Field and microstructural observations indicate that S_d foliations throughout the synform and antiform are continuous and contemporaneous. However, the S_d fabric exhibits a markedly different geometrical relationship to each of these structures. In the Bien Venue Synform, S_d is axial planar and generally obliquely transects the primary strike and dip of the supracrustal rocks where discernable. The S_d fabric in the Stentor Antiform, on the other hand, is conformable with S_p, the Stentor pluton - schist contact, as well as the foliation seen along the plutons southeastern margin (Sections 8.3.1), but cuts across the axial trace. S_d dips away from, and is also best developed immediately adjacent to, the pluton, and diminishes in intensity eastwards over a interval of ~5 km. Microstructural relationships indicate that andalusite and chloritoid porphyroblastesis in the quartz-muscovite schists was syn- to postkinematic with respect to the foliation (Section 4.3.1). L_d stretching lineations typically pitch steeply within the S_d schistosity surfaces and define an overall subradial pattern with respect to the Stentor pluton. Strain ellipsoids are dominantly of the oblate type.

The distribution, orientation and style of the D_d structures and fabrics indicate that D_d deformation was related to the emplacement of the Stentor pluton, either as diapir or as a ballooning pluton. Salient features of diapirs and plutons that have undergone ballooning include: (1) major deformation and alteration in the wall rocks; (2) a marked increase in strain intensity with proximity to the intrusion; (3) contact-parallel foliations within the intrusion and country rocks; (4) steep radial or tangential stretching lineation patterns; and (5) porphyroblast growth which is at least in part synkinematic with respect to the aureole foliation (e.g. Schwerdtner *et al.*, 1978; Coward, 1981; Van den Eeckhout *et al.*, 1986; Bateman, 1984, 1986; Courrioux, 1987; Paterson, 1989, England, 1990; Jelsma *et al.*, 1993). Structural features within the Stentor Antiform - Bien Venue Synform pair accord well with these criteria, and there is little doubt that the formation of the D_d structures resulted from the intrusion of the Stentor pluton at 3107 Ma. This deformation was analogous in many respects to that which accompanied the emplacement of the early trondhjemite gneiss plutons along the southwestern margin of the BGB (e.g. Anhaeusser, 1984; Kisters and Anhaeusser, 1993). Given the fact that the S_d foliation transects the axial trace of the Stentor Antiform, it may be concluded that the fabric is of a slightly younger age than the fold-forming event - i.e. the foliation was superimposed onto the fold.

The difficulties in distinguishing diapiric plutons from ballooning plutons have been discussed by England (1990) and Jelsma *et al.* (1993). According to England (1990, p. 931), diapiric emplacement " *... can only be proven beyond doubt where it is possible to demonstrate vertical uplift of country rocks in excess of the vertical thickness of the intrusion*". This necessitates detailed information regarding the three-dimensional geometry of the intrusive body and its enclosing successions. In the absence of such information, England (1990) and Jelsma *et al.* (1993) suggested that radial stretching lineation patterns, kinematic criteria showing a pluton-up movement sense, and pre- to synkinematic porphyroblast growth are typical of diapirism, while tangential linear fabric patterns and syn- to postkinematic porphyroblastesis are consistent with pluton ballooning.

Although structural features within the Stentor Antiform and Bien Venue Synform accord best with those of diapiric plutons, it is possible that the Stentor pluton underwent late-stage ballooning. This is likely to have occurred when one considers that the granitoid diapir was emplaced into silicic country rocks little different in density from itself. A decrease in the density contrast between the diapir and the enclosing rocks would have lessened the buoyancy forces, resulting in the cessation of movement at the top of the diapir (Brun and Pons, 1981; England, 1990). This, in turn, would have led to the inflation of the pluton as the tail-end of the diapir continued to rise (Figure 9.19).

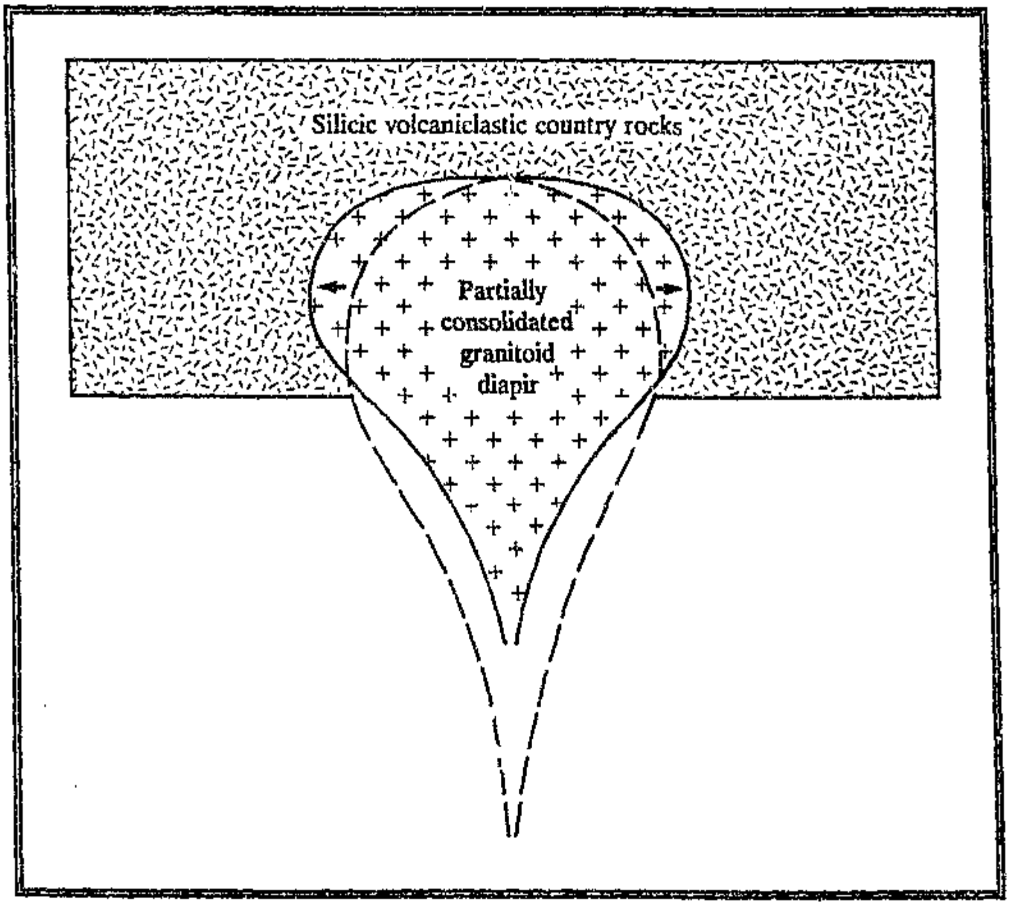

Figure 9.19 Schematic diagram illustrating a possible mechanism for late-stage inflation of a diapir (modified after the ballooning mongolfiere model of Brun and Pons, 1981). Cessation of ascent in the upper parts of the diapir in response to a decrease in the magnitude of the buoyancy forces results in ballooning as magma in the lower parts of the diapir continues to rise.

The following sequence of events leading to the formation and modification of the D_d structures is envisaged:

- North-northwest-directed compression led to the formation of the early D_m structures, including the Three Sisters and American Synclines, and the American and Barite Faults, which originally had easterly or east-northeasterly trends (Section 9.3.1).

- This was followed at 3107 Ma by the forceful intrusion of the Stentor pluton as a hot, partially consolidated diapir. The intrusion of the pluton led to the folding of the Barite Fault, the refolding of rocks in the extreme western part of the Three Sisters Syncline, the reorientation of the American Syncline and associated bounding fault, and gave rise to the Stentor Antiform - Bien Venue Synform couple.

- Concomitant development of a penetrative foliation in the crystallized parts of the pluton and a time-delayed foliation with associated lineation in the country rocks. Extensive contact metamorphism - metasomatism of the silicic metavolcanic rocks resulted in the hydrolysis of feldspar to muscovite, as well as the synkinematic growth of andalusite and, to a lesser extent, chloritoid (Section 5.2.1.1). Concomitant intrusion of he numerous quartz $\pm$ tourmaline veins and granitoid apophyses that occur parallel to the aureole foliation (Sections 4.3.8 and 8.3.1).

- Consolidation of the pluton. Thermal relaxation after intrusion led to the postkinematic growth of chloritoid and some andalusite, which was followed, in the waning stages, by the partial retrogression of these phases to chlorite and pyrophyllite, respectively (Section 5.2.1.2).

- Late-phase D_{m} shearing along the Revolver and Stentor - Overton Faults eliminated the southern extremities of the Bien Venue Synform as well as portions of the pluton (Section 9.3.1).

9.3.3 D_{final}

Field evidence suggests that the B_f structures are steeply dipping, oblique- and dip-slip faults. However, the sense of movement across these faults and, hence, the nature of the stresses involved in their formation, remains unclear. Nonetheless, the writer suspects that most represent normal faults.

10. SUMMARY AND CONCLUSIONS

The principal conclusions and suggestions of this study are summarized below.

10.1 Onverwacht Group

The Onverwacht rocks in the Three Sisters region consist of a variable assemblage of fine-grained basic-to-ultrabasic schists and amphibolites, with minor serpentinite and silicic schist. They are believed to form part of the Tjakastad Subgroup, specifically the Theespruit Formation. Relic structures are seldom preserved, so that the primary characteristics of the rocks cannot readily be determined. Nonetheless, available textural evidence suggests that they were derived mainly from volcanic-volcaniclastic protoliths. Chemical analyses suggest that the precursor suite ranged in composition from komatiite and komatiitic basalt through to basalt and dacite/rhyodacite. Coarse-textured lithologies, believed to represent metamorphosed gabbros and pyroxenites, also crop out in places. These rocks are considered to form an integral part of the Onverwacht succession, and are interpreted as subvolcanic intrusions.

Peak metamorphism of the Onverwacht rocks accompanied the intrusion of the Nelspruit batholith, and attained medium-grade in peripheral zones flanking the granitoids. Late-stage retrograde processes, ascribed to the influx of CO_2-bearing fluids either during the waning stages of contact metamorphism or associated with subsequent deformation of the supracrustal belt, have, however, led to the localized downgrading of the prograde assemblages.

10.2 Fig Tree Group

The Fig Tree Group in the northeastern sector of the BGB comprises three formations, viz., the Sheba, Belvue Road and Bien Venue Formations. Variably altered greywacke - shale - BIF assemblages that accumulated in a relatively deep-water environment, dominate the Sheba and Belvue Road Formations. Stratigraphically overlying the latter unit is a sequence of silicic schists, with volumetrically minor intercalations of basic-ultrabasic schist, phyllite, chert and cherty dolomite. These rocks have previously been considered to constitute part of the Theespruit Formation, but have been assigned by the writer to the Bien Venue Formation. U-Pb isotopic studies on zircons extracted from a sample collected near the top of this unit yielded an age of 3256 ± 1 [illegible]a (2σ). This age is ~200 Ma younger than the most recent high precision age estimates for the lower portions of the Onverwacht Group, and some 30 Ma older than age determinations on the rocks of the Schoongezicht Formation, precluding correlation of the Bien Venue rocks with either of these formations.

Due to severe alteration and deformation, it is not possible to determine the precise primary characteristics of the silicic schists. However, relic textures such as feldspar and bipyramidal quartz phenocrysts, and less commonly, conglomerate clasts composed of recrystallized chert and altered volcanic rock, attest to original volcanic / epiclastic protoliths. The schists also host Kuroko-like massive sulphide mineralization which is known to form in deep-marine settings. Thus, it is suggested that the rocks of the Bien Venue Formation, like those of the underlying Sheba and Belvue Road Formations, were mainly deposited in a deep-water environment.

Two main varieties of silicic schist are distinguishable on the basis of geochemistry and metamorphic mineralogy. These include: (1) quartz-muscovite ($\pm$ andalusite $\pm$ pyrophyllite $\pm$ chlorite $\pm$ chloritoid) schists which are typically characterised by high SiO_2 (> 72 wt %) and low CaO ($\leq$ 0.3 wt %), Na_2O (< 0.5 wt %) and Sr ($\leq$ 40 ppm) contents; and (2) biotite-oligoclase ($\pm$ chlorite $\pm$ carbonate $\pm$ quartz) schists which have lower SiO_2 concentrations (66 - 70 wt %) and elevated CaO ($\geq$ 0.9 wt %), Na_2O ($\geq$ 3.6 wt %) and Sr ($\gtrsim$ 65 ppm) abundances compared to the quartz-muscovite schists. The quartz-muscovite schis[illegible] which constitute the dominant lithology encountered in the Bien Venue Formation, were probably derived from dacitic-to-rhyodacitic precursors, and are similar to rocks found within the Theespruit Formation. The biotite-oligoclase schists, by contrast, appear to have had andesitic or dacitic primary compositions, and resemble lithologies comprising the Schoongezicht Formation.

Petrographic and geochemical data for the quartz-muscovite schists suggests that their primary characteristics have been radically changed during alteration. Mineralogical transformations were dominated by the extensive hydrolysis of primary feldspar to muscovite, followed by the partial alteration of muscovite to andalusite, chlorite and biotite. Mineral assemblages and paragenesis in areas away from the immediate contact zone with the Stentor pluton, which intrudes the schists, are indicative of low-grade conditions. Evaluation of the metamorphic conditions closer to the granitoid contact is hampered by a lack of suitable indicator minerals, but probably attained medium-grade, as indicated by the adjacent amphibolite-grade metavolcanics within the Onverwacht Group.

The alteration of the quartz-muscovite schists led to the marked depletion of Na, Ca and Sr, and also decoupled the LFSE's from the HFSE's. The LFSE distributions are primarily controlled by secondary muscovite, whereas the distribution of the HFSE's appears to reflect complexities associated with allovolumetric alteration of a compositionally heterogeneous precursor suite.

Comparison of the immobile element concentrations of the Bien Venue Formation rocks with modern volcanic suites indicates that they are characterised by a distinct arc-like geochemical signature. This suggests that the formation represents a period of arc volcanic activity terminating Fig Tree Group deposition in the northeastern sector of the BGB.

10.3 Moodies Group

The Moodies Group comprises an up to 2200 m thick succession of conglomerates, quartzites and subordinate siltstones which unconformably or paraconformably overlie a diverse variety of lithologies belonging to both the Fig Tree and Onverwacht Groups. Correlation of the siliciclastic assemblage with any particular formation of the Moodies Group as defined by SACS (1980) is not possible owing to marked lateral and vertical lithological variations. Nonetheless, the overall character of the rocks indicates that they are comparable to Moodies lithologies elsewhere in the BGB, and that they are the product of sedimentation in a high-energy, shallow-marine to subaerial depositional environment. The unusual coarseness and thickness of some conglomerate units along the northern flank of the BGB is not compatible with sedimentological models invoking a southerly source terrane for the Group (e.g. Eriksson, 1977, 1979, 1980b; Jackson *et al.*, 1987), but appears to conform with the results of recent investigations by Heubeck and Lowe (1993, 1994) who suggested that some Moodies sediments were derived from a northerly provenance area.

10.4 Granitoid rocks and late-stage intrusives

The western part of the region is underlain by a diverse variety of massive-to-gneissic granitoids, some of which have previously been considered to constitute part of the Stentor trondhjemite pluton. Field and geochemical work during the course of the present investigation indicates, however, that the Stentor pluton consists of equigranular-textured granitoid rocks that range in composition from granodiorite to adamellite. These rocks are comparable to those found within the Hebron and Berlin plutons. The latter bodies constitute a textural phase of the 3.1 Ga Nelspruit batholith, and it is suggested that the Stentor pluton also forms an integral part of the batholith. This conclusion is compatible with the results of recent high-precision isotopic studies indicating that the Stentor and Hebron plutons, as well as the Nelspruit Porphyritic Granite, are contemporaneous within error. Trace element modelling suggests that compositional variations within the Stentor pluton are the result of 10 - 75% fractional crystallization of a quartz + plagioclase + K- feldspar + biotite cumulus assemblage, consistent with previous chemical models that have been proposed for the Nelspruit batholith.

Rocks of the Nelspruit Migmatite and Gneiss Terrane crop out to the north and west of the Stentor pluton. The gneisses display a wide range of compositions from trondhjemite-to-granite (*sensu stricto*), b[illegible] are typically potassic, in places containing abundant K-feldspar megacrysts.

Late-stage magmatic activity in the region is manifest mainly in the form of diabase dykes, of presumed Early Proterozoic age, that intrude all pre-existing supracrustal and granitoid lithologies.

10.5 Structure

The structural architecture of the northeastern sector of the BGB is dominated by a series of northeast-trending, upright or northwesterly verging folds, such as the Three Sisters, Big Buffalo and Hlambanyathi Synclines, as well as similarly striking, subvertical or southeast-dipping faults, including the Barbrook, Revolver and Scotsman Faults. The latter structures are believed to have resulted mainly from reverse dip-slip displacement, with comparatively minor strike-slip movement. The major folds post-date the Moodies Group, but pre-date the granitoids of the Nelspruit batholith. The faulting outlasted the folding as well as the emplacement of the batholith.

Deformation of a more localized nature accompanied the diapiric emplacement of the Stentor pluton, and gave rise to two large-scale folds, namely the Stentor Antiform and the Bien Venue Synform, during the regional deformation event. The final tectonic event in the [illegible]gion led the formation of minor, northwest- to northeast-striking, oblique-slip normal faults.

10.6 Economic geology

The rocks of the region host deposits of gold, antimony, iron and talc, none of which is currently being exploited. Subeconomic exhalative-type massive sulphide mineralization occurs associated with silicic schists of the Bien Venue Formation. Geochemical comparison of these schists with silicic metavolcanic sequences hosting major VHMS deposits in the Superior Province of Canada suggests that their potential for . conomic base-metal mineralization is low.

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