Earthquake Research Institute
The University of Tokyo

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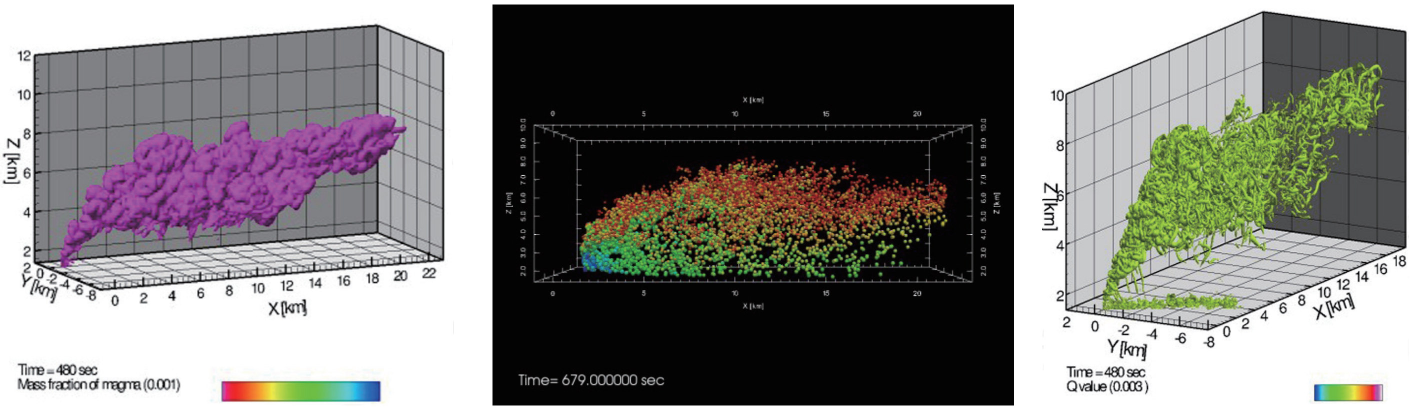


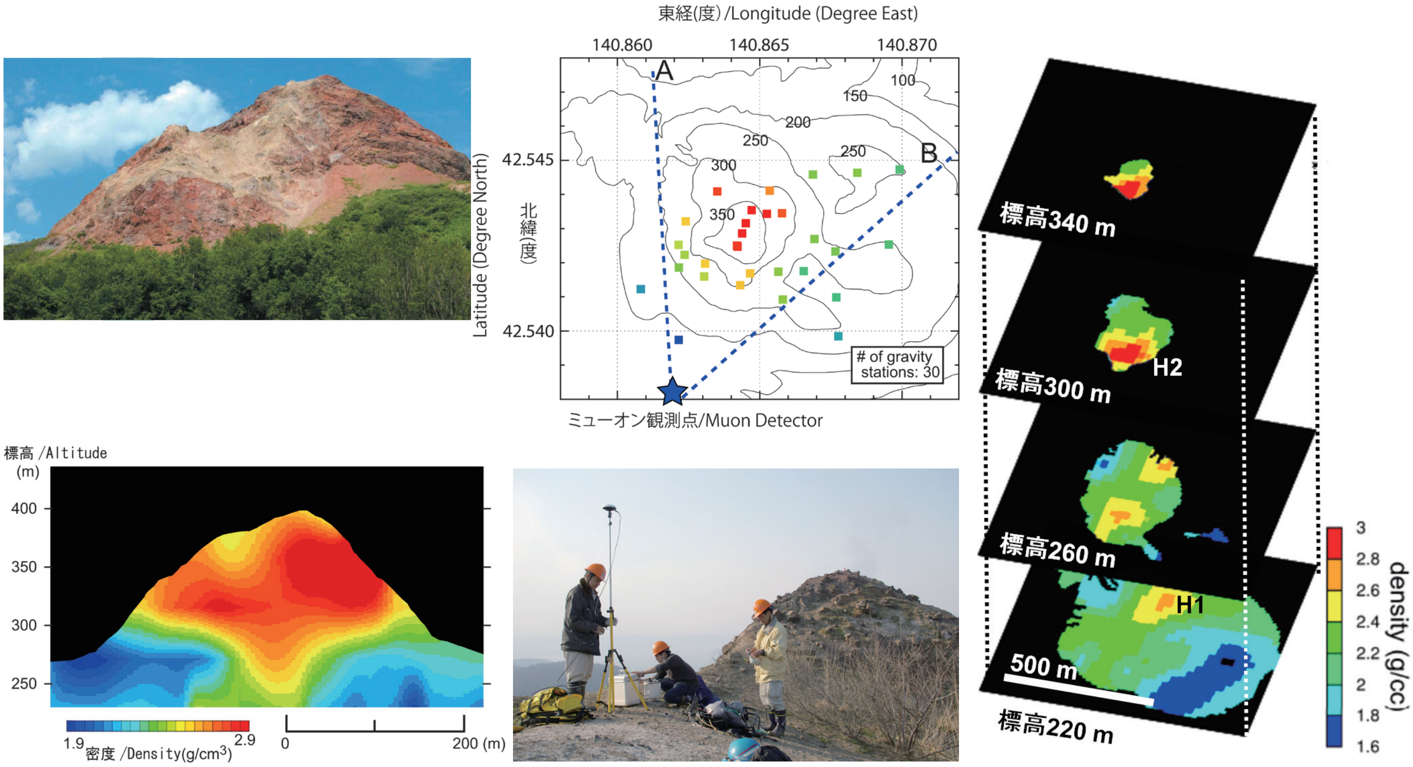
Figure: The 3D simulation results for the plume of the 2011 Shinmoe-dake eruptions. (left) Iso-surface that the concentration of the ejected material is 1 wt%. (center) Side view of the distributions of marker particles. Particle colors represent particle sizes. (right) Vortical structures in the volcanic plume.

3D NUMERICAL SIMULATION OF VOLCANIC PLUMES

Explosive volcanic eruptions are characterized by the formation of buoyant plumes and widespread dispersal of volcanic ash. The height of volcanic plume and the dispersal area of volcanic ash are the key observable quantities to estimate eruption conditions, including eruption intensity. In order to correctly reproduce the relationship between these quantities and eruption conditions, we are developing a 3D numerical model of volcanic plumes which uses a combination of a fluid dynamics model and marker particle method.

When the volcanic plumes are developed in the strong wind field such as the plumes during the 2011 eruptions of the Kirishima-Shinmoe-dake volcano, Japan, the plumes are distorted by wind and show bent-over trajectories and the volcanic ashes are transported far from the vent. Using our 3D numerical model, we simulate the plume of the 2011 Shinmoe-dake eruption. Our model has successfully reproduced the bent-over plume (left figure); the plume height agrees well with the weather radar echo observation made by Japan Meteorological Agency. The transport and deposition of volcanic ash are also simulated (center figure); in particular, the dispersal axis of the fall deposit within our simulations is consistent with field data observed by Volcanic Research Center, ERI. In addition, our model can reproduce the vortical structures in the plume (right figure), leading to the new insight into the dynamics of volcanic plumes.

(Assistant Prof. Yujiro Suzuki)



View of Showa-shinzan volcano (top left) and its cross section from 2D cosmic-ray imaging.
The cosmic ray data are combined with gravity data (measurement scene in the central photo, and gravity points in the map) enable us to make integrated inversion for 3D density distribution (right).
A high density spine can be seen extending from 260 meter above MS he top.

COSMIC-RAY RADIOGRAPHY COMBINED WITH CLASSICAL GRAVIMETRY FOR 3D IMAGING OF A VOLCANO

A novel imaging technique of cosmic-ray muon radiography provides us with a cross section through an object parallel to the plane of the detector, on which the average density along all the muon paths is projected, somewhat like X-ray radiography.

A good example can be seen in the 2D density profile of Showa-Shinzan volcano, Hokkaido, Japan. To our regret, however, we cannot say whether the density anomaly is located closer to the muon detector or further away from the center. To identify the 3D distribution of the anomaly (i.e. 3D imaging of density anomaly), we employed gravity data for our 3D imaging because gravity is sensitive to density variation as muon radiography. Integrated inversion of both muon radiography data and 30 point gravity anomaly data enable us to make an "anatomy" of Showa-Shinzan volcano. In particular, we can see a high density spine extending from 260 meter above sealevel to the top. If gravity data or muon radiography data were analyzed separately, it would be impossible to create the high resolution 3D image of a volcano. Lastly but not the least, it is interesting that the most classical physical tool (i.e. gravity) and the most advanced particle physics complement each other in the powerful 3D imaging.

(Center for the High Energy Geophysics Research)

U-TH RADIOACTIVE DISEQUILIBRIUM DATING OF SULFIDE MINERALS FROM A SUBMARINE HYDROTHERMAL DEPOSITS

The time scale for a hydrothermal activity is an important factor controlling the dimension of hydrothermal ore deposits and the evolution of chemosynthesis-based communities in a submarine hydrothermal system. ^{230}Th-^{234}U disequilibrium dating uses the increase of (^{230}Th/^{234}U) radioactivity ratio, which starts from zero in hydrothermal deposits. However, the decay pair analyzed using classical alpha spectrometry yielded no chronological information related to young samples. We attempted ^{230}Th-^{234}U disequilibrium dating for hydrothermal deposits with young ages from the South Mariana Trough using MC-ICP-MS.

A block of sulfide crust collected from an active hydrothermal mound in from the South Mariana Trough was used for dating. Fourteen sulfide samples were dated using ^{230}Th-^{234}U method to yield ages of 289–2086 years (Takamasa et al., 2013).

Most previous studies using radioactive isotopes with short half life (<1 kyr) have shown rapid growth of chimneys and have revealed that the lifetime of a hydrothermal field is shorter than 50-100 years. Our results, however, indicated that sulfide deposits of a few tens of centimeters' thickness can record the evolutional history of hydrothermal activity for more than 1 kyr.

(Prof. Shun'ichi Nakai)

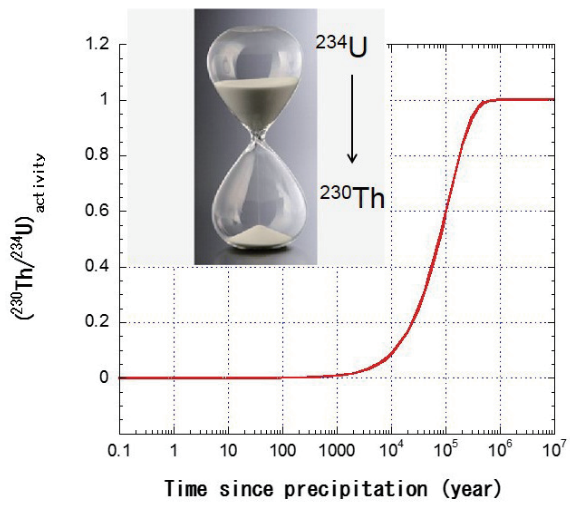


Fig. 1: Principle of U-Th radioactive disequilibrium dating. Hydrothermal fluids contain U but no Th. (^{230}Th/^{234}U) increases in sulfide minerals as time goes on.

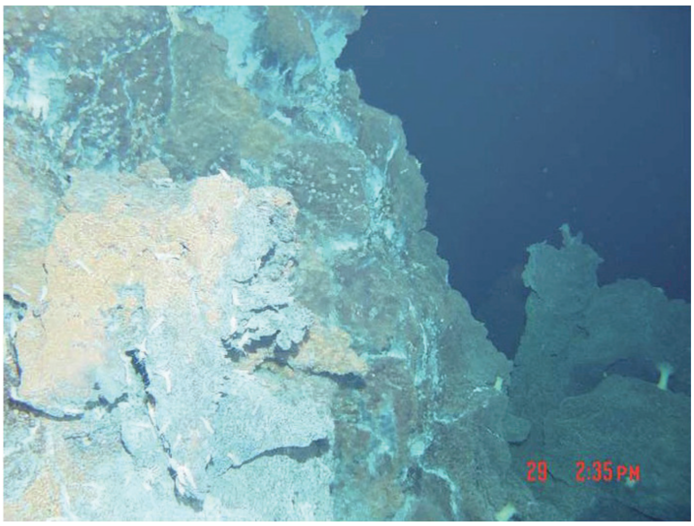


Fig. 2: Sulfide crust sample 903-R7 from South Mariana Trough. The block on the left side covered with shrimp was sampled and used for this study.

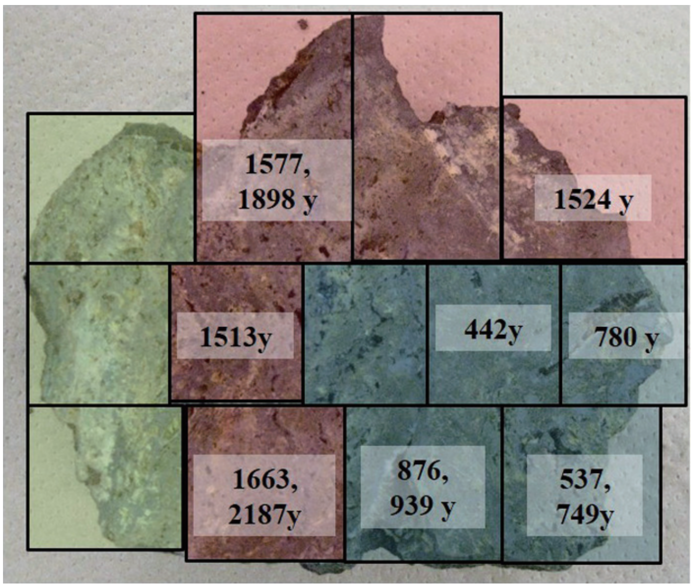


Fig.3: Slice of the sulfide crust used for this study. The distance between upper left side and lower right side is 17 cm. Ages represent ^{230}Th/^{234}U disequilibrium ages.

PREDICTING THE PROXIMITY OF MASSIVE EARTHQUAKE OCCURENCE BY MONITORING THE "LOW-FREQUENCY EARTHQUAKE"

At the Nankai trough, huge earthquakes occur every 100 to 150 years. Such earthquake is a phenomenon when a firmly locked fault plane breaks with high-speed rupture.

In the last decade, some different types of earthquakes have been found one after another. Deep low-frequency tremor that has longer shaking cycle than the usual earthquake, very-low-frequency earthquakes, short-term slow slip events (SSE) with continuous slow slip without shake, and long-term slow slip event are referred to collectively as “slow earthquake”. Amongst these “slow earthquakes”, the deep low-frequency tremor was found in 2002, from the observational data gained from Hi-net (High Sensitivity Seismograph Network Japan) of NIED (National Research Institute for Earth Science and Disaster Prevention). It is a phenomenon which an imperceptible vibration with a few Hz, continues for several days, and as a result of the analysis, we found out that it is occurring in the depth of 30-50km on the boundary surface of the overriding Eurasian Plate and the subducting Philippine Sea plate. Triggered by this discovery, it was found that the deep low-frequency tremor is occurring at several subducting zones in the world.

In 2004, it was revealed that the deep low-frequency tremor in southwest Japan is synchronizing with the short-term slow-slip event in which a slow slip continues for several days. This slip is a reverse fault that the hanging wall moves toward the Nankai Trough because the strain energy accumulated by subduction is released. Therefore, it impresses force upon seismogenic zone of the huge earthquake that lies adjacent in the shallow updip part, and if the strain of seismogenic zone is at its critical states, this slow earthquake may become the last push to trigger the huge earthquake.

The deep low-frequency tremor in southwest Japan occurs every half a year, and is migrating to the east or west. Also, a long-term slow slip event is occurring at several years interval. When strain accumulation of the huge earthquake source area is in critical state, there could be a difference in migration or occurring interval pattern of the these slow earthquakes. Therefore, by monitoring slow earthquakes, we might be able to know the degree of urgency of coming huge earthquake, and thus it is important to monitor these phenomenon precisely.

(Prof. Kazushige Obara)

Different slip property and interaction of slow earthquakes