Physical and chemical properties of cesium-bearing microparticles and their impact on the ocean

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1. Cs-bearing microparticles on land

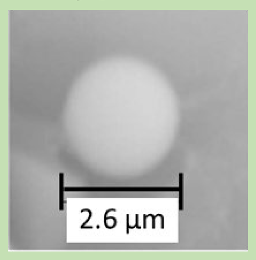
〈1-1. Introduction〉

Two types of Cs-bearing microparticles (CsMPs) from Fukushima Daiichi Nuclear Power Plant have been reported on land.

Similarities

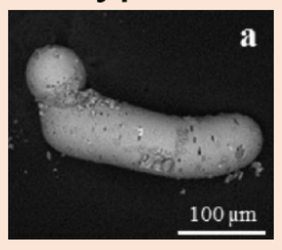
- matrix is SiO_2 → water-resistant
- including Cs and U → from FDNPP
- including Fe and Zn

Type-A



(Adachi et al., 2013)

Type-B



(Ono et al., 2017)

Differences

	Type-A	Type-B
^{134}Cs / ^{137}Cs	>1	<1
Size (µm)	~0.1-10	~10-1000
Shape	Mainly spherical	Various
^{137}Cs concentration (Bq/mm^3)	~10^8-10^9	~10^4-10^6
Elements	Na, Cl (volatile)	Ca, Ti (refractory)

〈1-2. Motivation〉

How CsMPs were generated?
→ related to physico-chemical condition of units at the accident

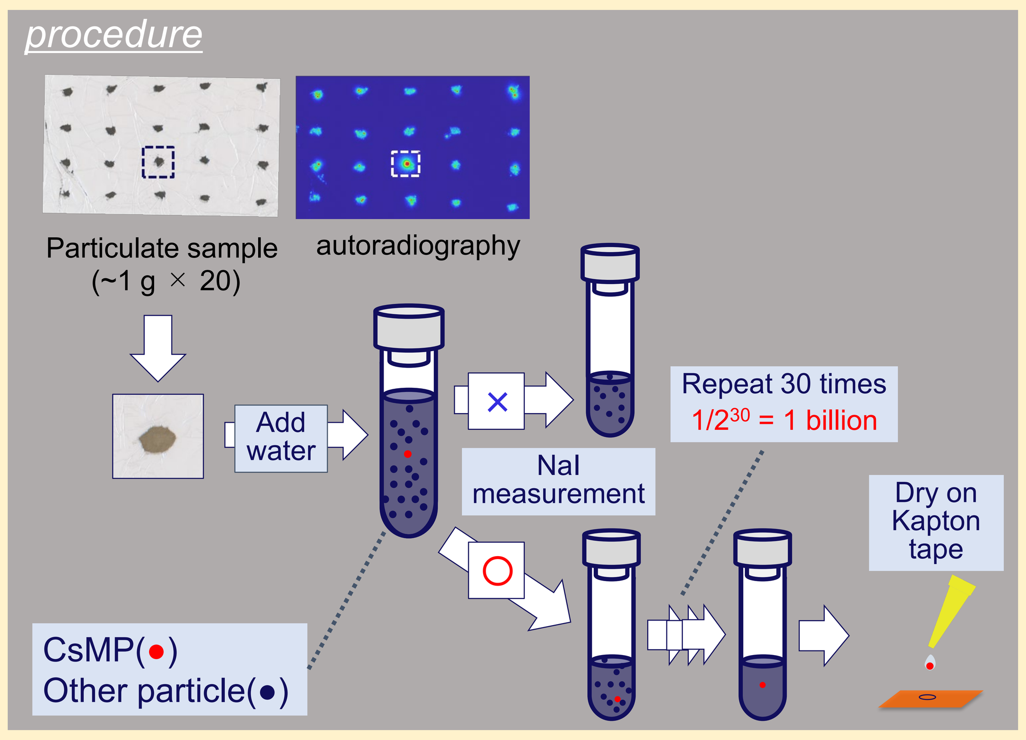
The number of reported particles was small because of the difficulty of separating.
→ wet separation method let us isolate CsMPs easily.

(Miura et al., 2018)

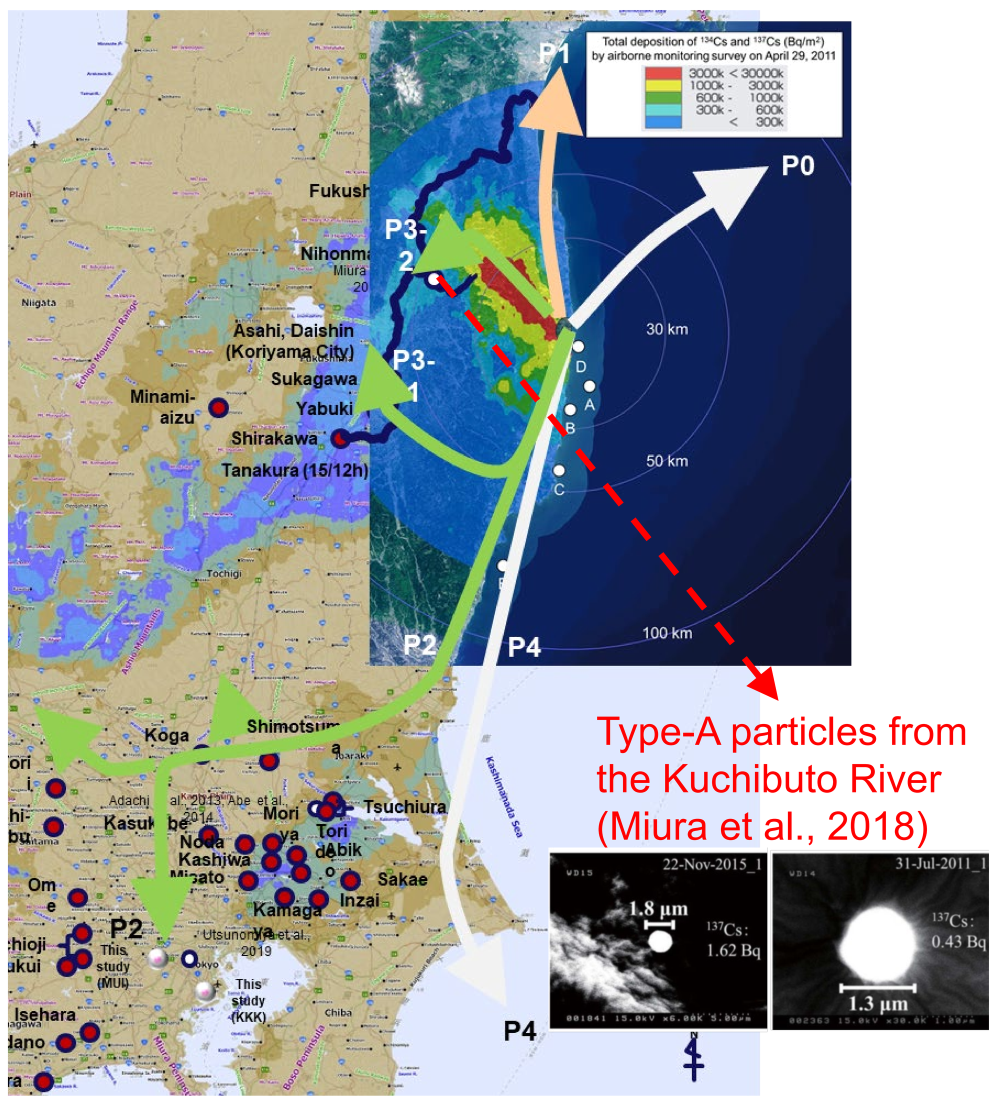
〈1-3. Wet separation method〉

We separated ~100 radioactive CsMPs by the new method to understand physical and chemical properties systematically

Previous method → 1 particle/day
This method → 1 particle/hour



〈1-4. Deposition area and migration through the river〉



Type-A particles from the Kuchibuto River (Miura et al., 2018)

Plumes (P2, P3) including Type-A particles from Unit 2

Type-A particles were deposited over a wide area including the Kanto region.

Miura et al. (2018) reported Type-A particles from suspended particles in the river.

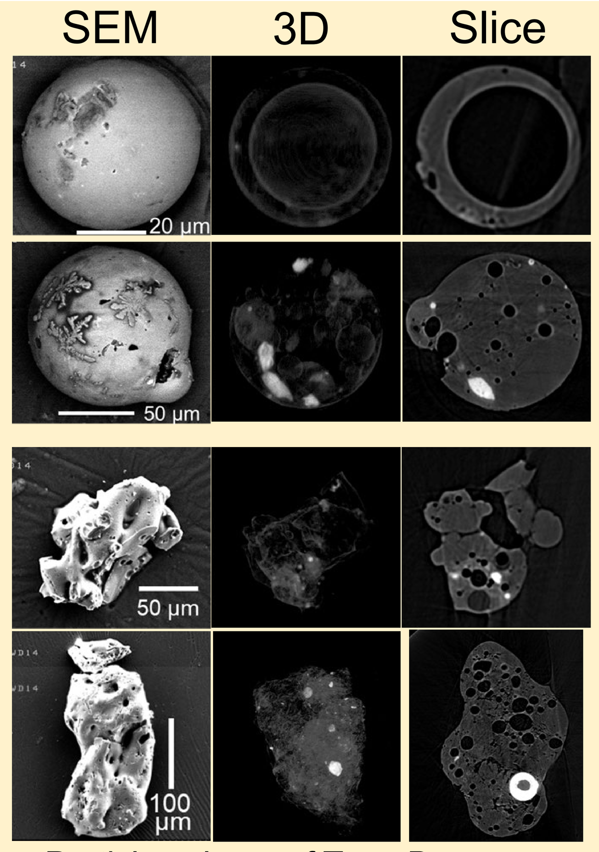
K_d value (solid-water distribution) of Cs in river is affected by CsMPs.

Plume (P1) including Type-B particles from Unit 1

Type-B particles were deposited in a limited area to the north due to their large size.

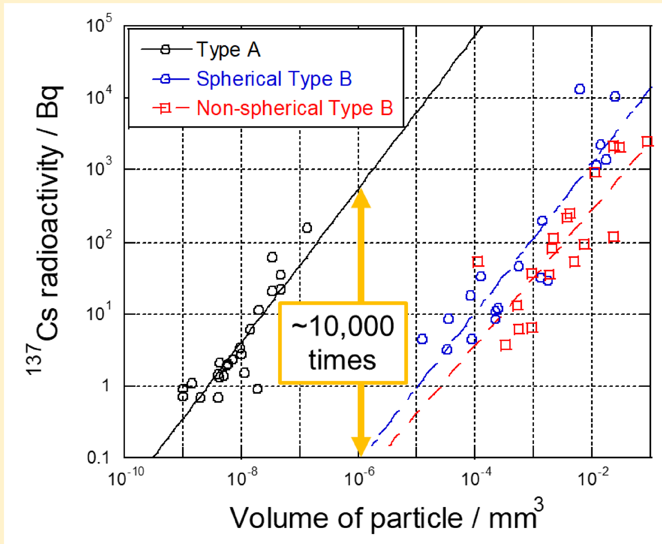
Tsuruta et al. (2014); Nakajima et al. (2017); Tsuruta et al. (2018); Katata et al. (2015); Chino et al. (2016); Tanabe (2012);TEPCO (2017)

〈1-5. X-ray µ-computed tomography (CT) for Type-B particles〉



- Particle volume of Type-B was calculated by CT.
- Fe exists heterogeneous.
- Type-B particles has a lot of voids.

Relationship between ^{137}Cs and volume of Types-A and -B particles



^{137}Cs concentration

~10,000 times difference between Types-A and -B

~10 times difference between Spherical and Non-spherical Type-B

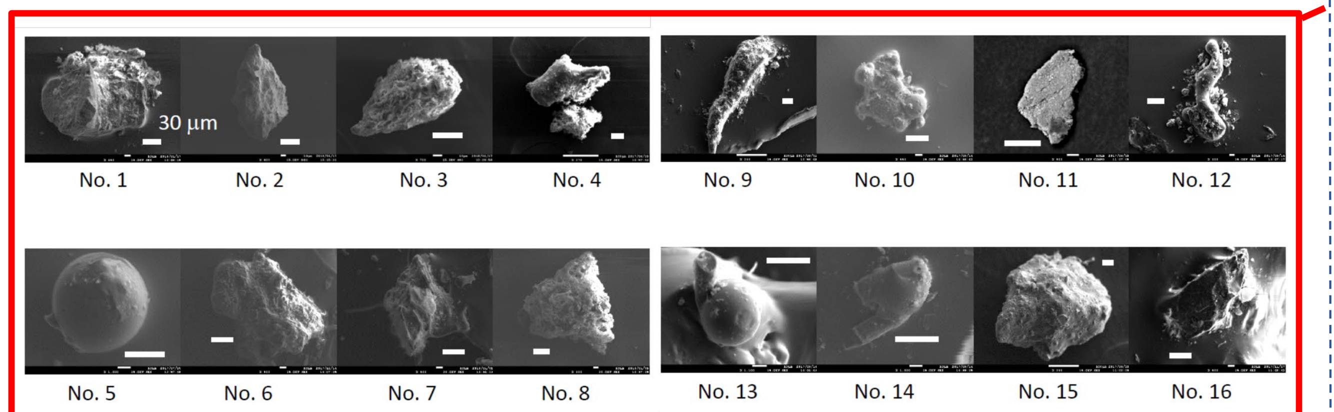
There are differences between Types-A and -B particles.
→ It is possible that these differences reflect physico-chemical condition of each unit at the accident.

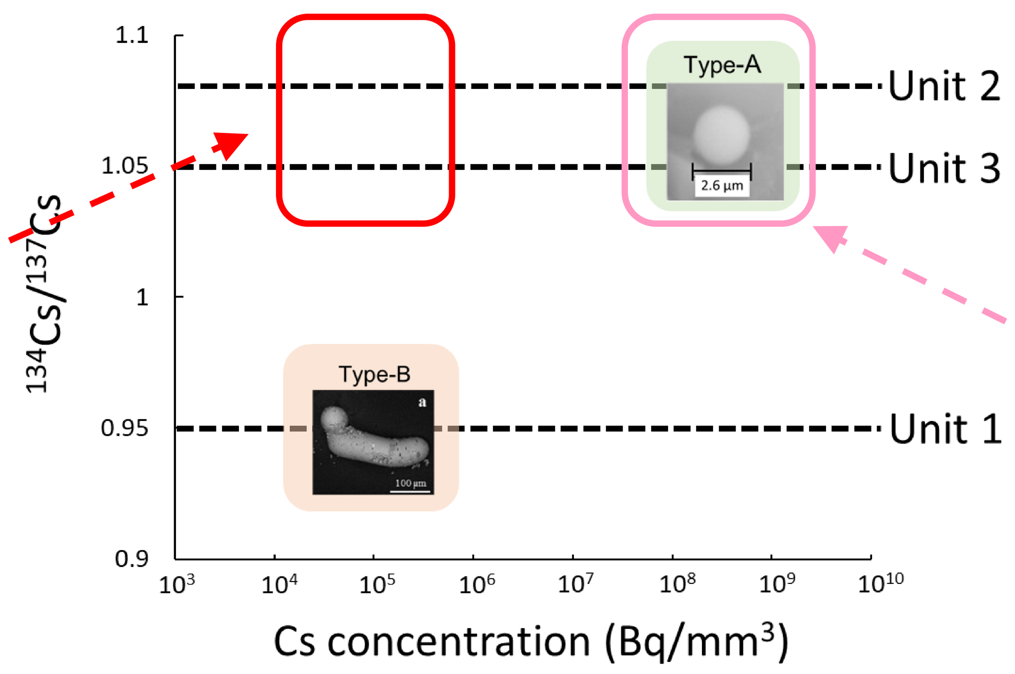
Unit 2・・・Type-A	Unit 1・・・Type-B
Gas (mainly Cs, H_2, Rb?) was emitted from blowout panel.	Melt (fuel and other materials) was emitted by hydrogen explosion.

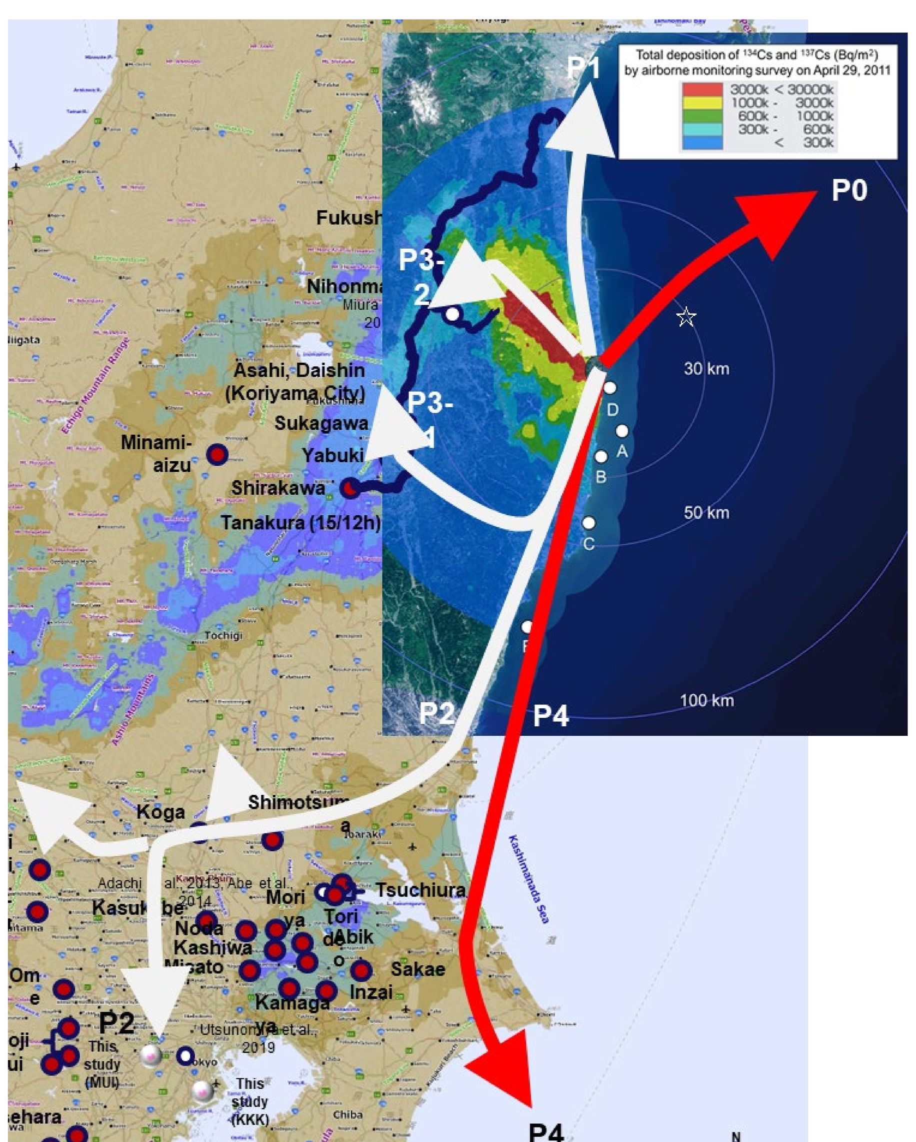
2. Cs-bearing microparticles in the ocean

〈2-1. Kubo et al. (2020)〉

25 CsMPs were isolated from marine sediment samples.







Plumes (P0, P4) from Unit 3

CsMPs from Unit 3 were deposited mainly onto the ocean surface.

Cs concentration and elemental composition of these CsMPs were consistent with Type-B particles but $^{134}Cs/^{137}Cs$ was >1.

The plume from Unit 3 was directed toward the ocean.

These CsMPs probably originated from Unit 3.

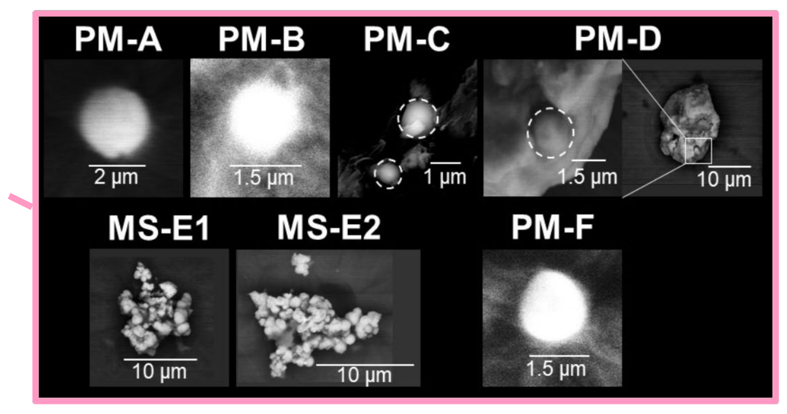
The contribution ratio of CsMPs to each sample ranged from 4.1–99.5% (median 58.8%).

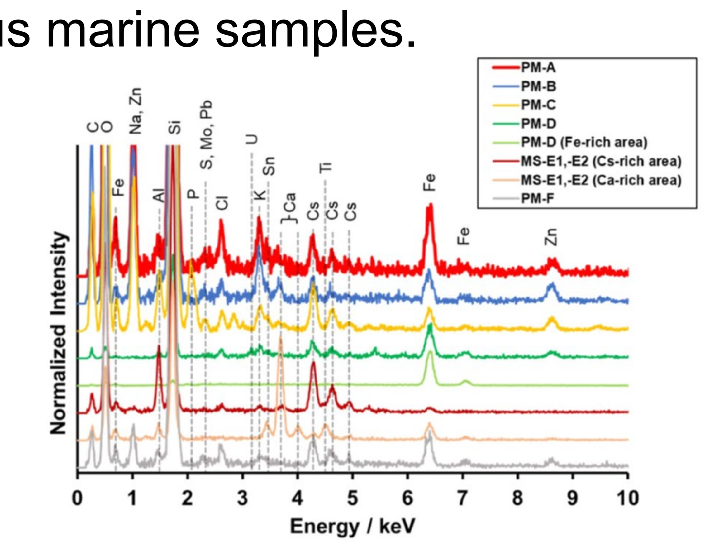
The large variation of Cs activity in marine sediments might be explained by the presence of CsMPs in the ocean.

$$\text{contribution ratio (\%)} = \frac{\text{Cs in CsMPs}}{\text{Cs in bulk sample}} \times 100$$

〈2-2. Miura et al. (submitted)〉

CsMPs were isolated from various marine samples.





- **PM-A, -B** (suspended particles)
- **PM-C** (plankton net)
- **PM-D** (sinking particles)
- **PM-F** (suspended particles at estuary)

Type-A particles

- **MS-E1, E-2** (marine sediment)

Cs concentration and $^{134}Cs/^{137}Cs$ of MS particles were consistent with Type-A particles but they look aggregate.

MS particles include Ca possibly from concrete. (Type-A particles do not include Ca.)

The molten core concrete interaction was more limited in Unit 2 than in Unit 3.

The plume from Unit 3 was directed toward the ocean.

MS-E1 and -E2 probably originated from Unit 3.

The presence of CsMPs can cause overestimation of the Kd of Cs for marine samples and a high apparent CF(concentration factor) of Cs for marine biota.

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