Introduction

- Soluble Cs
- Insoluble Cs

Sulfate aerosol
Kaneyasu et al. (2012), Tanaka et al. (2013)

Cs-bearing radioactive microparticle (CsMP)

FDNPP

Adachi et al. (2013)

Ono et al. (2017)
Introduction

Similarities
- main component is SiO₂ → water-insoluble property
- Cs, Fe, Zn and …
- U and fission products → from FDNPP

Differences

<table>
<thead>
<tr>
<th></th>
<th>Type A</th>
<th>Type B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Unit 2 or 3</td>
<td>Unit 1</td>
</tr>
<tr>
<td>Size</td>
<td>~1-3 μm</td>
<td>~50-300 μm</td>
</tr>
<tr>
<td>Shape</td>
<td>Spherical</td>
<td>Various</td>
</tr>
<tr>
<td>$^{137}$Cs activity</td>
<td>~0.5-4 Bq/particle</td>
<td>~30-100 Bq/particle</td>
</tr>
</tbody>
</table>
Purpose of this study

Separating CsMPs from ocean samples

Analyzing CsMPs by HPGe and SEM-EDS

★ Comparing CsMPs from ocean with CsMPs from land (Type-A or Type-B ?)

★ How CsMPs behave in the ocean?

★ What is the source of CsMPs?
Wet separation by autoradiography

From sediment

- Add water
- Type A or Type B (●)
- Other particle(●)

Nal measurement

Repeat 30 times
About $1/2^{30} = 1$ billion

Dry on Kapton tape

SEM EDS

Previous → 1 particle/day
This method → 1 particle/hour
(Miura et al., 2018)
A: filtration
July-2015

B: filtration
Dec-2013

C: plankton net
July-2011

D: sediment trap
Nov-2014

E: sediment core
June-2011

F: filtration
(at estuary)
Nov-2012
Relationship between $^{137}\text{Cs}$ radioactivity and volume of CsMP.

CsMPs from ocean samples were classified in Type-A particles from Unit 2 or 3 of the FDNPP because their size, elemental composition, $^{134}\text{Cs}/^{137}\text{Cs}$ and $^{137}\text{Cs}$ radioactivity per volume were similar to those of Type-A particles from terrestrial samples.
# Results

<table>
<thead>
<tr>
<th>Sampling point</th>
<th>Name</th>
<th>Date</th>
<th>Sampling method</th>
<th>$^{137}\text{Cs in CsMP}$</th>
<th>$^{137}\text{Cs}$ Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>P-43-I01</td>
<td>2015/7/29</td>
<td>Filtration by large-volume pumps</td>
<td>19.4</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>Hisanohama</td>
<td>2013/12/16</td>
<td>Filtration by large-volume pumps</td>
<td>1.80</td>
<td></td>
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<tr>
<td>C</td>
<td>UT06</td>
<td>2011/7/2</td>
<td>Plankton net</td>
<td></td>
<td>77</td>
</tr>
<tr>
<td>D</td>
<td>GST#5</td>
<td>2014/11/22</td>
<td>Sediment trap</td>
<td>3.46</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>4UB06-1</td>
<td>2011/6/20</td>
<td>Sediment core</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Watari</td>
<td>2012/11/30</td>
<td>Filtration</td>
<td>24.8</td>
<td></td>
</tr>
</tbody>
</table>

If a sample includes CsMP, $K_d$ value or CF of Cs will be overestimated because Cs in CsMP will be considered as adsorbing to clay minerals or adsorbed by plankton, respectively. Actually, Cs in CsMP is independent on $K_d$ value or CF due to its water-resistance character. When $K_d$ value and CF are discussed, Cs radioactivity of CsMPs should be excluded.
Results

Calculation using stokes’ law shows that CsMPs flow ~10,000 km horizontally until they deposit on the seafloor.

Density of CsMP: 3.0-3.5 g cm$^{-3}$
(calculated using elemental composition cited from Kogure et al. (2016))
Diameter of CsMP: 1 um
Water depth: 100 m

This result suggests that CsMPs flow away after they are transported into the ocean.

However...

- CsMPs were collected from suspended particles in coastal area in 2015.
- A CsMP was collected from an estuary sample of Abukuma river.

→ (i)CsMPs were continuously supplied from land area to the ocean.
  (ii) Rivers are possible sources of CsMPs in the ocean.
1. CsMPs separated from ocean samples (2011–2015)

CsMPs from ocean samples were classified in Type-A particles from Unit 2 or 3 of the FDNPP because their size, elemental composition, $^{134}\text{Cs}/^{137}\text{Cs}$ and $^{137}\text{Cs}$ radioactivity per volume were similar to those of Type-A particles from terrestrial samples.

2. Source of CsMPs (Type–A) from ocean samples

- Calculation using stokes’ law shows that CsMPs flow ~10,000 km horizontally until they deposit on the seafloor.
- CsMPs were collected from suspended particles in coastal area in 2015.
- A CsMP was collected from an estuary sample of Abukuma river.

→ these results suggests that (i) CsMPs were continuously supplied from land area to the ocean.
   (ii) river is possible source of CsMPs in the ocean.