Communs geol. Surv. Namibia, **8** *(1992/93), 157-160*

Note: Age of supergene ore bodies at Berg Aukas and Harasib 3a, Namibia

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Introduction

Most of the vanadium-rich ore bodies in the Otavi Mountainland, northern Namibia, are spatially related to Mississippi-type heavy metal sulphide ores emplaced in dolomites during the Palaeozoic. Most geologists have realised that the vanadium-rich bodies did not form at the same time as the sulphides, but that they accumulated in karst features developed sometime later. Estimates of the period of vanadium enrichment

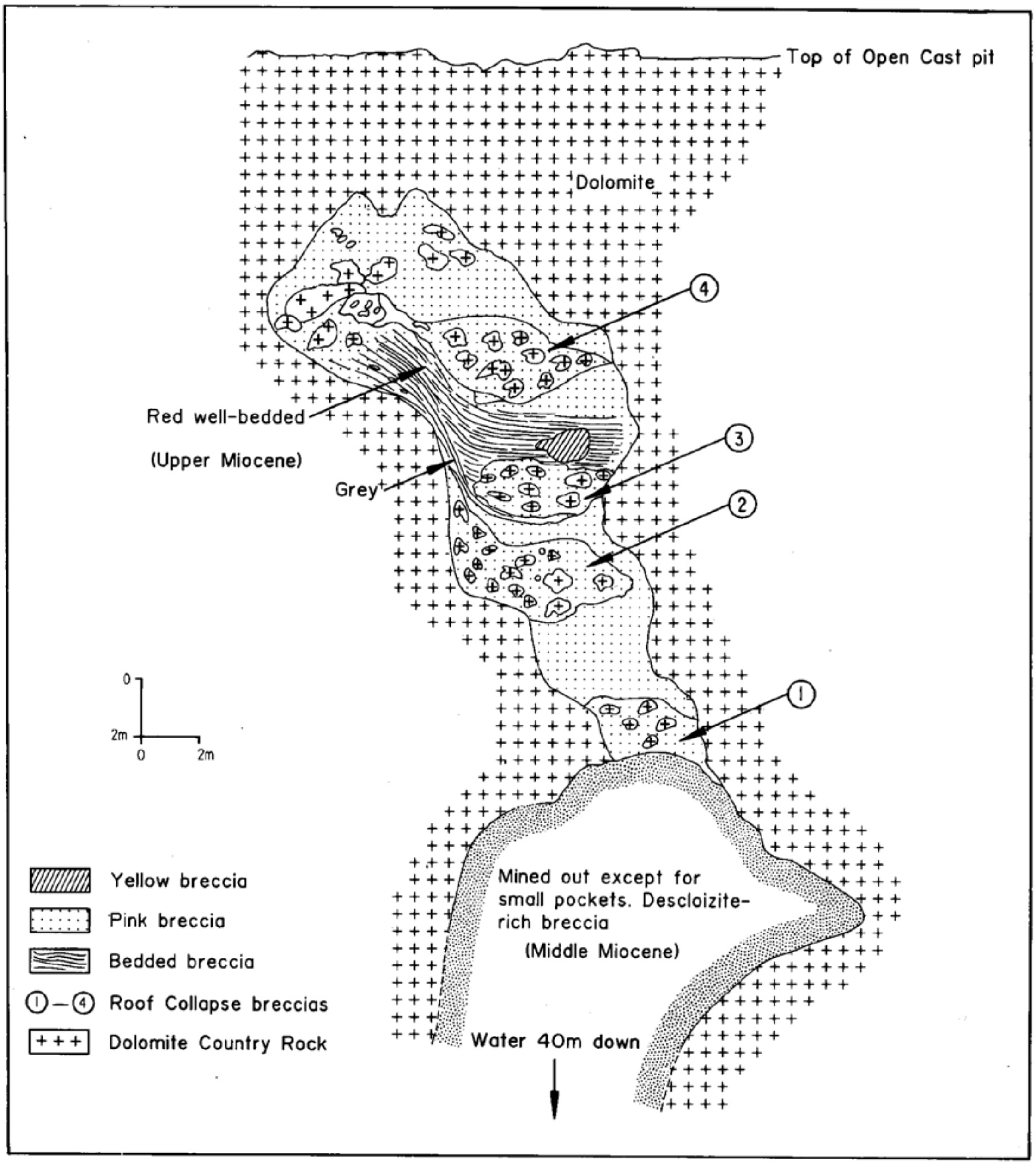

Figure 1: Field sketch of south wall of opencast pit at Central Ore Body (COB), Berg Aukas, Namibia. Note the stratified sediments infilling a cavern system developed in the dolomite country rock. The largely mined-out lower strata were rich in descloizite and mammalian fossils of middle-Miocene age

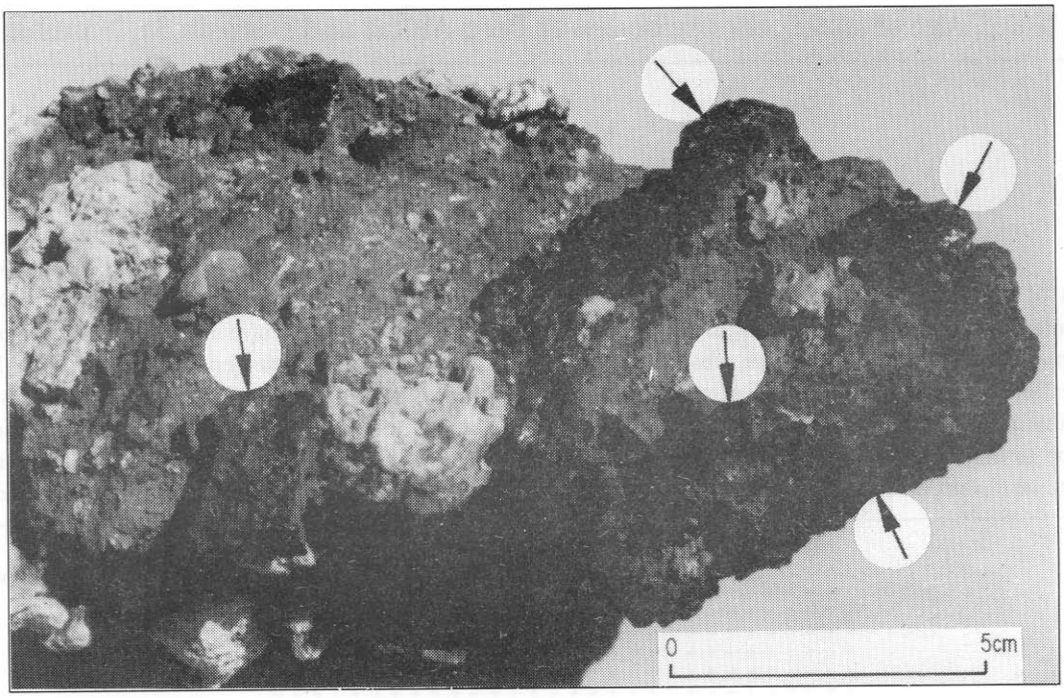

Figure 2: Photograph of a block of descloizite-rich breccia from Berg Aukas, Namibia (BER 42'92), containing middle-Miocene fossils. Note that a layer of euhedral descloizite crystals completely surrounded a block of fossil-rich breccia and that the ensemble is in turn surrounded by more fossiliferous breccia

vary greatly, more cautious workers such as Misiewicz (1988) citing only a post-Damaran genesis, whilst many other researchers have either failed to make an estimate or have indicated broadly Mesozoic or Tertiary ages for the supergene enrichment. Van der Westhuizen (1984) favoured a Tertiary age for genesis of the vanadium ores on the basis of geomorphological evidence and the absence of Karoo Sequence rocks in the Otavi karstfills. Verwoerd (1957) recognised that vanadium deposition occurred substantially later than sulphide emplacement and that it was related to karst fillings. He concluded that there were two major stages of supergene activity separated from the prior hypogene deposits by a long period of time. He considered that descloizite mineralisation occurred during the early phase of supergene activity and that it was contemporaneous with the deposition of desert sands in the cave systems, but he did not venture to provide a detailed estimate of the age of this activity. Van der Westhuizen *et al.* (1988) reported that the Otavi vanadium mineralisation was temporally related to Qua-ternary karstification.

Following palaeontological study of several of the vanadium-bearing karst fillings in the Otavi Mountainland, we are now in a position to provide a more detailed estimate of the age of supergene ore genesis, or rather of its later stages.

Fossiliferous cave breccias were found at two of the Otavi vanadium occurrences, Berg Aukas and Harasib 3a. The former is one of the largest vanadium ore bodies ever found, while the latter is an apparently uneconomic prospect, the scientific importance of which, nevertheless, is exceptional.

At both Berg Aukas and Harasib 3a the vanadium mineralisation is intimately associated with secondary karst fillings of various sorts, most of the sediment having been introduced into the caves from the ancient land surface, although there is much dolomite and other rock derived by roof and wall collapse of the enclosing country rock (Fig. 1). At both occurrences, these vanadiferous breccias are fossiliferous (Tables I and II). In several instances blocks of fossil-rich breccia have been found which are entirely enclosed by crusts of large descloizite crystals which are in turn enclosed in fossiliferous breccia (Fig. 2). In sample Ber 42'92 from Berg Aukas, the descloizite crystals can be seen to have grown on a chunk of fossil-rich pink breccia, the base of the crystals precisely moulding the original shape and surface texture of the breccia. On the outer surface the crystals are euhedral, suggesting growth without external hindrance. Because the descloizite encloses fossiliferous breccia, and is in its turn enclosed by similar fossil-bearing breccia, the age of descloizite crystallisation can be tied down precisely.

Berg Aukas

The breccias at Berg Aukas range in age from middle Miocene to Holocene (Comoy *et al.*, 1992; Senut *et al.*, 1991). A remnant of the original cave stratigraphy can be observed in the south wall of the Central Ore Body (COB) (Misiewicz, 1988: Plate 28) which is middle Miocene at the base and upper Miocene near the surface (Fig. 1). Pleistocene fillings appear to have been entirely mined out, though abundant blocks occur in the mine dump. Holocene breccias occur in a cave at the top of Berg Aukas. Study of many descloizite-rich breccia blocks reveals that all of them are middle Miocene in age, probably about 13 ± 1 Ma., and that upper Miocene, Pliocene, Pleistocene and Holocene breccias are either devoid of descloizite or contain only reworked and broken crystals and crystal masses. It is concluded therefore that a major portion of the Berg Aukas descloizite deposit formed late in the middle Miocene, and furthermore, that the period of genesis was relatively short, perhaps 1-2 million years.

It is interesting to note that the breccias contain many chiropteran bones and teeth, suggesting that the COB Cave was inhabited by bats. In most such caves, thick deposits of guano can form, unless the bat droppings are flushed away by underground waters. The possible role that bat guano, which is acidic and rich in phosphates, had upon ore genesis has yet to be considered. Other mammals found in the breccias indicate that the climate in the Otavi region during the middle Miocene was appreciably more humid than it is today.

Harasib 3a

Harasib 3a is a large prospect pit which yielded bright-red breccias containing large descloizite crystals of very much the same appearance as those found at Berg Aukas. Most of the crystals appear to be reworked from a pre-existing ore occurrence, although there are some blocks which contain primary descloizite filling vugs and cracks in the breccia. Fossils found in the breccias consist of typically upper Miocene micromammals, probably 9 ± 1 Ma. old (Senut *et al.*, 1991). As at Berg Aukas, chiropteran bones and teeth are common in the breccias. There are many more macroscelidian (elephant shrew) fossils at Harasib 3a than at Berg Aukas, suggesting perhaps that the climate was somewhat more arid than it was during the middle Miocene, but still more humid than it is today.

Primates	Otavipithecus namibiensis
Chiroptera	Megaderma sp.
	Hipposideros small
	Hipposideros medium
	Hipposideros commersoni
	Hipposideros indet.
	Rhinolophus 2 spp.
	Myotis sp.
	Molossidae indet.
Insectivora	Galerix sp.
	Macroscelididae sp.
Rodentia	cf *Apodecter* sp.
	cf Anomaluridae
	Vulcanisciurus sp.
	Sciuridae indet.
	cf *Notocricetodon* sp.
	cf *Protarsomys* sp.
	Myocricetodon 3 spp.
Carnivora	indet spp.

Table I: Faunal list of descIoizite-rich breccia, Berg Aukas, Namibia

Primates	Lorisidae indet.
Chiroptera	Rhinolophus sp.
Tenrecoidea	indet. sp.
Soricidae	indet. sp.
Macroscelidea	indet. sp.
Rodentia	cf *Apodecter* sp.
	cf *Paraulacodus* sp.
	Vulcanisciurus sp.
	Myocricetodon sp.
	Dendromuridae indet.
	Petromyscus sp.
	cf *Saccostomus* 2 spp.
	cf Nesomyinae sp.
	Karnimata sp.
	Bathyergidae sp.
	Graphiurinae
	Nakalimys lavocati

Table II: Faunal list of descIoizite-rich breccia, Harasib 3a, Namibia.

It is clear that both the Berg Aukas and Harasib 3a vanadium-rich ore bodies formed in caves which were open to the ancient land surface, and that ore genesis possibly occurred under temperature and pressure conditions not very different from atmospheric and hydrospheric conditions which occur in caves in humid regions of the world today. The introduction of organic matter, principally bat guano, may have played a role in ore genesis in such near surface deposits, although the spatial relation of vanadium deposits to sulphide deposits indicates that the latter may have had a more important influence upon the sites of ore emplacement. It could be that oxidation of the sulphides in the presence of water promoted karstification near the sulphide bodies by releasing acids into the enclosing dolomites, so that karst features tended to form preferentially close to sulphide bodies. However, more study needs to be done on this aspect of the Otavi ores. In this respect it is noted that fossiliferous karstfill breccias at Djebel Ressas (Lead or Bullet Mountain) in Tunisia (Mein and Pickford, 1992) are also spatially related to massive sulphide bodies which controlled the location of karstification in the enclosing dolomites.

Ore bodies at Abenab West and Baltika contain "sand fill" breccias said to contain aeolian sand which accumulated in karst settings. However these breccias proved to be azoic. Nevertheless, they possibly date from the same overall period as those from Berg Aukas and Harasib 3a.

In conclusion, the determination of the age of Otavi vanadium ore genesis as late middle Miocene (13 ± 1 Ma.) and early upper Miocene (9 ± 1 Ma.) temporally removes the vanadium ores from their close spatial partners, the Mississippi-type lead/copper/zinc deposits which are of Palaeozoic age. This temporal separation will have important implications on all theories of ore genesis in the Otavi Mountains.

Acknowledgements

I am anxious to acknowledge the help of my palaeontological colleagues Brigitte Senut, Pierre Mein, John Van Couvering and Glenn Conroy. S. Cloete draughted the sketch section and G. Brooker-Smith made the photograph of descloizite enclosing fossiliferous pink breccia. I thank Dr Brian Hoal for encouragement to publish this paper.

References

Conroy, G., Pickford, M., Senut, B., Van Couvering, J.A. and Mein, P. 1992. Otavipithecus hamibiensis, first Miocene hqminoid from southern Africa. *Nature*, **356**, 144-148.

Mein, P. and Pickford, M. 1992. Gisements karstiques pleistocenes au Djebel Ressas, Tunisie. *C. R. Acad. Sci. Paris*, **315**, 247-253.

Misiewicz, J.E. 1988. *The geology and Metallogeny of the Otavi Mountain land, Damara Orogen, SWA/ Namibia, with particular reference to the Berg Aukas Zn-Pb-V Deposit - a model of ore genesis*. MSc. Thesis, Rhodes University, Grahamstown.

Senut, B., Pickford, M., Mein, P., Conroy, G. and Van Couvering, J.A. 1992. Discovery of 12 new late Cainozoic fossiliferous sites in palaeokarsts of the Otavi Mountains, Namibia. *C.R. Acad. Sci. Paris*, **314**, 727,733.

Van der Westhuizen, W.A. 1984. *The nature, genesis and geochemistry of the supergene vanadium ores of the Otavi Mountain Land*. PhD. Thesis, Univ. Orange Free State, Bloemfontein.

Van der Westhuizen, W.A., Tordiffe, E.A.W., Loock, J.C. and De Bruiyn, H. 1988. Quaternary karstification and vanadium mineralization in the Otavi Mou.ntain Land, South West Africa/Namibia. *Palaeoecology of Africa, VIIIth SASQUA Conference*, **19**, 391-400.

Verwoerd, W.J. 1957. The mineralogy and genesis of the Lead-Zinc-Vanadium deposit of Abenab West in the Otavi Mountains, South West Africa. *Ann. Univ. Stellenbosch*, **33**, 235-319.