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VARIATION IN TITANIA AND ALUMINA CONTENT THROUGH A THREE KILOMETRES THICK BASALTIC LAVA PILE IN THE FAROES

by

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F. CHAYES (1964 and 1965) drew attention to the significance of titania and aluminia in distinguishing between "intraoceanic" and "circumoceanic" basalts. He found that most intraoceanic basalts contain more than 2.0% TiO_2, whereas most circumoceanic basalts contain less than 1.5% TiO_2. »There is overlap, of course, but far less than for any other major constituent« (CHAYES 1965 p. 129).

In a paper in preparation on the geology and petrology of the Faroes, J. RASMUSSEN and myself have presented well over a hundred chemical analyses of basaltic lavas from these islands. It was, therefore, easy to compare the Faroese analyses with the tables and histograms given by CHAYES (1964 p. 1582 and 1965 p. 128 and 130). The North Atlantic province shows rather mixed characters compared with several other basalt regions, a fact which has been noticed by several authors. I have recently expressed the opinion that this may be because there are two volcanic belts of different geological ages in the North Atlantic, which cross one another, and which have perhaps reached different stages in their evolution (NOE-NYGAARD, 1966).

The island group of the Faroes lie on the Wyville-Thompson Ridge belt as a stepping stone between Scotland and Iceland. The Faroese plateau basalts have a total thickness of 3000 metres (NOE-NYGAARD and J. RASMUSSEN, 1957, NOE-NYGAARD, 1962). The lava pile can be divided into three parts: a lower series, consisting of trap-forming, saturated non-porphyritic, iron rich "tholeiitic" lavas, a middle series which is dominated by thinly bedded lavas with plagioclase phenocrysts, also belonging to the tholeiitic suite, and an upper series, again trap-forming, in which basalts with 5–10% modal olivine predominate.

I shall only draw attention here to a few data pertaining to the bulk chemical composition. I have plotted the alumina values of about 115 basalt analyses from the Faroes on a histogram of the type used by CHAYES, and have redrawn his curves with reduced vertical scale to enable direct comparison. Fig. 1. shows the result. The alumina content of the Faroese basalts taken as a whole fits well into CHAYES' group of intraoceanic basalts. I then treated the values for titania in the same way. Fig. 2. Although here again the greater part of the analyses fall, with an indistinct double peak, into the intraoceanic basalt field, there is a clear, single peak outside to the left, which would belong to the circumoceanic group of CHAYES. This puzzled me.

I therefore spilt up the bulk curves into three, each one representing one of the three successive lava series. The result is seen in Fig. 3. If we look at titania, we find that the maximum TiO_2 content of 2.8% is found in the lavas of the lower series, that the lavas of the middle series have an intermediate content of ca. 2.3% TiO_2, and that the lowest value of ca. 1.0% TiO_2 is found in the upper series (the small peak to the right here is due to analyses belonging to a reappearance of a few (six) lava flows which petrographically belong to the middle series). In other words, the basaltic lavas become more »circumoceanic« upwards in the lava pile. If we then turn to alumina, we find the lowest Al_2O_3 value in the lower basalt series, and the highest in the upper series. The alumina content increases upwards, which means again that there is a tendency to become more »circumoceanic« with time.

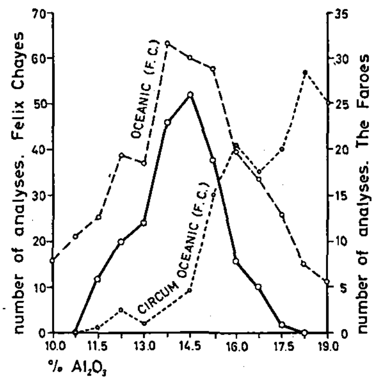

Fig. 1

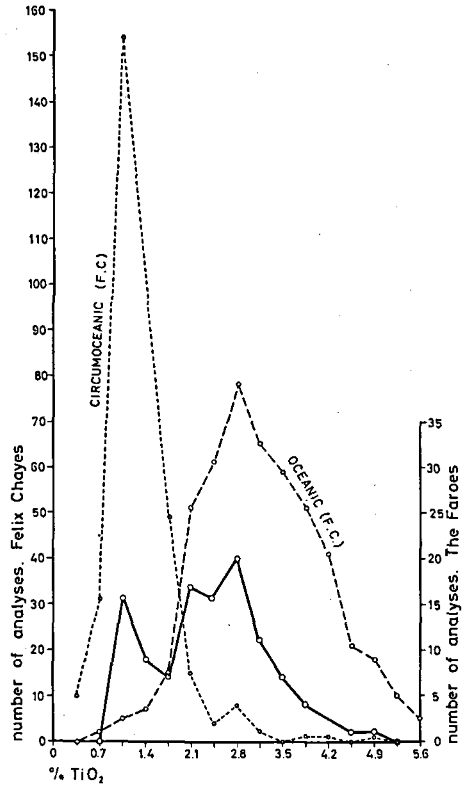

Fig. 2

Full drawn line: Values from the Faroes.

The distinction between intraoceanic and circumoceanic basalts given by CHAYES points in the first instance to variation in composition with geopraphic location while the above data from the Faroes is an example of variation in composition with time.

GREEN and RINGWOOD (1966) have shown in their high pressure experiments, that magma segregation following a high degree of partial melting at 40–60 kms produces olivine tholeiitic magmas, and that if these magmas move rapidly from this depth to shallow levels, at 2–5 kms, and fractionate here, a sequence of early tholeiites will result (GREEN and RINGWOOD, 1966 p. 176). They further argue that in the vaning phase of volcanic activity, in which early-formed magma batches will die out, there may be a cooling in the region of magma segregation, where then an olivine tholeiitic liquid is generated. I shall briefly try to compare this model with the lava sequence of the Faroes.

Saturated, iron-rich tholeiitic basalts with a high titania content were the first to be erupted. They were followed by lavas of related bulk composition, but with a lower content of titania. Titania is present mainly in ilmenite and clinopyroxenes, and the lower titania content may be due to the abundance of plagioclase phenocrysts in the lavas and the consequent reduction in the proportion of the groundmass. I think that these first two stages of volcanic activity in the Faroes were derived from shallow levels.

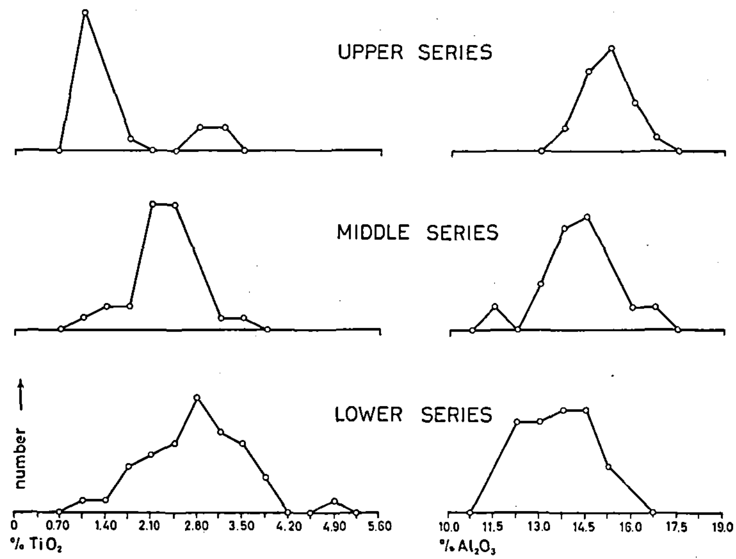

Fig. 3

The olivine basalts of the upper series were the last to be erupted, and their titania content is decidedly lower, i.e., they are »circumoceanic« in the sense of CHAYES. These upper lavas may have been generated as a result of cooling in the region of magma segregation. An evolution along these lines may have more than local interest, since it is not unlike that of the Hawaiian Islands.

What seem to be characteristic of the Faroes on the Wyville-Thompson Ridge belt is that the high titania content is connected with the iron-rich tholeiites of the first stages of volcanic activity. The olivine basalts of the last stage of volcanic activity show a moderate enrichment in alumina and a marked fall in titania.

If the data presented from the Faroes and those given by CHAYES should be explained in one and the same way, I find the following interpretation possible. Oceanic basalts which originate from relatively shallow levels below the oceanic crust have an »oceanic« titania content, whereas those derived from deeper levels have a »circumoceanic«. The deepgoing fractures along the continental margins would precisely favour a magmageneration from deep sources, probably therefore the basalts have also here a low content of titania.

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A TECHNIQUE FOR DEPICTION OF GRIND SECTIONS OF FORAMINIFERA BY AID OF COMPILED ELECTRONMICROGRAPHS

by

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During studies of growth patterns and microstructure of some Lower Tertiary buliminid foraminifera, it became necessary to develop a technique which would allow preparation of overlapping electronmicrographs of replicas of etched sections undisturbed by the bars of the grids.

Inspired by a technique described by KRINSLEY and BÉ (1965) the following technique was developed:

The foraminiferal test is embedded in Lakeside 70 cement and ground to a level a little above the axial plan. The Lakeside is dissolved in alcohol and the test is embedded in Araldit. By aid of a needle the test is placed in the same position in the Araldit as it had in the Lakeside. By this double embedding it is possible to avoid air bubbles in the ground face as the Araldit flows readily into the opened chambers. If Lakeside cement is used for the final embedding the stripping of the replica becomes impossible as the replication material will dissolve the surface of the cement. To obtain the correct depth when grinding, the process is carried out under binocular microscope. Instead of grinding powder small ground glass plates are used. Water is used as lubricant, which makes the ground glass transparent and the grinding can be stopped as soon as the correct level is reached. The section is etched with an aqueous saturated solution of EDTA. Etching intervals of 15–30 seconds are sufficient. Afterwards the section is washed in distilled water and dried. It is replicated with collodium dissolved in amylacetate and the stripped replica is shaded with carbon in a vacuum evaporator.

A hole a little larger than the section is cut in the grid and it is covered with a formvar film. The shaded replica is cut with a scalpel to get a suitable size. It is placed with the shaded side downwards on the formvar film. The collodium is then dissolved in a reflux unit. The central part (where the bars are missing) may stick to the substrate and cause some difficulty when the grid is removed. This can be avoided by placing the grids on nuts.

The replica is photographed in the electron microscope with ca. 25% overlap.

The above described method has also been applied in studies of shell structure in ammonites.

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