IAF HUMAN SPACEFLIGHT SYMPOSIUM (B3)
Interactive Presentations - IAF HUMAN SPACEFLIGHT SYMPOSIUM (IP)

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# ESA PANGAEA: A EUROPEAN CONTRIBUTION TO TRAINING ASTRONAUTS IN PLANETARY GEOLOGY

**Abstract**

Preparations for returning humans to the lunar surface is ongoing and geological exploration will form an important part of these future missions. Within this framework, PANGAEA (Planetary ANalogue Geological and Astrobiological Exercise for Astronauts) is a field training course designed by the European Space Agency (ESA) that seeks to address geological planetary exploration. PANGAEA has been running since 2016, and forms part of the basic and pre-assignment training for European astronauts and is open to trainees from other agencies. In total, 13 astronauts from ESA, NASA, JAXA and Roscosmos and additional 5 non-astronaut trainees including engineers, EVA and operation specialists have taken the course. PANGAEA leverages European analogue sites and the European planetary geology community to

teach planetary geology. The training intends to impart essential basic theoretical and practical knowledge of geology to prepare astronauts for advanced mission specific training. Significant focus is given to skills in areas relevant to future missions, such as scientific decision-making, working with a remotely located science team, and efficient documentation. Classroom and field lessons are tightly interwoven, with a time separation often of only hours between being introduced to a concept in the classroom and seeing it in the field. The primary field sites selected for the core course are Permo-Triassic terrigenous sequences in the Italian Dolomites, impact lithologies in the Ries Crater, Germany, and a comprehensive suite of volcanic deposits in Lanzarote, Spain. Each is used as a base to deliver the main learning sessions, respectively; 1) Earth geology, rock recognition and sedimentology on Earth and Mars, 2) Lunar geology and impact cratering, and 3) volcanism on Earth, Moon and Mars, execution of geological traverses, and sampling techniques. Since 2022, PANGAEA added the Flakstadøy intrusive complex in the Lofoten archipelago, Norway, as a potential analogue to the geological settings of the lunar primary crust. This additional part can act as a separate field trip or as a continuation of the core course. Whilst PANGAEA's primary focus is astronaut training, where appropriate and complementary to its training objectives, technologies being developed for future missions are used and tested by the trainees during geological traverses. This provides an opportunity to evaluate the performance of new equipment and software in analogue field environments, whilst also providing trainees with experience using technology that might support future missions.