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Rb-Sr GEOCHRONOLOGY OF THE MIDDLE TO LATE PROTEROZOIC AWASIB MOUNTAIN TERRANE

by

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ABSTRACT

Rb-Sr whole-rock age determinations on four suites of samples from the Awasib Mountain terrane in southern Namibia yield estimates consistent with the suspected Middle to Late Proterozoic origin of this crustal segment. Isochrons from the Aunis Granodiorite-gneiss and Haiber Flats Formation basaltic andesite give ages and initial $^{87}Sr/^{86}Sr$ ratios (R_o) of 1 271 ± 62 my, 0.7029 ± 3, and 1086 ± 44 my, 0.70305 ± 17, respectively. The estimated age of 1 038 ± 74 m.y. and R_o of 0.718 ± 15 for a rhyolite porphyry from the Haiber Flats Formation are within error of those deduced for the basaltic andesite, but have been derived from an errorchron. The younger, possibly subvolcanic, Awasib Granite yields an errorchron with an apparent age of 934 ± 70 m.y. and R_o of 0.719 ± 12. It seems likely that heterogeneity in the latter may be attributable to compositional variation in a postulated crustal source.

1. INTRODUCTION

The regional geology of the Awasib Mountain area has been reviewed and described by Hoal (1985). In summary, the terrane consists essentially of a partly deformed and metamorphosed volcano-sedimentary succession with associated high level plutons in a rifted basement that is probably of Namaqua age. The volcano-sedimentary sequence is correlated with the Sinclair Sequence, the type area of which is situated immediately to the east.

It is clear that much of the confusion relating to the origin of the Sinclair Sequence, viz. whether it is orogenic (Watters, 1974) or essentially anorogenic (Kröner, 1977), is the result of a paucity of data, especially geochemical and isotopic. The latter aspect, in the form of geochronology, has further clouded the issue with regard to the relationship between the Sinclair Sequence and its supposed basement, the Namaqualand Metamorphic Complex (NMC). The relatively undeformed Sinclair Sequence, which apparently overlies the NMC, has yielded ages, determined by a variety of radiometric techniques, that are both similar to and higher than ages determined for the NMC (see Hoal 1985, for a discussion of this paradox).

Lithotypes of both Sinclair and NMC affinity occur in the Awasib Mountain area which must, therefore, provide a unique opportunity for the study of the geochemical and isotopic evolution of this segment of Middle to Late Proterozoic crust. Consequently a cooperative geochronological project was initiated between the National Physical Research Laboratory (NPRL) and Geological Survey to try and solve some of these problems.

This paper reports the initial findings of this study, in which Rb-Sr isotopes have been determined for four suites of samples. Regional geology and sample locations are illustrated in Fig. 1. Sample sites were carefully chosen with a view to their importance in the lithostratigraphy and possible correlation with similar rock types in the Sinclair Sequence type-area.

2. PETROGRAPHY

2.1 Aunis Granodiorite-gneiss

This granodiorite-gneiss, previously named the Aunis Granodiorite (Hoal, 1985), is medium- to coarse-grained, sometimes massive in appearance and always contains biotite ± hornblende. The foliation is defined by quartz-rich layers and trails of ferromagnesian minerals which wrap around porphyroblasts of feldspar. The weathered surface is usually a buff, rusty-brown colour and is commonly characterised by resistant quartz ribs.

In thin section plagioclase comprises nearly 50 modal per cent, whereas K-feldspar (mostly microcline) is a minor constituent. Quartz, either as large strained crystals or smaller strain-free recrystallized grains, makes up between 20 and 30 modal per cent. Strongly pleochroic brown biotite and blue-green hornblende together constitute about 15 modal per cent, but hornblende is absent from more than half of the samples in the suite. The foliation is defined by seriate intergrowths of both strained and unstrained quartz, which may form ribbon structures that are commonly elongated in the plane of foliation, trails of ferromagnesian minerals (biotite and/or hornblende) with or without intergrown muscovite and epidote, and feldspar augen in the more highly deformed varieties. It would appear that recrystallisation, although widespread, is generally restricted to quartz and some of the ferromagnesian minerals. Accessory minerals include apatite, magnetite, sphene and zircon. Epidote, sericite and chlorite are common secondary minerals.

2.2 Haiber Flats Formation Basaltic Andesite

These basic flows are typically a dark greenish-grey

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colour on the fresh surface, but weather to a dark rusty-brown or mottled grey colour. Phenocrysts and less common amygdales are typical features of most flows.

In thin section phenocrysts of augite (largely pseudomorphed by actinolite), plagioclase and rare olivine are observed which range in size from less than 0.2 mm to around 5.0 mm (average about 0.6 mm). These phenocrysts constitute between 5 and 20 modal per cent. The groundmass is crypto- to microcrystalline and typically pilotaxitic or seriate in texture, though some flows are clearly trachytic. The groundmass consists largely of plagioclase (plus minor K-feldspar?), actinolite (after augite) and opaque minerals, the latter imparting to the groundmass its dark colour. The presence of amygdales is doubtful, since they may resemble fractured quartz xenocrysts with associated opaque minerals, epidote and uralite. The porphyritic texture is often best described as. glomeroporphyritic, with augite being the most abundant glomerocryst. Augite phenocrysts, which are predominant, are often completely uralitised and replaced by aggregates of uralite + opaques + epidote ± chlorite. These phenocrysts nevertheless have subhedral to euhedral crystal forms, are occasionally corroded, and commonly exhibit twinning or relict twinning. Plagioclase phenocrysts are relatively minor in amount and have generally been extensively saussuritised. Where albite twinning is present the composition of plagioclase approximates to calcic andesine or sodic labradorite.

2.3 Haiber Flats Formation Rhyolite Porphyry

These acid flows are characteristically highly porphyritic, red to blue-grey in colour on the fresh surface, and weather to a light brown colour. Flow structures are best seen on the weathered surface and are typically illustrated by flattened lithic fragments wrapped around feldspar and quartz phenocrysts.

In thin section phenocrysts of perthite (meso- and anti-perthite), plagioclase (frequently zoned albite-oligoclase), quartz (often embayed), microcline, orthoclase and magnetite vary in size between 0.05 and 3.5 mm (average about 0.9 mm). These phenocrysts constitute between 20 and 45 modal percent. The groundmass is largely a micro- to cryptocrystalline granular intergrowth of quartz and feldspar (probably the result of devitrification) with lesser amounts of opaque minerals, epidote, sericite and chlorite. A fluidal texture is widespread and is largely defined by trails of opaque minerals, lenses of relatively coarse quartzofeldspathic intergrowths (devitrification or lithic fragments), stringers of secondary minerals (usually micas or chlorite) and some alignment of phenocrysts. Compositional banding, illustrated by a variation in dark mineral content, and possibly grain size as well, may enhance the fluidal texture. Lithic fragments, which may be easily confused with patches of coarser-grained devitrification, are typically reddish in hand specimen and often appear to be more highly porphyritic than the host. The mineralogical composition of these fragments is similar to that of the host, but devitrification structures (spherulites and axiolitic growths) are much more common in the fragments.

Widespread undulatory extinction and occasional recrystallization along the margins of quartz phenocrysts are attributed to strain. Alteration (apart from devitrification) of the different mineral phases is variable but usually present to some degree in one or more of the following forms: sericite and lesser epidote after feldspar, albite after K-feldspar, chlorite + magnetite + carbonate after an original ferromagnesian mineral, and iron oxide disseminated in the groundmass.

2.4 Awasib Granite

This granite is typically a pink microgranite porphyry, but varies from a coarsely porphyritic microcrystalline granite to a more seriate very fine- to medium-grained granite. The weathering colour is usually reddish but may be buff and tends to emphasize the porphyritic nature of the rock.

In thin section phenocrysts of perthite (both microcline perthite and albitized orthoclase), plagioclase (albite-oligoclase), quartz and sometimes opaques (probably magnetite) can be seen to range in size from 0.3 to 7.0 mm (average about 1.0 mm) and constitute between 30 and 80 modal per cent. The groundmass is a microcrystalline or fine-grained granular to seriate intergrowth of quartz and feldspar with accessory opaques, chlorite (probably after biotite) and muscovite. Granophyric intergrowths may be developed to varying degrees. This granite is made up largely of quartz (between 30 and 50 modal per cent) and albitized K-feldspar (between 30 and 65 modal per cent).

Undulatory extinction in quartz phenocrysts, and sometimes in feldspar phenocrysts, is widespread and is interpreted as evidence of induced strain. Breakdown of quartz phenocrysts into relatively strain-free polycrystalline aggregates, widespread braid-perthite, extensive albitization of K-feldspar and quartz-filled fractures in feldspar are all features consistent with recrystallization subsequent to cooling.

3. ANALYTICAL PROCEDURES

Rubidium and strontium concentrations were determined by XRF analysis at the University of Pretoria using a Siemens SRS-1 spectrometer with a Mo tube; correction for matrix effects being made by monitoring the Mo Compton scattering peak. Replicate analysis of standards and samples determined by isotope dilution indicate uncertainties of 1.5 per cent in the Rb/Sr ratio for this technique.

The analytical procedures applied at the NPRL for Sr isotope analysis have been described by Harmer and Sharpe (1985) and Harmer (in press) and involve standard cation-exchange extraction of Sr following sample dissolution in HF-HNO_3-HCI. Blanks were in the order of 1 ng. Isotopic analyses were carried out on a VG 354 spectrometer equipped with a multi-collector array and automatic computer control of the analytical procedure. All ratios are normalised to $^{86}Sr/^{88}Sr = 0.1194$ and are relative to a value of 0.71023 ± 4 (2 std. deviations on 28 measurements) for NBS standard Sr salt SRM 987. Sample Sr ratios are reproducible to 0.01 per cent.

Data were regressed using the method of York (1969) with blanket weighting factors based on onesigma uncertainties of 1.5 per cent and 0.01 per cent in X and Y respectively. Goodness-of-fit of the regression line was tested by the value MSUM = SUMS/(n-2) as described by Brooks *et al*. (1972); scatter in the data in excess of the analytical uncertainty is reflected by MSUM > 2.5. In cases of excess, or "geological" scatter, the regression line is termed an "errorchron" and the errors for the age estimate are calculated by York (1966), which augments the errors to account for the scatter. Errorchron age estimates are identified by "*". All errors are given at the two-sigma level.

Epsilon UR ("U" uniform "Reservoir) values are calculated following Hawkesworth and Norry (1983, p. 250).

4. RESULTS

Results are shown in Tables 1 to 4 and plotted on conventional isochron diagrams in Figs. 2 to 5. A summary of the regression calculations is provided in Table 5.

4.1 Aunis Granodiorite-gneiss

Nine samples of the Aunis Granodiorite-gneiss define an isochron (MSUM = 1.3) with an age of 1 271 ± 62 m.y. and an initial $^{87}Sr/^{86}Sr$ ratio (R_o) of 0.7029 ± 3. Sample BH 745 was excluded from the regression as it appears slightly weathered in thin section and deviates from the isochron line by more than three times the analytical uncertainty. Exclusion of this datum has little effect on the age and R_o estimates (Table 5).

The R_o estimate for the Aunis Granodiorite-gneiss is low (epsilon UR of -2.73), an indication that the source material of this granitoid had Rb/Sr similar to, or lower than, chondritic mantle for an extended time period. This precludes a significant crustal pre-history or "residence time" for this unit, and implies that the estimated age reflects the time of primary derivation and crystallisation of the Aunis Granodiorite-gneiss.

4.2 Haiber Flats Formation Basaltic Andesite

The eight analysed samples define a precise isochron (MSUM = 0.8) with an age of 1 086 ± 44 m.y. and R_o of 0.70305 ± 17. Again, R_o is low (epsilon UR = -3.49) indicating a source region having slight time-integrated depletion in Rb/Sr relative to a "Bulk Earth" mantle composition.

4.3 Haiber Flats Formation Rhyolite Porphyry

These data, which exhibit significant scatter, define an errorchron (MSUM = 7.0) with an age of 1 038 ± 74*

TABLE 1: Aunis Granodiorite-gneiss

Sample No.	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$ atomic	$^{87}Sr/^{86}Sr$ atomic
BH 727	29.8	121	0.713	0.716092 (9)
BH 745	30.1	205	0.425	0.711309 (11)
BH 746	25.3	214	0.342	0.709116 (11)
BH 747	19.9	227	0.254	0.707662 (9)
BH 748	25.9	193	0.388	0.709769 (10)
BH 749	25.1	200	0.368	0.709506 (10)
BH 750	25.4	208	0.353	0.709146 (10)
BH 751	28.9	190	0.440	0.710815 (9)
BH 752	24.6	181	0.393	0.710147 (11)
BH 753	19.7	210	0.271	0.707816 (11)

TABLE 2: Haiber Flats Formation basaltic andesite

Sample No.	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$ atomic	$^{87}Sr/^{86}Sr$ atomic
BH 687	69.7	699	0.289	0.707629 (11)
BH 688	87.1	647	0.390	0.709198 (13)
BH 689	76.0	639	0.344	0.708456 (9)
BH 690	38.9	721	0.156	0.705441 (9)
BH 691	99.3	533	0.539	0.711218 (10)
BH 692	28.8	639	0.130	0.705067 (11)
BH 693	47.1	606	0.225	0.706572 (9)
BH 694	46.4	613	0.219	0.706388 (11)

TABLE 3: Haiber Flats Formation rhyolite porphyry

Sample No.	Rb ppm	Sr ppm	$\frac{87_{Rb}}{86_{Sr\ atomic}}$	$\frac{87_{Sr}}{86_{Sr\ atomic}}$
BH 504	163	48.7	9.8	0.871967 (15)
BH 513	152	37.8	11.8	0.892837 (25)
BH 585	182	30.1	14.9	0.974590 (21)
BH 611	185	46.9	11.6	0.886770 (17)
BH 697	181	46.4	11.5	0.889162 (11)
BH 705	162	32.4	14.8	0.930420 (8)
BH 706	160	25.0	19.0	0.985618 (14)
BH 707	290	16.5	55.0	1.536621 (24)
BH 708	249	47.0	15.7	0.962162 (13)
BH 709	252	26.0	29.3	1.171635 (10)

TABLE 4: Awasib Granite

Sample No.	Rb ppm	Sr ppm	$\frac{87_{Rb}}{86_{Sr\ atomic}}$	$\frac{87_{Sr}}{86_{Sr\ atomic}}$
BH 618	119	71.7	4.84	0.783254 (17)
BH 619	135	40.7	9.74	0.857796 (19)
BH 677	269	22.8	35.8	1.210401 (21)
BH 678	292	10.3	91.6	1.905123 (25)
BH 679	288	12.8	71.4	1.690058 (27)
BH 680	296	26.6	33.8	1.206653 (19)
BH 681	164	52.2	9.21	0.839888 (15)
BH 682	255	13.5	50.8	1.259227 (16)
BH 683	247	15.4	49.7	1 .43889 (58)
BH 684	281	10.0	91.0	1.92839 (50)
BH 685	179	31.0	17.1	0.924014 (10)

Sr isotopic ratios are relative to a value of 0.71023 for NBS standard Sr salt SRM 987. Values in brackets are the uncertainties for each measurement (2 std. errors x 10^6).

m.y. and R_o of 0.718 ± 15*. However, it is significant that both of these parameters are within error of those deduced for the basaltic andesite samples. The high R_o suggests a significant component of melted crust in the genesis of these rhyolites, although the rather large (augmented) error on the estimate precludes a definite conclusion.

Sample scatter may be attributed to one or more of the following: (i) the samples are not of the same age; (ii) the samples have different R_o; or (iii) the samples did not remain closed systems to Rb and Sr.

Field relationships suggest that option (i) is unlikely, but incorporation of exotic lithic fragments in the rhyolites could possibly account for differences in R_o during crystallisation of the lavas. However, as the rhyolites show extensive devitrification the most likely explanation is option (iii), i.e. loss of Rb and/or radiogenic Sr during post-crystallisation alteration, particularly during the formation of chlorite and epidote.

4.4 Awasib Granite

The eleven analyses of the Awasib Granite exhibit extreme scatter (MSUM = 36) and the apparent age of 934 ± 70* my and R_o of 0.719 ± 12* need to be interpreted with caution. Although not conclusive, the age estimate is consistent with field evidence, i.e. the granite is younger than the Haiber Flats Formation volcanics.

The Awasib Granite is holocrystalline and contains only minor secondary material (especially when com-

TABLE 5: Summary of regression calculations

	Age (m.y.)	R_o	MSUM (n)
Aunis Granodiorite gneiss:	1316 ± 144 *	0.7027 ± 8 *	6.4 (10)
(excluding sample BH 745)	1271 ± 62	0.7029 ± 3	1.3 (9)
Haiber Flats Formation:			
(i) basaltic andesite	1086 ± 44	0.70305 ± 17	0.82 (8)
(ii) rhyolite porphyry	1038 ± 74 *	0.718 ± 15 *	7.0 (10)
Awasib Granite:	934 ± 70 *	0.719 ± 12 *	36 (11)
(excluding sample BH 682)	957 ± 50 *	0.717 ± 8 *	15 (10)

*indicates "errorchron" systematics, augmented errors calculated using the technique of York (1966).

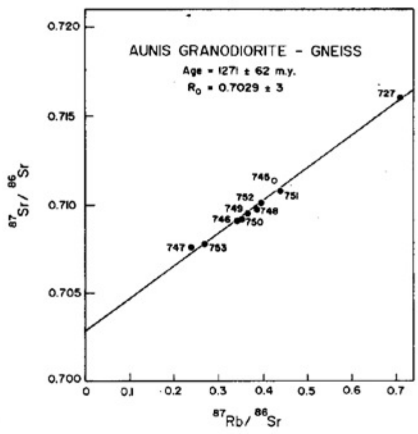

Fig. 2: Aunis Granodiorite-gneiss: whole-rock (nine-point) Rb-Sr isochron. The open symbol BH 745 was excluded from the regression line calculation.

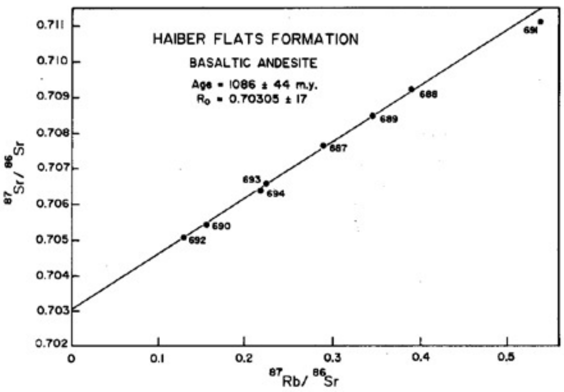

Fig. 3: Haiber Flats Formation basaltic andesite: whole-rock (eight-point) Rb-Sr isochron.

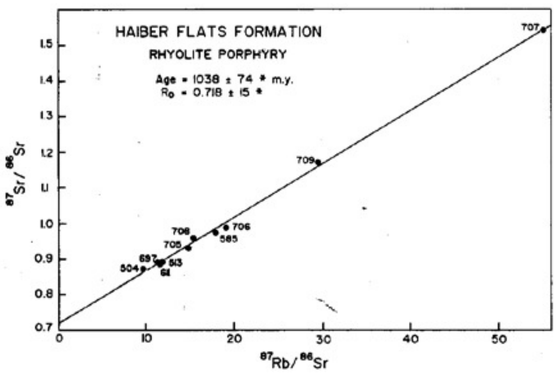

Fig. 4: Haiber Flats Formation rhyolite porphyry: whole-rock (ten-point) Rb-Sr errorchron.

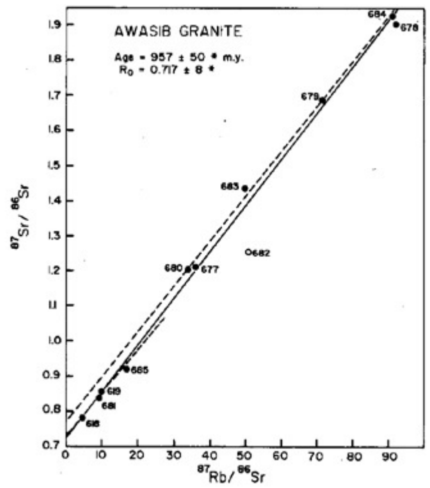

Fig. 5: Awasib Granite: solid line represents a whole-rock (ten-point) Rb-Sr errorchron; dashed lines are possible parallel errorchrons of about 895 m.y. age (see text). The open symbol BH 682 was excluded from the regression line calculation.

pared with the rhyolites), consequently it is unlikely that the large scatter is due entirely to secondary effects. The high apparent R_o may thus imply the involvement of pre-existing crustal material in the genesis of the Awasib Granite. It is likely that this material would be compositionally variable and hence incomplete mixing of partial melt fractions extracted from the crustal material would give rise to R_o heterogeneity in the parent magma.

If Awasib Granite data are divided into two groups on the basis of Rb/Sr ratio, i.e. high ratios (samples BH 677, 678, 679, 680, 683, 684) and low ratios (samples BH 618, 619, 681, 685), two sub-parallel errorchrons are apparent. These yield age estimates of 896 ± 72* m.y. (high ratios) and 895 ± 180* my, (low ratios) with R_o estimates of 0.77 ± 0.05* and 0.72 ± 0.02*, respectively. It is plausible, then, that scatter in this data set is attributable to variation in R_o at the time of crystallization. Incomplete mixing can produce misleading ages in whole-rock isotopic dating systems (Juteau *et al.*, 1984) and the deduced age for the Awasib Granite must be viewed with caution.

5. DISCUSSION

The age of 1 271 ± 62 m.y. obtained for the Aunis Granodiorite-gneiss is interpreted as representative of the primary crystallisation event of this intrusive, and hence provides a minimum age for the Kairab Complex basement in this area. The coincidence of this age with a likely maximum age of 1 300 my for the F_2M_2 Namaqua event (Cahen and Snelling, 1984, p. 65) is consistent with a previous correlation made between the Kairab Complex and the NMC (Hoal, 1985).

The age of the Haiber Flats Formation volcanism is provided by the isochron date of 1 086 ± 44 m.y. for the basaltic andesites. Open system behaviour during devitrification and alteration has given rise to errorchron systematics in the rhyolitic members but the estimated age of 1 038 ± 74* m.y. is comparable to that of the basaltic andesites.

Correlation of the Haiber Flats Formation with the Barby Formation (Hoal, 1985) would appear to be incorrect in view of the age of 1392 ± 33 my inferred for the latter by Watters (1982). However, the derivation of this age estimate is based on statistically dubious reasoning and requires critical evaluation. Consequently, Watters' (1982) Barby Formation data were recalculated with the NPRL regression program. The total data set yields an age estimate of 1238 ± 71* m.y. and R_o of 0.7028 ± 5* with an MSUM of 3.9 (apparently Watters (*op.cit.*) inadvertently quoted one sigma errors on his Figure 3). Excluding the samples 1557 and 1565, which deviate from the regression line by more than three times the uncertainty (in "X"), the remaining twelve data points yield an isochron estimate (MSUM = 0.9) of 1190 ± 38 m.y. and R_o of 0.70298 ± 27. The low MSUM indicates that further screening is unjustified. The two deviant samples 1557 and 1565 had R_o values of 0.7045 and 0.7043, respectively, at 1190 my (i.e. differing by more than the analytical uncertainty) implying that these rocks were derived from a source of different R_o composition than that of the bulk of the Barby Formation samples.

Independent support for the age of the Barby Formation is difficult to obtain as several granite bodies which have clearly intruded this formation paradoxically yield much older ages. These ages, which are largely based on U-Pb zircon isotopic determinations (reviewed by Watters, 1982), may reflect the existence of relic zircons in the approximate age range 1 250 to 1 350 my It is further suggested that the inherited (relic) zircons were derived from a source of similar age to the Kairab Complex or Aunis Granodiorite-gneiss basement in the Awasib Mountain terrane.

There appears to be little justification for Watters' (1982) preferred age of 1 392 ± 33 m.y. for the Barby Formation and consequently it is suggested that 1190 ± 38 m.y. is the best current estimate. On a more regional basis it is important to draw attention to the recent assertion by Cahen and Snelling (1984) that "the geochronological data would appear to rule out correlation of the Sinclair and Koras Groups despite marked similarities in lithology and tectonic setting." The same authors' preferred age of about 1 180 my for the Koras Group can, on the contrary, be said to be in good agreement with our best estimate for the Barby Formation. This estimate is still significantly older than the Haiber Flats Formation and a direct time correlation between these formations is not justified. Similarity in initial R_o suggests, however, that the basic volcanics of the Barby and Haiber Flats Formations were derived from similar source compositions.

It is not possible to confidently estimate the true age of the Awasib Granite from the available data since wide variations in R_o are suggested, probably due to incomplete mixing of crust-derived partial melts. However, field evidence and isotopic characteristics are consistent with a subvolcanic relationship between the Awasib Granite and the Haiber Flats Formation rhyolite porphyry.

6. REFERENCES

Brooks, C., Hart, S.R. and Wendt, I. 1972. Realistic use of two-error regression treatments applied to rubidium-strontium data. *Rev. Geophys. Space Phys.*, **10**, 551-577.

Cahen, L. and Snelling, N.J. 1984. *The geochronology and evolution of Africa*. Clarendon Press, Oxford, 512 pp.

Harmer, RE. and Sharpe, M.R. 1985. Field relations and strontium isotope systematics of the marginal rocks of the Eastern Bushveld Complex. *Econ. Geol.*, **80**, 813-837.

Harmer, R.E. (in press). Sr isotopic study of units of the Pienaars River Alkaline Complex, north of Pretoria, South Africa. *Trans. geol. Soc. S. Afr*.

Hawkesworth, C.J. and Norry, M.J. 1983. *Continental Basalts and Mantle Xenoliths*. Shiva, 272 pp.

Hoal, B.G. 1985. Preliminary report on the geology of the south-eastern part of Diamond Area No. 2, South West Africa/Namibia. *Communs geol. Surv. S.W. Africa/Namibia*, **1**, 9-21.

Juteau, M., Michard, A. Zimmerman, J. and Albarede, F. 1984. Isotopic heterogeneities in the granitic intrusion of Monte Capanne (Elba Island, Italy) and dating concepts. *J. Petrol*., **25**, 532-545.

Kröner, A. 1977. The Sinclair aulacogen - a late Proterozoic volcano-sedimentary association along the Namib Desert of southern Namibia (SWA). *Abstr. 9th Colloquium Afr. Geol.*, Gottingen, 82-83.

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.

Watters, B.R. 1982. A Sr-isotopic study of a suite of Precambrian shoshonites from the Sinclair Group in southern Namibia. *Trans. geol. Soc. S. Afr*., **85**, 81-86.

York, D. 1966. Least-squares fitting of a straight line. *Can. J. Phys*., **44**, 1079-1086.

York, D. 1969. Least-squares fitting of a straight line with correlated errors. *Earth Planet. Sci. Lett*., **5**, 320-324.

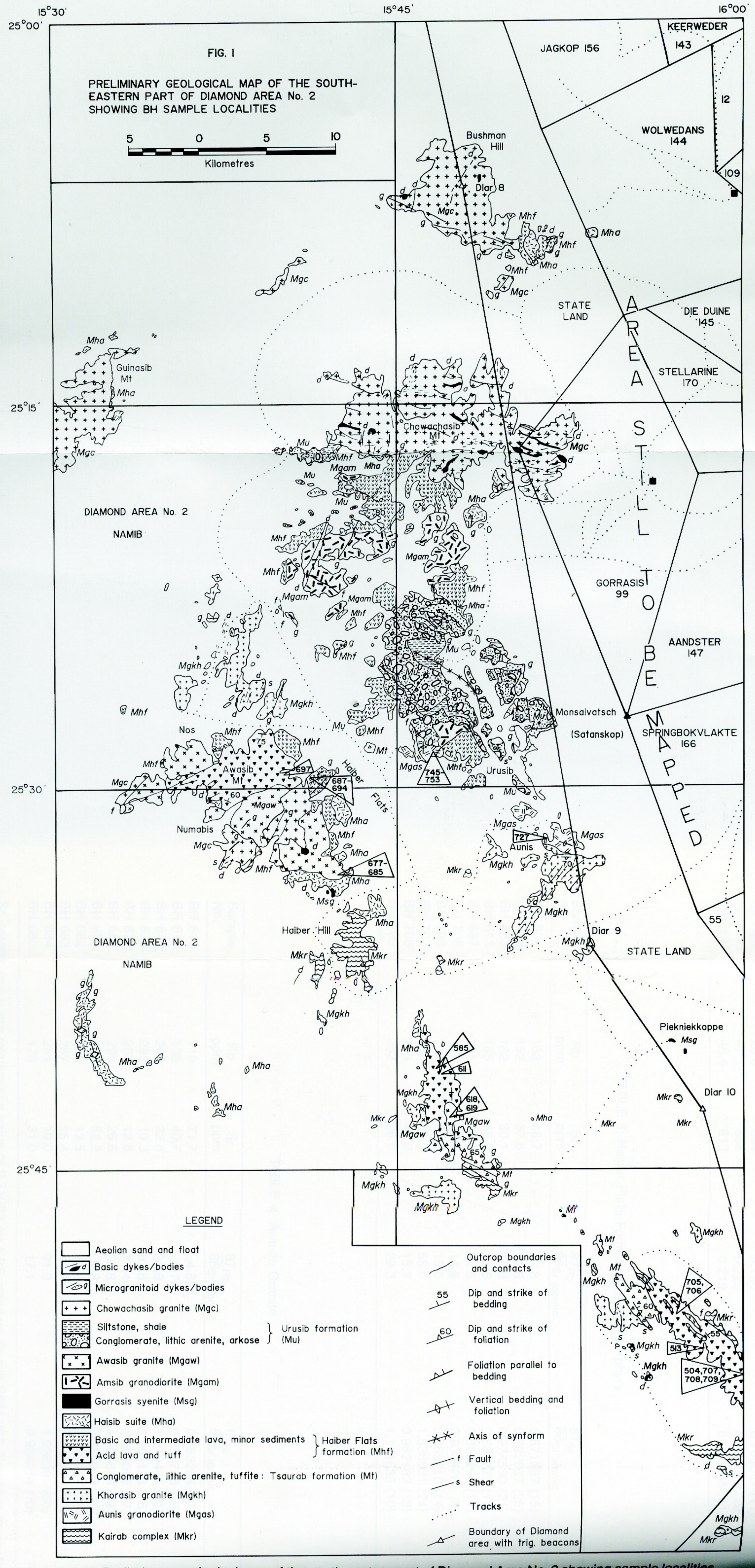

Fig. 1: Preliminary geological map of the south-eastern part of Diamond Area No. 2 showing sample localities.