

# The Crustal Structure of Eastern Iceland

I. L. Gibson

(Received 1966 March 21)

## *Summary*

A review and reinterpretation of the geological evidence suggests that the vertical thickness of the basalt pile in E. Iceland is between 2 and 4 km, a figure in agreement with geophysical observations.

## 1. Introduction

Studies by Walker (1959, 1960, 1963) have greatly extended our knowledge of Eastern Iceland. More recently these geological observations have been combined with geophysical studies (Bodvarsson & Walker 1964) to give an integrated picture of the crustal structure in Iceland. Unfortunately the agreement between the seismic-gravity model of the structure and the model deduced from the geological observation is far from satisfactory, particularly in Eastern Iceland. The extent of this disagreement has recently been stressed by Einarsson (1965) and can also be judged from the following two extracts:

‘A great thickness—10 km or more, measured at sea level—of Tertiary basalt lavas is exposed in Eastern Iceland’ (Walker 1965). Geophysical observations suggest that ‘layers which can, or are likely to be identified as Tertiary and post-Tertiary lavas appear to form a 2–4 km thick plateau overlying formation D’ (seismic velocity of layer D = 6.5 km/s approximately) (Bodvarsson & Walker 1964).

This short note is an attempt to reconcile these opposing viewpoints.

## 2. Geological observations

A complete review of the geology of Eastern Iceland is not necessary at the present time and the reader is directed to the publications cited above for a full discussion of the geological evidence. However, certain features are of considerable importance in connection with the crustal structure and these are discussed below.

The relationship of the lavas to the feeding dykes is perhaps one of the most important facts governing the structure of Eastern Iceland. Walker (1960) established clearly that the lavas are in general fed by the dykes, that the lavas thin up-dip and that the top of the lava pile lies only some 0.6–1.8 km above present sea level. It was also shown that the belt of active dyke injection had migrated relatively westwards or contracted during the Tertiary. However, during discussion of the crustal structure (Walker 1960, Bodvarsson & Walker 1964), no emphasis was placed on the fact that the dykes are not evenly distributed across the basalt pile but in fact occur in swarms.

This additional evidence clearly indicates that the lavas were erupted preferentially from one particular region for a considerable period of time. After this there was a major change in the pattern of volcanism with eruptions in a new

area further to the west. It seems likely that any relatively protracted period of volcanism from a single dyke swarm would produce a lenticular mass of lavas, the lens being elongate along the axis of the fissure swarm and thinning radially in all directions. Subsidence of the lava pile in the region of the feeding dykes would accentuate this tendency. Migration of the swarm to the west would produce a second basalt lens overlying part of the earlier mass. This relationship is partly produced by the progressive westward tilting of the basalt pile. Further periods of volcanism would produce additional lenses arranged to form a tabular volcanic pile (Fig. 1) resting on a hypothetical basement.

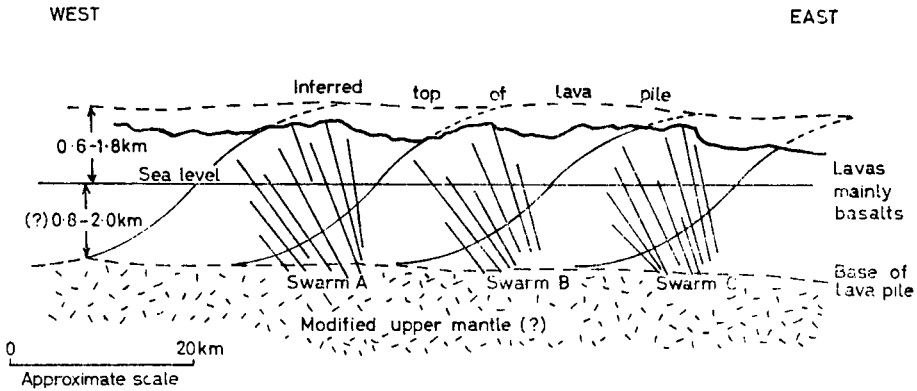


FIG. 1. Simplified diagrammatic cross-section through the lava pile in Eastern Iceland, showing the lenticular units, each the product of repeated eruptions from a dyke swarm. The dip, which actually averages about  $6^\circ$  has been greatly exaggerated.

This structure, first outlined in Gibson (1963), differs significantly from the one proposed by Walker (1960); each stratigraphic unit within the lava pile now thins not only up-dip but also down-dip, in each case away from the feeding dyke swarm. This will produce a definite base to the lava pile directly analogous to the theoretical top of the pile deduced by Walker from studies of the dyke swarm and secondary mineralization. It should be noted that this structure is in every respect compatible with Walker's careful geological observations as long as more than half of the lava pile occurs below sea level. Under these conditions only up-dip thinning will be observed.

The above discussion suggests that down-dip thinning should occur within the deeper parts of the Icelandic basalt pile. In fact thinning of this type was observed by the author during the investigation of the Reydarfjordur volcanic centre in E. Iceland (Gibson, Kinsman & Walker 1966). It appears that here, locally, more than half of some lenticular units are exposed above sea level. Careful stratigraphic studies show that these units thin not only up-dip but also down-dip. Isopachyte maps for two such units (Fig. 2) show clearly their lenticular shape, while studies by Walker on the Reydarfjordur dyke swarm indicate that in both cases the zone of maximum thickness corresponds closely to a region of intense dyke injection.

These at present isolated occurrences of down-dip thinning and the preponderance of up-dip thinning suggest that in general slightly more than half of the lava pile is concealed below sea level. Thus if from 0.6-1.8 km of lava are exposed above sea level (Walker 1964) perhaps some 0.8-2.0 km of lava are hidden. Thus strictly geological considerations suggest that the total vertical thickness of the lava pile varies from 1.4-3.8 km.

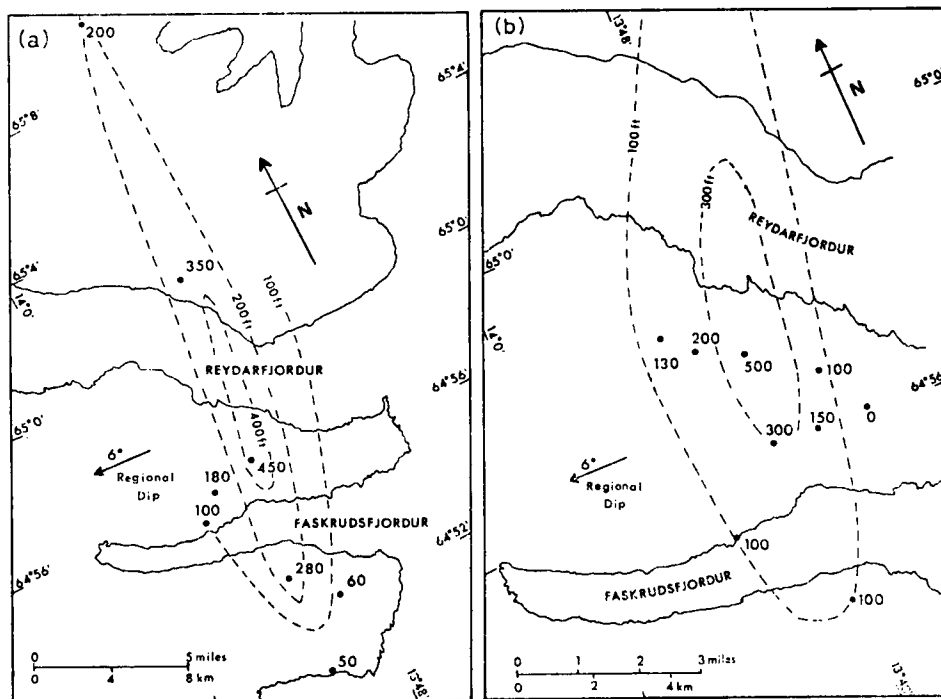


FIG. 2. Isopachyte maps for two stratigraphic units from the Reydarfjorður Acid Succession. Map (a), Unit  $T_1-T_2$ ; Map (b), lens of andesitic lavas from the first phase of volcanism from the Reydarfjorður centre. The measured thicknesses are given in feet. (See Gibson, Kinsman & Walker (1966) for further stratigraphic details). Note that both units are inclined towards the west in conformity with the regional dip, and that each thins both to the east and west, away from the central axis.

### 3. Conclusions

The geophysical estimate of the vertical thickness of basalt lavas in E. Iceland—2 to 4 km (Bodvarsson & Walker 1964)—agrees well with the thickness deduced, at an earlier date, from geological considerations. This suggests that the major seismic discontinuity at about 2 km in Iceland does in fact represent the base of the lava pile. The necessity for suggesting that the lavas continue into the 6 km/s layer is removed and one need no longer call on alteration or significant quantities of intrusive material to increase the  $P$ -velocity in the lavas to this high figure.

### Acknowledgments

The author wishes to acknowledge much helpful discussion with Dr G. P. L. Walker during and after field studies in Eastern Iceland.

*Department of Geology,  
Haile Selassie I University,  
P.O. Box 399,  
Addis Ababa,  
Ethiopia.*

1966 March.

## References

- Bodvarsson, G. & Walker, G. P. L., 1964. *Geophys. J. R. astr. Soc.*, **8**, 285.  
Einarsson, T., 1965. *Geophys. J. R. astr. Soc.*, **10**, 283.  
Gibson, I. L., 1963. Ph.D. thesis, University of London.  
Gibson, I. L., Kinsman, D. J. J. & Walker, G. P. L., 1966. In press.  
Walker, G. P. L., 1959. *Q. Jl geol. Soc. Lond.*, **114**, 367.  
Walker, G. P. L., 1960. *J. Geol.*, **68**, 515.  
Walker, G. P. L., 1963. *Q. Jl geol. Soc. Lond.*, **119**, 29.  
Walker, G. P. L., 1964. *Bull. volcan.*, **27**, 351.  
Walker, G. P. L., 1965. *Phil. Trans. R. Soc., A*, **258**, 199.