ALTERNATE TWIN DEFORMATION IN PLAGIOCLASE: POSSIBLE EVIDENCE OF SHOCK DEFORMATION IN CHARNOCKITIC ROCKS ASSOCIATED WITH THE WOODBURY STRUCTURE.

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Introduction: We previously reported evidence for shock-metamorphosed quartz and zircon in breccias collected from the floor and rim of the 7 km diameter Woodbury structure in west-central Georgia [1,2]. Quartz grains occasionally contain one to three sets of decorated planar microfabrics occurring in orientations consistent with shock-induced planar deformation features (PDFs). Rare detrital zircon inclusions also exhibit planar features and granular textures similar to those reported from confirmed impact structures and ejecta deposits [e.g., 3-5]. We also demonstrated the presence of coesite near the margin of one such zircon crystal using micro-Raman spectroscopy [2].

We concluded that at least some of the rocks (or the mineral grains they presently contain) associated with the Woodbury structure probably experienced an impact event sometime between ~1.1 Ga and Alleghenian metamorphism, but the precise timing and exact relationship of that event to the circular basin and the surrounding complex tectonic terrane thus far remains speculative.

While attempting to understand these relationships, our attention was drawn to a magnetic anomaly [6], approximately the same size and shape as the structure, but centered ~7 km south of the southern rim. The total anomaly exceeds ~100 nT from a central low to an annular high. The area is occupied predominately by Grenvillian charnockitic rocks (see Fig. 1). During subsequent petrographic investigations of the charnockites, we have identified possible signatures of shock metamorphism that may help constrain the genesis of the Woodbury structure.

Charnockites: Quartz norites to hyperstene-bearing granites in the Pine Mountain terrane were first described by [7]. Approximately 63 km^2 of these “charnockite suite” rocks occur in a belt of detached lobate bodies that crop out south and southeast of the Woodbury structure. The largest contiguous charnockite unit (~32 km^2) covers a conspicuously ovoid footprint immediately south-southwest of the structure, partially overlying the magnetic anomaly. Limited radiometric age data exist. A few U-Pb zircon dates establish only a maximum age of ~1.1 Ga [8], but the Georgia charnockites generally are accepted as part of the Grenvillian “window” in the Pine Mountain terrane [9].

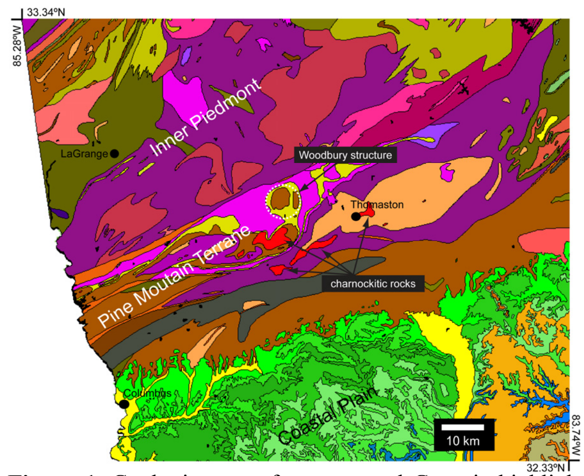

Figure 1. Geologic map of west-central Georgia highlighting the location of the Woodbury structure and Grenville-age charnockite (red).The samples discussed herein were collected from the large charnockitic unit immediately south of the structure. Map modified from [2, 3].

Most of the rocks we have examined are medium-grained garnet-bearing mangerites composed of perthitic microcline, plagioclase, and quartz with abundant myrmekitic and granophyric intergrowths and minor augite. The requisite orthopyroxene is present but largely replaced by biotite. In places, partially resorbed grains of alkali feldspar and plagioclase are observed to contain interesting microfabrics similar to those used by previous workers [e.g., 10-12] to distinguish shock metamorphism in feldspars at confirmed impact sites.

Alternate Twin Plagioclase Deformation: Stöffler [13,14] first reported the “asymmetric isotropization” of polysynthetically twinned plagioclase crystals in shocked rocks from the Ries crater. Since then numerous workers (see [15]) have observed the tendency for moderately shocked plagioclase to exhibit *alternate twin* arrangements of diaplectic glass, “ladder-like” PDFs, and/or undeformed twins. Presumably these regular patterns result because of the systematic variation of the lattice orientation in each twin to the shockwave. Short and Gold [11] and Gibson and Reimold [12] specifically discuss the occurrence of alternate-twin alteration and recrystallization arising from devitrification of diaplectic glass. Sometimes PDFs and partially isotropized material occur in the same set of twins. These features appear to be *bona fide* signatures of shock metamorphism The only similar endogenic features, of which we are aware, are "ladder texture" stacks of pericline twins between alternate albite twins from a meta-anorthosite studied by [16]. However, in that case the "rungs" appear to be optically obvious twins and they only occur normal to {010}. Shock-generated PDFs commonly are oblique to {010}.

Partially resorbed plagioclase grains in our charnockitic samples contain features similar to nearly all of those reported from shocked rocks [e.g., Fig. 2a-c]. Although pristine glass appears absent, recrystallized alternate twins (some containing PDF-like features) suggest its original presence. In addition to plagioclase deformation, poikolitic quartz inclusions in those feldspar grains sometimes contain orthogonal sets of decorated (i.e., annealed) planar fractures. And a few alkali feldspars contain either chaotic kink banding similar to [17] or checkerboard patterns.

Conclusions: The alternate twin deformation we observe in charnockitic rocks south of the Woodbury structure seems consistent with deformation attributed by many workers to shock metamorphism. There are three scenarios in which this discovery would not provide any insights into the nature of the Woodbury structure itself. 1) If these types of deformation are not unique to impact metamorphism, this may be the first reported case. 2) If deep crustal rocks during the Proterozoic retained a memory of early bombardment, the charnockitic melts may have simply inherited previously shocked xenocrysts. 3) Shocked materials in the charnockite could be merely coincidental to the nearby Woodbury structure.

In principle each of these alternatives is plausible, but we would argue that a close association of the structure and the charnockite may provide a simpler working hypothesis. There are several ways that they could be related. 1) An impact occurred after emplacement of the charnockite and Paleozoic cover sequences. Subsequently Appalachian thrusting separated upper and lower sections of the original structure. However, it seems difficult to reconcile this scenario with the observation that the possible shock features occur only in relic grains. 2) An impact may have occurred any time after deposition of the Pine Mountain cover sequence protoliths. The charnockite might represent an impact melt pool in the bottom of a crater that was subsequently decapitated and disassembled by thrusts and lateral faulting. 3) The charnockites could be tectonically displaced melts from a larger structure for which Woodbury represents the remnants of a central peak or peak-ring. We continue to test all of these possibilities.

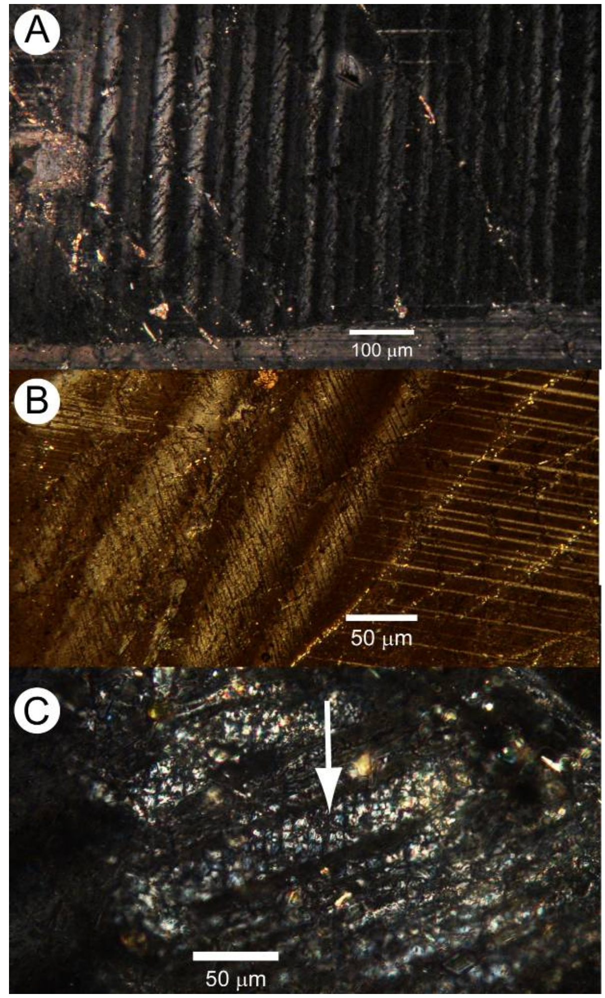

Figure 2. Photomicrographs (XPL) of plagioclase exhibiting alternate twin deformation including PDF-like structures oblique to twin planes (A,B). Alternate twins may be recrystallized (C) but retain planar features (arrow).

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