U-Pb COMPOSITION AND SHOCK MICROSTRUCTURES OF IN-SITU ACCESSORY PHASES ACROSS THE VREDEFORT IMPACT STRUCTURE, SOUTH AFRICA: A TERRESTRIAL ANALOGUE FOR DATING THE LUNAR SURFACE AND OTHER PLANETARY BODIES. C.L. Davis¹ and D.E. Moser¹, ¹Department of Earth Sciences, Western University, London, ON, CAN, N6K 367, cdavis59@uwo.ca.

Introduction: Highly refractory micro-minerals such as zircon, monazite and baddeleyite can survive and record intense shock metamorphism, and occasionally recrystallize to date impact events. Their microscale records have the potential to be used to deduce the timing and magnitude of large impacts in ex-situ solar system samples (i.e. meteorites, crystal clasts in breccias) provided we have a more complete understanding of mineral and isotopic response and variability to a large impact event. Terrestrial analogue sites, such as the Vredefort impact structure of South Africa, represent a rare opportunity to characterize the effects of complex and large (~300 km on Earth) impact events and impact-related melting on micro-minerals in-situ across a known pressure and temperature gradient.

The U and Pb composition (and therefore U-Pb isotopic dates) of shocked accessory phases respond to the passage and after-effects of a shockwave in a variety of ways, ranging from complete to zero U-Pb age-resetting [1]. On a regional scale, this dichotomy is attributed to radial distance from the crater center and the magnitude and duration of post-shock heating, broadly defining the so-called “hot-shock” and “cold-shock” zones, respectively [1]. On a microscopic scale, however, the mechanisms underlying the variation of Pb-loss among zircons within a single sample are poorly understood. The range of Pb-loss and age-resetting can occur within a single zircon population and occasionally within a single zircon. Previous studies have considered the Vredefort dome as an analogue for the lunar surface and other similar rocky bodies, based primarily on the similarity of some impact-induced textures and microstructures [2]. The recent report of glassy inclusions along planar features in zircon derived from shock melting of the host rock [1], and similar inclusions in lunar zircons [3,4] also raises the possibility of linking shock environments to crater floor composition of potential application to lunar impact chronology. Here we present progress using a combination of analytical techniques to elucidate the heterogeneous processes of an impact-related shockwave on minerals at the micro-scale, as well as the variable resilience of these phases despite severe shock heating.

Methods: Selected samples from across the shock metamorphic gradient and rock types of the Vredefort dome (near-center, intermediate, and collar locations) were analyzed. These samples were prepared as thin sections to allow for the in-situ analysis of accessory phases within the context of the surrounding mineralogy. Location mapping and analysis of microminerals was accomplished with a Hitachi SU6600 field emission scanning electron microscope at the Western Zircon Accessory Phase Laboratory using backscatter electron (BSE) imaging, secondary electron (SE) imaging, cathodoluminescence (CL, colour plus UV) imaging, and electron backscatter diffraction (EBSD).

Results: Rocks collected and analyzed thus far include samples of Archean granodioritic gneiss (InlandSee Leucogranofels) from the core, charnockitic felsic orthogneiss and mafic granulite from an intermediate location (Vredefort discontinuity) and foliated granitoid (Outer Granite Gneiss) from the collar regions. Multiple (U-Pb) dateable accessory phases (i.e. zircon, monazite) coexist within the majority of these rocks. At extreme shock levels in the core region, zircon and monazite exhibit microstructures ranging from crystallographically controlled planar features to entirely recrystallized and polycrystalline (granular) pseudomorphs. Inclusions of shock melt may play a role in nucleating the recrystallization of domains that date the impact event. Inclusions are also common in lower grade shock metamorphic regions (Fig. 1). Similar melt inclusions are reported in zircon from lunar impact breccias from Apollo sample returns, and the

Figure 1: Zircon F365 from sample V2-1 charnockitic gneiss showing at least two orientations (red arrows) of shock-generated inclusions of melt of the host rock distributed along the traces of planar microstructures.

plagioclase-rich charnockitic gneiss samples provide a valuable link to similarly plagioclase-rich lunar sam-
amples. Chemical and microstructural characterization of the inclusions and immediate grain environment are in progress. The inclusion chemistry, distribution, and spatially correlated U-Pb compositions will be measured in different grain settings in adjacent rock types across the shock metamorphic gradient at Vredefort. The results will hopefully resolve the mechanisms underlying the dichotomy between reset and non-reset U-Pb ages of accessory phases, and ultimately improve the accuracy of bombardment chronologies based on ex-situ, extraterrestrial U-bearing microminerals.