LOW TEMPERATURE INTERACTION OF HUMIDITY WITH THE LICHENS *BUELLIA FRIGIDA* AND *CIRCINARIA GYROSA*. J. Jänchen[1], J. Meeßen[2], S. Ott[2], F. J. Sánchez[3]; R. de la Torre[3], [1]Technical University of Applied Sciences Wildau, c/o ZeoSolar e.V., Volmerstr. 13, 12489 Berlin-Adlershof, Germany, e-mail address: jochen.jaenchen@th-wildau.de, [2]Institute of Botany, Heinrich-Heine-University Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany, e-mail address: joachimmeessen@gmx.de ,[3] Earth Observation department, Spanish Institute for Aerospace Technology-INTA, Ctra. Ajalvir km 4,5, 28850, Torrejón de Ardoz, Madrid, Spain, e-mail address: torrenr@inta.es.

Introduction: New results over extremophiles and observations of Mars missions regarding the detailed mineralogy, the occurrence of water in the equatorial region of Mars [1-3] as well as first announcements of MSL findings and their implications for the surface conditions have stirred up the debate about the development of life on Mars.

An important issue to be tackled in this research is the interaction of moisture of the planets atmosphere with soil components and possible existing organisms of the planet's surface because of the essential role of water for life. Building on previous work [4-5] we quantitatively examined the water vapor interaction and water-bearing properties of selected extremophiles, in particular lichens, in a broader expanse of surface temperature and pressure. Lichens are symbiotic organisms that are able to colonize a broad range of habitats worldwide and are especially successful under harsh to extreme environmental conditions.

The aim is to contribute to an improved understanding of extremophiles and exobiological aspects on earthlike bodies and to support data evaluation of in-situ missions such as MSL or ExoMars.

Experimental: *Samples.* Both lichens, *Buellia frigida* Darb. (1910) *and Circinaria gyrosa* (Sohrabi, 2012, http://urn.fi/URN:ISBN:978-952-10-7400-4, formerly *Aspicilia fruticulosa*), represent symbiotic and eukaryotic associations formed by a heterotrophic fungus and a photoautotrophic green alga. While *B. frigida* is an extremophile Antarctic endemite, *C. gyrosa* originates from continental arid areas (Spain). Both are well adapted to drought and high levels of solar UV-R experienced at their natural habitats but also to extremes of cold or heat, respectively [6-7]. *C. gyrosa* was found to survive (real and simulated) space exposure [8-10] without forming relevant amounts of UVR-shielding secondary lichen compounds (SLC), compared to *B. frigida* which forms melanins as a SLC in its cortex. Both lichens produce mucilage matrices with similar characteristics of EPS and *C. gyrosa* contains calciumoxalate monohydrate crystals [unpubl. data].

Methods. The dehydration properties and the decomposition (thermogravimetry, TG and differential thermogravimetry, DTG) were measured on a Netzsch STA 409 apparatus with a heating rate of 10 K/min up to 1273 K. Prior to the TG experiments the lichens were preconditioned at controlled atmosphere (six days over saturated ammonium chloride solution in a evacuated desiccator, $p/p_s=0.79$ or RH=79%). The sorption (hydration) isotherms were measured gravimetrically from 255-293 K with a McBain quartz spring balance equipped with MKS Baratron pressure sensors covering a range of 10^{-5}-10^{3} mbar. Before each sorption experiment, about 100 mg sample was degassed over night at 293 K and $p<10^{-5}$ mbar.

Results and discussion:
Fig. 1 gives information about the weakly (reversibly) sorbed water (mass loss up to about 400 K) as well as about the thermal decomposition up to 900 K of the two lichens. *C. gyrosa* from the dry warm environment took significant less water at RH=79% than *B. frigida*, adapted to the dry and cold Antarctic location, due to the different mass losses up to 400 K. Moreover, the

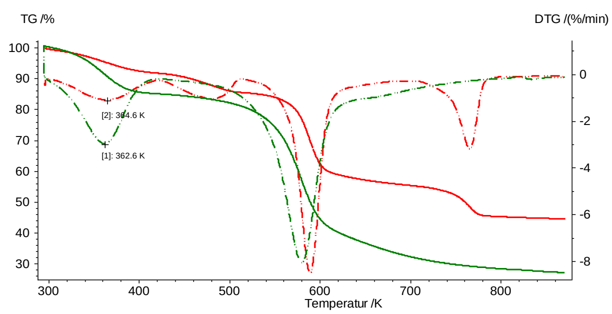

Fig. 1 TG and DTG profiles after hydration at RH=79% in a exsicator: *C. gyrosa* red, 2 and *B. frigida* green, 1. Solid line TG, dashed line DTG.

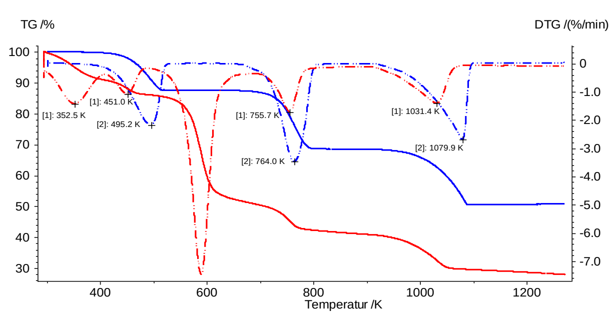

Fig. 2 TG and DTG profiles after hydration at RH=79% in a exsicator: synthetic calciumoxalat monohydrate blue, 2 and *C. gyrosa* red, 1. Solid line TG, dashed line DTG.

decomposition and carbonization process upon further heating in nitrogen of *C. gyrosa* shows two more steps in the TG compared with *B. frigida*. The reason for that fact seems to be the extra component calciumoxalat monohydrate (whewellite) of *C. gyrosa*. This compound decomposes in three steps [cf. 11]: ~490 K (hydrate water separates from $CaC_2O_4*H_2O$), ~760 K (formation of $CaCO_3$ and CO) and ~1050 K (formation of CaO and CO_2). These three steps can be found in principle in the TG/DTG profiles of *C. gyrosa* as well (cf. Fig. 2). The temperatures of these steps differ somewhat probably due to morphological differences between the synthetic and natural whewellite particles. Calciumoxalat monohydrate does not sorb any humidity at ambient temperature. So it shows no TG-step below 400 K for release of weakly sorbed water as the lichen do.

This weakly reversibly sorbed water of about 10-20 wt% at RH=79% will be investigated in more detail by hydration/dehydration isotherms close to Martian environmental conditions. The Fig. 3-5 summarize the results of these measurements. The isotherms are plotted as function of the relative humidity (RH) which put all isotherms of one organism in one bundle of curves for different temperatures. *C. gyrosa* (Fig. 3) fulfills this condition as other extremophiles investigated proved before [5]. Interestingly, *B. frigida* (Fig. 4) deviates from this rule and shows a difference between

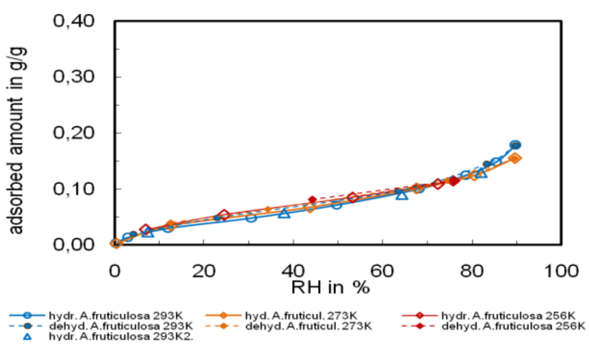

Fig. 3 Hydration/dehydration isotherms of *C. gyrosa* at 256-293 K.

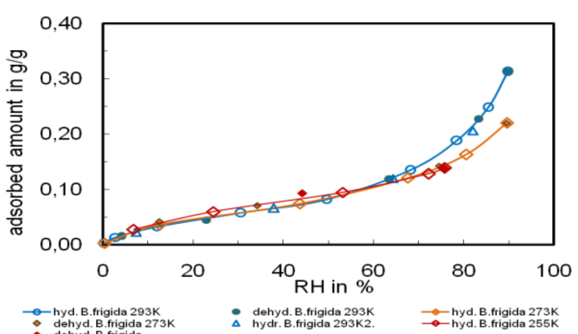

Fig. 4 Hydration/dehydration isotherms of *B. frigida* at 256-293 K.

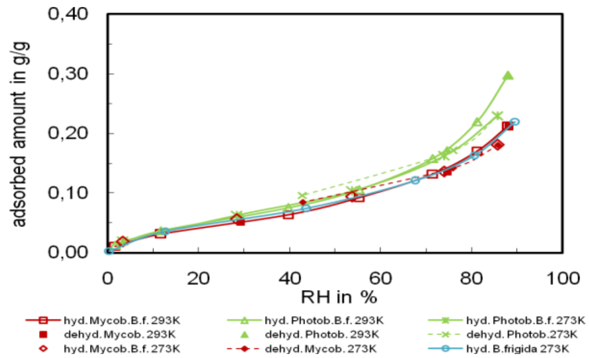

Fig. 5 Hydration isotherms of *B. frigida* at 273 K (blue); hydration/dehydration of the photobiont (green) and mycobiont (red) at 273 and 293 K.

298 K and the lower temperatures. A comparison of the single symbionts of *B. frigida* (Fig. 5) with the entire lichen thallus does not give an easy answer. At 273 K or lower the isotherm of the entire lichen is very close to the mycobiont (Fig. 5) and at 298 K the isotherm of the photobiont is close to the symbiotic lichen organism (not shown).

Important to note is the reversibility of the isothermes (water uptake and release follow the same curve) and relatively fast kinetics of the hydration/dehydration process. In all lichens it takes hours to minutes compared with days for *Nostoc commune* [5]. This observations are in line with the well known poikilohydric nature of lichens to dry out rapidly in case of insolation to prevent heat damage in the wet state.

Conclusion: By knowing the water vapor pressure or local humidity of a planet's atmosphere, the water content of possible occurring extremophiles (beside soil components) can be determined based on our results. These data can support a deepened evaluation of rover missions on Mars.

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