VACUUM ELECTROPLATING OR EVAPORITE SALT DEPOSITS ON THE SURFACE OF IO: WHAT WILL VOYAGER FIND? A. J. Dessler*, The Johns Hopkins University, Applied Physics Laboratory, Laurel, Maryland 20810, and T. W. Hill, Department of Space Physics and Astronomy, Rice University, Houston, Texas 77001

The surface of Io may be modified, both chemically and optically, by implantation of ions drawn from Jupiter's ionosphere. The mechanism is straightforward. The relative rotational motion between Io and Jupiter drives a Birkeland (magnetically field-aligned) current between Io and the Jovian ionosphere (1,2). The geometry is rather similar to that of a disc dynamo (Faraday disc generator), and the physical principle of the production of current is identical. One novel and significant feature of the Io/Jupiter current generator is that the resulting Birkeland current must flow through the magnetic mirror that exists between Io and Jupiter. That is, if we follow the magnetic tube of flux from Io down to Jupiter's ionosphere, we find the magnetic field B increases by more than a factor of 400. This implies that, in the absence of strong particle scattering, the velocity vector of a charged particle starting at Io must be aligned within about 3° of the local magnetic field if it is to reach the Jovian ionosphere. Particles with larger pitch angles will be reflected (mirrored) by the stronger field below; these mirrored particles do not contribute to the net Io/Jupiter Birkeland current. Rassbach (3) has pointed out that it requires an unreasonably large electric field component parallel to B to pull the mirroring particles downward into the ionosphere. Thus, Dessler and Hill (2) have concluded that the charge carriers that constitute the Io/Jupiter Birkeland current are drawn from Jupiter's ionosphere and flow upward along B, in which case magnetic mirroring cannot inhibit the particle motion.

Because the charge carriers move upward, ions drawn from Jupiter's ionosphere will bombard the surface of Io (4). The sense of the current is such as to have positive charge carriers flow to the side of Io that faces Jupiter and electrons flow to the opposite side. The rapid rotation of Jupiter further causes the current to be swept forward in the direction of Io's orbital motion (4,5). Thus, the ion bombardment of Io will be a maximum on the inner forward quadrant of Io, where "inner" is toward Jupiter and "forward" is the direction of Io's orbital motion.

In addition to the predominance of hydrogen and helium, some finite fraction of Jupiter's ionosphere must consist of elements such as sodium, potassium, and sulfur; such elements being either deposited by meteoric infall or brought up from below by turbulent convection. The ions will be implanted on Io's surface with energies of up to several hundred keV. Thus the inner hemisphere, and particularly the inner forward quadrant, of Io will be vacuum electroplated with ions that will change the electrical and optical properties of Io's surface. It has been proposed by Hill et al. (5) that the apparent localization of the source of atomic sodium sputtered from Io is caused by this vacuum-electroplating mechanism.

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An alternate hypothesis is the evaporite-salt hypothesis (6). The mechanism for this hypothesis is also straightforward. Primordial water ascends to the surface of Io during its early history and evaporates from Io leaving behind a thick bed of soluble material carried to the surface by the water. These salt deposits, which can be thought of as dry lake beds, can, of course, be localized so as to agree with the observation of localized emission of sodium from Io's surface.

Voyager 1 will pass close to Io during its encounter with Jupiter, and high-resolution pictures of Io's surface are planned. If the idea of vacuum electroplating is correct, these pictures should show a rather uniform surface, particularly over Io's inner hemisphere. If the evaporite salt hypothesis is correct, rather sharp contrast between regional features, such as would be produced by a dry lake bed, ought to be obvious.

Pictures of Io will be taken during the Voyager 1 encounter, which will occur just two weeks before this meeting. These pictures should enable us to decide between the vacuum-electroplating and the evaporite-salt hypotheses. If the vacuum-electroplating hypothesis is proved wrong, this paper will be read by title only.

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