N86-23100

A MID-ARCHEAN OPHIOLITE COMPLEX, BARBERTON MOUNTAIN LAND; M.J. de Wit, Lunar and Planetary Institute, 3303 NASA Rd. One, Houston, TX 77058 and BPI Geophysics, University of the Witwatersrand. Roger Hart, School of Oceangraphy OSU, Corvallis, Oregon 97331. Rodger Hart, SC Nuclear Sciences, University of the Witwatersrand, Johannesburg, South Africa.

New field observations and structurally restored geologic sections through the southern part of 3.5-3.6 Ga Barberton greenstone belt (Fig. 1) show that it's mafic to ultramafic rocks form a pseudostratigraphy comparable to that of Phanerozoic ophiolites; we refer to this ancient ophiolite as the Jamestown ophiolite complex[1]. It consists of an (in part sheeted, Fig. 2) intrusive-extrusive mafic-ultramafic section, underlain by a high-temperature tectono-metamorphic residual peridotitic base, and is capped by a chert-shale sequence which it locally intrudes. Geochemical data support an ophiolitic comparison (Fig. 3). Fractionation of high temperature melting PGE's (> 2500^{o}C) in the residual rocks suggest a lower mantle origin for the precursors this crust[2]. An oceanic rather than arc-related crustal section can be inferred from the absence of contemporaneous andesites. This ancient simatic crust was thin (<3 km), contains a large ultramafic component ($\simeq$25%), is pervasively hydrated (> 95%) with H_2O contents ranging between 1-15% and consequently has a low density ($\simeq$2.67 g/cm^3)[3].

The entire simatic section has also been chemically altered during its formation by hydrothermal interaction with the Archaean hydrosphere (Fig. 4). Only an igneous "ghost" major element geochemistry is preserved. This regionally open-system metasomatism may have increased the MgO content of the igneous rocks by as much as 15%. The most primitive parent liquids, from which the extrusive sequence evolved, may have been "picritic" in character. Rocks with a komatiitic chemistry may have been derived during crystal accumulation from picrite-crystal mushes (predominantly olivine-clinopyroxene) and/or by metasomatism during one or more subsequent episodes of hydration-dehydration (Fig. 5).

The Jamestown ophiolite complex provides the oldest record with evidence for the formation of oceanic lithosphere at constructive tectonic boundaries. Our observations are in agreement with models predicting higher oceanic Archean heat flux per unit ridge length than today, associated with deep mantle diapiric upflow. Because of its low density, this ophiolite resisted subduction during subsequent tectonism; it was obducted to form part of a thrust complex[3].

References

(1) de Wit, M.J., Hart, R. and Hart, R. (1985) The Jamestown ophiolite complex, Barberton Mountain Belt: a reconaissance study of a composite section through 3.5 Ga simatic lithosphere (under review). (2) Tredoux, M., de Wit, M.J., Hart, R., Armstrong, R., Sellschop, J.P.E., (1985) PGE in the 3.6 Bon Accord Ni-Fe-Co-Cr occurrence, Barberton South Africa: implications for crust-mantle-core segregation. 4th Intern. Platinum Symposium, Toronto, August, 1985, abstract; also de Wit et al. (1985), EOS, Nov. 12, p. 1114. (3) de Wit M.J. (1985) What the oldest rocks say, (abstract) Workshop on The Earth as a Planet, LPI and GSA, Orlando, Florida, Oct. 27.

de Wit, M. J. et. al.

ORIGINAL PAGE IS
OF POOR QUALITY

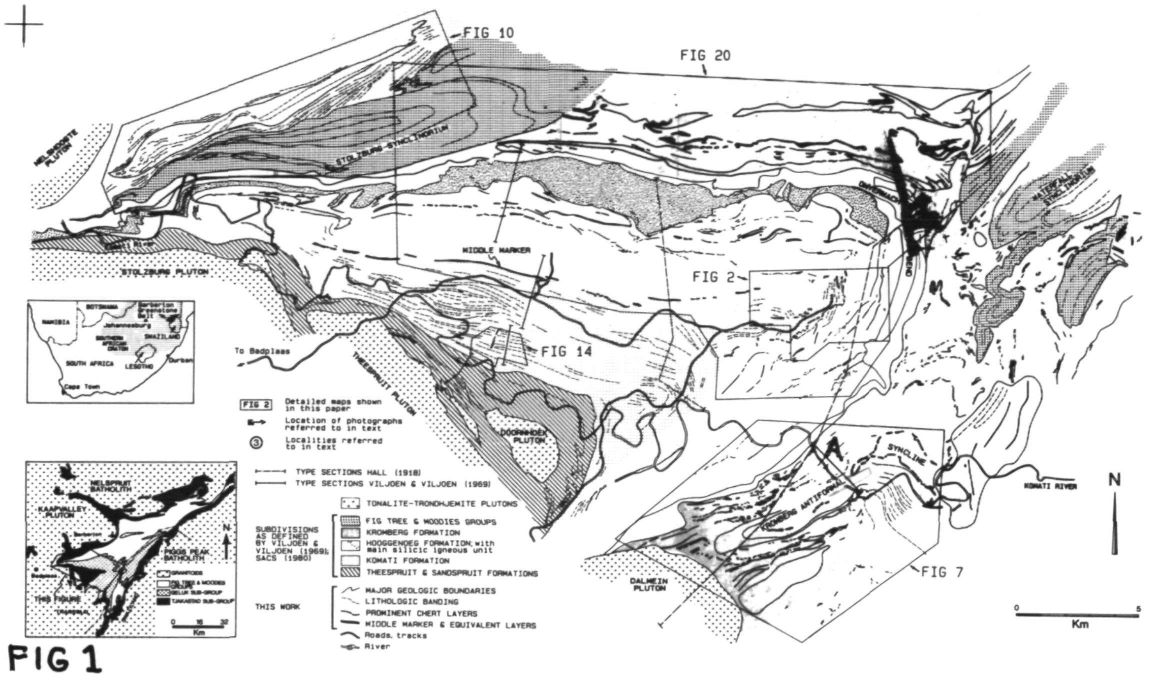


FIG 1

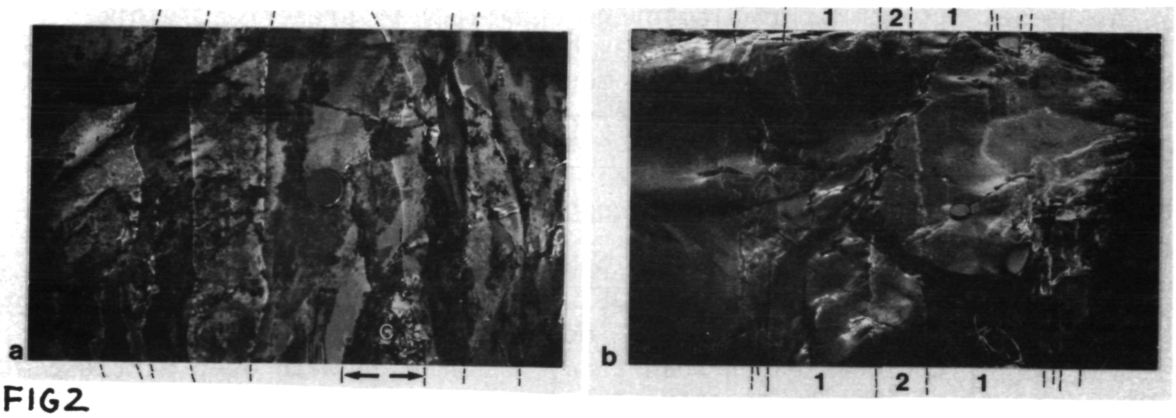


FIG2

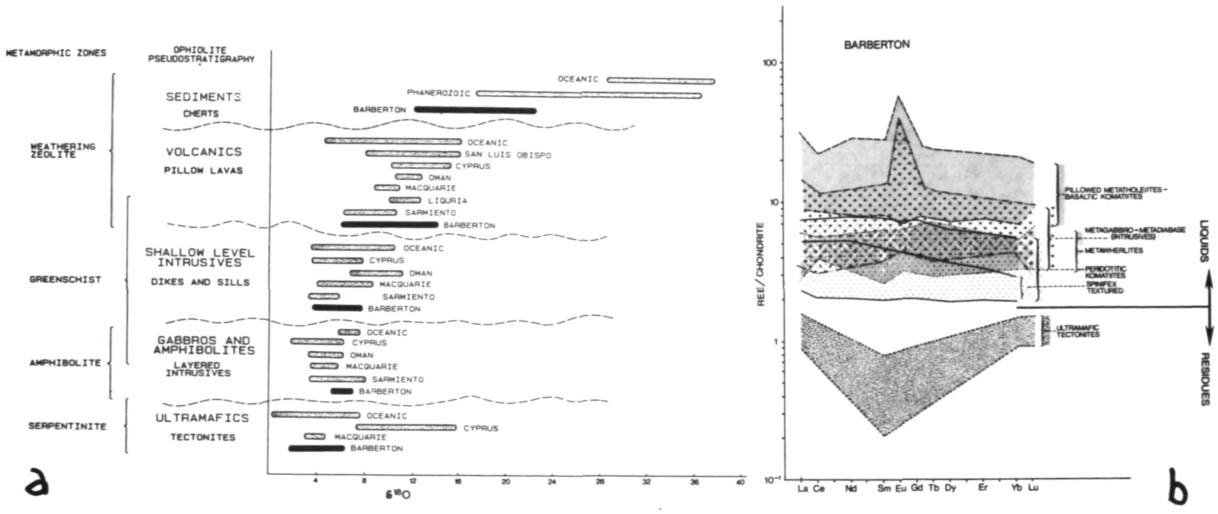


FIG 3

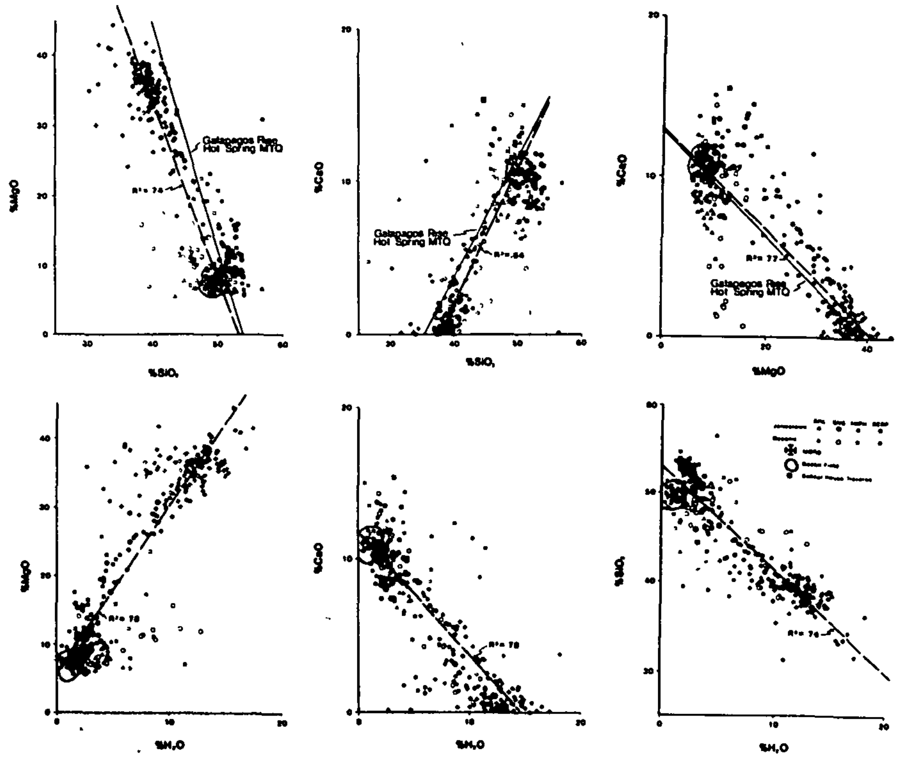


FIG.4

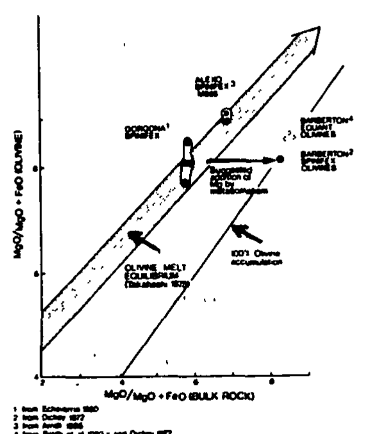


FIG.5

Figure Captions: (1) Simplified geological map of an area in the southern part of the Barberton greenstone belt studied between 1978 and 1985. (2) Vertical sheeted intrusives with pale chilled margins from a 30 meter river outcrop (exposed during 1984 draught) at locality A, Fig. 1. Note the remnant chert xenolith (a; arrow). (b) clearly depicts the splitting in two of an earlier intrusion (1) by a later one (2). (3) Representation of $\delta^{18}O$ (a) of the Barberton rocks (black) plotted in their restored pseudo-stratigraphic sequence compared to Phanerozoic ophiolites and oceanic crust (open symbols) (b) REE data from Barberton; this plot compares favourably with Phanerozoic ophiolites and oceanic crust. (4) Binary correlation plots of MgO, CaO, SiO, and H_2O for rocks of oceanic crust (open symbols) and from the Jamestown ophiolite complex (closed symbols). These plots illustrate the close correlation between the major oxides concentrations and the degree of hydration in these environments. For comparison, the slopes of the chemical flux in the Galapages hot spring fluids are also shown. (5) This figure shows that the bulk rock MgO/MgO + Feo ratio of Barberton Komatiites are enriched in MgO over that of the original melt. The enrichment may be the result of either crystal accumulation or magnesium metasomatism during hydrothermal alteration; there is textural evidence that both mechanism were important. At any rate the plot clearly shows that the MgO composition of the silicate liquids which formed the Barberton Komatiite was between that of Gorgona Island (15-22% MgO) and Alexo (28% MgO), and may have been of picritic composition. All diagrams from reference 1.

FELSIC IGNEOUS ROCKS WITHIN THE BARBERTON GREENSTONE BELT: HIGH CRUSTAL LEVEL EQUIVALENTS OF THE SURROUNDING TONALITE-TRONDHJEMITE TERRAIN, EMPLACED DURING THRUSTING. M.J. de Wit, Lunar and Planetary Institute, 3303 NASA Road One, Houston, TX 77058 and BPI Geophysics, University of the Witwatersrand, Johannesburg. A.H. Wilson, University of Natal, Pietesmaritzburg, South Africa.

Felsic rocks within the 3530 ± 50 myrs[1] simatic rocks of the Onverwacht Group of the Barberton greenstone belt have traditionally been mapped as recurring volcanic units within a continuous stratigraphic succession. In the past, these felsic units have been interpreted to be part of several mafic to felsic volcanic cycles within this sequence. Some of these silicic layers have been shown to be silicified simatic rocks[2,3]. Our field data (Fig. 1) indicates that the genuine felsic igneous rocks are predominantly shallow level intrusives and subsurface felsic domes associated with only minor volcanics and volcanoclastics. A 3.360 ± 1 myrs (U-Pb, zircon)[4] age from the main felsic intrusion indicates that its emplacement post-dated the simatic rocks of this greenstone belt between 120-220 myrs. Our geochemical results also show that the felsic igneous rocks are not directly related to the mafic-ultramafic rocks of the Onverwacht Group. On the contrary the major trace and REE data (Fig. 2) all indicate that these felsic units are high-level equivalents of the widespread, and time-equivalent, trondhjemite-tonalite plutons which either intrude the lower parts of the greenstone belt, or with which they are in tectonic contact.

Structural and stratigraphic analysis indicates that the felsic intrusions were emplaced along thrusts during sedimentation and a prolonged period of horizontal compressional stress exerted on the greenstone belt (Fig. 3). Thus, integrated, the data suggest that the simatic rocks of the Barberton greenstone belt were thrust across an actively stoping plutonic environment and that the greenstone belt is at least partly allochthonous (Fig. 4).

References

(1) Hamilton, P.J. et al. (1979) Sm-Nd dating of the Onverwacht Group volcanics, South Africa. Nature, 279, p. 298-300. (2) de Wit et al. (1982) Archean abiogenic and probable biogenic structures associated with mineralized hydrothermal vent systems and regional metasomatism with implications for greenstone belt studies. Econ. Geol., 77, p. 1783-1802. (3) Hanor, J.S. and Duchac, K.C. (1985) Geochemical consequences of the metasomatic conversion of an early Archean Komatiite sequence into chert. GSA Abstracts, Geol. Annual Meeting, Orlando, p. 603. (4) Van Niekerk, C.B. and Burger, A.J. (1969) A note on the mininum age of the acid lava of the onverwacht series of the Swaziland system. Trans. Geol. Soc. South Africa, 72, p. 9-21.

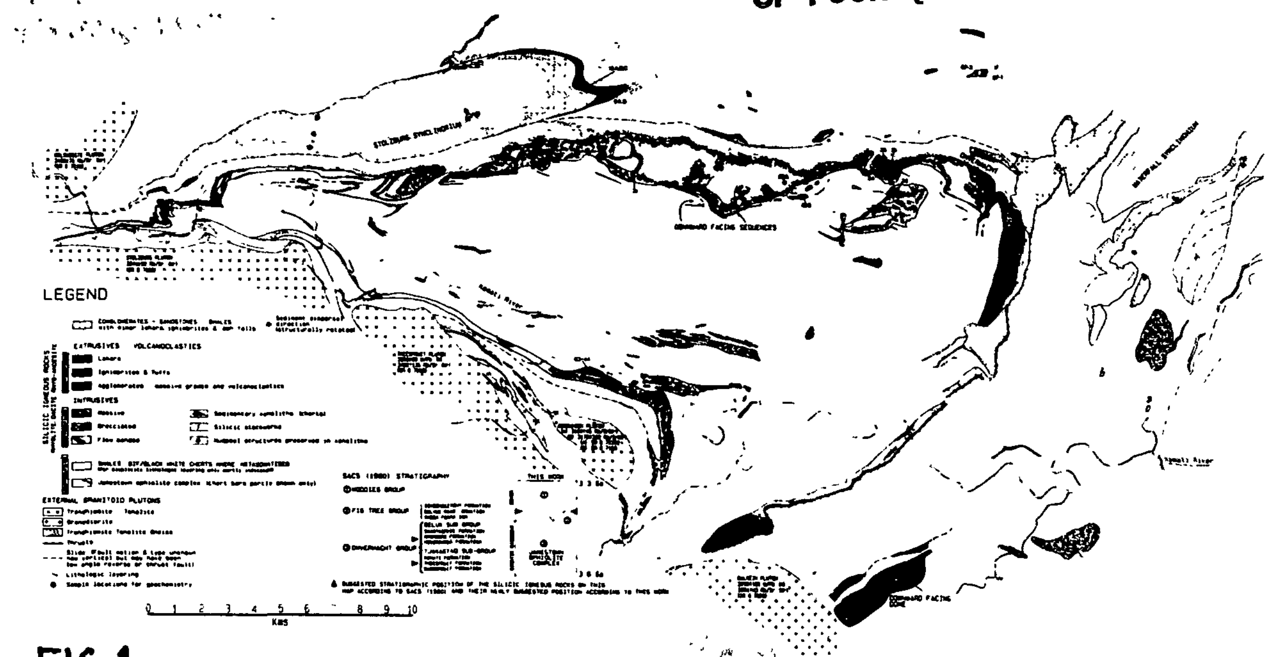
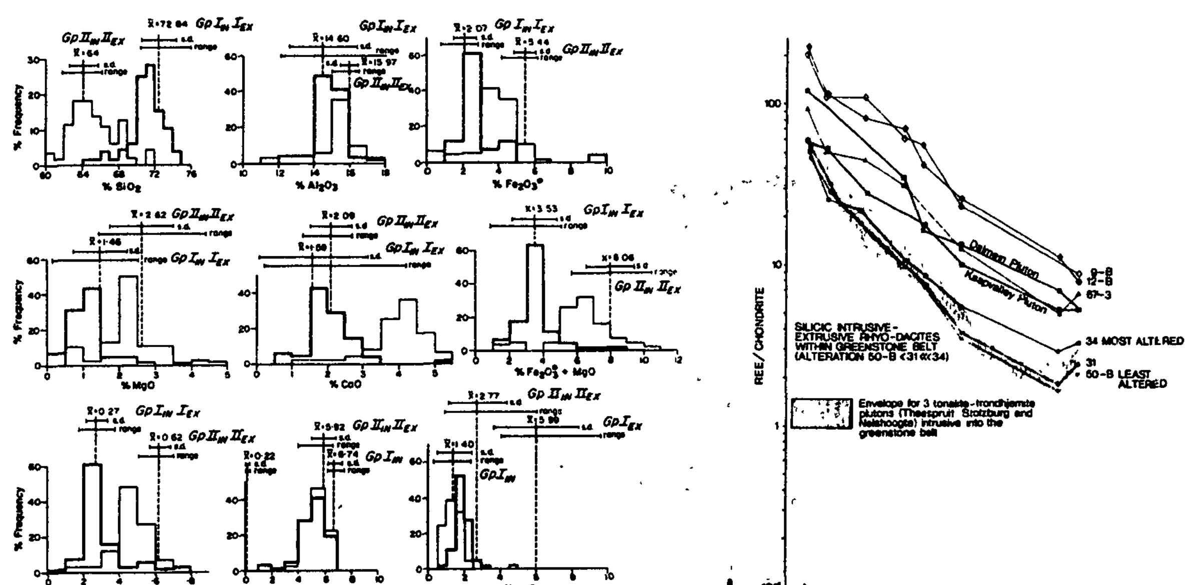


FIG. 1



a b

FIG. 2

Figure Captions: (1) Simplified geological map of the southern part of the Barberton greenstone belt, showing location of main silicic (felsic) rocks. (2) (a) Statistical analysis of major element data from the felsic igneous rocks within the study area, compared to those of the surrounding tonalite and trondhjemites. The felsic igneous rocks are clearly divided into two groups (I and II) in which both extrusive (ex) and intrusive (in) samples are represented. The two groups are geochemically similar to the trondhjemites (thin frequency boxes) and tonalites (bold frequency boxes) (b) Chondrite normalized REE patterns of intrusive and extrusive representatives of both groups of felsic igneous rocks from within the greenstone belt, compared to the granitoid plutons surrounding the greenstone belt.

FELSIC IGNEOUS ROCKS EMPLACED DURING THRUSTING

de Wit, M. J. and Wilson, A. H.

ORIGINAL PAGE IS OF POOR QUALITY

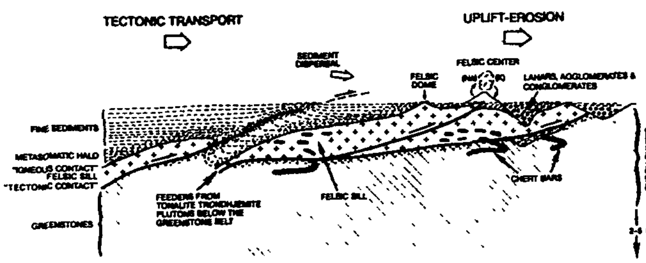


FIG.3

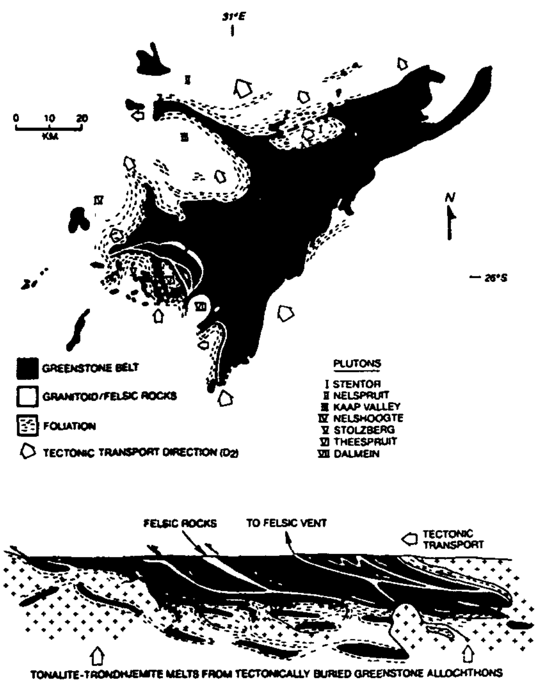


FIG 4

(3) Schematic representation of the tectonic-intrusive emplacement of the felsic igneous rocks as composite sills close to the interface between the mafic-ultramafic (simatic) rocks of the Onverwacht rocks (diagonal lines) and the overlying Fig Tree-like silts-shales. Note how the lower contacts of the sills are predominantly tectonic (thrusts) whilst the upper contacts are predominantly preserved igneous contacts. (4) Plan and section of the Barberton greenstone belt (black) and the surrounding granitoid terrain (white). The map shows the generalized D_2 tectonic transport directions, the felsic igneous rocks internal to the greenstone belt, and the gneissose fabric in the surrounding tonalite-trondhjemite plutons. Note that large scale stoping of the greenstone belt by the surrounding and intruding granitoids is suggested by the outcrop pattern of the felsic igneous rocks (eg. compare this pattern to the shape and outline of the Stentor pluton). The section schematically shows the lower parts (3-5 km) of the greenstone belt thrust over the granitoid terrain whilst the latter syntectonically intrudes and engulves the greenstone belt: this process is thought to have formed recumbent-like mantle-gneiss folds (probably sheath-like in 3-dimentions). Regional disruption and stoping of the greenstone belt occurs during intrusion of Na-rich felsic phases from the plutons of the granitoid terrain into the greenstone belts, along thrusts generated during the tectonic emplacement of the entire greenstone belt. The section represents a restoration prior to subsequent horizontal flattening which later deformed and rotated the rock units and their contacts into a pseudo-synformal structure. All diagrams from de Wit, Wilson and Armstrong (1985 under review).