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Suggested O.D.P. drilling dite description - T.F.Z. A contribution for discussion in the proponent group

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SUGGESTED O.D.P. DRILLING SITE DESCRIPTION - T.F.Z.

A CONTRIBUTION FOR DISCUSSION IN THE PROPONENT GROUP.

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1. Main criteria for site selection

The location for the suggested drill-sites described below has been chosen in order to obtain a core that could contribute to ocean history research of the seas north of Iceland. The following conditions make the location suitable:

1. A high sedimentation and subsidence rate.
2. Supposedly relatively fine-grained sedimentation, and regular layering, in spite of considerable tectonic activity.
3. A possibility for sampling a thick sequence with two holes, each about 1 km deep.
4. A good seismic coverage and definition.

2. Geological setting

The Eyjafjarðaráll Graben (E.G.) is a sedimentary basin within the Tjörnes Fracture Zone, characterized by graben-like extension and subsidence (see the map in fig. 1. and the regional context in figure 2.). This feature can be regarded as a part of the wider Flatey Sedimentary Basin. This graben constitutes a part of the rifting and extension within the diffuse T.F.Z., which displaces the axial rift zone of the Kolbeinsey Ridge, some 100 km towards the east to join with the Eastern Volcanic Zone of north-eastern Iceland. Earthquake seismicity indicates two main transform faults. The southern transform fault, the Flatey Transform Fault (or the Húsavík Faults) terminates the Eyjafjarðaráll Graben at the southern end. This strike slip feature joins the graben with the axial rift zone of Iceland. Apparently only a part of the spreading extension of the Kolbeinsey Ridge is transmitted to this fault through the E.G. graben. The northern transform fault is further to the north, and is considered to have been more active in recent times. It joins the southern end of the Kolbeinsey Ridge with the northernmost extension of the volcanic zone.

Seismic line F-6-85 shows the cross section of the Eyjafjarðaráll Graben sedimentary basin. A scematic interpretation is shown in figure 3. Enclosed is a seismic section (Appendix 1), a detailed overlay interpretation (App. 2), a diagram with water depth and potential data along the line (App. 3), and a shot-point map (App. 5) for exact location. The general trend of the E.G. is north-south, but the likely trend of faulting in the area of line F-6-85 is NNE-SSW (see Appendix 1). The extensional normal listric faults are well defined at typically 1 km intervals. Some faults affect the sea-floor and indicate progressively increasing movement down the fault plane to the basement. This shows that the tectonism is still active, and has probably been active during the entire basin history. This tectonic activity and associated subsidence is without doubt the main cause for the accumulation of these exceptionally thick sediments, the thickest yet discovered on the Iceland shelf. In the section of line F-6-85 the maximum thickness of the sediment is 2.5-3.0 km in the center, but diminishes to about 1 km at the ends.

The age of sediments and basement is quite uncertain, as is the case for most of the shelf off N-Iceland. Oldest rocks on shore to the south are about 10 My old, while the Kolbeinsey ridge to the north is just being formed. The age of the basement rocks in the E.G. are probably within this age range. As there are indications that the T.F.Z. became active some 6 My ago, due to a shift of the volcanic zone from a western position to its present position in NE-Iceland, we could postulate that the tectonism is ot this age, and that the basement rocks are of this age or older.

3. The structural interpretation of section F-6-85

The multichannel seismic migrated data are of good quality. Although the seismic "visibility" within the sediments are exceptionally good at this location, there exist some problems in defining the structural model. The pattern of normal listric faulting is quite clear down to a depth of 1.0-1.5 s below sea bottom. A number of reflection horizons can be tracked between fault blocks with varying degree of confidence, but as some 25 faults are found between the two proposed drilling sites, some uncertainty in the stratigraphic connection is unavoidable.

We have attempted to trace 6 horizons (A-F) across the section, especially between the two proposed drill-sites at SP 50 and 715. The preferred interpretation is shown in section in Appendix 4, and Table 1 gives the reflection time and depths at the two sites. The depths quoted here are derived from the velocity analysis (shown as insets in Appendices 6 and 7) and are only approximate.

The greatest discontinuity in the seismic pattern is at the east facing fault (or couple of faults) at location SP 330. The faults east of this location are presently very active, while those to the west are much less so. A possible interpretation would make this fault the uppermost expression of a major east sloping detachment fault plane through the crust, while the eastern faults would be antithetic to this fault (see fig. 3). This would explain why the maximum subsidence is offset to the east of the axis of the fault pattern.

The preferred interpretation (Appendix 2) traces the deepest observed horizon at location SP715 in the center of the basin to a much shallower location at SP50. (An "extreme solution" could join E at SP50 to D at SP 715, but there would still be a great difference in depth at the two locations.) The sequence, E-F found at SP50 at depths 510-1080 m b.s.f., is non-existent or hidden at depth in the deepest basin. Horizon-F is interpreted as the basaltic basement, but it is possible that some more sediments are found below.

At the other end of the scale, horizon A is at 350 m depth at SP715, but only at 50 m at SP50. This demonstrates that the center of deposition has shifted east from the time of sequence F-E. The intermediate sequence, from E to A, is about 2000 m thick at SP715 but corresponds to only 460 m at SP50.

The horizons B, C and D are rather difficult to define in the region of SP50. Horizon B is most likely at 200 m depth, or at most at 250 m. We have then chosen a solution that carries horizon D to a shallow level at 250 m depth. This implies that sequence E-D is of fairly even thickness over whole area, and is in line with the suggestion that the relative increase of subsidence east of fault-330 is a late phase of the basin development, in this case post-D in age. In this solution the sequence D-B is very thin.

An alternative solution, which is quite possible, is to take horizon D further down, which would give a more evenly proportional representation of the sequence E-B at SP50.

The seismic data do not show any indications of extrusive volcanism or intrusions within the graben. It is, however possible that a minor proportion of lava flows in intercalated in the sedimentary column. The strengthening of the reflection from horizon E in the region SP600-700 could for example be due to a lava flow. This scarcity of volcanic eruptive material is very uncharacteristic for a "spreading-axis" in the Iceland region, where lavas usually fill in the axis subsidence troughs.

Table 1. Approximate depths below the sea-floor (and below sea-level in brackets), at the proposed drilling sites. Water depth at SP-715 is 480 m, but 320 m at SP-50.

SITE:	**TFZSB-1 location SP-715**		**TFZSB-2 location SP-50**	
horizon	*twt(s)*	*depth(m)*	*twt(s)*	*depth(m)*
A	1.05	370 (850)	0.50	50 (370)
B	1.52	930 (1410)	20.63	200 (520)
C	1.75	1210 (1690)	/	/
D	1.97	1550 (2030)	0.70	250 (570)
E	2.32	2300 (2780)	0.95	510 (830)
F	/	/	1.32	1080 (1400)

4. Seismic velocity

Seismic refraction using sonobuoys were conducted on line F-1-85. One location in the graben close to our section (F-6-85) gives a simple model of a 1.3 km thick upper layer with velocity of about 2 km/s, and a 2.1 km thick lower sedimentary layer of 3.2 km/s. Basement velocity is 5.3 km/s, presumably basalts. This can be compared with another buoy on the horst to the east of the basin (Grímseyjarsund) where 2.4 km thick sediments are found. The velocity structure is similar, except that the upper low-velocity layer is only 0,2 km thick.

A velocity model of continuously increasing velocity with depth would probably be more accurate, as indicated by the reflection velocity analysis. The refraction result do, however, confirm the main features of the reflection interpretation, and demonstrate that the sedimentation is probably more fine-grained in the basin, as well as more rapid, compared to the structurally higher adjacent locations.

5. Drill-sites

Two drilling sites have been chosen for the purpose of sampling the entire sedimentary sequence with holes not deeper than about 1 km.

Site 1 is located in the center of the graben at SP 715, where the sedimentation is most rapid (App. 1 and 6). The purpose is to sample relatively young but thick sediments (i.e. high resolution). The sediments should also be relatively soft and fine grained at this location, at least the uppermost 500 m. Water depth is 480 m, and sediment thickness approx. 2.5 km. This hole should sample the sequence down through horizon C (1210 m), and eventually through D (1550 m).

The site is located on a 1.5 km wide relatively solid fault block, and near the western fault in order to avoid the westwards dipping fault plane to the east. Although both limiting normal faults are obviously active, the seismic data indicate no significant faulting within the block.

This location is suggested for a pilot hole in 1995, and a deeper penetration at a later date. (The slope of the faults is such that at 1500 m b.s.f.) the offset is also 1.5 km. This means if drill holes exceed 1.5 km, major faults can only be avoided by directional drilling.)

Site 2 is located on the western flank of the basin at **SP** 40 (App. 1 and 7). Water depth is 320 m, and sediment thickness 1080 m. This is the site chosen for sampling the deeper part of the basin stratigraphy. As discussed above, preferred seismic structural interpretation indicates that the lowermost sedimentary section, F-E, is relatively well represented at this site. A less desirable feature is that the sequence E-B is relatively thin, and likely to feature low resolution or hiatuses.

A List of Appendices:

1. A seismic section (half scale) for line F-6-85.
2. An overlay line drawing of section F-6-85, showing structural interpretation.
3. A diagram of water depth and potential data along the line F-6-85.
4. A seismic section of line ICE-C (half scale).
5. A shot point map for F-85 cruise, with annotated shot points and water depth.
6. A segment of seismic section F-6-85 (full scale) at location of drilling **Site 1**. The inset shows velocity-depth from the nearest velocity analysis.
7. A segment of seismic section F-6-85 (full scale) at location of drilling **Site 2**. The insets show velocity-depth from the two nearest velocity analysis locations.

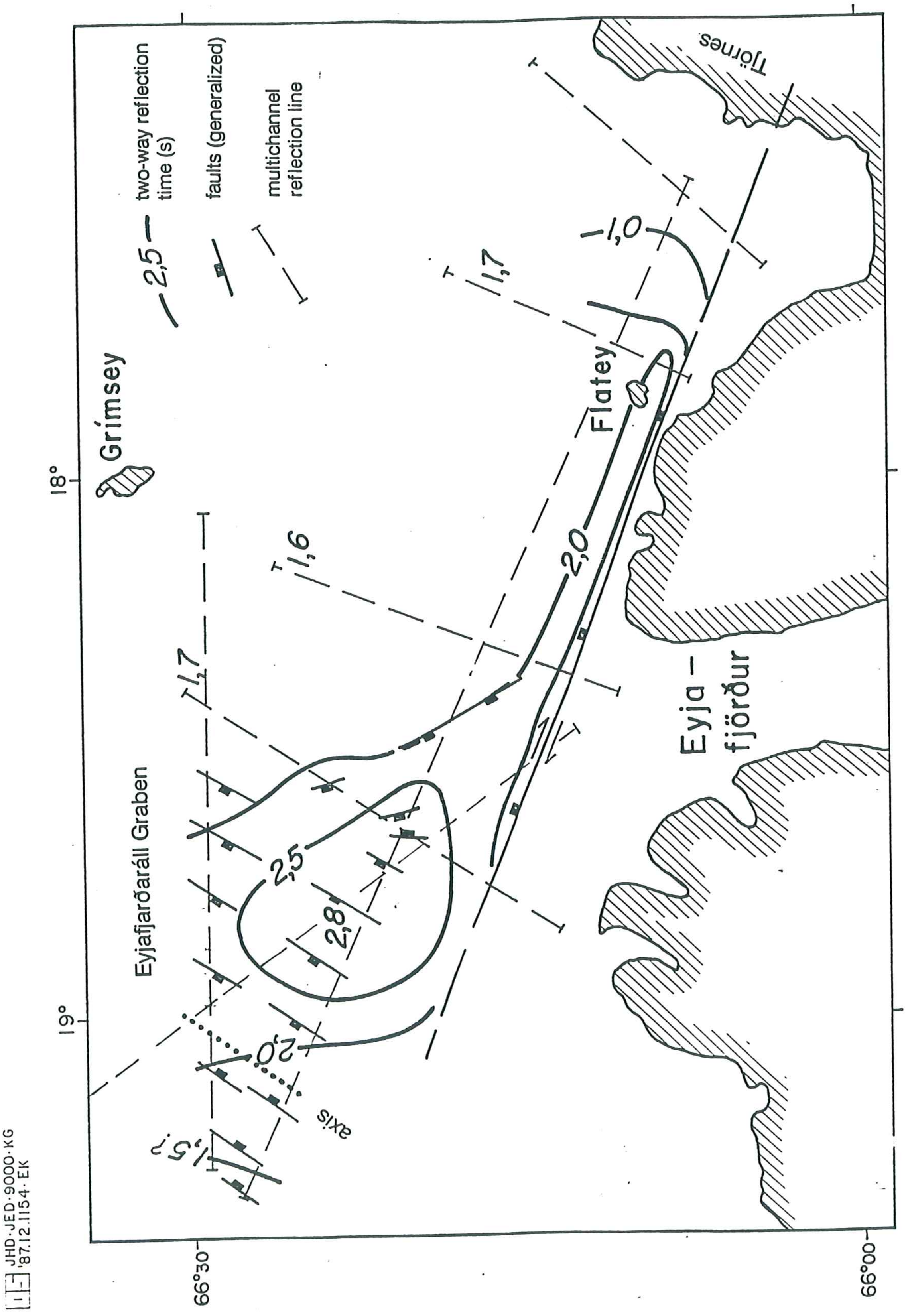

Figure 1. A map of the Tjörnes-Eyjafjarðaráll area: seismic survey line locations, generalized tectonic features interpreted from the seismic data and sedimentary thickness in two-way reflection time.

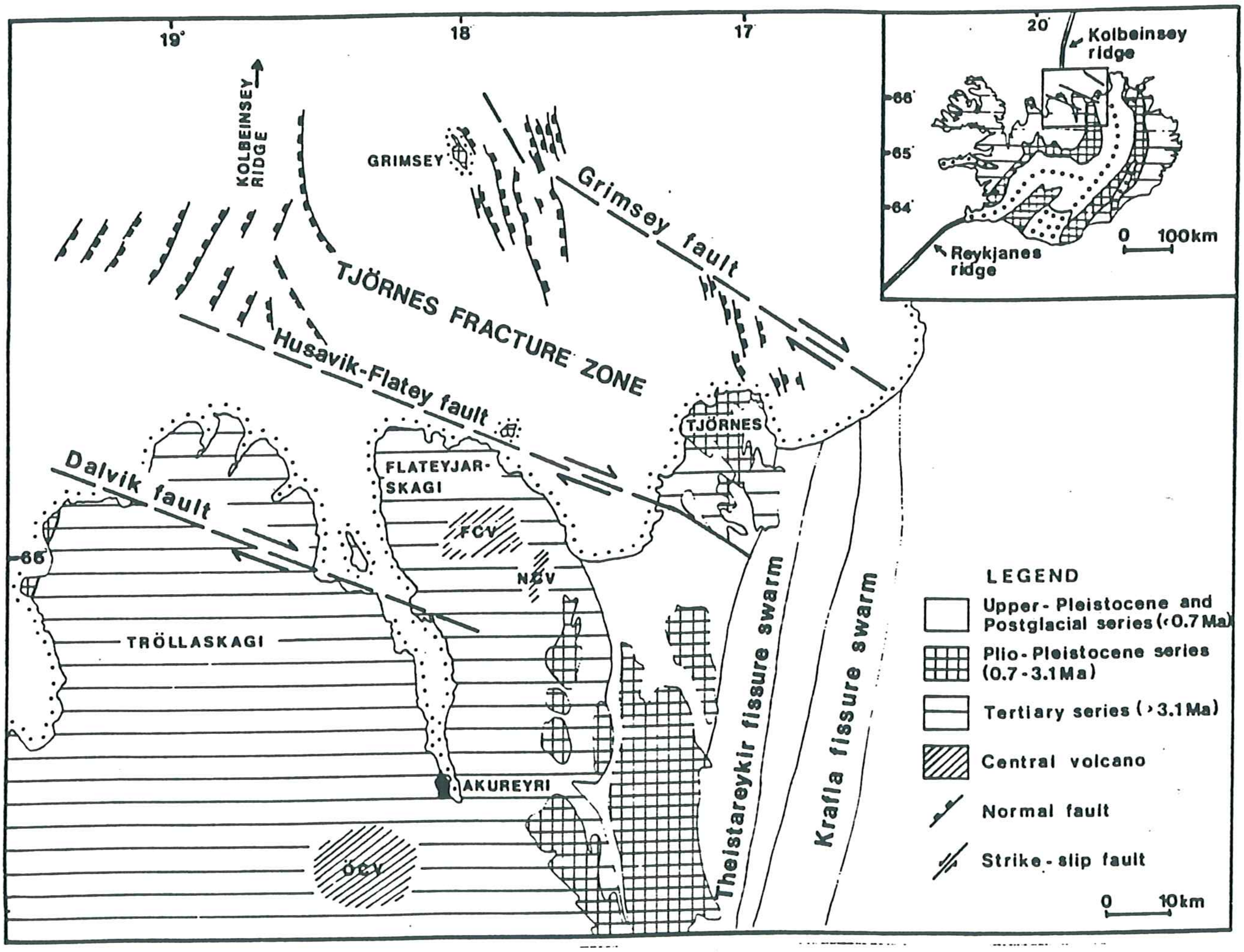

Figure 2. A generalized tectonic map of the Tjörnes Fracture Zone in N-Iceland (in Fjader et al. 1994, modified from Sæmundsson 1974, McMaster et al. 1977, and Flóvenz and Gunnarsson, 1991).

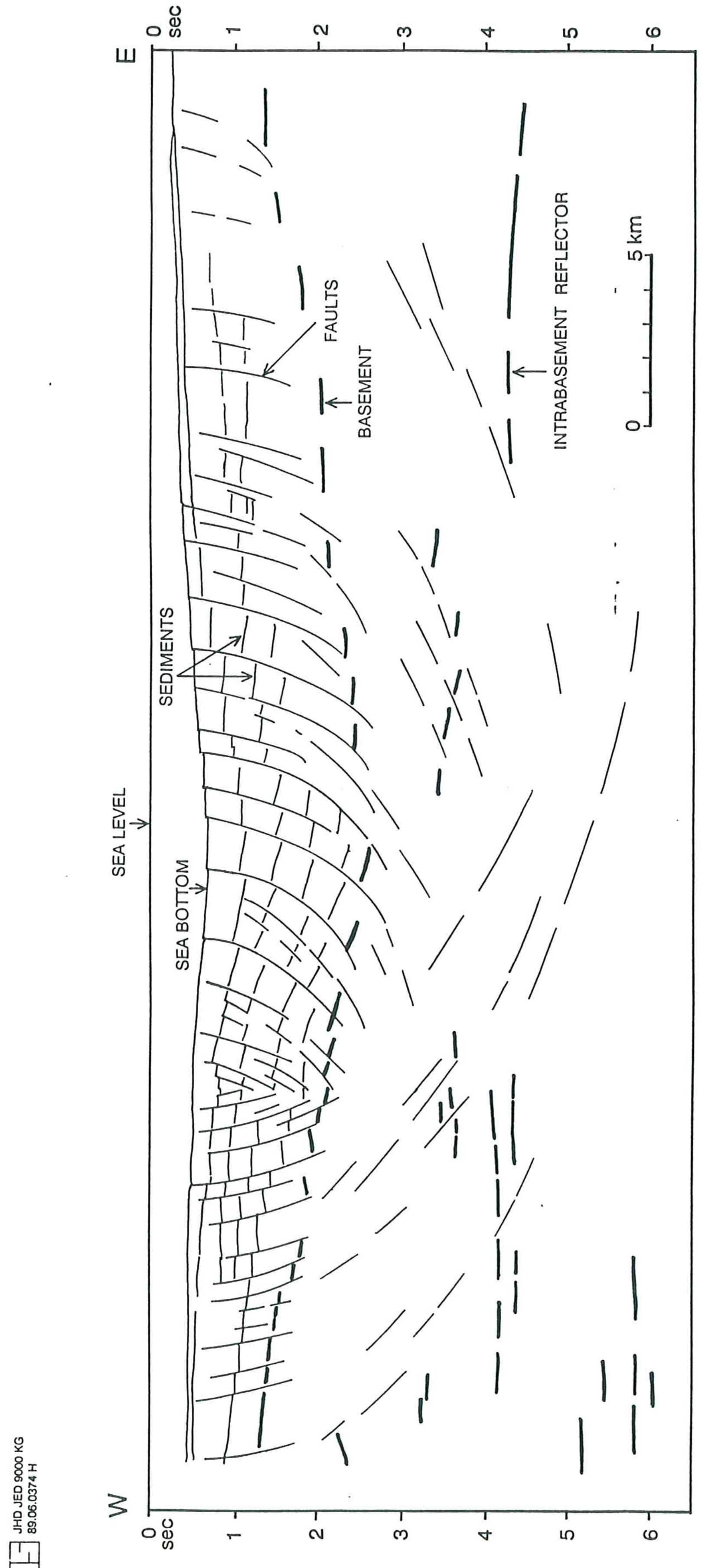

Figure 3. A cross section of the Eyjafjarðaráll Graben; a generalized interpretation of line F-6-85.