

Multi-elemental maps from the Mars Odyssey gamma ray spectrometer

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MARS ODYSSEY GAMMA RAY SPECTROMETER TEAM

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Introduction

The Mars Odyssey spacecraft has been in a 400 km polar orbit around Mars since early 2002. Since then, the Mars Odyssey gamma-ray spectrometer has collected gamma-ray spectra. These spectra in early 2002 helped to quantify the distribution of hydrogen, believed mainly to be water, in the top meter near the martian poles [1]. Initial gamma-ray results for K, Th, Si, and Fe have been presented [2-5]. More results for these 5 elements are reported here.

Data Reduction

Spectra are accumulated every ~20 seconds, corrected to a common gain, and added together to get adequate counting statistics. Depending on the signal strength, spectra are summed for different size bins (5°, 10°, or 15°), and the areas under the gamma-ray peaks are determined. These peak areas were then compared to calculations to get concentrations [2].

Results

The hydrogen content is in water equivalent by weight and is normalized to 94% water near the north pole. H concentrations assume that the H is uniformly distributed with depth to several meters and that the composition of the soil with respect to major neutron absorbing elements is the same as that of Mars Pathfinder soil [6]. In the regions never covered by CO₂, between 45 degrees north and south, H varies between ~2% and 7%. The H content increases polewards of 45° and reaches ~43% near the south pole.

For large regions (many degrees square), the concentrations of K and Th vary by factors of ~3 and are higher than in most Shergottites. The K/Th ratio is similar on average to that in Shergottites but varies by a factor of ~2, which could reflect both primary production and secondary alteration processes [4]. Iron abundances varies by a factor of ~2, but Si concentrations varies less.

Our preliminary concentrations do not show any strong correlations with other remote-sensing results for Mars, such as thermal inertia, albedo, and rock abundances [5]. The region between 40° and 60° N that was identified as "type 2" in TES spectra [7] is enriched in K and Th.

References

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Isotopic studies of the present and past mass balance of dissolved thallium in the oceans

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The Tl isotope compositions of most rivers are similar to the continental crust (as sampled by loess) with $\epsilon^{205}\text{Tl} \approx -2.5$. ($\epsilon^{205}\text{Tl}$ represents the deviation of the $^{205}\text{Tl}/^{203}\text{Tl}$ isotope ratio of a sample from NIST SRM 997 Tl standard in parts per 10⁴). The remainder of the riverine data is intermediate between the continental crust and seawater, which has $\epsilon^{205}\text{Tl} \approx -6$. These results differ significantly from the isotope compositions of pelagic sediments, which are a major oceanic sink of dissolved Tl. The authigenic phases of clays and biogenic oozes typically have $\epsilon^{205}\text{Tl}$ of between +2 and +5. Assuming that the oceans are in steady-state, the isotopic imbalance indicates that there are important additional oceanic Tl sources and sinks. It furthermore implies that the residence time of Tl cannot be calculated solely based on riverine fluxes or the enrichment of Tl in pelagic clays.

A survey of published concentration data suggests that rivers, hydrothermal fluids and volcanic aerosols are the main sources of dissolved oceanic Tl, but the relative importance of these fluxes is uncertain. The main sinks of Tl are scavenging from seawater by the authigenic phases of sediments and low-temperature basalt alteration. The latter process probably generates the larger output flux. Both input and output fluxes indicate an oceanic residence time about 15 to 30 kyr for Tl.

Variations in the relative intensities of the source and sink fluxes could drive changes in the Tl isotope composition of seawater and such a change has been inferred from the time-resolved Tl isotope data of serially sampled ferromanganese (Fe-Mn) crusts. These results are relevant, because the surface layers of Fe-Mn crusts display a relatively constant isotope fractionation relative to modern seawater. The Fe-Mn crusts older than 25 Ma show a systematic increase in $\epsilon^{205}\text{Tl}$ with decreasing age, from about +6 at 55 Ma to about +13 at 25 Ma. It is possible, albeit unlikely, that this increase is due to diagenetic alteration or that it reflects variations in ocean temperature. The most probable explanation is that this trend records a change in the Tl isotope composition of seawater.

An evaluation of which source or sink fluxes may be responsible for this change requires an understanding of the relative importance of the fluxes through time and their isotopic signatures. We are, therefore, presently in the process of determining the Tl isotope compositions of the remaining major oceanic sources and sinks of Tl.