VOLCANIC SYSTEMS AND SEGMENTATION OF THE PLATE BOUNDARY IN SW-ICELAND.

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The Mid Atlantic plate boundary breaks up into a complex series of rift- and transform zones as it passes the Iceland hotspot. In this presentation we define the segmentation of the plate boundary in SW-Iceland and the southwest insular shelf and describe the active volcanic systems, their petrochemistry and their connection to the structural elements of the zones. The Holocene volcanic eruption sites in Iceland have been grouped into volcanic systems, units that often possess common structural and petrochemical characteristics. Volcanic production is generally highest in the central region of each system and many of them have developed a central volcano with the associated production of intermediate and acid rocks. High-temperature hydrothermal activity is often connected to the central part of each system. The plate boundary in southwest Iceland and the southwest insular shelf divides into four segments of similar length, each of which has relatively homogeneous characteristics. These are the Northern Reykjanes Ridge, the Reykjanes Peninsula, the Langjökull Volcanic Rift Zone and the South Iceland Seismic Zone. What is labeled as the Western Volcanic Zone in this presentation comprises the Reykjanes Peninsula and the Langjökull Volcanic Rift Zone. The South Iceland Seismic Zone connects the Western and Eastern Volcanic Zones.

The crest of the Northern Reykjanes Ridge (62.90°-63.80°N) has an axis that is about 65 degrees oblique to the spreading direction. It is a narrow belt of low elongated en echelon ridges, superimposed on an elevated shelf. Rock dredges (altogether 45) indicate that the ridges are primarily made up of basaltic hyaloclastites, basalt pillow lavas are found at >250 m depth. The ridges are thought to be constructional in nature and possibly all represent postglacial submarine volcanism. If so, productivity has been similar in all the ridges and the ridges are comparable in lateral extent to the volcanic systems on the Reykjanes Peninsula. The elevated central part of the ridges is probably analogous to the elevated central portion of the volcanic systems on the Reykjanes Peninsula. The ridges are in many cases flanked by depressions but their connection to the volcanism can not be elaborated because of insufficient data. Ten submarine eruptions are known to have occurred on the crest of the Northern Reykjanes Ridge during historical times (1100 years) and two active high-temperature hydrothermal areas have been identified. We concur with previous suggestions that Recent volcanism on the Northern Reykjanes Ridge is restricted to eight submarine volcanic systems.

The Reykjanes Peninsula (63.80˚-64.19˚N) forms the transition between the Reykjanes Ridge and the volcanic zones of Iceland. It has an axis that is about 30˚ oblique to the spreading direction. Volcanism has been vigorous during Postglacial time and is characterized by small eruptions and low topographical relief. The eruption sites group into five volcanic systems which are arranged in an en echelon fashion within the volcanic zone. Only basaltic rocks appear to have been extruded during Postglacial time and the productivity of rocks has been similar in all the systems, at 0.1 km^3/km^2. The westernmost system, the Reykjanes system, is partly submarine and is not clearly separated from the next system to the east. The volcanic system Hengill, at the junction of the Reykjanes Peninsula, the Langjökull Volcanic Rift Zone and the South Iceland Seismic Zone, has developed a central volcano during late Pleistocene with small amounts of intermediate to acid volcanism. The small Grimsnes system, to the east of Hengill, could be added as the sixth system of this segment of the Western Volcanic Zone. Fissure swarms or rift zones are connected to all the volcanic systems. These are prominent swarms of rifting structures such as fissures, and normal faults, a few kilometers wide and a few tens of kilometers long, sometimes with the structure of a shallow graben. Five large hydrothermal areas are found on the Reykjanes Peninsula, they are all situated near the central region of the volcanic systems. It is suggested that the intensity of the hydrothermal activity on the Reykjanes Peninsula is connected with the high strike-slip component of rifting.

The Langjökull Volcanic Rift Zone (64.19˚-65.22˚N), has an axis which is 60˚ oblique to the spreading direction. The region is characterized by considerable relief and relatively few large eruptions. Only 32 Postglacial eruptions have been distinguished in this region, all basaltic, as compared to ≥ 180 eruptions on the Reykjanes Peninsula, including Grimsnes. The presence of distinct volcanic systems on basis of Postglacial volcanic activity is more difficult to pinpoint in the Langjökull Volcanic Rift Zone than in the before-mentioned segments of the Mid Atlantic Ridge. This is because of the low intensity of volcanic and intrusive activity. It appears that Recent volcanic activity (and also late-Pleistocene activity) is restricted to three active volcanic systems in the Langjökull Volcanic Rift Zone. The productivity during Postglacial time in the southernmost system is similar as on the Reykjanes Peninsula, but lower in the two northernmost systems. High-temperature hydrothermal activity is associated with two of the volcanic systems, Prestahnúkur and Hveravellir, which also have developed intermediate and acid rocks during Pleistocene time. The region contains several fissure swarms, some of which are connected to the suggested volcanic systems.

The South Iceland Seismic Zone is a nascent transform-type zone connecting the Western and Eastern Volcanic Zones. The zone is nearly parallel to the plate spreading direction and the general sense of motion is left lateral. Most of the larger earthquakes of this branch of the plate boundary occur on N-S striking faults that are arranged side-by-side, transversely to the zone, and are associated with right-lateral faulting. The left-lateral motion is therefore accomodated by right-lateral motion on the faults and slight rotation of the blocks between them. This type of of faulting has been termed “bookshelf faulting”, and may be a characteristic of immature transform plate boundaries. Similar set of bookshelf faults has been identified on the Reykjanes Peninsula, overprinting the tectonic fabric of the volcanic systems there, suggesting an alternating mode of tectonism along this highly oblique plate boundary.

A geochemical survey has recently been completed on the basaltic rocks belonging to the Brunhes magnetic epoch (< 0.78 Ma) in the Northern Reykjanes Ridge and the Western Volcanic Zone. A pronounced discontinuity at the western tip of the Reykjanes Peninsula is indicated by the data set with regard to some of the major and trace elements. The overall major and trace element chemistry of the basaltic rocks of the Reykjanes Peninsula is, however, similar to that of the Langjökull Volcanic Rift Zone. The new geochemical data do not show any systematic variations in chemistry with time in any part of the Western Volcanic Zone or the Northern Reykjanes Ridge. The geochemical data do not indicate that individual volcanic systems, as distinguished by the grouping of eruption sites, can be clearly separated by any major or trace element components, or combinations of these. On the other hand groups of two to four systems can be distinguished from neighboring groups. For example, the four westernmost systems on the Northern Reykjanes Ridge can be separated from the three others to the east on the ridge, and the three westernmost systems on the Reykjanes Peninsula can be separated from the three easternmost systems on that peninsula. The three suggested systems in the Langjökull Volcanic Rift Zone have produced basalts of very similar composition.

Magnetic anomalies at 1 km altitude within the Western Volcanic Zone are typically of the order of 1000 nT in amplitude. With respect to the geological structure of the volcanic zone, the most conspicuous positive anomalies are of two types i) Elongated highs of width around 10 km, sometimes coincident with fissure swarms and ridges of the volcanic systems and showing an en echelon pattern. However, the highs do not always correlate with local topography, and their sources may well reach 2-3 km depth. The zone of magnetic highs is often narrower than the zone of Brunhes epoch surface outcrops, for instance in the Reykjanes Peninsula. ii) Localized highs over volcanic edifices such as lava shields, tuyas and hyaloclastite ridges with pillow-lava cores. The size of the latter anomalies presumably reflects both the amount of normal-polarity crystalline rock present and its magnetization which depends on cooling rate and other factors. Localized anomalies associated with roots of central-volcano complexes are quite common in older regions of Iceland, but few if any anomalies of this type seem to be present in the Western Volcanic Zone.

The Langjökull Volcanic Rift Zone is marked by an elongated Bouguer gravity low of a few mGals while no obvious trends can be connected to the Reykjanes Peninsula. Individual volcanic systems cannot be distinguished in the areas where gravity point spacing is sparse but there are indications in areas of denser data spacing that at least some systems are associated with gravity lows. These lows may be caused by accumulations of hyaloclastites in subglacial eruptions during glacial periods. Localized gravity highs are largely absent; such highs in association with large central volcanoes and calderas are common in other parts of the volcanic zones and older regions in Iceland. This suggests relative scarcity of crustal magma chambers in the Langjökull Volcanic Rift Zone and the Reykjanes Peninsula.