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SAMPLING MARS: ANALYTICAL REQUIREMENTS AND WORK TO DO IN ADVANCE. Christian Koeberl, Institute of Geochemistry, Dr.-Karl-Lueger-Ring 1, A-1010 Vienna, Austria.

Introduction Sending a mission to Mars to collect samples and return them to the Earth for analysis is without doubt one of the most exciting and important tasks for planetary science in the near future. Many scientifically extremely important questions are associated with the knowledge of the composition and structure of Martian samples. Amongst the most exciting questions is the clarification of the SNC problem - to prove or disprove a possible Martian origin of these meteorites. Since SNC meteorites have been used to infer the chemistry of the planet Mars, and its evolution (including the accretion history), it would be important to know if the whole story is true. But before addressing possible scientific results, we have to deal with the analytical requirements, and with possible pre-return work.

Sample size considerations. It is unlikely to expect that a possible Mars sample return mission will bring back anything close to the amount returned by the Apollo missions. It will be more like the amount returned by the Luna missions, or at least in that order of a magnitude. This requires very careful sample selection, and very precise analytical techniques. These techniques should be able to use minimal sample sizes and on the other hand optimize the scientific output. The possibility to work with extremely small samples should not obstruct another problem: possible sampling errors. As we know from terrestrial geochemical studies, sampling procedures are quite complicated and elaborate to ensure avoiding sampling errors. The significance of analysing a milligram or submilligram sized sample and putting that in relationship with the genesis of whole planetary crusts has to be viewed with care. This leaves us with a dilemma: one one hand, we would like to minimize the sample size as far as possible in order to have the possibility of returning as many different samples as possible, and on the other hand we have to take a sample large enough to be representative. Whole rock samples are very useful, but should not exceed the 20-50 g range, except in cases of extreme inhomogeneity, because for larger samples the information tends to become redundant. Soil samples should be in the 2-10 g range, permitting the splitting of the returned samples for studies in different laboratories with variety of techniques. If we assume that the average analyst (with an average analytical technique) is able to work with some 10 milligrams of a soil sample, then about 100 different studies can be made per sample and still leave enough for back-up and future work, which should be an essential requirement (like it is for lunar rocks). Whole-rock studies will be more material-consuming, because of the integrated approach. Studies of single minerals are highly desirable. In addition, we have the problem that several analytical techniques need more than 10 mg of sample material, at least if considering the state-of-the-art today. This leads to the second topic.

Pre-return improvement of analytical techniques. This may be seen in analogy to the developments associated with the study of lunar rocks. One example could be the improvement in the electron microprobe analysis technique, which would not have seen such fast and thorough improvement without lunar science. We can expect something similar to happen if Martian samples are to be returned to Earth. This also leads to an important spin-off of analytical technology, a consideration which is, in view of recent science policy decisions, rather useful.

Amongst the techniques which would require improvements are the following: analysis of trace elements and isotopes in single minerals. The investigation of the chemical and isotopic properties of single minerals within a mineral (or rock-) assemblage was proven to be of great geochemical significance. Describing the history of a rock from formation to collection should be the ultimate goal, and very often the minerals contained in a rock have had different histories. The extraction and analysis of minerals pertinent to age determinations has to be improved considerably. The ion probe dating techniques in use for zircon dating have shown great potential, but do not yet seem to be a routine analytical tool due to too many uncertainties. This very useful technique will have to be improved before being used on precious Martian samples. The same will apply for radiochemical studies of certain trace elements. Amongst the more interesting elements in a geochemical sense are volatile trace elements. Due to analytical problems, and also due to interpretative problems, these elements have not been used according to their geochemical importance. Examples would be the group of the halogens, or elements like Li, B, As, Sb, Se, Cd, Ag, Te, or In. The analytical requirement would be to improve the techniques associated with the the analysis of these elements (like radiochemical neutron activation analysis) to gain higher sensitivity, better reproducibility, and precision. Also, these elements are most vulnerable to post-collection alterations of the samples, such as sterilization procedures. Without going into details we can assume that most of the information contained in volatile elements (like the chemistry of sedimentary processes, or volcanic eruptive processes) will be destroyed if the samples are subjected to anything which comes close to a classical sterilization procedure. We have to consider not only the information contained in the distribution of volatile elements, but also the information contained in the structure of highly volatile compounds, like ices (which may be present in Martian surface samples). Also some inorganic compounds (carbonates, hydrated minerals) are extremely vulnerable to sample alterations, but would contain very important information. Thus all post-collection sample alteration procedures should be either avoided or carefully monitored and kept to minimum.

Another requirement would be the development of improved sample preparation and handling techniques, which do not exist in the necessary extent for such fragile and precious samples. Analog studies (e.g. with Antarctic meteorites) could be very useful. Further points on the wish-list would be the xploration of new geochemically significant isotope systems, like osmium isotopes, or platinum isotopes. These procedures still require rather large sample sizes, and isolation, extraction, and detection systems will have to be improved for Martian samples.

Conclusions. This short list is merely a starting point, and should serve only for stimulating pre-return science. With a project as complex and possibly scientifically rewarding as a Mars sample return mission, considerable thoughts and efforts have to go in pre-return scientific requirements. The improvement of analytical techniques and facilities is of crucial importance.