

Analysis of Radar Images of the Active Volcanic Zone at Krafla, Iceland: The Effects of Look Azimuth Biasing: J. B. Garvin# and R. S. Williams Jr.*, #NASA/GSFC, Geodynamics Branch, Greenbelt, MD 20771; *Geophysics Division, 927 National Center, USGS, Reston, VA 22092.

The geomorphic expression of Mid-Ocean-Ridge (MOR) volcanism in a subaerial setting occurs uniquely on Earth in Iceland, and the most recent MOR eruptive activity has been concentrated in the Northeastern Volcanic Zone in an area known as *Krafla*. Within the *Krafla* region are many of the key morphologic elements of MOR-related basaltic volcanism, as well as volcanic explosion craters, subglacial lava shields, tectonic fissure swarms known as *gjar*, and basaltic-andesite flows with well-developed ogives (pressure-ridges). Deposits of basaltic tephra and hyaloclastite can also be found, and an incipient collapse caldera (*Krafla* itself) is well-established. The most recent series of eruptions were of the fissure type, with extensive flows of both a'a and pahoehoe covering a 10 km long zone to the east of the Gaesafjoll subglacial lava shield. The diverse range of pristine basaltic volcanic constructs that are manifested in the *Krafla* region has motivated our geomorphic analysis of the area from the perspective of high-resolution, airborne SAR imagery, in comparison with vertical airphotos and orbital panchromatic imagery collected by the SPOT satellite. One of our prime objectives has been to use the synoptic perspective offered by remote sensing imagery of different kinds to evaluate how severely look-azimuth biasing effects recognition of basic structure and geomorphology of an active volcanic zone. For this reason, our collaborators on this project, INTERA Technologies, collected X-band digital SAR imagery at a 15 degree incidence angle (average) and at 8 m per pixel resolution in *three different look directions*: from the *East, West, and South*. Since orbital constraints prevent the Magellan SAR from imaging known venusian volcanic areas of interest (e.g., at *Beta Regio* etc.) at more than one look azimuth, there is a real concern that many diagnostic structures may appear "invisible" in the Magellan imaging dataset (especially those features oriented parallel to the look direction). In fact, our experience with one look direction INTERA SAR imagery of the *Reykjanes* region in southwestern Iceland clearly indicates that major tension fractures that cut many of the recent volcanic features such as the lava shields cannot be observed, in spite of their clear expression in airphotos and orbital SPOT multispectral imagery [Garvin et al., 1989]. Therefore, our objective has been to quantify the degree to which the basic volcanic and structural features can be mapped from directional SAR imagery as a function of the look azimuth. To accomplish this, we have independently mapped the current expression of volcanic and tectonic constructs within the *Krafla* region on the E, W, and N-looking SAR images, as well as from SPOT Panchromatic imagery acquired in 1987. The INTERA SAR images were acquired in October of 1988 and provide imagery for the region that supercedes the most recent airphoto survey conducted by the Landmaelingar Islands Aerial Photographic Service; thus we have no recent maps to compare with except for those which describe the various lava flow emplacement episodes from 1981-1984 in the *Krafla* region. A second phase of this study (to commence shortly) will involve digital co-registration of the 3 INTERA SAR images (designated E, W, and N on the basis of their look direction) to the SPOT Panchromatic image. This analysis will permit an even more quantitative assessment of the degree to which major features can be observed as a function of look azimuth. We believe that our results will have a bearing on the reliable interpretation of Magellan images of volcanic zones on Venus, many of which appear (on the basis of 1 km resolution *Venera* and *Arecibo* images) to be of a basaltic, fissure-fed variety (e.g., the volcanic plains of *Sedna* etc.).

Our initial observations of the E, W, and N images indicates that fresh a'a lava surfaces are extremely radar-bright (rough at 3 cm to meter scales) independent of look direction -- this suggests that these flows do not have strong flow-direction related structures at meter and cm scales, which is consistent with typical Icelandic a'a lava surfaces in general. The November 1981 *Krafla* flow has the most pronounced radar-bright appearance (saturated in the optically correlated INTERA imagery). The structural expression of the incipient *Krafla* caldera cannot be observed in any of the SAR images, independent of look direction. The oriented (mostly N-S) tectonic fissures and cracks (*gjar*) are well-expressed at all three look directions; this result is rather surprising given their strong preferred orientation, but the high spatial resolution and extreme obliquity of the INTERA SAR imagery serves to enhance the expression of these extensional features, even in the N-looking image. The lava shields

(i.e. *Theistareykjabunga*) and the sub-glacial varieties can all be identified at all three look directions as well. The appearance of the *Hverfjall* tephra ring and nearby *Ludent* (both ~ 1 km in diameter craterform structures involving a hydromagmatic eruption phase) are distinctive at each of the three look directions, although the basal surge deposit that lies beyond the rim crest of these depressions is quite variable. Our basic impression from a preliminary analysis of the effects of look azimuth biasing on interpretation of the geology of an active MOR volcanic zone is that up to 30% of the diagnostic features can be missed at any given look direction, but that having two orthogonal look direction images is probably sufficient to prevent gross mis-interpretation. In fact, the strong directional orientation of structural elements within the Krafla region may provide on an end-member test of the effects of azimuth biasing, as older volcanic zones (on Earth and Venus) may have undergone several eruptive phases with different structural fabrics (i.e., not just a single N-S fabric as at Krafla). Our analysis is continuing, and results of our digital co-registration are expected by late 1989, and in time to assist Magellan scientists with image interpretation. {This research was partially supported through NASA Code EEL RTOP 677-43-28 to Garvin and Williams. We gratefully acknowledge the cooperation and support of INTERA Technologies, and Garth Lawrence; we are also grateful for the permission to work in Iceland granted us by the Iceland National Research Council.}

REFERENCES:

Garvin J. B. , R. S. Williams, and J. Jónsson (1989) *Geologic Remote Sensing of Iceland: An Imaging Radar and Laser Altimeter Approach to Problems in Planetary Volcanology*, *in press* in Proc. of 28th International Geological Congress, July, 1989, Washington, DC, 6 pp.