Understanding Planetary Processes through Laboratory Study of Terrestrial Analogues

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Abstract

Terrestrial analogue research for planetary processes has drawn significant attention and made vast advancements in recent years. The research focuses on the study of terrestrial samples, which are found to be analogous to similar materials on other planetary bodies. Since in-situ sample analysis is yet to be achieved, scientists find analogue research a suitable method to understand the processes and environmental conditions on other planetary bodies. Analyses of returned samples, meteorites, and remote orbital datasets from interplanetary missions in the past few decades have led to significant findings regarding the origin, evolution, chemical composition, as well as geological processes on other planetary bodies. Given these present knowledge about the physical and chemical characteristics of any parent planetary body, terrestrial samples of equivalent rocks or minerals are being collected, examined and subjected to chemical analyses to infer about their genesis, formation mechanism, and environmental conditions prevailed at the time of formation of these minerals and/or rocks. The results obtained from the characterization of these terrestrial samples can be extrapolated to the lunar or Martian scenario, which in turn tells us about their formation history and environmental conditions persist or rather prevailed on these planetary bodies. The spectral characteristics of the terrestrial samples in response to different wavelengths of electromagnetic radiation have been measured and recorded. These spectral measurements of different analogue samples can be used for the identification of similar materials on other planetary bodies through orbital remote sensing data. Comparing the spectral information obtained from orbital data with that of the spectral library and the identification based on the best match with the library data. Also, the spectral data of terrestrial samples can be used for the calibration of the instruments to be flown in future planetary missions. The data can also act as ground-truth for the spectral calibration of the obtained data for accurate interpretation. The spectral measurements of the terrestrial samples are being made under laboratory based conditions to avoid the effects of atmospheric

constituents. The analogue samples can also be analyzed and studied in simulated environments set up in the laboratories, which would enable us to decipher their formation conditions on corresponding planetary bodies and facilitate our interpretation irrespective of the influence of terrestrial contamination. The astrobiological studies can be taken forward using this method. The conditions which favor the thriving of microorganisms can be examined, which will help us figure out the possibilities of their presence in other planetary environments. Terrestrial analogue sites in India have been explored by many researchers. The jarosite deposits and gypsum-clay association from Rann of Kachchh, banded iron formation from Singhbhum region, Sittampundi anorthosite complex, serpentinites and magnesite from Salem region are few among the many promising terrestrial analogue sites in India which have been studied by planetary scientists to understand their chemical and spectral characteristics as well as formation conditions. The spectral-chemical analyses of Sittampundi anorthosites have revealed that they are equivalent to lunar anorthosites, and a lunar yard has been prepared using these samples. The jarosite deposits from Kachchh region of Gujarat were found to have chemical and spectral similarities with the jarosite occurrences on Mars. Hence, the terrestrial analogue studies will help planetary scientists to have a better understanding of similar processes operated on the other planets.