The MARVIN project: a Micrometeorite hARVester IN antarctic snow. J. Duprat\textsuperscript{1}, B. Dachwald\textsuperscript{2}, M. Hilchenbach\textsuperscript{3}, C. Engrand\textsuperscript{1}, C. Espe\textsuperscript{4}, M. Feldmann\textsuperscript{2}, G. Francke\textsuperscript{2}, M. Görög\textsuperscript{2}, N. Lüsing\textsuperscript{2}, F. Langenhorst\textsuperscript{4}.

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**Introduction:** Antarctic MicroMeteorites (AMMs) are interplanetary dust particles that survived their entry into the atmosphere. Their mineralogical, chemical and isotopic study allows to gain insight into the formation of the Solar System [1]. By contrast with larger bodies (i.e. meteorites) that are mainly from the asteroid belt, AMMs may originate from both inner solar system parent bodies (i.e. asteroids) and from parent bodies coming from much larger heliocentric distances (i.e. comets). The possibility to distinguish asteroidal from cometary dust will greatly benefit from the analyses of cometary samples from 81P/Wild2 returned by the STARDUST mission [2], and the future in situ analysis of comet Churyumov-Gerasimenko by the European ROSETTA mission in 2014 [3]. Recovery and identification of cometary particles in Antarctic snow is of fundamental interest as such collections can provide particles about an order of magnitude larger in size compared to those probed by space missions. The proposed Micrometeorite hARVester IN Antarctic snow (MARVIN) is an automated drilling and melting probe dedicated to collect micrometeorites from Antarctic snow. It will operate at the vicinity of CONCORDIA station in central Antarctica.

**Central Antarctica key features:** The central regions of Antarctica have crucial advantages for collecting interplanetary dust. Surrounded by oceans, the Antarctic continent itself is well preserved from terrestrial dust. In the central regions of the continent, the depletion in terrestrial dust is even more extreme as the wind regime is blowing from the center to the coast and the surface snow is totally isolated from the bedrock by several kilometers of ice. Over the last decade, the CSNSM developed a research program to collect AMMs in the snow at the vicinity of CONCORDIA station [4].

In the course of this program, we demonstrated that more than 50% of the collected particles within the AMMs size range (20-500 μm) are of extraterrestrial (ET) origin [5]. However, it is most probable that the intrinsic ET/T dust ratio of Dome C snow is much higher and that the collections performed so far still suffer from various contaminations occurring during the snow sampling, melting and sieving procedure.

Another key feature of central Antarctica is that, once trapped in the ultra-clean surface snow, the AMMs endure minimal terrestrial weathering (aqueous or mechanical). The aim of the MARVIN project is to obtain a collection that will take full advantage of the unique characteristics of Dome C snow.

**Figure 1:** External view of MARVIN

![External view of MARVIN](image1)

**The MARVIN project:** MARVIN is an automated drilling and melting probe dedicated to collect AMMs (Fig. 1). It will be developed at FH Aachen University of Applied Sciences (Germany). It is based on the technology of the IceMole project [6]. The IceMole is a novel combined drilling and melting probe that ingests a clean ice core through a hollow ice screw for scientific in situ analysis inside the probe. Furthermore, the ice screw generates a driving force that allows horizontal (and even upwards) movement of the probe in ice. The IceMole was successfully tested in September 2010 on the Swiss Morteratsch glacier [6].

**Figure 2:** MARVIN's drive and tubing system

For MARVIN, some adaptations of the original IceMole will be performed to optimize it for micrometeorite harvesting in snow. The ice screw will be enlarged to the size of the front face area of the probe, so that large volumes of snow can be ingested into the
probe (Fig. 2). The snow is continually melted and sieved in ultra-clean conditions inside the probe. External fluids are not required in the processing of dust. Thus, MARVIN is an ideal tool for AMM sampling in snow, avoiding all risks of contamination.

During one deployment (~35 m of drilling), MARVIN can filter ~2 m³ of snow. The probe has an aluminum casing and is propelled by a stainless steel ice screw that generates a velocity of ~3 m/h. For stability and steering in the snow, MARVIN possesses four fins. Inside the ice screw, the snow is crushed and transported with an Auger through a tubing system to the so-called Filter-Heater-Unit (FHU, see Fig. 3). The tubing system has a bypass tube, so that the initial (potentially contaminated) snow is not directed to the FHU, but to the outside of the probe.

**Figure 3: MARVIN's Filter-Heater-Unit**

The FHU is accessible from outside and the filters can be easily removed and replaced. Inside the FHU, the snow is gently heated by a warm water system. The meltwater runs through the filter system, where the AMMs are recovered. The filter system can be equipped with different filters (e.g. 10, 20 or 30 µm). To protect the filtered particles, two glass covers will seal the filter before it is removed. The probe receives the required power from a surface generator via a cable. Table I summarizes the most important technical data for MARVIN.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity</td>
<td>3 m/h</td>
</tr>
<tr>
<td>Dimensions</td>
<td>200 x 200 x 1000 mm</td>
</tr>
<tr>
<td>Screw diameter</td>
<td>300 mm</td>
</tr>
<tr>
<td>Power supply</td>
<td>20 kW</td>
</tr>
<tr>
<td>Communication</td>
<td>CAN bus, powerline modem</td>
</tr>
<tr>
<td>Weight</td>
<td>~40 kg</td>
</tr>
</tbody>
</table>

**Table 1: Technical data for MARVIN**

**MARVIN science:** The MARVIN design will allow a sampling that is expected to be almost free of contamination for particles on the 5-1000 micron size range. It will be the first time that such an ultra-clean collection can be achieved. The MARVIN probe controls the snow melting process and the temperature of the water resulting from the snow melting in order to minimize the particles’ exposition time to water. As a result, the proposed experiment should provide a collection of AMMs with very low terrestrial alteration (mechanical and aqueous).

The unique features of central Antarctic snow allow the recovery of AMMs with exceptionally high content in carbonaceous matter (i.e. UltraCarbonaceous AMMs, UCAMMs). The organic compound of UCAMMs exhibits extreme Deuterium enrichments [7]. Both the elemental and isotopic composition of UCAMMs indicates that these particles most probably originate from comets. These particles are difficult to identify and, so far, we have identified very few UCAMMs (about 10) in the CONCORDIA collection. The cleanliness of the MARVIN collection should allow recovering substantially more UCAMMs. The mineralogical and isotopic studies of these exceptional particles can provide valuable constraints on the nature of the solids that were present in the cold regions of the protoplanetary disk during solar system formation.

Although the main goal will be to search for large size cometary particles (i.e UCAMMs), since the filters collected will be almost free of terrestrial dust contamination added during the collection process, this project optimizes the chances to identify new types of rare interplanetary dust that could not be identified in previous collections. In a summer field season, MARVIN should process about 30 m³ of snow. Considering collecting all particles above 20 µm, several thousands AMMs should be collected in each field season. Such a collection can bring a valuable constraint on the extra-terrestrial dust flux reaching the Earth’s surface. Besides these goals, the collection will provide numerous unaltered particles of considerable interest to study the interplanetary dust encountered by our planet.

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**References:**