6 METAMORPHISM AND P-T PATHS OF THE CENTRAL ZONE

The high-grade metamorphic rocks of the Limpopo CZ (Horrocks, 1980; Harris & Holland, 1984; Windley et al., 1984; Droop, 1989; Tsunogae & Miyano, 1989; Van Reenen et al., 1990) has a unique, polymetamorphic history (Barton et al., 1990; Holzer et al., 1998; Kröner et al., 1999). Evidence for the earliest metamorphism is mainly reflected by magmatic activity with relict traces of an early deformation restricted to outcrops of the SRG exposed in the Sand River near Musina (Figure 7). This mid-Archaean event predates mafic dykes at 3000 Ma (e.g. Barton et al., 1990; Kröner et al., 1999) and it's metamorphic record is largely erased by later high-grade tectono-metamorphic overprints and therefore still poorly understood (e.g. Holzer et al., 1998).

Peak metamorphism, as described by many workers (e.g. Light, 1982; Van Reenen et al., 1990; Barton & Van Reenen, 1992b; Treloar et al., 1992; Roering et al., 1992a) is defined by a clockwise *P-T* path in which peak granulite facies metamorphism (M_1) is followed by isothermal decompression (ID) (M_2) and finally by retrogression (M_3) (Figure 20) (e.g. Light & Watkeys, 1977; Watkeys et al., 1983; Harris & Holland, 1984; Van Reenen et al., 1988, 1990; Droop, 1989; Stevens & Van Reenen, 1992). Detailed paragenetic analysis of widely developed retrograde *Crd*-bearing mineral assemblages in aluminous rocks (metapelites) from different parts of the CZ in South Africa and Botswana led to the conclusion that ID *P-T* paths (Horrocks, 1983; Harris & Holland, 1984; Tsunogae & Miyano, 1989; van Reenen et al., 1990; Windley et al., 1994; Droop, 1989) reflect a single exhumation (Figure 21), that at the time was considered to have occurred in the late-Archaean.

Peak metamorphism during M_1 is believed to have been in excess of 9.5 kbar and 800-850 °C, based on thermodynamic calculations including clinopyroxene-plagioclase geobarometry, and garnet-clinopyroxene and clinopyroxene-orthopyroxene geothermometry in mafic and calc-silicate gneisses (Watkeys et al., 1993; Watkeys, 1984). Isothermal decompression (M_2) continued to about 3-5 kbar at 600-750°C and is reflected by the following decompression driven reactions (e.g. Van Reenen et al., 1990):

Grt + Sil + Qtz = Crd and

Grt + Qtz = Crd + Opx.

These reactions occur in metapelitic granulites from both cross folds and circular folds (Pienaar, 1985; Pretorius, 1986), suggesting that both structures developed under granulite facies conditions (Roering et al., 1992a). The latest metamorphic event (M_3) was controlled by the influx of H_2O-rich fluids as is documented by hydration reactions in metapelitic gneiss:

Opx + Qtz + H_2O = anthophyllite (Van Reenen et al., 1990);

Crd + H_2O = gedrite + kyanite + Qtz (Van Reenen et al., 1990) and

Grt + Qtz + H_2O = Crd + gedrite (Hisada et al., 1994).

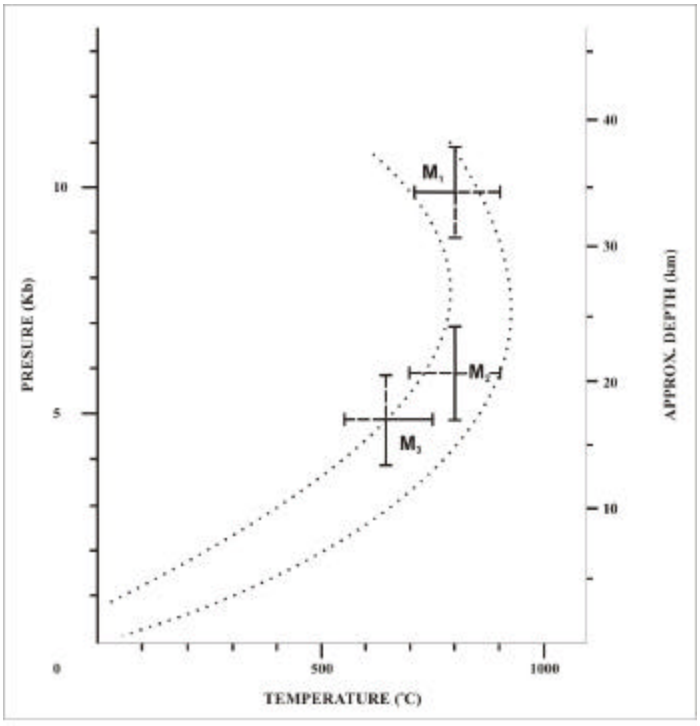

Figure 20: Retrograde metamorphic *P-T* path showing three distinct metamorphic episodes M_1, M_2 and M_3 in the Central Zone (Modified after Watkeys, 1984).

More recent *P-T* paths for metapelitic gneiss from the CZ in the Beauty area, and from the Baklykraal area (Figure 1) were calculated by Perchuk et al. (2000) and Van Reenen et al. (in press). These authors calculated *P-T* paths based on the well-developed reaction texture:

Grt + Sil + Qtz = Crd.

The calculated *P-T* paths only reflect decompression-cooling (DC) (Figure 21) during a single exhumation event.

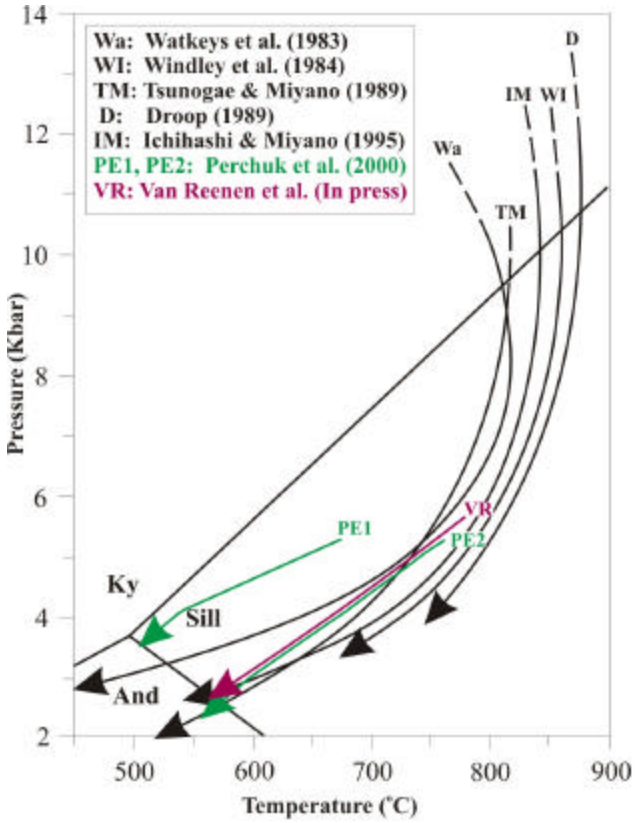

Figure 21: Published *P-T* trajectories for the Central Zone (Modified after Idhihashi and Miyano, 1995) **WA**: Watkeys et al. (1983) based on various rocks types; **WI**: Windley et al. (1984) based on sapphirine/kornerupine-bearing assemblages; **TM**: Tsunogae & Miyano (1989) based on metapelitic gneisses from the BBC in the Tshipise area; **D**: Droop (1989) also based on sapphirine/kornerupine-bearing assemblages found 13 Km north of Beitbridge; **IM**: Ichihashi and Miyano (1995) based on high-grade pelitic gneisses at a single locality 20 km northeast of Beitbridge; **PE1**, **PE2**: Perchuk et al. (2000) based on pelitic gneisses in the Beauty area west of Swartwater; **VR**: Van Reenen et al. (in press) based on pelitic gneisses from the Baklykraal cross fold west of Alldays.

Other workers (e.g. Barton et al, 1994; Holzer et al., 1998; Schaller et al., 1999) interpreted the ID *P-T* paths in Figure 21 as reflecting a major orogeny in the Paleoproterozoic. Furthermore, Holzer et al. (1998) proposed an anticlockwise *P-T* path for the late-Archaean event, reflecting low-pressure granulite facies metamorphism associated with voluminous granitic and charnockitic plutonism. Evidence for this anticlockwise *P-T* path is based mainly on the results of unpublished data (Holzer, 1995) for metapelitic gneiss xenoliths in the Bulai

Pluton from the "Three Sisters" area on the farm Boston, about 20 km WNW of Musina (Figure 15 a). In this interpretation, sillimanite (+ cordierite + garnet) grew at the expense of chiastolitic andalusite, thereby implying a prograde metamorphic reaction at high temperatures and low pressures.

From this discussion, it is clear that different workers disagree on most aspects of the metamorphic history of the CZ, including the timing and nature of high-grade events that affected this zone, as well as the shape of the *P-T* paths.