A GEOLOGICAL SUMMARY OF THE BELINGWE GREENSTONE BELT

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INTRODUCTION

The Belingwe Greenstone Belt contains a variety of igneous and metamorphic rocks, set in a granite-gneiss terrain. Five main tectonic units are identified. The oldest unit is the ~3.5 Ga Shabani-Tokwe Gneiss Complex, forming much of the terrain to the east of the belt and partly underlying much of the greenstones. The second unit consists of ~2800 – 2900 Ma gneiss and granites, including the Mashaba Tonalite east of Belingwe and the Chingezi Gneiss and Chingezi Tonalite to the west.

Two distinct greenstone sequences occur. The older, lower greenstones, collectively termed the Mtshingwe Group, comprise the Hokonui, Bend, Brooklands and Koodoovale Formations; the younger upper greenstones, the Ngezi Group, comprise the Manjeri, Reliance, Zeederbergs and Cheshire Formations (Table 1).

On the east side of the belt the basal unit of the upper Ngezi Group, the Manjeri Formation, lies unconformably on the Shabani Gneiss; in the south and west of the belt this unconformity transgresses on to the Mtshingwe Group. It is probable that the Brooklands Formation of the Mtshingwe Group also lies unconformably on gneisses of the Shabani Gneiss Complex. The basal contact of the Mtshingwe Group on the western side of the greenstone belt is not well understood and is discussed further below.

Younger than all the greenstones are the adamellite plutons of the Chilimanzi suite and the Great Dyke, as well as various other suites of dykes.

GEOCHRONOLOGY

The five main tectonic units (with approximate ages, from Rb-Sr, Sm-Nd and Pd-Pb data of varying reliability) in the area are:

Shabani Gneiss	~3.5 Ga
Mashaba & Chingezi granitic & gneissic rocks	~2.9 Ga
Mtshingwe Group	~2.8-2.9 Ga
Ngezi Group	~2.7 Ga
Younger (Chibi) Granites	~2.6 Ga

Table 2 lists the presently available geochronological information. Each group of ages represents a period of crust formation, major deformation and metamorphism. The Sm-Nd depleted mantle model ages (Chauvel et al., 1983; Taylor et al., 1991) demonstrate major period of crustal growth at ca. 3.5 Ga, 2.9 Ga and 2.7 Ga. The age of the Mtshingwe Group is not well known but is probably similar to the 2.9 to 2.8 Ga age of the Chingezi Gneiss terrain (see later). In contrast, the Ngezi Group is relatively precisely dated as 2690 ± 13 Ma by the Pb-Pb cm-slice method (Chauvel et al., 1983). Rb-Sr ages on biotite whole-rock pairs (Hawkesworth et al., 1979) suggest that minerals over much of the southern part of the craton cooled through their blocking temperatures between 2.6 – 2.0 Ga ago. Biotite Rb-Sr ages in the southeast of the area (e.g. Shabani Gneiss from the Ngezi River) record dates between 2.06 – 1.83 Ga, synchronous with cooling events in the adjacent Limpopo Belt. Depleted-mantle model Sm-Nd ages between 2830 Ma and 3550 Ma on argillites and cherts from the Hokonui and Manjeri Formations indicate the heterogeneity of the older crustal sources supplying sediment to the belt (Menuge, 1985; Table 2).

TABLE 1

GREENSTONE BELT

GROUP	FORMATION	LITHOLOGIES
Ngezi	Cheshire	Argillite, conglomerate, BIF, limestone with stromotolites
	Zeederbergs	mafic extrusives, some intrusive and pyroclastic rocks
	Reliance	komatiitic basalt, komatiite
	Manjeri	all sedimentary types including stromatolitic limestone
Mtshingwe (2.8-2.9 Ga)	Koodoovale	conglomerate agglomerate
	Bend	Komatiitic basalt, komatiite, banded iron-formation
	Hokonui	Bimodal mafic and andesitic to dactic pyroclastic
	Bvute	mafic extrusive (Orpen 1978, included in Hokonui by Martin 1978)
	Brooklands	mixed volcanic and sedimentary, including komatiitic basalt, basalt argillites, BIF, and quartzite.

INTRUSIVE ROCK

Shabani Granite		medium-grained homogeneous partly porphyritic granite (adamellite) (2.6 Ga)
Chingezi-Mashaba Tonalite		medium-grained mostly homogeneous felsic tonalite (2.8-2.9 Ga)
Chingezi-Palawan Gneiss		banded gneiss, multiple pegmatite aplite and deformation events (2.8-2.9 Ga)
Shabani Gneiss		deformation events (2.8-3.5 Ga)
Ultramafic Complex		dominantly dunite (serpentinite) minor pyroxenite or gabbro (2.6 Ga)

TABLE 2. Isotopic Ages from the Belingwe Area

Rock Unit	Method	Age ± 2ó Ma	$^{87}Sr^{86}SR$, ∈Nd or µ1 (Pb)	Source	Comment
1) Mineral Ages	Rb-Sr mineral to w.r.				
Shabani Gneiss	biotite	1920			
Zarubi Quarry	feldspar	1870		Hawkesworth	
	epidote	1810		et al. (1979)	
Chibi Batholith	muscovite	1600			
Mukwake Quarry	biotite	1830			
	feldspar	3030		" "	meaningless age
Augen gneiss	biotite	2060			
Ngezi river	hornblende	2090		" "	
	feldspar	2360			
Mashaba	muscovite	2910		" "	Identical to whole-rock
Tonalite	biotite	2500			
	feldspar	2450			
	epidote	2000			
2) Great Dyke	Rb-Sr w.r.	2460± 16	0.7026 ± 4	Hamilton (1977)	
3) Chilimanzi Suite granites					
Fort Victoria area combined isochron	Rb-Sr w.r.	2570± 25	0.704 ± 1	Hickman (1978)	
Chibi batholith Mukwake Quarry	Rb-Sr w.r.	2470 ± 440	0.7047*	Hawkesworth et al. (1979)	*initial ratio calculated at 2570 Ma
Chibi batholith Zarubi Quarry	Rb-Sr w.r.	2560 ± 220	0.7014*	" "	*initial ratio calculated at 2570 Ma
4) Ngezi Group Greenstones					
Volcanic rocks Belingwe	Pb-Pb thin slices	2690 ± 13 2720 ± 270	8.38 8.20	Chauvel et al. (1983), Chapter 8.	
	∈Nd		0.4 to 3.2	" " "	model ∈Nd at Pb-Pb age
Regional isochron	Sm-Nd w.r.	2640 ± 140		Hamilton et al. (1977)	samples from several green-stone belts and includes komatiites, basalts & felsic volcanic rocks
Regional isochron	Rb-Sr w.r.	2700 ± 470	0.7029 ± 2	Jahn & Condie (1976)	includes few samples of Mtshingwe Group
Manjeri Formation					
Argillite	T_{DM} Sm-Nd	3320 ± 100		Menuge (1985)	Crustal sources of variable
" "		2920 ± 30		"	age. Clastic sources possibly
" "	"	2830 ± 40		"	younger than chemical
Ironstone	"	3410 ± 70		"	sources.
5) Mtshingwe Group					
Hokonui Formation	Rb-Sr w.r.	2460 ± 600	0.7056 ± 4	Hawkesworth et	high initial ratio implies reset,
felsic volcanics				al. (1979)	younger than overlying strata
argillites &	T_{DM} Sm-Nd	3550 ± 50		Menuge (1985)	Older crustal contribution to
cherts		3090 ± 60			sediments, Upper limit on age.
6) Chingezi Tonalite					
Locality 81/8	Pb-Pb w.r.	2800 ± 76	8.2	Taylor et	combined mean Pb-Pb age
	Rb-Sr w.r.	2818 ± 78	0.7016 ± 2	al. (1991)	of three Chingezi Tonalite
	Sm-Nd T_{DM}	34050		" "	suites combined: 2833 ± 43 Ma
Locality 81/9	Pb-Pb w.r.	2874 ± 32	8.4	" "	
					three samples from tonalite
	Sm-Nd T_{DM}	2950			clasts in Hokonui agglom-erate have indistinguishable Pb isotopic compositions
Locality 81/10	Pb-Pb w.r.	2825 ± 100	8.1		
	Rb-Sr w.r.	2723 ± 102	0.7015± 3	" " "	
7) Chingezi Gneiss	Rb-Sr w.r.	2810 ± 70	0.7017± 6	Hawkesworth et al. (1979)	

TABLE 2. Isotopic Ages from the Belingwe Area (cont.)

Rock Unit	Method	Age ± 2ó Ma	$^{87}Sr^{86}SR$, ∈Nd or µ1 (Pb)	Source	Comment
8) Shabani-Tokwe gneiss complex					
Ngezi Tonalite g plug	Rb-Sr w.r.	3500± 800	0.710 ± 2	Hawkesworth et	large error due to small spread
(see Chapter 3)				al. (1970)	in Rb/Sr ratio
Ngezi Augen gneiss	Rb-Sr w.r.	3250± 120	0.704 ± 2	" " "	high initial ration. May be reset
Shabani area	Rb-Sr w.r.	3495± 120	0.700 ± 1	Moorbath et (1977)	
homogeneous &	Pb-Pb w.r.	3088± 46	9.0	Taylor et al. (1991)	Interpreted as reset
banded gneiss	Sm-Nd T_{DM}	3460 3460 3240		" " " " " "	

THE GRANITOID CRUST

The granitoid crust exhibits a wide range of compositions and wide range of deformational states.

The Shabani Gneiss

The 3.5 Ga gneisses east of the Belingwe Belt consists of migmatitic and isoclinally folded banded gneisses, containing abundant folded cross-cutting aplites and pegmatites, as well as homogeneous foliated tonalitic or granodiorite rocks. Isoclinal folds have steeply dipping generally north-south striking axial planes. Intercalated with the gneisses are greenstone relicts, including amphibolites, ultramafic rocks, quartz schists and banded ironstones.

Some outcrops in the Ngezi River have been studied in detail. Here a 200 m thick schist inclusion, intercalated within banded gneisses, contains metasediments, amphibolite and metamorphosed ultramafic rock. This schist inclusion is cut by a small 3.5 ± 0.8 Ga (Rb-Sr whole rock age) tonalite plug. The schist inclusion is thought to be older than the adjacent greenstones of the Brooklands Formation, part of the Mtshingwe Group.

Gneisses in the area include strongly foliated or banded tonalites, granodiorites and adamellites, cut by basic to acid dykes. Most of the rock is banded gneiss, with 1-5 cm thick dark and light bands; infolded into this are homogeneous grey gneisses and augen gneisses. More homogeneous granodioritic gneisses outcrop below the exposures of the basal unconformity of the Ngezi Group, along the northwest margin of the greenstone belt. These gneisses are dated at 3495 ± 120 Ma (Rb-Sr whole-rock age, Moorbath et al., 1977) and have Sm-Nd depleted mantle model ages between 3240 and 3460 Ma (Taylor et al., 1991).

The 2900 Ma Terrain: Chingeze Gneiss Complex and Mashaba Tonalite

2800 to 2900 Ma granitoid rocks outcrop west and southwest of the greenstone belt. In the west the migmatitic and isoclinally folded Chingezi Gneisses with banding striking north or northwest but swinging east-west south of the greenstone belt (Orpen, 1978), are probably a continuation of the Palawan gneiss northwest of the Great Dyke (Martin, 1978, 1983). These may extend west to areas of migmatite and gneiss near Shangani mapped by Harrison (1969), as far north as the Gwenoro Dam migmatites (Stowe, 1968) and the Rhodesdale Batholith, the latter dated at 2976 ± 132 Ma by the Pb-Pb whole-rock method and with a depleted mantle Sm-Nd model age of 2990 Ma (Taylor et al., 1991). The predominantly tonalite and granodiorite gneisses exhibit a wide range in compositions.

Chingezi Gneisses are dated at 2810 ± 70 Ma (Rb-Sr whole-rock isochron, Hawkesworth et al., 1979). The Chingezi Gneiss is intruded by a number of weakly foliated pre-Mashaba-Chibi dyke-swarm plutons of diorite, tonalite and adamellite which include the Chingezi Tonalite. Sample suites from four localities of the Chingezi tonalite have Pb-Pb whole-rock ages between 2874 ±32 and 2686 ± 94 Ma and Rb-Sr whole-rock ages between 2818 ± 78 Ma and 2647 ± 102 (Taylor et al., 1991; all ages listed in Table 2). The most easterly locality sampled (Pb-Pb age = 2874 ± 32 Ma) intrudes the Bvute Formation and basal Hokonui Formation, in addition to the Chingezi Gneiss. Large clasts of a similar tonalite are mapped within an agglomerate of the Hokonui Formation. Pb isotopic analyses of three samples of the tonalite blocks are indistinguishable from a regional Pb-Pb whole-rock isochron of all Chingezi Tonalite samples (2925 ± 30 Ma), although Taylor et al. (1991) caution against inclusion of sample suites from disparate localities in one regression. Depleted mantle model Sm-Nd ages between 2980 and 3050 Ma confirm the inference from two-stage model f_1 and initial $^{87}Sr/^{86}Sr$ ratios that the '2900 Ma' age represents a major period of crustal growth.

The ~2833 ± 43 Ma mean age of the three more easterly Chingezi Tonalite samples places a minimum age on the Hokonui Formation. It is possible that the Chingezi Tonalite and Hokonui Formation are cogenetic.

The Mashaba Tonalite, a composite body of massive foliated tonalite or more rarely of banded gneiss, is dated at 2870 ± 160 Ma (Rb-Sr whole-rock isochron, Hawkesworth et al., 1979). It outcrops over an extensive but poorly exposed area in the east where it is a continuation from the type area to the east (Wilson, 1968, 1973). Contact relations between the Shabani Gneiss and Mashaba Tonalite are poorly exposed, although Martin (1983) describes them gradational.

STRATIGRAPHY OF THE MTSHINGWE GROUP

The Mtshingwe Group comprises four formations: the Hokonui, Bend and Koodoovale Formations in the west, and the Brooklands Formation in the east. These formations are unconformably overlain by the Ngezi Group. The nature of the basal part of the Mtshingwe Group is unclear. Orpen (1978) recognises a major unit, the Bvute Formation, is isoclinally folded and foliated amphibolite up to 5 km in width, situated between the Chingezi Gneiss and the overlying Mtshingwe Group rocks. On its western contact the amphibolite is infolded with Chingezi Gneiss. At the contact between the Bvute and the Hokonui Formations, Orpen interpreted repetitions of amphibolite mafic and felsic rock as possible interfolding between these two units. To the north Martin (1978, 1983) mapped a sequence of interbedded greenschist facies mafic and felsic rocks as alternating mafic and felsic lava flows within the Hokonui Formation, a relationship which Orpen also recognises. Towards the base of this formation (i.e. towards the intrusive contact of the Chingezi Tonalite), Martin records that mafic rocks predominate with metamorphic grade increasing to amphibolite facies. However in this very poorly exposed area there is no prominent foliation, except in rare hornblende schists.

The age of the Mtshingwe Group greenstones is bracketed by the intrusive and possibly cogenetic Chingezi Tonalite (~2833 ± 43 Ma) and the unconformably overlying Ngezi Group greenstones dated by Pb-Pb cm-slices at 2690 ± 13 Ma (Chauvel et al., 1983).

The Hokonui Formation

The Hokonui formation consists of a sequence of andesitic, dacitic and rhyolitic lavas, pyroclastic and re-sedimented volcanic material of similar composition, together with minor amounts of dolerite and fine-grained greenstones. The outcrop width of the sequence is up to 8 km but some of this may include the Bvute Formation in the north and may also reflect structural repetition. The Hokonui Formation is calc-alkaline in character, and possibly represents the remains of a large volcanic complex.

The massive greenstones are composed of a fine-grained aggregate of tremolite-actinolite, chlorite, clinozoisite, albite and quartz. No relict igneous textures are preserved. Agglomerates and assorted pyroclastics and tuffs form the bulk of the formation. Clasts in these rocks range up to about 60 cm across, vary from angular to well-rounded, and are predominantly of porphyritic felsic volcanics, but include occasional greenstone clasts and even fragments of bedded tuff.

The Bend Formation

The Bend Formation is dominantly komatiitic. It includes repeated cycles of komatiite, komatiitic basalt and basalt, interbedded with ironstone and chert, and is capped by a major banded ironstone bed which forms Belingwe Peak. The formation overlies the Hokonui Formation in the north, and the Bvute Formation in the south. It is disconformably overlain by the Koodoovale Formation in the core of the Bend Syncline. North of the Bend Syncline both the Koodoovale and Bend formations are progressively cut out by the Manjeri Formation. The maximum present-day thickness of the Bend Formation is 6 km in the core of the syncline, decreasing to about 2 km on the limbs. Original thickness was possibly in the order of 2 – 4 km but this has now been affected by structural repetition.

Komatiites occur in stratiform bodies, probably mostly flows, ranging from a few metres to 50 m thick. Typically the basal zones of these bodies are made of pseudomorphs after cumulate olivine, while the upper parts contain distinctive pseudomorphs after coarse olivine spinifex crystals. Some of the thicker stratiform bodies may be mapped for several km along strike. No pillowed komatiite outcrops have been identified, but in rare outcrops chert cappings exist above spinifex-textured units, suggesting that the komatiite was extrusive.

Komatiitic basalts and basalts are common and frequently display clinopyroxene spinifex textures, with needles up to 40 cm long. Pillows are abundant, usually less than one metre across, but sometimes ranging up to 3 m in long axis. Some spherulitic pillowed basalts occur – these are typically Ti and Fe-rich compared to the majority of the Bend suite. Massive basalt and komatiitic basalt flows occur in many parts of the sequence, sometimes showing coarse grained ophitic textures. Fresh clinopyroxenes and a fine grained groundmass after glass are preserved in the fresher samples, although most mafic volcanics are metamorphosed to tremolite-epidote-chlorite-albite-sphene-quartz bearing assemblages. Olivine is invariably serpentinised. Despite metamorphic alteration, igneous textures are generally well preserved.

At least ten oxide-facies banded ironstone horizons occur in the Formation: these are mostly thin (2-30 m), with little lateral facies variation, although the uppermost horizon is 100 m thick. Most ironstone horizons have great lateral continuity, and one of them can be traced for the entire strike length of the Bend formation (20 km).

The Koodoovale Formation

This formation consists mainly of conglomerates and assorted finer-grained sedimentary rocks, with a locally developed unit of felsic agglomerate. The formation occurs in the core of the Bend Syncline, above the Bend Formation and is unconformably overlain by the Manjeri Formation which oversteps its margins. The Koodoovale formation ranges from 2 km thick in the core of the syncline to less than 1 km on the limbs; much of this variation may be related to deformation and erosion. The basal contact of the Koodoovale Formation is erosive with a few major channels cut into the underlying ironstone of the Bend Formation. No angular discordance is recorded.

The conglomerate is the dominant rock type in outcrop, although this predominance may in part be a consequence of preferential exposure. The rock outcrops as lenticular bodies 200 m by 50 m, surrounded by areas of poor exposure. Scattered outcrops in the poorly exposed areas are typically finer-grained. Clasts in the conglomerate range up to 50 cm in diameter and are mostly moderately well sorted and well-rounded.

Clasts were derived from most of the underlying rock types. Granitoid clasts include adamellites and tonalites (possibly including material from the Chingezi Gneiss). The common felsic volcanic clasts may come from the Hokonui Formation. Other clasts include typical Bend Formation material such as basalts, spinifex-textured komatiitic rocks, dolerites and abundant chert and banded ironstone clasts.

In the southern limb of the Peak Syncline is a locally developed felsic agglomerate which interdigitates laterally with conglomerate. Clasts in the agglomerate are similar to Hokonui Formation felsic material.

The Brooklands Formation

The Brooklands Formation includes the supracrustal rocks lying below the basal Manjeri Formation unconformity in the southeast portion of the greenstone belt. Isolated remnants of greenstone rocks to the north may be correlated with the Brooklands Formation. The sequence consists of a conformable set of sedimentary and volcanic rocks, thought to have been laid down on the older gneissic terrain. Detritus from this terrain is incorporated in the Brooklands breccias and conglomerates. The Brooklands Formation was deformed and eroded prior to the deposition of the Manjeri Formation, which oversteps from the gneissic basement in the north on to the Brooklands sequence in the south.

The rocks have been metamorphosed in the greenschist facies, with actinolite, chlorite and albite characteristic of metavolcanic rocks, and phengitic muscovite and chlorite typical of the fine-grained pelites. In two localities relict andalusite and diopside occur, probably in the thermal aureole of a granite intrusion. In the following discussion non-metamorphic terminology is used.

Four members have been identified in the formation. The lowermost Ndakosi Member contains mainly sedimentary rocks, including chloritic phyllites, siltstones and conglomerates, together with some mafic and ultramafic rocks (possibly intrusive). The Roselyn Member consists of komatiitic basalts and less magnesian komatiites, together with massive serpentinite bodies derived from intrusive dunite bodies of uncertain age. Above this is the Mnene River Member, which contains varied fine grained and silicified sedimentary rocks and the uppermost member is the Pemba Member consisting of basalt and komatiitic basalt, together with minor fine-grained sediment, chert and ironstone.

Many later intrusions cut the Brooklands Formation; whether parts of the Roselyn and Pemba Members are intrusive is uncertain. The correlation of the Brooklands Formation with the Bend Formation is based on structural evidence. The very considerable lateral facies variation within the Brooklands Formation makes the poor lithological correlation with the distant Bend Formation not altogether surprising.

THE MTSHINGWE GROUP GREENSTONES: STRUCTURAL SETTING

Western Area

In the west of the area the Bend Formation is apparently conformable upon the Hokonui Formation. However, the contact is now faulted and it is thus unlikely that the original relationships between the two formations will ever be known. Both formations contain rocks of varied metamorphic grade (partly depending on the proximity of later granitic intrusives), with occasional relict primary minerals being preserved. The best preserved Bend Formation rocks are lowest greenschist grade komatiitic basalts. Away from the Chibi Batholith the metamorphic grade is indistinguishable from that of the Ngezi Group.

Structural work is aided by the presence of common indicators of younging direction, especially in the Bend Formation.

In the core of the syncline the Bend Formation is disconformably overlain by the Koodoovale Formation, but there is no evidence for angular unconformity or any major time-gap (see later). Both formations are folded about the Peak Syncline, plunging 65º NNE. To the south the related Dube anticline folds the Bend and Koodoovale Formations.

The basal relationships between the Hokonui and Bvute Formations are not well understood. It is also possible that in part at least the vent agglomerates of the Hokonui Formation and the Chingezi Tonalite are coeval.

Eastern Area

The Brooklands Formation also displays the major syncline which is occupied by the Bend Formation, although later folding events have rotated the axis to plunge steeply northwest. The formation shows marked lateral facies variation, becoming much thicker and more varied in the core of the syncline. It is possible that the siting of the syncline may have been tectonically linked, with the syncline forming over the site of maximum subsidence. After or during the folding, major erosion took place; in the south the basal Ngezi Group is sub-parallel to the Brooklands strata, but to the northeast the Brooklands Formation has been entirely removed (if it were ever present), and Ngezi Group rocks lie directly on ancient Shabani gneiss.

The correlation between the western and eastern parts of the Mtshingwe Group is on structural grounds and the stratigraphic evidence for correlation is not as good. If unfolded, Brooklands would lie 30 km or more away from the western part of the group. Thus, in view of the very rapid lateral facies changes in Brooklands, it is considered that despite this poor stratigraphic correlation the two rock suites may be provisionally equated, in the absence, as yet, of geochronological control.

STRATIGRAPHY OF THE NGEZI GROUP

Four formations are recognized in the Ngezi Group: the Manjeri, Reliance, Zeederbergs and Cheshire Formations. They form a relatively undeformed, coherent stratigraphic suite overlying a basement which was made of gneiss and the eroded remnants of the Mtshingwe Group. The basal contact is well exposed in at least three localities and may be mapped and identified around most of the perimeter of the upper greenstones. The upper greenstones are dated at 2690 ± 13 Ma (Pb-Pb isochron, Chauvel et al., 1983), an age consistent with an earlier regional Sm-Nd isochron of 2640 ± 140 Ma (Hamilton et al., 1977) and regional Rb-Sr studies (Hawkesworth et al., 1975).

The Manjeri Formation

The Manjeri Formation contains the basal sedimentary rocks of the upper greenstone succession laid down on a varied terrain of tonalite, gneiss and eroded older greenstone relicts. The formation is typically 50-100 m thick. The type section of the formation has been described by Bickle et al. (1975) and Martin (1978). At the type section, basal conglomerates and quartz sandstones pass upward to varied intertidal sandstones and siltstones displaying flaser-bedding and ripple marks, and associated with chert and oxide-facies banded ironstone. Above this are rocks which were probably deposited in slightly deeper water, including graded arkosic sandstone and greywacke, capped by a thin bed of sulphide-facies ironstone. The sulphide-facies ironstone is sheared, but the persistence of this bed suggests that no major structural break occurs at this level.

The two other localities at which the unconformity is well exposed and has been studied show a broadly similar sequence. Near Zvishavane, banded ironstone passes up into arkosic sandstone and coarse conglomerates containing clasts derived from the granite-gneiss terrain. The sequence is capped by ironstone. In the west of the belt by the Mtshingwe River, basal conglomerates and pebbled beds pass into shallow water sandstone, siltstone and then to laminated quartzite. Sedimentary structures are common in the rocks and symmetrical ripple-mark pavements are well exposed in places. Other outcrops of the unconformity occur but have not been studied in detail.

One notable feature of the Manjeri Formation is the presence of stromatolites in limestone south of the type section (Bickle et al., 1975; Martin et al., 1980). These stromatolites probably formed in an intertidal environment. Much of the limestone in the formation displays possible cyanobacterial lamination, although in many areas it is too deformed to preserve depositional structures.

The Reliance Formation

The Manjeri Formation passes directly and with apparent conformity into the Reliance Formation, which consists dominantly of komatiites and komatiitic basalts. Rocks of the Reliance Formation outcrop within less than a metre of the Manjeri Formation sulphide-facies ironstone at the type locality of the Manjeri Formation, where there is no evidence of major tectonic discontinuity. Significant shear zones are present within the Reliance Formation, although there is no evidence that these disrupt the distinctive stratigraphy.

The Reliance Formation contains very little intercalated sediment, apart from rare chert stringers. It is approximately 1 km thick. The most continuous exposure is at the type section, described by Bickle et al. (1975) and Nisbet et al. (1977). The sequence is: magnesian basalts and basaltic komatiites, passing to ultramafic pillow lavas and flows, followed by further basaltic komatiites and then tuffs and minor breccias. Several thick (up to 40m) concordant bodies, sills or flows occur in the succession, especially in the lower, basaltic komatiite part. These sills or flows may be traced for distances of 5 to 10 km. Clinopyroxene and olivine spinifex textures are commonly developed throughout the formation.

Matamorphism is usually in the low greenschist or sub-greenschist facies, but with considerable local variation in grade. Fresh clinopyroxene is frequently preserved. Fresh olivine is less common, but occurs in several localities, notably in the Nengerere River and near Zvishavane where the formation has been drilled (Nisbet et al., 1987). At least part of the serpentinisation of olivine appears to have taken place during recent weathering and fresher material may occur at depth (this recent alteration is apparent in olivine-rich rocks at the Shabani Mine to the east and the Great Dyke to the west). The petrology and geochemistry of the Reliance Formation is discussed by Nisbet et al. (1987).

The Zeederbergs Formation

This formation consists mainly of basaltic lavas and is up to 6 km thick on both limbs of the syncline. It directly and conformably overlies the Reliance Formation.

The formation contains a typically monotonous sequence of basaltic pillow lavas, flows and possible sills, and breccias, and contains minor intercalations of tuff and hyaloclastic debris. In the field there appears to be little significant variation in the formation from bottom to top, and available geochemical results support this. Petrographically, the lavas typically consist of needles and laths of clinopyroxene and abundant plagioclase set in a fine grained groundmass. Clinopyroxene and plagioclase microphenocrysts are common, but olivine is not found. Many rocks display coarse spherulitic textures, with ocelli being slightly richer in feldspar. Spinifex textures occur, but are rare.

Very little intercalated sediment is seen in the sequence, apart from occasional chert stringers and possible sedimentary intercalations near the top of the formation. The metamorphic grade ranges up to the greenschist facies and epidote is common. Near intrusive granite hornblende-epidote-plagioclase assemblages are seen.

The Cheshire Formation

The Cheshire Formation is the uppermost formation present in the greenstone belt. It occupies the core of the syncline, for the most part resting with conformity on the Zeeberbergs Formation. It does, however, contain clastic material derived in part from the latter. The maximum breadth of the Cheshire Formation is 5 km, suggesting a possible thickness in excess of 2 km, although tectonic thickening and complex local structures may contribute to this.

At the base, the formation typically consists of a basal conglomerate or limestone (in the west), or auriferous ironstone. The conglomerate contains well-rounded clasts of mafic rocks.

Ripple marks are occasionally seen in the siltstone, indicating shallow water deposition. The argillite and siltstone form much of the thickness of the Cheshire Formation. Near the top of the succession thin banded ironstones are common. The metamorphic grade is variable, but locally very low with brown kerogen present in some samples (Abell et al., 1985).

To the west of the syncline axis a very important limestone member, containing thick algal laminated limestone occurs. In several localities stromatolites are exposed (Bickle et al., 1975 and Martin et al., 1980). Associated with the stromatolites are intercalations of sandstone and siltstone displaying common sedimentary structures including ripple marking, cross-bedding and polygonal mudcracks.

THE NGEZI GROUP: GENERAL SETTING

The Ngezi Group forms the central north-northwest trending syncline of the greenstone belt. West of the main synclinal axis Cheshire Formation rocks are repeated by a smaller anticline and syncline. The southern closure of the main syncline can be mapped in the Cheshire Farm area, although fold closures outlined by ironstone stringers are tightly pinched. In the north the closure is obscured by deformation. As in the Mtshingwe Group, the first deformation produced little internal strain and many primary volcanic and sedimentary textures are almost perfectly preserved. Intrusion of the Chibi batholith (Chilimanzi suite) at 2570 Ma postdates the synclinal folding and truncates the southern Ngezi Group.

LATE ARCHAEAN INTRUSIONS

A variety of major plutonic bodies outcrop in the area; these include both ultramafic bodies and dykes and younger granites. They have been discussed in detail by Martin (1978) and will only be briefly mentioned here.

Of the ultramafic complexes the most significant are the Shabani Complex, the Vukwe Serpentinite and the Gurumba Tumba Serpentinite (Martin, 1978; Orpen, 1978). Nisbet et al. (1977) present arguments to suggest that the Shabani Complex may be the remnants of a large magma chamber in which fractionation took place from a komatiitic parent liquid to form basalts similar to those in the Zeederbergs Formation.

The younger granites include the Shabani Granite, which intrudes the Ngezi Group (Catherall, 1973), and the Chibi Granite, which has cut off the southern end of the greenstone belt, producing a marked metamorphic aureole. Both of these granites are of complex internal structure and locally show well developed fabrics. Samples of this suite from south east of the Belingwe Greenstone Belt have been dated at 2570 ± 25 Ma (Rb-Sr whole-rock, Hickman, 1978).

Intrusion of the Great Dyke and the East Dyke, at 2460 ± 16 Ma (Hamilton, 1977) was followed by dextral displacement on the Mtshingwe Fault and some folding in the greenstone belt. Later uplift and minor deformation as well as various episodes of dyke intrusion probably took place about 1.8 Ga ago.

STRATIGRAPHIC IMPLICATIONS

The geological relationships observed in the Belingwe belt have implications for the tectonic significance of greenstone belts and have prompted a reassessment of the stratigraphy of the entire Zimbabwe Archaean Craton.

The well preserved unconformity between the Ngezi Group greenstones and older greenstones and granitoid gneisses demonstrates that this sequence, including the komatiitic volcanics, evolved in a continental environment. The markedly different stratigraphies of the Ngezi Group greenstones and the components of the Mtshingwe Group imply that these units formed in markedly different tectonic settings; no one model is likely to account for all greenstone belts.

The distinct stratigraphic sequences observed facilitate lithostratigraphic correlations. In particular, Wilson et al. (1978), Wilson (1979) and Stagman (1978) have shown that the basic stratigraphic units of the Belingwe belt (the lower Mtshingwe) and upper (Ngezi) greenstones) can be traced across the craton and marker horizons have now been identified in most greenstone belts in the region. The regional correlation has now been accepted by the Geological Survey as the basis for nomenclature in the Archaean terrane of Zimbabwe (Stagman, 1978).

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