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POLARIMETRIC RADAR FOR REMOTE PREDICTIVE GEOLOGICAL MAPPING

Abstract

Remote predictive geologic mapping substantially reduces costs and hazards associated with traditional mapping techniques by reducing time needed in the field. Further, many geologically interesting regions, such as the Canadian High Arctic or Mars, are inaccessible due to their remoteness. Therefore, there is increased pressure on industries and agencies to develop remote exploration methods using satellite observation techniques.

Synthetic aperture radar (SAR) is an under-used tool for geological exploration. When used in conjunction with other remote sensing techniques (for example, spectroscopy) SAR can be a powerful instrument for differentiating rock units. A key step in developing remote mapping techniques is ground-truthing, that is, comparing orbital observations with in person field investigations. This study uses RADARSAT-2 C-Band (5.6 cm) and PALSAR-1 L-Band (23 cm) quad-polarization radar data, visible near infrared (VNIR) and thermal infrared (TIR) spectroscopy data, and field investigations of salt diapirs on Axel Heiberg Island, Canada.

Salt diapirs are mounds of evaporite minerals that rise buoyantly through overlying rock beds. As they rise, diapirs can produce traps for petroleum reservoirs and lead-zinc ore deposits, making them common targets for economic exploration. However, salt minerals sourced from the diapirs are often mobilized and transported elsewhere. X-Ray Diffraction (XRD) of collected salt samples confirm that the remobilized salts on Axel Heiberg Island share composition with the salt diapirs and associated perennial springs. Therefore, these salts share spectral signatures with the diapirs, meaning it is necessary to look beyond VNIR and TIR images to differentiate between diapirs and secondary salts.

In this study, we have mapped regional spectral signatures of gypsum and anhydrite salts on western Axel Heiberg Island. Eight new RADARSAT-2 images and nine pre-existing PALSAR-1 polarimetric images have been acquired over the study site, from which we extract statistics of the radar signatures over mapped salt regions. Salt minerals are softer and more soluble than other rock constituents. Subsequently, salt diapirs erode more readily than other rocks and diapirs appear rough in SAR. In contrast, secondary salt deposits are found precipitating on radar-smooth surfaces such as floodplains, gullies, and hillslopes. Ground-truthing in the 2017 field season confirms that the salt diapirs are rough from the millimetre to meter scales, whereas the secondary salts are precipitating on smoother surfaces. Therefore, we have shown that SAR can be used to differentiate diapiric and non-diapiric salt by their contrasting rough and smooth surfaces, respectively.