GEOMORPHIC CLASSIFICATION OF ICELANDIC AND MARTIAN VOLCANOES: LIMITATIONS OF COMPARATIVE PLANETOLOGY RESEARCH FROM LANDSAT AND VIKING ORBITER IMAGES*

Richard S. Williams, Jr.
U.S. Geological Survey
Reston, Virginia 22092

Summary

As a result of collaborative research by Elliot C. Morris (U.S. Geological Survey's Branch of Astrogeology), the late Sigurdur Thorarinsson (University of Iceland), and me to develop a comprehensive geomorphic classification of Icelandic and Martian volcanoes, we identified some limitations in using orbital images of planetary surfaces for comparative landform analyses. In our study the principal orbital images used were Landsat MSS images of Earth and nominal Viking Orbiter images of Mars. Both are roughly comparable in having a pixel size which corresponds to about 100 m on the planetary surface. A volcanic landform on either planet must have a horizontal dimension of at least 200 m to be discernible on orbital images. A twofold bias is directly introduced into any comparative analysis of volcanic landforms on Mars versus those in Iceland because of this scale limitation. First, the 200-m cutoff of landforms may "delete" more types of volcanic landforms on Earth than on Mars or vice versa. Second, volcanic landforms in Iceland, too small to be resolved on orbital images, may be represented by larger counterparts on Mars or vice versa.

Iceland was selected as the best region on Earth for comparing volcanic landforms with those on Mars because of the tremendous variety of types of volcanoes in Iceland. The previous geomorphic research by Sigurdur Thorarinsson in developing a classification of Iceland's volcanoes, the enormous body of geologic literature on Iceland's volcanoes, and the wealth of thematic maps, aerial photographs, and various types of satellite images of Iceland provided comprehensive source material. The classification scheme divides Iceland's volcanoes into 3 compositional groups: basalt, rhyolite, and central (mixed), and further subdivides them on the basis of nature of volcanic activity (explosive or effusive), environment during formation (subaerial or subglacial), and form of feeder conduit (central or linear). Pseudocraters were also included as a special "volcano" landform that formed under unusual conditions. Only 8 of the 25 discrete types of subaerial and(or) subglacial Icelandic volcanoes could be unambiguously identified on Landsat MSS images: lava shield, table mountain, subglacial ridge, mixed cone row, tephra ring, flow dome, composite cone, and composite volcano massif. Five other volcano types could be identified only because their location was found on other source material (e.g., aerial photographs, maps, etc.). The other 12 types had dimensions too small to be recorded.

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A number of geomorphologists have used Viking Orbiter images of the Martian surface to classify volcanoes on the basis of their morphologic similarity to volcanoes on Earth. Elliot Morris found that the classification scheme used for Icelandic volcanoes cannot be directly applied to Martian volcanoes because the criteria, which are used to classify the former, either are not known or must be inferred for the latter. Five principal types of volcanoes have been recognized on Viking Orbiter images of the Martian surface: lava shields, domes, composite cones, highland paterae, and volcano-tectonic depressions. The highland paterae apparently have no known counterpart volcano landform on Earth, but the other 4 Martian volcano types are represented by 4 counterpart volcano landforms recognized on Landsat MSS images of Iceland. Two of the 8 volcano types discernible on Landsat MSS images of Iceland are subglacial and may not have a counterpart landform on Mars. The other two types, mixed cone row and tephra ring, are barely discernible on Landsat MSS images of Iceland; if their counterparts on Mars are smaller, then they may not be recorded on nominal Viking Orbiter images of Mars.