A Structural Interpretation of the Northern Margin of the Limpopo Orogenic Belt, Southern Africa

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A structural interpretation of the northern margin of the Limpopo orogenic belt, southern Africa

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The northern margin of the Limpopo belt can be considered as a large-scale ductile shear zone with up to 200 km right-lateral displacement.

This contribution is a summary of preliminary work carried out in the Limpopo belt by the Research Institute of African Geology, University of Leeds, as part of a project whose ultimate aim is the quantification of strain and displacement in the ancient orogenic belts of southern Africa.

As Cox *et al.* (1965) and Mason (1969, and elsewhere in this volume) have pointed out, the Limpopo belt can be divided into three major tectonic zones (figure 1). A complexly folded central zone with large-scale north–south trending periclinal structures, is bounded by marginal zones which may be analogous with the 'straightening zones' of Hepworth (1967). The present note is primarily concerned with the north marginal zone of the belt, which has the form of a ductile shear belt analogous with smaller scale structures which have been described from deformed igneous rocks and basement gneisses elsewhere in the world (Teall 1885; Ramsay & Graham 1970). The north–south trending structures of the central part of the Limpopo belt curve into the northern zone and tighten (figure 2); a cataclastic fabric is locally developed, but no new fold structures are visible. The lineations within the straightening zone plunge at less than 5° and the finite stretching direction and hence the movement direction is almost horizontal. The Great Dyke of Rhodesia dated at 2650 Ma by Robertson & Van Breemen (1970) cuts the cataclastic fabric and the tightened early structures and therefore gives a minimum age for most of the deformation within the northern straightening zone.

Assuming the northern zone was developed by a mechanism of simple shear, it is possible, from the change in orientation of the early structures, to estimate the values of shear strain throughout the belt and eventually construct a contoured map of shear strain values and strain ratios (cf. Ramsay & Graham 1970). Even if there was a component of flattening across the belt as well as simple shear, it is still possible to give a minimum estimate of displacement.

Figure 3*a* shows structural trends in the Pikwe area of Botswana, obtained by detailed mapping with photo-geological interpretation. To the south of the shear zone the structure is defined by upright fold axial planes trending N 40°. These axial planes are progressively deformed until they trend approximately N 80° in the centre of the shear zone (figure 3*a*). The area is cut by a series of dextral transcurrent faults, of which most important is the Lethakane fault, believed to have developed during the final stages of shear deformation. An attempt has been made to remove the effects of the fault assuming a purely transcurrent movement direction as shown in figure 3*b*.

The method described by Ramsay & Graham (1970) was used to determine the variation in shear strain γ across two sections of the zone. The results, shown graphically in figure 3*b*, indicate mean strains of $\gamma = 1.7$ and $\gamma = 2.0$ for sections A and B respectively with corresponding total displacements of 30 and 50 km. An estimate derived by a similar method, of the displacement along the north marginal zone in southern Rhodesia, is of the order of 200 km. The discrepancy in these figures may be explained either by the dying out of the shear zone towards the west, or by movements being taken up along west-northwest trending belts of more intense deformation, north of the north marginal zone, in the region south and west of Bulawayo (figure 2).

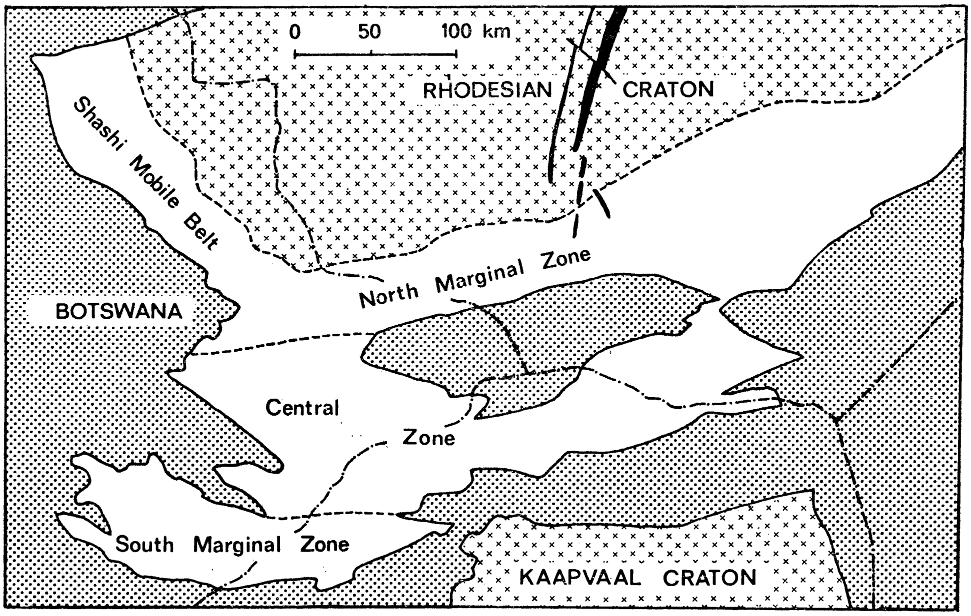

FIGURE 1. Simplified map of the Limpopo belt to show the position of north and south marginal zones (after Cox *et al.* 1965; Mason 1969) and the Shashi mobile belt (after Bennett 1970). Cover rocks are stippled, the craton is shown by crosses.

A belt of mylonitized charnockites and pyroxene-bearing tonalites of probable igneous origin, containing granulite facies metasedimentary relics, occurs in the north marginal zone of the Limpopo belt in Rhodesia (figure 2) (Robertson 1968). Traced southwestwards this belt of charnockites becomes obscured by Karroo cover. The granulite facies metamorphism is a very early event in the history of the Limpopo belt, much older than the northern marginal zone itself, and we should expect the granulites to re-appear in the central zone, south of the Karroo cover. The occurrence in this area, of a broad antiformal hinge zone which plunges southwards, may account for the termination of the outcrop of the granulite facies rocks. In Botswana, the marginal zone contains only rocks in amphibolite facies.

The north–south trending folds deform a mylonitic or blastomylonitic fabric which in Rhodesia post-dates the granulite facies metamorphism. The enveloping surface of the periclinal north–south trending structures is approximately flat lying. Thus it seems probable that the mylonites originated with a more or less horizontal orientation.

The northern margin of the Limpopo belt is difficult to define. The early structures of the central part of the belt can be traced into the north marginal zone but cannot be traced on to the Rhodesia craton, mainly because of the large amount of granite developed in the critical area. The effects of the deformation which produced the north marginal straightening zone can be traced on to the craton as far north as Fort Victoria; cataclastic fabrics and shear zones cut

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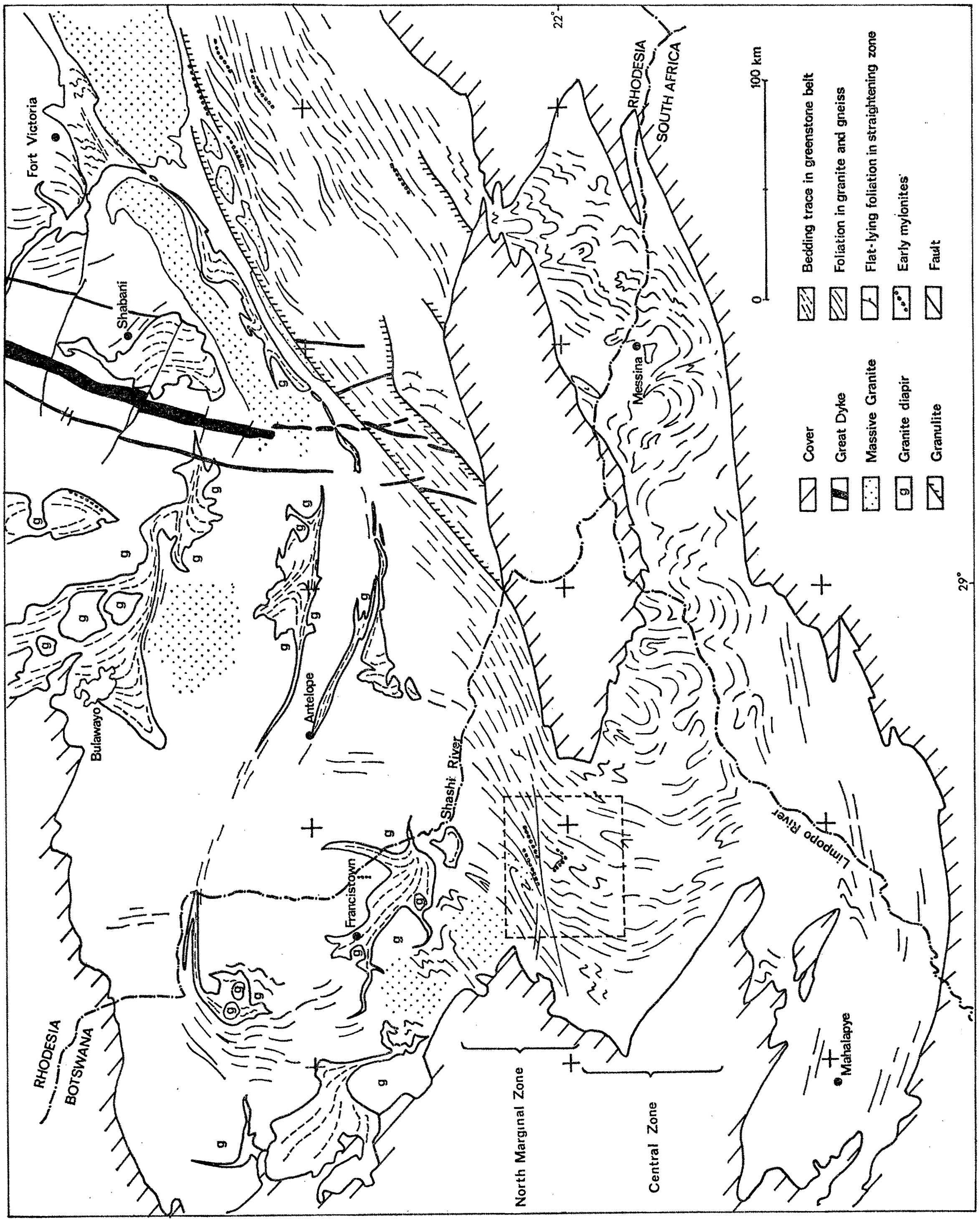

Figure 2. Structural trends of the Limpopo belt and southern part of the Rhodesian craton. A detailed analysis has been made of the area enclosed by the dashed lines (figure 3).

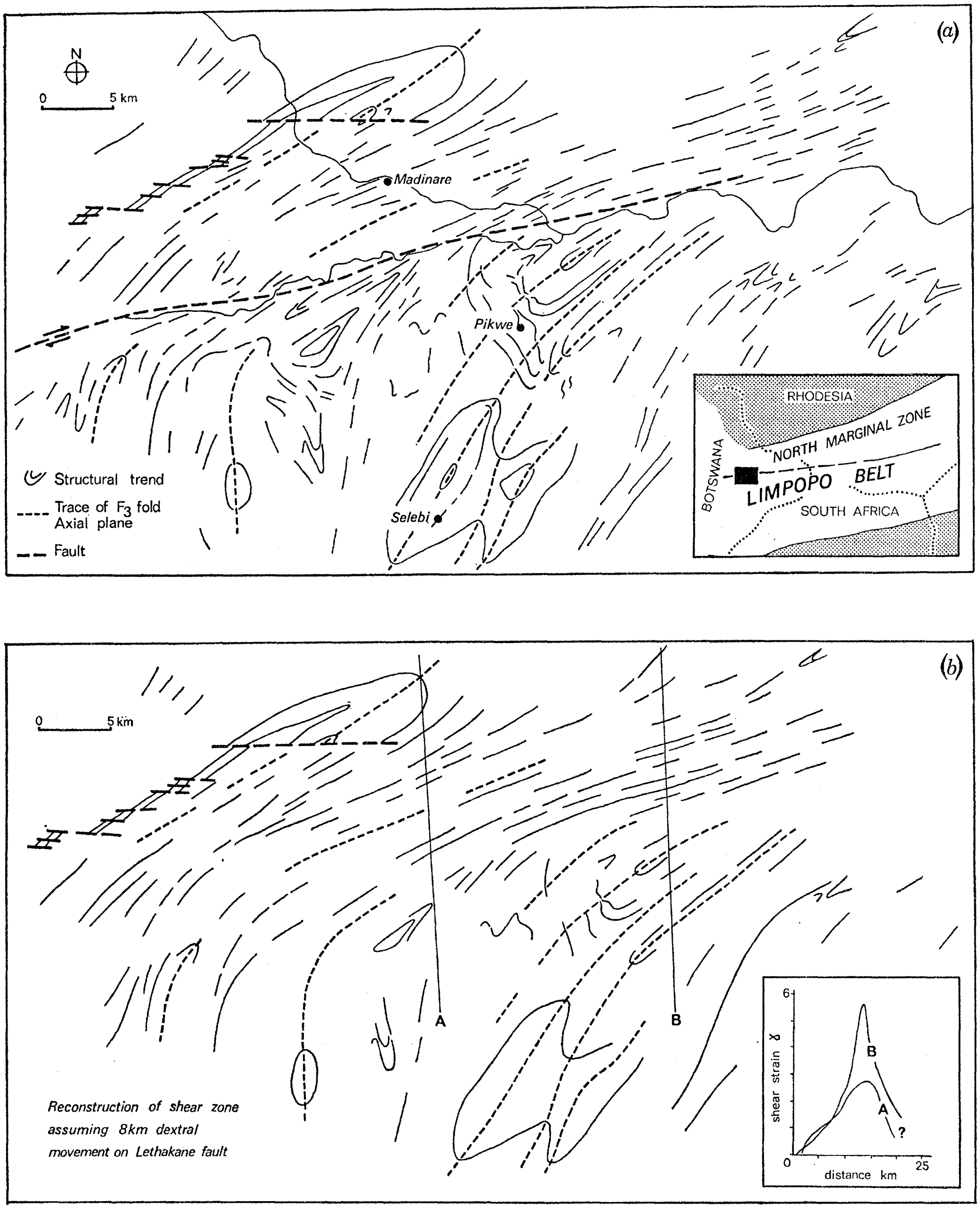

FIGURE 3. The Lethakane shear zone, Botswana, for explanation see text.

the granite and the Fort Victoria and Belingwe greenstone belts have the east-northeast Limpopo trend.

In Botswana, the north marginal zone is bounded to the north by the Shashi mobile belt (Bennett 1970), and Bennett (1972) has suggested that it might be possible to correlate the structures of the Limpopo and Shashi mobile belts. Throughout the north marginal zone of the Limpopo belt in Rhodesia and Botswana and in the southern part of the Rhodesian craton, there is a later structure with a west-northwest trend. This structure may occur either as a crenulation cleavage, a new regional cataclastic fabric or a cataclastic fabric localized in shear belts.

We conclude that the north marginal zone of the Limpopo orogenic belt is essentially a ductile shear zone with up to 200 km dextral movement. It separates a cratonic environment of granites and slightly metamorphosed greenstone belts from an environment of rocks with granulite or upper amphibolite facies metamorphism with a complex deformation history. The difference between these two environments may be the result of different tectonic levels. Several straightening zones analogous with the northern marginal zone of the Limpopo belt exist within southern Africa. Any analysis of relative cratonic movements in this part of the continent should give the sum of the displacements in all these various deformation zones.

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References (Coward *et al.*)

Bennett, J. D. 1970 Craton–mobile belt relations with particular reference to the Mosetse–Matsitama area, north-eastern Botswana. *Geol. Mag.* **107**, 113–123.

Bennett, J. D. 1972 The tectono-metamorphic complex of eastern Botswana. *Rep. geol. Surv. Botswana.*

Cox, K. G., Johnson, R. L., Monkman, L. J., Stillman, C. J., Vail, J. R. & Wood, D. N. 1965 The geology of the Nuanetsi igneous province. *Phil. Trans. R. Soc. Lond.* A **257**, 71–218.

Hepworth, J. V. 1967 The photogeological recognition of ancient orogenic belts in Africa. *Q. Jl geol. Soc. Lond.* **123**, 253–292.

Mason, R. 1969 Transcurrent dislocations in the Limpopo orogenic belt. *Proc. geol. Soc. Lond.* **1655**, 93–96.

Ramsay, J. G. & Graham, R. H. 1970 Strain variation in shear belts. *Can. J. Earth Sci.* **7**, 786–813.

Robertson, I. D. M. 1968 Granulite metamorphism of the basement complex in the Limpopo metamorphic zone. In *Symposium on the Rhodesian Basement* (ed. D. J. L. Vissar). *Trans. geol. Soc. S. Afr.* (annex) **71**, 125–133.

Robertson, I. D. M. & Van Breemen, O. 1970 The southern satellite dykes of the Great Dyke of Rhodesia. *Spec. Publ. geol. Soc. S. Afr.* **1.**

Teall, J. J. H. 1885 The metamorphism of dolerite into hornblende schist. *Q. Jl geol. Soc. Lond.* **41**, 133–152.