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# CONTRASTING STYLES OF SEDIMENTATION IN METASEDIMENTS OF THE KUISEB FORMATION NEAR GOROB, SWA/NAMIBIA

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**ABSTRACT**

The structural footwall of the Matchless Member amphibolites at Gorob Mine is formed by staurolite-kyanite/sillimanite bearing metasediments of the Kuiseb Formation. Although the sequence underwent at least three phases of deformation and despite the relatively high metamorphic grade corresponding to about 600°C/6 kb, different lithotypes with locally well preserved sedimentary structures display evidence for two distinct styles of sedimentation. Repeated graded units are common and suggest a turbiditic deposition. On the other hand, major metapsammite units are intercalated in a channel-like fashion within the metaturbidites. Locally, these metapsammites contain abundant, well defined lenticles which, nevertheless, have a composition similar to the host rocks. Field observations and petrographic evidence suggest that the lenticles were derived from originally discrete bodies, presumably soft-sediment clasts, ripped off in a deep-sea channel enviroment during the deposition of the turbiditic sequence.

## 1. INTRODUCTION

The investigated area is situated within the intracontinental branch of the Damara Orogen, about 1,5 km south-east of the abandoned mining settlement of Gorob (Fig. 1) and some 200 km south-west of Windhoek.

The structural footwall of the Matchless Member amphibolite is formed by metasediments of the Kuiseb Formation. These enclose the Vendome ore body (Fig. 2) which represents one of several copper prospects in the Gorob area.

Sawyer (1981) has outlined the deformational and metamorphic history of the area on a regional scale and Killick (1983) has given a very brief description of the country rocks of the Gorob ore lens (Fig. 1). Preserved sedimentary structures such as graded bedding in rocks of the Kuiseb Formation adjacent to the Matchless Member amphibolites have been recorded by Miller (1983) from the Rutile River gorge, about 60 km to the north-east.

The aim of this paper is to give a description of the sedimentary sequence enclosing the Vendome ore body and to point out the differences between the main types of metasediments. Special emphasis is devoted to isolated lenticular inclusions within massive psammitic schist units.

## 2. GENERAL GEOLOGY

In the Gorob area the southern band of the Matchless Member amphibolites has a variable thickness from 150 to 400 m (Fig. 1) and is intercalated with metasediments, particulary near its southern boundary. In addition, three strongly stretched and boudinaged layers of metagabbro crop out in the southern part of the area (Fig. 2).

Similar to the Gorob ore body (Killick, 1983), two distinct quartzitic layers enclosed by metasediments delineate the Vendome ore body. The- zonation of the latter, with a magnetite-quartzite forming the lower part, indicates that the sequence is overturned. Although the rocks of the Gorob area were affected by at least three

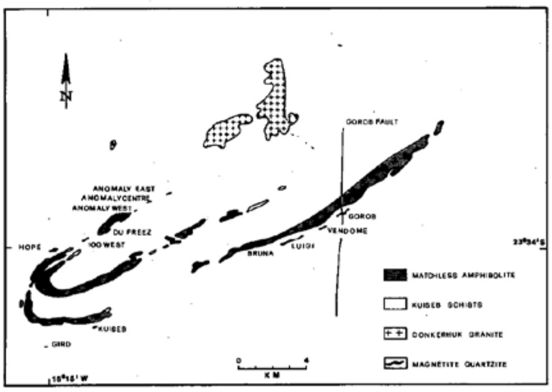


Fig. 1: The Gorob-Hope copper prospect. Ore bodies are indicated by the outcrops of the associated magnetite quartzites. After Hoffmann (1976).

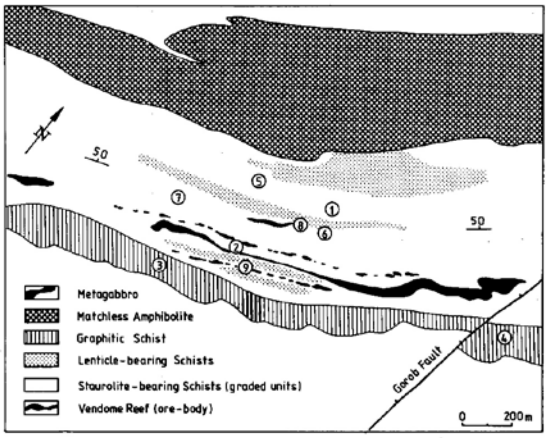


Fig. 2: Sketch map of the area around the Vendome ore body. The numbers in circles refer to locality numbers in the text.

phases of deformation and underwent metamorphism of relatively high grade, corresponding to temperatures of about 600°C and pressures of about 6 kb (Preussinger, 1987), original sedimentary structures are locally well preserved and units of different lithological character can be traced.

## 3. LITHOLOGY

### 3.1 Graded Units

During mapping it became apparent that the common interlayering of pelitic and psammitic schists represents repeated graded units ranging in thickness from 20 cm up to 10 m. They are best developed at localities 1, 2, 3, 4 and 5 (Fig. 2). The typical features of these graded units are summarized in Fig. 3. Each unit is limited by sharp lower and upper boundaries and normally comprises three intervals:

Interval I is formed by psammitic schist, consisting mainly of quartz and biotite and minor plagioclase, muscovite and garnet. Within this interval an often boudinaged layer of hornblende-garnet gneiss is commonly developed (Fig. 4).

Interval II is represented by coarser recrystallized quartz-biotite-staurolite-plagioclase schist often containing garnet. Staurolite porphyroblasts may reach 1 cm in size. Patches of quartz-biotite-garnet schist are common.

Interval III is formed by very coarse-grained biotite-staurolite-quartz schist with folded and boudinaged veins of quartz. The rims around these quartz boudings are characterized by a striking porphyroblastic recrystallization of biotite, garnet and staurolite.

These three intervals are not always fully developed, particulary in thinner units, in which the intervals I and II are dominant (Fig. 5), thus displaying a variable pelite/psammite ratio. The lateral development, however, is very constant.

Along the Gorob River the graded units are characterized by a high content of graphite which gradually decreases to the south. The boudinaged layers of hornblende-garnet gneiss of interval I are equivalent to what has been referred to as calc-silicate rock in the regional literature. In the Gorob area however, these rocks have no real calc-silicate composition and are here named hornblende-garnet gneiss according to their most conspicuous minerals. Large, often poikiloblastic hornblendes and garnets overgrow a matrix of fine-grained plagioclase and quartz. A few samples also have considerable amounts of epidote as part of the matrix. Very massive boudings of this rock type (up to 1 m thick) occur at localities 6 and 7.

Fig. 4: Intervals I and II of a 3 m thick graded unit from locality 3 with a very massive layer of hornblende-garnet gneiss. Graded bedding indicates normal way up.

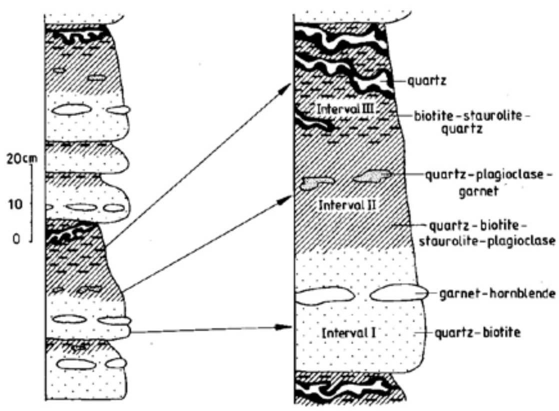


**Fig. 3: Profile of graded units observed at locality 2 and explanation of one idealized unit.**

### 3.2 Massive Metapsammite Units

Four major metapsammite units which are confined to three different areas have been mapped (Fig. 2). In contrast to the graded units, grading is very weakly developed locally, but normally absent. In general the rocks are very homogeneous on the scale of an outcrop. They are intercalated within the graded units in a channel-like fashion, varying in thickness over short distances. Even though some of these variations and interfingering with the graded units may be explained by folding locally, there is no obvious tectonic control on the complete thinning out of the metapsammites in places (Fig. 2). They may reach 80 m in thickness.

Clearly defined isolated lenticles occur in particular horizons, ranging in size from 0.2 x 1.0 x 2.5 cm to 4 x 35 x 60cm. They tend to weather out on rock sur-

Fig. 5: Graded units from locality 4. Only the intervals I and II are developed. Graded bedding indicates overturning of the sequence.

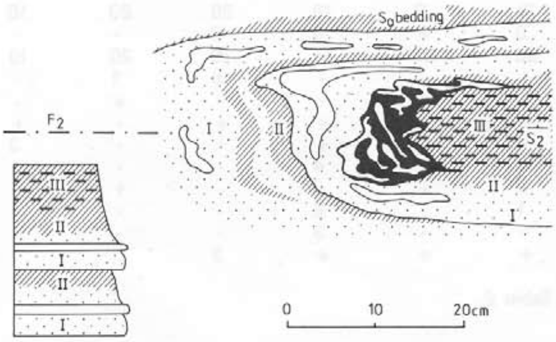


Fig. 6: Folded graded units observed in outcrop at locality 8 and hypothetical pre-deformational sedimentary column (left). Symbols as in Fig. 3.

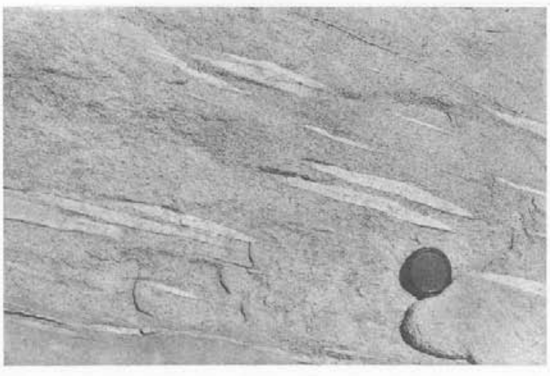

Fig. 7: Lenticles within a massive unit of metapsammites.

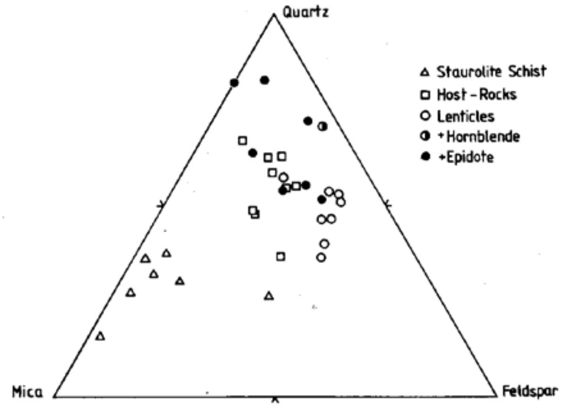


Fig. 8: Modal composition plot of lenticles, host rocks and staurolite schists (see Table 1 and 2).

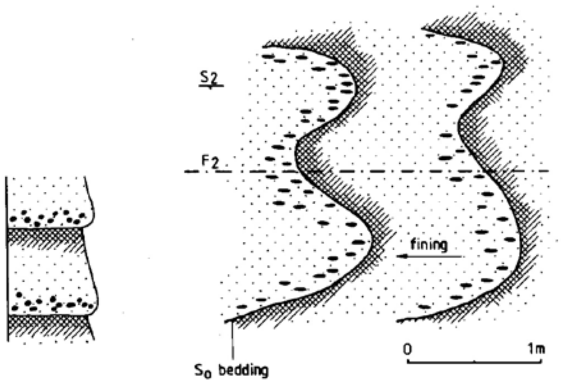


Fig. 9: Sketch plan of folded lenticle-bearing metapsammites from locality 8 and hypothetical pre-deformational sedimentary column (left).

face and are strongly aligned parallel to the S, foliation (Figs. 7 and 9). Although the lenticles are well-defined, they commonly have a composition similar to the enclosing host rocks. Quartz, plagioclase and biotite are the principal components of both lenticles and host rocks. Nevertheless, the amount of biotite is often lower in the lenticles while plagioclase is more abundant. A particular type of lenticle, however, is relatively poor in plagioclase but contains up to 36 volume per cent epidote (Fig 8). Many of the analysed lenticles (Table 2) contain chlorite, which partly or completely replaced biotite. This and the advanced alteration of plagioclase either to sericite or to epidote are characteristic features of the lenticles in thin section. With few exceptions, the lenticles are also rich in apatite. Similar features, interpreted as elongated pebbles, have been recorded by de Waal (1966, p. 164, Fig. 29) from the Kuiseb Formation near Aros.

## 4. DISCUSSION

The compositional variation of the graded units from a quartz-rich base to an aluminium-rich top is interpreted as reflecting a primary sedimentary grading and, hence, deposition by turbidity currents. The common interlayers of hornblende-garnet gneiss could be explained as detrital carbonate in the turbidites. The field relations of metapsammites and graded units favour an interpretation of the metapsammites as channel-fill deposits, but no Further classification (e.g. as grain flows) can be given, due to the lack of preserved sedimentary structures. The presence of discrete lenticles within these metapsammite units is of particular interest for establishing the mode of deposition of the metasedimentary sequence in the Gorob area. For the latter the following models may be considered:

a) They represent tectonically disrupted layers (e.g. boudins) initially formed by
   - sedimentary interlayering
   - or metamorphic segregation.
b) The lenticles are derived from originally discrete bodies such as
   - clastic fragments
   - or concretionary nodules.

To discriminate between these alternatives the following features are important:

1. The lenticles are neither metamorphosed (impure) limestones nor metamorphosed cherts and thus cannot be derived from these common compositional types of concretionary nodules.
2. In contrast to the boudins of calc-silicate frequently occurring in the Kuiseb Formation (Porada, 1973) and of hornblende-garnet gneiss in the Gorob area and other parts of the Kuiseb Formation, the lenticles show minor compositional differences to their psammitic host rocks. Therefore, in the absence of competency contrast there is no reason for them to have been formed by boudinage processes.
3. Even in fold hinges the lenticles are strongly flattened parallel to $S_2$. The bedding/foliation angle has no influence on shape and orientation of the lenticles. In contrast to folded and boudinaged layers of hornblende-garnet gneiss in the area, the lenticles are not arranged conformably with the general textural pattern, as shown in Figs. 6 and 9. In some cases, clearly-defined bedding planes are exposed next to the lenticles at high angle to their orientation (Fig. 9). If the lenticles were disrupted layers, the bedding planes should be disrupted the same way.
4. In places the lenticles are partly resorbed or cut by segregation veins, which were themselves folded by $F_2$. Consequently the veins are pre-$D_2$ features and, accordingly, the lenticles must be still older, presumably premetamorphic features.
5. In some cases weak grading can be recognized within the otherwise homogeneous metapsammite units. In these cases the lenticles are more abundant in the lower parts of the units.

In the light of these features, we conclude that the lenticles are derived from originally discrete bodies.

TABLE 1: Modal Composition of Host Rocks

| Sample HP | 4 | 80* | 94 | 95* | 97 | 98* | 103* | 104/1* | 105/2* |
|---|---|---|---|---|---|---|---|---|---|
| Volume % | | | | | | | | | |
| quartz | 51 | 48 | 62 | 46 | 66 | 40 | 53 | 58 | 59 |
| plagioclase | 24 | 18 | 20 | 21 | 9 | 18 | 26 | 20 | 16 |
| muscovite | - | + | - | 3 | + | 6 | 2 | - | - |
| biotite | 19 | 29 | 17 | 26 | 23 | 18 | 10 | 20 | 19 |
| chlorite | - | + | - | + | - | - | 5 | 1 | - |
| garnet | 3 | - | 1 | + | - | - | - | + | - |
| apatite | + | + | 1 | + | + | + | + | - | + |
| epidote | - | - | - | - | - | + | - | - | 3 |
| calcite | - | - | - | - | - | 4 | - | - | - |
| zircon | + | + | + | + | + | - | - | + | + |
| scapolite | - | + | - | 1 | - | 8 | - | - | - |
| sphene | - | - | - | - | - | 3 | - | - | - |
| opaques | 2 | 2 | + | + | + | + | 3 | 1 | 1 |

*see also Table 2

TABLE 2: Modal Composition of Lenticles

| Sample HP | 79/1 | 80* | 95* | 98* | 102/1 | 102/2 | 102/3 | 103* | 104/1* | 104/2 | 105/2* | 106/1 | 107 | 154/1 | 154/2 | 155 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume% | | | | | | | | | | | | | | | | |
| quartz | 53 | 35 | 35 | 44 | 49 | 46 | 47 | 48 | 48 | 44 | 60 | 39 | 46 | 44 | 61 | 51 |
| plagioclase | 4 | 35 | 40 | 21 | 32 | 31 | 25 | 37 | 34 | 37 | 18 | 8 | + | 35 | 22 | 21 |
| muscovite | + | - | 6 | 9 | 3 | 6 | 5 | 5 | 2 | 1 | - | 1 | - | 4 | - | 7 |
| biotite | 7 | 16 | 6 | + | + | - | - | - | 2 | 11 | 5 | 12 | 8 | 6 | 3 | 3 |
| chlorite | + | + | 8 | 8 | 7 | 5 | 5 | 4 | 4 | 1 | - | 1 | 2 | 5 | - | 7 |
| garnet | - | 8 | 1 | - | 2 | - | 3 | - | 1 | 1 | - | - | - | + | 2 | - |
| hornblende | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 9 | - |
| apatite | - | 5 | 3 | 3 | 4 | 4 | 3 | 3 | 4 | 5 | 2 | + | 3 | 3 | + | 2 |
| epidote | 33 | - | - | 2 | + | 2 | 6 | + | + | - | 12 | 36 | 36 | - | + | + |
| calcite | 2 | - | - | 3 | + | 1 | 1 | - | + | - | - | 1 | 1 | + | + | 3 |
| zircon | - | + | + | - | - | - | - | - | - | + | - | + | - | - | - | + |
| tourmaline | - | - | - | + | - | - | - | - | - | - | - | + | - | - | - | - |
| scapolite | - | - | 2 | 6 | - | + | - | + | + | - | - | - | - | - | - | 5 |
| sphene | - | - | - | 4 | - | - | - | - | + | - | - | + | 3 | - | - | - |
| opaques | - | 1 | + | + | 4 | 6 | 4 | 3 | 4 | 1 | 3 | - | + | 2 | 2 | 1 |

*see also Table 1

Their possible formation by concretionary processes cannot be entirely ruled out, even though the composition of the lenticles is not typical for calcareous or silicic concretions. Therefore the lenticles are probably derived from clastic fragments, probably soft-sediment clasts ripped off in a submarine channel environment during the deposition of the turbiditic sequence.

The whole assemblage of graded units with psammitic intercalations, hornblende-garnet gneisses, graphitic schists, magnetite quartzites, mafic metavolcanics and metagabbro forms a unique stratigraphic zone within the Kuiseb Formation.

## 5. ACKNOWLEDGEMENTS

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