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MEVTV STUDY: EARLY TECTONIC EVOLUTION OF MARS - CRUSTAL DICHOTOMY TO VALLES MARINERIS; H. V. Frey and R. A. Schultz, Geodynamics Branch, Goddard Space Flight Center, Greenbelt MD 20771

In this study we addressed several fundamental problems in the early impact, tectonic and volcanic evolution of the martian lithosphere: (a) origin and evolution of the fundamental crustal dichotomy, including development of the highland/lowland transition zone; (b) growth and evolution of the Valles Marineris; and (c) nature and role of major resurfacing events in early martian history. Below we briefly summarize our results in these areas.

(a) Origin and Evolution of the Martian Crustal Dichotomy

Both internal and external processes have been invoked to explain this fundamental characteristic of the martian lithosphere. We suggest that major, basin-forming impacts have played a prominent role in the origin and development of the crustal dichotomy (1,2,3). Our study revealed little direct support for the single giant impact hypothesis (4), but did suggest a number of new, previously unrecognized large impacts basins (5). Independent evidence for the Daedalia, Utopia and Elysium Basins has been presented by others (6,7,8). Most of the largest recognized basins are in the northern or western hemispheres; we believe that the overlap of these basins is responsible for the lower topography and prolonged volcanism which characterizes the northern lowland plains, and perhaps also for the growth of major volcano-tectonic complexes such as Elysium and Tharsis (3,9). A speculative model for the evolution of the northern lowlands in the Utopia-Elysium region was developed within this context (9,10). More work needs to be done to refine the inventory of major impact basins for Mars and to relate these basins to the earliest crustal development of the planet. We have found evidence in the cumulative frequency curves as well as in the morphology of the basins for a signficant change in properties at Argyre-sized basins (D~1850 km) and at Chryse size basins (D~3600 km) (5). These changes may be related to lithospheric structure at the time of basin formation or to fundamental differences in the impacting population.

(b) Growth and Evolution of the Valles Marineris

Valles Marineris is a complex system of ancient grabens that were modified by erosion and deposition. Our detailed studies addressed several fundamental issues on trough origin and growth. Relative orientations of Coprates Chasma and wrinkle ridges and grabens located on the adjacent southern plateau suggest that the ridges and grabens grew under multiple stress states and probably predate Coprates Chasma itself (11). New structural mapping of the region (12,13) details the discontinuous distribution and interrelationships of wrinkle ridges, grabens and pit-crater chains around the troughs. Although the trough system is often assumed to have nucleated as small pit-craters, pit-crater chains appear to be distinct structures, not trough precursors (14). Unambiguous evidence for strike-slip faulting was found in Early Hesperian ridged plains materials to the south in Coprates (15,16,17). Detailed mapping of the echelon set of plateau grabens located on Ophir Planum and the adjacent Coprates trough bounding faults is unravelling the sequence of faulting in central Valles Marineris. The curving geometries of grabens in Ophir and trough faults near Melas Chasma indicate that the local stress state was spatially variable, but probably regionally uniform, during early trough growth (18). Our work reveals unexpected complexities in the growth and tectonic development of the Valles Marineris region.

(c) Major Resurfacing Events in Martian History

Resurfacing has been a major process during most of martian history, but detailing the characteristics of major events has been difficult. We have adapted the Neukum and Hiller technique (19) for larger crater diameters in order to study older terrains and the resurfacing which has modified them. We showed that a major resurfacing event within and around the highland/lowland transition zone occured at the time of ridged plains emplacement in Lunae Planum and elsewhere (20). Similar study of the Tempe Terra region in western Mars shows that comparable resurfacing at about the same time occurred there (21) as well as in Xanthe Terra, Lunae Planum and Coprates (22,23). It appears that there was a major, perhaps planet-wide resurfacing on Mars corresponding to the eruption of Lunae Planum Age (LPA) ridged plains. We also find evidence for an older resurfacing event which can be related to intercrater plains development (cratered plateau material) recognized in geologic studies (24). In the Tempe region a common-age resurfacing event younger than LPA affecting the cratered terrain and adjacent plains-forming lowland units appears to correlate with the Vastitas Borealis Formation (21,24). We have also extracted information on the thickness of materials associated with different resurfacing events from the cumulative frequency curves. Thicknesses associated with the major LPA resurfacing vary greatly depending on location: in the Lunae Planum, Tempe and Coprates ridged plains 350-600 m is common (21,23,25) but in the adjacent cratered terrain in Xanthe Terra, Tempe Terra and elsewhere the correpsonding value is less than 100 m. These results can provide an independent stratigraphy based on major resurfacing events correlated at many places around Mars, which can both date the resurfacing events and also locate the depth to older, now buried surfaces.

In a related study (26) we find evidence that what have been mapped as Noachian age ridged plains in Memnonia and Argyre may be Early Hesperian in age. These plains are sufficiently thin that a large number of medium-sized craters show through from an older surface below. This may mean that the eruption of ridged plains was more temporally confined than previously thought, which would have important implications for the thermal history of Mars.

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