WERE MORB-LIKE MARE BASALTS GENERATED IN ABSENCE OF ANY PLATE-TECTONICS LIKE SET UP IN EARLY ARCHAEAN?

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1. INTRODUCTION

Phanerozoic plate tectonics is prime mechanism for the formation of the Archaean crusts on our planet Earth [1-4], the process is presently suggested to be in operation only from the Ordovician onward [5], and the existence of modern plate tectonic set up in the Archaean is now questionable [6, 7]. One of the major problems in proper understanding the mechanism of growth of the terrestrial crusts in the Archaean is perhaps the wide application of geochemical discrimination diagrams in literature, which have their basis on the Phanerozoic tectonic settings [8], although suggestions were there that siliceous liquids of similar compositions could have been generated by diverse magma-tectonic processes [9].

2. WHAT WE DID

We have classified the lunar fractures into two principal types namely cracks emerging from large craters and the cracks on the basaltic floor regions. To evaluate the cause of possible origin of these fractures we did orientation analysis of these fractures and compared those fractures with tectonically originated East African rift system (EARS) and cooling related origin of martian mud crack. We also compared trace element geochemistry of basalts. We modeled the development of fracture system within Rima Hyginus (Fig. 1) in this context.

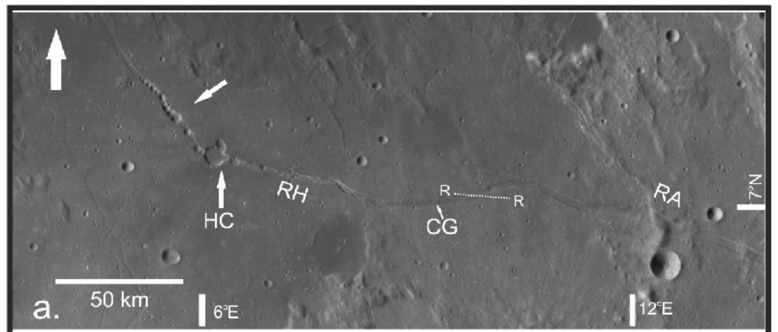

Fig. 1. Rima Hyginus crater and associated area. RH- Rima Hyginus, RA- Rima Ariadeus, HC- Hyginus Crater, CG- Cross Graben, PC- Pit Chains, RR- Reverse Fault.

3. FRACTURE PATTERN ANALYSIS

Within the Kopff crater, the existing fracture patterns show dissimilarity in disposition to the fracture systems encountered in the EARS on the Earth (Fig. 2). The fracture pattern within the Kopff crater (Fig. 2a) is very similar to the fracture rose pattern of desiccation cracks on dry lake beds observed on the Mars (Fig. 2b) [10]. The fracture frequency azimuthal rose diagram for the Kopff crater does not show any preferred fracture density pattern and orientation similar to those in the EARS (Fig. 2c).

SUMMARY

WE DISCUSS THE ABSENCE OF TERRESTRIAL PLATE TECTONISM IN EARLY ARCHAEAN TIME: FROM FRACTURE ANALYSES AND GEOCHEMICAL STUDY OF MARE BASALTS ON THE LUNAR CRUST

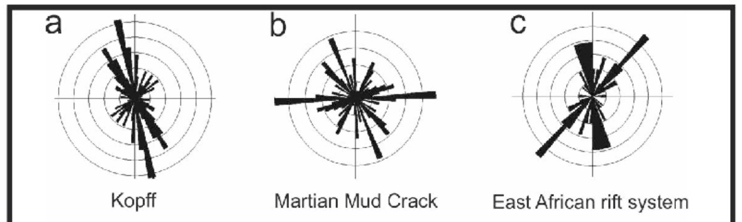

Fig. 2. Frequency-azimuth rose diagram of fracture systematics in (a) Kopff crater (Moon), (b) dessicated mud (on Mars), and (c) East African Rift valley (Earth).

4. RESULTS OBTAINED FROM FRACTURE PATTERN ANALYSES

Fracture systems of the area enclosed by the Rima Hyginus to the west and the Rima Ariadaeus to the east were analysed [11] (Fig. 1). There is ENE-WSW oriented cross graben, detached at its north central region, en-echelon faults (Fig. 3a & 3b) within the southern margin, which has several tectonic horses bounded by faults. Deploying Anderson's hypothesis on fracture formation, we show a sequence of stress regime, which varies in orientation through time as the fractures evolve (Fig. 4). Switching of principal tectonic stress directions with time over a small area (< 50 km²) suggest the absence of any time-consistent large scale tectonic stresses within the lunar crust. The situation is in contrast to the plate-tectonic set up driven by self-regulating internal thermal convection [12] within Earth.

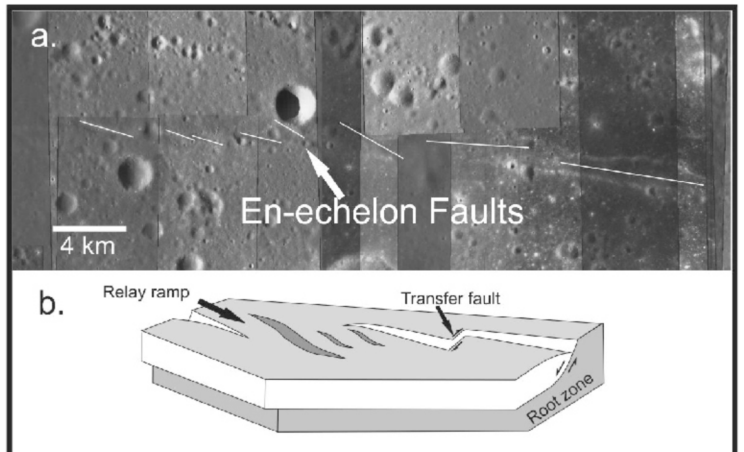

Fig. 3 a) En-echelon faults (Western side of the Hyginus crater). **b)** Schematic diagram of en-echelon faults.

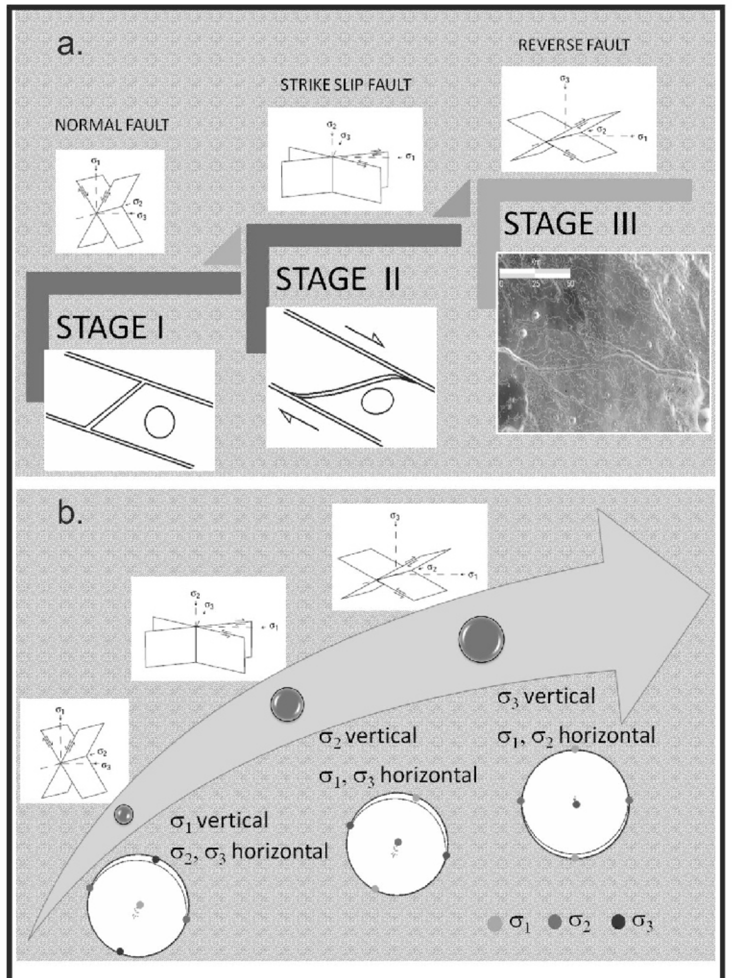

Fig. 4. Model of development of the fracture system within the Rima Hyginus. Changing orientation of the principal stress direction with time.

5.LUNAR BASALT GEOCHEMISTRY

Our synthesis on incompatible trace element geochemistry showed that the L-Ti mare basalts (from Apollo 12 and 15 sites) (Fig. 5) are similar in composition to that of the terrestrial enriched (E)-MORB, whereas H-Ti mare basalts (from Apollo 11 and 17 sites) have chemistry between terrestrial E-MORB and Ocean Island Basalt (OIB), although the H-Ti mare basalt is moderately enriched in Nb and Ta and also significantly enriched in HREEs [13], [14]. We have further re-examined our findings using more sensitive incompatible trace element ratios Nb/Yb versus Th/Yb plot [15](Fig. 6).

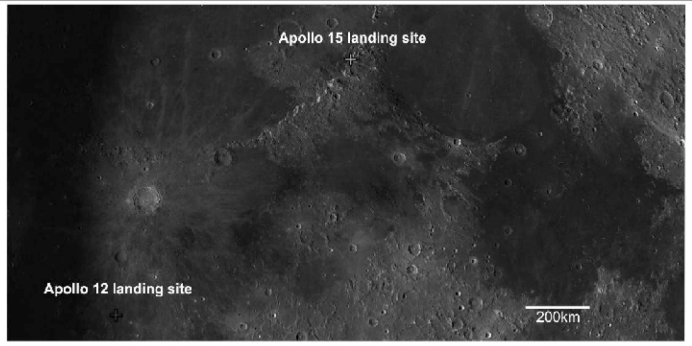

Fig. 5. LRO-WAC mossaic of lunar surface. Apollo landing sites are marked with "+".

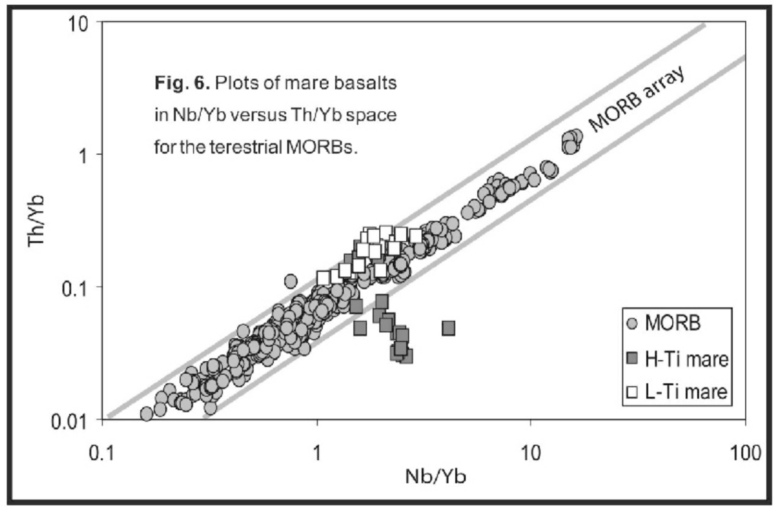

Fig. 6. Plots of mare basalts in Nb/Yb versus Th/Yb space for the terrestrial MORBs.

6. DISCUSSION

Continental scale fractures could be due to the channel ways for the outpouring of lunar basalts [16], are dissimilar to the terrestrial fracture system. These fractures on the lunar crust could have originated by mega-impact [17] followed by out pouring of basaltic magma in the later part of lunar crustal evolution, or desiccation cracks developed on the surface of cooling basaltic melts (Fig. 2). So it can be concluded that the terrestrial MORB-like L-Ti mare basalt [18, 19] could also be generated in the absence of any modern plate tectonic-like set up present on the Earth, although it is believed that the terrestrial MORBs of the Phanerozoic age are generated only in the MOR system [20]. The H-Ti mare basalts are although follow in part the terrestrial MORB trend in figure 4, these basalts have relatively low Th/Yb ratios. These H-Ti basalts also have extremely high Nb/U (> 100) and low Pb/Nb ratios (≥0.02), which are uncommon for the terrestrial analogs [20]. It appears that the source mantle of the H-Ti mare basalts perhaps experienced a previous history of hydrothermal activity that depleted it in Pb, Th and U. Further studies in this regard are in progress.

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