KING'S BOWL, IDAHO – A VOLCANIC ANALOG FOR FISSURE ERUPTIONS, PIT CRATERS AND DIKE INJECTION ALONG RIMA HYGINUS, MOON, AND CYANE FOSSAE, MARS.

Scott S. Hughes[1], Shannon E. Kobs Nawotniak[1], Derek W.G. Sears[2,3], W. Brent Garry[4], Christopher W. Haberle[5], Jacob E. Bleacher[4], Darlene S. S. Lim[2,3], Jennifer L. Heldmann[2], and the FINESSE Team. [1]Dept. of Geosciences, Stop 8072, Idaho State University, Pocatello, ID, 83209, [2]NASA Ames Research Center, Moffett Field, CA, U.S.A., [3]BAER Institute, NASA Ames Research Center, Moffett Field, CA, U.S.A., [4]Planetary Geodynamics Laboratory, Code 698, NASA Goddard Space Flight Center, Greenbelt, MD, 20771, [5]Mars Space Flight Facility, Arizona State University, Tempe, AZ, 85287

Introduction: Terrestrial analogs to lunar linear rilles and martian graben are scarce, yet important to debates on planetary tectonism vs. magmatism. Models proposed for graben formation on the Moon and Mars by dike injection [1,2], are supported by their association with volcanic deposits. Although the relative contributions of regional tectonic stresses vs. magmatic intrusion remain unclear on both planetary bodies, recent models have elucidated magmatic processes related to dike emplacement at Alba Mons [3] and Rima Hyginus [4]. In particular, dike intrusion models of radial graben at Alba Mons, Arsia Mons and Syria Planum [5,6,7] indicate strong association of graben with magmatic processes during growth of Tharsis volcanoes. Chains of pit craters along rift zones can be attributed to gas escape or volcanic explosion during dike injection [4,7,8] although collapse of surface material above a vacated rift system cannot be ruled out.

Terrestrial Analog. King's Bowl (KB) eruptive fissure and lava field (Fig. 1) on the eastern Snake River Plain (ESRP) is recognized as a terrestrial analog for pit-crater collapse and eruptive fissures on the Moon and Mars [9,10,11], and constructs from explosive release of volatiles (volcanic or impact processes) on the Moon, Mars and near-Earth asteroids. KB also provides insight into the formation of pitted terrains on Mars and on some asteroids such as Vesta. The site is one of the primary targets of the SSERVI team FINESSE (Field Investigations to Enable Solar System Science and Exploration) team. It serves as a unique analog to certain volcanic graben, especially those at Cyane Fossae (Fig. 2) and Hyginus Rille (Fig. 3) that have fissure-like qualities: narrow rifts, collapse pits and location in lava fields of similar age. We suggest that KB, the incipient stage growth of monogenetic low shields on the ESRP [10—13], is an essential analog to plains-style volcanism on planetary bodies.

King's Bowl is an "aborted" eruption of no more than ~0.02 km^3 of lava (~3 km^2 area) dated at 2,220 ± 100 B.P that was cut short in early stages of shield growth [10-12]. Ongoing field work at KB includes differential GPS surveys (pit craters, lava lake, and pyroclastic ejecta), sample collection, documentation of size, density, and location of blocks ejected from the central pit, and investigation of outcrops to assess details of the geologic history.

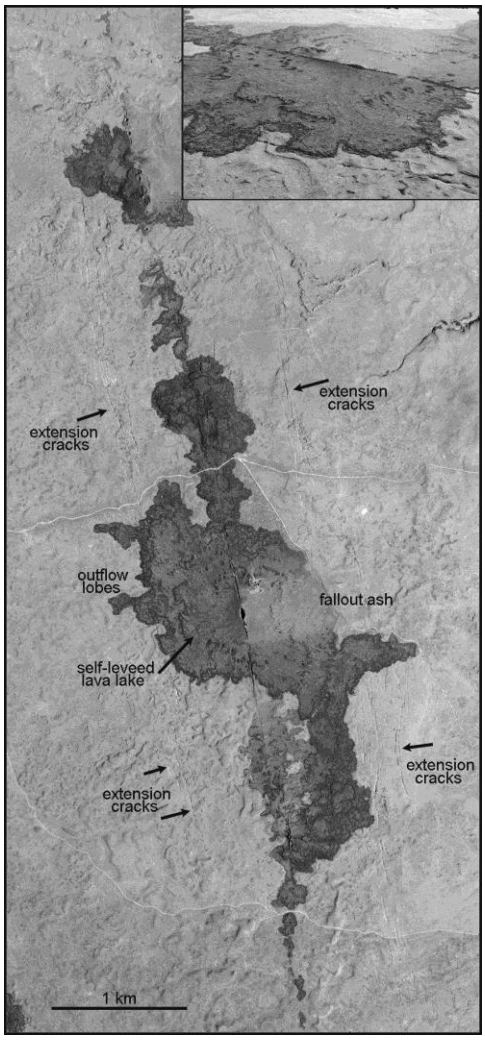

Fig. 1. Composite georeferenced orthoimage and aerial image (inset) of KB field with en echelon eruptive fissures, crustal extension cracks, lava lake, several explosion pit craters including King's Bowl (central pit) and downwind ash deposits.

Kings Bowl erupted along a ~7 km long series of en echelon fissures forming spatter ramparts and cones. Dike injection caused extension cracks on either side of the fissure system. Lava filled low-lying areas to create a small lava lake, which began to drain back into the fissures when magma supply was cut off. Lava drain-back resulted in fissure collapse, phreatic explosions and pit formation.

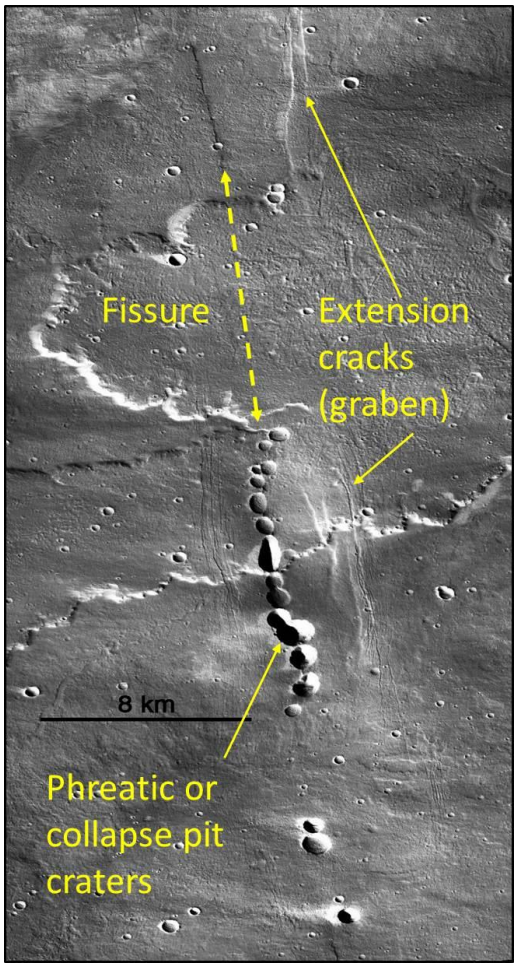

Fig. 2. Aligned pits and linear structures (dike related) in the Cyane Fossae region of Mars located at 35.52° Lat., 240.06° Lon. MRO CTX Image: P06 003515 2155 XI 35N120W [NASA/JPL/MSSS].

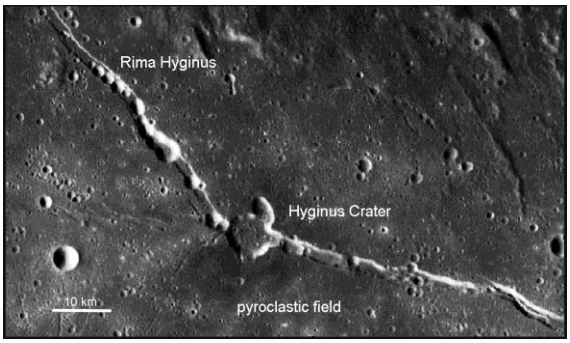

Fig. 3. LROC image of Hyginus Crater (7.8°N, 6.3°E) and Rima Hyginus [NASA/GSFC/ASU]. This linear rille with aligned pit craters and main crater surrounded by pyroclastic deposits likely portrays a dike intrusion that failed to reach the surface [4].

Discussion. Quantitative analysis of KB pit ejecta indicates that the largest phreatic explosion released $6.8x10^{10}$ to $3.0x10^{11}$ J equivalent to vaporizing 30-130k liters of water and expelled ~$6.1x10^{7}$ kg rock mass. This study suggests similarities to impact crater ejecta on Earth and other planetary bodies and a similarity of pit formation whether derived by impact or phreatic explosion processes [14,15].

Our current investigation provides additional details of processes in four stages of development: (1) Pressurized magma locally extended the crust by ~10m due to dike injection [9,16], which is the dominant cause of graben and pit crater formation in rift systems [17,18]. A self-leveed lava lake, fed by an ~2m wide eruptive fissure, filled a shallow topographic depression to ~10 m thickness; lava that breached the lake levees formed outflow lobes in some areas. (2) Magma supply was cut off; lava began to drain back causing the lake to subside into the open ~2m wide linear void; lateral support was reduced significantly causing breakup and collapse of fissure walls. (3) As groundwater poured into the open fissure, phreatic explosions ejected blocks up to ~2m diameter (many penetrated the lava lake surface); multiple open pits were vacated by phreatic explosions. (4) Lava lake continued to drain leaving lava mounds that mark the high stand and a surface strewn with ejected blocks.

Potential sequence at Cyane Fossae: Based on morphological similarities between KB and CF, we propose that CF was formed as a result of dike intrusion into the shallow crust. Surficial stretching associated with the dike injection resulted in graben formation symmetric around the dike. While lava did not erupt effusively from the dike, shallow fuel-coolant-interaction with volatiles resulted in a series of blast pits. Similarly, Hyginus exhibits pyroclastic deposits and possible young lavas on the floor of the main crater, consistent with the dike injection model [4].

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