2024

High-energy Geophysics: Earth sciences and geotechnics via measuring cosmic rays. — The research group was established in 2024 thanks to 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). This new group develops measurement procedures based on the tracking of cosmic muons, conducts Earth science researches (volcanology, geology, atmospheric physics) and develops their social utilization (natural hazard assessment, infrastructure monitoring, mining) in accordance with the green transformation, digital transition and focus areas of John von Neumann Program.

Volcano muography. — We are studying active volcanism by analyzing muographic data acquired at Sakurajima volcano, Japan in collaboration with The University of Tokyo. In a recent study [1], we visually monitored magma dynamics between two adjacent active craters. Muographic density images taken during the eruptions showed an increase in magma density beneath the activated crater and a decrease beneath the deactivated crater. Beneath the active craters of Sakurajima volcano, a branched conduit structure was inferred from the inversely correlated mass densities (Figure 1). Here muography found to be applicable to simultaneously tracking the movements and changes in the state of volcanic materials in multiple vents that may helps the assessment of volcanic hazards. From March to December 2024, we conducted the muography of Unzen volcano, Japan in collaboration with Sabo Frontier Foundation. Structural analysis of the deposited volcanic ejecta is expected to contribute to the assessment of the stability of volcanic edifice. Preliminary image visualized a low-density region for the deposited volcanic ejecta. Data analysis is ongoing.

Studying oceanic lithosphere via muography of ophiolites. — Studying oceanic lithosphere is motivated by the desire of better understanding of how natural resources produced, how natural hazards triggered. Ophiolites provide information about the structure and evolution of oceanic lithosphere that has not yet been assessed by drilling experiments. We launched the first muographic experiment to explore the density structure of a crust-mantle (Moho) transition zone in the Samail Ophiolite in collaboration with Kanazawa University and Ministry of Energy and Minerals of the Sultanate of Oman [2]. Data collection and analysis are in progress [3].

Developing novel methodology for muon tomographic imaging. — Our team is dedicated to develop novel methodology for improving the capabilities of muography for underground exploration in mining industry, speleology, civil engineering and other related fields [4,5]. Methology is tested using the data collected by “Lendület” Innovative Gaseous Detector Development Group and Muon Solutions Oy. A recent application of methodology helped to reveal a hidden crack zone (Figure 1) above the so called Királylaki tunnel in Buda mountains [4].

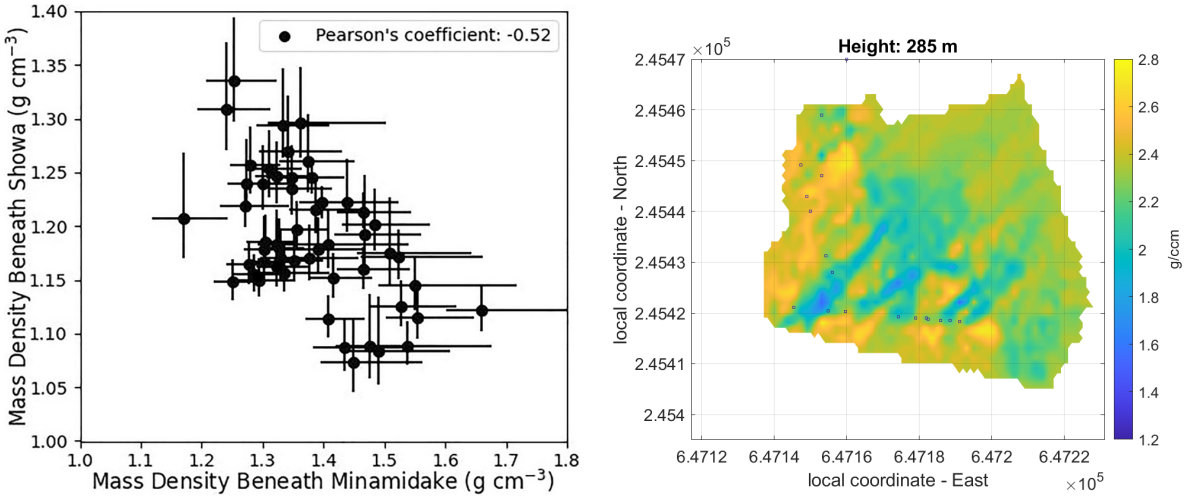

Figure 1. Left panel: Scatter plot of density values measured beneath the Minamidake and Showa craters of Sakurajima volcano, Kyushu, Japan. The Pearson's coefficient was found to -0.52 that indicates a moderate anti-correlation between the mass densities. This result suggests a branched linkage between the two active craters [1]. **Right panel:** Horizontal section of 3D reconstructed rock density distribution. A series of high-resolution subsurface muographic measurements allows the study of the fine internal structure of geological objects up to 100-150 m thick. Low-density fracture zones of tectonic origin (blue-coloured patches) are clearly traced in the cross-section.

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