N92-10907

GEOLOGIC MAPPING OF NORTHERN LUNAE PLANUM, MARS

Robert A. Craddock and Ted A. Maxwell, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560

Lunae Planum is an elevated region east of the Tharsis rise and is approximately the size of the Tibetan Plateau of China (>1,200,000 km^2). Ridged plains containing numerous Sacra Dorsa wrinkle ridges, cross-cutting Sacra Fossae grabens, and lobate scarps compose this martian plateau. Because the Sacra Dorsa are circumferential to the Tharsis rise, many investigators suspect that isostatic or loading stresses from the formation of Tharsis generated these features [1,2]. Over 3 km of relief associated with Kasei Valles separate Lunae Planum from Tharsis to the west [3]. The tilt of this Martian plateau may have also controlled fluvial sheet flows, which eventually created the eastern Lunae Planum outflow complex [i.e., Maja, Vedra, Maumee, and Bahram Valles; 4]. Geologic mapping of the northern Lunae Planum region was undertaken to better understand the emplacement history of the ridged plains, the structural history of deformation, and the periods of fluvial processes that have modified the region. These investigations are important for several reasons: the history of plains emplacement yields information valuable for understanding the evolution of Tharsis volcanism, interpretation of structural deformation has implications on the lithology of the martian crust, and determining the history and fate of martian volatiles is dependent upon knowing the periods of outflow activity.

Because of the occurrence of wrinkle ridges and lobate scarps in high resolution images, numerous investigators have interpreted the ridged plains as being the result of flood volcanism [e.g., 5,6]. Previously, however, no direct evidence has been presented to support this interpretation and the consideration that the ridged plains may be sedimentary in origin has been suggested [7,8]. Viking orbiter images (51A41-46) show numerous linear features 1- to 5-km-long, oriented roughly between 30° and 60° NE and NW, and frequently associated with low albedo materials. We interpret these features as volcanic fissures similar to those which occur in terrestrial flood basalt provinces. Major differences between these features and terrestrial fissures include the size (up to a factor or two larger) and the two sets of preferred orientation as opposed to one [9]. Commonly low albedo materials on Mars are aligned on the same side of topographic obstacles within a region and have thermophysical properties indicative of coarse-grained, windblown sediments [e.g., intracrater deposits; 10]. However, uniformly dark surfaces in the martian highlands have been interpreted as exposed lava flows [11]. The lack of preferred orientation, smooth edges, and close association with linear features suggests that some low albedo materials in northern Lunae Planum are exposed or partially buried lava flows also.

A number of flow fronts in the area investigated are superimposed on wrinkle ridge arches, indicating that plains emplacement and ridge formation were not events separated in time. Crater count statistics suggest that rather than being formed in a single event, the Lunae Planum surface is composed of multiple aged surfaces which vary in N(1) ages with longitude. Crater ages of eastern Lunae Planum are older than central

Lunae Planum, suggesting that later flows were not as extensive as initial flows that may have originated from the Tharsis region. These observations indicate that Lunae Planum may have experienced regional volcanism as part of Tharsis precursor volcanism, but with time this volcanism became local. Lunae Planum volcanism probably continued through the structural deformation associated with the formation of Tharsis--or at least until the end of the early Hesperian.

Because martian wrinkle ridges closely resemble lunar mare ridges and Columbia Basalt anticlines, they are commonly interpreted to represent structural features formed as a result of buckling followed by reverse or thrust faulting [7,8]. Interpretation of the mechanics necessary for creating the Sacra Dorsa wrinkle ridges has been undertaken by other investigators and involves modelling the ridged plains as linear elastic [8,12] or linear viscous material [8,13]. These models must be capable of not only explaining the periodic spacing of the wrinkle ridges, but the erosive nature of the ridged plains materials as well [i.e., Kasei Valles terraces, chaotic terrain, and wall erosion; 14]. If the ridged plains have the rheologic properties of an elastic material, they are relatively thick (>2.4 km; 8). Below 1 km, the ridged plains must have contained a volatile-rich zone, which cemented the material after deformation to explain Kasei Valles terracing. If the ridged plains have the rheologic properties of a viscous material, then the ridged plains should be relatively thin (>750 m; 8), and Kasei Valles terracing can be explained as the contact between ridged plains and underlying regolith.

Kasei Valles are nearly as long as the Mississippi River in the United States (>2,500 km). For over half of their distance, Kasei Valles flow N20°E before splitting into two main channels which flow N80°E into Chryse Planitia. The relief from the floors of Kasei Valles to the top of Lunae Planum is more than 3 km in some places [3,14]. The wrinkle ridges on Lunae Planum have not been affected by the erosional processes which formed these channels, and in some places ridges on the channel floors are continuous with ridges on the plateau. These observations suggest that Kasei Valles were following pre-existing topography, most likely the result of faulting. The upper, N80°E trending portion of Kasei Valles can be explained as a series of faults radial to the center of Tharsis as predicted by Tharsis isostatic stress models [1,2]. However, the fault controlling the southern, N20°E trending portion of Kasei Valles cannot be explained by any existing Tharsis stress models. We propose that the faults controlling the flow of Kasei Valles volatiles and some of the relief between the channels and Lunae Planum were the result of crustal adjustments following the formation of Tharsis and the evacuation of a large amount of mantle material (~110,000,000 km^3). The uplift of Lunae Planum, if volatile-rich, may have also produced a large, regional hydrostatic head in local aquifers. Crustal adjustments, resulting faulting, and susequent effects on volatile resovoirs may have initiated the formation of Kasei Valles and the eastern Lunae Planum outflow complex.

These results were presented at the Annual Geological Society of America Conference in Dallas, Texas, Oct. 29-Nov. 1, 1990 and the 22nd Lunar and Planetary Science Conference in Houston, Texas, March 18-22, 1991. Supported by NASA Grant NAGW-1780.

References: [1] Banerdt, W.B. et al., J. Geophys. Res., 87, 9723-9733, 1982. [2] Sleep, N.H. and R.J. Phillips, J. Geophys. Res., 90, 4469-4489, 1985. [3] Downs, G.S. et al., J. Geophys. Res., 87, 9747-9754, 1982. [4] De Hon, R.A., Lunar Planet. Sci., XVIII, 227-228, 1987. [5] Greeley, R. et al., J. Geophys. Res., 82, 4093-4109, 1977. [6] Hartmann, W.K. et al., In Basaltic Volcanism on the Terrestrial Planets, Pergamon, New York, 1981. [7] Watters, T.R., J. Geophys. Res., 93, 10,236-10,254, 1988. [8] Watters, T.R., paper submitted to J. Geophys. Res., 1990. [9] Swanson, D.A. et al., Am. J. Sci., 275, 877-905, 1975. [10] Christensen, P.R., Icarus, 56, 496-518, 1983. [11] Wilhelms, D.E. and R.J. Baldwin, Proc. Lunar Planet. Sci., 19th, 355-365, 1989. [12] Plescia, J.B. and M.P. Golombek, Geo. Soc. Am. Bull., 97, 1289-1299, 1986. [13] Zuber, M.T. and L.L. Aist, J. Geophys. Res., 95, 14,215-14,230, 1990. [14] Robinson, M.S. and K.L. Tanaka, Geology, 18, 902-905, 1990.