5 MAJOR STRUCTURAL FEATURES OF THE CENTRAL ZONE

The CZ of the LB displays two major structural features: (1) a roughly east-west oriented crustal-scale shear zone referred to as the "Mahalapye -Tshipise Straightening Zone" that forms the southern boundary of the CZ (Figure 1), and (2) a "Cross Folded Zone" to the north of the Straightening Zone (e.g. Holzer, 1995) (Figure 17).

5.1 The Mahalapye -Tshipise Straightening Zone

The southern boundary of the CZ is characterized by a 5–10-km-wide shear zone referred to as the Mahalapye – Tshipise Straightening Zone (MTSZ) (Figure 1) (Holzer et al., 1998). This crustal-scale shear zone is characterized by strongly flattened and steeply dipping planar structures mainly developed in rocks of the BBC such as orthogneisses, calc-silicates, metapelites, metagreywackes and pegmatites that commonly occur throughout the CZ. Although the MTSZ can be traced across the entire CZ as a single linear feature, different authors interpret the mode of occurrence and kinematic behaviour of different segments differently. In the eastern part of the CZ, the MTSZ is referred to as the Tshipise Straightening Zone. This section of the MTSZ has initially been interpreted by Roering et al. (1992a) to be part of a prominent, deep-skinned system of shear zones evident on the vibroseis profile across the LB. The Tshipise Straightening Zone is characterised by a general ENE foliation trend, dipping between 40^o to 70^o towards SSE (Holzer, 1998). Isoclinal folds are intrafolial while and stretching lineations within these planes are defined by elongated feldspar, garnet rods, and sillimanite in metapelites and hornblende in amphibolites. Holzer (1998) described the lineations and fold axis to be parallel, typically plunging = 20^o towards WSW. He also links orientation of all planar structures to a NNW to NW directed shortening that led to an intense overprinting of earlier structures and to a thinning of all lithological units (Holzer, 1998). Parallel oriented feldspar, quartz and biotite that define a relic foliation, are preserved as inclusions within poikiloblastic garnet. Holzer (1998) also recorded highly ductile deformation in the Tshipise Straightening Zone, where shearing was accompanied by partial melting and mobilization of leucosomes. Holzer (1998), however, suggested that the crystallization of the youngest melt patches partly postdates the latest high-grade deformation. Age data obtained from various minerals in the Tshipise Straightening Zone can be bracketed between 2034 ± 32 Ma and 1983 ± 8 Ma, therefore constraining the high-grade event in this zone to the Paleoproterozoic (Holzer, 1998).

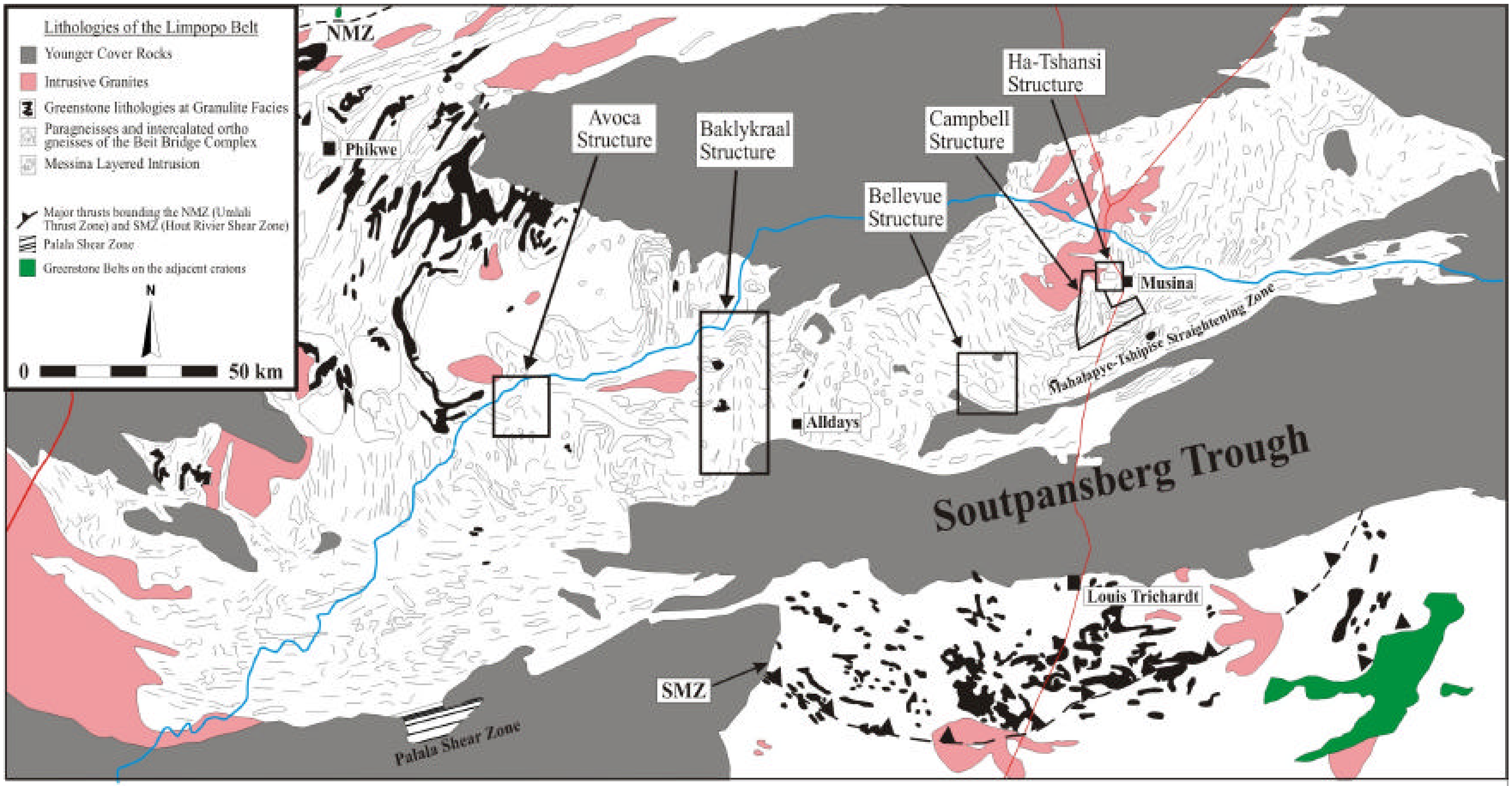

Figure 17:The Central Zone of the Limpopo Belt showing the major structural features of the Cross Folded Zone, as well as the location of the Mahalapye-Tshipise-Straightening Zone and the Palala Shear Zone (Afer Van Kal, 2004).

In the western part of the CZ, the MTSZ is referred to as the Mahalapye Straightening Zone (Figure 1) (McCourt & Vearncombe, 1987; 1992). According to Chavagnac et al. (2001), the structural character of this western section of the MTSZ becomes progressively more ductile towards the Mahalapye Complex in the westernmost extension of the CZ in Botswana. Partial melting and leucosome mobilization were interpreted by Holzer et al. (1998) as contemporaneous with the shearing. Holzer et al. (1999) described the shear bands and rotated porphyroclasts indicating oblique-slip with *dextral*, north-up components. A garnet Sm-Nd age of 2023 ± 7 Ma was interpreted to reflect garnet growth during incongruent melting at peak metamorphic conditions (Chavagnac et al., 2001).

The Palala Shear Zone in the central part of the MTSZ is an ENE-trending, 10 km wide mylonitic zone expressed in the Koedoesrand Window (Figure 2) where it forms the southern boundary of the CZ. It has been subdivided into southern, central, and northern domains (McCourt, 1983). In all three domains, the foliation dips to the north. Mineral elongation lineations are mainly subhorizontal. The sense of shearing and timing of deformation is controversial. McCourt & Vearncombe (1987, 1992) and Broekhuizen & McCourt (1995) describe an early phase of *sinistral* high-grade shearing followed by a *dextral* low-grade event. The high-grade event is interpreted to be Archaean in age (2600 to 2700 Ma), whereas the low-grade event is allocated to the Paleoproterozoic (2000 to 1800 Ma).

Schaller et al. (1999) postulate regional *dextral* strike-slip movement along the entire Palala Shear Zone, based on shear sense indicators. Age data obtained by Schaller et al. (1999) showed that the main deformation evolved at ~ 2000 Ma, based on age data measured from different domains in the Koedoesrand Window (Figure 2). Relict granulite facies paragenesis dated at 2602 ± 40 Ma (PbSL on garnet), reflect the late-Archaean precursor to the shearing related to the Palala Shear Zone. Schaller et al. (1999) documented that the Palala Shear Zone played an important role during the exhumation of the granulites of the CZ, and that this shear zone is associated with a transpressive orogeny that occurred at ~ 2000 Ma.

5.2 The Cross Folded Zone

The "Cross Folded Zone" of the CZ (Figure 17) is characterized by the presence of large scale, circular to oval shaped folds and by large NNW-SSE trending "cross folds". Within the large circular structures, the foliation is steeply dipping and defines cylindrical geometries, while mineral stretching lineations developed as a *single population* parallel to the core axis of the folds that consistently dips in a general SSW direction (e.g. the Avoca fold, figure 18)

Large and small-scale sheath folds are an integral component of the regional foliation pattern of the CZ (Figure 17) and are developed in rocks of the BBC, the Grey Gneiss Unit (Alldays Gneiss), and the Singelele Gneiss. Several examples occur: a major circular structure on the

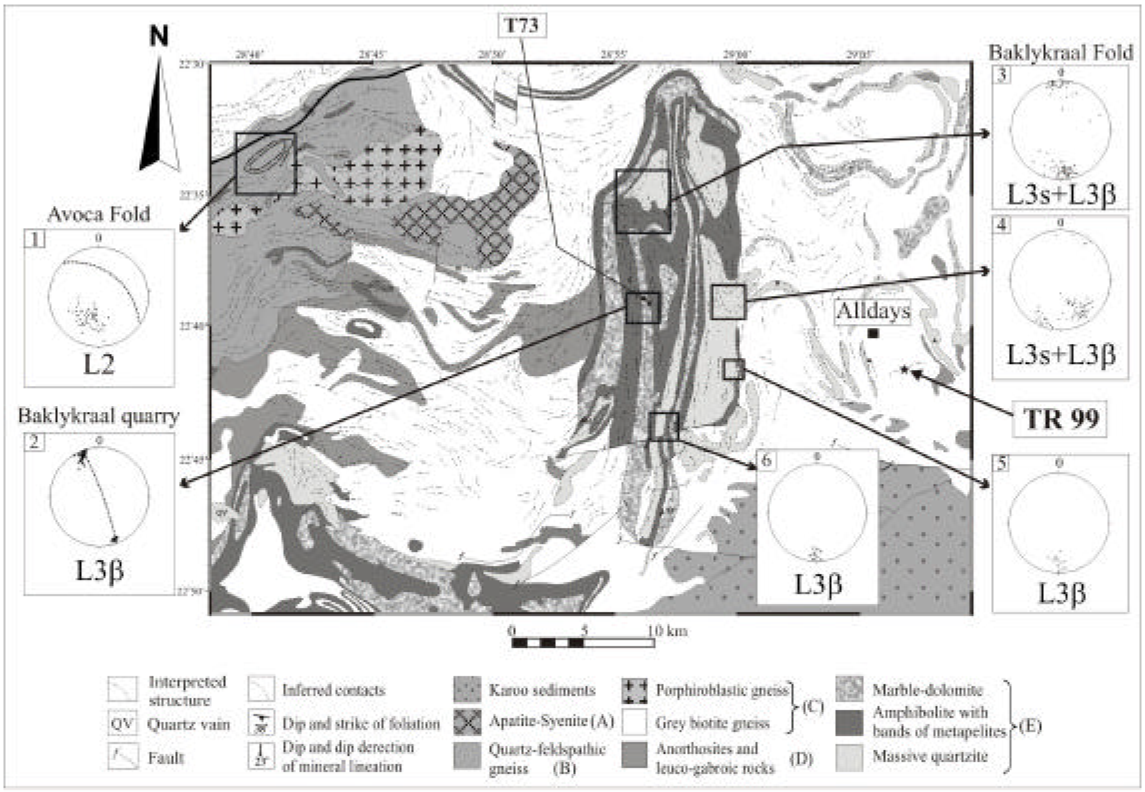

Figure 18 : Geological map of the Baklykraal area showing the Baklykraal cross fold and Avoca sheath fold, and stereographic projections of structural data from this study and from Feldtmann, 1996 (Baklykraal quarry). A =Madiapala Metasyenite, B = Singelele Gneiss, C = Alldays Gneiss, D = Messina Layered Intrusion, E = Beit Bridge Complex. Sample localities are indicated by sample numbers T73 and TR99.

farm Bellevue (Roering et al., 1992a) southwest of Musina (Figure 17) comprising a variety of rocks, including quartzo-feldspathic gneisses (Singelele Gneiss), mafic gneisses, quartzites, marble, calc-silicates and metapelitic gneisses; a large oval-shaped structure on the farm Avoca west of Alldays expressed in quartzo-feldspathic gneisses (Singelele Gneiss) and Alldays Gneiss (Roering et al., 1992a) (Figure 18) and the Ha-Tshansi fold (Van Kal, 2004) (Figure 13, 17). Different interpretations have been presented for the development and age relationship of the circular shaped folds in the CZ: (1) Roering et al. (1992a), Smit et al. (1992), and Smit & Van Reenen (1997) suggested, on the basis of this distinct geometric pattern, that closed structures in both the CZ and SMZ represent mega-sheath folds rather than superimposed folding as previously suggested (e.g. Fripp, 1983); (2) Fripp (1983) and Holzer (1998) described the circular folds as structures that developed as the result of superimposed folding; (3) a photogeological interpretation of the CZ in the vicinity of Musina (Bahnemann, 1972) (Figure 19), however, clearly show that existing sheath folds are strongly flattened by deformation along the MTSZ and are also transposed and elongated by cross folds, suggesting that the sheath folds could be older than both the cross folds and the deformation associated with the MTSZ.

The "Cross Folded Zone" is also characterized by large NNW-SSE trending "cross folds" (e.g. Söhnge, 1946; Pienaar, 1985; Pretorius, 1986). These major structures are a distinct feature of the CZ and are, in contrast to the sheath folds, mainly developed in rocks of the supracrustal BBC sequence (or the Kraaifontein Formation, Pienaar, 1985). The major phase of folding associated with the development of the cross folds dramatically transposes earlier structures, including sheath folds, into large NNW directed folds (Figure 17) with fold axes plunging at variable but shallow angles to the SSE. The best-exposed cross folds in the CZ include the Campbell fold near Musina (Figure 17), and the very large Baklykraal fold located about 25 km west of Alldays (Figure 17). Both folds consist of a well-layered sequence of metasediments (magnetite quartzites and quartzites, calc-silicates, and pelites) quartzo-feldspathic gneisses, amphibolites, and lenses of ultramafic rock belonging to the BBC (Holzer et al., 1998; Van Reenen et al., in press) (Figure 13). Holzer (1998) describes both cross and circular fold structures in the CZ as the result of the same deformation event.

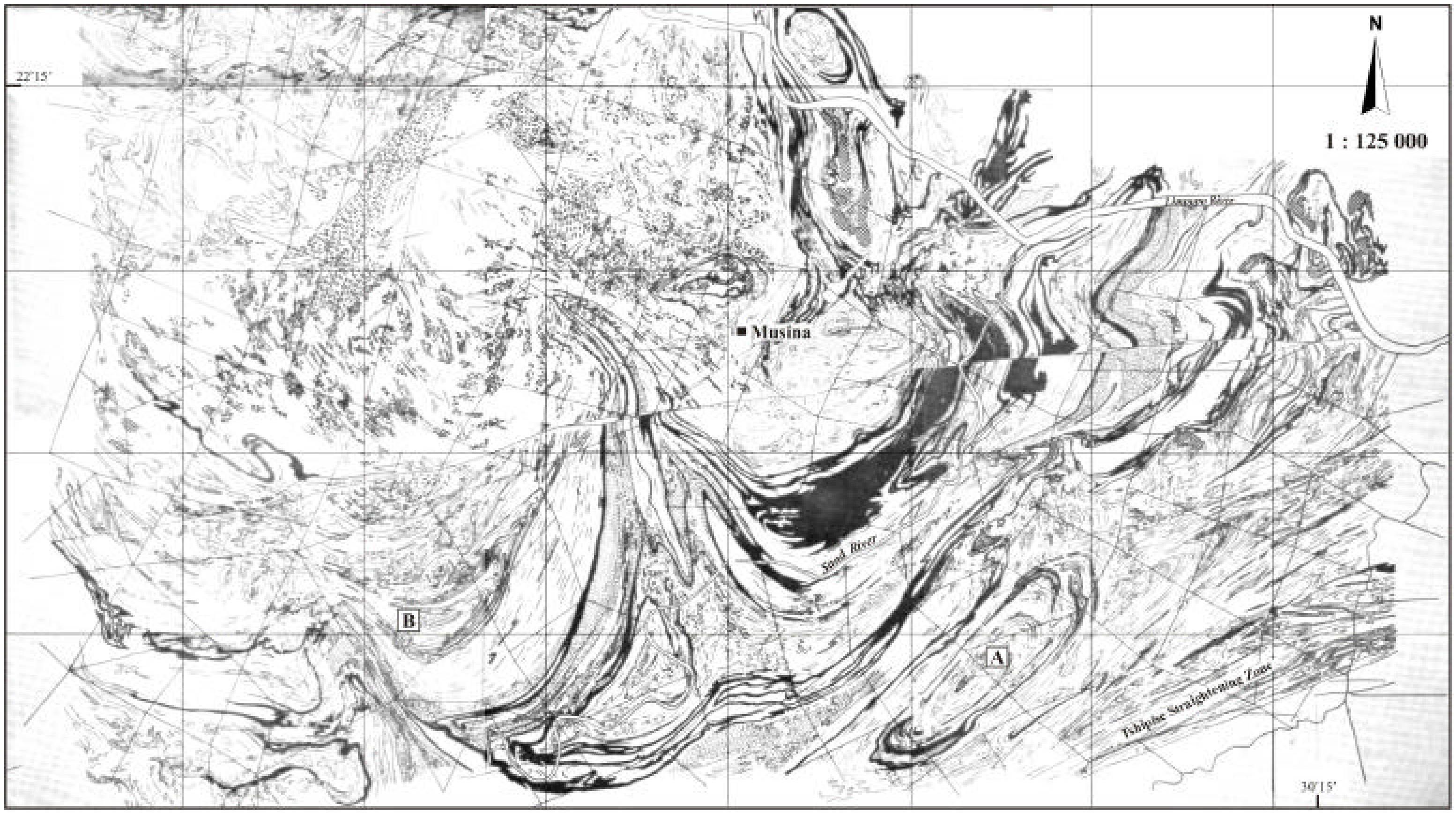

Figure 19: Photogeological interpretation of the Musina area (Modified after Bahnemann, 1972). This interpretation shows that circular folds are strongly flattened by the Tshipise Straightening Zone (A) and is also transposed and elongated by the cross folds (B).