PRELIMINARY RESULTS OF GEOPHYSICAL PROPERTIES OF GRANITES TAKEN FROM A TRANSECT THROUGH THE VREDEFORT IMPACT STRUCTURE. M. S. Huber[1], S.P.S. Gulick[2,3,4], N. Tisato[2,3], E. Kovaleva[5], M. Clark[6], and F. Fourie[7], [1]Zavaritsky Institute of Geology and Geochemistry, Ural Branch of the Russian Academy of Sciences, Russia, [2]Department of Geological Sciences, Jackson School of Geosciences, University of Texas at Austin, TX USA, [3]Center for Planetary Systems Habitability, University of Texas at Austin, TX USA, [4]Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, TX USA , [5]Department of Earth Science, University of the Western Cape, Belville, South Africa, [6]Department of Geology, University of the Free State, Bloemfontein, South Africa, [7]Institute for Groundwater Studies, University of the Free State, Bloemfontein, South Africa

Introduction: The process of impact crater formation involves the passage of a shockwave through the crust of the target planet. Shockwaves are known to cause shock deformation and physical changes on the macro- and microscopic scales. Such shock deformation can have profound effects on the physical properties of target rocks. Recent observations of the ca. 66 Ma, 200 km diameter Chicxulub impact structure have shown that the rocks in the peak ring structure experienced a significant increase in porosity as well as a decrease in density and velocity as a result of the shock metamorphism [1]. The Chicxulub samples were taken from the upper portions of the intact peak ring of the impact structure (IODP/ICDP Expedition 364 drill core [2]). It is unclear to what extent these physical changes take place deeper in such large impact basins.

The Vredefort impact structure, South Africa, is among the largest impact structures in the world, with an estimated original diameter of 250-300 km [3]. The structure is estimated to have eroded down approximately 10 km [4] in the last 2.02 Ga [5], thereby providing a unique exposure of the deep architecture within the central uplift of a large impact basin.

The Chicxulub impact structure and Vredefort impact structure provide two sections through impact basins at different depths. By comparing these craters to one another, the processes by which physical changes occur can be constrained and better understood. Therefore, in this study, we analyze a transect of granitoid samples from the central portions of Vredefort Dome to the collar rocks. We measured acoustic velocities, dynamic elastic properties, and porosity of each sample.

Methods: Eleven samples were collected from the Vredefort structure along a rough transect that started at the Inlandsee (the approximate center of the structure), and continued for 21.5 km to the NW to the Kopjeskraal farm. Samples were extracted using a rock saw with the permission of landowners. The samples consist of a variety of granitoids of the TTG suite.

The samples were processed by the Core Laboratories company in Houston, TX, USA, for a variety of properties, including ultrasonic velocities and porosities, measured by the pulse-transmission method and the Boyle's Law method, respectively.

Results: The compressional velocities (Vp and Vs) change through the transect. Vp of the samples ranges from 5.17 to 6.09 km/s. Vp increases from 5.17 km/s at the Inlandsee to 6.09 km/s at a distance of 11.9 km, but from 13.8 to 21.5 km distance, again decreases to range between 5.18 and 5.55 km/s (Fig. 1A). The Vs of the samples ranges from 3.14 to 3.59 km/s. The Vs increases from 3.18 at the Inlandsee to 3.59 at 11.9 km distance, and slightly increases from 3.14 to 3.37 km/s from 13.8 to 21.5 km distance (Fig. 1B). The porosity of the samples ranges from 0.23 to 1.20%. At the Inlandsee, the porosity is 0.96%, decreasing to 0.24% at 11.9 km distance. The maximum porosity values are at 13.8 (1.19%) and 21.5 km (1.20%) (Fig. 1D).

Discussion: The process by which the central uplift and peak ring of an impact structure develop is challenging to study with physical data, as the affected rocks are often too deeply buried to be studied in detail. Numerical models of this process have shown that the angle of impact can strongly influence the shock effect on deep crustal rocks during an impact event [6], with steeper impacts resulting in more convolute crustal structures than the shallow angle impact events. Numerical models are limited, however, in the timescale that they can effectively model, and also have difficulty modeling faults.

The physical properties of the measured samples are significantly different than the expected results from equivalent lithologies unaffected by shock metamorphism. The density of undeformed granodiorite is typically 2.76-2.81 g/cm^3, which is higher than any samples measured in this study. Both the Vp and Vs of the Vredefort samples are lower than expected for crystalline rocks that originate at 10 km depth, but these values may be affected by the high porosity of the granitoids. Porosity values of undeformed granodiorite have been measured up to 0.48% [7], but samples in this study have been measured at significantly higher porosities (up to 1.20%). These changes suggest that the physical properties of the deep crustal rocks within an impact basin are permanently altered, even when signs of shock deformation are not macroscopically visible.

Additionally, the Vp/Vs of the samples are variable, with a generally negative correlation with porosity (Fig. 2) that differs from general observations of granites [8].

The measured change in physical properties of the granitoids at Vredefort between a distance of 11.9 and 13.8 km from the center of the impact structure is suggestive of a physical boundary. At approximately this distance, previous workers documented a zone of charnockite (e.g., [9]) and described the so-called "Vredefort discontinuity." The existence of such a discontinuity has been disputed (e.g., [10]). Our results may support the idea that some form of crustal discontinuity is present.

Further work, such as analysis of velocity and crack density under confining pressure, will help to clarify the processes responsible for these observations. Although these results are still preliminary, it is clear that such measurements are useful for determining the existence and extent of irregularities within impact structures and support inferences of porosity enhancement by impact processes on terrestrial planets [2,11].

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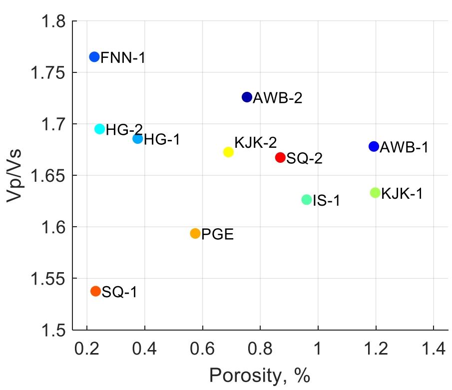

Figure 2: Vp/Vs vs Porosity.

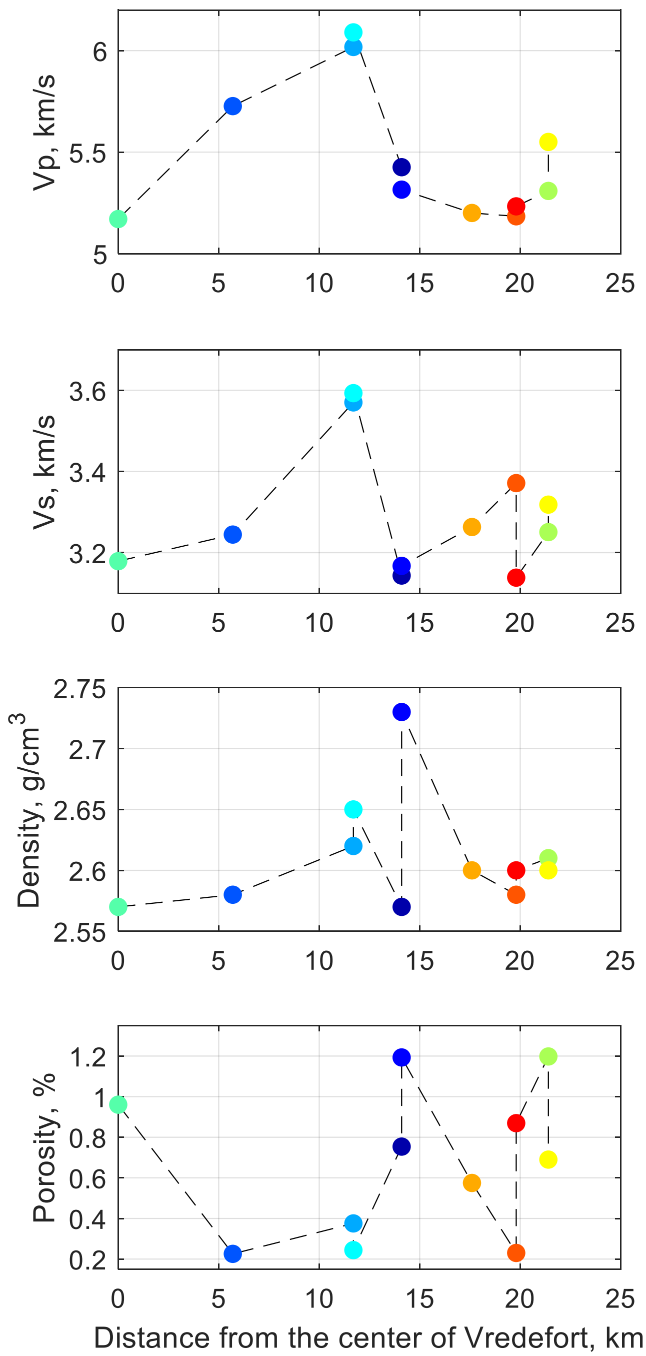

Figure 1: Vp, Vs, density, and porosity vs. distance from Inlandsee.