GLOBAL LINEATIONS AND REGIONAL STRUCTURAL MAPPING OF IO'S PATERAE AND MOUNTAINS: IMPLICATIONS FOR CRUSTAL STRESSES AND FEATURE EVOLUTION. A. A. Ahern[1], J. Radebaugh[1], E. H. Christiansen[1], R. A. Harris[1], and E. S. Tass[2] [1]Brigham Young University, Department of Geological Sciences, Provo, UT 84602 [2]Brigham Young University, Department of Statistics, Provo, UT 84602, *alexandra.ahern@gmail.com*

Introduction: Io, known for its many volcanic features, also has some of the tallest, steepest mountains in the Solar System [1]. They appear to be tectonic, rather than volcanic, in origin, existing as isolated edifices or complexes [2, 6]. Mountains exhibit a slight anticorrelation with volcanic centers globally, [3], but almost half have an adjacent patera [4]. Formation mechanisms for Io's mountains are many. Some propose that Io's constant and rapid resurfacing adds compressive stress to the crust, causing it to buckle and thrust upward [5, 6]. Others have suggested that the mountains build up as a result of differences in heat flow within the lithosphere, generating compressive stresses at its base [7, 8]. Many other explanations, such as shortening due to tidal massaging [9] and swelling from extension and upwelling [10] have been put forth. Nevertheless, the relative roles of global and regional-scale stresses, the reasons for mountain variabilities, and the relationships of mountains and paterae remain unclear. We attempt to clarify these relations and constrain mountain formation through global spatial statistics and structural mapping of mountain and patera systems on Io.

Spatial Relationships: We identifed a number of structural features and mountain characteristics on Io to better understand variability of and possible relationships between features, such as lineations, areas, orientations, and relative fill (of paterae) by volcanics. These have all been digitized in ArcGIS on the Io Global Color, North Pole, and South Pole Mosaics (~1.3-21 km/pixel) for global continuity.

We divided lineations specifically into structural lineations and patera edge lineations (patera straight margins) and refined and augmented previous datasets [11]. Analysis of our total measurement dataset reveals that structural lineations associated with mountains have a preferred orientation of 45°-135°, whereas patera edge lineations are largely random (Fig. 1). This may suggest that mountain formation is affected by global-scale stresses but that patera structure is not. Instead, early formed, pervasive fractures in the crust may govern patera collapse in most locations, rather than current stress regimes [12]. In some cases, there are significant localized clusters of structural features with relatively uniform orientations, indicating local stress fields or responses may be more important than global stresses. Mountains and paterae are likely to be related since 42% of Io's mountains have adjacent paterae [4, 13].

We conclude that there may be global processes affecting the formation and evolution of Io's mountains. Yet overprinting by local stresses or responses to global stress plays a significant role in orientations and morphologies of individual mountains. In certain regions, crustal composition or buried, pre-existing structures may contribute to the observed variations.

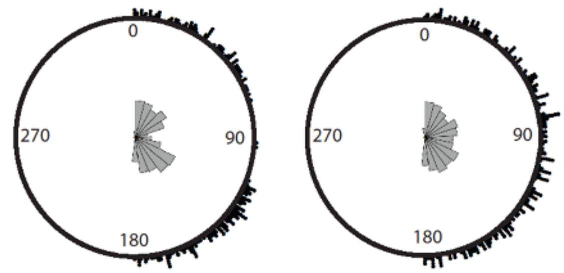

Figure 1: Half-rose diagrams of structural lineations (left; n=353) and patera edge linations (right; n=306) identified and measured in this study. Structural lineations exhibit preference to a 45°-135° orientation, but patera edge lineations do not have a preferred orientation.

Structural Mapping: We have produced structural maps of some mountains imaged at high resolution by *Galileo* and *Voyage*r: Hi'iaka, Shamshu, Tohil, Zal, and Euboea Mon(te)s. These locations were selected based on image resolution, tectonic complexity, and the potential for tectonic and volcanic insights. The base images have been projected orthographically to eliminate distortions. Each map has accompanying cross-sections and tectonic reconstructions. Hi'iaka Montes is discussed here as an example (Fig. 2).

Hi'iaka Montes. Hi'iaka Montes consists of two main mountains—North Hi'iaka Mons (8.8° S, 79° E, 12998 km^2) and South Hi'iaka Mons (1.9° S, 82.3° E, 9370 km^2). High-angle reverse faults on the western and eastern side of the Hi'iaka Montes complex separate a large crustal block containing both mountains from surrounding plains. We interpret this block to be similar to those bounded by high-angle reverse faults in Laramide-type structures of the western U.S., indicating the possibility of a thick-skinned compressional tectonic regime on Io. These same kind of fault-bounded blocks bound Tohil, Shamshu, Euboea, and Zal Montes. The sub-parallel features on the Hi'iaka plateaus were likely createfrom extension above the neutral surface during uplift orcould be small-wavelength folds. Shortening of the crust in this area oblique to bounding reverse faults has produced a dextral strike-slip fault running between the two mountains, breaking apart the larger crustal block.

The northern arm of North Hi'iaka Mons has accommodated oblique strike-slip motion through restraining bends, which have built up the high ridges in the north. However, the southern edge of South Hi'iaka Mons is undergoing extension and collapse through normal faulting. The different responses in the two locations may result from crustal anisotropies or buried subsurface structural boundaries. Transtensional basins opened on the eastern side of North Hi'iaka and the western side of South Hi'iaka, where formation of a patera may have been facilitated by rifting resulting from strike-slip movement. Subsequent shortening has occurred, indicated by arcuate reverse faults that deform deposits in the northeastern basin.

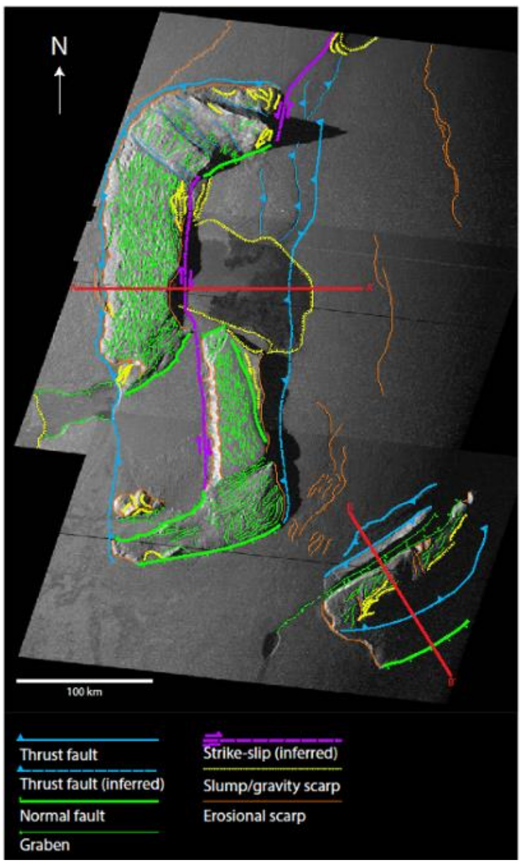

Figure 2: Hi'iaka Region. Reprojected *Galileo* image (~250 m/pixel) of the Hi'iaka Montes complex, overlain by structural interpretations from this study

The Hi'iaka region, along with others analyzed in this study, shows that strike-slip movement is a common process occurring within and along the margins of large crustal blocks that form mountains on Io. Many of the faults in the area are buried by surficial volcanic deposits and are not visible but control how the crust has responded to larger-scale stress inputs.

Discussion and Conclusions: We propose that Io's mountains result from different stress regimes involving global and local-scale processes. Some structures may be new and others reactivated due to volcanic loading [5,6] and tidal flexing [4]. The youngest tectonic features are superimposed over other structures that formed by different stress orientations, which indicates multiple deformational events. Current or recent stress orientations in Io's crust are often oblique to basement faults, generating oblique strike-slip motion and transtensional and transpressional features along these faults.

The model we present accounts for the seemingly random orientations of mountains across the surface of Io, along with the high degree of variability in mountain sizes, shapes, and heights. Much depends on the angle between the current stress and basement faults (Fig. 3). Burial by volcanic materials, as well as gaps in image resolution, prevent structural analysis of large parts of Io, but mountains and paterae provide clues to the greater processes at work modifying Io's surface.

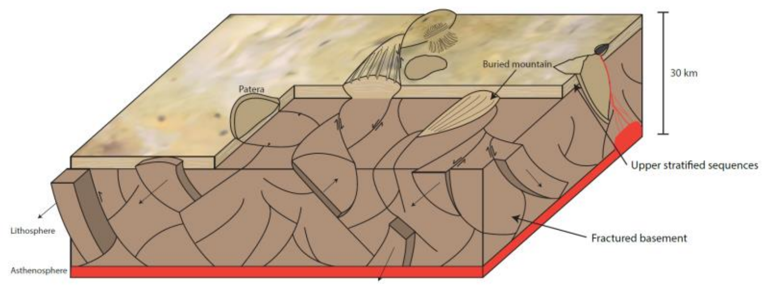

Figure 3: Generalized block diagram of the model presented in this study.

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