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THE STRUCTURE OF THE EASTERN PORTION OF THE MURCHISON RANGE

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ABSTRACT

The structural history of the eastern portion of the Murchison greenstone belt can be explained in terms of three deformational events. Early high-angle faults, formed during gravity slumping of unstable ensimatic crust, provided a regional synformal framework for the preservation of linear homoclinal and synclinal greenstone belt assemblages. A second stage of deformation was initiated by the emplacement of discrete diapiric tonalite/trondhjemite plutons into and around the greenstone belt margins, leading to the development of the "granite-greenstone pattern". Cleavage, lineation, flattening of early open folds, and reactivation of early faults developed concomitantly, and with increasing intensity, throughout the second stage of deformation. Syntectonic granitoids were emplaced along subvertical upthrusts and high-angled reverse faults developed between the first and second stages of deformation. A third and final deformation event is registered in the sinistral ductile shear zones of the Letaba shear zone along the northern flank of the Letaba schist belt. Kinkband, crenulation, and chevron folds are related to this final event of deformation.

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CONTENTS

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THE STRUCTURE OF THE EASTERN PORTION OF THE MURCHISON RANGE

I. INTRODUCTION

The east-northeast-trending Murchison greenstone belt (also known as the Murchison Range or Murchison schist belt) in the northeastern Transvaal, comprises a 140km-long greenstone belt assemblage of volcanic and sedimentary rocks with a strongly superimposed conformable schistose fabric. The Murchison schist belt is intruded, deformed, and locally metamorphosed by compositionally and chronologically diverse granitic rock types (Vearncombe et al., 1991.). From beneath the Transvaal Drakensberg escarpment where it is about 10km wide the Murchison Range widens to about 20km in the vicinity of Letsitele, and then tapers to about 7km in width near the boundary of the Letaba Game Reserve in the east where the belt splits into two narrower schist belts referred to as the Letaba and Bawa schist belts, respectively (Figure 1). The structural elements developed in the Bawa and Letaba schist belts as well as the interpretation of the structural history of this area, provides the focus of attention of this contribution.

Structural features which distinguish the Murchison Range from the Barberton greenstone belt as well as other Archaean greenstone assemblages have been documented by Vearncombe and Van Reenen (1986), Vearncombe (1988), and Vearncombe et al. (1991). Among these are the penetrative schistose fabrics and the oblique-to dip-slip dominated ductile deformations recorded in the bulk of the assemblages comprising the Range. Despite these differences there are structures developed within the Bawa and Letaba schist belts which suggest episodic Archaean greenstone belt deformation after the manner proposed by Anhaeusser (1975, 1984). This style of deformation is related primarily to gravity-induced vertical tectonism and involves slumping and warping of unstable crustal material, followed by progressive isoclinal folding and subvertical faulting. This is followed, in turn, by deformation accompanying the emplacement of diapiric plutons within and around the perimeters of greenstone belts.

In the eastern portion of the Murchison Range schistosity is particularly well developed and is present in all rock types except the more massive serpentinite bodies which are flattened in the plane of the regional foliation. Competent rock types such as quartzites and contact amphibolites preserve cleavage and lineations, but a coarse-grained, fibrous texture is developed in strongly deformed mafic and ultramafic rocks.

Geological mapping of the study area was originally undertaken on 1:10 000 aerial photographs and subsequently compiled at a scale of 1:20 000 (Minnitt, 1975). This mapping is presented in reduced format in Figure 2.

II. STRUCTURE OF THE BAWA SCHIST BELT

The Bawa schist belt comprises a narrow, wedge-shaped syncline which tapers in plan from west to east. The synclinal axis has an undulating habit, but generally plunges at a low angle to the west. Protruding from the southwestern margin of the Bawa schist belt, on the farm Leeuwspruit 18 LU, is a southeasterly trending synclinal structure preserving ultramafic komatiitic volcanic rocks (Figure 2). This subsidiary syncline is separated from the major Bawa synclinorium by an anticline, along which several small pegmatite bodies have intruded.

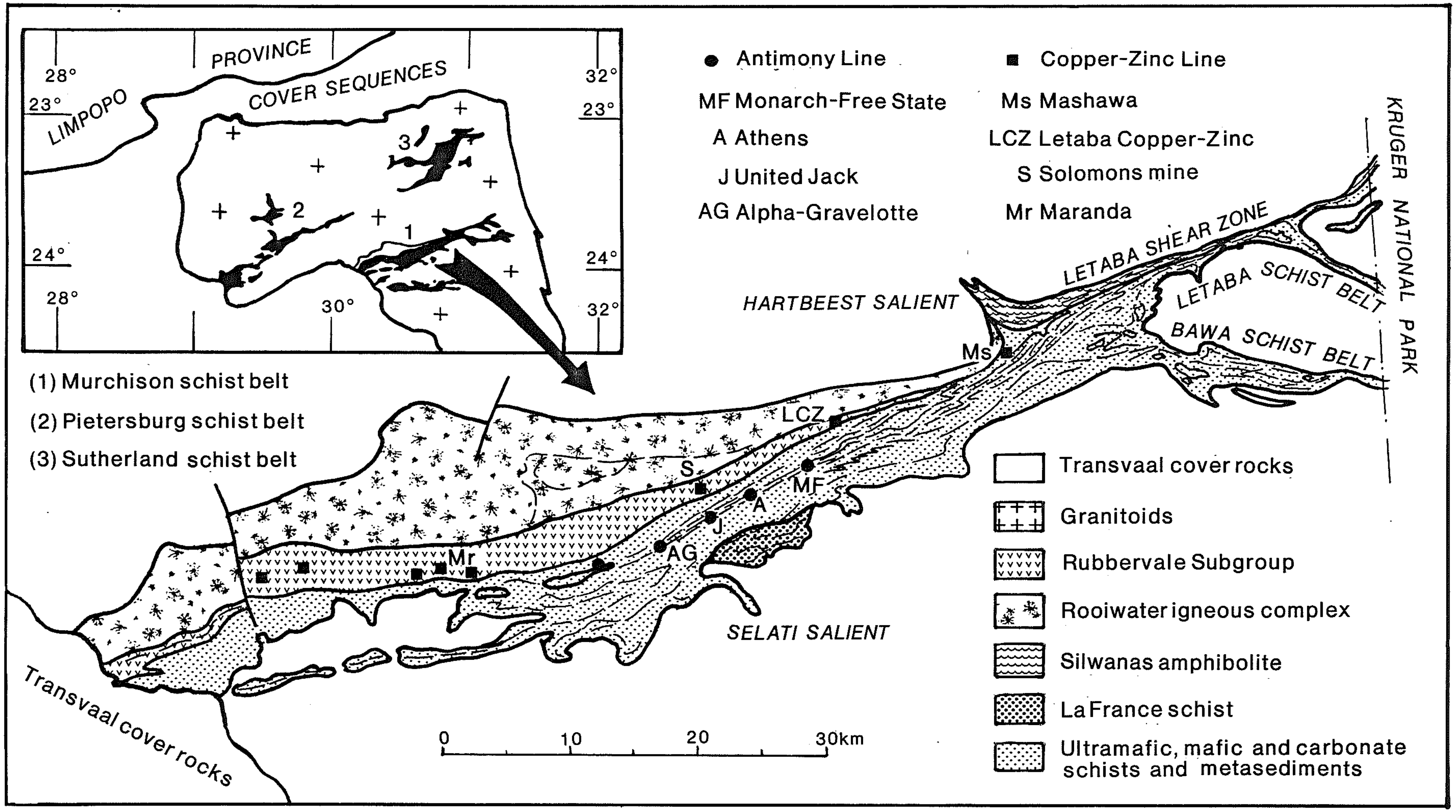

Figure 1: Simplified geological map showing the location of the Murchison greenstone belt (schist belt) in the northeastern Transvaal. Aspects of the structural geology of the eastern portion of the schist belt are shown in greater detail in Figures 2 and 3.

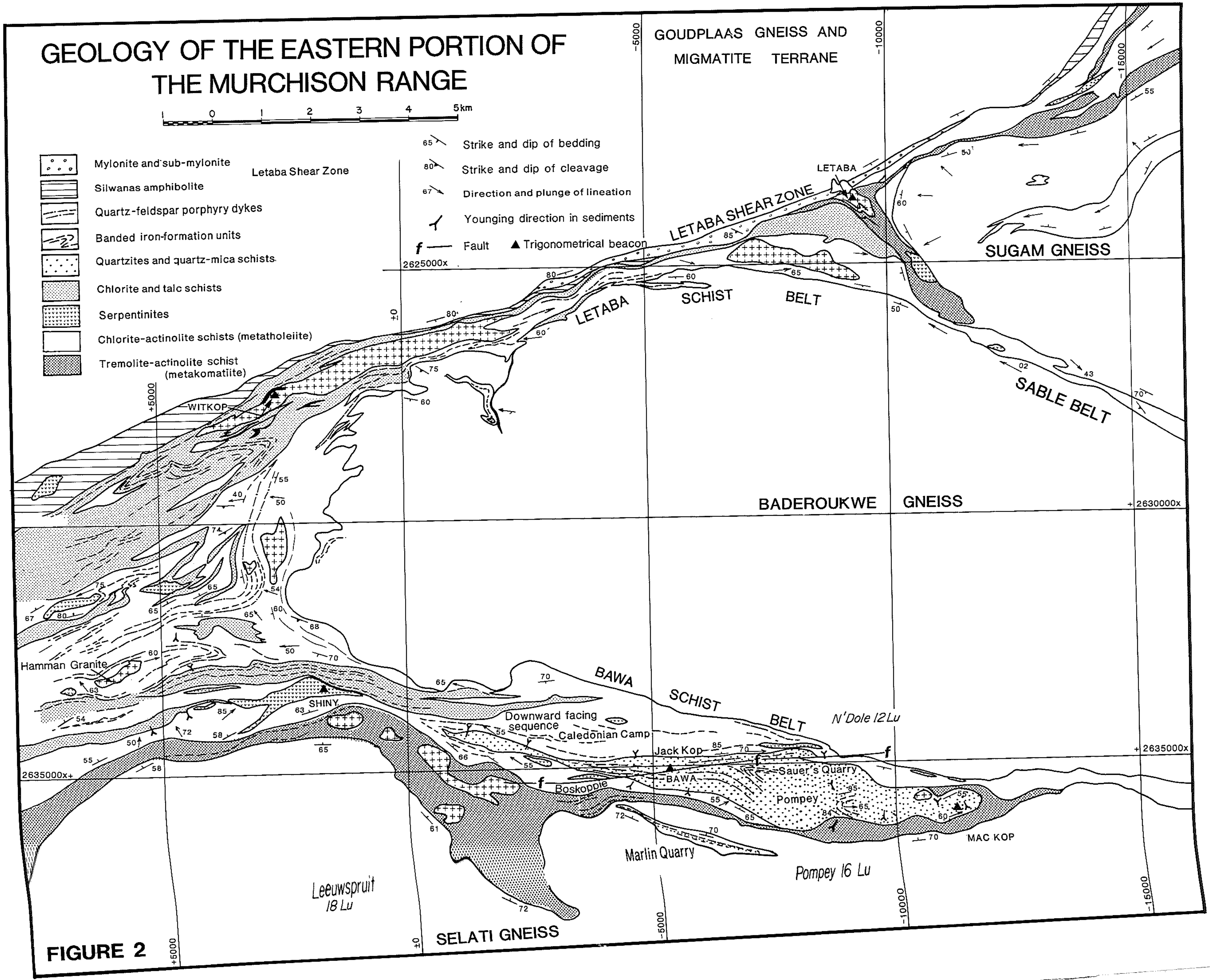
GEOLOGY OF THE EASTERN PORTION OF
THE MURCHISON RANGE
0 1 2 3 4 5km
Mylonite and sub-mylonite
Letaba Shear Zone
Silwanas amphibolite
Quartz-feldspar porphyry dykes
Banded iron-formation units
Quartzites and quartz-mica schists
Chlorite and talc schists
Serpentinites
Chlorite-actinolite schists (metatholeiite)
Tremolite-actinolite schist (metakomatiite)
Strike and dip of bedding
Strike and dip of cleavage
Direction and plunge of lineation
Younging direction in sediments
Fault
Trigonometrical beacon
GOUDPLAAS GNEISS AND
MIGMATITE TERRANE
LETABA
LETABA SHEAR ZONE
SUGAM GNEISS
LETABA
SCHIST
BELT
SABLE BELT
WITKOP
BADEROUKWE GNEISS
Hamman Granite
SHINY
BAWA
SCHIST
BELT
N'Dole 12 Lu
Downward facing
sequence
Caledonian Camp
Jack Kop
Sauer's Quarry
BAWA
Boskoppie
Pompey
MAC KOP
Marlin Quarry
Pompey 16 Lu
Leeuwspruit
18 Lu
SELATI GNEISS
2625000x
2630000x
2635000x
+5000
±0
-5000
-10000
-15000

FIGURE 2

Arenaceous sediments occupy a canoe-shaped synclinal keel in the core of the Bawa schist belt and provide the main clues to the structure of the schist belt as a whole. Outcrops of the arenaceous strata are not continuous along the length of the belt, but the prominent foliation in the quartzite has regulated the growth of the flora in such a way that the suboutcrop of the quartzites is clearly discernable on aerial photographs of the area.

From west to east the synclinal fold axis of the Bawa schist belt passes south of Caledonian Camp and extends eastwards through Lamai quarries and on into the region north of Jack Kop (Figure 2). The fold axis can further be traced through the region south of Sauer's Quarry as well as through the fold closure south of the farm N'Dole 12 LU, and on into the area south of Mac Kop (Figure 2). The position of the synclinal axis was defined by making use of the younging directions preserved in the cross-bedded foresets found in the arenaceous sediments. East of Sauer's Quarry, the syncline widens and it becomes difficult to accurately position the fold axis again until the fold closure south of the farm N'Dole 12 LU is approached (Figure 2).

Vearncombe et al. (1991) acknowledged that the deformational history of the Bawa schist belt was complex, basing their conclusions on:

(1) bedding-cleavage intersections and fold plunges which are steep in both the east and west; and
(2) the inconsistencies of bedding-cleavage relationships with respect to their position on the fold structure.

Four fold closures have been identified along the synclinal axis of the Bawa schist belt. Three of these were identified on the basis of younging directions in strata (Minnitt, 1975), and a fourth being observed in the quartz-mica schists southwest of the Caledonian Camp (Vearncombe et al., 1991). From east to west the fold closures are located on Figure 2 as follows:

(1) south of Mac Kop (Mac Kop);
(2) on the farm Pompey 16 LU (Pompey);
(3) south of Sauer's Quarry (Sauer's Quarry); and
(4) southwest of Caledonian Camp (Caledonian Camp).

(A) Mac Kop

The Mac Kop fold closure occurs immediately south of the Mac Kop (MAC) trigonometrical beacon which is sited on the north limb of the fold. The sediments here terminate abruptly east of this fold closure, the latter representing the nose of a canoe-shaped fold which is overturned to the west. Lineations measured on the limbs and in the nose of this fold, plunge steeply to the east.

Vearncombe et al. (1991) referred to the easterly outcrops of this sequence of orthoquartzites and conglomerates as "subdomain D". They recognized that the fold was neutral and that an east-southeast to east-west cleavage obliquely transects both limbs of the structure.

(B) Pompey

The synclinal fold closure on the farm Pompey 16 LU, plunges to the east at 65°. The structure was more precisely defined by Vearncombe and his co-workers (1991) as a synformal syncline i.e. the folded layers have retained their correct depositional sequence within the synformal structure (Ramsay, 1967). Furthermore, they reported that the cleavage is axial planar and related to the fold structure.

(C) Sauer's Quarry

Trendlines on aerial photographs suggest the presence of a fold closure located immediately south of Sauer's Quarry. Although the nose of the closure could not be verified in the field due to poor exposure, younging directions clearly indicate a synclinal structure. The area described here as the Sauer's Quarry closure is referred to by Vearncombe et al. (1991), as "subdomain C", and it is overprinted by an east-northeast-orientated cleavage. Crossing the Bawa schist belt in this area, and orientated in an east-northeast direction, is a right-lateral fault with a 300m displacement, which extends from Jack Kop to the farm N'Dole 12 LU. At the western extremity the fault runs into a zone of pervasive carbonatization known as Boskoppie, which is accompanied by an irregularly shaped intrusive lamprophyre body along the northern flank of the fault. It is likely that the zone of carbonatization and the emplacement of the lamprophyre body are related to the right-lateral faulting. Drag folding along this fault was responsible for the development of the Jack Kop anticlinal fold which plunges 85° to the east. North of the right-lateral fault (which is conformable and coincident with the symmetrical, upright, synclinal axis in the vicinity of Sauer's Quarry), i.e. within the northern limb of the syncline, cleavage and bedding aresubparallel or slightly oblique. In the southern limb the trend of the bedding is east-southeast and oblique to the cleavage. Vearncombe et al. (1991) have interpreted this to indicate that the cleavage shows no genetic relationship to the fold structure.

(D) Caledonian Camp

A sequence of alternating micaceous quartzites and chloritic schists are developed due west of Caledonian Camp. The area is referred to as "subdomain A" by Vearncombe et al. (1991) and these rocks have been folded into a WNW-plunging antiform with the cleavage fanning around the fold structure. They also found that sedimentary structures are downward facing on the cleavage and that asymmetric parasitic folds support the antiformal interpretation. The dip of the bedding in the quartzitic schists suggests that the antiform is asymmetrical and slightly overturned to the south.

(E) Marlin Quarry

Marlin Quarry is developed in a steeply northward-dipping sequence of quartz-sericite (pyrophyllite) - tourmaline schists. These schists can be cleaved into sheets about 15mm thick and are marketed as an attractive paving tile. Cleavage and bedding in this area are subparallel and where they are coincident in the micaceous schists recovery from the quarry is high. Along strike where the cleavage becomes slightly oblique to bedding the fissility of the schists is seriously affected and it is generally not possible to quarry the schists in such areas.

(F) Other Features

Other structurally noteworthy features of the Bawa schist belt include the lineation along the cleavage-bedding intersection, as well as a mineral stretching lineation that varies from east to west across the belt. East of Jack Kop the mineral and cleavage-bedding intersections plunge steeply to the east, but to the west of Jack Kop the lineations dip steeply to the west. While the foliation and bedding in the volcanic and arenaceous sediments remains consistently to the north at steep angles (75 - 90°) it is suggested that the change in the direction of plunge of the lineation may be a function of a change in the dip of the cleavage.

(G) Deformation History

Vearncombe et al. (1991) explained the structure of the Bawa schist belt in terms of complex geometrical surfaces involving right-way-up and overturned strata, produced during an early deformation, which were folded during a second deformational event. They interpreted the synforms in the Jack Kop and Mac Kop areas as first phase structures. The antiformal syncline and the synformal syncline of the Caledonian Camp and Pompey areas were considered to be second phase deformation structures, as is the cleavage. Although the geometrical arrangement is considered to be similar to that on the north side of the Antimony Line, further to the west where the oblique to dip-slip reverse faults are indicative of a thrust tectonic regime, there is no indication of the sense of movement.

III. STRUCTURE OF THE LETABA SCHIST BELT

The Letaba schist belt is preserved in a narrow Y-shaped synform with the limbs of the schist belt varying from 300 to 800m in width (Figure 2). The schist belt attains its maximum width in the vicinity of the Letaba trigonometrical beacon where it occupies the tricuspate zone of intersection between the Letaba, Sugam, and Baderoukwe gneissic plutons. Similar areas in other greenstone belts have been referred to as "triangular synclines" (Sutton, 1971), and are usually the sites of intense structural deformation.

Measurements of the strike and dip of schistosity along the east-northeast trending limbs of the schist belt indicate subvertical to southerly dipping planes of schistosity between 30 and 90°. Lineations which include cleavage-bedding intersection and mineral stretch lineations dip consistently to the east and east-southeast between 10 and 60°. Schistosity in the Sable Range is subvertical and is orientated parallel to the east-southeast trend of the schist belt.

(A) Letaba Shear Zone

Graham (1974) described a sinistral ductile shear zone along the northern margin of the Murchison schist belt. The Letaba shear zone, which affected both greenstone schists and granitoids along the northern flank of the Letaba schist belt, and which was considered to be a dextral strike-slip shear zone, was first described by Fripp *et al*. (1980). These authors included mafic mylonites (Silwanas amphibolite), pseudotachylite, and up to 6km of anastomosing heterogeneous mylonite in the northern granitoid (Letaba Granite, Minnitt, 1975), within the domain of the Letaba shear zone.

Originally described as hornfelsic tuffs (Minnitt, 1975) the dark brown, strongly cleaved-to-mylonitic quartz-hornblende gneisses, with an intense flattening fabric, have been classified with a suite of rocks referred to as Silwanas amphibolite by Vearncombe *et al*. (1991). Geochemically, these rocks have been shown to be tholeiitic in composition

(Minnitt, 1975). Cross-cutting pseudotachylite veins and subparallel breccia zones no more than a few tens of centimetres wide, are related to N30°E-trending fault zones. The breccia zones and pseudotachylite post-date all other structures as well as cross-cutting quartz veins. Intense flattening fabrics indicate that simple shear was only a component of the deformation. Vearncombe et al. (1991) have shown that rocks of Silwanas amphibolite, preserved in the Hartbeest salient west of the study area, have the highest strain ratios of any rocks in the Murchison Range, namely 15:3,6:1, and that the strains in the salient are constrictional.

The possibility that mylonites were developed along the northern flank of the Letaba schist belt, was suggested by Minnitt (1975), who described these rocks as cyclically alternating acid tuffs and porphyries. These rocks were later interpreted as granitoid mylonites and semi-mylonites having both S and LS fabrics (Vearncombe et al., 1991). It was also noted that the rarely developed mineral lineation is sub-horizontal and that the composite planar fabrics could indicate sinistral movement along the shear zone.

IV. STRUCTURE OF THE WITKOP-SHINY SECTION

The Witkop-Shiny Section of the Murchison Range is flanked on the northern side by tonalitic-trondhjemitic gneisses of the Goudplaas Gneiss (Letaba Gneiss). On the southern flank the greenstone schist belt is intruded by the Selati trondhjemitic gneiss, while on the east, emplacement of the east-west, elongated, Baderoukwe diapiric pluton has resulted in the arcuate trends of the Letaba and Bawa schist belts.

Banded iron-formation units constitute the best available marker beds in the Witkop-Shiny Section. They are useful lithologic and structural markers on a local scale even though they are discontinuous. Banded iron-formations are significant because they record the complete history of the deformation. A number of shallow-dipping, leucocratic quartz-feldspar porphyry dyke- or sill-like intrusives are developed in the Witkop-Shiny Section. These intrusive bodies transgress lithologic boundaries, and contain a D_2 fabric evidenced by the alignment of tremolite laths. It is possible that the porphyritic intrusives represent derivatives of the compositionally similar sodic tonalite-trondhjemite plutons which have been determined by geophysical means to lie at shallow depths beneath the greenstone belt cover in the Witkop-Shiny Section (De Beer, 1982; De Beer et al., 1984). Further to the west Vearncombe et al. (1991), demonstrated that granodiorites along the geophysical discontinuity were syntectonically emplaced between the D_1 and D_2 cleavage forming events.

Five conspicuous fold closures are developed in the Witkop-Shiny Section. The largest of the folds is located in the centre of the area and is outlined by curvilinear units of quartz-feldspar porphyry, and is accentuated by curved bands of chloritic schists in the core (Figure 2).

Although mylonite, submylonite, and intense flattening fabrics have been recognised along the left-lateral Letaba shear zone, the extent of the shear domain has not yet been specified. The influence of the shear zone is evident in the pronounced schistosity in the mafic volcanics, as well as the folding in the quartz-feldspar dykes south of the Silwanas amphibolite contact. The prominent ridge of white vein quartz, known as

Witkop, is developed along the faulted contact between Silwanas amphibolite and chloritic-talcose schists. The sigmoidal S-shape of this topographic feature indicates that the sense of movement along this fault was left lateral.

In the south-central areas of the Witkop-Shiny Section outcrops of banded iron-formation define an S-shaped isoclinal fold. An elongate pod of granite, which Vearncombe et al. (1991) refer to as the Hamman Granite, lies in the core of the east-west orientated anticlinal structure in the southern portion of this S-fold (Figure 2).

V. GRANITIC ROCKS

The granitic rocks surrounding the eastern portions of the Murchison Range are intrusive into the greenstone schist belt assemblages and are responsible for the deformation and metamorphism affecting the region. The granitic terrane is predominantly underlain by leucocratic, biotite-trondhjemitic gneisses and migmatites, the latter rock types being volumetrically the most important varieties. Pegmatitic, aplitic, and adamellitic phases are present in minor amounts.

The intrusive character of the granitic rocks in the eastern portion of the Murchison Range is based largely on contact relationships, evidence from metamorphism, and the occurrence of mafic xenoliths in the granites. Abundant discreet, contorted, and lenticular amphibolite xenoliths (up to 20m in length) occur as remnants of contact amphibolites in homogeneous, strongly foliated, biotite-trondhjemite gneiss along the northern contact of the Letaba schist belt. Xenoliths in the marginal trondhjemitic gneisses occur as discreet entities with very little assimilation by the surrounding trondhjemitic host rocks. Diffusion of the xenolith-granitic contacts as well as increased fragmentation, deformation, and assimilation of mafic material by the granitic rocks are apparent as the more homogeneous trondhjemites grade northwards into the migmatite terrane (Goudplaas Gneiss).

The Sugam and Baderoukwe diapiric tonalite/trondhjemite plutons display varying contact relationships with the adjacent greenstone schists. Outcrops of the Sugam trondhjemite gneiss dip steeply towards the adjacent greenstone schist belts in the marginal areas of the pluton where a strong tangential fabric is developed. The Baderoukwe trondhjemitic diapir also has a well-developed gneissic fabric due to the subparallel orientation of mafic minerals (biotite, together with some hornblende). Furthermore, the granite-greenstone contacts are generally concordant, the contained foliation and lineation in the granitic gneisses being parallel to the schistosity and lineation in the adjacent metavolcanics. The alignment of mafic xenoliths parallel to the granite-greenstone contact is reproduced on a smaller scale by the subparallel alignment of metamorphic minerals which impart a strong planar fabric to the xenoliths. In addition, the trondhjemitic gneisses are largely responsible for the deformation in the adjacent greenstone schist belts, this aspect of the structure being well-illustrated where the eastern portions of the Letaba schist belt are deformed by the Sugam diapiric intrusive body. Lit-par-lit injection of granitic apophyses parallel to the granite-greenstone contacts is a common feature found around the margins of trondhjemitic gneiss plutons (Anhaeusser, 1969, 1984; Anhaeusser and Robb, 1980; Viljoen and Viljoen, 1969). Such features are commonly observed in the Baderoukwe granitic gneiss where trondhjemitic wedges intrude the Letaba schist belt. In this area, the foliation in the granitic rocks and the greenstone belts is concordant although the granitoids may also display transgressive relationships in places. The discordant, somewhat ragged appearance of the granite-greenstone contact around the western edge of the Baderoukwe trondhjemitic gneiss pluton could be due to stoping or assimilation of greenstone schists during passive emplacement of the granitic body.

A prominent geophysical discontinuity, which is developed along the entire length of the Murchison Range (Vearncombe et al., 1991), also manifests itself in the eastern portion of the Murchison Range (De Beer et al., 1984, 1986). A series of profiles show granitoids near surface, beneath or in close proximity to, the Antimony Line in the west and over the central portions of the Witkop-Shiny Section in the east. Intrusive granitic bodies such as the Hamman Granite (Figure 2) are probably connected at depth with the granitoid intrusions along the Antimony Line.

Vearncombe et al. (1991) have suggested that the granitoid was intruded along the Antimony Line in a dynamic geotectonic environment. It is possible therefore that the contact relationships along the western perimeter of the Baderoukwe trondhjemite gneiss pluton may represent a tectonically modified configuration.

VI. STRUCTURAL HISTORY RELATED TO THE ANTIMONY LINE

The assemblage of greenstone belt schists along the Antimony Line preserves several heterogeneous phases of deformation which were described by Boocock et al. (1984). The deformation fabrics within the broad ductile shear zone become increasingly intense and more closely spaced as the semi-brittle deformation zone - referred to as the Antimony Line - is approached from north to south. To the north and south, away from the immediate environs of the Antimony Line, D_1 fabrics, which are best preserved in arenaceous strata, are restricted to thin conformable slip zones, with locally intense slaty cleavage and subvertical stretch lineations. North of and adjacent to the Antimony Line, tightly spaced D_1 isoclinal folds have been interpreted from changes in the younging directions seen in graded and cross-bedded arenaceous sediments. Intense and pervasive D_1 fabrics occur subparallel to bedding in the area immediately adjacent to the Antimony Line. Within the Antimony Line itself an intense D_1 fabric masks all earlier features and surrounds pods of competent rock types which have preserved isoclinal folds developed during the heterogeneous deformation (Vearncombe et al., 1991). A steep north-dipping shear zone, in which S-C structures (Berthe et al., 1979) indicate a north over south reverse sense of movement, was also identified in the vicinity of Jack Shaft by Boocock et al. (1984).
These features, as well as the oblique-to down-dip orientation of mineral lineations and elongate shape fabrics (implying the direction of movement), were used by Vearncombe et al. (1991) to propose the analogy between the structures north of the Antimony Line and nappe structures.

D_2 fold structures and cleavage were recognized away from and within the Antimony Line by Vearncombe et al. (1991). D_2 folding of bedding and D_1 structures is manifest as asymmetric S folds which vary from close to tight, and accommodate considerable amounts of unevenly distributed shortening by buckling. Plunges of D_2 folds vary from 50° to 80° to the west between the old Belleview Gold Mine and the currently operating antimony mines. A subvertical east-west orientated, spaced D_2 cleavage in rocks north, south, and within the Antimony Line is axial planar to the asymmetric S folds. Vearncombe and his co-workers (1991) also suggested that D_2 deformation was responsible for rotation of flatter D_1 structures and bedding into their present upright to vertical positions.

D_3 structures principally comprise kink bands at orientations of 30° and 160°, but include all ductile structures post-dating the D_2 deformation. Two variably orientated crenulation cleavages are common in the chlorite and talc schists.

VII. STRUCTURAL HISTORY OF THE EASTERN PORTION OF THE MURCHISON RANGE

The interpretation of the structural events in the eastern portion of the Murchison Range has been adapted from the interpretation, given by Anhaeusser (1975, 1984), of the tectonic evolution of Archaean greenstone belts. The basis for Anhaeusser's (1975, 1984) interpretation of Archaean structural evolution was the "gregarious batholith" map of the Zimbabwe Craton compiled by Macgregor (1951), and also exemplified in the Barberton Mountain Land, South Africa and the east Pilbara district of western Australia. Greenstone belt-type volcanic successions are believed to have once extended across the Zimbabwe and Kaapvaal cratons of southern Africa (Anhaeusser, 1975). These were subsequently, dismembered, fragmented, partly assimilated, migmatized, and complexly folded in response to gravitational adjustments during emplacements of granitic magmas. Furthermore, the granites were held responsible for most of the metamorphism and the typical arcuate structures or "granite-greenstone pattern" common to many greenstone belts (Anhaeusser et al., 1969; Anhaeusser, 1975, 1984).

In broad terms the tectonic history of greenstone belts is seen by Anhaeusser (1975, 1984) as having developed in two stages. Stage 1, which essentially involved vertical tectonics, was considered to have been initiated by gravitational slumping and the development of mega-undulations on a thin unstable ensimatic lithosphere. This deformational stage was responsible for the development of the main fold trends of the greenstone belts which, in the Archaean terrane of South Arica, has a dominantly northeast to east-northeast orientation. Stage 1 also included the formation of longitudinal high-angled slides or faults which developed parallel to the main fold trends and gave rise to the preferential preservation of synclinoria, the latter thought to have been formed during gravitational slumping. At the same time, the elimination of many of the intervening anticlinal structures was accomplished.

The linear nature and east-northeast trend of the Murchison Range would have been established during Stage 1 events. While Vearncombe et al. (1991) are of the opinion that the D_1 structures in the Murchison Range formed in a subhorizontal tectonic régime (thereby accommodating features they interpret as nappe structures), it is possible that the D_1 structural elements could have developed by means of high-angle reverse faults or upthrusts.

It was postulated by Anhaeusser (1975) that progressive folding and faulting depressed the root zones of greenstone belts into pressure-temperature environments where differential anatectic melting could occur, leading eventually to the production of the discrete diapiric tonalite/trondhjemite plutons so commonly found emplaced around the margins, or intruded into, greenstone belts. The Sugam and Baderoukwe trondhjemitic gneiss bodies might thus represent plutons whose emplacement can be linked with the last phases of Stage 1 deformation in the tectonic history of the eastern portion of the Murchison Range.

The emplacement of the diapiric plutons initiated what Anhaeusser (1975, 1984) defined as Stage 2 in the structural history of Archaean greenstone belts. This event was responsible for the formation of arcuate schist belt tongues typified, in the Murchison Range, by the Bawa and Letaba schist belts, and triangular synclines, a good example of which is present in the Letaba schist belt (Figure 3). The variety of Stage 2 structures were developed concomitantly and include four elements, the principal one being the formation of schistosity in the greenstone belts and the parallel fabric or foliation developed around the margins of the diapiric plutons. This foliation, parallel to the granite-greenstone contacts, is well represented in the Sugam trondhjemitic gneiss pluton and portions of the Baderoukwe pluton. Mineral stretch lineations were developed concomitantly with the schistosity and usually have steep, down-dip or oblique orientations.

Emplacement of tonalitic/trondhjemitic diapirs would commonly be accompanied by the formation of large-scale inflections, the formation of disharmonic folds, and the flattening of early open folds in competent massive formations. Evidence of large-scale inflections is clearly preserved in the most easterly exposures of the quartzite in the Bawa schist belt (Figure 3). Furthermore, large-scale folding of the type produced during Stage 2 deformation is preserved in the "triangular syncline" in the Letaba schist belt (Figure 3). Anhaeusser (1975, 1984) related the final phases of Stage 2 style deformation to continued upward emplacement of the intrusive granitic diapirs, which resulted in reactivation of early, possibly Stage 1, regional faults. This final phase of deformation was considered to be responsible for the formation of kinkband, crenulation, and chevron folds (the D_3 structures of Vearncombe et al., 1991). Structures of this type have been noted in the Witkop-Shiny Section. Structural features developed during Stage 2 deformation, and recognized in the eastern portion of the Murchison Range, are summarized in Figure 3. These and related structures in the area support the general applicability of the deformational model outlined by Anhaeusser (1975, 1984) for Archaean greenstone belts.

Apart from later episodes of epirogenesis, during which numerous dyke swarms were introduced into the crust, tectonic activity in the Barberton greenstone belt ceased about 2600 Ma ago, after the emplacement of the late post-tectonic granite plutons (Anhaeusser, 1969, 1975; Viljoen and Viljoen, 1969; Hunter, 1974; Robb, 1983). By contrast tectonic events in the Murchison greenstone belt continued well into Transvaal times (2,2 Ma ago), the effects of these events being recorded in the sedimentational and structural history of the Transvaal Supergroup. The Selati Trough, which preserves an accummulation of sediments many times thicker than the surrounding areas, was a subsiding tectonic environment throughout the depositional history of the Wolkberg Group of the Transvaal Supergroup, and overlies the westward projection of the axis of the Murchison Range (Button, 1972, 1974). Tectonic reactivation, after the deposition of the Olifants River Group, resulted in the formation of the Mhalpitsi Fold Belt, which also overlies the westward projection of the axis of the Murchison Range.

Button (1974) considered that the differences in the structural behaviour of Archaean greenstone belts was related to the depth to which their root zones extended. Shallow-rooted greenstone belts, underlain by

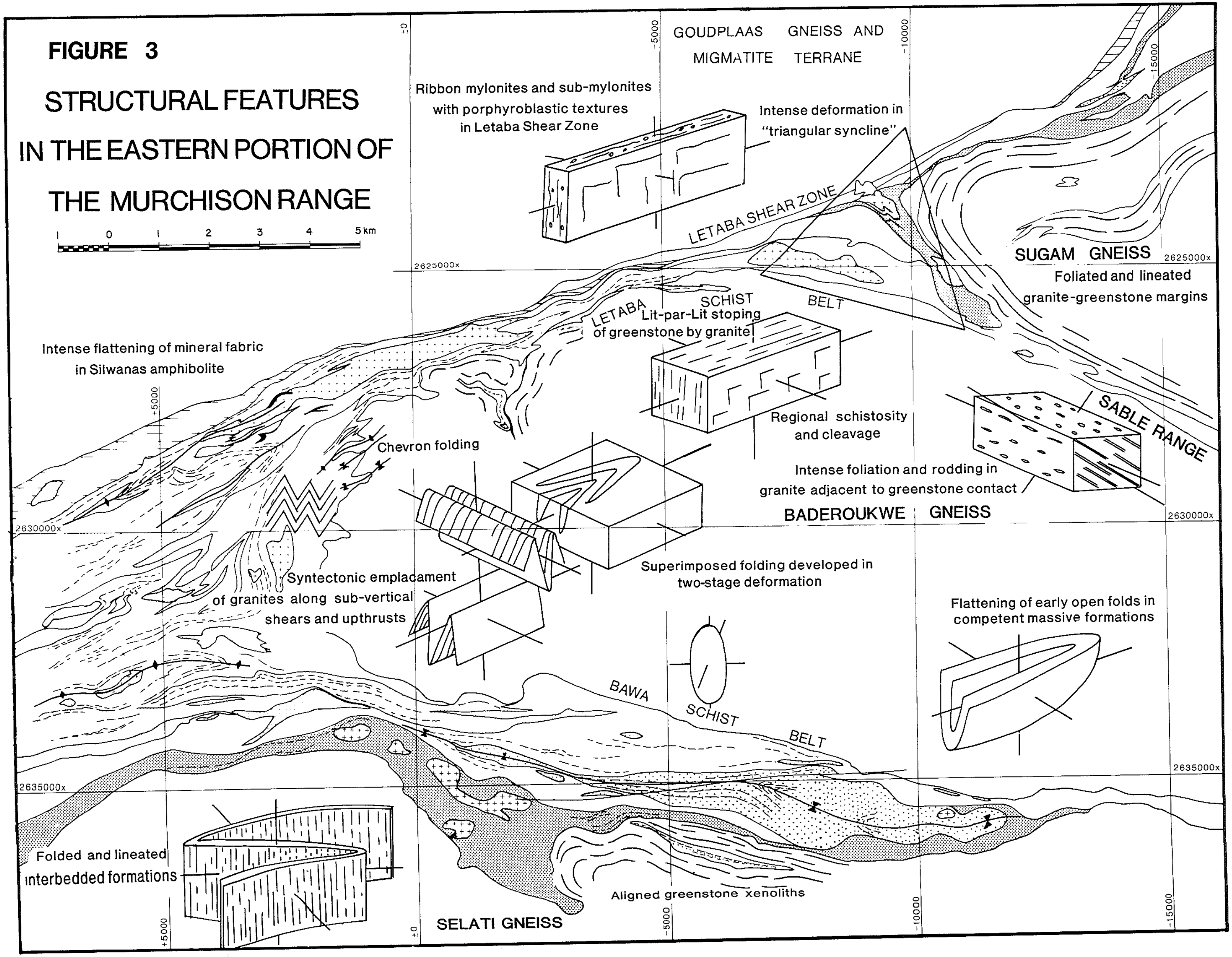

FIGURE 3
STRUCTURAL FEATURES IN THE EASTERN PORTION OF THE MURCHISON RANGE

rigid granitic crust would, according to his views, not be affected by lateral movement between granitic blocks. Conversely, deep-rooted belts constitute crustal inhomogeneities which would, during sedimentation of overlying formations, give rise to features such as the Selati Trough. In addition, accommodation of lateral movements of granitic blocks by deep-rooted belts may have been responsible for the formation of features such as the Mhlaptsi Fold Belt. Surface geological mapping has shown the Antimony Line to be a subvertical structure intruded by fingers of granodiorite (Vearncombe et al., 1988). The deep structure has been investigated by geoelectrical soundings and gravity surveys (De Beer, 1982; De Beer et al., 1984). Geoelectrical data indicate maximum depths of 8,8 to 12,3km and that most of the belt has a depth extent of less than 4,5km. An absolute maximum depth of 12km has been established for the belt by means of gravity data. Geophysical data indicates, furthermore, that the Antimony Line is underlain by a discontinuity which persists from the embayment of the Maranda granitic body in the west to the Baderoukwe gneiss pluton in the east. Locally developed exposures of granodiorite along the strike of the discontinuity, as well as geophysical modelling indicate an intrusive granodiorite body (De Beer, 1982; De Beer et al., 1984; Vearncombe et al., 1988). This body was found by Vearncombe and his co-workers to be syntectonic having been emplaced between the D_1 and D_2 deformation events.

Anhaeusser (1975, 1984) maintained that a distinctive feature of the structural style of Archaean greenstone belts is the irregular distribution or absence of an all pervasive penetrative cleavage or schistosity. The pervasive schistosity and planar fabric developed through most rock types in the Murchison Range is therefore an unusual feature and may possibly be related to the prolonged tectonic activity suffered by the region as well as the narrowness of the belt (Minnitt, 1975).

In summary, the regional east-northeast trend of the Murchison Range appears to have been produced during the Stage 1 deformation, while the structural features developed during the deformational Stage 2, and which have been recognized in the eastern portion of the Murchison Range, are considered to have formed during the emplacement of diapiric trondhjemitic bodies, including the Baderoukwe and Sugam plutons.

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