ANALYSIS OF DEFORMATION LAMELLAE IN QUARTZ GRAINS FROM THE ROOIBERG FELSITE, BUSHVELD COMPLEX, SOUTH AFRICA, AND ASSOCIATED ROCKS. Paul C. Buchanan and W.U. Reimold, Department of Geology, University of the Witwatersrand, Private Bag 3, Wits 2050, Johannesburg, South Africa.

SUMMARY: Deformation lamellae are found in quartz grains throughout the Rooiberg Group, Transvaal Sequence [1] of the Bushveld Complex, a proposed impact structure [2]. Occurrence of these lamellae in the Rooiberg felsites indicates formation after crystallization of this unit and precludes generation at the same time as a hypothesized impact melt represented by the Rooiberg Group. These features are similar to deformation lamellae in quartzites adjacent to a shear zone in the Kuopio-Kinahmi area, Finland [3] and are significantly different from planar deformation features (PDFs) in quartz associated with hypervelocity impact. These features are the result of localized tectonic processes that were active throughout the region and are not indicative of meteorite impact.

INTRODUCTION: The Bushveld Complex contains the largest known terrestrial layered mafic intrusion, as well as a suite of felsic and granitic rocks; the area where Bushveld rocks either crop out or are present at subsurface levels is approximately 65,000 km² [4]. The Rooiberg Group is a thick sequence of felsic volcanic rocks and associated sediments that marks the first phase of volcanic activity associated with this complex. Twist and French [5] estimated that the original volume of this felsic unit may have been 300,000 km³. Some authors [e.g., 2] interpret the Bushveld Complex as the result of meteorite impact, based partly on its shape, which could be interpreted as several closely-spaced ring features, and partly on its petrologic similarity to the Sudbury Igneous Complex, a known impact structure. According to this interpretation, the Rooiberg Group represents an impact melt sheet and associated rocks. A second hypothesis suggests that the Bushveld Complex is the result of mantle plume activity and that the Rooiberg Group represents extruded liquids derived by partial melting of sediments subducted under southern Africa [6,7] or of lower crustal materials by a mantle plume [Hatton and Schwerizer, in prep.]. Determination of whether there is any direct evidence for impact in Bushveld-related rocks is important to evaluate the relative merits of these hypotheses. We are not aware of any shatter cones associated with the Bushveld; cone fractures reported by Reimold and Minnitt [8] from the Mpumalanga Province to the east of the Bushveld Complex are percussion marks of sedimentary origin. Labuschagne [9] described deformation lamellae that resemble PDFs in quartzite from Rooiberg rocks in the Union Tin Mine. The goal of this article is to present a petrographic analysis of these deformation lamellae, to document their geographic and stratigraphic distribution, and to determine whether they are impact-related.

DESCRIPTION: These lamellae (Fig. 1a, b) are significantly different characteristics than those documented by Alexopoulos et al. [10] for shock-generated PDFs. They are slightly curved or undulating, in contrast to PDFs, which are planar. A histogram of the angles between quartz c-axes and normals to these features is shown in Fig. 2. Lamellae are discontinuous and commonly occur only at edges or corners of grains or in elongated areas that extend through grains (Fig. 1a) and display undulatory extinction; in the latter occurrences, lamellae are approximately perpendicular to the direction of elongation. Lamellae generally are spaced further apart (>15 microns) than PDFs. Commonly only one set of lamellae occurs in a grain; rare grains display two sets. When viewed under a petrographic microscope with crossed nicks, some of these lamellae appear to be composed of thin layers of material that reach extinction at a slightly different position than surrounding quartz. They are similar to deformation lamellae described from 'glassy' quartzites adjacent to a tectonic shear zone in the Kuopio-Kinahmi area of Finland [3]; general textural features are similar and the histograms of angles between quartz c-axes and normals to lamellae also are similar.

These lamellae are found in quartz grains in Rooiberg and pre-Rooiberg rocks in localized areas throughout the Bushveld (Fig. 3). They are present in the pre-Rooiberg Magaliesberg Quartzite Formation of the Pretoria Group, Transvaal Sequence near Potgietersrus in the northern Bushveld; however, these features are not found in the Magaliesberg Quartzite from the Hippo Quarry near Pretoria. These lamellae are found in both quartzite and felsite from the Kwaagasan Formation (Rooiberg Group) in the Union Tin Mine; Labuschagne [9] documented faulting adjacent to the quartzite sampling location. Similar features are present in volcanic Rooiberg strata north of Marble Hall [Robb and Reimold, pers. comm.], and in sandstones from the upper part of the Rooiberg Group, which crop out near Leskop Dam in the southern Bushveld; faulting has been documented at both of these locations.

DISCUSSION AND CONCLUSIONS: The presence of deformation lamellae in felsite of the Kwaagasan Formation, Rooiberg Group indicates that generation of these features occurred after crystallization of the formation. Hence, these features could not have been cogenetic with a hypothetical impact melt represented by the Rooiberg Group. The close proximity of the rocks containing these deformation lamellae to documented faults and their similarity to tectonic deformation lamellae suggest a similar origin for these features. The Bushveld Complex may or may not have been formed by meteorite impact; these lamellae, however, are not PDFs and they are not indicative of impact processes. Our results support those of French [11] who did not find PDFs in quartzite xenoliths from the Rooiberg Group that Rhodes [2] suggested might represent fragments of target material.

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Figure 1. Two examples of deformation lamellae in quartz from the Rooiberg Group, Bushveld Complex. Width of field of both photographs is ~0.7 mm. a) transmitted light b) crossed polars.

Figure 2. Histogram of angles (in degrees) between c axes and normals to deformation lamellae in quartz grains from the Rooiberg Group, Bushveld Complex and the pre-Bushveld Magaliesberg Quartzite from the Pretoria Group.

Figure 3. Geologic map of the Bushveld Complex, South Africa.