View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

EXPLOSIVE VOLCANIC DEPOSITS ON MARS: PRELIMINARY INVESTIGATIONS

D.A. Crown, L.A. Leshin, and R. Greeley, Department of Geology, Arizona State University, Tempe, Arizona 85287

The existence of explosive volcanism and the identification of related eruptive products on Mars have been the subject of much controversy. Most research regarding martian volcanism has centered around basaltic volcanism. Terrestrial analog studies, photogeologic investigations, Viking Lander chemical analyses, and remote sensing information all indicate the presence of basaltic volcanism on both regional and local scales [1]. Small-scale explosive volcanism is indicated by possible cinder cones [2-4] and "pseudo craters" resembling those in Iceland [5]. A possible ash-fall deposit associated with Hecates Tholus has been proposed [6], and volcanic density currents have been suggested to explain features surrounding volcanoes in the Tharsis region [7]. The possibility of explosive volcanism on a larger scale was implied by Malin's [8] comparison of the Elysium region of Mars and the Tibesti region on Earth. Other investigators have considered the existence of rhyolitic lava flows [9] and silicic domes [10], but the occurrence of silicic volcanism, which is commonly explosive in nature on the Earth, has received little support [11]. Large-scale explosive volcanism was suggested to account for the basal scarp [12] and aureole deposits [13] of Olympus Mons, as well as deposits covering > 10^6 km^2 in the Amazonis, Memnonia, and Aeolis regions [14,15]. The deposits in Amazonis Planitia were proposed to be pyroclastics on the basis of similarities (such as complementary joint sets and thick flow sheets) to ignimbrites in the Pancake Range of Central Nevada [15], but the morphology observed on Mars may not be definitive of ignimbrites, and the deposits have also been suggested to be of a non-volcanic polar origin [16] and mantling deposits of an aeolian origin [17]. The formation of the martian highland paterae, which are distinguished by low, broad forms, radial channels, lobate ridges, and central caldera complexes [18], has been attributed to explosive volcanism. Originally, Potter [19] suggested that the highland paterae were formed by eruptions of extremely fluid basaltic lava, but Pike [20] noted the morphometric correlation of the highland paterae with large ash sheets on Earth. Greeley and Spudis [1] proposed that the highland paterae were formed by phreatomagmatic eruptions in an early period of martian history.

Two investigations have been undertaken to examine possible large-scale explosive volcanic deposits on Mars. The first includes an analysis of Viking Infrared Thermal Mapper (IRTM) data covering the vast deposits in the Amazonis, Memnonia, and Aeolis regions. These "postulated ignimbrites" have been mapped by Scott and Tanaka [15], and at least five high-resolution nighttime IRTM data tracks cross the deposits. Preliminary analysis of the data covering Amazonis Planitia show that local features (such as yardangs) have anomalous thermal inertias but the "ignimbrites" as a whole do not consistently have significantly different thermal inertias from their surroundings. However, this does not necessarily discount the existence of ignimbrites, as local features and apparent mantling by a fine layer of dust can dominate thermal inertias [21]. Further investigation including examination of lower resolution data is needed to provide a complete characterization of these deposits using IRTM data and to ascertain whether they possess a discernable thermal signature.

Preliminary photogeologic and IRTM studies of the large and small highland paterae [22] have also begun. Two high-resolution nighttime tracks trending NW-SE cross Apollinaris Patera, which is located adjacent to the lowland-highland scarp (9°S, 186°W). In both the northern and southern regions of Apollinaris Patera thermal inertias are significantly greater than those observed in the surrounding areas. The thermal signature of Apollinaris Patera is more prominent on its southern flanks; within the southernmost of the two tracks thermal inertias increase from ~ 3.0 - 3.5 in the region surrounding Apollinaris Patera to a high of greater than 6.0 (x 10^{-3} cal cm^{-2} $sec^{-1/2}/K^{-1}$) on the volcano and within the northern track from ~ 1.9 to a high of 3.4. Lower thermal inertias on the northern flanks of Apollinaris Patera are consistent with the regional trend reflecting the transition from the cratered uplands to the smooth plains [21] and also with observations of less morphologic detail on the northern flanks suggesting more thoroughly mantled surfaces. Continued analysis of IRTM data covering the large and small highland paterae will determine if the paterae possess distinctive thermal signatures.

The purpose of IRTM studies of postulated martian explosive volcanic deposits is to determine the physical properties of the proposed ignimbrites. If volcanic deposits are exposed at the surface, high thermal inertias, as are observed for Apollinaris Patera, should be present. However, the thermal signature of the paterae, for instance, may not be the result of a primary volcanic surface. If a distinctive thermal signature is observed, it may be only an indirect reflection of the volcanic deposits. Nevertheless, this would allow a characterization (by albedo, thermal inertia, and rock abundance [23]) of the material controlling the thermal properties of the paterae and should provide important information for the consideration of explosive volcanism on Mars.

Although many investigators have considered explosive volcanism on Mars, currently much of the evidence for extensive deposits is tenuous, and the occurrence of large-scale explosive volcanism remains controversial. The present studies are intended to address the question in more detail with the aid of new and previously unused sources of information. The implications of explosive volcanism are critical to understanding the evolution of the martian surface. In combination with the examination of possible martian explosive volcanic deposits, this investigation will also include a remote sensing analysis and a field examination of a selected terrestrial analog. Due to their morphologic similarities, ignimbrites in the Central Andes are presently the best candidates as analogs for the martian highland paterae.

References

[1] Greeley, R., and Spudis, P.D., 1981, *Rev. Geophys. Space Phys., 19,* 13-41.
[2] West, M., 1974, *Icarus, 21,* 1-11.
[3] Mouginis-Mark, P.J., 1981, *Proc. Lunar Planet. Sci. Conf., 12th,* 1431-1447.
[4] Lucchitta, B.K., 1985, *Lunar Planet. Sci. Conf., XVI,* 503-504.
[5] Frey, H., and Jarosewich, M., 1982, *J. Geophys. Res., 87,* 9867-9879.
[6] Mouginis-Mark, P.J., Wilson, L., and Head, J.W., 1982, *J. Geophys. Res.,87,* 9890-9904.
[7] Reimers, C.E., and Komar, P.D., 1979, *Icarus, 39,* 88-100.
[8] Malin, M.C., 1977, *Geol. Soc. Am. Bull., 88,* 908-919.
[9] Fink. J., 1980, *Geology, 8,* 250-254.
[10] Plescia, J.B., 1981, *Icarus, 45,* 586-601.
[11] Francis, P.W., and Wood, C.A., 1982, *J. Geophys. Res., 87,* 9881-9889.
[12] King, J.S., and Riehle, J.R., 1974, *Icarus, 23,* 300-317.
[13] Morris, E.C., 1980, *NASA TM-82385,* 252-254.
[14] Scott, D.H., and Tanaka, K., 1980, *NASA TM-82385,* 255-257.
[15] Scott, D.H., and Tanaka, K., 1982, *J. Geophys. Res., 87,* 1179-1190.

[16] Schultz, P.H., and Lutz-Garihan, A.B., 1981, *Lunar Planet. Sci. Conf., XII,* 946-948.

[17] Greeley, R., Williams, S.H., White, B.R., Pollack, J.B., and Marshall, J.R., 1985, in *Models in Geomorphology*, ed. M.J. Woldenberg, Allen & Unwin, Boston, 373-422.

[18] Plescia, J.B., and Saunders, R.S., 1979, *Proc. Lunar Planet. Sci. Conf., 10th,* 2841-2859.

[19] Potter, D., 1976, *U.S. Geol. Survey Misc. Geol. Inv. Map I-941.*

[20] Pike, R.J., 1978, *Proc. Lunar Planet. Sci. Conf., 9th*, 3239-3273.

[21] Zimbelman, J.R., and Leshin, L.A., 1986, submitted to *Proc. Lunar Planet. Sci. Conf., 17th.*

[22] Albin, E.F., 1986, Master's Thesis (unpublished), Arizona State University, 84 pp.

[23] Christensen, P.R., 1982, *J. Geophys. Res., 87*, 9985-9998.