

The challenges of studying meteorite impacts into carbonate rocks: Jephtha Knob Kentucky. A. D. Schedl¹ and A. Seabolt, ¹Department of Physics, West Virginia State University, schedlad@wvstateu.edu

Introduction: This abstract supports the conclusions of [1, 2, & 3] that Jephtha Knob is an impact structure. These studies used XRD peak broadening in carbonates to argue that Jephtha Knob is an impact structure. Of particular interest is Fox [3] who used Skala et al. [4] XRD barometer for dolomite which plots FWHM (Full width-half maximum) against 2θ for Jephtha Knob core JK78-3. 8 of 47 samples show evidence show shock pressures >0 to 4.7 GPa and 5 samples show shock pressures from 4.7 to 17.0 GPa. The rest of the samples, 34, show no evidence of shock. Other important characteristics of the data are that peak broadening only occurs in samples at depths > 200 m (core length 366 m) and shocked samples for $2\theta > 100^\circ$, FWHM are lower than the calibrations curves in [4]. Other purposes for this abstract are to suggest an explanation for these observations and to suggest a way of improving sampling for the XRD method.

Methods: The approach here is to use calcite twin analysis to test impact origin for samples from core JK78-1. Previously, Schedl et al. [5] using surface samples and applying Jamison and Spang's [6] calcite paleostress peizometer determined a differential stress of ≈ 250 MPa near the center of Jephtha Knob. This is an order of magnitude larger than the calcite recorded regional tectonic stresses [7] arguing for an impact origin for Jephtha Knob.

20 thin sections were made from samples at different depths from cores JK78-1 and JK78-3. The thin sections were stained with alizarin red and potassium ferricyanide, because calcite and dolomite are difficult to distinguish in unstained samples. Thin sections from core JK78-1 at depths of 187 to 218 m contain calcite. For these thin sections the calcite grains with 0, 1, 2 and 3 twins were counted along traverses 0.5 mm apart. This was done so large calcite grains were not counted twice. Calcite grains that did not show complete extinction, when the microscope stage was rotated were also not counted.

Results and Interpretation: Table 1 shows the calcite twin results. Three generations of dolomite from oldest to youngest were recognized: 1) cataclastic dolomite; 2) equant and interlocking dolomite and 3) ferronan dolomite lining vugs and open fractures. Two generations of calcite are present: 1) zones of heavily twinned calcite and 2) zones of relatively untwinned calcite. Fox [3] also noted this last generation of calcite in core JK78-3 in veins and large calcite crystals. The cataclastic dolomite and twinned calcite

are presumed to be tied to the formation of Jephtha. Sample JK1-3 shows zones of relatively untwinned calcite in thin section and this explains the low stress estimate for calcite with 1 or more twins of 53 MPa. A large number of 0 and 1 twinned grains were introduced after the formation of Jephtha Knob. In table 1 the infinite sign, ∞ , indicates that the stresses were outside the range of the curves in [6]. For these reasons we will use the differential stress estimates from the % of grains with 3 twins. This gives differential stresses of 170-570 MPa.

The central region of the Jephtha Knob structure is overlain by horizontal lower Silurian Brassfield Formation (?). Thus, there was no more than a few hundred meters of rock overlying the Upper Ordovician rocks in the JK78 cores. As such, the twinned calcites were 200 to 400 m below the surface at the time the structure formed. The depths and differential stresses for Jephtha Knob, lie far outside the differential stresses inferred from calcites for orogenic belts Figure 1 [8].

Table 1: Inferred Differential Stresses ($\sigma_1 - \sigma_3$) from calcite.

Sample	Depth (m)	≥ 1 twin (MPa)	≥ 2 twin (MPa)	3 twin (MPa)	1σ (%)
JK1-3	187	53	220	180	5.0
JK1-4	198	240	440	570	7.4
JK1-5	200	125	400	170	3.9
JK1-6	213	∞	∞	570	4.7
JK1-7	218	∞	670	400	4.1

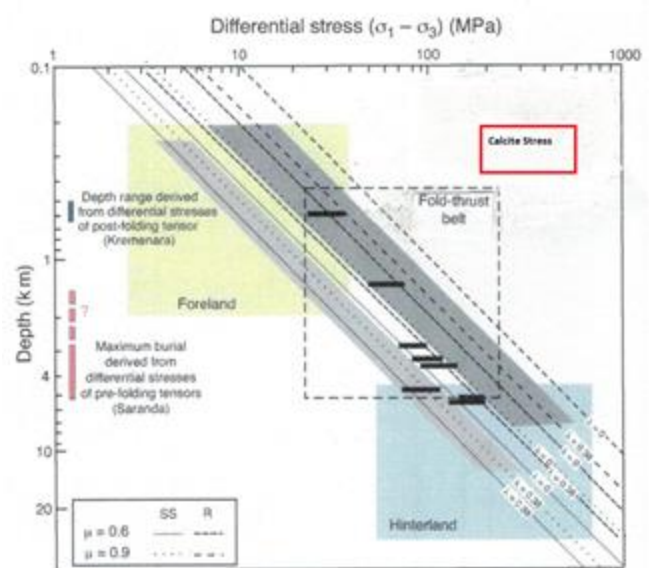


Figure 1: The red rectangle indicates the depths and differential stresses for JK78-1. The diagonal lines are the failure envelopes for different fluid pressures and internal cohesions [8].

The best explanation for Jephtha Knob is that it is an impact structure.

Discussion: Jephtha Knob rocks above the core are conglomerate/breccias, i. e., resurge deposits. Thus, seawater was a source of some of the dolomitizing fluids at Jephtha Knob. A geochemical study of the Jephtha Knob cores, JK78-1 and JK78-3 by the New York State Museum reveals that the dolomites are hydrothermal in origin: Fluid inclusions in the dolomites have homogenization temperatures of 85-115°C; the $\delta^{18}\text{O}_{\text{SMOW}}$ is -7 to -2; the dolomites are enriched in Fe and Mn and many of the dolomites have $^{87}\text{Sr}/^{86}\text{Sr}$ ratios >0.709 . The radiogenic nature of the strontium isotopes indicates that the dolomitizing waters interacted with basement or arkosic clastic rocks. Thus, the hydrothermal system extended to a minimum depth of 1.5 km (A possible depth of the transient crater?).

Other evidence for hydrothermal activity is that most of the quartz does not show undulatory extinct, hexagonal quartz cross sections are present and in open space fillings quartz has prismatic terminations. This suggests that much of the quartz is authigenic and post dates impact. This may in part explain the absence of shocked quartz. Also euhedral pyrite is found throughout both cores.

The large scale and intense nature of the hydrothermal system at Jephtha Knob could explain why most of the samples, 34/47, do not show evidence of shock. Prior to impact many of these rocks were dolomitic-limestone and they were dolomitized shortly after impact. Fox [3] analyzed powders made from pulverized thin section size chips, so for samples showing greater than ambient pressure, he was analyzing mixtures of shocked and unshocked dolomite. This is why his Fox's [3] data diverged from Skala et al.'s [4] curves for $20>100^\circ$. Since the major source of dolomitizing fluids is the ocean, shocked dolomite is more likely to survive at greater depth. The above suggest that a better way to sample pre-impact dolomite is to use thin sections to guide sampling of the chip by drilling. Hopefully, drilling will not cause peak broadening.

Groshong's [9] calcite strain gauge is now being applied to thin section JK1-8, because it may be possible to constrain the samples original orientation. Schedl's [10] results suggest that the greatest shortening direction is parallel to the direction the shock wave is propagating. Calcite twin analysis shows that orogeny produces initial-greatest-shortening directions that are horizontal and bedding parallel [7 & 8]. Thus, if the greatest shortening direction is steeply inclined, this is additional evidence that Jephtha Knob is an impact structure.

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