BASALTS FROM SANTORINI VOLCANO: A NEW CANDIDATE MARTIAN ANALOGUE

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Introduction: Our understanding of the Earth's interior has developed over many years of observations from and interactions among geophysics, geodesy, geochemistry, petrology, and other disciplines. Our corresponding level of understanding of Mars' interior, however, is still in a primitive stage due to the paucity of *in-situ* geophysical measurements and lack of returned samples. Unfortunately, the NASA Insight mission to Mars (initial launch date in 2016), with an advanced seismometer and geothermal probe, has been postponed for at least two years. Hence we continue to seek pathways for reconstruction of Martian crust and its properties (e.g., geothermal gradient) using information from rocks (e.g. shergottites). Such research is often guided by comparison with terrestrial areas considered to be Martian analogues. Here we focus on an outcrop on the southern part of Santorini Volcano (Balos cove, 36°21.7'N, 25°23.8'E), one of the few basaltic localities in the Aegean (Greece). The primary goal is to evaluate the resemblance of mineralogical and physical properties of Santorini rocks with verified Martian analogues (basalts; [1]) loaned from the International Space Analogue Rock Store (ISAR) and to examine its potential as a Martian analogue sampling site.

Materials and Methods: We collected 20 samples based on their freshness, integrity and basaltic appearance in the field. We used a range of techniques to characterize their texture, porosity (using ImageJ/PhaseQuant [2] on 2D sections & 3D micro–CT models), chemistry and spectroscopic properties: optical microscopy, micro-CT (SKYSCAN 1172), Scanning Electron Microscopy (JEOL JSM 5600), Infrared–Attenuated Total Reflectance (IR–ATR; Bruker Equinox 55), Raman Spectroscopy (RS: Renishaw inVia Reflex) and X-ray Diffraction (XRD; SIEMENS D-500). We made detailed comparisons with one thin section (09SJ15-1; analogue to Gusev basalt [1]), two basalt fragments (09SJ15, 05IS01) and four basalt powders (09SJ15, 05IS01,-03 & 07ZA20-1) loaned by ISAR. Data for 09SJ15 are published [1] but we re-analyzed it to obtain an internally consistent database for Santorini and ISAR rocks.

Results: Basalts from Santorini contain olivine (Ol) and clinopyroxene (Cpx)(phenocrysts; <600 μm diameter) in a fine groundmass of crystals (<100 μm diameter) of Ol, Cpx, plagioclase (Pl) and magnetite (Mt) with variable minor glass. Rare quartz (Qtz) crystals are interpreted as xenocrysts. Santorini basalts exhibit a pilotaxitic to trachytic texture as inferred by the randomly oriented to flow-oriented tabular Pl, respectively. The predominant minerals are calcic Pl (core An_{78-85} and rim An_{60-76}; 45-50 vol.%), Cpx ($En_{36-48}Wo_{41-44}Fs_{11-21}$; 10-15 vol.%) and Ol ($Fo_{74-88}$; 10-12 vol.%). Idiormorphic to subidiomorphic Mt (<10μm diameter) is a minor constituent (~1-2 vol.%) in the less mafic samples; compositions vary, with TiO_2 in the range 1.9-16.5 wt.%. The fine component of groundmass consists of idiomorphic Cpx and Ol microlites, and scarce devitrified glass. Porosity estimates are 7-15 vol.%.

RS and IR-ATR have potential for *in situ* mineral determination on future ExoMars and NASA-Mars2020 missions, assuming effective deconvolution algorithms can reconstruct individual mineral composition from mixed mineral spectra. We used Fityk (ver. 0.9.8), a Levenberg-Marquardt algorithm, and LogNormal distributions to optimize deconvolution for constituent minerals of Santorini and ISAR rocks (RS and IR-ATR data from RRUFF database [3]). The RS spectra of ol from Santorini and ISAR rocks display the same characteristic bands at 820-823 cm^{-1} and 853-856 cm^{-1}. Pyroxene bands at 661-665 cm^{-1} and 1002-1004 cm^{-1} and plag peaks at 475-479 cm^{-1} and 506-508 cm^{-1} are shared by Santorini and ISAR basalt 09SJ15-1. Glass with Cpx-like composition is found only in the most mafic Santorini sample and in 09SJ15. Likewise, the dominant bands in deconvolved IR-ATR spectra from both Santorini basalts and ISAR rocks, at ~875, 1130 and 970 cm^{-1}, can be assigned to Ol, calcic Pl and augite, respectively. XRD confirms that Santorini rocks appear unweathered, with dominant minerals being anorthitic Pl (mainly labradorite), Cpx (mix of diopside and augite) and Ol (forsteritic). XRD of ISAR sample 07ZA20 indicates a relatively altered assemblage of calcic Pl, Cpx (mainly augite), Qtz and hydrated minerals including actinolite and chlorite. Samples 09SJ15 and 05IS01-03 are fresher and more primitive, with Fo_{90} Ol and pyroxenes (Mg#57) associated with tabular Pl, spinel and glass; also include secondary amphibole and oxides, and xenocrystic Qtz like the Santorini basalts.

Conclusions: We compared volcanic rocks from Santorini to ISAR basalts from Iceland (05IS01, 05IS03), South Africa (07ZA20-1) and Norway (09SJ15), which are considered as strong candidates for Martian analogues. Texture, mineralogy, physical and spectroscopic properties of the Santorini basalts are notably similar to accepted Martian analogues [1]. Hence Santorini expands the list of terrestrial Mars-simulant sites. We are currently comparing our datasets to Martian meteorites and Mars rover data to evaluate if Santorini might be a better analogue than the others.

References: [1] Bost N. et al. 2013. *Planet. Space Science* 82-83: 113-127. [2] Elangovan P. et al. 2012. *Computers and Geosciences* 48: 323-329. [3] Lafuente B. et al. 2015. *Highlights in Mineralogical Crystallography* 1-30.