In situ use of microwaves to determine remotely the water content of minerals

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The rovers Spirit and Opportunity are equipped with instruments to determine the chemistry of the minerals found on Mars. An emphasis has been placed on trying to correctly identify water-bearing minerals. While the Alpha-Particle-X-Ray spectrometer is used to determine elemental chemistry of minerals it cannot detect hydrogen. It also cannot determine the structure the minerals. These two drawbacks inhibit the direct determination of water in the samples. We propose to expose minerals to a microwave source and measure their heat gain as a method to determine if they contain water. A small microwave source and pyrometer could be included on future missions to determine if minerals contain water. To test this method we used a commercial microwave oven (2.4 GHz and 1000 Watts) and pyrometer to determine heating trends of several rock-forming minerals.

Minerals with higher amounts of water and/or hydroxide content should heat more than those with less amounts of water when exposed to microwaves over the same period of time. Minerals showed different heating patterns based on their water and or hydroxide content. Minerals that contained no water or hydroxide in their structure (i.e. quartz, calcite, anhydrite) showed little temperature increase with microwave heating. Clay minerals and zeolites showed a general increase in temperature with time. Borate minerals showed patterns of heating with time based on the amount of water and/or hydroxide contained in their structure.

Generally, minerals showed heating trends based on their water and/or hydroxide content: minerals with little or no water heated less over time, while minerals containing abundant water heated more over time. There were exceptions to the hypothesis, which indicate that other bonds may be microwave active. More experiments and a better theoretical understanding of the interactions of microwaves with minerals are needed before this method could be used to remotely determine water content. However the method shows promise as a means to determine the water content of rock-forming minerals, and possibly, by changing the frequency of the microwaves, to determine other chemical constituents of minerals.