Japan Association of Mineralogical Sciences

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NEW INTERNATIONAL RESEARCH PROJECT

Eliminating Radionuclides in Seawater at Fukushima Daiichi Nuclear Power Plant — The Use of Halophilic Microorganisms

The fuel debris from Units 1–3 of the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi nuclear power plant (FDNPP) was stabilized by circulative cooling using seawater and by using water within a primary containment vessel (PCV). However, the incursion of more than 300 tons per day of groundwater through the FDNPP, in addition to some groundwater entering the PCV, has resulted in the generation of large quantities of contaminated water. This contaminated water is currently being treated by TEPCO, who are taking three countermeasures:

1. *Eliminate the contamination sources* The level of 62 nuclides in the contaminated water is reduced using multi-nuclide removal equipment, called ALPS (advanced liquid processing system). This removes the contaminants by sorption into adsorbent materials and by coprecipitating the contaminants with iron and/or carbonates. The treated wastewater is then stored in tanks because it still contains tritium (Fig. 1).

Figure 1 Large storage tanks used to house treated contaminated water.

2. *Isolate non-contaminated water from contamination* Uncontaminated groundwater is continuously being pumped to bypass the FDNPP, reducing groundwater flow from 400 m^3 to 300 m^3 per day. On the landward side, an impermeable wall of frozen soil will be used to reduce groundwater inflow into the buildings. Waterproof pavements have been installed to reduce rainwater infiltration into the ground and to protect radiation workers from mobile contaminants.

3. *Prevent leakage of contaminated water* Impermeable walls on the seaward side are now being constructed and will extend around the harbour. These walls will prevent the transport of contaminated waters.

Even with these countermeasures, radionuclides of ^{137}Cs and ^{90}Sr are being detected in the seawater intake channel and in the port at the TEPCO site (Fig. 2). In 2014, the highest concentrations of ^{137}Cs and ^{90}Sr inside the water intake channel of Units 1–4 was 73 Bq/L and 220 Bq/L, respectively; inside the port these values were 7.3 Bq/L and 49 Bq/L, respectively. The challenge, therefore, is to decontaminate

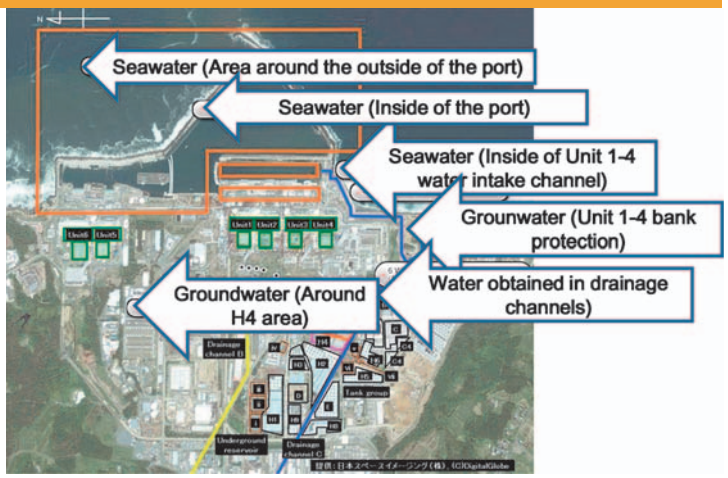

Figure 2 Plan view and sampling locations of the TEPCO Fukushima Daiichi Nuclear Power Plant site.

this water before it is transported further into the environment. Currently, TEPCO is using zeolite to remove ^{90}Sr from seawater; this produces more than 200 kg/m^3 of waste sorbent.

New research on novel restoration materials is being conducted by an international team led by Dr Toshihiko Ohnuki (Japan Atomic Energy Research Agency), with collaborators from the Shibaura Institute of Technology of Japan (abbreviation Shibaura TU), the Kyushu University of Japan, and Dr Joseph Hriljec and investigators from the University of Birmingham (abbreviation UB; UK). This joint research is being funded by Japan Science and Technology Agency (JST) for the Japanese team and by the Engineering and Physical Sciences Research Council (EPSRC) (grant EP/M012719/1) for the UK team.

There are three objectives of this international team. First, to use halophilic ("salt-loving") microorganisms to eliminate radionuclides from local seawater (Fig. 3). Second, to prevent the dispersion of the halophilic microorganisms out from the harbour area by using magnetized materials attached to the microorganisms. The novelty of using magnetized materials attached to the halophilic microorganisms is that the movement of the organisms, along with their radionuclide cargo, is designed to be controlled. Magnetized halophilic microorganisms could, therefore, be used to decontaminate the port seawater of the FDNPP. Third, to develop novel fluidized adsorbent materials to inject directly into the contaminated subsurface area. These adsorbent

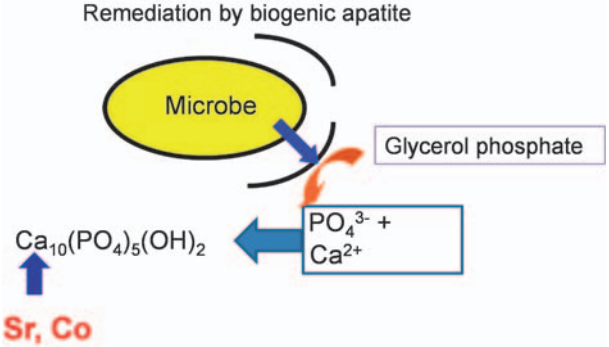

Figure 3 Radionuclides of ^{90}Sr and ^{60}Co can be eliminated by biogenic minerals from contaminated seawater and groundwater. This example shows biogenic hydroxylapatite as an entrapment mineral for Sr^{2+} and Co^{2+}.

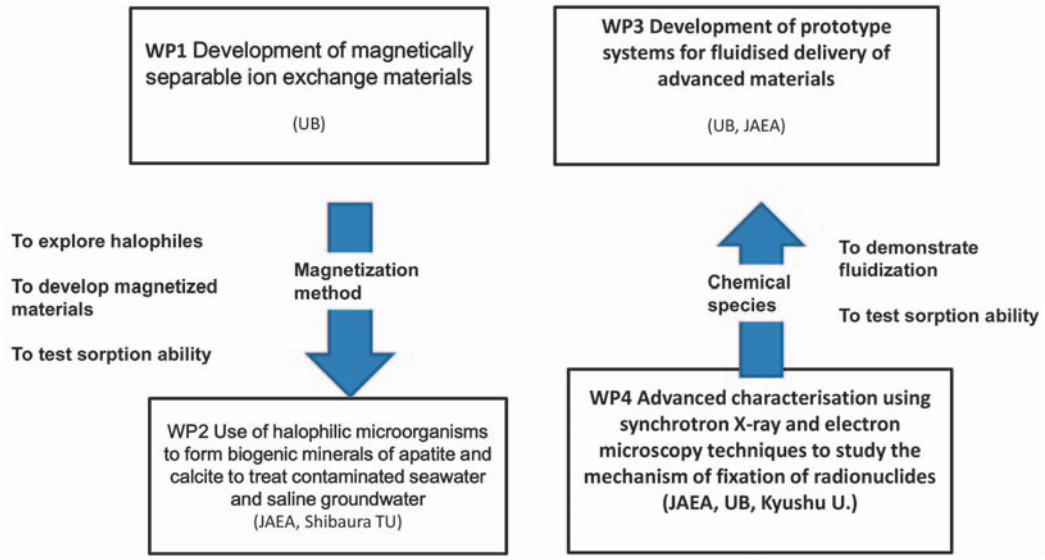

Figure 4 Collaboration flow chart of Japanese and international participants for four remediation/analytical work packages (see text).

materials would be designed to be poured or injected into the ground to form porous barriers that could then trap the targeted radionuclides and prevent further migration.

To achieve the above objectives, four work packages have been proposed:

1) Develop magnetically separable ion exchange materials
2) Use halophilic microorganisms to form biogenic minerals to treat contaminated seawater and saline groundwater
3) Develop prototype systems for the fluidized delivery of advanced materials
4) Develop advanced characterization using synchrotron X-ray and electron microscopy techniques to elucidate the mechanism of radionuclide fixation

The collaboration flow chart of participants in each work package is shown in Figure 4. The joint research will build on the work of an established internationally lead team for the development of novel systems for immobilizing Cs^{+}, Sr^{2+} and Co^{2+}. This research project, the culmination of the previous "projects" started in 2014, will extend for 3 years.

Dr. Toshihiko Ohnuki
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JAMS AT THE JpGU2015 MEETING

The Japan Geoscience Union Meeting 2015 (JpGU 2015) was held on 24–28 May 2015 in the Makuhari Messe Convention Centre at Chiba (outside Tokyo). The meeting had 189 scientific sessions, including 55 international sessions, and was attended by approximately 7000 participants. During the meeting, the Japan Association of Mineralogical Sciences (JAMS) had an exhibition booth to advertise our journals—*Journal of Mineralogical and Petrological Sciences (JMPS)* and *Ganseki Koubutsu Kagaku (GKK)*—as well as books authored by our members and back issues of *Elements*. The number of international sessions at the JpGU meeting is increasing year by year, and next year's JpGU will be held 22–26 May 2016, once again, in the Makuhari Messe. There are planned approximately 70 international sessions, including 10–15 Japan Geoscience Union–American Geophysical Union joint sessions. We look forward to your participation.

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Original Articles

Sr–Nd–Pb–Hf isotopic constraints on the diversity of magma sources beneath the Aden Ridge (central Gulf of Aden) and plume–ridge interaction Ryuichi SHINJO, Daniel MESHESHA, Yuji ORIHASHI, Satoru HARAGUCHI and Kensaku TAMAKI

Crustal assembly of the Antananarivo and Masora domains, central–eastern Madagascar: constraints from U–Pb zircon geochronology and whole-rock geochemistry of meta-granitoids Takashi ICHIKI, Masahiro ISHIKAWA, Jun-Ichi KIMURA, Ryoko SENDA and Raymond RAKOTONDRAZAFY

Cs-sorption in weathered biotite from Fukushima granitic soil Ryosuke KIKUCHI, Hiroki MUKAI, Chisaki KURAMATA and Toshihiro KOGURE

Mieite-(Y), $Y_4Ti(SiO_4)_2O[F,(OH)]_6$, a new mineral in a pegmatite at Souri Valley, Komono, Mie Prefecture, central Japan Ritsuro MIYAWAKI, Satoshi MATSUBARA, Kazumi YOKOYAMA, Masako SHIGEOKA, Koichi MOMMA and Sadaoki YAMAMOTO

Letters

Spatial U-Pb age distribution of plutonic rocks in the central Abukuma Plateau, northeastern Japan Arc Yoshiaki KON, Terumi EJIMA, Sayaka MORITA and Tetsuichi TAKAGI

Yukonite and wallkilldellite-(Fe) from the Kiura mine, Oita Prefecture, Japan Satomi ENJU and Seiichiro UEHARA