VUSE, VU Science Experiments at Igluna, a Science Showcase for a Moon Ice Habitat. B. De Winter[1], M. Heemskerk[2], T. Clement[3] , B. Foing[3,5,6] , T.Benavides[4] , VU Amsterdam Igluna Team (B. Albers , M. Daeter, A. Kruijver, D. Beentjes, S. van Bloois, I. Brouwer, M. Berg, R. Korthouwer, A. Dingemans , G. Vaessen), ILEWG Igluna team (A. Sitnikova, G vd Sanden, M. Grosjean, D. Moritz et al) and Swiss Space Centre (T.Benevides , O. Kirchmann, K. Kunstmann, D. Bass, Y. Delessert) [1]VU Amsterdam (dewinterbram@hotmail.com), [2]VU Amsterdam (marczijnmailadres@gmail.com), [3]VU Amsterdam, [4]Swiss Space Centre, [5]ESA ESTEC, [6]ILEWG

Introduction: Igluna is as a demonstrator pilot project aimed at supporting and accelerating the ESA_Lab initiative. Coordinated by the Swiss Space Center [1], the purpose of this mission is to investigate an approach for realizing a human habitat on the moon, directly built in the ice craters near the poles and will be tested in a similar extreme environment inside a glacier cave in Zermatt, Switzerland. Within this project a group of 15 students from VU Amsterdam perform the VUSE project. This project is designed to be a showcase for geology, glaciology and astrobiology experiments around a moon-ice habitat. The experiments will be performed in June 2019 in Zermatt. The VUSE project is building on work and experience from the euromoonmars and ILEWG [2] group. The project is a part of a concept of Moon Village [3-4], proposed by ESA, COSPAR and ILEWG.

Goals: The VU Amsterdam team consists of geologists and biologists with experience and knowledge in planetary science. The VUSE project has the goal to construct the history of the glacier with a science module realistic to ice research on the moon. The VUSE team will perform ice core analysis to research the chemical composition of the glacial ice and soil in the ice. The Analysis will be performed inside a SMART-ICE lab, designed by ILEWG Igluna Team. To complement the chemical analysis, remote sensing and geological field data will be acquired with drones, remote controlled telescopes and cameras and astronaut simulations.

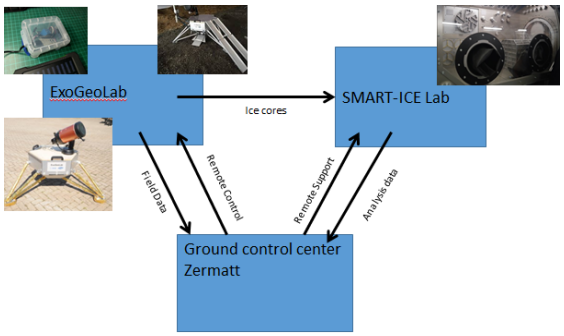

Figure 1, System overview with the three main systems and their connection

Scientific Systems: The VUSE project consists of three separate systems that work autonomously from eachother, but can communicate with each other. The first system will be build around the ILEWG ExoGeoLab [5] and will be stationed on the glacier. The second system will be inside the Igluna habitat and will be stationed in the SMART-ICE Lab. The third system will be a ground control centre in the village of Zermatt. The ground control centre has remote camera vision and helps the crew at the glacier with instructions.

ExoGeoLab: The ExoGeolab will be equipped with different telescopes and cameras. Those instruments will help with astronaut simulations around the lander and will be teleoperated [5] and controlled from a ground station in the village of Zermatt. From this lander the astronauts can control drones that will scout the area around the lander and spot interesting locations for sampling ice or rocks.

SMART-ICE Lab: The samples picked by the analog astronauts can be analysed in the lab inside the habitat. Inside this lab the astronaut will have access to different analysis instruments. Microscopes and possibly polarized microscopes can help with describing structures in ice and rocks [6-7]. For the polarized microscope the astronaut will make thin ice sections. A spectrometer [5] can be used to detect organics and colour of the samples. Several other analyses can be done by partially melting the ice samples and cores and analyzng the pH,

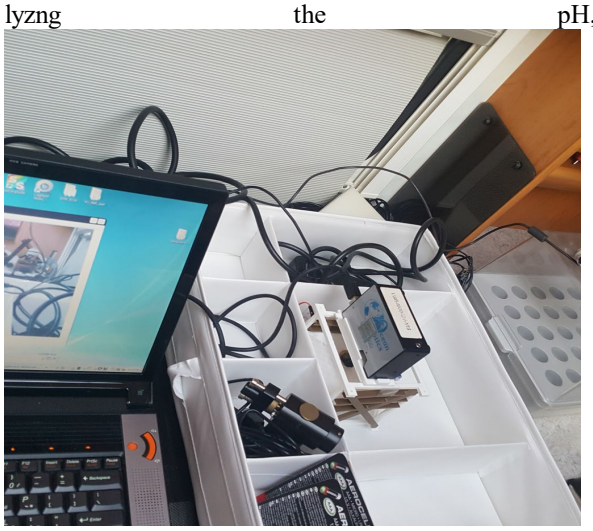

Figure 2, VUSE geology and astrobiology setup with vis-NIR spectrometer and life science experiments (right) at the ILEWG ExoHab at ESTEC.

electrical conductivity and weight of dust in the samples.

The SMART-ICE lab will also facilitate a life science experiment within the VUSE project. Biology and Geology students from the VU Amsterdam are designing a experiment realistic for experiments that can be performed in Moon habitats.

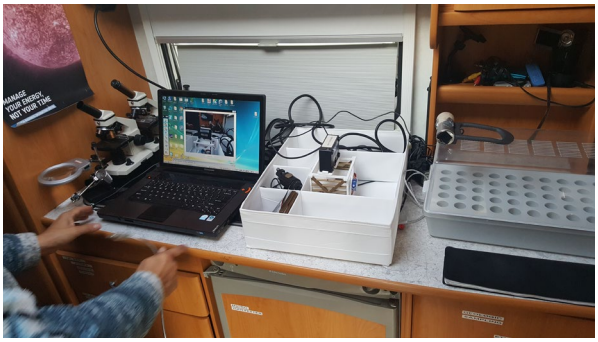

Figure 3. Prototype test bench in analog simulation habitat at ExoHab, ESTEC. Compact setup with microscopes, spectrometer, control computer and prototype astrobiology experiment. All can be stored in white boxes, displayed in middle of picture.

Ground Control Centre Zermatt: During the experiments in Zermatt two VUSE crew members will be at the glacial habitat and two will be at ground control centre in the village of Zermatt. The ground control centre will operate the remote controlled instruments and support the team members at the glacier. The ground control centre will also be in direct connection with the team members in Amsterdam. Those members will process and analyse the data and can support the ground control centre in Zermatt.

Testing: Before the VUSE project final experiment in Zermatt, the project will be tested on different locations and environments. All those tests will help with designing the perfect protocols for the experiments and experience on how to perform those experiments. In February the VUSE team will be a part of remote support for campaigns in HI-SEAS Hawaii and MDRS-205 in the Utah desert. In the HI-SEAS campaign we will get the opportunity to test some geology analysis instruments. Because of the volcanic geology history, we will not be able to test the ice equipment (unless ice is present on surface or lava tubes), but we will test the analysis instruments on volcanic rocks. In MDRS-205 we will test the remote support and communication with experience of the Euromoonmars team with previous crew missions[8]. Our team will perform remote support and will prepare geology EVAs for the crew. Together with the remote geology, the samples taken on EVA will conclude in a small geology research. In October 2018 the VUSE project tested the first prototype in the volcanic Eifel region in Germany. The VUSE team did a successful simulation of picking samples with analog astronauts. The ground control centre was able to control this action with remote controlled telescopes and drones. The analog astronauts were able to pick interesting volcanic samples and analyse them with a microscope and a vis-nir spectrometer. To improve the performance from the Eifel test, the VUSE team performed the weeks after the test several small scale test at European Space Research & Technology Centre (ESTEC) and successfully assembled a geological laboratory module with working cameras, spectrometer, microscope and power systems within the smallest package possible. In advance to the Zermatt final test the VUSE project will do several other tests, for example in ice conditions until the package is ready to perform at the glacier in Zermatt.

Events and outreach: One of the main policies of the VUSE project is that the project must be open for the public. Our team is very active on social media, conferences and public events. Several times in a year the VUSE team organized events like the VU Space Day, where we invited experts to give talks to students from VU and other universities in the Netherlands. The VUSE team is taking part in several other activities in the Euromoonmars group and is often represented at ESTEC workshops to brainstorm with engineering students, art students and other science students.

Acknowledgements: We acknowledge the VU Amsterdam Science Experiments (VUSE) Igluna team (including B. Albers, M. Daeter, A. Kruijver, D. Beentjes, S. van Bloois, M. Grosjean, I. Brouwer, M. Berg, R. Korthouwer, A. Dingemans, G. Vaessen) We thank the Igluna coordinators at the Swiss Space Centre (including T. Benavides, O. Kirchhoff, K. Kunstmann, D. Bass and Y. Delessert). We thank ESA and ILEWG (prof. B. Foing) for supporting the VUSE project.

References:[1] https://www.spacecenter.ch/igluna/, [2] Foing, B.H (2017) LPS49, Abstract #5073 [3] Foing, B.H, (2018) EGU2018, 18534, [4], Foing, B.H (2018) LPS49, Abstract #1988, [5] Lillo, A (2018), LPS49, Abstract #1242, [6] Vos, H.C (2017) LPS48, Abstract #2419, [7] Vos, H.C (2017) LPS48, Abstract #2359 [8] Foing, B.H (2011) Analogue Sites for Mars Missions: MSL and Beyond (2011), Abstract #6029 .