Fulvio Franchi – Visit Report ATOMKI (Debrecen, Hungary)

Between the 24th and 30th of May 2022 I have been visiting Dr Zoltán Juhász at the spectroscopy laboratory at ATOMKI, Debrecen (Hungary).

The main goals of this visit were as follows:

1) Initiate a new collaboration between Botswana and Hungary for the investigation of potential analogues of Icy Moons;
2) Train the applicant on the practical aspects on how to run a successful spectral facility in view of the development of a spectroscopy lab at BIUST.
3) Widening the participation in Europlanet activities by creating a new collaboration between Africa and underrepresented country in EU;
4) Involve into Europlanet project new potential stakeholders currently active in the study of climate but with potential interest in the field of Planetary Science.

This visit followed a 2 weeks scientific cruise in the Arctic Sea (led by the Arctic University of Norway) during which I have collected several samples of ice. The peculiarity of this ice is that is found over a stretch of the continental platform and continental slope extremely rich in methane (and hydrothermal) emissions. For this reason, the system was identified as terrestrial analogue of Enceladus, the icy moon of Saturn.

The colleagues at ATOMKI have agreed in helping me to set up a protocol and avail their knowledge and facilities in the preparation of the ice samples for spectral analysis. Three set of samples were prepared for analysis with a quadrupole mass spectrometer (QMS), namely ice from the Arctic pack, deep seawater over gas hydrates-rich sediments, gas from the dissociation of gas hydrates.

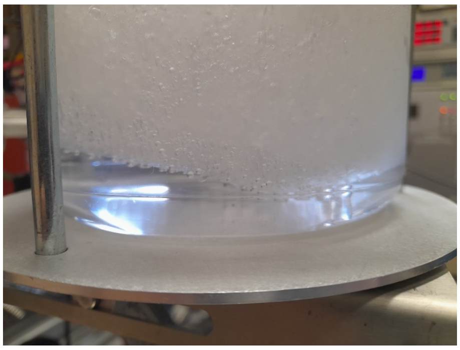

Figure 1. Setup prepared for the study of gases in ice. Ice samples was placed in a vessel connected to the newly commissioned ice chamber (left) equipped with a QMS. Bubbles of gas in the vessel during melting (right).

ICE SAMPLES

A special plastic vessel prepared for the purpose of QMS gas analysis by the colleagues at ATOMKI was attached to the chamber developed for ice investigations at the ECRIS laboratory (Fig. 1). Ice was introduced in the vessel and gases released during melting (Fig. 1B) were analysed by the QMS with both Secondary Electron Multiplier (SEM) and Faraday Cup (FC) detectors. The obtained mass spectra revealed the presence of different chemical species identifiable by their specific mass (work in progress). A software is developed at ATOMKI to unravel species with overlapping mass spectra and to yield isotopic ratios.

Samples of ice were also analysed with a ATR Bruker Alpha spectrometer using reflected IR technique (Fig. 2). Aim was to identify presence of micro-bubbles of methane in the ice reproducing what could be considered as an analogue of the measurement that we might receive from orbiter missions around one of the icy moons.

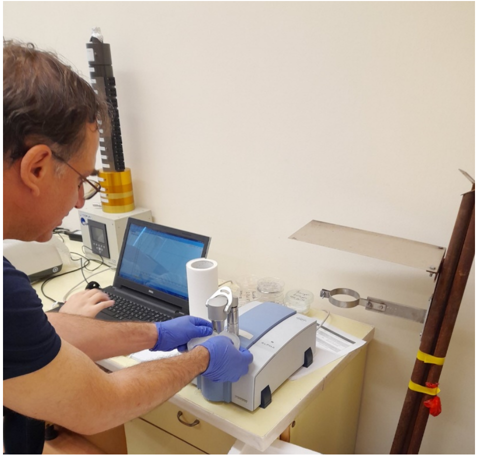

Figure 2. Sample of ice (3 cm thick) analysed with the ATR Bruker spectrometer.

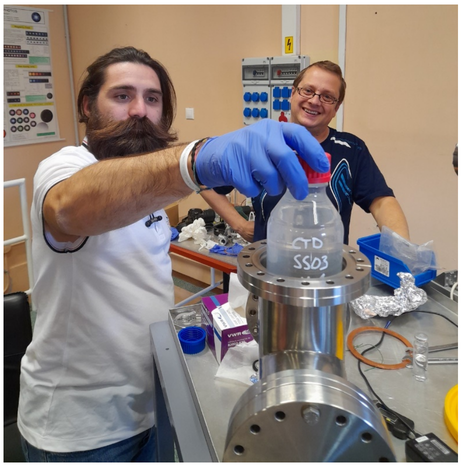

Figure 3. Placing the sample of sea water into the special vessel created at ATOMKI. The vessel was linked to the ice chamber and the QMS systems.

WATER SAMPLE

Dissolved gases and water vapour from a deep-sea water sample (ca. 1450 m depth) was analysed with the QMS (Fig. 3). One of the aim of this analysis was to attempt a study of the isotopic composition of O in this deep water that should be affected by gas (methane) hydrates dissociation (hence enriched in ^{18}O). The introduction of the gas from the sample bottle to the chamber without mixing with air was the main technical challenge. A metal vessel was mounted with a syringe made for rupturing the seal on the 500ml bottle and release the gas from the head space inside the bottle into the chamber. The method worked well but the technique needs to be refined and data processing is still ongoing. Though directly, we could not detect methane in the samples, preliminary analysis shows very high ^{18}O concentration, which will be checked by other methods.

GAS SAMPLE

Samples of gas from the dissociation of gas hydrates where analysed with the QMS. The plastic vessel was mounted with a syringe made for rupturing the seal on the vial and release the gas in the chamber. This method worked very well and we were able to identify methane in the gas from the gas hydrates. The vial with gas was analysed with absorption IR spectroscopy before the QMS investigation. This has shown the clear presence of methane in the sample, too.

CONCLUSION

I believe that the study of natural methane content in ice from the Arctic pack will have a strong relevance as an analogue for the study of Icy Moons such as Europa and Enceladus. Preliminary observation on these celestial bodies have reportedly shown the presence of methane. How the methane was produced and what relationship exists between the methane and potential life forms is still matter for speculations. The only way to get closer to the truth is by testing natural materials on Earth that resemble the conditions existing on the icy moons. We believe that the ice formed above and/or in proximity of methane cold seeps in the Arctic sea might provide the right substratum to test our ability to characterize methane occurrences elsewhere in the Solar System. We are therefore developing a method to prepare natural ice from the Arctic for analysis and run mass spectroscopy for the characterization of the methane contents. The work will continue back in Botswana where the lessons learnt will help us improve our spectroscopy labs.

This visit kick-started a new collaboration between BIUST and ATOMKI and has benefitted from the collaboration of Prof. Panieri at CAGE institute of The Arctic University of Norway, which is active in the field of climate studies, and has shown interest in Planetary Science.