matters arising

Coesite and stishovite in the Vredefort, South Africa

RECENTLY I have been involved in tectonophysical research in the Witwatersrand collar sequence of the Vredefort dome, concentrating on microfabric studies in the collar quartzites with particular reference to the shock metamorphic microstructures found in some of these rocks. These shock microstructures include planar features, crystallographically controlled cleavage, crystallographically controlled faults and mosaic extinction. Other microstructures include extreme undulose extinction and deformation bands.

Planar features are the most widely accepted indicators of shock deformation and in the Vredefort collar quartzites they occur as decorated, planar discontinuities parallel to crystallographic planes in the quartz. The crystallographic orientation of planar features can be used to estimate the magnitude of shock pressures sustained by the rock sample[1-3], and has been used with considerable success at the Charlevoix and Slate Islands structures[2,3]. The technique involves measuring the orientation of planar features in 20 to 30 grains in a sample, classifying each grain on the basis of its planar feature content[1], and assigning to each a pressure value calculated from experimental data[2,3]. The shock pressure in the rock is then calculated as the mean of shock pressures in individual grains.

Samples from the Witwatersrand collar (Fig. 1) have been used in the type of analysis described above. Shock estimates range from 59 to 148 kbar. A diagram showing estimated shock pressure as a function of distance from the core–collar contact is shown in Fig. 2 in which the curve of best fit is nonlinear and given by

$$P_{sh} = 145.47D^{-0.39}$$

where P_{sh} is the estimated shock pressure and D is the distance from the core-collar contact. There is a strongly evident decrease in shock pressure away from the contact.

Many of the shock microstructures in the Lower Witwatersrand quartzites, however, have been recovered and recrystallised. The amount of recrystallisation increases towards the core, from minor recrystallisation away from the core (in which minor amounts of new quartz occur along planar features and grain boundaries) through major recrystallisation (where a large percentage of the rock is recrystallised with only relict primary grains), so that the Hospital Hill quartzites are completely recrystallised. Minor recrystallisation extends to the outermost quartzites of the collar. Major recrystallisation, however, occurs in a zone[4] which has the same shape as, but is not as extensive as, the limit of contact metamorphism in the collar (which is shown in Fig. 1), so that it is probable that recrystallisation in the quartzites is a result of the thermal metamorphism which produced the contact metamorphic metapelites in the collar.

Stöffler[5] has demonstrated that after their formation, coesite and stishovite are metastable and susceptible to reversion during thermal metamorphism. Certainly one would expect that large amounts of high pressure quartz polymorphs would be found in the lowermost Witwatersrand rocks (those closest to the core) since this is where the shock pressures are greatest (Fig. 2). However, as Martini has shown, none are found; samples from the Hospital Hill quartzite examined by Martini (those from Marra 395, Fig. 1 and Vlakspruit 1180, which is off Fig. 1 to the south-west) are barren. However, Martini did find coesite and stishovite at Weltevrede 167 and coesite at Ospan 238 which are high up in the Witwatersrand sequence (Fig. 1).

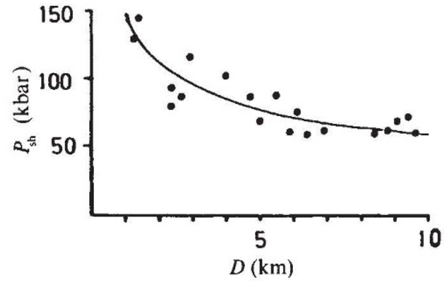

Fig. 2 A plot of estimated shock pressure (P_{sh}) against distance from the core–collar contact (D) for samples from the Vredefort collar sequence.

I suggest, therefore, that no polymorphs are found in the lowermost collar rocks because they were affected by the post-shock, metamorphic overprint. Only those rocks not strongly affected by metamorphism and/or recrystallisation (that is, the rocks further from the core) would retain their high pressure polymorphs of quartz.

The sample which Martini took on Nooitgedacht 508 (Fig. 1) is, however, barren. This is well outside the thermal aureole and does not fit comfortably into the model outlined above. My sample from Nooitgedacht 508 (sample 9, Fig. 1) shows evidence of minor amounts of recrystallisation along planar features; this indicates that these rocks were very slightly affected by the metamorphism. This may account for the lack of high pressure minerals in these rocks.

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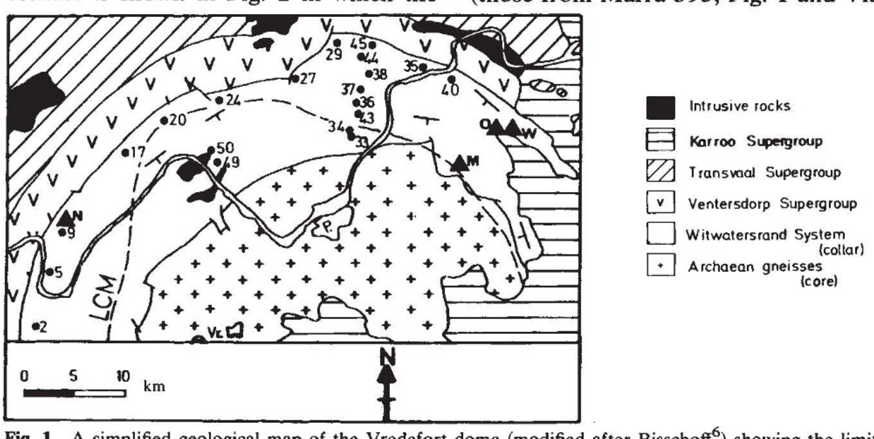

Fig. 1 A simplified geological map of the Vredefort dome (modified after Bisschoff[6]) showing the limit of metamorphism in the collar (LCM)[6] and the localities of samples used in the shock pressure analysis (dots). The approximate localities of farms on which Martini[7] took samples are shown as triangles where W is Weltevrede 167, O is Ospan 238, M is Marra 395 and N is Nooitgedacht 508. The towns of Parys (P) and Vredefort (Vr) are also shown.

MARTINI REPLIES—The microfabric investigations conducted by Lilly are of great interest as they not only confirm the very high pressure conditions having

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