



Shock metamorphosed Granite of the Chicxulub Impact Basin and very low seismic velocities: A case study.

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Summary

Here we detail current investigations in to the unusual physical properties of the Chicxulub peak ring shocked granite which include pressurized wave speed measurements, helium pycnometry, and thin section microscopy. Collected during IODP's expedition 364, a 1300 m borehole was drilled in to the Chicxulub basin's central uplift. (peak ring) Over 500 meters of shocked granitic core was collected. The uplifted deep crystalline crustal rock shows unusual properties with porosities up to 13% and seismic wave speeds of $\sim 2/3$ those expected with polycrystalline mineralogical models

Introduction

As a well preserved complex crater, the Chicxulub impact basin presents a rare opportunity to science. Common throughout the solar system, yet rarely well preserved on earth, complex craters are hypothesized by the dynamic collapse model (Morgan et al., 2016) to result from two competing post-impact processes in large scale impacts; 1) Inward collapse of steep, incompetent crater walls and 2) Rebound of the shock compressed crater floor. IODP's borehole M0077A in the Chicxulub basin's central peak ring (fig. 1) is the first time a crater's peak ring has been directly sampled. (Gulick et al., 2013) Our research group collected and processed the vertical seismic profile during exp. 364. (Nixon et al., 2017) Extremely low seismic wave speeds were immediately apparent in the field, which piqued further probes in to the exotic

Chicxulub Impact Basin Location

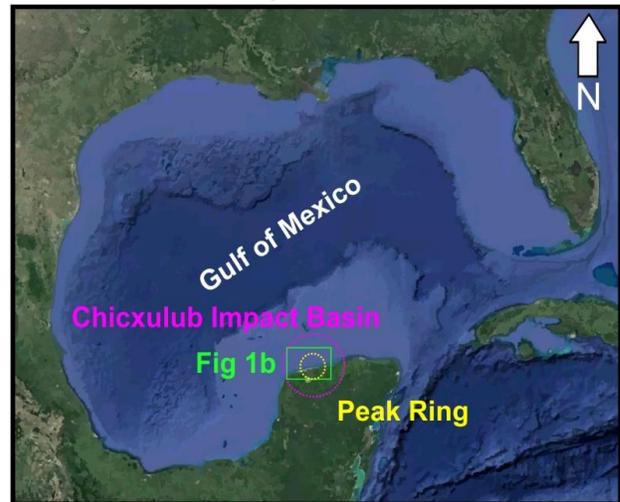


Fig. 1. Impact basin is shown with respect to Gulf of Mexico. Basin located beneath Yucatan platform dominated by carbonate facies.

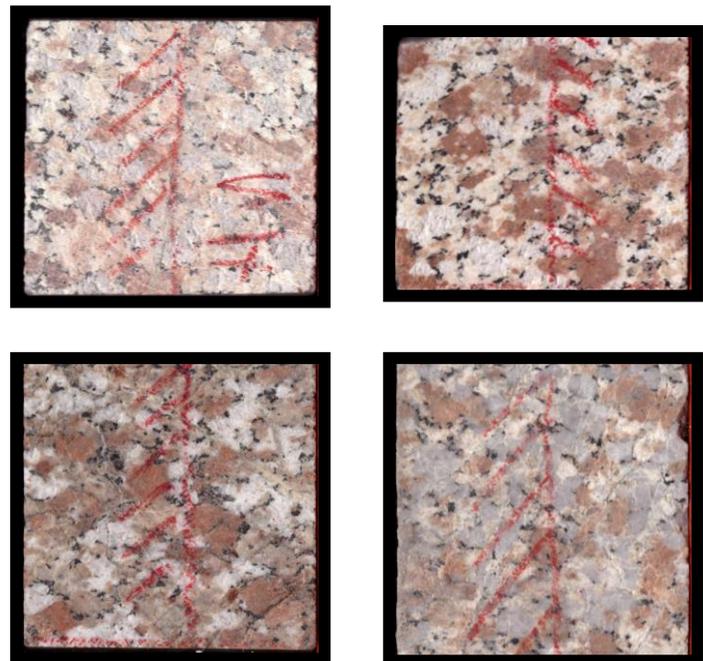


Fig. 2. Shock affected granitic samples from Chicxulub peak ring borehole M0077A

materials extracted from deep below the Gulf of Mexico.

Preliminary Results

~ 20 kg of shocked granite and melt samples from the M0077A borehole have been selected from the IODP core repository in Bremen, Germany. (fig. 2) In general, the granitic samples are quite fractured and fragile. With porosities of up to 13% which is well in excess of the typical values of 1% in nearby, non-shocked granites, (Mayr et al., 2009) it is assumed the anomalously low wave speeds are a function of the shock induced porosity. The samples have been subjected to pressurized high frequency wave speed measurements up to 200 MPa, which shows a nonlinear increase of wave speed with pressure. (fig. 3) The granitic samples typically show ambient p-velocities of ~4000 m/s which is much less than measured values of ~6000 m/s for similar granites. (Mayr et al., 2009) The increasing pressure dependence is presumed to be due to closure of pores. A deviation point in the trend is observed in all samples at ~70-100 MPa. Currently underway, thin section electron microscopy analysis should elucidate the porosity details; the current hypothesis is that the deviation point is the pressure at which planar deformational features are completely closed from pressure and larger scale porosity dominates the wave speed deviations.

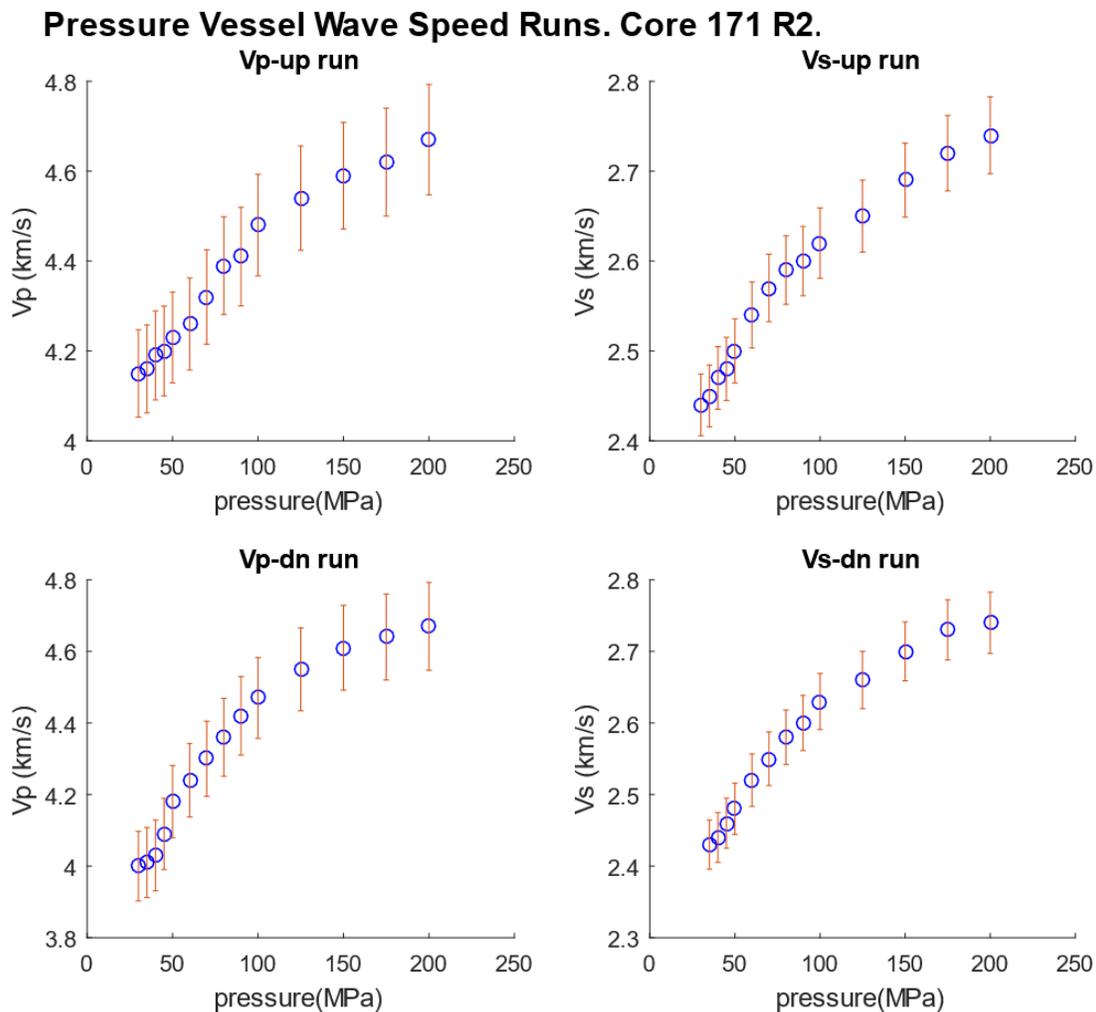


Fig. 3. Wave speed pressure runs for a shocked Chicxulub peak ring sample. Deviation point is seen at ~70-100 MPa

Outlook

Morphological effects of shock metamorphism have been extremely well investigated since Shoemaker's ground breaking verification of the Barringer structure as an astroblemy. (Chao et al., 1960) However, petrophysical properties of shocked rocks are not as well understood. The large inventory of shocked Chicxulub granites present a unique opportunity to develop empirical and theoretical relationships between morphological shock metamorphism effects and physical property deviations. Continued investigations on the previously aforementioned samples may yield exciting results on the poorly understood physical properties of shock metamorphism.

References

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