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High-Mg region induced stress field in the H-2 quadrangle of Mercury

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Abstract

A structural analysis performed on the Victoria quadrangle (H-2) of Mercury highlights that the geochemical variations of the high-Mg region (HMR) well correspond to a structural dichotomy in this area. The spatial distribution of non-parallel fault systems inside and outside the HMR is caused by a non-isotropic stress field.

1. Introduction

The High-Mg region (HMR) is a large area of Mercury (30-150°W; 25°S-60°N), where the highest Mg/Si ratio is observed (mostly > 0.5) [1], and where crustal densities should be higher with respect to the surrounding areas [2]. The highest Mg/Si ratio and stronger lateral geochemical contrasts with respect to the surrounding terrains are located in the H-2 quadrangle of Mercury (0-90°W; 22.5-65°N). This area also encompasses Carnegie Rupes, Victoria Rupes, Endeavour Rupes and Antoniadi Dorsum, some of the major morpho-structures on the planet. We updated the structural mapping of [3] and exploited the stratigraphic information of the geological map of the H-2 quadrangle [4], and compared it to the existing petrological and geophysical datasets in order to analyze the relationship between faults and the geochemical variations.

2. Data and Methods

We used NASA MESSENGER data to perform geomorphological, structural, and timing analyses of fault systems, in order to correlate fault geometry and kinematics to Mercury's crustal properties. The structural study of the area was done by means of spatial and morphological analysis, rendered in rose-diagrams. The kinematic analysis was performed using the method described in [4] that uses faulted craters as markers to quantify fault slip parameters that were used to assess the finite strain field by applying a stress inversion analysis. Finally, the fault timing analysis was done by means of the buffered crater counting technique.

3. Results

Three non-parallel fault systems occur in the Victoria quadrangle of Mercury. The most prominent system (Victoria System, VS) includes the NNW-SSE trending Victoria Rupes – Endeavour Rupes – Antoniadi Dorsum (VEA) array. West and northwest of the VS, two additional fault systems with NE-SW (Larrocha System, LS) and NW-SE (Carnegie System, CS) trend are found. The timing analysis reveals that the three systems are coeval and were active up to ~3.7 Ga. The kinematic analysis of faulted craters reveals a standard ~30° angle for Carnegie Rupes, but very low angles (~10°) along the VEA array, and the derived stress inversion analysis reveals an ENE-WSW trending regional shortening axis. Results of the stress inversion and age relationships, together with geometrical and morpho-structural observations suggest that the NE-SW and NW-SE systems were respectively right-transcurrent and left-transpressional at the same time when the computed strain field was active. The HMR highlights a geochemical dichotomy that broadly corresponds to the spatial difference in the distribution of VS versus LS structures. Specifically, whereas LS is mostly found within the HMR, VS form the eastern and the northeastern boundary of the region.

4. Discussion and Conclusions

The spatial correlation between the geochemistry and the regional-scale tectonic patterns leads to important insights on the evolution, orientation and kinematics of faults. It is possible that the lateral geomechanical variations of the crust combined with tidal despinning and global contraction processes drove the localization and slip pattern of faults in a kinematically consistent displacement field. Thus, we suggest that the HMR worked as a dense passive “plate”, where global contraction stresses concentrated mostly at its borders. Furthermore, the high-rate magma production inferred for this geochemical region [2] may have controlled the nucleation of low-angle faults due to interstitial gas and fluids overpressure, or because of the strength drop caused by sin-kinematic magma intrusion. The observable structural and compositional relationships evolved in concert, playing a major role in shaping this area of Mercury [Fig. 1]. The faults have followed previous HMR discontinuities and, in turn, may have deformed the HMR itself. In order to verify these relationships elsewhere on the planet, and find out the exact tectonic evolution of this wide region, we will compare the structural asset of other areas that are encompassed within, or at the borders of the HMR.

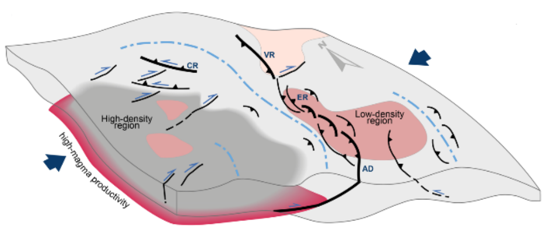

Figure 1: Block-diagram showing the hypothesized stress-field status of the H-2 quadrangle during the Early Calorian, no later than 3.7 Ga.

Acknowledgements

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