New Views of Io

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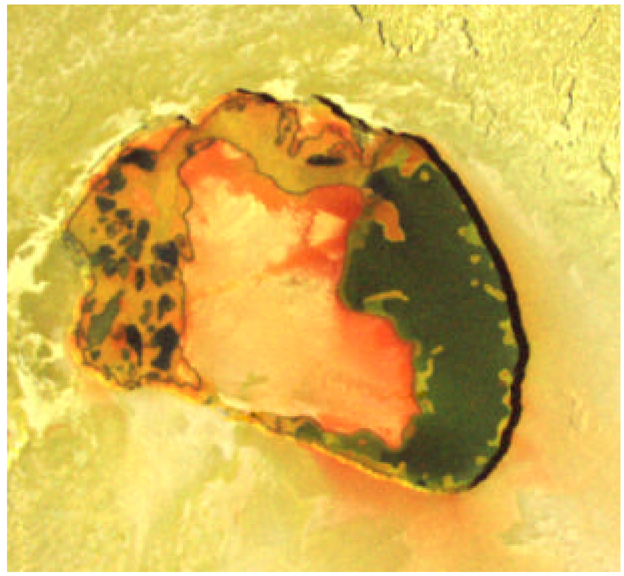
Our view of Io is being reshaped as the final data from the Galileo Era of Io exploration are being analyzed. While we emphasize data from the Solid State Imaging camera, the combination of the different Galileo instruments is providing synergistic constraints on the processes operating on and within this hyperactive body. Furthermore, it is the interaction between volcanism and tectonism that is providing the deepest insights into the fundamental workings of Io. We discuss 3 major topics here (1) the role of sulfur vs silicate volcanism, (2) the structure of the Ionian crust, and (3) the possible presence of a magma ocean within Io.

While the post-Voyager consensus was strongly in favor of extensive sulfur volcanism on Io, the Galileo data has repeatedly failed to provide any conclusive evidence sulfur lava flows. In fact, the Galileo data has confirmed the suggestion of Carr (1986) that many of the low temperature hot spots seen by Voyager are actually cooling silicate flows. Galileo SSI data has shown that many volcanic centers are too hot to be sulfur and that several are too hot to be basalts. While Galileo NIMS has detected several hot spots cool enough to be explained by sulfur lavas, most of these are clearly associated with recent silicate eruptions. Thus no conclusive thermal evidence for sulfur volcanism exists. The best evidence for sulfur volcanism comes in the form of bright yellow flows. While the simplest explanation is that these are flows of liquid sulfur, an alternative possibility is that they are silicate flows coated with sulfur. Most of the surface of Io is a yellowish-white due to a coating of sulfurdioxide and sulfur. On a warm lava surface, the sulfurdioxide would be unstable, leaving only a lag deposit of sulfur. Thus, in sharp contrast to the post-Voyager view of Io, we cannot find strong evidence for extensive sulfur volcanism.

This is not to say that sulfur compounds do not clearly play a critical role in the structure of the Ionian crust. Instead, it appears that sulfurous materials are mobilized by nearby silicate volcanism. Figure 1, of Tupan Patera is a spectacular example of a location where hot silicate lavas appear to be melting sulfur from the confining cliff walls. Sulfurdioxide is apparently vaporized. Sulfur and sulfurdioxide are both converted from the solid to the liquid state at depths of only a few kilometers within Io's crust. The extreme compressional stresses expected in most of Io's crust (due to the rapid subsidence of the crust in response to the rapid resurfacing rate) should force these sulfurous fluids toward the surface. Thus we expect the upper few kilometers of Io's crust to contain a high volume fraction of low-density, volatile, sulfur compounds. Rising silicate magma should pond at the base of this volatile-rich zone because the magma is suddenly denser than the surrounding crust. The production of large sills directly under the volatile rich zones is to be expected. The heat from these sills should effectively mobilize the overlying volatiles, producing a large depression in the ground. Once much of the low-density volatiles are driven off, the magma can proceed to the surface and form lava flows and lakes.



The extreme volcanic activity on Io should have led to extreme chemical fractionation of the crust. However, the high temperature lavas we observe suggest that very primitive melts are being generated today. One possible explanation is that a global magma ocean exists below the crust, allowing complete mixing of the crust back into the mantle. The measurement of an intrinsic magnetic field at Io would have ruled out the presence of a magma ocean. Such a field would indicate strong motions in a liquid core, presumably driven by a core that is hotter than the mantle. Galileo has conclusively shown that Io does not have an intrinsic magnetic field, leaving open the possibility of a magma ocean. We have also revisited some of the theoretical studies suggesting that a magma ocean is not physically plausible and have found these studies to be sufficiently flawed to throw their conclusions in doubt. We await a future mission to Io to determine the final truth about the interior of Io.