EPSC Abstracts
Vol. 8, EPSC2013-207, 2013
European Planetary Science Congress 2013

The International Space Analogue Rockstore (ISAR) for *in situ* instrument testing: relevance for Martian missions.

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Abstract

In order to prepare the next *in situ* space missions we have created a collection of analogue rocks for calibrating and testing present and future space flight instruments. This collection is called the International Space Analogue Rockstore (ISAR) and is hosted at the CNRS and the Observatoire des Sciences de l'Univers en Région Centre (OSUC), in Orléans, France. In the context of the present MSL mission and to the future ExoMars-2018 mission, the first samples where chosen for their relevance to Mars. These samples are available for calibrating and testing space instrumentation and are now being used by several instruments on ExoMars and MSL. Use of the same suite of samples to calibrate all the instruments of a single mission will greatly increase their complementarity and thus to improve the interpretation of the analyses carried out *in situ*.

1. Introduction

The Mars Science Laboratory (MSL, NASA) and the future ExoMars (2018) and Mars-2020 missions have and will have instrument suites to investigate the texture and composition of the surface rocks, as well as the inorganic and organic composition of subsurface samples obtained by drilling. Testing the instruments with the same suite of Mars-analogue rocks will help in optimizing the science return of the mission. With this objective in mind, a collection of rocks that have been fully characterised by standard laboratory instrumentation is being prepared in Orléans, France [1, 2]. The ultimate goal is to offer the scientific community a suite of relevant analogue rocks and minerals coupled to an online database comprising the maximum amount of information on materials that are analogues of Mars and of other planetary bodies in the near future. The database will contain both reference (laboratory) data and results from analyses using the planetary instruments or models. Here we present a selection of samples for testing instruments, presently used for testing all the ExoMars instruments and some of the MSL ones (SAM, ChemCam). Other samples will become ready as our collection expands.

2. Methods

Textural and compositional information was obtained using standard laboratory instruments. Structural and textural information was provided by visual field and hand specimen observation, as well as optical and electron microscopy study of thin sections and etched rock surfaces. Mineralogical analyses (spot and mapping) were made on rock surfaces, thin sections and powdered samples, depending on instrument type. All data are collected in an online data-base of analogue materials that accompanies the collection: **www.isar.cnrs-orleans.fr** (Fig.1).

Figure 1: Flash this code to access the ISAR website.

3. Materials

Our rock collection covers many of the lithologies found on Mars [4, 5] and includes pure minerals, a variety of basalts (plus cumulates), volcanic sands deposited in shallow-water environments, a banded iron formation (BIF), and an artificial nontronite (Table 1). Some of the rocks have been subjected to hydrothermal alteration (silicification) and some of them contain fossil, carbonaceous traces of life.

3.1 Sediments

3.5-3.3 Ga-old volcanic sands (hydro-thermally-silicified) from the Pilbara, Australia, and from Barberton, South Africa, that contain carbonaceous traces of microorganisms (99ZA01, 00AU05). A banded iron formation (BIF) from the Pilbara, Australia (06AU01). A laboratory-produced nontronite (10AR01). Nontronite is a typical alteration product of volcanic rocks. Hydrothermal carbonate (precipitate on the Svalbard basalt) and altered crustal basalt (09SJ05, 11CY04). Hydrothermal silica (chert, 99ZA01, 00AU04). BIF (06AU01).

3.2 Basalts

The ISAR contains a range of basalts. (1) An ultramafic, tephritic basalt from Svalbard (Norway) with carbonate concretions in vesicules, and hydrothermal carbonate crusts (09SJ15), similar to those observed in the Martian meteorite ALH84001 [7]. This basalt also contains dunite xenoliths that can be considered as cumulates (*sensu lato*). (2) A primitive basalt from Etna (Italy, 09IT01). (3) An altered, silicified ultramafic basalt from Barberton (South-Africa, 10ZA20). (4) An altered, silicified komatiitic basalt from Barberton (South-Africa, 10ZA06). (5) A fresh komatiite from Dundonald (Canada, 11CA02). (6) An altered phonolite from El Teide (Tenerife, 09IC08). However, according to the recent observations by the Mars Exploration Rover (MER) Spirit, Martian basalts are chemically very different from terrestrial basalts, being characterized in particular by high Mg and Fe contents [6]. (7) Artificial Martian basalts were thus synthetised to complete the ISAR collection (11AR01, 11AR02 and 12AR01) [7].

4. Discussion and Conclusions

The preliminary suite of rocks and minerals proposed here are relevant Mars-analogues in terms of composition, texture, and origin.The ISAR is an ongoing project for which we presently have an initial selection of laboratory-characterised rocks and minerals that are being used for testing the ExoMars instrument suite. The available dataset will be completed by organics analysis of the samples, and further rocks and minerals including evaporates and hydrothermal deposits. The online database, **www.isar.cnrs-orleans.fr** containing all optical, textural and compositional information is easier accesible to mission scientists and instrument builders.

Table 1: Partial list of the ISAR samples, available in the website.

Type	ISAR number	Name
Volcanic rocks	09IT01	Primitive basalt
	09SJ15	Pricritic basalt
	09IC08	Altered phonolite
	09ZA20	Altered basalt (silicified)
	11CA02	Komatiite
	10ZA09	Altered Komatiite(silicified and carbonated
	11AR01	Artificial basalt [7]
	11AR02	Artificial basalt [7]
	12AR01	Artificial basalt
Magmatic rock	09SV02	Dunite (xenoliths)
Sedimentary rocks	09SJ05	Mg-Fe-rich carbonates (associated with basalt)
	11CY04	Hydrothermal carbonates
	99ZA01	Carbonaceous hydrothermal chert
	99ZA05	Hydrothermal chert sill in silicified volcaniclastic sediments
	06AU01	BIF
	00AU05	Silicified volcanic sediments (chert)
	00AU04	Hydrothermal Chert vein in pyroclastic volcanic sediments
	10AR01	Artificial nontronite

Acknowledgements

CNES, OSUC, AMASE, NASA (ASTEP), ESA PRODEX for funding.

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