First X-ray diffraction measurements on Mars

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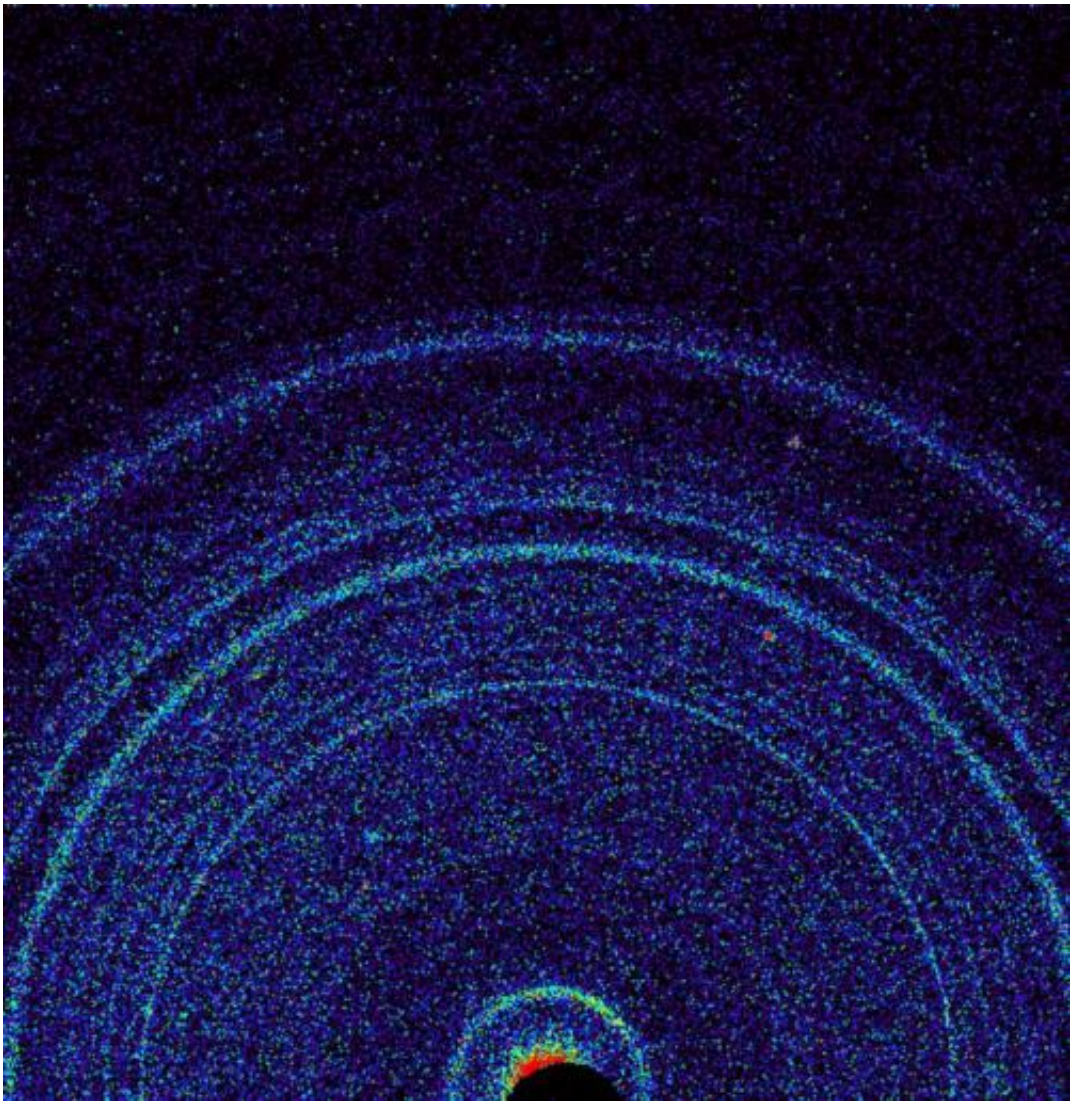

Two-dimensional XRD pattern for the Rocknest aeolian bedform (dune). Credit: David Bish et al.

In 2012 the Mars Science Laboratory landed in the fascinating Gale crater. The Gale crater is of such great interest because of the 5.5 km high mountain of layered materials in the middle. This material tells an intricate story of the history of Mars, perhaps spanning much of the existence of this mysterious planet.

Once positioned, the Curiosity rover began field studies on its drive toward Aeolis Mons (also unofficially known as Mount Sharp), the central peak within the crater. Curiosity has travelled more than 9.4 km so far and during its trip up the mountain, Curiosity has begun taking samples of the mountain's lower slopes.

CheMin is one of ten instruments on or inside Curiosity, all designed to provide detailed information on the rocks, soils and atmosphere. CheMin is actually a miniaturised X-ray diffraction/X-ray fluorescence (XRD/XRF) instrument, approximately the size of a shoebox, that uses transmission geometry with an energy-discriminating CCD detector to obtain unparalleled results in quite challenging conditions.

Five samples have been analysed by CheMin so far, namely a soil sample, three samples drilled from mudstones and a sample drilled from a sandstone. Rietveld and full-pattern analysis of the XRD data have revealed a complex mineralogy, with contributions from parent igneous rocks, amorphous components and several minerals relating to aqueous alteration, for example clay minerals and hydrated sulphates. In addition to quantitative mineralogy, Rietveld refinements also provide unit-cell parameters for the major phases, which can be used to infer the chemical compositions of individual minerals and, by difference, the composition of the amorphous component. Coincidentally CheMin's first XRD analysis on Mars coincided with the 100th anniversary of the discovery of XRD by von Laue.

So far CheMin has returned excellent diffraction data comparable in

many respects with data available on Earth. It has managed this even though several aspects of the instrument, particularly its small size limit the quality of the XRD data. These limitations could, however, be improved through modification of the instrument geometry. One of the most significant issues limiting remote operation is the requirement for powder XRD of a finely powdered sample. CheMin largely surmounts this difficulty through the use of its unique sample vibration device.

Data obtained so far has already provided new insights into processes on Mars, and the instrument promises to return data that will answer numerous questions and shed further light on the history of the Gale crater.

Work is already progressing in developing an upgraded instrument with changes in the reflection geometry. Coupled with data-processing software interface advances, we may see future improvements to non-contact diffraction analysis of the surfaces of planetary bodies.

More information: Bish et al. (2014). *IUCrJ*, 1, 514-522; DOI: 10.1107/S2052252514021150

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