Research project at the PAS Scientific Centre in Paris

Characterization of a hydrothermal fissure at a tectonic plate boundary between Africa and Arabia

This project is conducted within the bilateral cooperation agreement between the Polish Academy of Sciences and CNRS.

Daniel Mège is a geologist active in the field of the evolution of the Earth and other planets. Trained at University Paris-Saclay, Orsay, his research activities brought him at DLR in Berlin, the University of Nevada, Reno, Clermont-Auvergne University, Pierre & Marie-Curie University, University of Nantes, the Institute of Geological Sciences PAS, where he was in charge of developing a planetary geoscience research group supported by the Foundation for Polish Science, and the Space Research Centre PAS, where he leads various terrestrial and planetary geosciences projects in relation to space exploration missions. Appointed by the European Space Agency as a Guest Investigator of the ExoMars Trace Gas Orbiter (TGO) mission, and again supported by the Foundation for Polish Science, his team is specializing in deciphering the tectonic, volcanic and hydrothermal evolution of Mars, with emphasis on implications for habitats and ore resources.

During two field seasons in 2018 and 2019, a Europlanet-funded project led him and his team to a terrestrial field area in Afar, Ethiopia, where some hydrothermal processes similar to those his team is studying on Mars are observed. This field area is the salt flat of the Asale (or Karum) dry lake, in the Danakil depression, 127 m below sea level, one of the hottest places on Earth, where air temperature commonly goes to 50˚C during day time.

View of the Asale dry lake from Mount Dallol. Photograph by H. Choe, 2019.

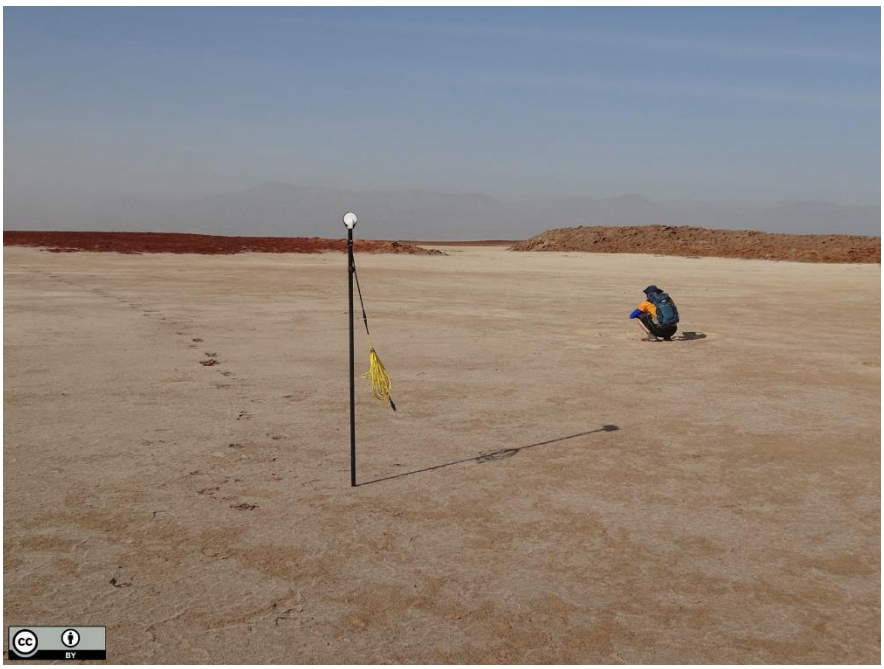
The studied area is part of the volcanic and hydrothermal system of Mount Dallol, one of the most hostile environments on Earth, where sulfuric acid springs have pH < -1. The team included researchers from Germany (Ernst Hauber, DLR), South Korea (Hanjin Choe, Pusan National University), and France (Jérôme Dyment, Institut de physique du globe de Paris).

The top of Mount Dallol, looking West. The ponds contain pure sulfuric acid. Photograph by D. Mège, 2018.

At the boundary between the African tectonic plate and the Danakil tectonic microplate, where the next segment of the southern Red Sea ocean spreading centre is incipient, Daniel Mège and his team discovered a hydrothermal fissure system that testifies to the geological processes that occur at this major tectonic boundary of the terrestrial crust.

A segment of the tectonic and hydrothermal fissure discovered by the team in lake Asale, close to Dallol. The orange water colour is due to the presence of dissolved iron and sulphur. Photograph by D. Mège, 2019.

Several methods have been used to characterize the hydrothermal fissure and its neighbourhood, including geological observations and measurements, evolution tracking using satellite imagery in various wavelengths over 70 years, and magnetic properties with a very high sensitivity.



High-precision Overhauser field magnetometer (Gem Systems, provided by the Magnetic Observatory service of CNRS-INSU at IPGP) used to measure the magnetic field on the ground in lake Asale, and infer subsurface magnetic anomalies. H. Choe for scale. Photograph by D. Mège, 2019.

Within the framework of the bilateral cooperation between CNRS and PAN, Daniel Mège is staying at the PAN scientific centre in Paris between February and June 2023 in order to work closely with his colleagues from France, and also South Korea (thanks to a South Korean grant), at the Marine Geosciences Department of Institut de Physique du globe de Paris in order to finalize magnetic models and scientific papers reporting their discoveries.

The stay will also initiate a new cooperation dedicated to the interpretation of magnetic anomalies in the Martian crust in relation to hydrothermal activity generated by large meteorite impacts such as the one that gave birth to the Borealis basin 4.5 billion years ago, which may have once almost shattered the planet. That starting project has been funded by the Polish National Research Centre (NCN), and involves Claudio Orlanducci, a new PhD student at the Space Research Centre of the Polish Academy of Sciences trained at the IRSPS international research school at Gabriele d'Annunzio University in Pescara, Italy.