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Note: Mafic dykes in the pre-Damara basement, south-east of Usakos, central Namibia

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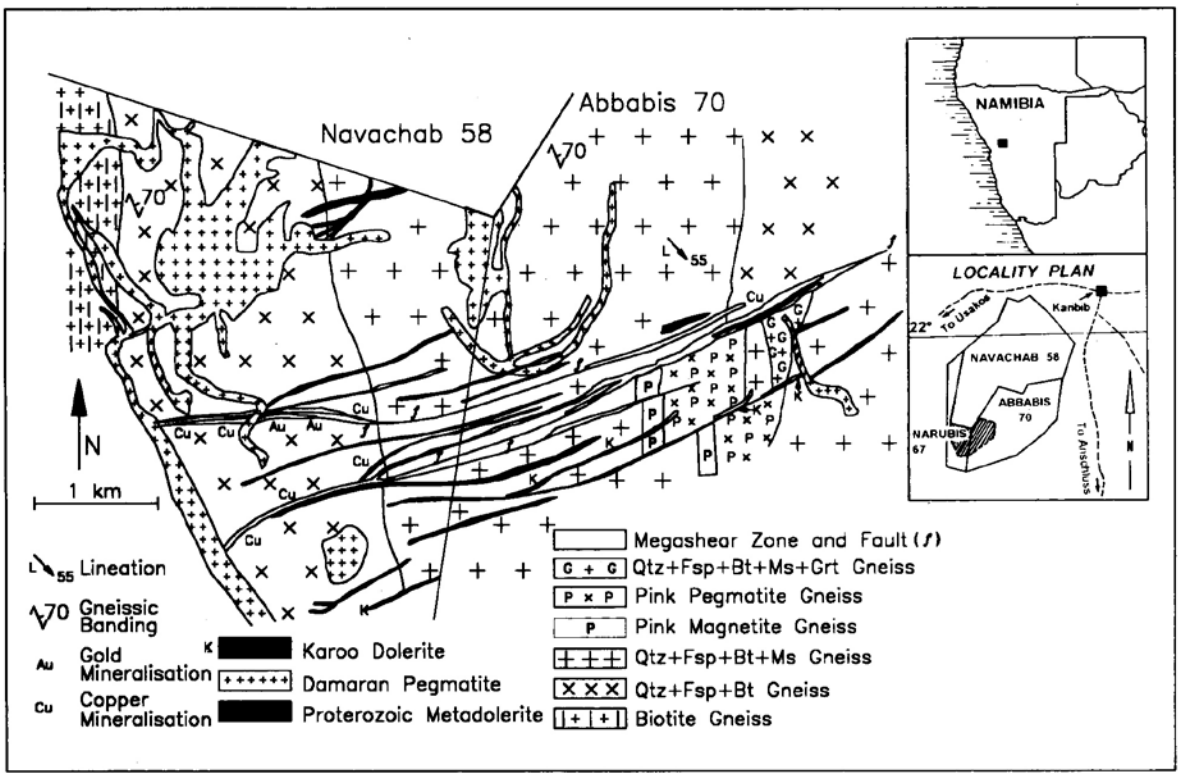

Figure 1: Simplified geological map of a portion of the Abbabis Inlier, south-west of Usakos (after Steven, 1993)

Introduction

The aim of this note is to draw attention to an ENE-trending, late Proterozoic metadolerite swarm that occurs 25 km south-east of Usakos in pre-Damara basement. The dolerites were first recorded by Gevers (1931) who described sills and sheets with relict ophitic texture and possible amygdales in the 'Abbabis System'. The swarm appears to crosscut large tracts of basement gneiss which underlie the southern Central Zone (CZ) of the Damara Orogen and to be largely responsible for the ENE-trending magnetic grain (Corner, 1983) of this terrane. The dykes run parallel to sub-vertical mega-shears (a recently identified shear belt; Steven, 1993) and are spatially associated with shear zone-hosted gold mineralisation. The Usakos metadolerites bear similarities with a mafic dyke swarm near Swakopmund (Jacob, 1988, pers. comm.). A possible relationship with the Gannakouriep dyke swarm of southern Namibia (Hunter and Reid, 1987; Ransome, 1991; Reid *et al.*, 1991) is discussed.

Geological setting

The metadolerites intrude pre-Damara basement gneisses of the Abbabis Inlier on the farms Abbabis 70, Narubis 67 and Navachab 58 (Fig. 1). The host rocks are members of the 1.9 Ga old (Jacob *et al.*, 1978) Narubis Granitoid Complex (Brandt, 1987). The metadolerites are intruded parallel to major ENE-trending shear zones that show evidence for significant lateral displacement (Steven, 1993). Dyke emplacement occurred along lines of pre-existing weakness in the basement, but post-dated the development of the mega-shears. As far as can be determined from the fairly good exposure in the Usakos-Karibib area, dykes do not crosscut the overlying late Proterozoic Damaran sequence, but are themselves cut by pegmatite sills (Steven, 1993) that are almost certainly of late Damaran age (Haack and Gohn, 1988). However, at the type locality of the Pan-African Daheim Formation mafic lavas and pyroclastic rocks north of Karibib (where basement rocks are not exposed at surface but are indicated from the aeromagnetic data to underlie the region; Corner 1983), a case could be made

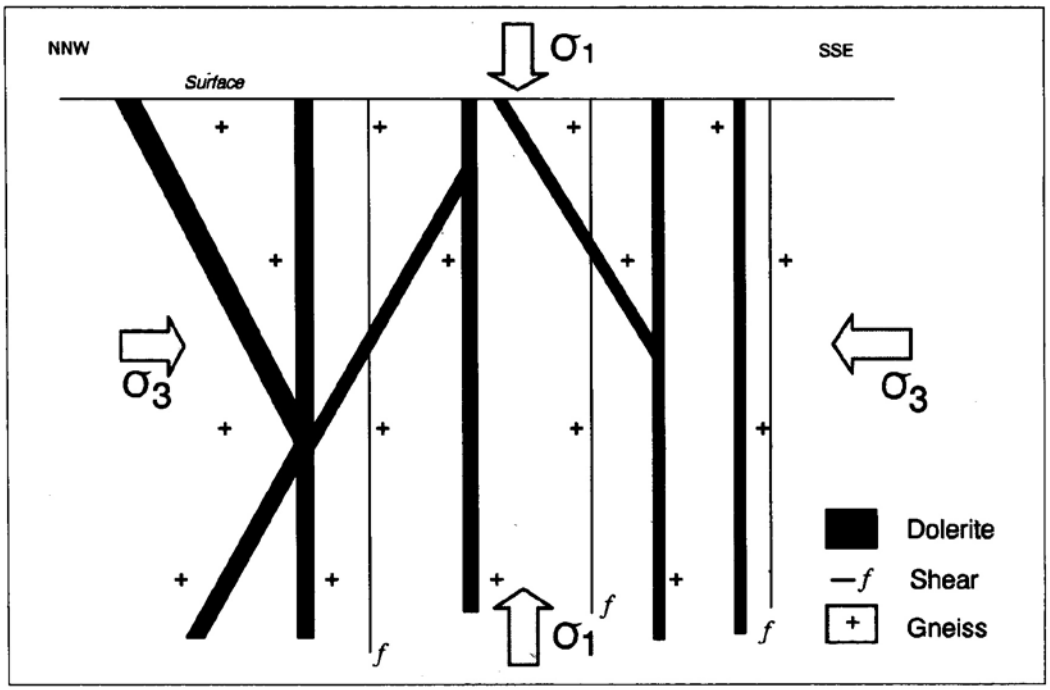

Figure 2: Cross-section showing orientation of metadolerites in the Abbabis Inlier and indicated stress field at the time of their emplacement

for a relationship between the mafic dyke swarm and the Damaran volcanic rocks (see discussion below).

Nature and petrography of the metadolerites

The majority of the metadolerites are subvertical dykes, though there are minor conjugate sets that dip 60° to the NNW and SSE. Dykes are up to several tens of metres wide and there are approximately 8-10 intrusions per kilometre. They have undergone greenschist facies metamorphism and minor post-crystallisation deformation. The term metadolerite is preferred over ortho-amphibolite because their intrusive nature can be seen readily in the field. A small number of dykes possess a faint foliation but the majority are unfoliated and comprise actinolitic hornblende, plagioclase, minor quartz, K-feldspar, opaques and traces of epidote, chlorite and malachite. Biotite comprises up to ten modal per cent in what appears to be an older generation of metadolerite dyke (as determined from crosscutting relationships), but none of the mica appears to be primary. In these earlier dykes, strained, primary (igneous) andesine-labradorite laths up to 5 mm long are surrounded by randomly oriented metamorphic amphibole and biotite. Dykes with significant modal biotite are presumably more potassic, but whether this is a reflection of the alkaline affinity of the magma from which the dolerite crystallised or results from metasomatism associated with the Damaran orogeny is unknown. A distinctive lithotype intimately associated with the metadolerites in the vicinity of shear zones is enigmatic, coarse-grained, orbicular aggregates of anthophyllite, chlorite and magnetite. In common with the shear zones, these anthophyllite-chlorite-magnetite rocks possess anomalous gold contents (up to 1 g/t Au).

Significance of the Usakos dyke swarm

Three points of interest are emphasised. The first of these is that there seems little doubt that emplacement of the Usakos metadolerite swarm is related to rifting because the conjugate dyke geometry is suggestive of an extensional regime (Fig. 2). The Damara Sequence rests on rifted continental crust (Fig. 3; Miller, 1983). North-east/east-northeast-trending faults played a major role in controlling sedimentation in central Namibia (Miller, 1983; Steven, 1993). In the Central Zone of the Damara Orogen near Usakos, one of these structures, the Omaruru Lineament, marks a monoclinal downfold of stratigraphy on the northern side of the Abbabis Inlier (Fig. 3). Thus the dyke swarm appears to mark the hinge zone of Damaran rifting in the Central Zone. Dating of these dolerites would place time constraints on the rifting that occurred at the start of the Damaran episode. The earliest Damaran sediments may have accumulated between 900 and 1000 Ma ago (Miller, 1983), but the earliest reliable time constraint is provided by V-Pb ages of 730-750 Ma for zircons in the Naauwpoort Formation alkali rhyolites (Miller and Burger, 1983) at the top of the Nosib Group. This Naauwpoort age is not a maximum age of the Damara Sequence.

Secondly, not all of the metadolerites in the Abba-

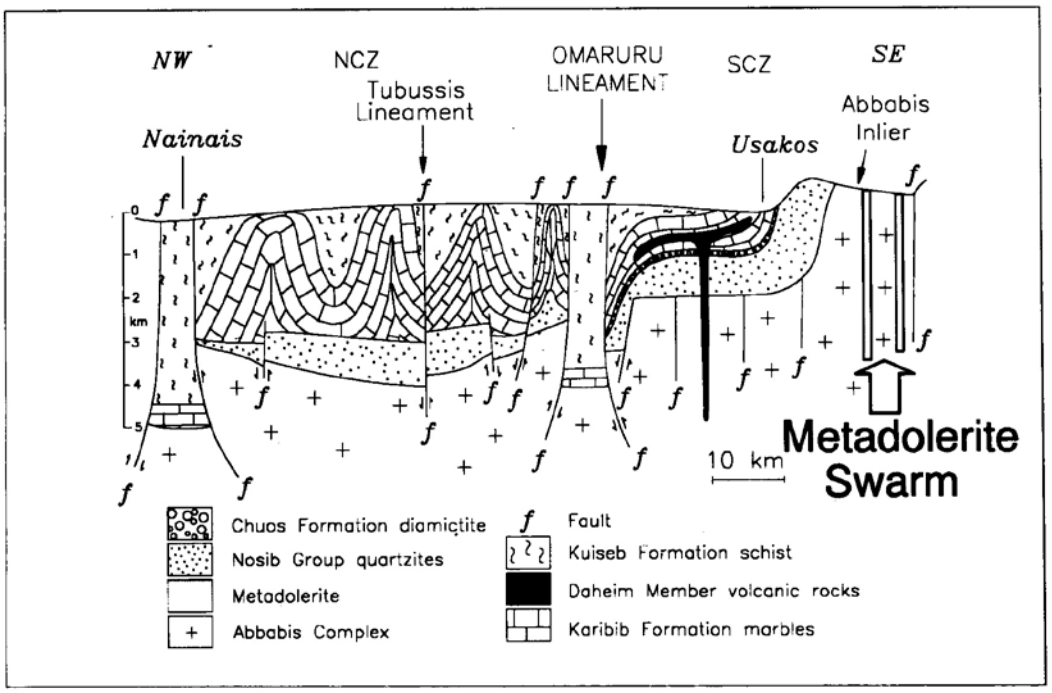

Figure 3: Cross-section through the Central Zone of the Damara Orogen showing basement faults and metadolerite swarm in the underlying mid-Proterozoic basement (after Steven, 1993). Note feeder to Daheim Member volcanic rocks.

bis Inlier are necessarily of pre-/early-Damaran age. Some of the swarm may have been the feeder zone for the Pan-African Daheim Member (Karibib Formation) mafic lavas and pyroclastic rocks (Fig. 3) that crop out on the northern side of the Abbabis Inlier. Pirajno and Jacob (1991) consider that gold was leached from these volcanic rocks and subsequently redistributed and concentrated in a stockwork of marble-hosted auriferous quartz veins at the Navachab Gold Mine and the Onguati and Brown Mountain Prospects.

Thirdly, Smith (1965), Kröner (1982) and Steven (1993) described the presence of enigmatic hornblendite and differentiated gabbro inclusions (Miller, 1983) in late Damaran granites and pegmatites. Derivation of these xenoliths from late Proterozoic dykes in the underlying basement might be a plausible explanation.

	Gannakouriep	Usakos
Swarm Length	300 km	130 km
Swarm Width	~150 km	>15 km
Orientation	N/NE-trending	ENE-trending
Dyke Thickness	5-1000 m	1-30 m
Oldest Host	2.0 Ga	1.9 Ga
Intrude Pan-African?	basal Stinkfontein	*not as far as can be ascertained
Composition	gabbro, dolerite mildly alkaline	dolerite (mildly alkaline?)
Primary Cpx	yes	no
Emplacement Age	717 Ma	?

Table 1: Features of the Gannakouriep (Reid *et al.*, 1991) and Usakos mafic dyke swarms

*a possible relationship with the Daheim Formation is discussed in the text

Comparison with the Gannakouriep dyke swarm

The rifting that initiated the Pan-African event elsewhere in Namibia was accompanied by mafic magmatism. The Gannakouriep mafic dyke swarm that straddles the South African/Namibian border was intruded during crustal extension associated with the early phases of the late Precambrian Gariepian orogeny (Reid *et al*., 1991). A full discussion of late Proterozoic dyke emplacement in southern and central Namibia is beyond the scope of this note, but the most obvious features of the Gannakouriep (Reid *et al.*. 1991) and Usakos swarms are summarised in Table 1. If the Usakos dykes extend to the Namibian coast near Swakopmund, the swarm has a length of 130 km. An Rb-Sr internal isochron age of 717 ± 11 Ma obtained on unmetamorphosed relict gabbro was considered by Reid *et al.* (1991) to be an emplacement age for the Gannakouriep swarm and provided a direct age constraint on the Gariep. Dolerites in southern Namibia intrude the basal Stinkfontein Formation of the Pan-African Gariep Group which was already steeply dipping prior to dyke emplacement (Reid *et al.*,

1991). In contrast, in the inland branch of the orogen, the available evidence indicates that dyke emplacement occurred *before* deposition of the Pan-African Etusis Formation (Nosib Group).

Conclusion

The mafic dyke swarm south-east of Usakos is thought to mark the start of Damaran rifting in the inland branch of the orogen in a similar manner to the Gannakouriep dykes, but possible connections between some of the metadolerites and Daheim metavolcanic rocks should also be investigated.

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References

Brandt, R. 1987. A revised stratigraphy for the Abbabis Complex in the Abbabis inlier, Namibia. *South African Journal of Geology*, **90** (3), 314-323.

Corner, B. 1983. An interpretation of the aeromagnetic data covering the western portion of the Damara Orogen in S.W.A./Namibia. *Special Publication of the Geological Society of South Africa*, **11**, 339-354.

Gevers, T.W. 1931. *The fundamental complex of western; Damaraland, South West Africa.* Unpublished D.Sc. thesis, University of Cape Town, 163 pp

Haack, U. and Gohn, E. 1988. Rb-Sr Data on some pegmatites in the Damara Orogen. *Communications of the Geological Survey of Namibia*, **4**, 13-18.

Hunter, D.R. and Reid, D.L. 1987. Mafic dyke swarms in southern Africa. *In*: Halls, H.C. and Fahrig, W.F., Editors, *Mafic dyke swarms*, Geological Association of Canada Special Paper **34**, 445-456.

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. *Geologische Rundschau*, **67**(2), 706-718.

Kröner, A. 1982. Rb-Sr geochronology and tectonic evolution of the Pan-African Damara Belt of Namibia, Southwestern Africa. *American Journal of Science*, **282**, 1471-1507.

Miller, R. McG. 1983. The Pan-African Damara Orogen of S.W.A./Namibia. *Special Publication of the Geological Society of South Africa*, **11**, 431-515.

Miller, R. McG. and Burger, A.J. 1983. U-Pb zircon age of the early Damaran Naauwpoort Formation. *Special Publication of the Geological Society of South Africa*, **11**, 267-272.

Pirajno, F. and Jacob, R.E. 1991. Gold mineralisation in the intracontinental branch of the Damara Orogen, Namibia. *Journal of African Earth Sciences*, **13**, 305-311.

Ransome, LG.D. 1991. *The geodynamics, kinematics and geochemistry of the Gannakouriep dyke swarm*. Unpublished M.Sc. thesis, Department of Geochemistry, University of Cape Town.

Reid, D.L., Ransome, LG.D., Onstott, T.C. and Adams, C.J. 1991. Time of emplacement and metamorphism of late Precambrian mafic dykes associated with the Pan-African Gariep orogeny, southern Africa: implications for the age of the Nama Group. *Journal of African Earth Sciences*, **13**, 531-541.

Smith, D.A.M. 1965. The geology of the area around the Khan and Swakop Rivers in S.W.A. *Memoir of the Geological Survey of South Africa, South West Africa Series*, **3**, 113 pp.

Steven, N.M. 1993. A study of epigenetic mineralisation in the Central Zone of the Damara Orogen, Namibia with special reference to gold, tungsten, tin and rare earth elements. *Memoir of the Geological Survey of Namibia*, **16**, 166 pp.