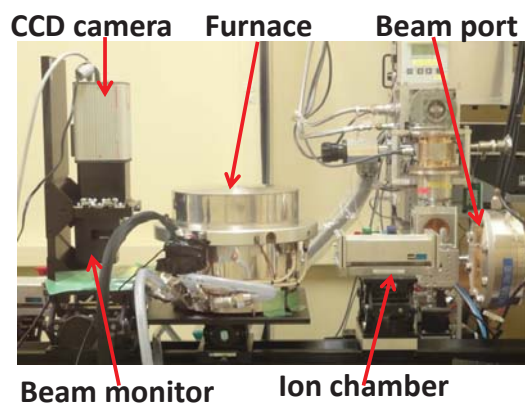
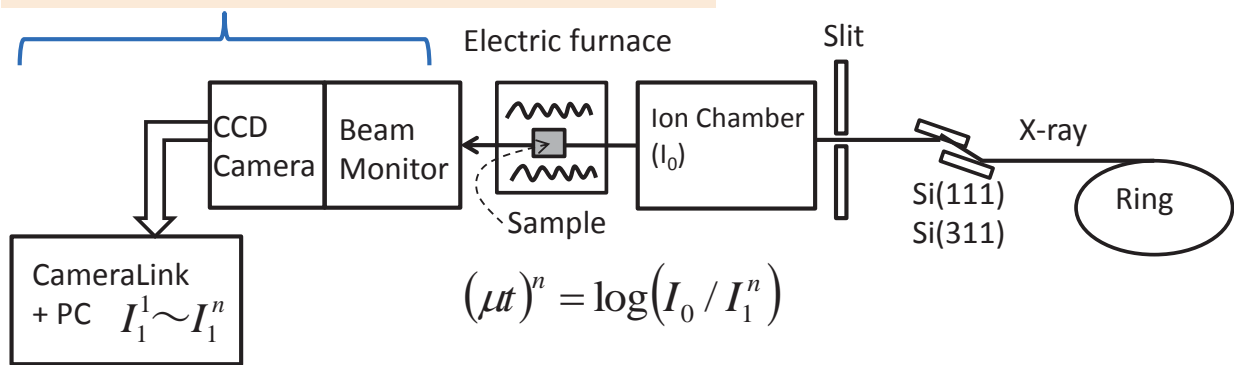


From EXAFS function, we may identify the kind of clay minerals which Cs adsorbed.

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# Layout of imaging and imaging XAFS measurement

Ion chamber is replaced by the imaging system



5

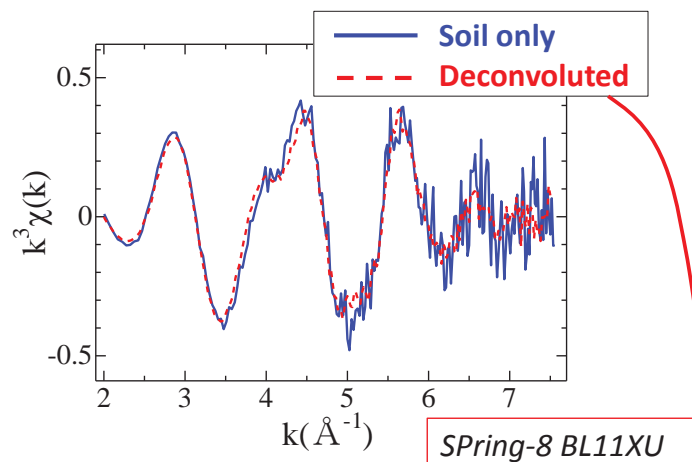
## (1) X-ray imaging observation of soil at heating

Composition of the soil  
(Kajiuchi, Iitate-Vill. Fukushima)

Comp.	wt%	mp: °C
Na <sub>2</sub> O	1.82	1132
MgO	0.72	2830
Al <sub>2</sub> O <sub>3</sub>	16.75	2054
SiO <sub>2</sub>	61.17	1710
K <sub>2</sub> O	0.82	*763
CaO	1.35	2900
TiO <sub>2</sub>	0.46	1800
Fe <sub>2</sub> O <sub>3</sub>	4.26	*1565

basicity 0.022 \* decompose

Heating the Cs-adsorbed soil under air atmosphere to 1500°C



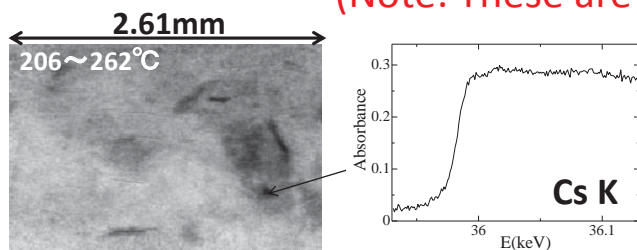
Cs adsorption clay minerals in the soil	Illite	75.9%
	Vermiculite	8.2%
	Kaolinite	15.9%

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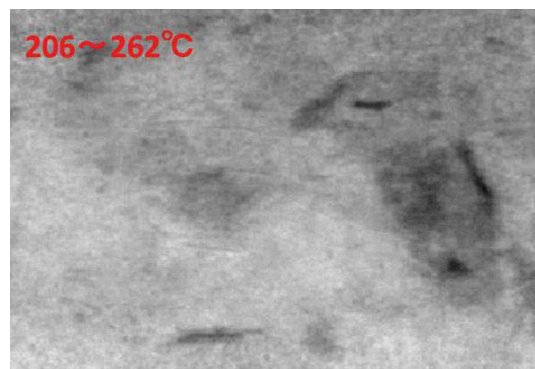
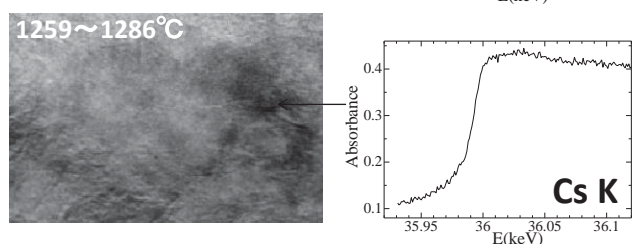
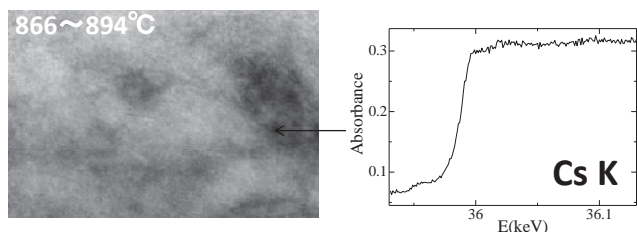
(Continue)

## Cs distribution maps obtained from imaging XAFS data

(Note: These are **NOT** CCD images)



Cs in the soil did not move by the heating



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## Summary of Cs behavior at some heating experiments

Common experimental condition:

- ① under air atmosphere
- ② Max. temperature 1500°C
- ③ using Cs K-edge

Materials (Cs-adsorbed)	Additives (No cesium)	Result after the heating
Soil	none	Most cesium remained
Kaolinite	Vermiculite	Most cesium remained
Ash	none	Most cesium disappeared
Ash	Kaolinite	Some cesium remained
Ash	Vermiculite	Most cesium remained

**Further works are in progress**

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## (2) L<sub>3</sub>-edge imaging XAFS analysis of Cs in clay mineral/soil

Edge	E(keV)
<b>K</b>	<b>35.985</b>
L <sub>1</sub>	5.714
L <sub>2</sub>	5.359
<b>L<sub>3</sub></b>	<b>5.012</b>

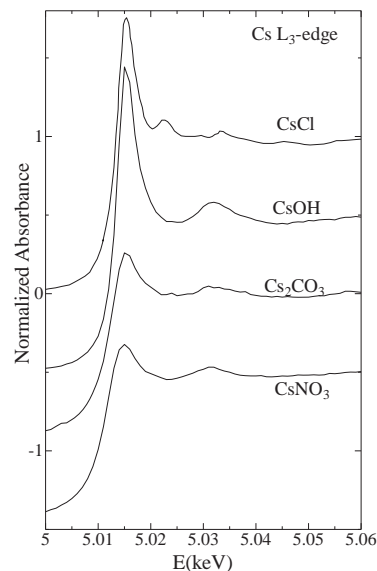
Why we use L<sub>3</sub>-edge in addition to K-edge ?

We should choose which absorption edge is appropriate, depending on the condition of samples and the purpose of analysis.

For example,

(a) In the heating experiment, we **have to use a sample vessel**. Therefore, the K-edge (higher energy) is better.

(b) In the experiment of fly ash, we handle **very thin film**. Therefore, the L<sub>3</sub>-edge (lower energy) is better.



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We have had a serious problem in the Cs L<sub>3</sub>-edge XAFS

**Titanium(Ti)** is contained in most environmental samples like soil.

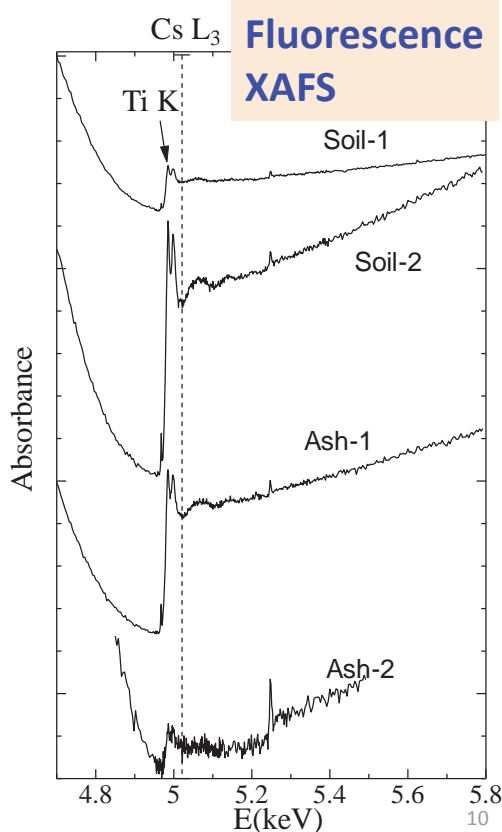
Element	Abs. edge	Fluorescence
Ti K	4.965keV	4.286keV (K $\alpha$ )
Cs L <sub>3</sub>	5.012keV	4.510keV (L $\alpha$ )

The absorption edge energy of Cs L<sub>3</sub>-edge is close to that of Ti K-edge.



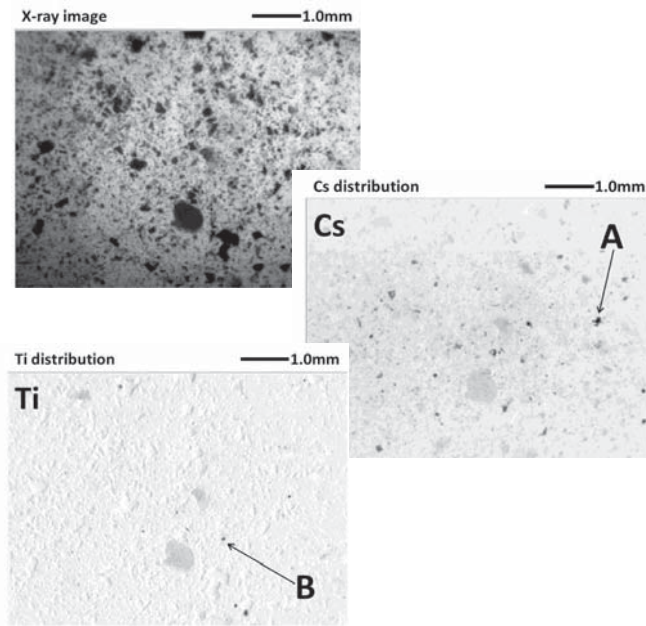
It is very difficult or impossible to use the Cs L<sub>3</sub>-edge for normal XAFS measurement of soil and ash.

Most researchers **GIVE UP using L<sub>3</sub>-edge** for chemical analysis of cesium.

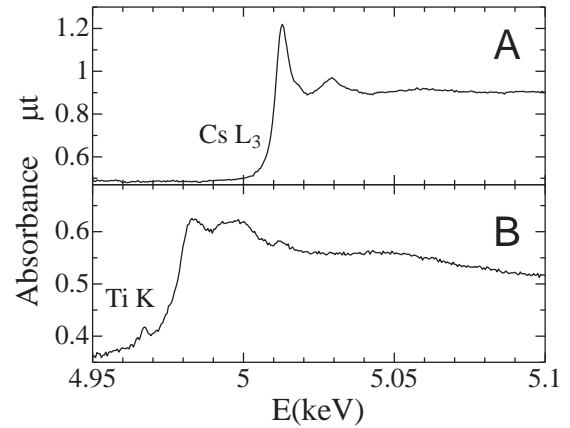


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The distribution of Cs in the soil sample does not necessarily accord with that of Ti.



Imaging XAFS has position sensitivity !



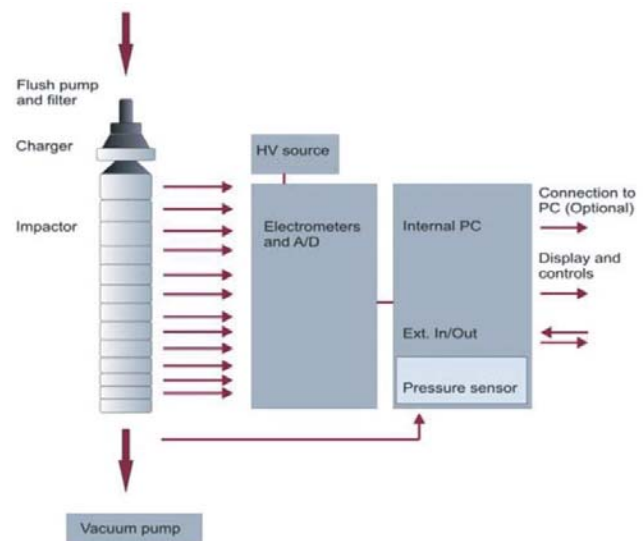
The imaging XAFS technique make it possible to use Cs  $L_3$ -edge in XAFS analysis of environmental samples.

### (3) Imaging XAFS analysis of Cs in fly ash

Fly ash was collected on Al foil by using the DEKATI-ELPI+ impactor



Typical example of Fly ash on aluminum foil

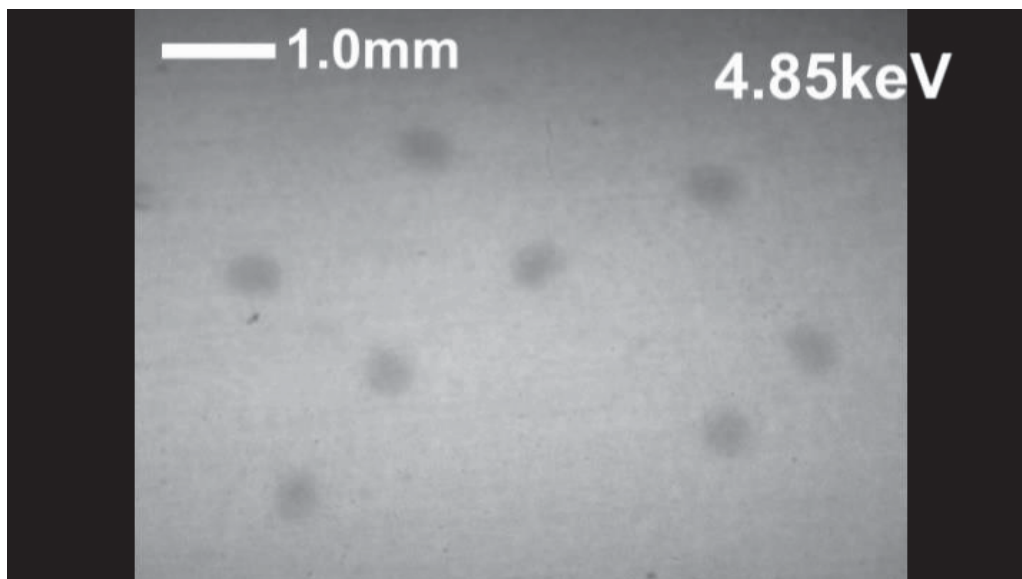


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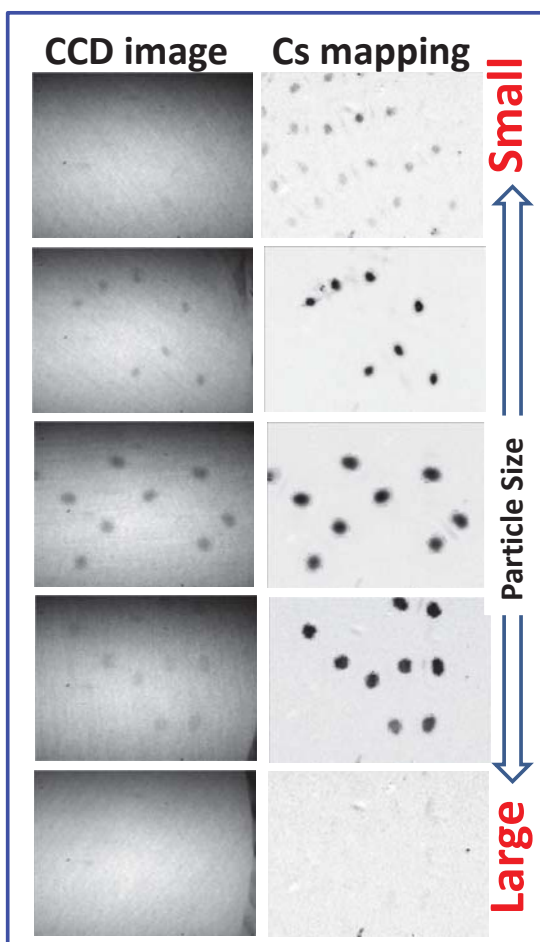
## Imaging XAFS of Cs in the fly ash

Movie: CCD images for X-ray energy scan from 4.85 to 5.40keV

Note color changes at 5.012keV(L<sub>3</sub>-edge) and 5.359keV(L<sub>2</sub>-edge)



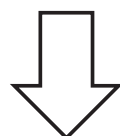
13



Information on Cs mapping can be available from imaging XAFS analysis.

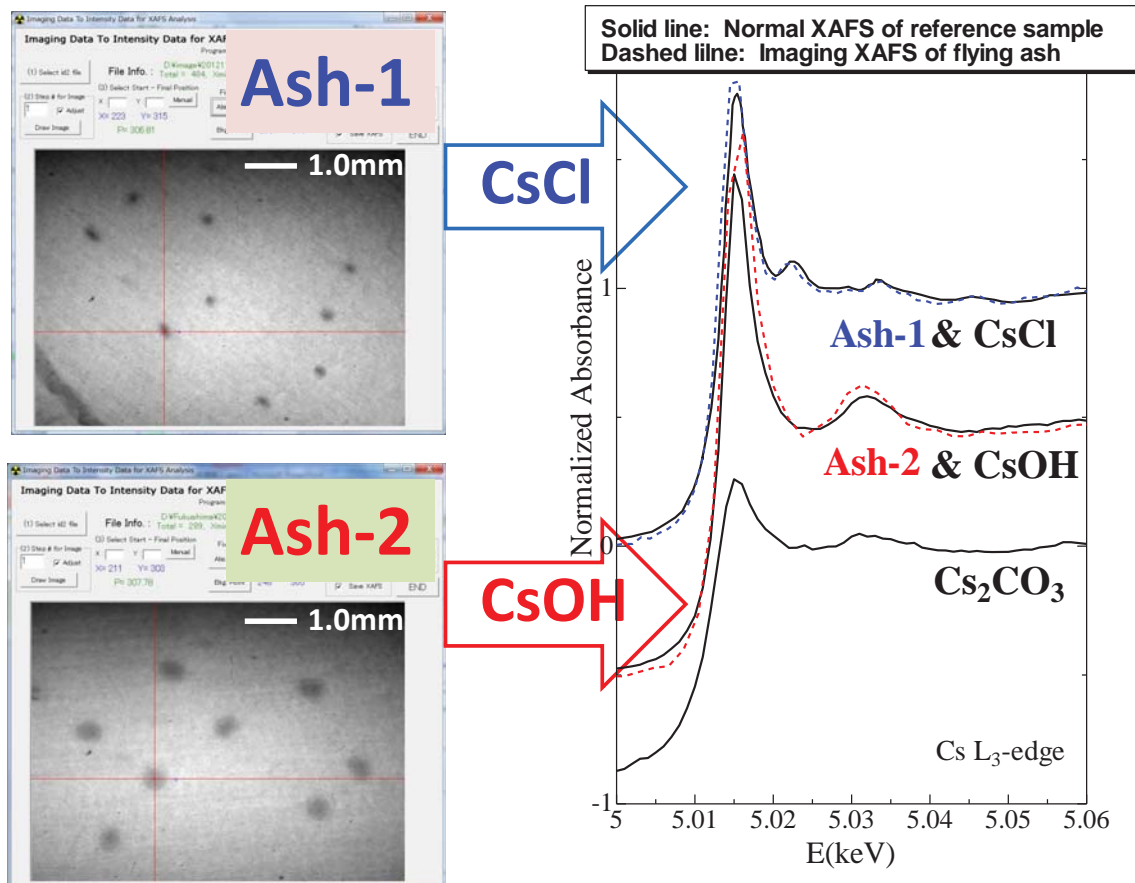


We can evaluate **quantity of cesium** and **size dependence** of fly ash.



In addition, **chemical form of cesium corresponding to each spot** can be identified by obtaining imaging XAFS spectrum.

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## Summary

1. In-situ X-ray imaging observation at heating process was demonstrated in this presentation. Such kinds of works are still in progress in the synchrotron facility.
2. Imaging XAFS technique has position sensitivity. We showed possibility of Cs  $L_3$ -edge imaging XAFS technique.
3. As a typical example of Cs  $L_3$ -edge analysis, we introduced imaging XAFS work on the fly ash. We are now searching appropriate condition of incinerator operation.

*Special thanks to my colleagues*

*Takeshi OSUGI(JAEA) Incineration process R&D, sample preparation*

*Mitsuo AKABORI(JAEA) High-temp. XAFS at the Photon Factory, KEK*

*Hideaki SHIWAKU(JAEA) High-energy Quick scan XAFS at the SPring-8*

*Shinichi SUZUKI(JAEA) Chemical analysis of the Cs-adsorbed sample*

*Tsuyoshi YAITA(JAEA) Project leader of Cs adsorption and desorption*

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