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TECTONIC SETTING OF THE LATE PROTEROZOIC KHOMAS HOCHLAND ACCRETIONARY PRISM OF THE DAMARA OROGEN, CENTRAL NAMIBIA

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by

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ABSTRACT

The Khomas Trough in central Namibia forms part of the Late Proterozoic Damara Orogen (900-450 Ma) and comprises thick, multiply deformed metagreywackes and metapelites of the Kuiseb Formation. Minor lithologies are graphite schists, calc-silicates and scapolite schists. The intercalated Matchless Amphibolite contains tholeiitic metavolcanic rocks, including pillow lavas and breccias, as well as metagabbroic lenses, graphite schists, and a marble unit. Original sedimentary structures, the vertical facies distribution of progradational and retrogradational cycles, and the lateral extent of major sedimentary units indicate that major parts of the sedimentary protolith have been deposited on an elongate deep-sea fan. The regional structural pattern is characterized by three phases of coaxial deformation with folds verging consistently to the southeast. The structural regime is markedly heterogeneous and is associated with thrusting which developed elongate thrust slices traceable laterally for at least 100 km. The thermal evolution comprises a prolonged metamorphism with the peak occurring late in the deformational history.

These features are explained in a tectono-sedimentary model which involves the evolution of an accretionary prism, here named the Khomas Hochland accretionary prism, within a convergent continental margin setting. Pelagic and submarine fan sedimentation in the Khomas Trough was accompanied by slope and rise sedimentation on the southern passive margin of the continent (Kalahari Craton) and shallow shelf environments predominated in the north (Congo Craton). Subsequent closing of the Khomas Trough occurred along a northwest-dipping subduction zone. The submarine fan sediments of the elongate trench and some pelagic sediments were scraped off and accreted against the northern margin. Continental collision resulted in: (1) obduction of the accretionary prism onto the Kalahari Craton, involving the emplacement of the Matchless Amphibolite and serpentinite pods together with basement slices; (2) strong southeast vergent folding and thrusting; (3) extensive shortening; (4) crustal thickening; (5) development of large-scale southward-directed thrust nappes onto the southern foreland; (6) rising geotherms following cessation of subduction, which initiated prograde regional metamorphism; and (7) widespread granitic plutonism.

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INTRODUCTION

The tectonic evolution of active continental margins is still enigmatic in many orogens of pre-Palaeozoic age. This is mainly due to intense deformation and metamorphism and the lack of biostratigraphic control. Within the metasedimentary sequences of such orogens, delicate sedimentary structures which are essential for palaeoenvironmental interpretations may be destroyed by metamorphic recrystallization and penetrative deformation. Furthermore, lithologies are mostly monotonous without marker horizons and the sedimentary successions have usually been severely disrupted by subsequent phases of folding and thrusting. The uplift history of the orogens may be long-lasting, reaching the high temperature - low pressure peak of prograde metamorphism after the main deformation events. Age dating to determine the timing of deposition is therefore often inconclusive in such metasedimentary rocks. The latter factors also apply partly to the Late Proterozoic Damara Orogen in Namibia where strongly opposing models of the crustal evolution have been presented (initially Martin & Porada, 1977 versus Blaine, 1977).

Palaeoenvironmental interpretations in the southern Damara Orogen have previously been based upon lithological considerations and not facies analysis and these have been combined with some structural, petrological, and geochemical information to infer various models of the tectonic setting. Studies of the Kuiseb Formation in the Khomas Trough (Fig. 1) have led to the discovery of surprisingly well-preserved sedimentary structures (Kukla *et al.*, 1990), which have enabled the writers to undertake, for the first time, a detailed sedimentary facies analysis. Together with structural and petrological studies, these sedimentary structures help to constrain the setting of the Khomas Trough as a whole. This paper synthesises the results of the investigations and proposes a new model for the development of the inland branch of the Damara Orogen.

The study strip is a north-south trending, 80 km long river section through the Khomas Hochland, about 120 km west of Windhoek (Fig. 1). Important structural and sedimentological markers have also been mapped laterally (Fig. 2).

GEOLOGICAL SETTING AND ROCK RELATIONSHIPS OF THE SOUTHERN DAMARA OROGEN

The Khomas Trough in Central Namibia forms part of the inland branch (Fig. 1) of the Late Proterozoic Damara Orogen (900-450 Ma). It comprises mainly multiply deformed metapsammites (quartz-plagioclase-mica schists) and metapelites (mica-quartz-plagioclase schists) of the Kuiseb Formation, which attain a thickness of several thousand metres. Minor lithologies include graphite schists, calc-silicate layers, and spindles (Porada, 1973) as well as scapolite schists (epigenetic scapolitization of predominantly pelitic schists). The Matchless Amphibolite is interposed within the metasedimentary sequence (Fig. 1). Alpine-type ultramafic bodies are structurally emplaced in the southern portion of the Khomas Trough (Barnes, 1982). A subdivision of the Khomas Trough has recently been attempted by Kukla *et al.* (1988) using structural and sedimentological markers such as graphite schists, scapolite schists, thick pelitic units, metamorphosed carbonates (marble and tremolite schist), and major zones of

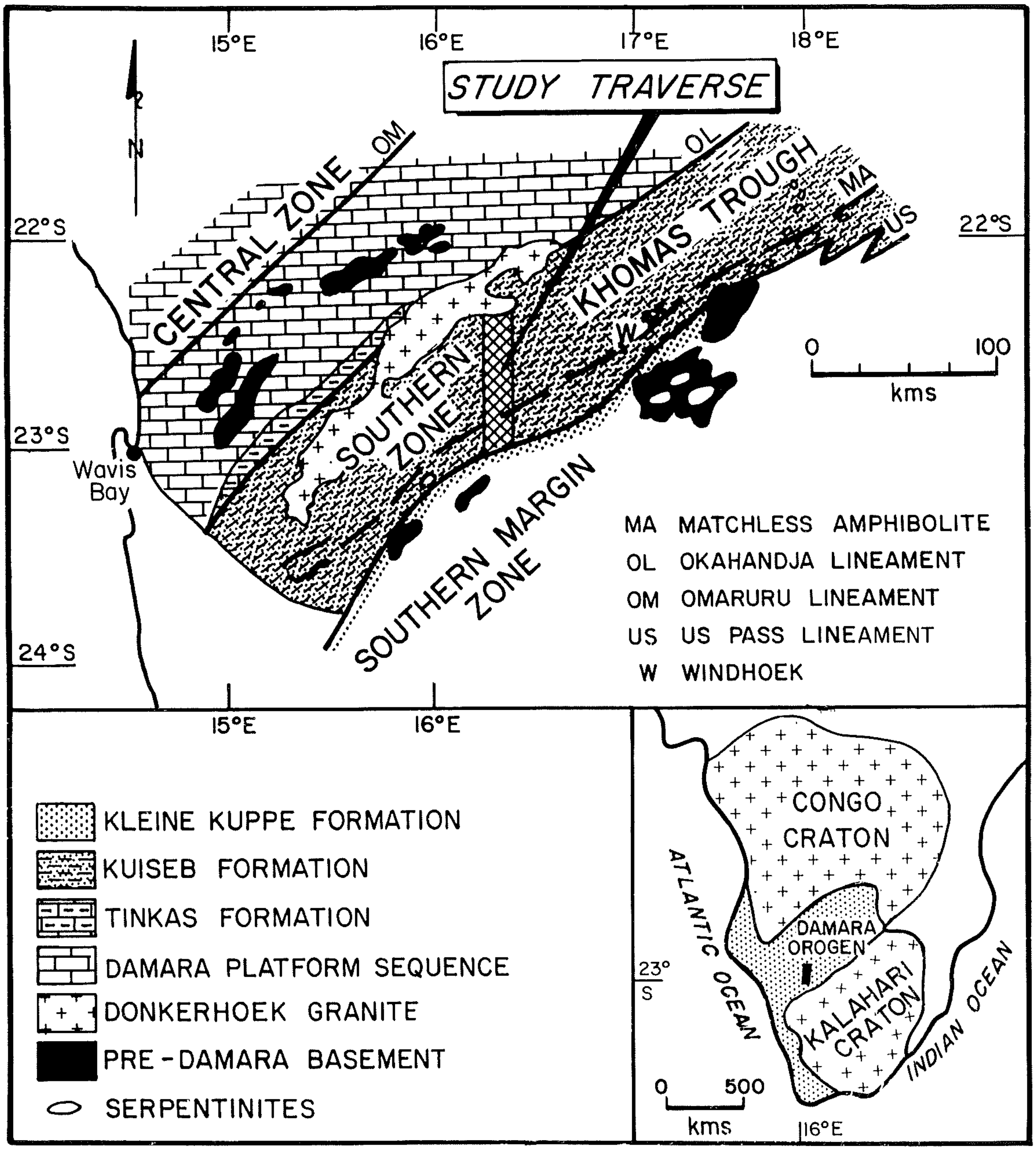

Figure 1: Location of the study traverse and tectonostratigraphic zones in the inland branch of the Damara Orogen (modified after Miller et al., 1983). Note position of the Okahandja (OL) and Us Pass (US) Lineaments and the Matchless Amphibolite (MA).

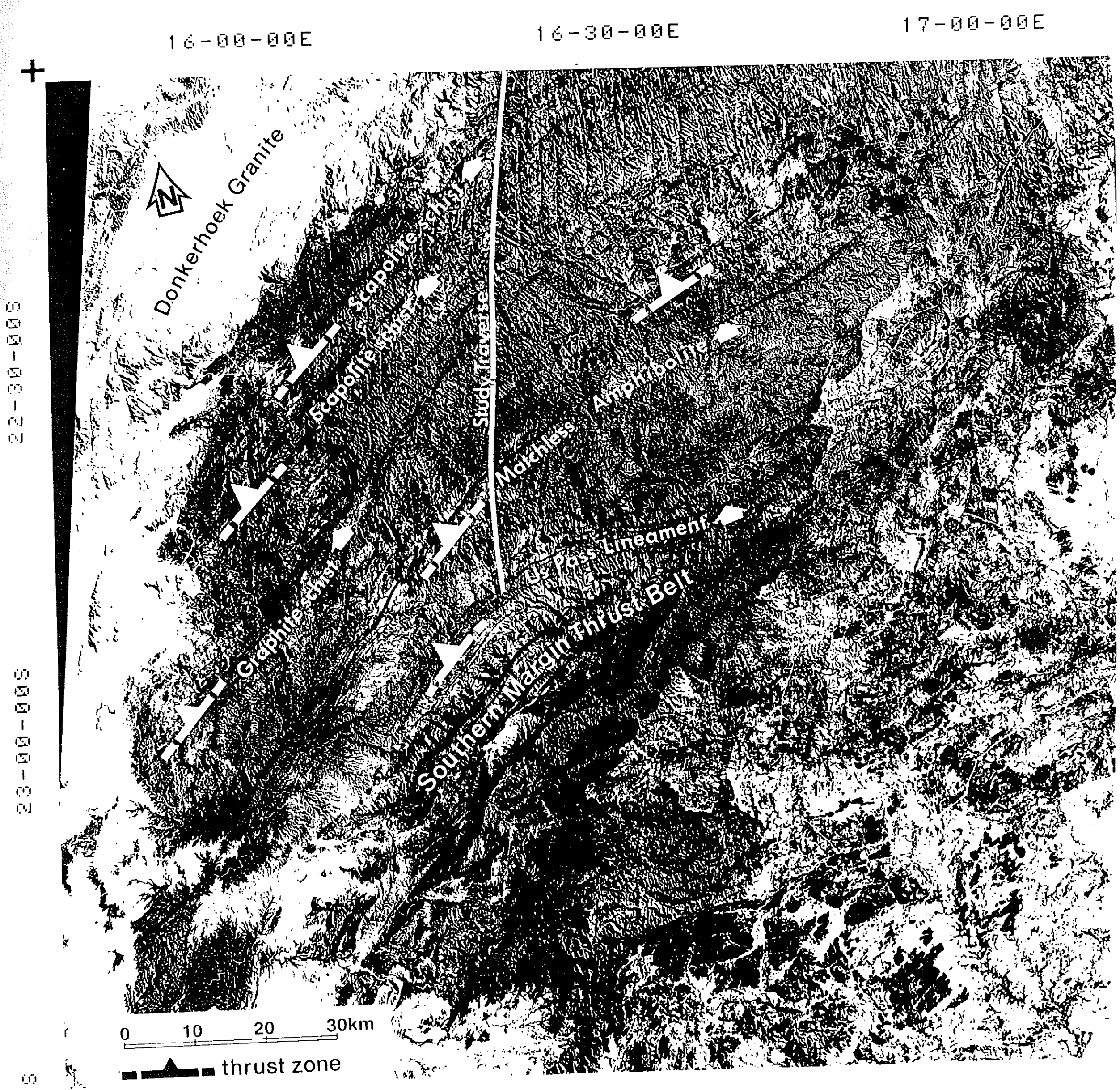

Figure 2: Landsat image of the Central and Western Khomas Trough showing marker units and major thrust zones. Note their lateral extent (reproduced with permission of the Satellite Applications Centre of the CSIR).

high strain which represent thrust zones. These sedimentological and structural features may be seen on a Landsat image which emphasises the extreme lateral persistence of the marker horizons (Fig. 2).

Porada & Wittig (1983) have established that, towards the north, the Kuiseb Formation interfingers with calcareous turbidites of the Tinkas Formation, a lateral equivalent of the platform carbonates of the Karibib Formation (Fig. 3). South of the trough the allochthonous thrusted platform/margin sequence of the Southern Margin Zone (Hoffmann, 1983) comprises conglomerates, quartzites, glacio-marine diamictites, pelitic schists, amphibolites, ultramafic pods, and basement inliers (Fig. 3).

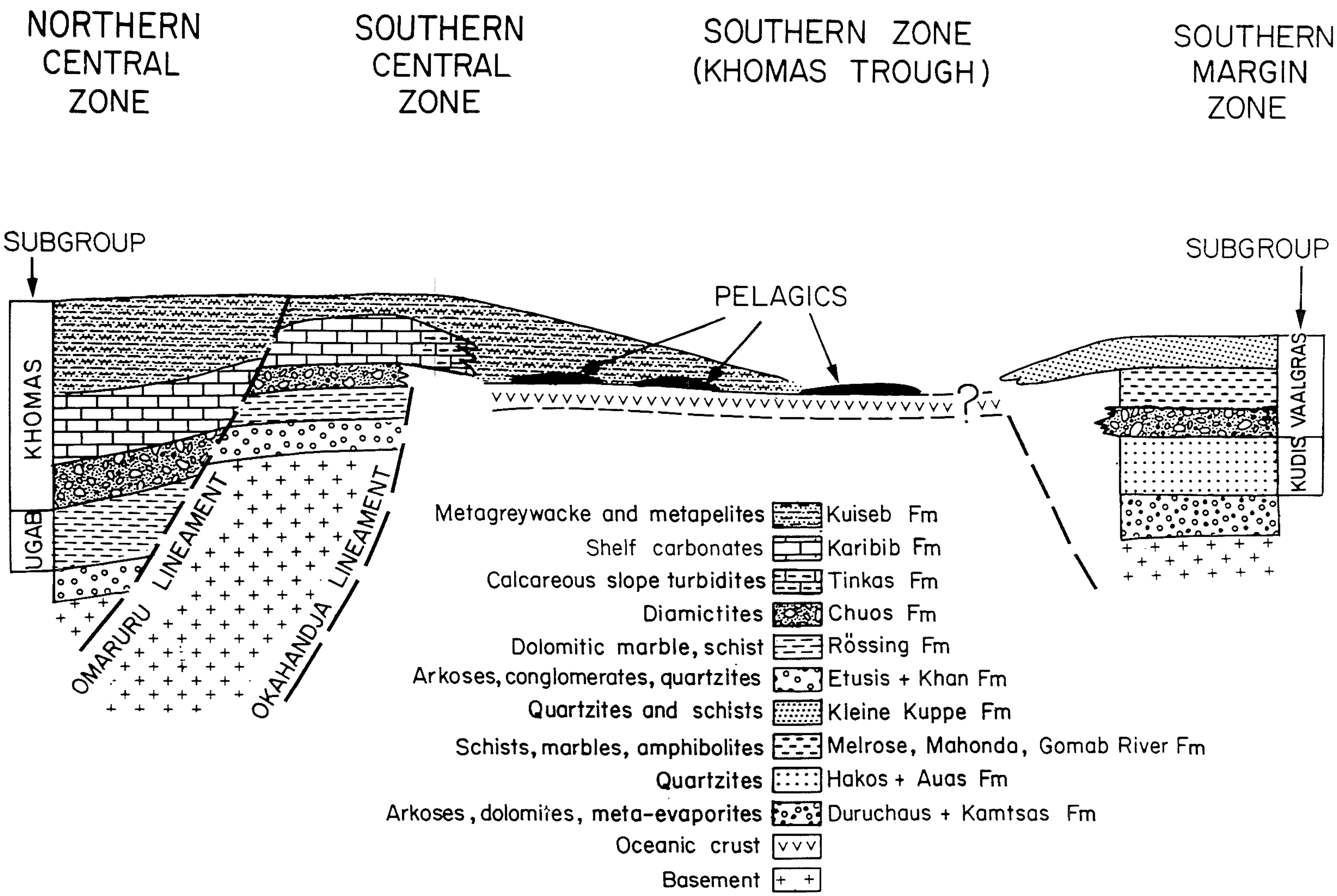

Figure 3: *Rock relationships of the Southern Zone (Khomas Trough) and adjacent areas in the Damara Orogen. Stratigraphic contacts are emphasised in their palinspastic context. Note the development of a platform sequence in the north (Central Zone) and of a platform/margin sequence in the south of the Khomas Trough. Correlations and terminology of the Southern Margin Belt and the southern and northern Central Zone are after Hoffmann (1983), Henry et al. (1990), and Badenhorst (1987), respectively.*

SUBMARINE FAN SEDIMENTATION

Metasedimentary units of the Kuiseb Formation range from centimetres to about 5 m in thickness. Psammites occur either as discrete layers or they grade from quartz-rich compositions at the base to mica-rich compositions at the top. This compositional grading represents original graded bedding and has previously been used to infer that the sediments in the Khomas Trough have been deposited by turbidity currents (Miller *et al.*, 1983; Preussinger *et al.*, 1987). Throughout most of the study area delicate sedimentary structures have been found in areas of low strain even within the sillimanite-grade of amphibolite facies metamorphism. Structures discovered include cross-stratification, load structures, scour surfaces, flute casts, rip-up clasts and clastic dykes (Figure 4), all of which have been documented in Kukla *et al.* (1990). A high proportion of the units displaying sedimentary structures are arranged in Bouma sequences (Bouma, 1962) indicating that the sedimentary protoliths were deposited by turbidity currents. Using bedding style, vertical bed thickness distribution, variations in the psammite/pelite ratio, and sedimentary structures, facies have been recognised and defined in the Kuiseb schists. According to the turbidite facies classification of Pickering *et al.* (1986) facies classes B, C, D, and E are present. Furthermore, analysis of sedimentary sections shows that the vertical arrangement of facies defines nested thickening- and thinning-upward cycles of progradational and retrogradational character (Kukla *et al.*, 1988). The cycles are developed on all scales (Fig. 5) and are traceable on the Landsat image (Fig. 2) for at least 150 km along tectonic strike. Palaeocurrents obtained from sets of cross-laminae and flute casts indicate sediment transport along the axis of the Khomas Trough from the east-northeast. Figure 4 shows major cycles with reference to marker lithologies (Fig. 2), and one of the measured sections with well-preserved sedimentary structures.

The documentation of the sedimentary structures and the first application of facies analysis in the Kuiseb schists of the Khomas Trough has led to a palaeoenvironmental interpretation. The organization of the sequence into cyclic and non-cyclic successions on a variety of scales and the lateral extent of sedimentary units have been interpreted by Kukla *et al.* (1988, 1990) as deposits of a mixed-sediment, elongate, deep-sea fan, as defined by Nelson & Nilsen (1984). A large terrigenous source area, as indicated by palaeocurrent data, occurs towards the eastern end of the trough.

THE MATCHLESS AMPHIBOLITE

The Matchless Amphibolite is a 350 km long and up to 3 km wide (Miller, 1983) sequence of deformed oceanic tholeiitic metavolcanics (Finnemore, 1978), including pillow lavas (Fig. 6). Metagabbroic lenses, pelitic schists, graphite schists, small amounts of chert clasts, breccias, and a 2m-thick marble horizon (Figs. 6, 7A) are associated with the amphibolite in the study area. In parts of the sequence graded layering is an important way-up indicator.

The interposition of various lithologies within the Matchless Amphibolite is associated with the development of high- and low-strain zones. Throughout the sequence, high-strain has been taken up

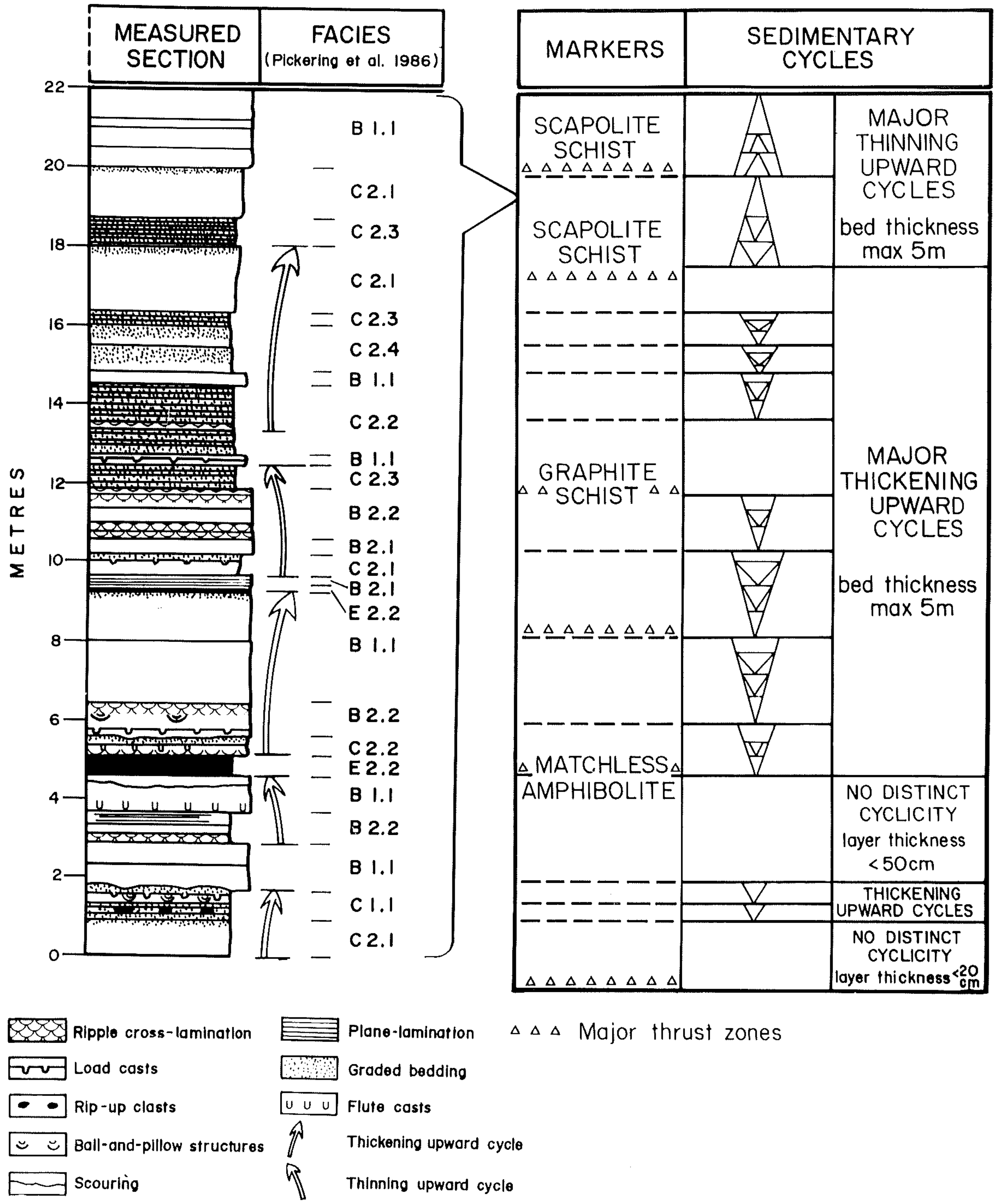

Figure 4: Sedimentary cycles and marker units in which is located a detailed measured section with sedimentary facies analysed. Larger-scale cycles and marker units may be traced for long distances laterally on the Landsat image (Fig. 3).

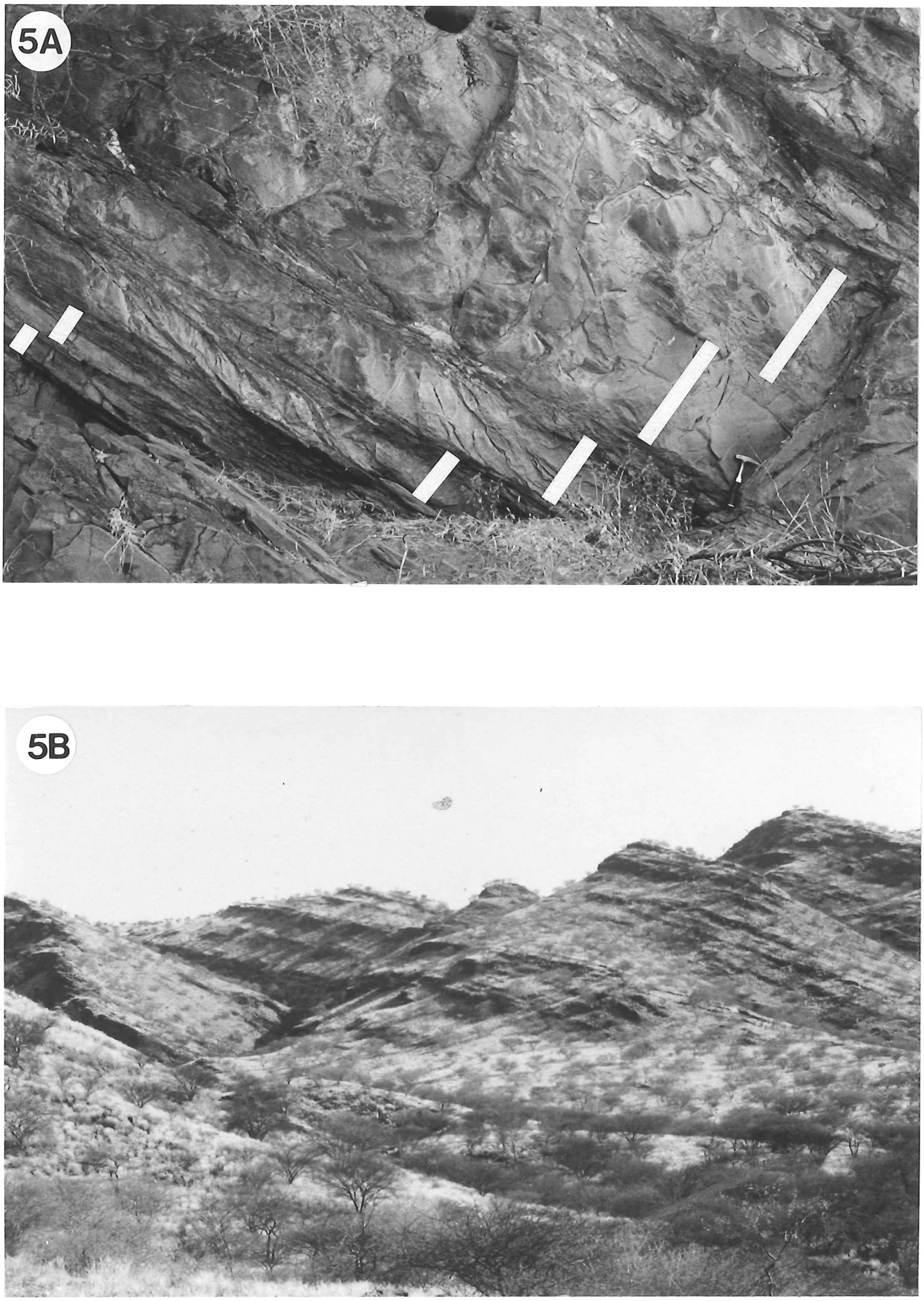

Figure 5: *Photographs showing sedimentary cycles. (A) Small-scale cycle (3,5 m) on the farm Tsawisis. (B) Medium-scale (approximately 200 m) thickening-upward cycles etched in the landscape on the farm Dagbreek.*

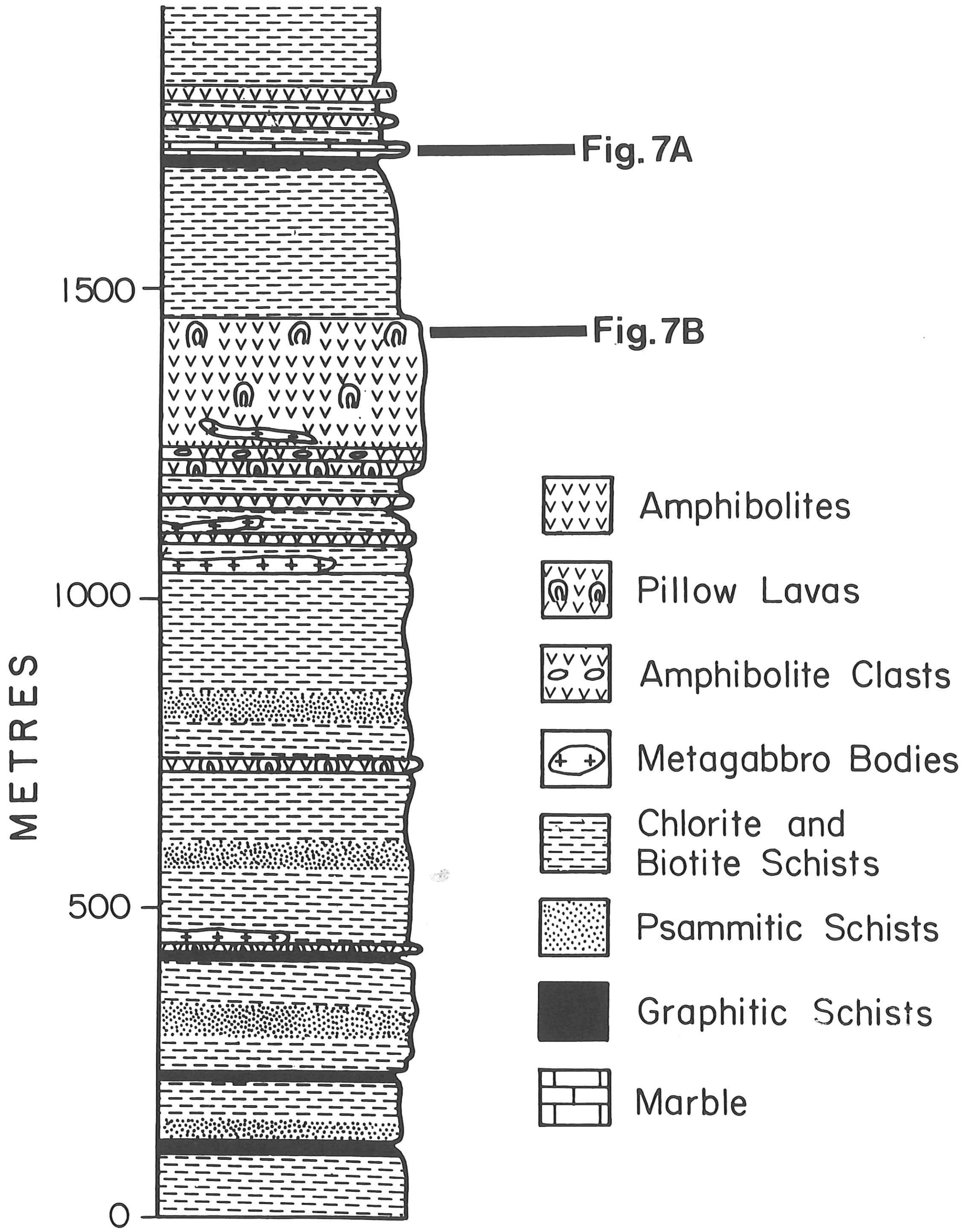

Figure 6: Measured section showing the Matchless Amphibolite sequence in the study traverse (farm Annelie). Amphibolites represent deformed oceanic tholeiitic metavolcanics. Note the shape and position of metagabbro lenses.

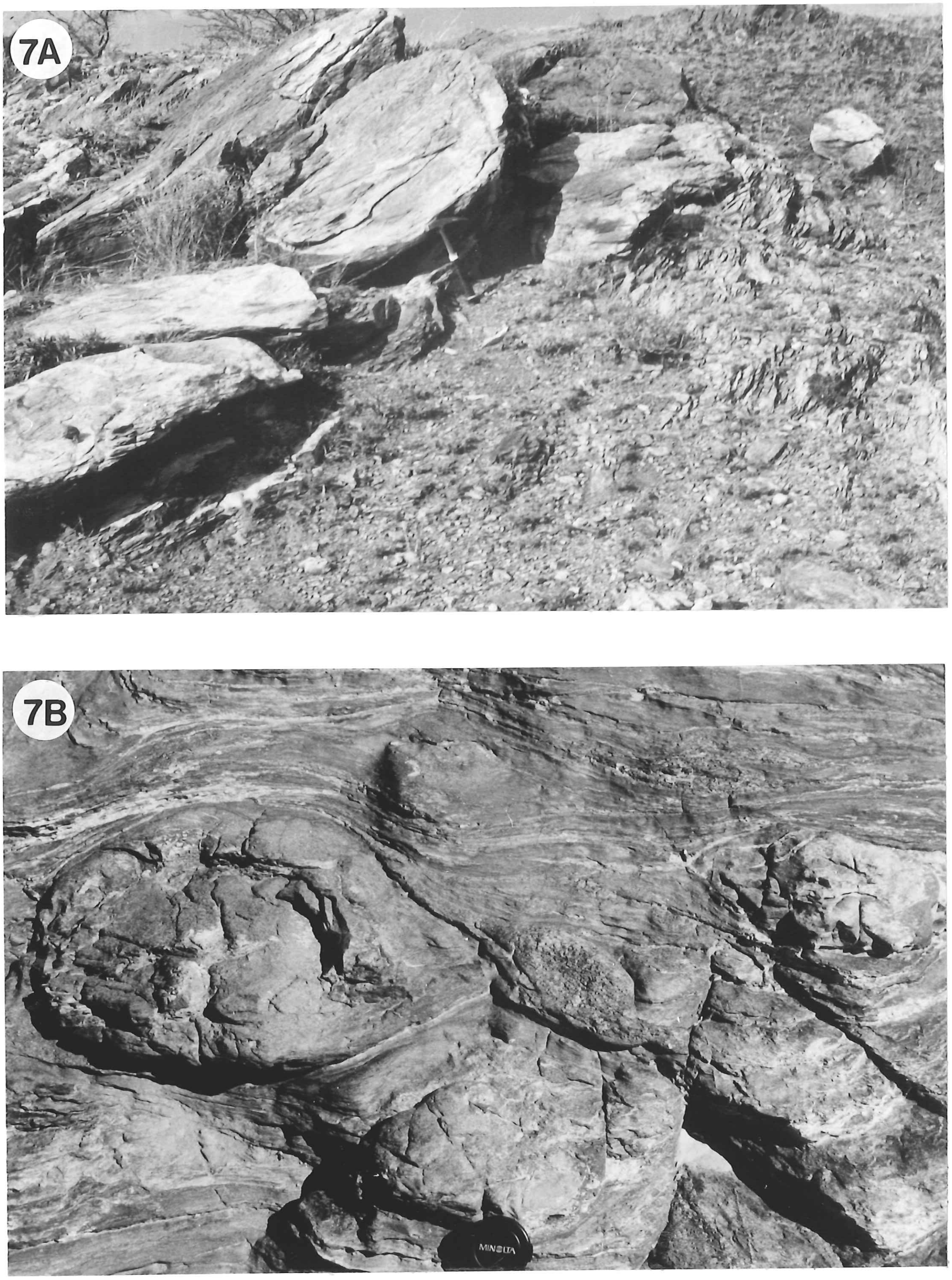

Figure 7: Geological features of the Matchless Amphibolite (located in Fig. 6). (A) Pelagic sedimentary units of marble and graphite schist lying above the amphibolite. (B) Undeformed pillow structures wrapped around by extremely sheared pillows and inter-pillow fillings. The sheared pillows give a striped appearance.

preferentially by units of low competence such as pelites and carbonate-replaced volcanics. Some pillow lavas have preserved the original spheroidal shape whereas others have been extremely elongated (Figure 7B). Other structural features include thrusts with an associated down-dip lineation, shear zones, and boudinage structures, which indicate layer-parallel extension. In the study area the metagabbroic rocks only occur as structurally emplaced lenses within the sequence, mostly at contacts of metasediment with amphibolite. The particular depositional and structural styles within the Matchless sequence are illustrated in Figure 6. Structural emplacement is indicated in the lower parts of the sequence with the interposition of thinly layered amphibolites, pelitic schists and graphitic schists, with metagabbro lenses and, elsewhere, ultramafic pods (Barnes, 1982). Upper parts of the sequence show a more coherent relationship between carbonate-rich amphibolites and units of graphite schist and marble.

The origin of the Matchless Amphibolite and its associated massive sulphide deposits have been discussed by Klemd *et al.*, (1987), Breitkopf & Maiden, (1988), and Häussinger (1990). The non recognition of a complete ophiolitic sequence (Martin, 1983), mélange deposits, and obvious structural discontinuities, have been used in arguments against an oceanic crustal origin. Others have interpreted the MORB compositions of the metabasalts (Finnemore, 1978) as indicating their origin in a mid-ocean ridge type setting (Miller, 1983). Breitkopf & Maiden (1987) have geochemically identified ocean ridge basalts and within-plate basalts.

The writers, have, however, shown that the sequence comprises pillow lavas, pelagics (graphite schists, marble, pelites), and metagabbros and, in consequence, interpret the Matchless Amphibolite as the sliced-off upper part of an ophiolitic sequence. This was structurally emplaced into its present position within the Kuiseb schists, with which it has both stratigraphic and structural contacts.

EVIDENCE FOR AN IMBRICATE THRUST PILE

Preserved sedimentary layering and sedimentary structures provide good stratigraphic control in delineating fold structures. Four phases of deformation have been discerned, the initial three of which show coaxial folding (Kukla *et al.*, 1988). Fold axes are subhorizontal and consistently have an east-northeasterly trend, with folds verging towards the south-southeast. The first deformation overturned parts of the sequence and was associated with thrusting. This was followed by open to tight folding which overprinted the earlier overturned folds to develop downward-facing structures in parts of the sequence (Kukla *et al.*, 1989). This second deformation has regional significance and was associated with a major phase of thrusting and faulting and the shearing-out of the steep limbs of some of the F_2 folds. A schematic structural profile along the study traverse is shown in Figure 8, indicating the change in fold style across the Khomas Trough. This shows a steepening of the structures towards the north and the position of major thrust zones which are mostly associated with the pelitic portions of the sequence. The third deformation is characterized by intensified shearing with the development of a pronounced penetrative cleavage and folds within high-strain shear zones. These shear zones acted as conduits for intensive fluid migration, strongly supported by the development of the scapolite schists in the northern Khomas Trough. Epigenetic scapolitization occurred along veins and fractures, but broadly

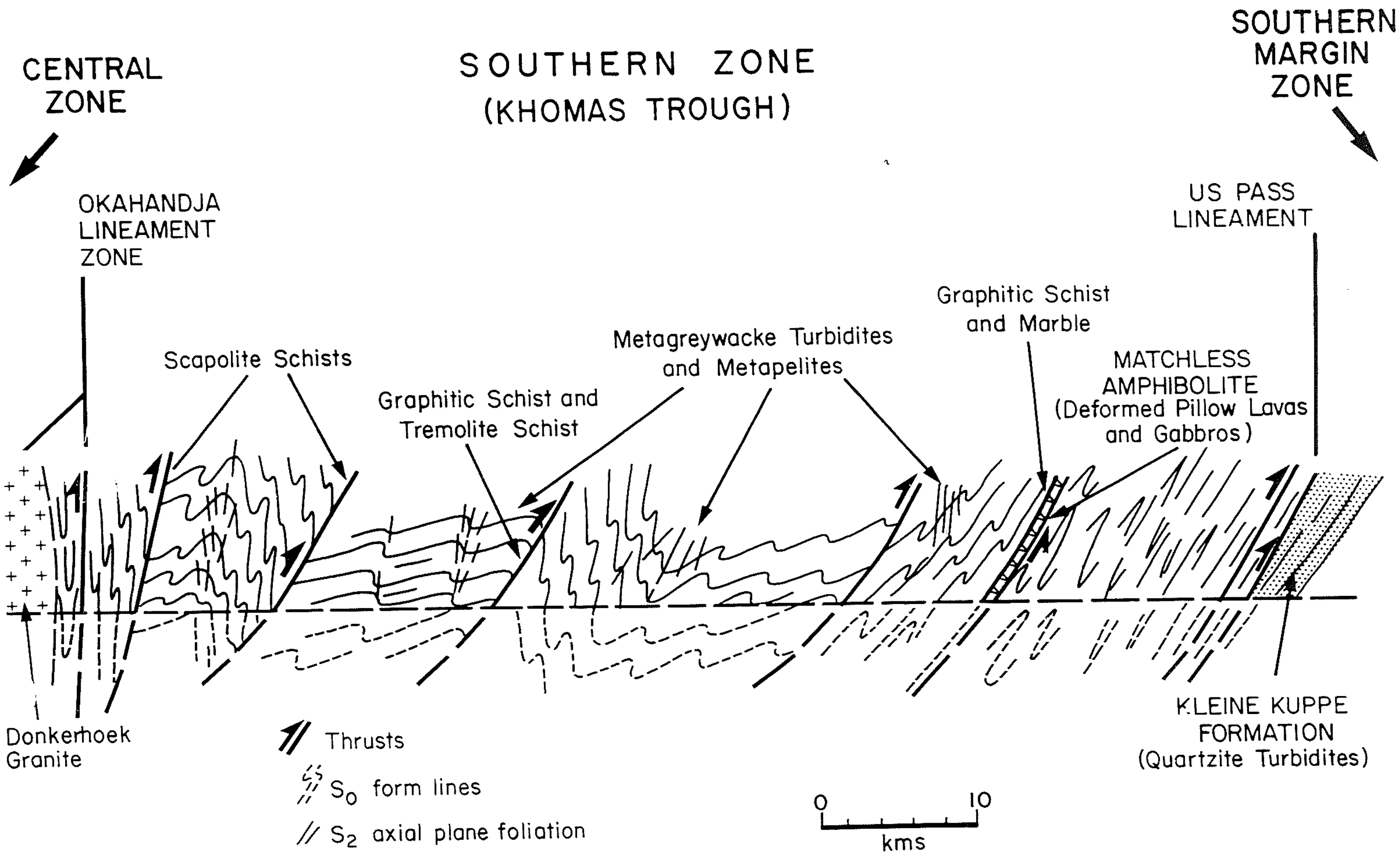

Figure 8: *Simplified structural profile across the western Khomas Trough showing the organization of the sequence into distinct thrust slices relative to the major D_2 phase of folding. Graphite schist/marble/tremolite schist sequences and thick pelitic units, which have been epigenetically scapolitized (post-D_3), are probably structurally repeated.*

followed the major thrust dislocations interpreted from structural data (Figure 8). Fluid inclusion data (Kukla, in prep.) indicate high salinities of the impregnating fluids (up to 35 wt% NaCl). In contrast to the earlier deformation phases, the D_4 phase is represented by crenulation cleavages and kink folds. Late, right-lateral, strike-slip displacement along the northern margin of the Khomas Trough (Okahandja Lineament) is evident by the clockwise rotation of structural elements.

The strain distribution throughout the area is distinctly heterogeneous. On a small scale this is demonstrated by the differential development of fabrics in more quartz-rich (low-strain) and more mica-rich (high-strain) lithologies. Strain markers such as calc-silicate spindles and pillows in the Matchless Amphibolite show considerable fluctuations of axial ratios on a metre-by-metre scale within the stratigraphy. High-strain zones show a remarkable development of F_3 folds and an S_3 cleavage. Earlier fabrics are largely overprinted and original sedimentary structures are completely obliterated in these zones. Major shear zones are developed in thick pelitic units and are the ultimate expression of the heterogeneous distribution of strain. The zones of high strain and shear represent structural discontinuities in the form of thrust zones which have been described previously by Kukla *et al.* (1988). Folding and thrusting have resulted in structural repetitions of the sedimentary sequence. Similarities in the depositional nature of (1) the graphite schist - marble association at the Matchless Amphibolite and (2) the graphite schist - tremolite schist association in the centre of the Khomas Trough, indicate repetition of sequences (Figure 8). This is supported by the apparent repetition of thick pelitic and calc-silicate-rich successions which are epigenetically scapolitized (Figure 8).

On the basis of these data the writers interpret the Kuiseb Formation in this part of the orogen as representing a sequence of metasediments and amphibolites which has been imbricated by thrusting. This has developed elongate thrust slices with a lateral extent of at least 100 km. The individual slices are floored by thick pelitic units. It is noteworthy that the structural evolution is one of progressive deformation, emphasized by the inheritance of the major thrusts from one phase to the next.

ASPECTS OF THE THERMAL EVOLUTION

The metamorphic evolution of the Southern Damara Orogen has been studied by various authors. Hoffer (1977) mapped metamorphic isograds, which describe a concentric distribution around an area close to Walvis Bay on the Atlantic coast (Fig. 1), where partial melting of pelitic lithologies occurs. Sawyer (1981), Hartmann *et al.* (1983) and Kasch (1983) subsequently confirmed that metamorphic temperatures increase and pressures decrease inward towards the Central Zone. Pressure estimates for the southern Khomas Trough vary considerably, with the highest (up to 11 kb) obtained by Kasch (1983). The P-T studies of Behr *et al.* (1983) imply different metamorphic peak conditions for the northern Khomas Trough (650°C; 4,5 kb) and the southern Khomas Trough (480-580°C; 6-9 kb). Häussinger (1990) has estimated 600°C and 6 kb for mineral assemblages containing sillimanite and kyanite at the western end of the Khomas Trough and described two distinct staurolite generations (syn- and post-D_2) in this area. Isotope information further indicates prograde metamorphism over a period of 100 Ma or more as synthesized by Miller (1983).

Although metamorphic studies are still in progress, a preliminary summary of initial results can be given. At the southern margin of the Khomas Trough assemblages comprising kyanite, staurolite, biotite, muscovite, and garnet confirm lower amphibolite facies conditions. The assemblage staurolite + muscovite + quartz is stable over most of the Khomas Trough and kyanite is replaced by andalusite in a very narrow zone (5 km). Further north the staurolite-out isograd is reached and sillimanite + biotite is the critical assemblage indicating P-T conditions of 3-4 kb and 600-660°C, as estimated by Kukla et al. (1990). At the northern margin of the trough migmatization occurs suggesting a regional metamorphism temperature peak of about 700°C.

With reference to the time path, mineral growth of staurolite and sillimanite occurred from syn-D_2 to syn-D_3. The retrograde path involved formation of hornblende, intense muscovitization of sillimanite, andalusite, and staurolite; chloritization of garnet and biotite; and fluid migration in retrograde shear zones (Peacock, 1987) as indicated by the scapolitization in the northern Khomas Trough.

Summarized, the prograde amphibolite-facies metamorphism in this part of the orogen involves the change from kyanite to andalusite and finally to sillimanite-bearing assemblages from south to north. This confirms that metamorphism in large parts of the Khomas Trough is rather a function of increasing temperature than of pressure.

THE KHOMAS HOCHLAND ACCRETIONARY PRISM: DISCUSSION AND CONCLUSIONS

Previous discussions on the geodynamic evolution of the inland branch of the Damara Orogen have mainly concentrated on whether or not oceanic crust formed to be subsequently subducted during continental convergence. Aulacogen-related models include those of Martin & Porada (1977) and Porada (1983) and the delamination model of Kröner (1982). Ocean floor subduction models include the subduction of a wide ocean (Hartnady, 1978; Kasch, 1979; Barnes & Sawyer, 1980), the subduction of a narrow, Red Sea-type ocean (Miller, 1983) and small ocean basins associated with strike-slip shear movements (Downing & Coward, 1981). In the subduction models the Matchless Amphibolite and ultramafic bodies are represented as the remnants of the oceanic crustal phase. Blaine (1977) summarized his structural investigations in the eastern Khomas Trough and presented a fore-arc model for this part of the orogen on the basis of contrasting tectonic styles of the Central Zone and the Khomas Trough. This was partly supported by Miller *et al.* (1983), who argued on the basis of a geochemical maturity index that the Khomas Trough north of the Matchless Amphibolite contains fore-arc deposits and older subduction complex deposits towards the south. Downing & Coward (1981) and Hoffmann (1983) speculated on an accretionary wedge setting for the Khomas Trough. In his review article Martin (1983), with the data available to him at that time, discussed continental and ocean floor subduction models. In view of an ocean-floor setting his major concerns were the absence of high-pressure phases and ophiolitic sequences as well as the lack of evidence for deep-sea sediments which would indicate the previous development of an ocean basin. The striking sedimentological and structural asymmetries within the inland branch of the orogen has recently led Henry *et al.* (1990) to relate the early rift phase to the development of two low-angle detachment systems. This ultimately resulted in the evolution of the Khomas Sea between the Kalahari and Congo Cratons.

New results from research by the writers may help to discriminate between these various interpretations. Studies of the sedimentology have shown that the sediments within the Khomas Trough were deposited on an elongate deep-sea fan system of considerable extent. A major source area is indicated towards the east-northeast. Intercalated graphite schists, carbonates, and thick pelites confirm that fan sedimentation and pelagic sedimentation were contemporaneous within the basin. The inferred palaeoenvironmental setting is illustrated in Figure 9. Deformation patterns within the Khomas Trough reveal that the metasediments are organized within imbricate elongate thrust slices which exhibit a structural evolution from early thrusting and folding through the development of shear zones to strike-slip dislocation.

In this paper the writers combine sedimentological and structural information in a model which involves the convergence and collision of the Kalahari Craton with the Congo Craton (Fig. 10). In this model, the Kuiseb Formation sediments within the Khomas Trough accumulated on an elongate submarine fan within an ocean trench. The accretionary prism evolved through the offscraping of sediment from the descending oceanic crustal slab. The dominance of metasediments within the present day Khomas Trough indicates a high sediment input into the subduction-related oceanic trench with subsequent accretion of preferentially clastic sediment instead of oceanic basalts and pelagics. Early deformation occurred within the prism and the shallow (south) to steep (north) structural asymmetry was initiated during this stage (Fig. 10A).

The collision-phase involved strong south-east vergent folding and thrusting and nappe emplacement (Korn & Martin, 1959; Hoffmann, 1983). Within the trough the collision-phase D_2 deformation produced isoclinal and open folds. Further deformation developed high-strain retrograde shear zones which mark the transition from compressional to extensional tectonics. Within the latter regime the clockwise rotation of structural elements during dextral strike-slip movements along the Okahandja Lineament occurred and partially opened a path for the ascent of the Donkerhoek Granite (Figure 10B).

In the writers' model the Matchless Amphibolite represents uppermost oceanic crust (pillow lavas and pelagics) which was either sliced off an oceanic crustal topographic high to be incorporated into the accretionary prism or, alternatively, represents obducted oceanic crustal material. The latter possibility gains extra support in the recognition by Barnes (1982) of emplaced Alpine-type ultramafic pods close to and south of the Matchless Amphibolite (Fig. 10B). Basement slices are also tectonically interleaved with amphibolites and ultramafic lithologies in the Southern Margin Zone (Hoffmann, 1983).

In view of the lack of recognition of blueschist terrane in the Damara Orogen, the protracted crustal development, including long periods of sedimentation, tectonism, and metamorphism (Kasch, 1983; Miller, 1983) has to be considered. Uplift of the thickened continental crust during relaxation of isotherms has been explained by buoyant rise (Kasch, 1983). Furthermore, the coherent isograd pattern implies that tectonic uplift to emplace high-pressure terrane, e.g. by underplating (Platt, 1986), might have played a minor role during exhumation. This, together with the long-lasting metamorphic history of the Khomas Trough, was probably responsible for the obliteration of high-pressure assemblages during rising geotherms in a manner similar to that described by Draper & Bone (1980).

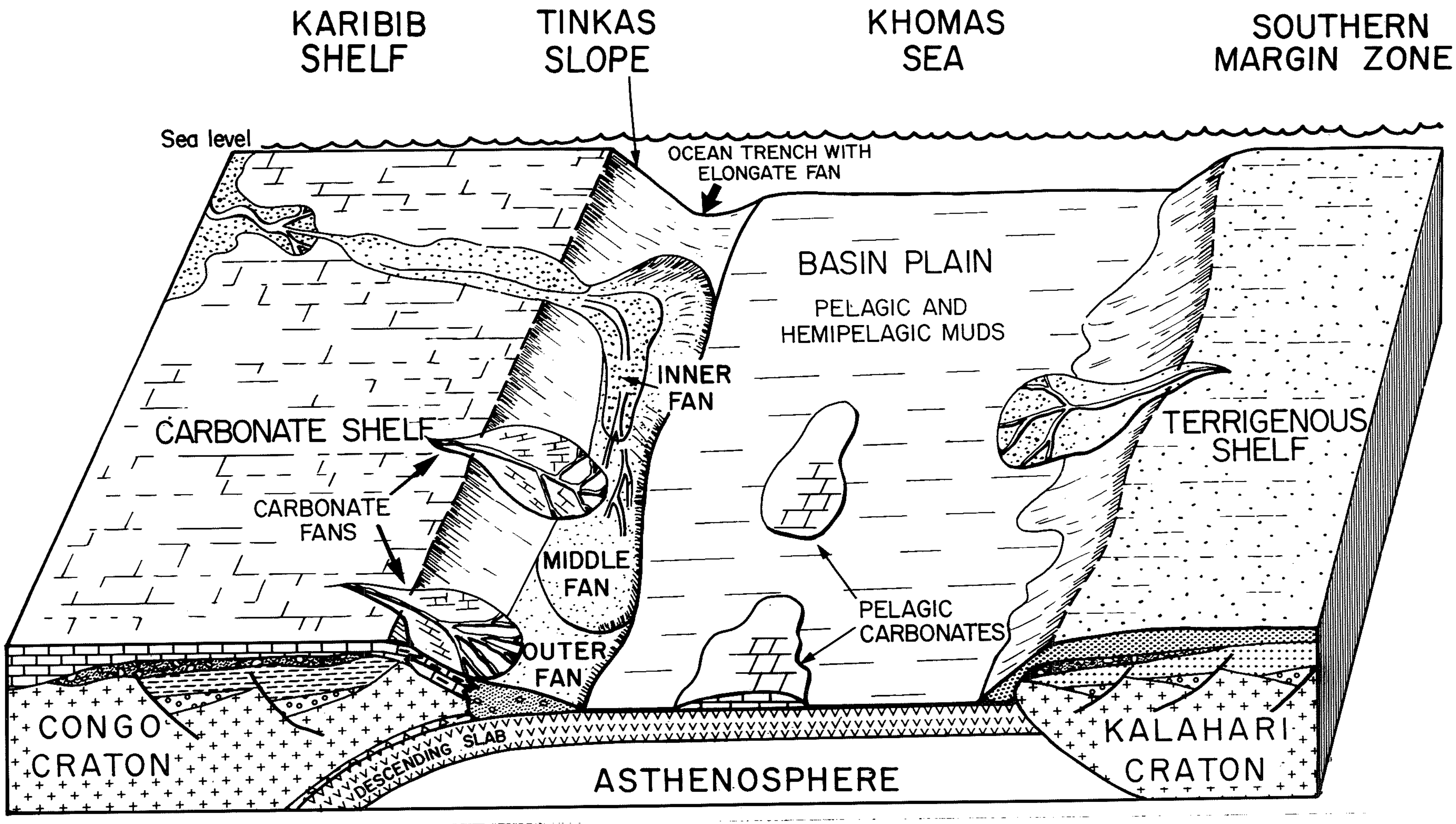

Figure 9: *Depositional palaeoenvironments during late continental convergence. The elongate submarine fan transports large amounts of clastic sediments from an easterly source area along the trench axis. Pelagic and hemipelagic sedimentation dominates the basin plain. Clastic deposition characterizes the southern cratonic shelf. The Karibib carbonate shelf and the calcareous Tinkas slope turbidites (Porada & Wittig, 1983) border the Khomas Sea towards the north. The greywackes and muds of the Kuiseb Formation originate either from a mountain belt to the east of the basin or they have been transported through the carbonate shelf into the basin via an entrenched submarine canyon located to the east of the exposed Khomas Trough, as indicated in this figure.*

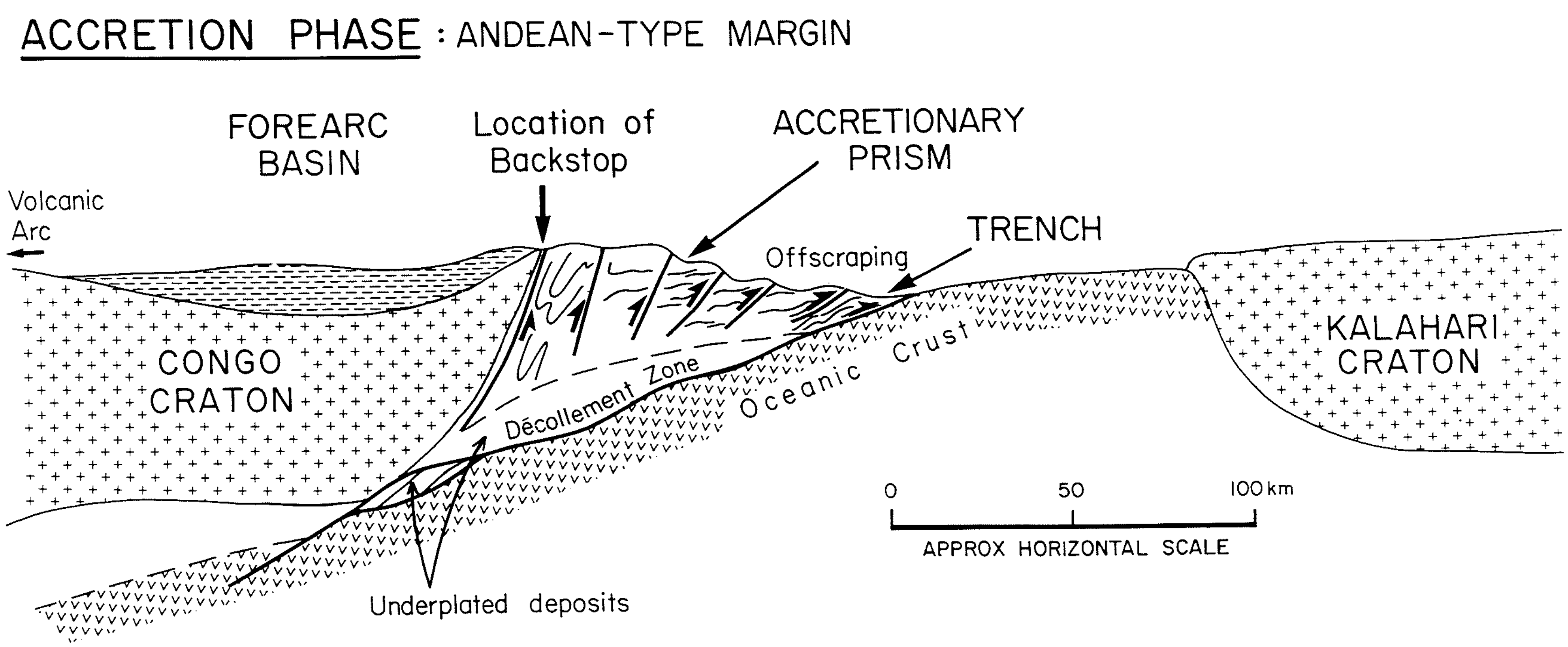

Figure 10A: *Tectonic setting of the southern Damara Orogen during late convergence of the Congo and Kalahari Cratons. The oceanic trench contains the elongate submarine fan and the accretionary prism evolves through the offscraping of sediment from the descending slab. Early folding and thrusting occurs within the prism.*

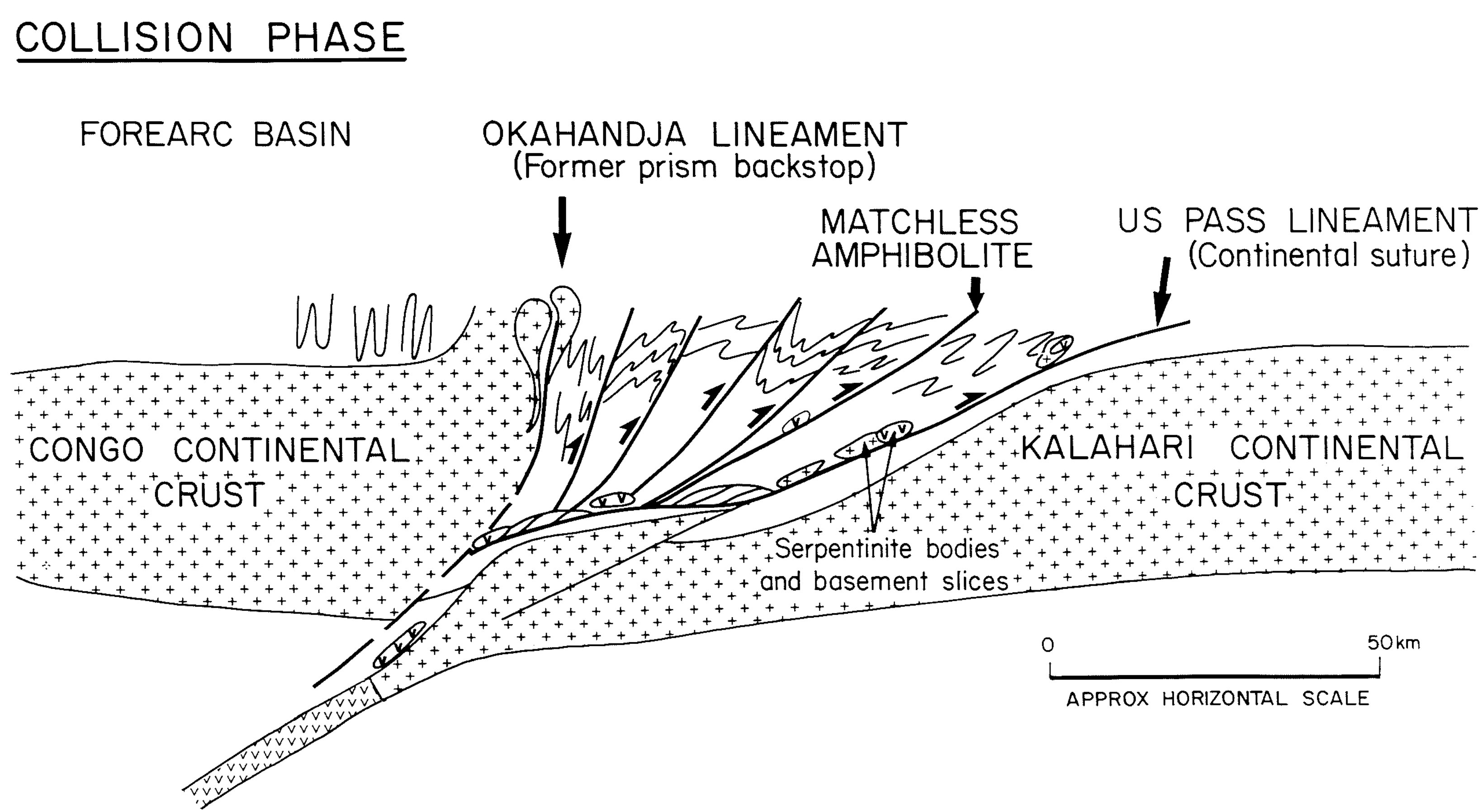

Figure 10B: Collision between the Congo and Kalahari Cratons. This was accompanied by strong south-southeast vergent folding and thrusting. The Matchless Amphibolite was either sliced off an oceanic crustal topographic high during the development of the accretionary prism or, more probably, represents structural emplacement during the obduction of oceanic crust and the accretionary prism over the Kalahari Cratonic Foreland. The latter possibility is supported by the emplacement of Alpine-type ultramafic pods close to and south of the Matchless Amphibolite.

In conclusion, the writers believe that the model of an accretionary prism is appropriate to explain structural styles, sedimentation patterns, and regional aspects of the Khomas Trough. The size, the tectonic setting, and the time sequence of events within the Khomas Hochland accretionary prism may be compared with similar recent and ancient settings. The structural and depositional styles are most reminiscent of the Lower Palaeozoic Southern Upland accretionary prism (e.g. Leggett *et al.*, 1979) in view of: (1) a series of imbricate thrust slices steepening towards the backstop (the Southern Uplands Fault may be compared with the Okahandja Lineament in this regard); (2) extreme lateral persistence (> 200 km) of stratigraphic marker horizons and thrust faults; (3) preserved volcanics being mostly basalts, basaltic breccias and gabbros; (4) the predominance of lateral trench-fill turbidite sedimentation, and (5) no recognizable mélange deposits.

The Chugach terrane in Alaska has been explained as a Cretaceous trench-fill deposit (Nilsen & Zuffa, 1982; Sample & Moore, 1987). Broad similarities with the Khomas Trough exist in terms of: (1) linear extent (2000 km long, 100 km wide); (2) contained lithologies such as sandstones, siltstones, shales, limestones, basalts, and ultramafics (although sheeted dyke complexes are also described); (3) late-phase granite intrusions towards the fore-arc; and (4) structural style comprising coaxial deformation "seawards" and noncoaxial deformation with rotation and strike-slip faulting "landwards".

The time sequence of events during deformation of the Shumagin region of the modern Aleutian trench (Lewis *et al.*, 1988) also bears striking similarities to features of the Khomas Trough. This involves successively: (1) folding and thrust faulting (early thrust cored anticlines detected in seismic profiles); (2) thrust faulting; and (3) strike-slip faulting all of which occurred progressively under a constant principal stress regime.

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