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B. UNIVERSITY RESEARCH PROJECTS SPONSORED ENTIRELY OR IN PART BY THE GEOLOGICAL SURVEY: PROGRESS REPORTS FOR 1982/83

GEOLOGY AND GEOCHEMISTRY OF THE BARBY FORMATION, SINCLAIR SEQUENCE

Progress Report for 1982/1983

by

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1. INTRODUCTION AND OBJECTIVE OF STUDY

The Sinclair Sequence is situated in South West Africa approximately 100 km south-west of Maltahöhe. The rocks are dominantly igneous in origin and comprise both extrusive and intrusive varieties. The present study is primarily concerned with the volcanic rocks of the Barby Formation.

The objectives of the study are as follows:

(i) Document and compare rock types in selected traverses through the sequence.
(ii) Establish field relationships in the areas through which traverses have been made by limited mapping.
(iii) Carry out detailed petrographic investigations of all rock types.
(iv) Carry out chemical analyses on whole rocks for the major element oxides SiO_2, $A1_20_3$, FeO/Fe_2O_3, MnO, CaO, Na_2O, K_2O, TiO_2. P_2O_5 and trace elements Rb, Sr, Y, Zr, Nb, Th, U, Pb, Cu, Ni, Zn, V, Cr, Sc, La and Ceo
(v) Carry out electron microprobe analysis on mineral phases on selected samples.
(vi) Determine the geological history of the sequence and the geotectonic setting on the basis of petrogenetic modelling.
(vii) On the basis of the petrogenesis, evaluate the economic potential of the sequence and make recommendations for possible mineral exploration.

2. AREAS OF INVESTIGATION

The area under consideration extends from Welverdiend 140 in the north to Klein Haremub 1 in the south. The detailed investigation will be carried out in the northern area on Vrede 80, Nubib 42 and Welverdiend 140 and will be accompanied by a superficial investigation on Aubures 22, Klein Haremub 1 and Sinclair Mine 2 in the southern area, the latter mainly for comparative purposes as this is the type area of previous work.

3. PREVIOUS WORK

The area in question has been mapped by Watters (1974) and a portion of the northern area has been surveyed by K. Schalk of the Geological Survey, Windhoek. Up to the present time there are only limited geological data available for the rocks in the study area.

4. GEOLOGICAL REPORT

4.1 Geochemistry

Eighty samples were prepared for analysis and analysed for major and trace elements as the first phase of the geochemical investigation. In this report comparisons will largely be made to the work of Watters. Complete suites of samples from the traverses were not analysed as it was felt that an overall assessment of the geochemical variation was desirable in the first phase. The objectives of the first phase of the geochemical investigation were:

(i) Delineation of the expected geochemical range and broad classification of the rock types.
(ii) Comparison of the ranges of chemical compositions and the fields of data with those presented by Watters.
(iii) Assessment of the validity of some important chemical criteria used by Watters in the light of more complete data.
(iv) Identification, on a chemical basis, of spatially distinct areas and provisional relation of these to stratigraphy.
(v) Isolation of problem areas and selection of portions of the sequence which are likely to be most informative in unravelling the geological history of the area.

In this report reference will be made largely to the major element geochemical data as these provide, on first phase approach, most information for the critical selection of specific areas for complete analysis. However, it is clear that the trace elements will ultimately be most useful as petrogenetic indicators and discriminators for distinct spatial and temporal associations.

The major element data presented in Figs. 1-3 exclude all previous analyses. Two symbols are used for the presentation of those data - closed circles are for all samples taken in the northern area on Welverdiend 140 and Nubib 42 (referred to as "northern localities") whereas open circles are for samples from Vrede 80 and Haremub 1 in the southern area (referred to as "southern localities"). It is also of importance to recognize that the NW-SE strike and easterly dip of the succession impose a stratigraphic constraint on the two areas. Rocks of the northern area stratigraphically overlie those of the southern area, there are, however, complications arising from later folding and faulting.

The AFM diagram (Fig. 1) shows important differences when compared with the data presented by Watters (1974).

Two distinct fields are obvious, with basic samples from the northern areas showing strong tholeiitic affini-

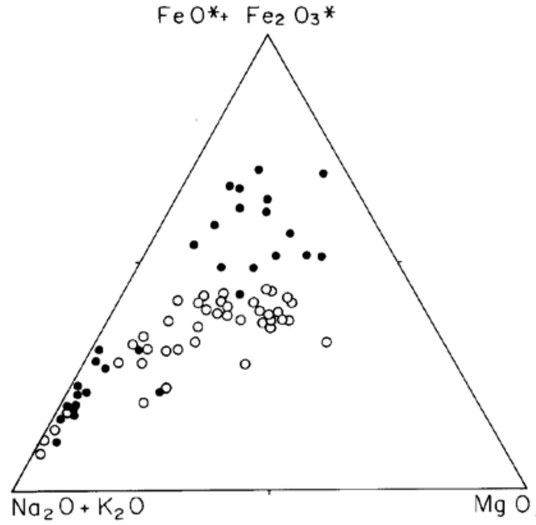

Fig. 1: AFM diagram for analyses of Barby volcanics. Open and closed circles are respectively for samples taken from southern and northern areas.

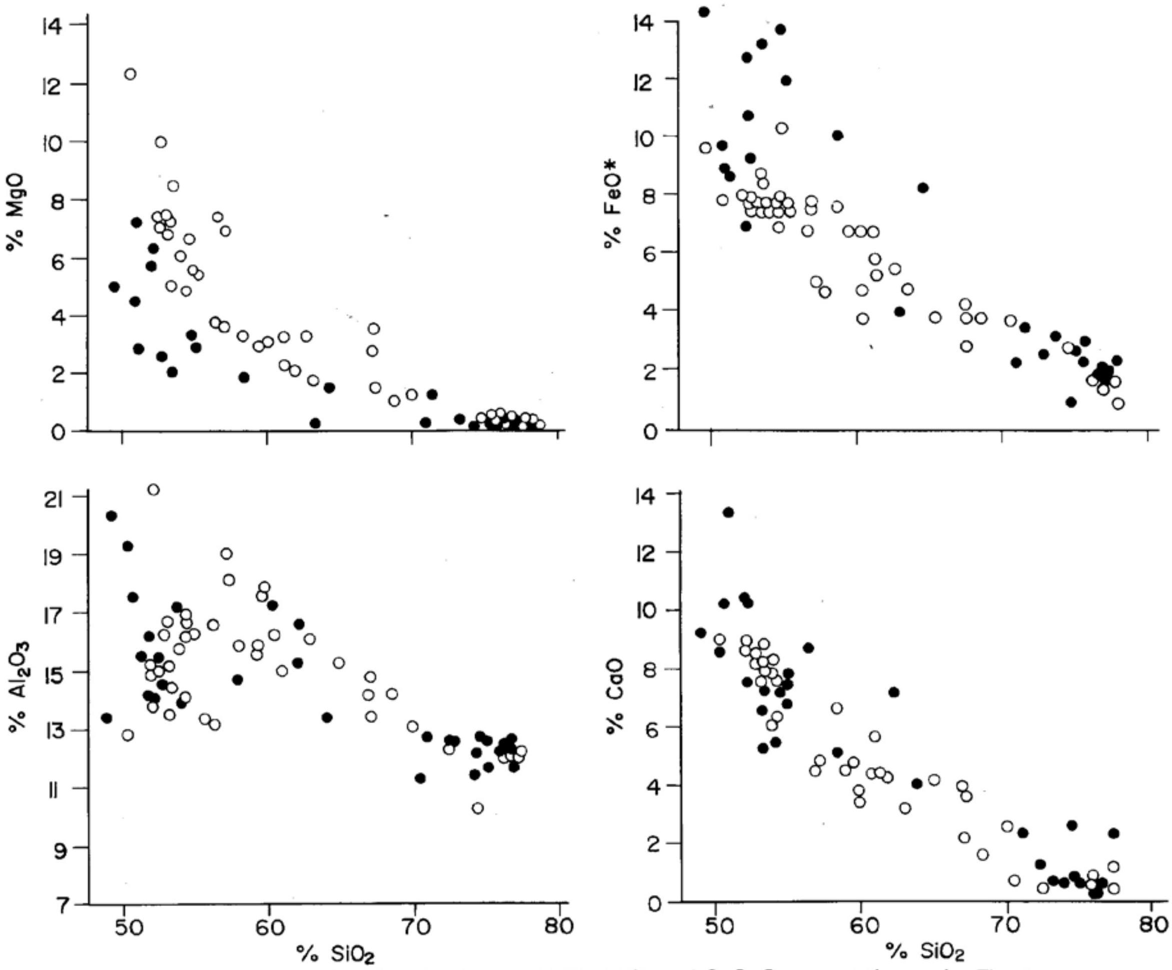

Fig. 2: Silica variation diagrams for MgO, (total Fe as FeO), Al_2O_3 and CaO. Ornamentation as for Fig. 1.

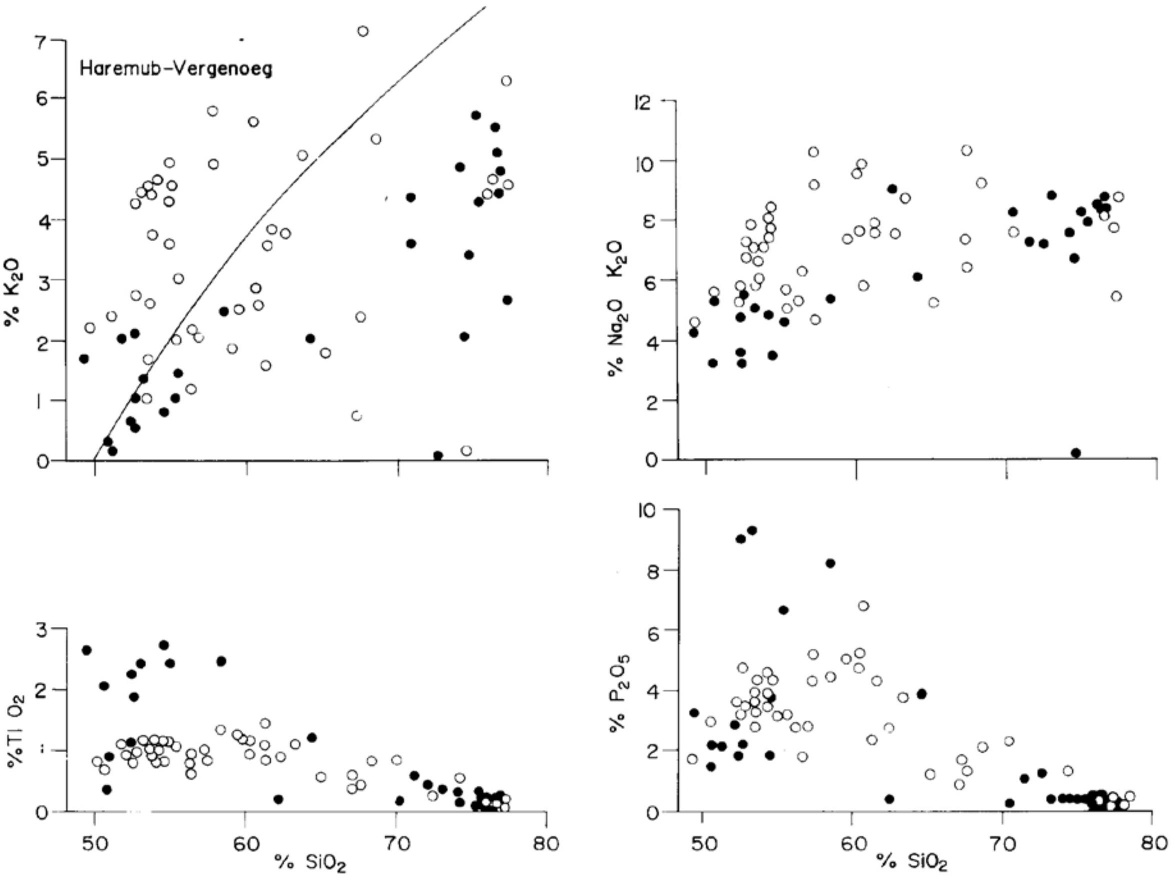

Fig. 3: Silica variation diagrams for the alkalies, TiO_2 and P_2O_5. Ornamentation as for Fig. 1.

ties, whereas those from the southern area are calc-alkaline, on the basis of this diagram. This confirms the two broad groups recognized by Watters on rather sparse data. Rocks from the southern area show a complete range in compositions to the high alkali side of the diagram, whereas those from the north (stratigraphically higher) exhibit a distinct bimodality. It is essential that this bimodality be confirmed or refuted on the basis of further analyses.

Silica variation diagrams show that some elements are strong discriminators between samples from the northern and southern localities. The subdivision of rock types for present convenience is as follows (although these will be reclassified at a later stage): basalt, 49-58 per cent SiO_2; intermediate volcanics, 59-68 per cent SiO_2; and rhyolites, 69-78 per cent SiO_2. The calc-alkaline (southern) suite of rocks shows continuity over the entire range, whereas the tholeiitic (northern) samples are concentrated in the basaltic and rhyolitic fields. Basalts from the northern and southern area are clearly distinguished on the basis of MgO, FeO (as total Fe), alkalies and TiO_2.

Aluminium for the southern basalts does not show the erratic fluctuations suggested by Watters and may be related to fractionation of an early Al_2O_3 phase. Fractionation of a calcium-rich phase such as clinopyroxene and a magnesium-rich phase such as olivine is suggested by the inflexion points in the CaO and MgO variation diagrams. In the rocks of intermediate composition plagioclase may be a fractionating phase. The possibility of fractionation in the calc-alkaline suite is directly opposed to the suggestion made by Watters. This point will be clarified in due course.

Basalts of the northern suite show significant scatter of CaO, FeO and Al_2O_3 but it should be noted that samples collected from the same area have greater chemical coherence. This spatial constraint will be fully investigated as more samples are analysed.

The plot for K_2O (Fig. 3) is informative. The line shown in the diagram divides samples from the southern area into two distinct groups - those from the Haremub-Vergenoeg area (extreme south) and those from Vrede 80 farther north.

On this basis the calc-alkaline rocks may be divided into high and low potassic varieties. The tholeiites from the north are generally low in K_2O although the diagram shows the existence of high K_2O basalts. On a stratigraphic basis there is some evidence that the lowest rocks are potassium-rich, whereas those higher in the sequence are potassium-poor. This again is in direct contrast to the work of Watters and has significant implications regarding a petrogenetic model. The plot for combined alkalies is broadly similar to that for KP, but is less discriminating. The tholeiitic rocks tend to form a more continuous trend on this plot.

Basalts from the northern and southern areas are well separated on the basis of TiO_2, although three samples have comparatively low levels of this oxide. Further analyses will prove or refute the possible existence of two tholeiitic basalt types. Phosphorus also appears to discriminate between two tholeiitic basalt populations.

The acid volcanics (greater than 69 per cent SiO_2) exhibit a high degree of overlap for samples from the northern and southern areas with convergent trends for MgO, FeO and Al_2O_3.

Watters distinguishes two types of rhyolites - high-Ca and low-Ca varieties with corresponding differences in the contents of SiO_2 and MgO.

The data presented here show two samples (from the northern area) with abnormally high CaO contents. These CaO values are not matched by higher MgO. It is suggested that the two groups distinguished by Watters are, in fact, related by a fractionation process, particularly so as the two groups showed a significant difference in SiO_2 content. Further detailed work in the present study will clarify this point.

Trace element analyses show overall differences between the rocks of the northern and southern areas and are powerful discriminators for the two groups of acid rocks.

It is clear from the limited geochemical work carried out to date that the Sinclair succession is extremely complex.

Further detailed investigation, as intended in this study, will provide the basis for establishing the geotectonic setting of the sequence. It is only on this basis that the economic potential of the area may be soundly evaluated.

5. REFERENCES

Watters, B.R. 1974. Stratigraphy, igneous petrology and evolution of the Sinclair Group in southern South West Africa. *Bull. Precambr. Res. Unit., Univ. Cape Town*, **16**, 235 pp.