Melting probes as a means to access the subsurface of Mars' polar caps and Jupiter's ice moons

J. Biele, S. Ulamec, O. Funke, M. Engelhardt

DLR German Aerospace Center, Institute for Space Simulation, Cologne, Germany

(jens.biele@dlr.de, / Fax: +49-2203-61471 / Phone: +49-2203-601-4563)

There is a high scientific interest in exploring certain planetary icy environments in the solar system (Mars' polar caps, Europa and other icy satellites) motivated by the search for traces of life in these extreme environments as well as interest in planetary climate history as in the case of Mars. A promising technique to penetrate thick ice layers with small and reliable probes which do not require the heavy, complex and expensive equipment of a drilling rig is by melting. Contamination avoidance with respect to planetary protection requirements can be fulfilled using melting probes, since the melting channel refreezes behind the probe and shuts off the contact to the surface; also, in-situ decontamination of the probe is possible.

Melting probes can be equipped with a suite of scientific instruments that are capable e.g. of determining the chemical and isotopic composition of the embedded or dissolved materials, of the ices themselves, of the dust content and possible traces of indigenous biological activity. Due to the still rather high energy demand to overcome the melting enthalpy, in case of extraterrestrial application (e.g. Europa or polar caps of Mars), only heating with radioactive isotopes seems feasible for reaching greater depths. The necessary power is driven by the desired penetration velocity (linearly) and the dimensions of the probe (proportional to the cross section). On Mars, however, solar cells could be used to power small tethered melting probes in polar summer.

While such probes have successfully been used for terrestrial applications, e.g., in Antarctica in the 1990ies, the technology is not yet mature for space applications; for example, the behaviour in vacuum (below the triple point pressure of water, i.e., 611 Pa) needs to be assessed. We will report briefly on our laboratory tests with melting probes in vacuum and under very low temperatures to this end. Practical issues (impact of dust on the performance, gravity dependence, prevention of blocking, attitude control, power supply, communications) and engineering concepts will be discussed.

For future missions to Europa (in particular in view of the ESA Cosmic Vision Programme), if planned to include a Surface Package, a melting probe may be the most adequate (and most easily realized) way to access the subsurface areas, protected from the intense ionising radiation in the Jovian system and most interesting from a biochemical and biological point of view.