**TOPOGRAPHIC FINGERPRINT OF ERUPTION ENVIRONMENT: EVIDENCE FROM REYKJANES PENINSULA, ICELAND.** Gro B. M. Pedersen[1,2] and Pablo Grosse[3]. [1]Nordic Volcanological Center, Institute of Earth Sciences, University of Iceland, Sturlugata 7, 101 Reykjavík, Iceland. [2]Department of Earth Sciences, University of Aarhus, Hoeegh-Guldberggade 2, 8000 Aarhus C, Denmark (grobirkefeldt@gmail.com). [3]CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) and Fundación Miguel Lillo, San Miguel de Tucumán, Argentina.

**Introduction:** Morphometric studies of volcanoes based on remote sensing data allows analysis of remote and inaccessible volcanoes and provide important information on the geologic evolution of planets. Therefore, constraining the topographic characteristics of terrestrial volcanoes is an important step for being able to use volcano geomorphometry for comparative planetology, and there is therefore a strong need for further investigations.

Previous studies include [1] who compared morphometric parameters from 655 terrestrial edifices with 20 extra terrestrial volcanoes in order to discuss resemblance and differences with lunar and martian edifices. Likewise, [2] investigated monogenetic cones on Earth, Moon and Mars, [3] compared morphometry of cones and shields on Venus, Mars and Earth, while [4] investigated the similarities between Earth seafloor volcanoes and pancake domes on Venus.

The primary morphometric parameters for these studies have been edifice height, edifice width, crater width and average values for slope [e.g. 1-2;5]. Most studies have been focused on classification of volcano type, while a few investigations have extended the studies to include predictions on viscosity of lavas and flow rate [6] or compare topographic profiles with volcano growth models [7-8].

However, so far no investigations have been carried out in order to resolve the morphometric differences between volcanic edifices erupted subglacially compared to subaerially erupted edifces. Here, we therefore examine topographic fingerprint of basaltic volcanism emplaced subaerially and subglacially. We use standardized morphometric analysis of the volcanic edifices [9] and compare with a geologic map of the area as well as high resolution air photos in order to; (1) Find the most diagnostic morphometric parameters for eruption environment; (2) Resolve volcanic landform elements and (3) evaluate if volcano geomorphometry is applicable for advanced mapping techniques such as object-based image analysis (OBIA).

**Geologic setting:** The study area is the Reykjanes Peninsula, where 33 monogenetic volcanic edifices where choosen (Fig. 1). The Reykjanes Volcanic Belt connects the Reykjanes midoceanic spreading ridge with the Western volcanic zone and consists of four volcanic systems. They display a variety of pristine Quaternary subglacial and subaerial volcanic edifices, which are easily accessible and has been completely mapped at 1:100,000 scale [10]. Moreover, the region is sparsely vegetated and is therefore ideal for planetary analog studies of volcano geomorphometry.

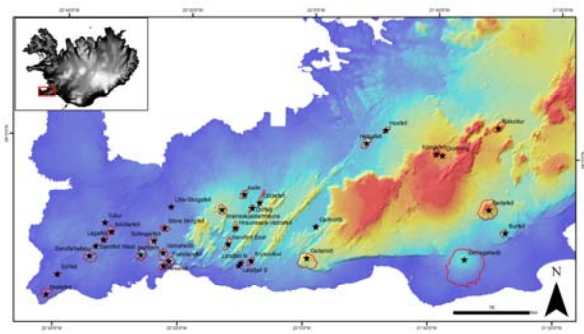

Figure 1. Reykjanes Peninsula. Black stars mark volcanic landforms used in the morphometric analysis and the red lines are the delineated edifice boundaries.

**Data and Methodology:** The geomorphometric analysis is based on the digital elevation model IS 50V (20m/pixel) and is compared to the geologic map by [10] and aerial photographs (15-50cm/pixel). We apply a standardized methodology for morphometric characterization of the volcanic edifices, where the morphometric parameters are acquired through the MORVOLC code [9,11]. The volcanic edifice boundary is defined by concave break of slope at the base of the edifice (Fig. 2, from [11]). It is delineated as a minimum path on a boundary layer (BL) defined as:

$$BL = \text{Profile curvature}_{norm} * f + \text{Slope}_{norm} * (1-f)$$

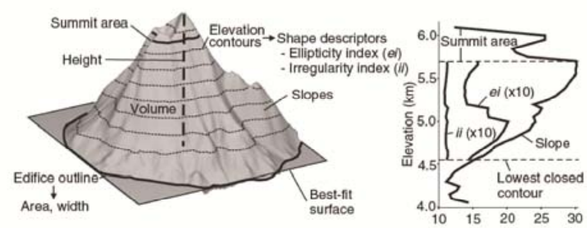


**Figure 2.** Illustration of morphometric parameters calculated by MORVOLC and corresponding diagram for slope and shape developement as a function of height. From [11].

**Results:** Classification based on slope values proves successful in discriminating subaerial edifices from subglacial edifices (Fig. 3). Subaerial shields have average slopes between 2.8°-6.5°, which is at least 6° less than the average slopes of subglacial edifices. Moreover, the shields can be sub-divided into tholeite (2.8-4.6 °) and picrite (5.3-6.5 °) shields based on average slope. Subglacial edifices can be subdivided into 3 groups based on their volume and suggests an evolutionary growth trend starting with small elliptical, linear ridges (~$2*10^{-3}$-$7*10^{-3}$ $km^3$) to flat topped, table-shaped mountains (~$100*10^{-3}$ -$640*10^{-3}$ $km^3$), with an intermediate growth stage (~$10*10^{-3}$ - $80*10^{-3}$ $km^3$) of very variable and irregular complex edifices. Further analysis of topographic profiles, slope frequency and elevational slope development, show that it is possible to resolve individual land elements based on break in slope, such as lava cap, hyaloclastite apron, hyaloclastite slope and hyaloclastite summit. The boundary between hyaloclastite breccia and lava cap represents a passage zone that marks late-stage subaerial lava-fed deltas and is clearly defined by convex breaks in slope.

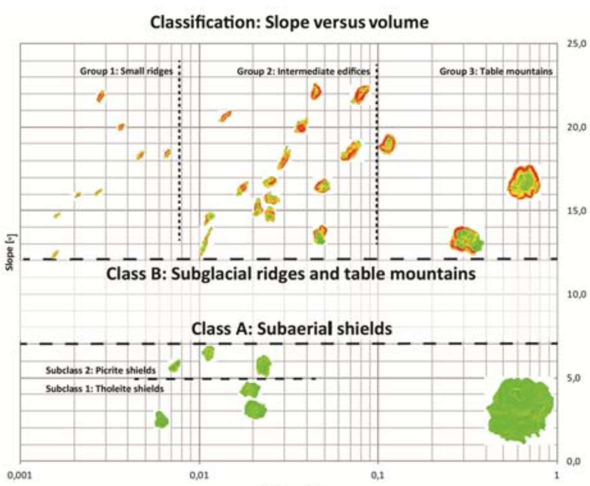


**Figure 3.** The 33 edifices (here represented by a green to red colored slope map ranging from 0 to 30° ) were divided into classes (A1, A2 & B) based on slope. Class A is low sloping edifces (7) and correspond to lava shields. Class B is steep sloping edifces (26) and correspond to subglacial edifices and was subdivided into groups based on size (volume).

**Conclusions:** (1) Slope values are a very strong parameter to differentiate between subaerial and subglacial landforms. Moreover, it can be used to differentiate between tholeite and picrite lava shields. Small subglacial ridges can be distinguisghed from table mountains by size (volume is the best paramter), but it is not possible to distinguish pillow lavas (effusive) from hyaloclastite (explosive). (2) Break in slope allows division of landforms into the following landform elements: (A) Lava cone, lava cap, subglacial aprons (either hyaloclastite or pillor lava) and subglacial flanks (either hyaloclastite or pillor lava). (3) Segmentation for OBIA based on slope maps will provide good edifice delimitation for subglacial edifces. Moreover it seems feasible that landform elements can be resolved. Especially the break between edifice flank and lava cap (allowing automatic identification of transition between purely subglacial eruptions and eruptions with a subaerial phase).

**References:** [1] R. J. Pike (1978) *LPSC IX*, 3239-3273. [2] C.A. Wood (1979) *LPSC X*, 2815-2840. [3] B. E. Kortz and J. W. Head (2001) *LPSC XXXII*, 1422. [4] D. K. Smith (1996) *J. Volcanol. Geotherm. Res.73*, 47-64. [5] J. B. Pleisca (2004) *JGR 109*, E03003, 1-26. [6] P.M. Schenk et al (2004) *Icarus 169*, 98-110. [7] D. Baratoux et al. (2009) *J. Volcanol. Geotherm. Res.185*, 47-68. [8] A. Lacey et al. (1981) *EPSL 54*, 139-143. [9] P. Grosse et al. (2012) *Geomorphology 136*, 114-131. [10] K. Sæmundsson et al. (2010) *Geological map of Southwest Iceland*, ISOR, 1:100.000. [11] P. Grosse et al. (2009) *Geology 37*, E06010, 651-654.