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Search for past life on Mars: Physical and chemical characterization of minerals of biotic and abiotic origin

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Several lines of evidence suggest that early Mars once had liquid water on its surface, a denser atmosphere and a mild climate. Similar environmental conditions led to the origin of life on the Earth more than 3.5 billion years ago; consequently, life might also have originated on Mars. The Viking landers searched for evidence of organic molecules on the surface of Mars, and found that the Martian soil is depleted in organics at ppb levels at the landing sites. We contend that inorganic compounds could give us interesting clues as to the existence of possible biological activity in future astrobiological missions to Mars. Consequently, we have investigated the physical and chemical properties of calcite, which could be expected on Mars because liquid water was certainly present on the surface of early Mars and carbon dioxide was abundant in its atmosphere. Calcite is interesting because on Earth this mineral is produced by abiotic processes as well as by biological activity. One may suppose that crystalline defects and trace element in the crystal lattice and the growth speed of biotic calcites must indicate a difference between them and pure abiotic calcites. We investigated twelve different terrestrial calcite samples from various origins: biotic, diagenetic and abiotic. The minerals were studied by X-ray diffraction and electron scanning microscopy to determine their mineralogical and chemical composition, and differential thermal analysis coupled to thermogravimetric analysis (DTA-TG) to determine their thermal behavior. Our results show that the thermal degradation of abiotic calcite starts at a temperature at least 40°C higher than the degradation temperature of any biotic calcite investigated. Consequently, in the case of a Martian in-situ study or in a sample return mission, the analysis of Martian minerals by DTA-TG represents a promising approach to detect evidence of past biological activity on Mars.