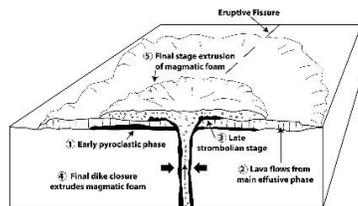


**LUNAR IRREGULAR MARE PATCH (IMP) SUB-TYPES: LINKING THEIR ORIGIN THROUGH HYBRID RELATIONSHIPS DISPLAYED AT CAUCHY 5 SMALL SHIELD VOLCANO.** L. Qiao<sup>1,2</sup>, J. W. Head<sup>2</sup>, L. Wilson<sup>3</sup> and Z. Ling<sup>1</sup>, <sup>1</sup>Inst. Space Sci., Shandong Univ., Weihai, 264209, China, <sup>2</sup>Dep. Earth, Env. & Planet. Sci., Brown Univ., Providence, RI, 02912, USA, <sup>3</sup>Lancaster Env. Centre, Lancaster Univ., Lancaster LA1 4YQ, UK (LeQiao.GEO@Gmail.com).

**Introduction:** The distinctive Ina structure is composed of unusual bulbous-shaped mounds surrounded by hummocky and blocky floor units [1]. Recent observations have identified 70 small similar features, termed Irregular Mare Patches (IMPs) [2,3]. These IMPs can be subdivided into two categories. (1) A small number of larger features (3-5 km in size) related to pit craters/vents. They often have mounds which are large enough to be dated using impact populations. Braden et al. found all of these to be younger than 100 Ma and interpreted them as small basaltic eruptions within the last 100 Ma [3]. (2) A much larger number of “mare-IMPs” dominantly smaller than ~300 m, and distributed in the maria with no clear relation to a pit crater/vent. Whether the two IMP sub-types have similar origins is unknown due to the fact that 1) the morphologies of each sub-type have some similarities, but also some differences, and 2) the smaller mare-IMPs are too small to date confidently.

**Hypotheses for the Origin of Lunar IMPs:** Following the identification of the 70 IMPs and the dating of the three largest ones, different interpretations emerged. Several investigations examined the waning-stages of eruptions in dike-tip pit craters, and the geologic characteristics the large IMPs Ina and Sosigenes, and showed that many IMP characteristics can be explained in this final-stage eruptive context [4-6]. Specifically, the floor hummocky and blocky units are interpreted as the very vesicular and porous lava lake crust, and the convex mounds are extruded magmatic foams; foam physical properties (aerogel-like) inhibit typical impact crater formation and regolith development, creating an artificially young crater retention age. This mechanism is also applicable to waning-stage dike closure associated with mare fissure eruptions (Fig. 1), providing a potential explanation for the many smaller IMPs.



**Fig. 1.** Model for final-stage foam-rich mare basalt extrusions in unconfined fissure mare foam flows [4].

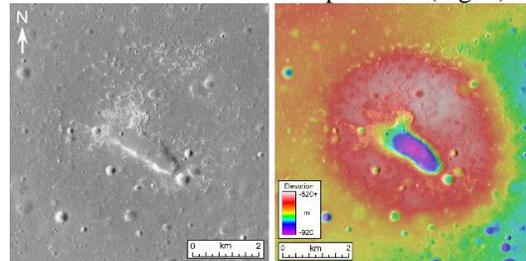
**Cauchy 5 Small Shield Volcano: Linking the Two IMP Sub-Types:** We find that the relationships displayed at the Cauchy 5 small shield volcano summit and flanks may provide a hybrid example of the genetic link

between the two IMP sub-types. The Cauchy 5 small shield volcano (Fig. 2) is a typical lunar small shield volcano (diameter ~5–6 km, height ~40 m) [7]. A major large IMP has been identified at the summit pit crater floor [3] (Fig. 2), which can thus be readily interpreted through the closing-stage eruption model [4-6].

Cauchy 5 also shows many differences. (1) The elongate vent is perturbed to the west and north, suggesting this feature might have been an exit breach for waning-stage summit pit crater lava lake activity. (2) Mound and rough terrains typical of the largest IMPs occur on the NW and north rims, indicating that the waning-stage lava lake and magmatic foams spilled out over the pit crater rim. (3) Many small mare-like IMPs occur on the northern flank and SE rim (Fig. 2); they are very similar to the many mare small IMPs [3].

We interpret the history of the Cauchy 5 shield volcano as follows: 1) The Cauchy 5 small shield was constructed over a linear dike; 2) Magmatic volatiles were concentrated in the dike to produce very vesicular, foamy magmas [4]; 3) Foamy magma was then extruded into the pit crater and built up beneath the lava lake crust [4]; 4) Foamy magma filled the summit pit and overflowed to produce foamy lava flows on the north flanks and SE rim (Fig. 2). These meters-thick foam-rich rim and flank flows formed many small mare-type IMPs; 6) Waning-stage pit crater floor activities formed the largest IMP on the floor. All of these activities took place more than 3 Ga ago.

The Cauchy 5 small shield volcano thus provides a hybrid example which links the small and large IMP types. We interpret the mare-type small IMPs on the rim and flanks to be very analogous to the mare-type magmatic foam extrusions inferred to occur in the closing-stages of mare fissure eruptions where the waning stage foams are not contained within a pit crater (Fig. 1)



**Fig. 2.** Image and topography of Cauchy 5 small shield volcano.

**References:** [1] Whitaker (1972) *NASA SP-289*, 25-84. [2] Stooke (2012) *LPSC XLIII*, #1011. [3] Braden et al. (2014) *NGEO* 7, 787. [4] Wilson & Head (2017) *JVGR* 335, 113. [5] Qiao et al. (2017) *Geology* 45, 455. [6] Qiao et al. (2017) *MAPS*, doi:10.1111/maps.13003. [7] Head & Gifford (1980) *Moon & Planets* 22, 235.