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THE BRANDBERG WEST FORMATION - A LATE PROTEROZOIC CARBONATE TURBIDITE?

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ABSTRACT

The Brandberg West Formation of the Damara Sequence in the lower Ugab River area consists of a basal portion of interbedded siliciclastic and calcareous sediments, and an overlying sequence of blue-grey marbles. The sedimentary fea¬
tures preserved in the basal portion of the formation suggest accomulation by mass flow processes. This conclusion is . supported by the turbiditic character of the underlying and overlying siliciclastic formations. The blue-grey marbles are, however, hemipelagic deposits which accumulated in a periplatform environment.

1. INTRODUCTION

The Brandberg West Formation is a thin but laterally very persistent sequence of alternating marbles and metagreywackes. The formation forms part of a 1 700 m thick succession of marbles, metagreywackes and schists in the Southern Kaoko Zone of the Damara Orogen (Miller, 1983) (Fig. 1a; Table 1). The distribution of the Brandberg West Formation is shown in Fig. 1b.

The object of this study is to examine the sedimentary features of this formation, and to interpret the sedimentary environment in which it was deposited. The only previous sedimentological description of this formation is that by Miller *et al.* (1983), who interpreted the sequence as being entirely turbiditic.

The entire Damara Sequence in the lower Ugab River area was correlated by Jeppe (1952) with the Swakop Group, but Miller (1973) correlated the sequence with the Kuiseb Formation, on the basis that it consists largely of siliciclastic material (Table 1). However Miller *et al.* (1983) reverted to Jeppe's original correlation based on the presence of pebbles in the Brak River Formation (Jeppe's "Middle Schist"), which they interpreted as glacial dropstone material, thus suggesting a correlation with the Chuos Formation. The two marble units were therefore correlated with the Karibib Formation and the Ugab Subgroup (Table 1).

The maximum grade of metamorphism is greenschist facies, and many of the siliciclastic rocks display a post-tectonic biotite overgrowth. The major folds, orientated N-S, are all largely westward verge nt, with overturned limbs being thickened and upright ones thinned. The marbles have largely recrystallised during metamorphism. The strong deformation has modified many of the sedimentary structures, especially in the marble units.

2. THE BRANDBERG WEST FORMATION (BWFm)

This formation is only 15-24 m thick, but can be traced along strike for at least 300 km. Although major changes in thickness related to deformation occur, the BWFm is remarkably uniform in thickness. The BWFm can be subdivided into a basal portion, consisting of alternating white marble (Facies A) and schist (Facies C) layers, and an upper portion comprising thin to thickly bedded blue marbles (Facies B; Fig. 2a and Fig. 2b). There is a pronounced increase in carbonate content with stratigraphic height in this formation (Fig. 2c).

3. FACIES TYPES

There are four main facies types present in the BWFm:

TABLE 1: Lithostratigraphic subdivisions of the Damara Sequence along the lower Ugab River (after Miller *et al.*, 1983).

STRATIGRAPHIC SUBDIVISION						THICKNESS (m)
Jeppe (1952)		Miller (1973)		Miller *et al.* (1983)		
Upper schist	correlates Kuiseb Fm.	Amis River Fm.	correlates	Amis River Fm.	correlates Kuiseb Fm.	650
Upper marble	Karibib Fm.	Gemsbok River Fm.	KUISEB FM	Gemsbok River Fm.	Karibib Fm.	200
Middle schist	Chuos Fm.	Brak River Fm.		Brak River Fm.	Chuos Fm.	350
Lower marble		Brandberg West Mbr.		Brandberg West Mbr.	Rössing Fm.	15-24
Lower schist	Nosib Gp.	Zebra River Fm.		Zebraputs Fm	Okonguarri Fm.	500

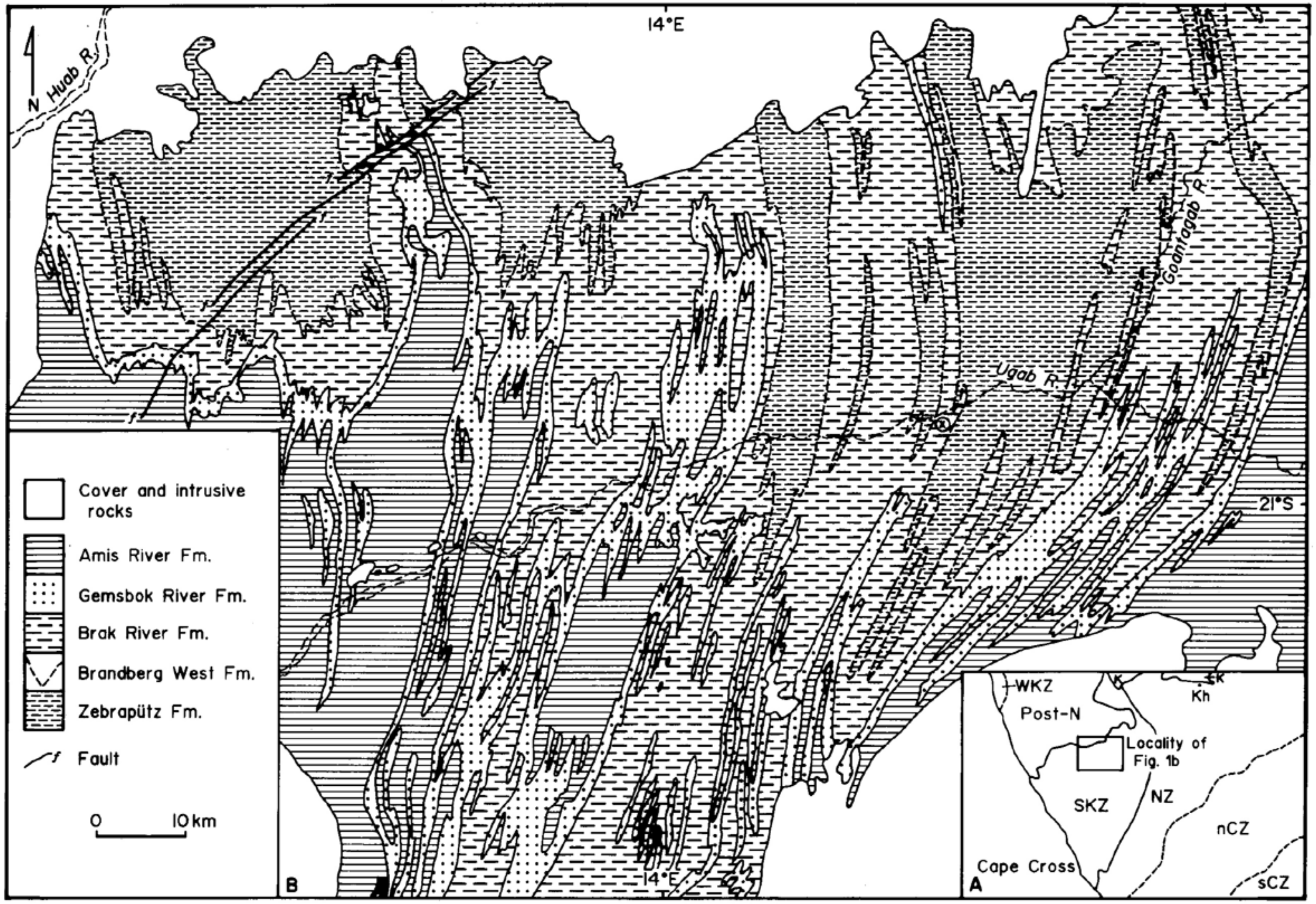

Fig.1a: Simplified tectonic sketch map of the Damara Orogen showing the locality of the study area. Kh = Khorixas; K = Karoo sediments and lavas; NZ = Northern Zone; nCZ = northern Central Zone; Post-N = Post Namibian igneous and sedimentary rocks; SKZ = Southern Kaoko Zone; sCZ = southern Central Zone; WKZ = West Kaoko Zone.

Fig. 1b: Simplified geological map of the study area showing the distribution of the Brandberg West Formation. X = Locality of section shown in Fig. 2a.

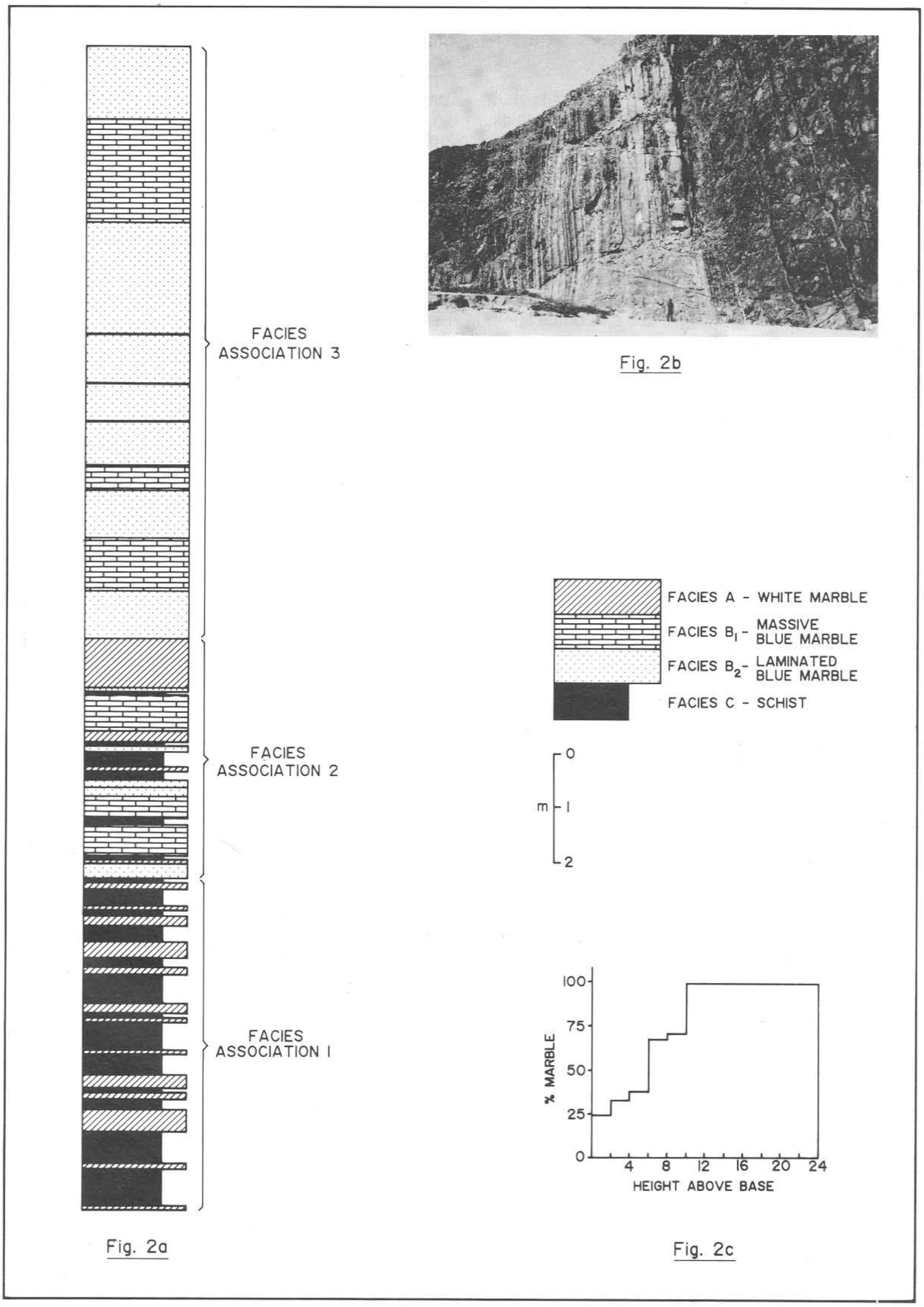

Fig. 2a: Stratigraphic log of the Brandberg West Formation measured 2 km west of the old Brandberg West Mine well in the Ugab River (20°58'S; 14°07'30"E).

Fig. 2b: Photograph of the BWFm at the measured locality shown in Fig. 2a.
Fig. 2c: Histogram showing a progressive increase in carbonate content with stratigrapic height in the BWFm.

Facies A: This facies is represented by fine- to medium-grained white marble. Bedding varies from thin to thick, and individual beds are laterally persistent for many tens of metres. Contacts are generally sharp. Ripple and parallel lamination are present. This lithotype is interpreted as a calc-arenite deposited by mass-flow processes on a carbonate margin.

Facies B1: This facies is characterised by light to dark blue fine-grained marble. The bedding is medium to thick, individual units are of uniform thickness and are laterally persistent for many kilometres. Contacts with the underlying and overlying beds are flat planar.

Facies B2: This facies consists of thin to very thinly bedded blue marble. The only sedimentary structure observed is a very thin lamination. Individual beds are evenly-bedded, of constant thickness and are laterally persistent for many kilometres. Facies B1 and B2 are interpreted as periplatform oozes deposited adjacent to a carbonate shelf.

Facies C: Facies C is represented by dark, fine- to medium-grained greywacke and schist. The bedding varies from thin to thick, with parallel lamination being the only sedimentary structure observed. Contacts are sharp and planar. Individual beds are of uniform thickness and are laterally persistent for many tens of metres. These rocks are similar in composition and texture to the underlying and overlying schists, which are of turbiditic origin, and are likewise interpreted as siliciclastic turbidites.

4. FACIES ASSOCIATIONS

Association 1: (Facies A and C) This association is found in the basal half of the BWFm (Fig. 2a and 2b). It is a prominent feature and represents alternating periods of calcareous and siliciclastic mass flow deposition.

Association 2: (Facies A, C, B1 and B2) This facies association is found in the middle part of the BWFm and probably reflects a progressive change from mass flow deposition to the quieter, hemipelagic conditions of facies association 3.

Association 3: (Facies B1 and B2) These two lithofacies are very similar and reflect quiescent deep water conditions where hemipelagic settling of carbonate mud occurred. This mud was probably derived from the continental shelf.

5. DISCUSSION AND CONCLUSIONS

The persistence and regular nature of individual units in the basal portion of the BWFm suggests a turbiditic origin (Miller *et al.*, 1983). This is supported by the fact that both the underlying and overlying siliciclastic formations have many of the characteristics of turbidites, such as lateral persistence of beds, regular nature of bedding, Bouma sequences, flute casts, load structures, rip-up clasts and graded bedding. The carbonates are unlikely to be of pelagic origin as true pelagic carbonates are not known from rocks older than Upper Silurian (Tucker, 1974). However, the upper blue marbles (Facies B1 and B2) are similar in appearance to the hemipelagic deposits described by Mcllreath and James (1984). These deposits are typically grey-blue, with planar contracts and very thin lamination (Cook and Mullins, 1983). Periplatform oozes are the most common form of deep water carbonate in the Precambrian (Mcllreath and James, 1984).

The palaeogeography of a basin in which siliciclastics and calc-arenites were deposited in regular alternation is problematical. However, a number of differences exist between calc-arenite and siliciclastic deposition on continental margins, and these have been summarised by Mcllreath and James (1984) and Mullins and Cook (1986).

Firstly, carbonate debris is delivered all along the platform margin. This implies a linear rather than a point source supply of clastic sediment from the carbonate shelf. The deposit resulting from this form of sedimentation is a debris apron, as it has a morphology that is distinct from that of a fan (Mcllreath, 1977; Mullins *et al.*, 1984; Mcllreath and James, 1984; Mullins and Cook, 1986). The calc-arenites which are deposited on the fringes of this apron also do not have a point source. The lateral persistence of the BWFm suggests that it may be of this type of deposit. Calc-arenites can form adjacent to any carbonate platform, whether it is of the bypass or depositional margin type (Enos and Moore, 1983). In contrast, many siliciclastic submarine fans have a localised source area (Howell and Normark, 1983). The major fans of the world today are associated with major river systems (e.g. the Bengal Fan).

In addition, Schlager and Ginsburg (1981) pointed out that in siliciclastic systems a lower sea-level causes an increase in erosion, and consequently an increase in supply of terrigenous sediment to the deep sea. The reverse is true for carbonate systems. Droxler and Schlager (1985) have shown that there was an increase in carbonate turbidite sedimentation in the Bahamas during interglacial high sea-level stands during the Quaternary. Siliciclastic material is trapped by the inner shelf and the abyssal plain receives little of this type of material. During lowstands the shelf is bypassed and sediment is transported to the deep sea, but little carbonate material is produced and carried to the abyssal plain.

A model combining these two factors could help explain the origin of the interbedded calc-arenites and greywackes. A rise in sea-level could cause a major river system, which had been supplying terrigenous material to the basin, to become secondary to a developing carbonate platform. The input of terrigenous material would be gradually reduced until no longer significant, but floods could still provide sediment to the point source, and this sediment would periodically be transported by mass flow processes to the basin. During intervening periods of quiescence the carbonate platform would also provide the slope with clastic carbonate material, thus causing the interbedding. With rising sealevel the locus of carbonate deposition would have moved landwards, and little clastic material could reach the basin margin. Carbonate muds could, however, be transported seawards by tidal or storm currents (Mcllreath and James, 1984), and would settle out in the quiescent conditions adjacent to the platform as a hemipelagic deposit. A major drop in sea-level would cause a return to high rates of supply of terrigenous material such that greywackes and schists would again dominate the succession.

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