3-D magnetotelluric survey of a Miocene-Quaternary volcanic province in NW Svalbard

Alexander Minakov[a], Maxim Smirnov[b], Kim Senger[c,d], Peter Betlem[a,c], Jan Inge Faleide[a], Anniken Helland-Hansen[e], Rafael Kenji Horota[c,f], Horst Kämpf[g], Agnes Kontny[h], Sverre Planke[a,i], Sebastian Tappe[e], Maria Telmon[e], Shunguo Wang[j], and Dmitrii Zastrozhnov[a]

[a]Department of Geosciences, University of Oslo, Oslo, Norway, alexamin@uio.no; [b]Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, Luleå, Sweden, maxim.smirnov@ltu.se; [c]Department of Arctic Geology, The University Centre in Svalbard, Longyearbyen, Norway, kims@unis.no; [d]Geodynamics of the Polar Regions, Department of Geosciences, University of Bremen, Bremen, Germany; [e]Department of Geosciences, University of Tromsø - The Arctic University of Norway, Tromsø, Norway, sebastian.tappe@uit.no; [f]Department of Earth Science, University of Bergen, Bergen, Norway; [g]German Research Center for Geosciences, Potsdam, Germany, kaempf@gfz-potsdam.de; [h]Institute of Applied Geosciences, Karlsruhe Institute of Technology, Karlsruhe, Germany, agnes.kontny@kit.edu; [i]VBER, Oslo, Norway, planke@vbpr.no; [j]NTNU, Department of Electronic Systems, Trondheim, Norway, shunguo.wang@ntnu.no.

The Woodfjorden-Bockfjorden area in northwestern Svalbard hosts the world's northernmost onshore thermal springs, three extinct Quaternary volcanoes and extensive Miocene basalts that overlie an uplifted Devonian sedimentary basin. The thermal springs and volcanoes are located along a major fault system. The magnetotelluric (MT) method is known as an efficient tool for studying crustal structures in young volcanic areas. The resulting electrical resistivity models inverted from MT data provide valuable information about deep mineralization, subsurface fluids, and temperature distribution.

As a part of multi-disciplinary geoscience expedition in July 2023, we conducted the first semi-regional three-dimensional (3-D) MT survey covering an area of about 20x20 km, to enhance our understanding of the crustal structure underlying the volcanic landforms and active thermal springs. This knowledge aids the characterization of the magmatic plumbing system in the crust, which is crucial for understanding the Late Cenozoic evolution of the mantle-derived basaltic volcanism in this area and its relation to the seafloor spreading in the adjacent Arctic and northeastern Atlantic oceanic basins. The broadband MT data were acquired at 9 sites positioned within the Devonian sedimentary basin, and 3 sites within the Mesoproterozoic basement near the Quaternary Sverrefjellet volcano. The stations were installed mostly on smooth terrain, such as alluvial fans and marine terraces. For simultaneous data recording, we utilized two MT instruments. These instruments were equipped with horizontal coil magnetometers and pairs of LEMI non-polarizing electrodes deployed with a dipole length of about 50 m. The time series data of electrical and magnetic fields were acquired with a sampling frequency of 20 Hz, and a night burst recording of 1000 Hz using the EarthData recording unit. Initial inspection of the recorded time series indicated good data quality.

We employ the robust estimation of the magnetotelluric impedance tensor using a multi-variate processing technique. To map the subsurface electrical resistivity distribution, we will combine the new impedance tensor data with several existing broadband MT measurements in the vicinity of the Quaternary eruptive center and invert the combined dataset using ModEM, a well-tested 3-D MT inversion code. Joint interpretation of the 3-D resistivity model with other collected geoscientific data (geological maps, digital outcrop models, petrological and geochemical data) will shed light on the subsurface distribution of geothermal fluids, faults and crustal architecture of the Miocene-Quaternary volcanic province in NW Svalbard.