2025.

High-energy Geophysics: Earth sciences and geotechnics via measuring cosmic rays. — The research group focuses on R&D of muography and its applications in accordance with green transformation, digital transition and focus areas of John von Neumann Program with the support of HUN-REN Welcome Home and Foreign Researcher Recruitment Programme (L. Oláh, 2024-2028) and National Research, Development and Innovation Office, Thematic Excellence Program (D. Varga, 2022-2026).

Volcano muography. — We continued the research of volcanism at the Sakurajima volcano in Japan in collaboration with The University of Tokyo [1]. Using monthly muography data measured directly beneath the crater of Sakurajima, ground surface deformation data measured around two adjacent craters, and gas observation data collected by the Japan Meteorological Agency at both craters, we quantitatively correlated observed density, surface uplift and subsidence, and volcanic gas flow rates from September 2018 to July 2023, and determined the Volcanic Unrest Index (VUI), which is an activity index introduced to semi-quantitatively assess the intensity of volcanic activity compared to historical activity levels [2]. This index can be incorporated into probabilistic hazard models to improve eruption forecasts and risk mitigation strategies. Ground deformation source modeling and muographic mass density monitoring were applied for studying the plumbing system of Sakurajima volcano [3]. These observations suggest the presence of a deep magma channel around sea level which feeds Minamidake A and B craters, and the existence of a shallow magma chamber about 350–450 m beneath the active craters which feeds all craters (Figure 1). Joint measurement of ground surface deformations and cosmic-ray muons allows simultaneous monitoring of shallow volcanic processes that may allow more reliable assessment of impending eruption sequences of Showa crater of Sakurajima volcano. We continued the analysis of data that were collected from March to December 2024 at Unzen volcano in Japan in collaboration with Sabo Frontier Foundation to contribute to the assessment of the stability of volcanic edifice. Preliminary density image shows that the lava lobes weakened since the eruption 1990-1995, and the time series of density-lengths did not show weakening of the edifice during the measurement period.

Studying oceanic lithosphere via muography of Samail Ophiolite. — We conducted the muographic experiments at Al Jel and at Wadi Fizh to explore the density structure of a crust-mantle (Moho) transition zones in the Samail Ophiolite with the Kanazawa University and the Ministry of Energy and Minerals of the Sultanate of Oman. Data collection and analysis are in progress [4].

Developing muon tomography and underground applications. — Our team focused on improving underground exploration in civil engineering, mining industry and other fields by developing novel methodology [4,5]. Recent application of methodology helped to reveal a hidden crack zone in Buda Hills [5], and confirm the location of partially collapsed, inaccessible mined-out stopes and indicate the existence of a possible cave nearby in Esztramos Hill [6].

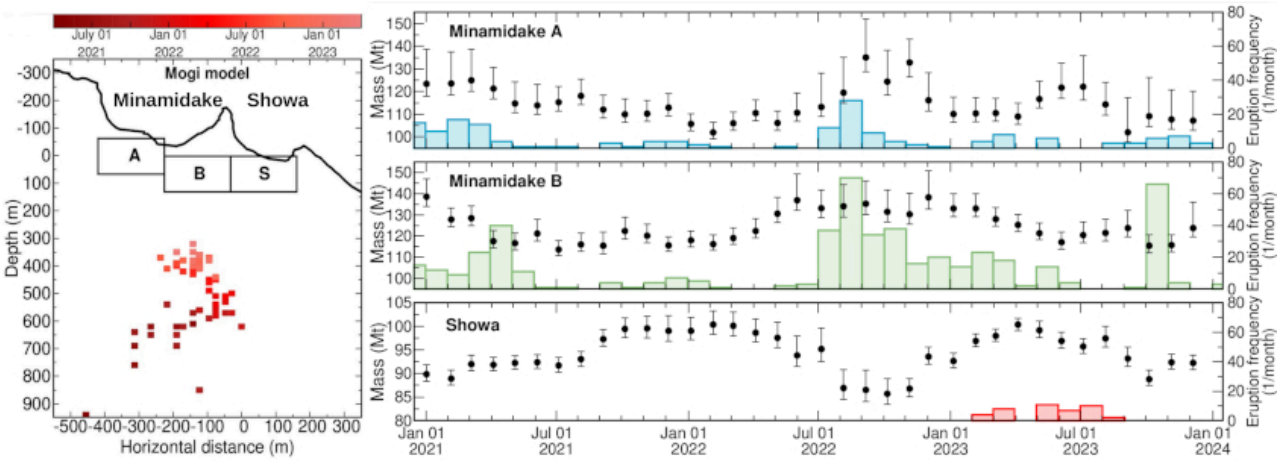

Figure 1. Left panel: Mogi modeling of ground surface deformations measured around the active craters of Sakurajima volcano. **Right panels:** Muographically measured mass chances beneath the craters and eruption frequencies [3].

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