Letters of Intent: EPR
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Emplacement of Submarine Lava Flows and Deducing Eruption Processes at the EPR ISS: A Ridge2000 Post-Doctoral Fellowship

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The objective of the proposed post-doctoral research is to further our understanding of lava emplacement and eruption processes through analyzing the development of submarine lava flow fields – specifically channelized flows. In terms of lava distribution, the basic physical processes governing the emplacement of submarine lava flow fields are similar to those for subaerial flows. My experience and techniques developed during my studies of Venusian, Martian, and terrestrial subaerial lava flows can be directly applied to submarine volcanic terrains. We seek to explore a number of interrelated hypotheses associated with submarine flow fields and their application to understanding submarine eruption dynamics and emplacement processes:

(1) Submarine lava transport should be concentrated toward the interior of flow units because it is more thermally efficient. This should result in channels and jumbled sheets being concentrated toward the interior portions of flow units. Furthermore, these areas should also display increased effects of lava flow inflation and are likely to be sites of extensive collapse where lava has been withdrawn from the interior of the conduit.

(2) Breakouts of lava from within the flows should be spatially associated with changes in slope. The breakout units should typically be thicker, rougher, and have a higher phenocryst content than adjacent flow units.

(3) Remobilized flow units, if present, should be concentrated near areas of inflation.

(4) One difference expected between submarine and subaerial lava flows is in the role of gas. Recent analysis of delicate structures in submarine flows indicates that lava interaction with steam generated at the lava-seawater interface during rapid transport across the seafloor is significant [Perfit et al., 2003, submitted to Nature]. Detailed petrological, morphological, and geochemical investigation of internal structures of sheet and channelized flow surfaces along and across flows, including precise measurements of glassy margins and surface structures, will provide constraints to help test the hypotheses put forth by Perfit et al. [2003].

For my post-doctoral studies in support of Ridge2000 EPR ISS research, I plan to test these hypotheses by utilizing detailed DSL-120A sonar backscatter and 675 kHz scanning sonar bathymetry data, high-resolution visible-wavelength photographs, and samples of EPR lava flows. Maps will be generated for flow fields at several locations based on sonar data and using the photographs as “ground truth”. The first hypothesis, concerning concentration of channelized flow surfaces and jumbled sheets, will be tested by co-registering the sonar and digital photographic data to determine the distribution of various flow facies and structures. The distribution of channels and jumbled sheets (indicative of relatively high flow rates [Gregg and Fink, 1995]), and inflation features (such as lava pillars [Gregg and Chadwick, 1996; Gregg et al., 1996] and tumuli [Walker, 1991; Rossi and Gudmundsson, 1996]) will be evaluated within the context of flow fields using Geographical Information Systems (GIS) spatial analysis, following the methodology of Byrnes and Crown [2001]. Parameters such as temperature, crystal/liquid ratio, viscosity, and effusion rate will be constrained based on previous modeling and observations [Bonatti and Harrison, 1988; Gregg and Fornari, 1998] and analog experiments [Griffiths and Fink, 1992; Gregg and Fink, 1995, 2000], providing further insights into spatial variations in submarine flow field development and how they can help deduce eruptive history. The second hypothesis, concerning lava breakouts, will be tested by comparing the mapped flow units with bathymetry data. Breakouts will be identified as units that are fed from local sources within the flow field and that stratigraphically superpose other local units. Their thickness and surface roughness will be evaluated based on the high-resolution sonar data and photographs. Their distribution will be examined relative to their proximity to inflation features and fine-scale bathymetry-derived slopes using GIS analyses. Petrologic relationships between the lava breakouts and adjacent flow units will be examined by collecting samples during the research cruise to the EPR that is scheduled for December 2003. The third hypothesis, concerning remobilized flow units, will be tested through a GIS analysis of the distribution of remobilized units relative to inflation features. Remobilization will be identified by a jumbled surface texture (based on sonar backscatter) that preserves primary morphologies indicative of having been initially emplaced under a different flow regime (based on photographs that exist and additional ones to be collected during the December 2003 Alvin cruise to the EPR. These types of units have been described by Byrnes and Crown [2001] for subaerial Hawaiian lava flows (cf. Wentworth and Macdonald [1953] and Peterson and Tilling [1980]). The fourth hypothesis concerning the formation of possible vapor related surface features and textures, will be evaluated primarily through analysis of lava flow samples. Glassy margins and drip features will be characterized to compare cooling rates of the outermost glassy crust and the interior glassy skin formed at the steam/lava interface. The concentration of water and seawater solids in the basalt will be geochemically and morphologically (using SEM) compared between the exterior and interior glassy layers in order to assess chemical interactions between the lava and a briny vapor.