POST-IMPACT THERMAL HISTORY OF THE CHESAPEAKE BAY IMPACT STRUCTURE, BASED ON DOWNHOLE VITRINITE REFLECTANCE, ICDP-USGS EYREVILLE DEEP CORES AND OTHER CORES.

M. L. Malinconico[1], W. S. Sanford[2], and J. W. Horton, Jr.[1] [1]U.S. Geological Survey, MS 926A, Reston, VA 20192, USA, mmalinconico@usgs.gov, [2]U.S. Geological Survey, MS 431, Reston, VA 20192, USA

Introduction: The late Eocene Chesapeake Bay impact structure (CBIS) has been a target of research and water resource drilling for the last two decades, culminating with the 1,766-m deep ICDP-USGS Eyreville corehole in Northampton County, Virginia. This corehole in the deepest part (moat) of the ~38 km diameter central crater [1] provides a long vertical section for sampling to understand post-impact heat transfer processes in a layered, water-sediment-rock target.

Post-impact advective and conductive heating of impact crater-fill materials is common due to residual heat from the impact, melt sheets or segregations, uplifted crustal geotherms, and (or) hydrothermal circulation [2]. This study examines the post-impact thermal history of the CBIS using downhole vitrinite reflectance data from the Eyreville corehole, from the Cape Charles test hole over the central uplift, and previous data from coreholes in and near the outer part of the structure (annular trough) [3].

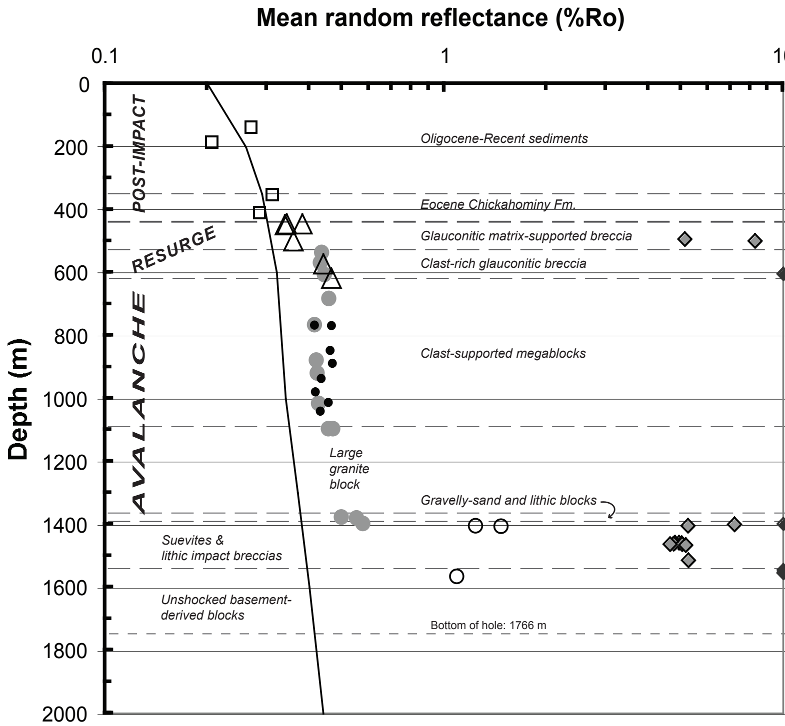
Results: The Eyreville vitrinite reflectance data show the effects of advective and conductive heating. Thermal maturity of post-impact Coastal Plain sediments (0- 444 m) is typical for the region (0.2- 0.31% R_o) (Figure 1). However, thermal maturity in the underlying sedimentary breccias and sediment megablocks is above background levels; it increases from 444 m to 525 m depth, and then remains constant at ~ 0.44% to the top of a 275-m basement-derived granite body at 1,096 m. This isothermal pattern is typical of vertical advective fluid flow. Below the granite, a short interval of gravelly sand (1371-1397 m) shows an exponential increase in reflectance from 0.47% to 0.59% R_o attributed to conductive heat from an underlying sequence of suevites and clast-rich impact melt rocks (1397-1474 m). Reflectances in the uppermost suevite are 1.2-1.4% R_o. Much higher reflectances (4-8%) of centimeter-scale shale/siltstone clasts, in the suevites and upper sedimentary breccias, are attributed to a pre-impact (Paleozoic?) metamorphic event. Conductive heat from the suevites and impact-melt rocks alone, however, would be insufficient to affect the temperature of sediments more than several tens of meters above the suevite. In numerical calculations of heat flow with kinetic reflectance evolution, modeling the Eyreville suevite as a 385˚C cooling "sill" accompanied by compaction-driven vertical fluid flow (0.046 m/year) of fluids from the suevite and deeper basement brines (120˚C) through the sediment breccias for 10,000 years closely reproduces the measured reflectance values.

Reflectance values from the Cape Charles borehole over the central uplift (Figure 2) show a similar pattern increasing exponentially with depth from 0.41% to 0.96% in a 90 m contact metamorphic zone above crystalline-clast suevite and crystalline megablocks, and a shallower isoreflectance section (~0.41%) in the upper sediment clast breccia. The thermal aureole is larger at Cape Charles than at the Eyreville site, indicating higher heat flow and (or) thicker heat producing units over the central uplift. Previous data from boreholes in the outer part of the structure (annular trough) [3] reveal no impact-related thermal effects (Figure 3).

Discussion: Thermal maturity measurements and modeling indicate that the crater fill, while heated above background passive-margin gradients, was not as hot as previously hypothesized [3, 4]. Models of CBIS thermal history prior to the Eyreville drilling assumed that deep melt sheets would provide enough heat to produce residual brine from boiling seawater entrapped in the crater fill. However, a large, coherent melt sheet was not found at depths penetrated by the Eyreville core, and modeling of the downhole reflectance data reveals that heat conduction from a deeper heat layer would not reproduce the observations of this study, particularly the isoreflectance interval in the sediment breccias.

Groundwater salinities at and above that of seawater are associated with the crater, and understanding processes that formed the saline ground water was a goal of the scientific drilling [1, 5]. Modeled, moderately heated (120˚ C) vertical fluid flow from below the drilled section is consistent with patterns of microbe and brine distribution [6, 7]. The results of this study demonstrate the importance of compaction-driven fluid flow in distributing heat in impact craters, particularly marine craters having undercompacted sedimentary fill overlying fractured basement rocks.

References: [1] Gohn G. S. (2006) *EOS, 87,* 349, 355. [2] Naumov M. V. (2005) *Geofluids, 5,* 165-184. [3] Harvey S. V. (2004) unpub. M. S. thesis, Virginia Polytechnical Institute, 35 p. [4] Sanford W. S. (2005) *Geofluids, 5,* 185-201. [5] Sanford W. S. et al. (2004) *EOS, 85,* 369, 377. [6] Cockell et al. (2007) *GSA Abs, 39, 6,* 534. [7] Sanford W. S. et al. (2007) *GSA Abs, 39, 6,* 534.



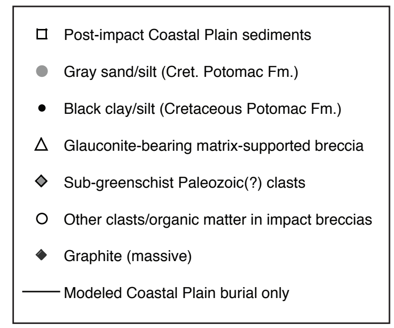


Figure 1: ICDP-USGS Eyreville core (Chesapeake Bay impact crater moat) vitrinite reflectance data, discriminated by lithology.

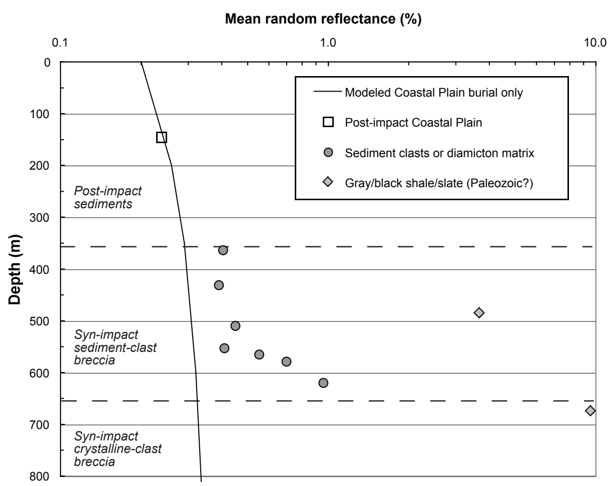


Figure 2 (left): Vitrinite reflectance data from the Cape Charles test hole, central uplift, Chesapeake Bay impact structure.

Figure 3 (below): Interpretive radial cross-section of the Chesapeake Bay impact structure showing general stratigraphy, vitrinite reflectance contours, and relative drill hole locations.