VOLCANIC AND TECTONIC EVOLUTION OF MARTIAN IMPACT BASINS R. Wichman and P.H. Schultz, Dept. of Geological Sciences, Brown University, Providence, RI, 02912.

INTRODUCTION: The tectonic and volcanic history of Mars can be separated into an early period of impact basin controlled activity and a late period concentrated in the Tharsis/Elysium region. Previous studies have shown the concentration of early volcanic and tectonic activity along zones of weakness radial and concentric to basin structures (1) and have dated major linear tectonic patterns in the highlands (2). In this study we focus on the timing and sequence of activity about two basins, thereby establishing a progression of basin-controlled modification.

APPROACH: Crater counts made on volcanic plains and constructs peripheral to the Isidis and Hellas basins and associated major graben and scarp/ridge systems are used to date volcanic and tectonic activity. Volcanic features and units have sufficient area for standard crater counting techniques. As linear features, however, tectonic structures prevent the application of areal crater counting methods and a technique (2,3) which derives a relative age from the number of craters superposing a linear feature must be used. The mean crater diameter of the superposed crater population is combined with the feature length to provide a value compatible with areal crater ages. The technique has been tested on surfaces of known age and for features with constrained stratigraphic relations. Provided the craters are much larger than the cross-sectional width of the dated feature, the derived ages correlate well with areal counts.

RESULTS: Figures 1 and 2 present the developed basin volcanic/tectonic sequences and indicate a similar evolution of tectonic and volcanic activity about the Isidis and Hellas basins. After basin formation (and outer scarp development) radial troughs form: the Amenthes Rupes for Isidis and the Hadriaca Patera/Tyrrhena Patera trough for Hellas. These are radially elongate, downdropped sections of the basin massif ring subsequently inundated by plains. Other partly buried radial troughs about both Isidis and Hellas have been identified on the basis of channel mapping.

Concentric systems of arcuate graben up to 1 basin radius from the basin rim are next to form. The graben about Isidis vary from 2-20 km in width and occur to the northwest and east of the basin near the basin rim. The Hellas graben are from 20-80 km wide and occur to the west and northwest with activity apparently moving away from the basin with time. During the last stages of concentric faulting and immediately thereafter, high-standing plains of considerable thickness are formed on the basin rim near the end of a concentric trough set: Syrtis Major Planum, between 2-3 km thick (4,5) and approximately 900 km diameter; and "Malea" Planum, southwest of Hellas about 700 km in diameter (apparently thick but with no reliable depth determinations). Plains volcanism elsewhere in the basin area occurs coincidentally with planum development. Patera construction succeeds the plains volcanism on the basin rim.

The second cycle of volcanism about Hellas develops the intercrater plains to the southwest and coincides with activity about Isidis. Hesperia Planum and Hadriaca Patera (nearly equidistant from Hellas and Isidis) also form at this time. Later low-relief ridges formed across the dated basin features reflect regional stresses deflected but not controlled by basin structures (6). In contrast with lunar basins, planum-concentric ridges do not develop.

DISCUSSION: The derived progression after basin formation is as follows: radial rifting; concentric faulting merging with planum formation on the basin rim; and finally general plains volcanism about the basin region. Volcanic styles apparently evolve over time from widespread plains volcanism to the construction of localized paterae and shields. After the development of Syrtis Major and Hesperia, basin-controlled activity ends.

Radial and concentric faulting about impact basins on the Moon has been modelled in the past. Early radial faulting as a result of stress concentration and isostatic basin uplift (7) is consistent with the observed early radial trough formation. The formation of concentric graben as a result of loading flexure (8) may not be directly applicable. The comparable lunar features are much smaller (< 5 km) and form after initial mare flood basalts which are modelled as the causative load. The martian fractures predate the basin volcanic sequences and their scale would appear unreasonable for a flexural origin. Furthermore, the Moon has no analogue to Syrtis Major and "Malea" Plana, which seem to be associated with the concentric graben. Some process other

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than simple basin loading must be invoked to explain these features.

Syrtis Major Planum and "Malea" Planum represent large amounts of magma apparently released by weaknesses due to the concentric fractures and apparently only occur once in basin history. A mechanism allowing this is the rotation of the planetary lithosphere. Calculations indicate that such a process is possible over a relatively short (200 my) time period. If short-termed basin adjustment after impact results in uplifted mantle material, reorientation would expose crustal rock to enhanced heat flows. Thermal expansion over the plume results in large volumes of partial melt accumulating beneath the basin rim. The consistent pattern of patera formation with declining plains volcanism could reflect the evolution of such a partial melt body.

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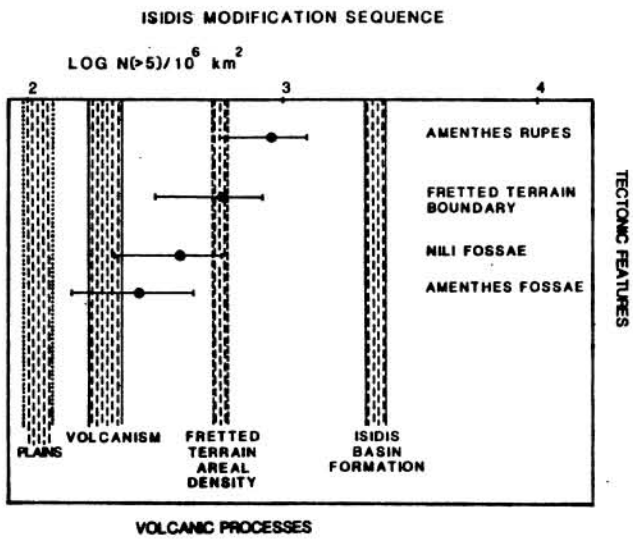

FIGURE 1: A plot of crater-dated tectonic systems and major units around Isidis. Volcanism (vertical hachures) includes Syrtis Major Planum and plains volcanism to the east. The plains unit dates the formation of fractured plains north of the dichotomy. Tectonism (dots with error bars) represents results from linear crater-count approach.

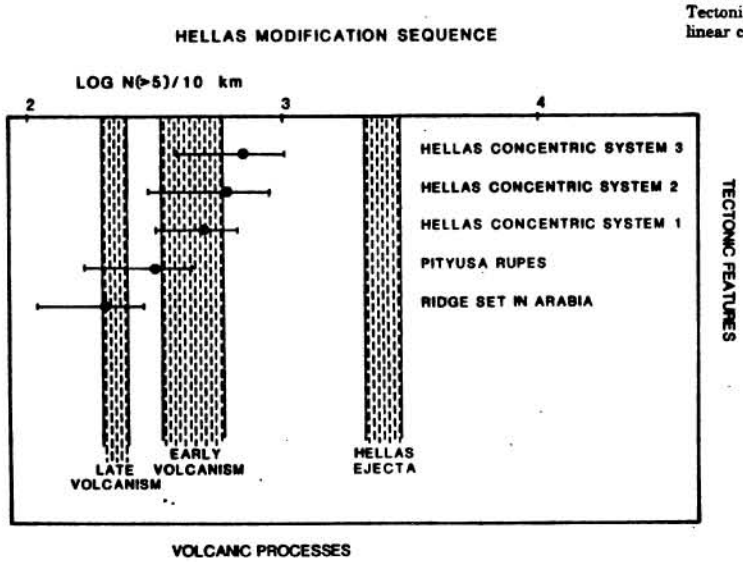

FIGURE 2: Age plot of crater-dated tectonic systems and volcanic episodes around Hellas. Volcanism (vertical hachures) divides into early volcanism in the "Malea" Planum sequence and Tyrrhena Patera construction, and late volcanism in Hesperia Planum, intercrater plains northwest of "Malea" Planum and Hadriaca Patera. Tectonism (dots with error bars) represents results from linear crater-count approach.