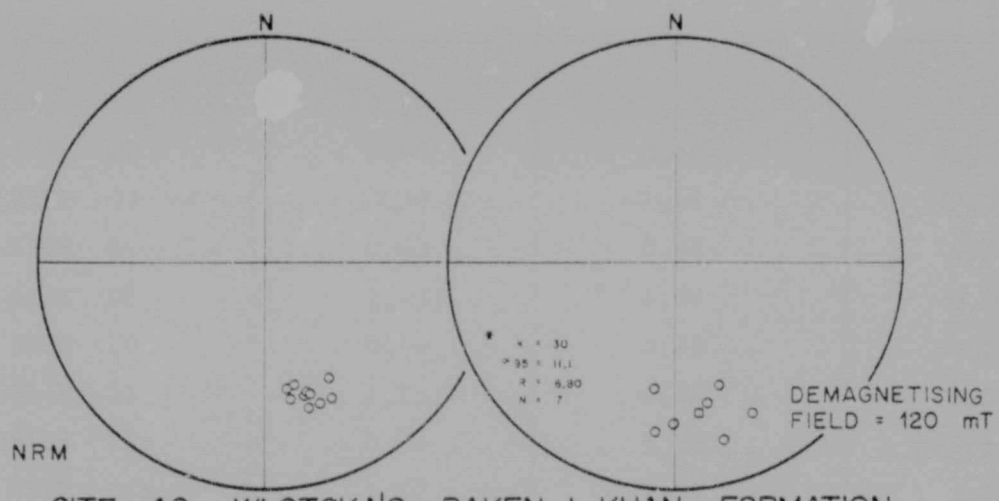
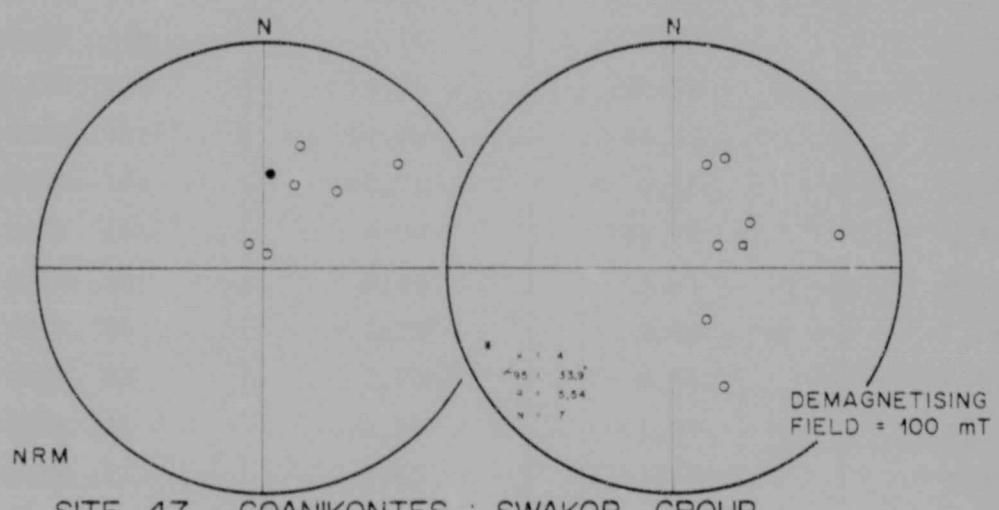
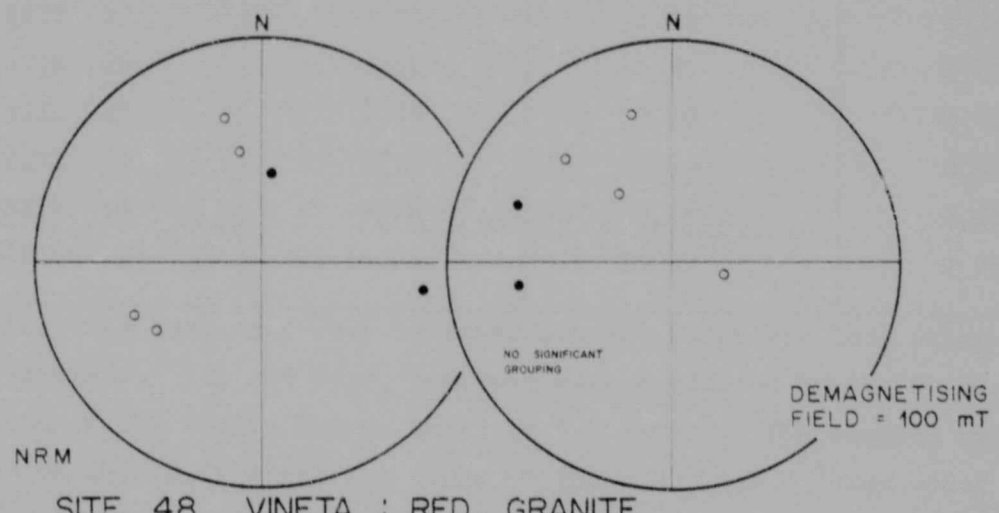


SITE 46 WLOTSKA'S BAKEN : KHAN FORMATION



SITE 47 GOANIKONTES : SWAKOP GROUP



SITE 48 VINETA : RED GRANITE

● POSITIVE INCLINATION
○ NEGATIVE INCLINATION
■ □ SITE MEANS
• FISHER STATISTICS AS DEFINED IN TEXT

TABLE A3 : $FeO - Fe_2O_3 - TiO_2$ CONCENTRATIONS OF THE PALAEOMAGNETIC SAMPLES

SAMPLE NO	FeO %	Fe_2O_3 %	TiO_2 %
SITE 01	0,54	0,057	0,068
SITE 02	0,45	0,66	0,147
SITE 03	0,54	1,21	0,371
SITE 04	0,63	0,68	0,261
SITE 07	2,23	4,85	0,66
SITE 10	0,80	0,32	0,088
SITE 11	1,16	4,36	0,573
SITE 15a	0,71	2,16	0,522
SITE 15b	1,27	2,24	0,40
SITE 16a	1,16	3,29	0,626
SITE 16b	1,57	1,83	0,39
SITE 18a	0,71	1,566	0,295
SITE 18b *	9,74	70,98	11,18
SITE 18c *	10,06	84,32	1,11
SITE 19a	0,71	0,16	0,057
SITE 19b *	6,20	88,61	0,84
SITE 20	0,54	3,61	0,715
SITE 21	1,25	3,89	1,063
SITE 23	1,70	0,04	0,222
SITE 24	2,05	1,87	0,582
SITE 25	0,62	4,17	0,35
SITE 26a	1,07	0,79	0,138
SITE 26b	0,99	,84	1,37
SITE 27	1,25	1,92	0,385
SITE 28	1,52	1,32	0,398
SITE 29	0,80	0,70	0,138
SITE 31	3,13	2,60	0,928
SITE 46	9,66	0,78	0,66
GELUK 1 *	16,75	76,89	2,21

TiO_2 analyses were conducted by McLachlan and Lazar Pty Ltd, using the XRF technique. FeO and Fe_2O_3 analyses were conducted by the Chemistry division of the Atomic Energy Board (W R O Jacob). The samples were subjected to cold acid digestion using HF and H_2SO_4, and V^{5+} was added as an oxidising agent. The amount of FeO was then determined by back filtration and the use of standard solutions. Total Fe content was determined using the XRF technique and calculation thus yielded the Fe_2O_3 content.

*'Magnetite' samples

APPENDIX A4.

DEPENDANCE OF MAGNETIC ANOMALY FORM ON DIRECTION OF MAGNETISATION.

When interpreting magnetic data it is essential to bear in mind that the form of a magnetic anomaly may change drastically over a given structure, depending on the direction of magnetisation whithin that structure. This may result in completely erroneous conclusions with regard to the exact location of the causative body and its direction of dip. Most rocks acquire a secondary or viscous remanent magnetisation which is induced by the earth's present-day field and many researchers, in the absence of palaeomagnetic data, perforce assume that magnetisation is induced.

The Damara orogen is an excellent example of where such an assumption cannot be made. The palaeomagnetic results (Chapter 4) clearly indicate a direction of natural remanent magnetisation for the Nosib Group rocks which is very different to the present-day field direction (declination = 334°; inclination = +54°). Utilizing the magnetisation parameters derived in this study, total-field magnetic anomalies have been calculated, assuming both induced and remanent magnetisation, for two simple two-dimensional structures, i.e. an anticline which is uniformly magnetised (Figs. 21a, 21b), and the same anticline with only the limbs being magnetised (Figs. 22a, 22b).

The method of Talwani and Heirtzler (1964) was used in the calculation of the magnetic anomalies. The apparent 'depth of burial' of the structures is 200m and was included to simulate the average aircraft terrain-clearance used for the surveys in the area. The structures were extended only to a depth of 3 depth-units (say kilometres) since most of the Nosib rocks probably do not extend beyond this. Any further depth extensions would in fact not change the basic anomaly forms but only introduce longer wavelength components. The structures were kept simple to illustrate the point. Fig 17 (section 5.2) represents a more realistic model of the complex structures found in the area.

The results in Figs 21 and 22 clearly demonstrate the origin of the negative magnetic anomalies which are discussed in this thesis. Figs 21a and 22a illustrate the anomaly forms for magnetisation induced by the earth's present-day field, as is mostly the case for the Swakop Group rocks, and Figs 21b and 22b for remanent magnetisation as is found in the Nosib rocks. The aeromagnetic maps of the area (Fig 3) should be viewed in the context of these results.

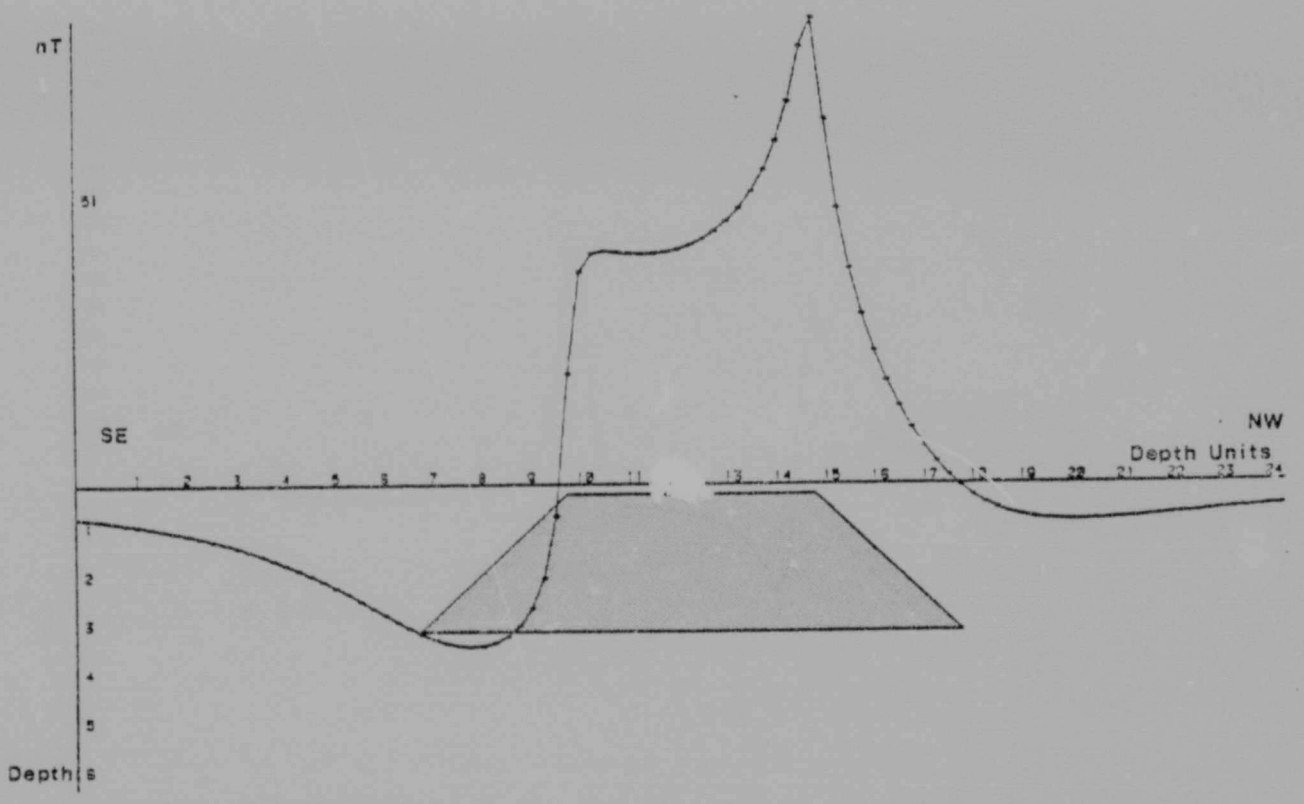


Fig 21a. Total-field magnetic anomaly over a simulated anticline with uniform induced magnetisation (declination = 340; inclination = -60°; field intensity = 30000 n T ; susceptibility = 0,01 SI) Traverse bearing is 105° which is perpendicular to strike.

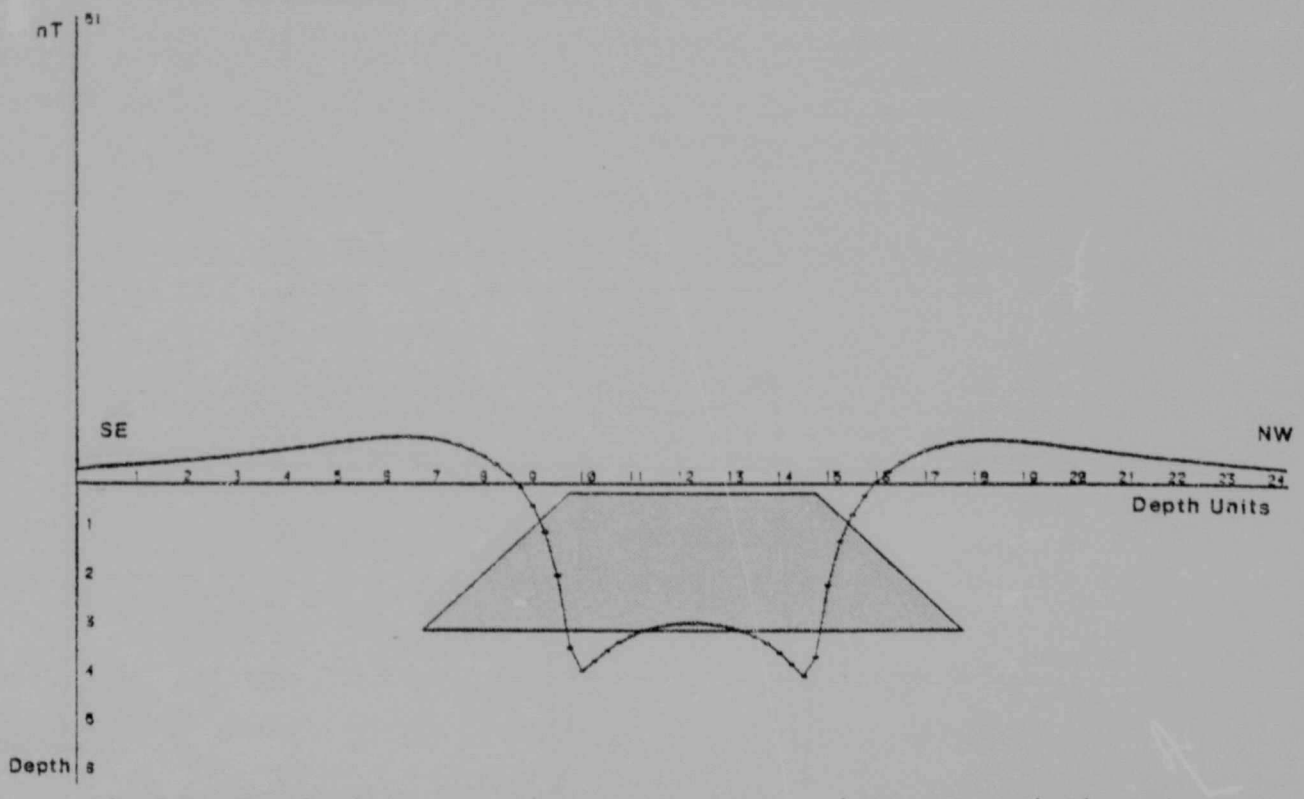


Fig 21b. Total-field magnetic anomaly over a simulated anticline with uniform remanent magnetisation (declination = 334°; inclination = +54°; intensity = 0,8 Amp. m^{-1}).Traverse bearing is 105° which is perpendicular to strike.

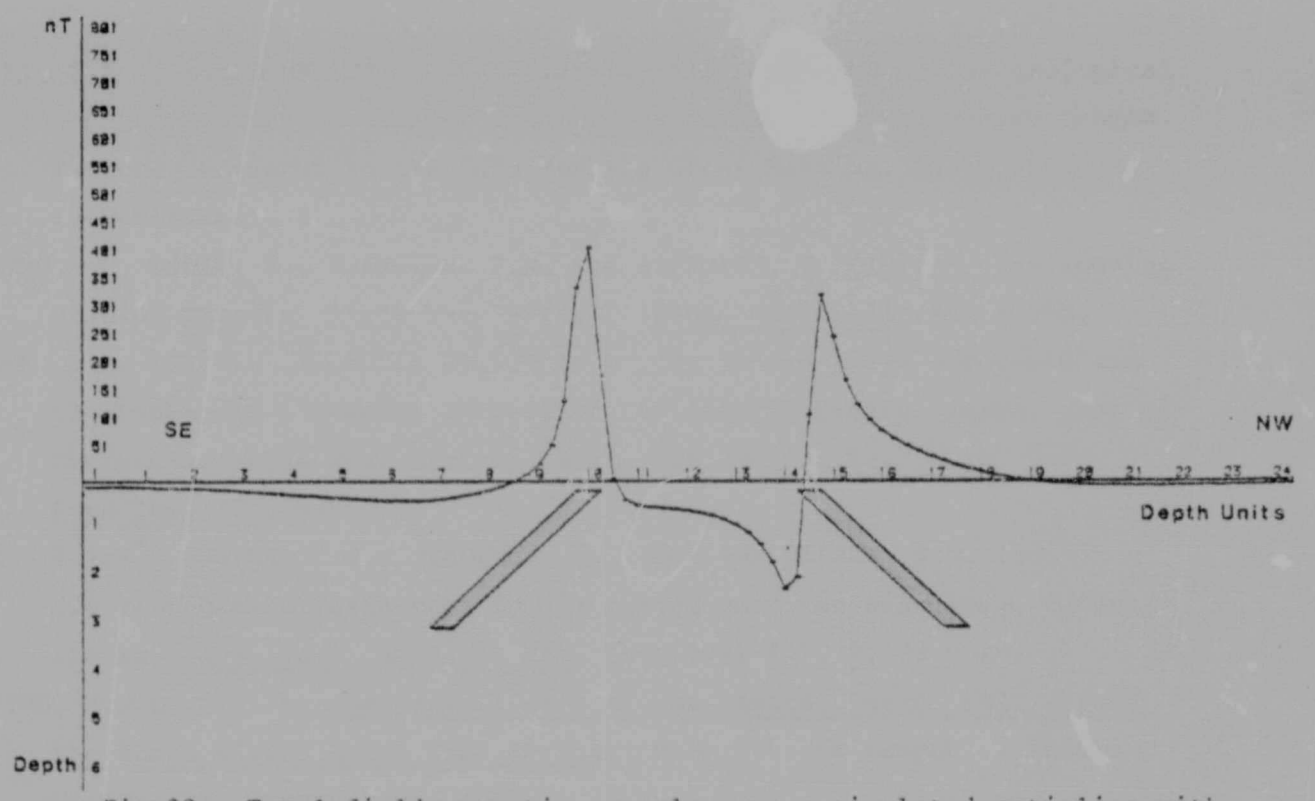


Fig 22a. Total-field magnetic anomaly over a simulated anticline with induced magnetisation in limbs only (declination = 340°; inclination = -60°; field intensity = 30000 n T; susceptibility = 0,01 SI). Traverse bearing is 105° which is perpendicular to strike.

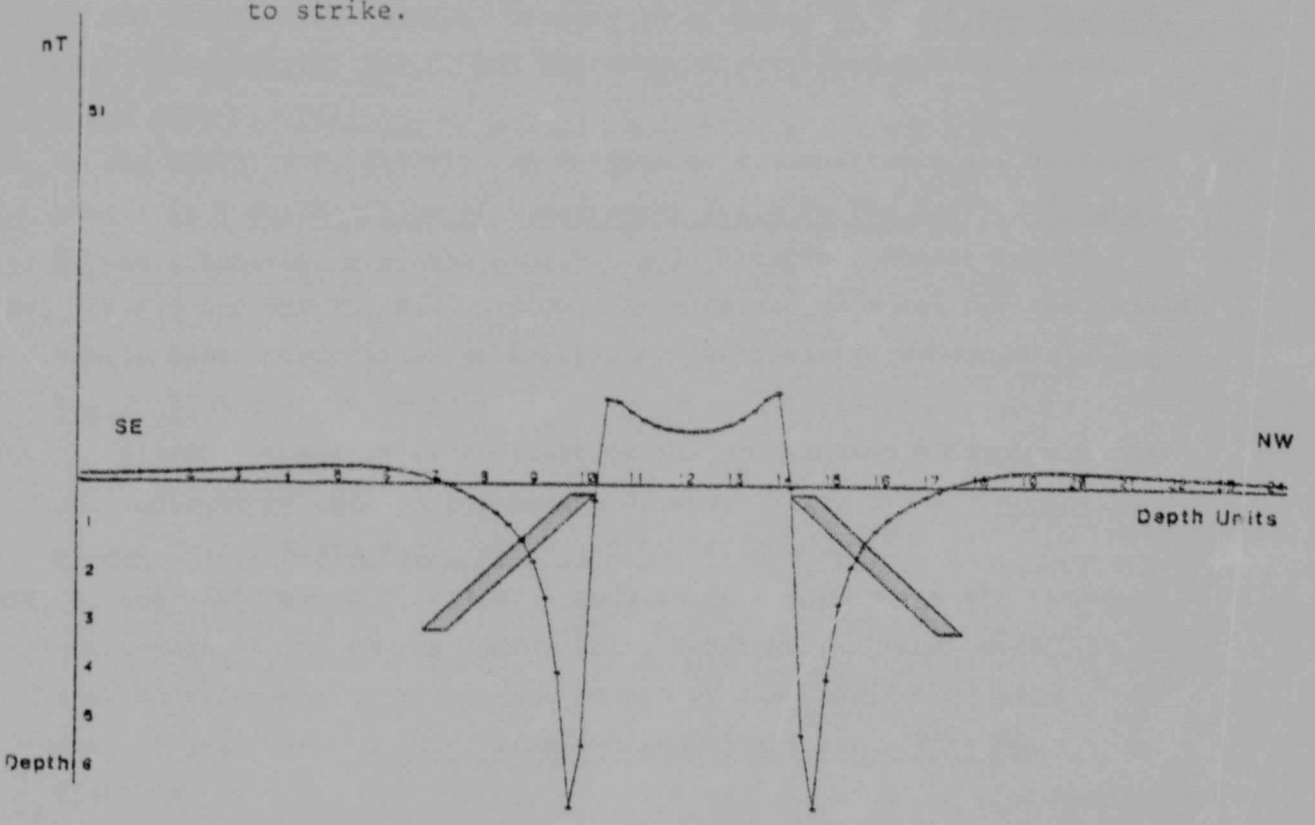


Fig 22b. Total-field magnetic anomaly over a simulated anticline with remanent magnetisation in limbs only (declination = 334°; inclination = +5[illegible]°; intensity = 0,8 Amp.m^{-1}). Traverse bearing is 105° which is perpendicular to strike.

9 REFERENCES

BARNES, J.F.H. and HAMBLETON-JONES, B.B. (1978): A review of the geological and geochemical setting of uraniferous granites in the Damara Orogen. Lecture delivered to the IAEA Working Group Meeting, Nancy, France. (Unpublished).

BERNING, J., COOKE, R., HIEMSTRA, S.A. and HOFFMANN, U. (1976): The Rössing uranium deposit, South West Africa. Econ. Geol., 71, 351 - 368.

BLAINE, J.L. (1977): Tectonic evolution of the Waldau Ridge structure and the Okahandja lineament in part of the central Damara Orogen, west of Okahandja, South West Africa. Bull. Precambrian Res. Unit, Univ. Cape Town, 21, 99p.

BOTHA, B.J.V., GUNTER, C.J., SCHOEMAN, P.J. and VAN REENEN, D.D. (1975): Die voor-Damara gesteentes in die gebied suid van Brandberg, Suidwes-Afrika. Ann. geol. Surv. S. Afr. (for 1971-72), 9, 75 - 78.

BUNTING, F.J.L. (1977): Geology of part of the central Damara belt around the Tumas River, South West Africa. M.Sc. thesis (unpubl.) Rhodes University, Grahamstown, 168 p.

BURKE, K., DEWEY, J.F. and KIDD, W.S.K. (1977): World distribution of sutures - the sites of former oceans. Tectonophysics, 40, 69 - 99.

BURKE, K. and DEWEY, J.F. (1972): Orogeny in Africa. In : African Geology, eds., Dessauvagie, T.F.J. and Whiteman, A.J., Ibadan Univ. Press, 583 - 608.

BURKE, K. and DEWEY, J.F. (1973): An outline of Precambrian plate development. In : Implications of Continental drift to the Earth Sciences, 2, eds., Tarling, D.H. and Runcorn, S.R., Academic Press, London.

BARNES, J.F.H., and SAWYER, E.W. (1980): An alternative model for the Damaran Mobile Belt: Ocean crust subduction or continental convergence. Pre. Res., 13, No. 4, 297 - 336.

CORNER, B. (1975): A preliminary report on the correlation between magnetic and radiometric data in the Damara Orogenic Belt, S W A. S. Afr. Atomic Energy Board Rep., PIN-281 C/V, Pretoria.

CORNER, B. and HENTHORN, D.I. (1978): Results of a palaeomagnetic survey undertaken in the Damara Mobile Belt, South West Africa, with special reference to the magnetisation of the Uraniferous pegmatitic granites. S. Afr. Atomic Energy Board Rep., PEL-260, Pretoria.

CORNER, B. (in press): An interpretation of the aeromagnetic data covering the western portion of the Damara orogen in South West Africa (Namibia) In : Spec. Publn. geol. Soc. S. Afr. on the Damara orogen.

CREER, K.M. (1967): Thermal demagnetisation by the continuous method. In : Developments in solid earth geophysics, Vol. 3, Methods in Palaeomagnetism, eds., Collinson, Creer, Runcorn, Elsevier, 287 - 295.

DAY, R., FULLER, M.D., and SCHMIDT, V.A. (1976): Magnetic hysteresis properties of synthetic titanomagnetites. J. Geophys. Res., 81, 873.

DAY, R. (1977): TRM and its variation with grain size: A review. In : Origin of Thermoremanent Magnetization, Ed. D.J. Dunlop, Adv. Earth Planet. Sci., 1, 1 - 33.

DOBRIN, M.B. (1960): An Introduction to Geophysical Prospecting. Second Ed., Kogakusha Press, Tokyo.

DUNLOP, D.J. (1979): On the use of Zijderveld vector diagrams in multicomponent palaeomagnetic studies. Phys. Earth Planet. Int., 20, 12 - 24.

EDWARDS, J. (1980): An experiment relating to rotational remanent magnetisation and frequency of demagnetising field. Geophys. J. R. astr. Soc., 60, 283 - 288.

FISHER, R.A. (1953): Dispersion on a Sphere. Proc. Roy. Soc., London, 217.

GEVERS, T.W. (1963): Geology along the northwestern margin of the Khomas Highlands between Otjimbingwe, Karibib, and Okahandja, South West Africa. Trans. geol. Soc. S. Afr., 66, 199 - 258.

GRANT, F.S. and WEST, G.F. (1965): Interpretation theory in applied geophysics, McGraw-Hill.

HAACK, U. and HOFFER, E. (1976): K/Ar ages of biotites from the Damara Orogen, South West Africa. Trans. geol. Soc. S. Afr., 79, 213 - 216.

HAILWOOD, E.A. and MOLYNEUX, L. (1974): Anhysteretic remanent magnetisation due to asymmetrical alternating fields. Geophys. J.R. astr. Soc., 39, 421 - 434.

HAMBLETON-JONES, B.B., LEVIN, M., WAGENER, G.F., NEL, A., and HARTLIEB, J. (in press): Surficial uranium occurrences of southern Africa. In : New Ore Deposits Volume, Publ. by Geol. Soc. S.A.

HENTHORN, D.I. (1978): Palaeomagnetic Investigation into the possible correlation between the Buschmannsklippe Formation and Nama System, S W A. Internal Report GH-2430, Geol. Surv. S. Afr., Pretoria.

HOFFER, E. (1977): Mineralparagenesen und reaktionen in den Al-reichen metapeliten des zentralen Damara-Orogen. Unpubl. Rep. Sonderforschungsbereich 48, Univ. Göttingen.

IRVING, E. (1964): Palaeomagnetism. J. Wiley and Sons, New York.

JACOB, R.E. (1974a): Geology and metamorphic petrology of part of the

Damara Orogen along the lower Swakop River, South West Africa. Bull. Precambrian Res. Unit, Univ. Cape Town, 17, 185 p.

JACOB, R.E. (1974b): The radioactive mineralisation in part of the central Damara Belt, South West Africa, and its possible origin. S. Afr. Atomic Energy Board Rep., PIN-234 BR, Pretoria, 17 p.

JACOB, R.E. and KRÖNER, A. (1977): The Stratigraphic position of supposed Pre-Damara rocks in the Damara Belt South of the Brandberg, South West Africa. Trans. geol. Soc. S. Afr., 80, 97 - 99.

JACOB, R.E., KRÖNER, A. and BURGER, A.J. (1978): Areal extent and first U-Pb age of the pre-Damaran Abbabis Complex in the central Damara Belt of South West Africa (Namibia). Geol. Rdsch., 67, 706 - 718.

JACOB, R.E. (1978): Granite genesis and associated mineralisation in part of the central Damara Belt. Spec. Publn., geol. Soc. S. Afr., 4, 417 - 432.

JACOB, R.E., CORNER, B. and BRYNARD, H.J. (in press): The regional geological and structural setting of the uraniferous granitic provinces in southern Africa. In : New Ore Deposits Volume, Publ. by Geol. Soc. S.A.

KRÖNER, A. (1977): Precambrian mobile belts of southern and eastern Africa - ancient sutures or sites of ensialic mobility? A case for crustal evolution towards plate tectonics. Tectonophysics, 40, 101 - 135.

KRÖNER, A. and HAWKESWORTH, C.J. (1977): Late Pan-African emplacement ages for Rössing alaskitic granite (Damara belt) and Rooi Lepel bostonite (Gariep Belt) in Namibia and their significance for the timing of metamorphic events. 20th a. Rep. res. Inst. afr. Geol., Univ. Leeds, 14 - 17.

KRÖNER, A., HALPERN, M. and JACOB, R.E. (1978): Rb-Sr geochronology in favour of polymetamorphism in the Pan African Damara Belt of Namibia (South West Africa). Geol. Rdsch., 67, 688 - 706.

LEVI, S. (1977): The effect of magnetite particle size on palaeointensity determinations of the geomagnetic field. Phys. Earth Planet. Int., 13, 245 - 259.

MARTIN, H. (1965): The Precambrian geology of South West Africa and Namaqualand. Precambr. Res. Unit, Univ. Cape Town, 159 p.

MARTIN, H. and PORADA, H. (1977): The intracratonic branch of the Damara Orogen in South West Africa. I. Discussion of geodynamic models. Precambr. Res., 5, 311 - 338.

McELHINNY, M.W. (1966): An improved method for demagnetising rocks in alternating magnetic fields. Geophys. J.R. astr. Soc., 10,369-374.

McELHINNY, M.W. and McWILLIAMS, M.O. (1977): Precambrian geodynamics - a palaeomagnetic view. Tectonophysics, 40, 137 - 159.

McELHINNY, M.W., GIDDINGS, J.W. and EMBLETON, B.J.J. (1974): Palaeomagnetic results and late Precambrian glaciations. Nature, 248.

MILLER, R. McG. (1973): The Salem Granite Suite, South West Africa: genesis by partial melting of Khomas schists. Mem. geol. Surv. S. Afr., 64, 97 p.

MILLER, R. McG. (1979): The Okahandja lineament, a fundamental tectonic boundary in the Damara Orogen of South West Africa/Namibia. Trans. geol. Soc. S. Afr., 82, 349 - 361.

MOLYNEUX, L. (1971): Research note: A complete result magnetometer for measuring the remanent magnetisation of rocks. Geophys. J.R. astr. Soc., 24, 429 - 434.

NAGATA, T. (1961): Rock magnetism. Maruzen Company Ltd., Tokyo.

O'REILLY, W. and BANERJEE, S.K. (1967): Mechanism of oxidation in titanomagnetites, a magnetic study. Mineral Mag., 36.

RAMBERG, H. (1967): Gravity deformation of the Earth's crust. London Academic Press, 214 p.

ROERING, C. (1961): The mode of emplacement of certain Li- and Be-bearing pegmatites in the Karibib district, South West Africa. Inf. Circ. Econ. Geol. res. Unit. 4, Univ. Witwatersrand, 38 p.

SAWYER, E.W. (1978): Damaran structural and metamorphic geology of an area southeast of Walvis Bay, S.W. Africa/Namibia. (Unpubl.) M.Sc. thesis Univ. of Cape Town, 205 p.

SMITH, D.A.M. (1965): The geology of the area around the Khan and Swakop Rivers in South West Africa. Mem. geol. Surv. S. Afr., 3, (S W A Series), 113 p.

SOUTH AFRICAN COMMITTEE FOR STRATIGRAPHY (1980): In : Lithostratigraphy of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda, Compl., Kent, L.E., Handb. geol. Surv. S. Afr., 8.

STACEY, F.D. and BANERJEE, S.K. (1974): The physical principles of rock magnetism. (Developments in Solid Earth Geophysics series, No. 5), Elsevier, Amsterdam.

STUPAVSKY, M. and SYMONS, D.T.A. (1978): Separation of magnetic components from AF demagnetisation data by least squares computer methods. J. Geophys. Res., 83, No B10, 4925 - 4931.

TALWANI, M. and HEIRTZLER, J.R. (1964): Computation of magnetic anomalies caused by two dimensional structures of arbitrary shape. Computers in the Mineral Industries. Publ. by the School of Earth Sciences, Stanford Univ.

TALWANI, M., WORZEL, J.L. and LANDISMAN, M. (1959): Rapid gravity computations for two-dimensional bodies with application to the Mendocino submarine fracture zone. J. Geophys. Res., 64(1).

VERHOOGEN, J. (1962): Oxidation of iron-titanium oxides in igneous rocks. J. Geol., 70.

VON BACKSTRÖM, J.W. (1970): The Rössing Uranium Deposit near Swakopmund, South West Africa. Uranium Exploration Geology. Int. Atomic Energy Agency, Proc. of a Panel, Vienna.

VON BACKSTRÖM, J.W. and JACOB, R.E. (1979): Uranium in South Africa and South West Africa. Phil. Trans. R. Soc. Lond. A., 291, 307 - 319.

WILSON, R.L. and LOMAX, R. (1972): Magnetic remanence related to slow rotation of ferromagnetic material in alternating magnetic fields. Geophys. J.R. astr. Soc., 30, 295 - 303.

ZIJDERVELD, J.D.A. (1967): A.C. demagnetisation of rocks: Analysis of results. In : Developments in solid earth geophysics, vol. 3, Methods in Palaeomagnetism, eds. Collinson, Creer, Runcorn, Elsevier, 254 - 286.

10. SELECTED BIBLIOGRAPHY

AHRENDT, H., HUNZIKER, J.C. and WEBER, K. (1978): Age and degree of metamorphism and time of nappe emplacement along the southern margin of the Damara Orogen, Namibia (South West Africa). Geol. Rdsch., Band 67, Heft 2, 719 - 742.

BERNER, H., RAMBERG, H. and STEPHANSSON, O. (1972): Diapirism in theory and experiment. Tectonophysics, 15, 197 - 218.

BRIDEN, J.C. (1970): Palaeomagnetic polar-wander curve for Africa. Palaeogeophysics, Ed., Runcorn, S.R., Academic Press, London.

CANN, J.R. (1970): Upward movement of granitic magma. Geol. Mag., 107(4), Printed in G. Britain.

DENNIS, J.G. and JACOBY, W.R. (1980): Geodynamic processes and deformation in orogenic belts. Tectonophysics, 63, 261 - 273.

ELLIS, J.R., AUSTIN, S.R. and DROULLARD, R.F. (1968): Magnetic susceptibility and geochemical relationships as uranium prospecting guides. U.S. Atomic En. Comm. Publ. AEC-RID-4, Grand Junction, Colorado.

EMBLETON, B.J.J. and VALENCIO, D.A. (1977): Palaeomagnetism and the reconstruction of Gondwanaland. Tectonophysics. 40, 1 - 12.

ESKOLA, F.E. (1949): The problem of mantled gneiss domes. Jour. Geol. Soc., vol. 104(4), On Mantled Gneiss Domes, London.

GEOLOGICAL MAP OF SOUTH WEST AFRICA/NAMIBIA (1980): Geol. Surv. S. Afr.

McCUNN, H.J. (1973): Vertical uplift explanation for plate tectonics. Bull. Am. Ass. Petro. Geol., 57(a), 1644 - 1657.

McELHINNY, M.W. (1973): Palaeomagnetism and plate tectonics. Cambridge Univ. Press.

McELHINNY, M.W. and COWLEY, J.A. (1977): Palaeomagnetic directions and pole positions - XIV, Pole numbers 14/1 to 14/574. Geophys. J.R. astr. Soc., 49, 313 - 356.

McELHINNY, M.W. and COWLEY, J.A. (1978): Palaeomagnetic directions and pole positions - XV, Pole numbers 15/1 to 15/232. Geophys. J.R. astr. Soc., 52, 259 - 278.

MILLER, R. McG., KLEIN, J.A., WATSON, N.I., and BRANDT, R. (in prep.): The Damaran Granites. Damara NGP Vol., Publ. by Geol. Soc. S.A.

NASH, C.R. (1971): Metamorphic petrology of the SJ area, Swakopmund district, South West Africa. Bull. Precambrian Res. Unit, Univ. Cape Town, 9, 77 p.

SCHMIDT, P.W. and MORRIS, W.A. (1977): An alternative view of the Gondwana Palaeozoic apparent polar-wander path. Can. J. Earth Sci., 14, 2674 - 2698.

SCHOEMAN, P.J. (1970): Die Geologie van 'n gebied Noord van die Omaruru-delta Suidwes-Afrika. Unpubl. M.Sc. Thesis, Univ. Orange Free State, Bloemfontein.

TUCKER, P. and O'REILLY, W. (1980): The acquisition of thermoremanent magnetisation by multidomain single-crystal titanomagnetite. Geophys. J.R. astr. Soc., 60, 21 - 36.

TOENS, P.D. (1975): The geology of part of the southern foreland of the Damara Orogenic Belt in South West Africa and Botswana. Geol. Rdsch., 64, 175 - 192.

TOENS, P.D. (1974): Continents Apart. In : 'Nuclear Active' S. Afr. Atomic Energy Board Spec. Publn., Pretoria.

TOENS, P.D., OOSTHUYZEN, E.J., JACOB, R.E., BRITZ, R.J.N., HAMBLETON-JONES, B.B. and SMIT, M.C.B. (1979): A mineralogical, petrological and geochemical study of a suite of rocks from the Damara Orogenic Belt, South West Africa. S. Afr. Atomic Energy Board Rep. PEL-269, Pretoria.

VAN DER VOO, R. and CHANNELL, J.E.T. (1980): Palaeomagnetism in orogenic belts. Rev. Geophys. Space Phys., 18, 455 - 481.

WYNNE-EDWARDS, J.R. (1976): Proterozoic ensialic orogenesis: The millipede model of ductile plate tectonics. Am. J. Sci., 276, 927 - 953.

Fig 3 Aeromagnetic colour-composite map of portion of the Damara Orogenic Belt

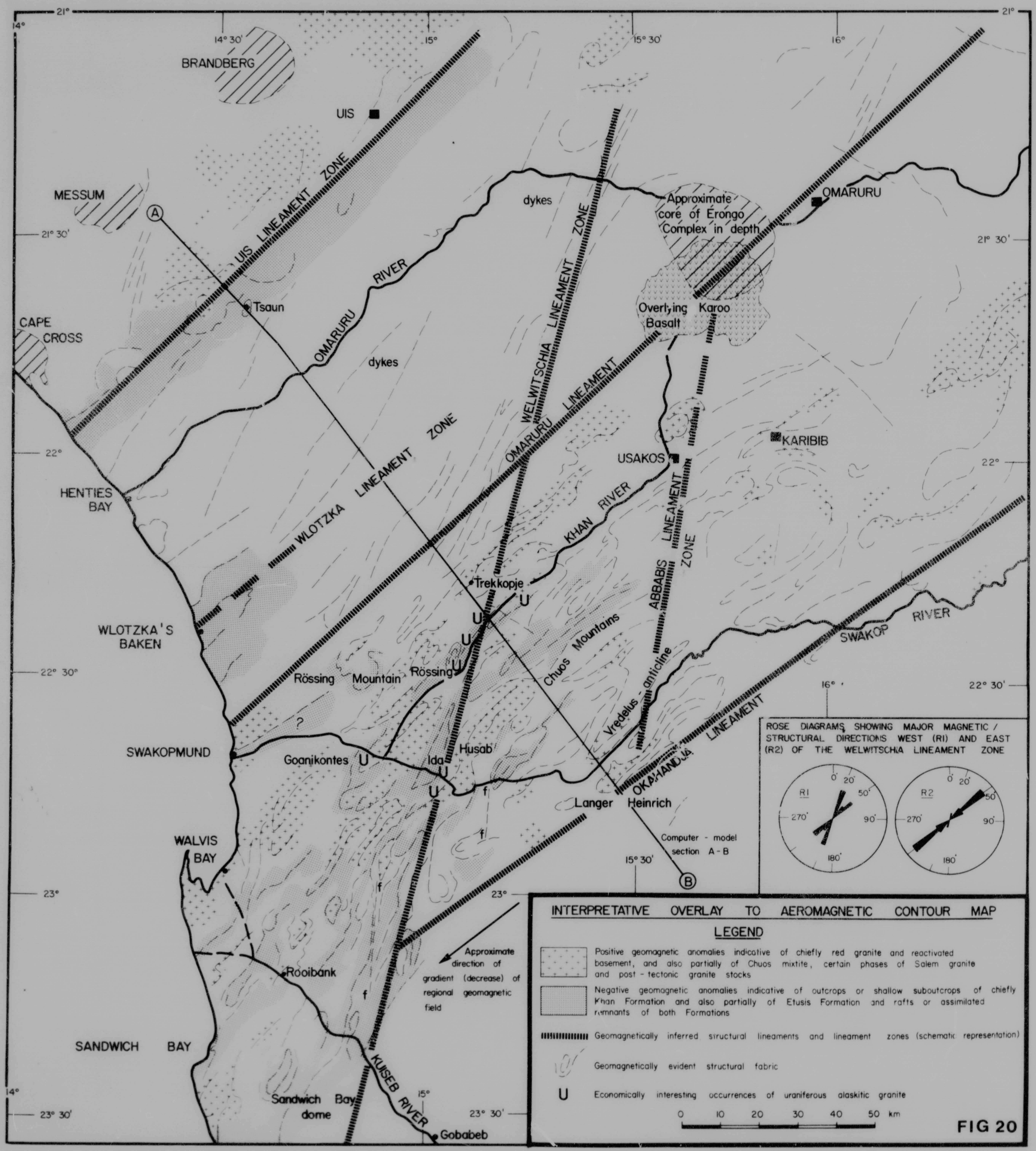

21°
14°
14° 30'
15°
15° 30'
16°
BRANDBERG
UIS
UIS LINEAMENT ZONE
MESSUM
21° 30'
A
Tsaun
CAPE CROSS
OMARURU RIVER
dykes
Approximate core of Erongo Complex in depth
OMARURU
Overlying Karoo Basalt
WELWITSCHIA LINEAMENT ZONE
OMARURU LINEAMENT
22°
HENTIES BAY
WLOTZKA LINEAMENT ZONE
USAKOS
KARIBIB
KHAN RIVER
ABBABIS LINEAMENT ZONE
Trekkopje
WLOTZKA'S BAKEN
22° 30'
Rössing Mountain
Rössing
Chuos Mountains
Vredelus - anticline
SWAKOP RIVER
SWAKOPMUND
Goanikontes
Ida
Husab
OKAHANDJA LINEAMENT
Langer Heinrich
Computer - model section A - B
B
WALVIS BAY
23°
15° 30'
Rooibank
SANDWICH BAY
KUISEB RIVER
Sandwich Bay dome
Gobabeb
23° 30'
ROSE DIAGRAMS SHOWING MAJOR MAGNETIC / STRUCTURAL DIRECTIONS WEST (R1) AND EAST (R2) OF THE WELWITSCHIA LINEAMENT ZONE
R1
R2
0° 20° 50° 90° 180° 270°
INTERPRETATIVE OVERLAY TO AEROMAGNETIC CONTOUR MAP
LEGEND
Positive geomagnetic anomalies indicative of chiefly red granite and reactivated basement, and also partially of Chuos mixtite, certain phases of Salem granite and post - tectonic granite stocks
Negative geomagnetic anomalies indicative of outcrops or shallow suboutcrops of chiefly Khan Formation and also partially of Etusis Formation and rafts or assimilated remnants of both Formations
Geomagnetically inferred structural lineaments and lineament zones (schematic representation)
Geomagnetically evident structural fabric
U Economically interesting occurrences of uraniferous alaskitic granite
0 10 20 30 40 50 km

FIG 20