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DIAPIRIC STRUCTURES IN THE BUSHVELD, NORTHEASTERN TRANSVAAL

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by

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ABSTRACT

Domal occurrences of Bushveld floor rocks, comprising Pretoria Group metasediments, occur along the margins of and within the northeastern sector of the Bushveld Layered Sequence. In some of the structures, floor rock domes occur at the level of the main magnetite seam, some 8-9 km stratigraphically above their normal level of outcrop. Gravity and magnetic lows characterize some of the domes, indicating that they are not underlain by the layered mafic rocks of the Bushveld Complex. The domes are thought to be diapirs. Conditions favouring diapirism were the 0,35 gm/cm^3 density contrast between floor metasediments and the overlying layered mafic rocks, and the plastic condition of the pelitic metasediments, caused by heat from the intrusives. Flowage within the diapirs is indicated by gneissic-textured metaquartzites, by aligned metamorphic minerals and by stretched pebbles. Deformed fabrics and bent plagioclase crystals suggest diapiric intrusion into the not-yet-cooled mafic cumulate rocks. The diapiric action apparently continued for a relatively long period of time, since the entire Bushveld Complex (including the granitic phase) thins towards the diapirs. The diapirs have potential economic importance, since they have elevated some of the economic units of complex to relatively shallow depths.

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I. INTRODUCTION

Mapping of the northeastern Bushveld Complex (Figure 1) has revealed a number of anticlines and domes (Schwellnus et al., 1962; Molyneux, 1974; Marlow and Van der Merwe, 1977; personal observation, 1973) in the Pretoria Group sediments which underlie the complex in this area. This style of deformation is apparently most often restricted to areas where the Bushveld Layered Sequence is exceptionally thick, and where metamorphic effects extend relatively far down into the floor rocks. The domed structures have the effect in many cases of bringing floor rocks into contact with upper levels of the Bushveld Layered Sequence. Some of the folds have been interpreted as the response to lateral forces of intrusion of large volumes of gabbroic magma (Schwellnus et al., 1962). This explanation does not satisfy a critical scrutiny. Why are such folds not common around the remainder of the Bushveld Complex? Can this mechanism explain floor rock domes very close to upper units of the Layered Sequence, or the apparent continued growth of the domes through to Bushveld granite times? This note explores the concept that diapiric tectonics are an important factor in Bushveld geology.

II. DIAPIRISM

Diapiric structures originate in stratified rocks where a gravitational imbalance exists due to a heavier stratum being superimposed on a lighter one (O'Brien, 1968). They are particularly common in evaporite-bearing successions, where relatively light halite or gypsum are buried beneath heavier sediments. Ideally, the underlying low-density stratum should be a plastic one, capable of flowing very slowly.

Diapirs start with a doming action in certain locations. Once incipient domes are formed, the low-density layer around the dome is thinned by plastic flow towards the now-rising dome. A rim-syncline results, and continuing deposition in this syncline can promote further diapiric action. With time the diapir changes gradually into a rising pillar or wall, which first domes and then pierces the overlying strata. Eventually the pillar may neck out, and a teardrop-shaped body can continue to rise towards surface.

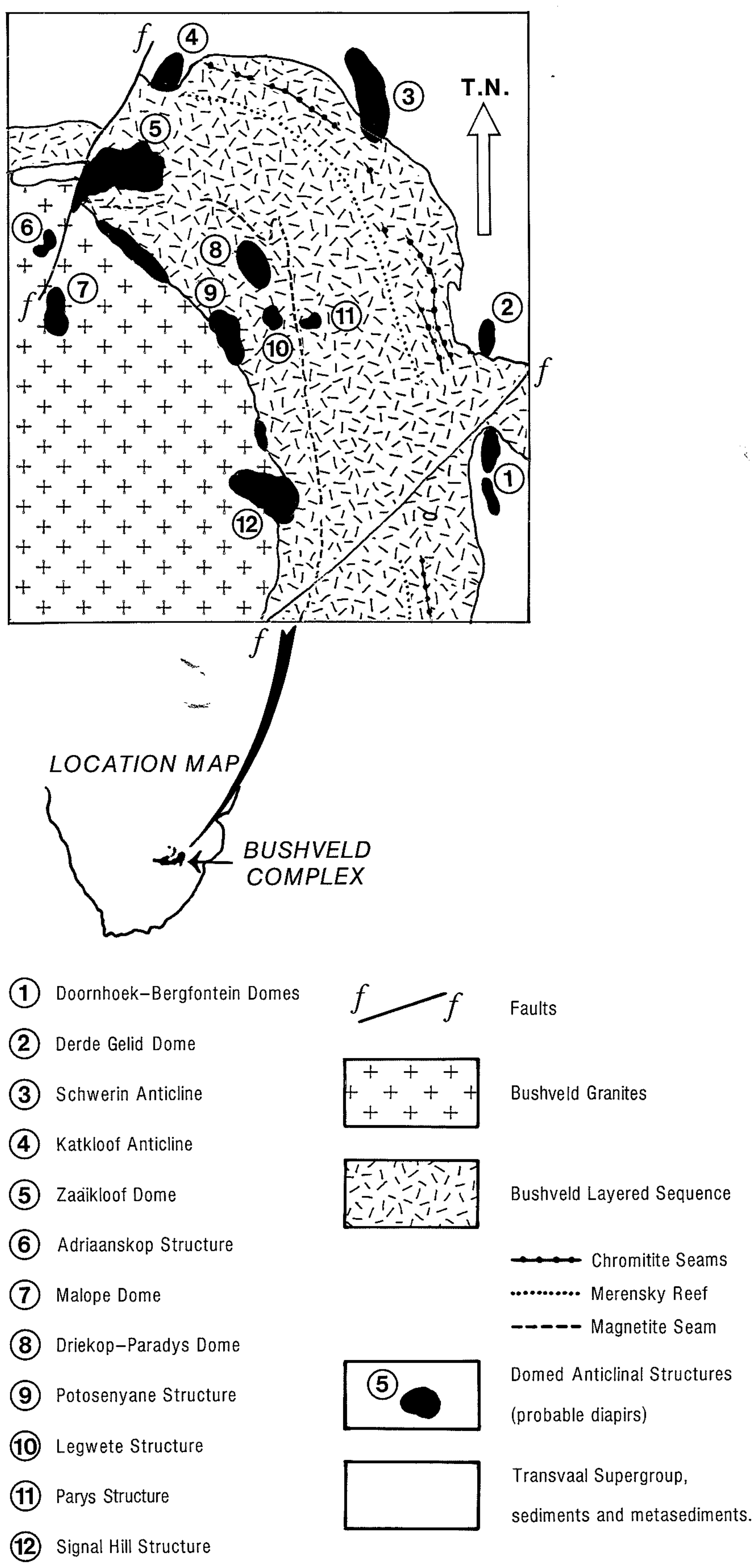
III. BUSHVELD SETTING FOR DIAPIRISM

The Bushveld Layered Sequence is a body of mafic rocks 9-10 km thick in the Eastern Transvaal (Willemse, 1964). It was intruded at a temperature in excess of 1 000°C. It's mean density is about 3,11 gm/cm^3 (Biesheuvel, 1970). The floor sediments (mean density of 2,75 gm/cm^3) were strongly heated by the intrusives. Metamorphic cordierite, andalusite, staurolite, garnet and biotite are common. In places, the low-melting shaly sediments show flow-folding, and can be assumed to have been plastic (Button, 1976). Partial melting of hornfelses is not uncommon, the rocks being veined by the low-melting fraction of quartz and feldspar (Schwellnus et al., 1962; Button, 1976).

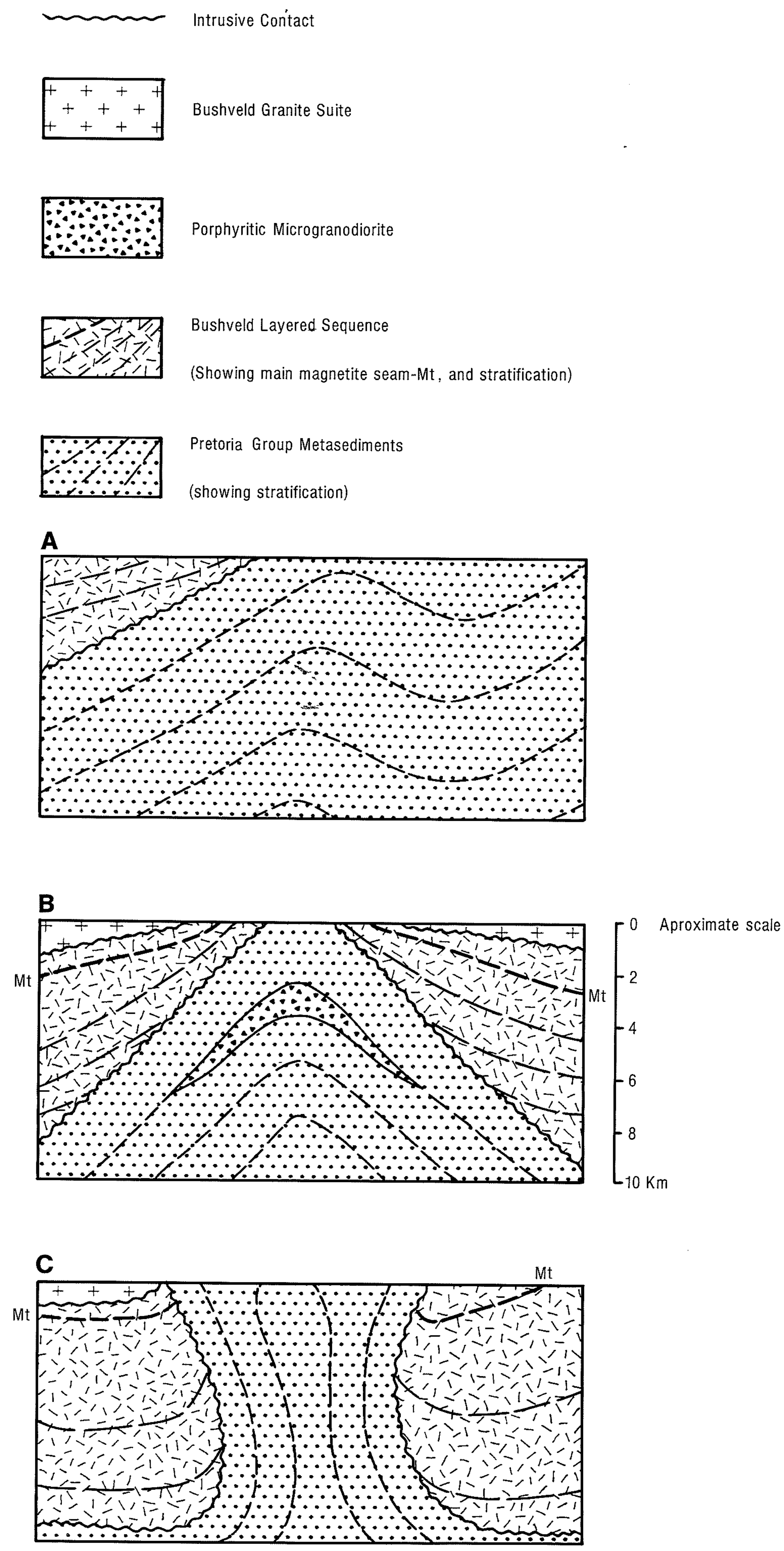
The factors favouring diapirism are present in the Bushveld. A 9-10 km thick mass of dense mafic and ultramafic rock resting on hot, relatively light, plasticized sedimentary rocks is an invitation to a diapiric orgy.

IV. THE STRUCTURES

Various stages of diapiric development are believed to be represented in the northeastern Bushveld. The earliest stages of gentle doming can be seen around Burgersfort, in the Doornhoek-Bergfontein and Derde Gelid domes (Figure 1). The dips are relatively low, and the structures have risen only a modest amount (Figure 2A). A more developed stage is that of the Malope and Zaaikloof domes and the Schwerin anticline (Marlow and Van der Merwe, 1977; Schwellnus et al., 1962). Flanks of the folds dip at up to 50 or 60 degrees. The metasedimentary core of the diapir shows evidence of flowage, in the form of aligned metamorphic minerals (Button, 1976), gneissic-textured metaquartzites (personal observation, 1978) and stretched pebbles (Schwellnus et al., 1962).



<u>Figure 1</u> : Map showing location of domed and anticlinal structures in the northeastern Bushveld Complex (modified after 1:1 000 000 geological map of the South African Geological Survey, and after Molyneux, 1974).



<u>Figure 2</u> : Schematic diagram showing different stages in the development of diapiric structures in the northeastern Bushveld Complex.

Piercement into the layered mafic rocks is indicated by a deformed fabric such as the drawn out mottles and bent plagioclase crystals in anorthositic rocks around the Malope Dome. Here, a thinning of the Bushveld Layered Sequence has been established (Marlow and Van der Merwe, 1977), and indicates ongoing diapirism during magmatic sedimentation. Diapirism apparently continued through to the time of emplacement of the Bushveld granitic suite, which is relatively thin over the Malope diapir.

Decollément within the rising core of the diapir is thought to have promoted the intrusion of the phacolith of porphyritic microgranodiorite in the Pretoria Group sediments flooring the Schwerin fold (Figure 2B).

A third stage is represented by the Katkloof fold and by the Driekop-Paradys dome. In the former, one limb of the fold is overturned, while in the dome, the stratified rocks of the diapiric core are overturned (Figure 2C), as evidenced by stratigraphic sequence and sedimentary structures (Schwellnus et al., 1962; Molyneux, 1974; personal observation, 1973). Vertical piercement of the diapir of the order of 9-10 km is indicated for the Driekop-Paradys structure, since floor rocks are situated at the stratigraphic level of the main magnetite seam.

In the past, some of the 'fragments' of floor rock metasediment have been presumed to be 'floating' xenoliths in the complex. If this were the case, they should show gravity and magnetic patterns similar to those of the Bushveld Layered Sequence. Marlow and Van der Merwe (1977) have shown that the Malope dome is not a xenolith within the Layered Sequence, since it exhibits a marked gravity deficiency. It is an updomed structure in the Bushveld floor. Some of the domed structures shown in Figure 1 fall within the region covered by the aero-magnetic survey of the Geological Survey. The Driekop-Paradys structure, for example, is a magnetic low. This would not be the case if it was underlain by the full sequence of the Bushveld basic phase, with its magnetite bands.

V. CONCLUSIONS

The combination of heavy mafic intrusives resting on lighter plastic metasediments resulted in diapiric structures with a vertical piercement of up to 9 km. Many of the diapirs probably started to rise shortly after the mafic magmas were emplaced. For example, the basal pyroxenites and chromitite seams wedge out against the Katkloof structure. Others, such as the Malope Dome, rose more gradually, and a much-thinned sequence, including chromitite and magnetite seams, was deposited. Plastic flow in the diapir core and in the surrounding crystal mush is indicated by aligned metamorphic minerals and by drawn out structures and bent plagioclase crystals in mafic cumulate rocks.

VI. ECONOMIC IMPORTANCE

Hitherto unknown chromite, magnetite and gossan outcrops were discovered by Marlow and Van der Merwe (1977) around the Malope dome. Chromitite outcrops around and close to the nose of the Zaaikloof dome (Schwellnus et al., 1962). It is concluded that similar relationships may well pertain to some or all of the other diapiric structures shown in Figure 1. The structures should be examined for these types of mineralization. Even if there are not outcropping economic horizons, the possibility should be considered that such layers may have wedged out against, or have been pierced by, the rising diapir, and could lie at relatively shallow depths around the structures (Figure 3).

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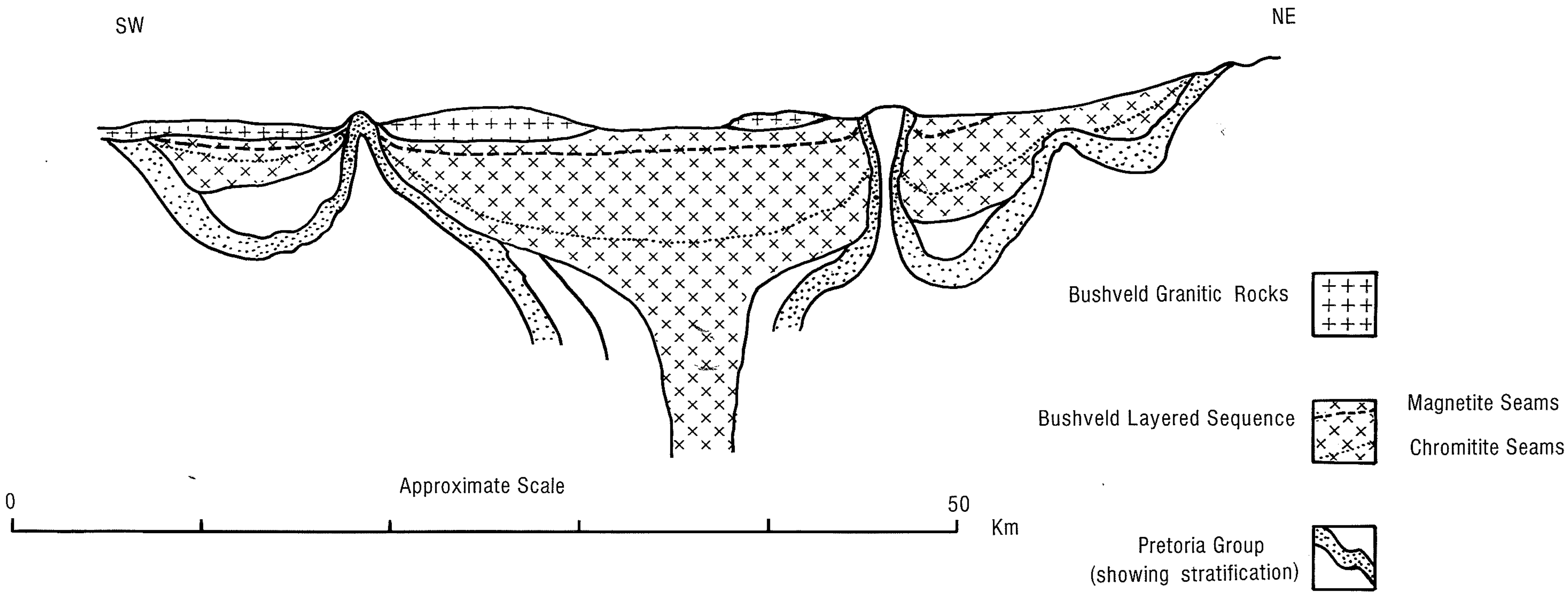

Figure 3 : *Schematic section through the Bushveld Layered Sequence, showing the effects of diapirism on the chromitite and magnetite seams of the Bushveld Layered Sequence.*

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