Chesapeake Bay Crater

Geology and Geophysics of a Late Eocene Submarine Impact Structure

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Contents of CD-ROM

Fig. 6.14. Ten core segments recovered from NASA Langley corehole showing: *A*, slightly weathered crystalline basement rocks; *B*, strongly weathered crystalline basement rocks overlain by basal breccia; *C-E*, silts and sands of displaced sedimentary megablocks (*C*, massive, fluidized? sand from décollement zone; *D*, horizontal stratification; *E*, inclined stratification); *F-J*, succession of upward-fining breccias (*F*, clast-supported sediment-clast breccia with no matrix; *G*, matrix-supported breccia with moderately large sedimentary clasts; *H*, matrix-supported breccia with small sedimentary clasts; *I*, nearly 100% matrix of glauconitic quartz sand; *J*, continuation of matrix interval, overlain in succession by flowin unit, fallout layer, and laminated dead zone, and capped by Chickahominy Formation (marine clay). Numbers at top of each segment indicate drill depth at top of segment.

Fig. 6.16. Three segments of split cores from matrix of Exmore breccia (from Exmore corehole). Note scattered dark glauconite grains (*G*), variable orientations of mollusc shells (*M*; white streaks), and dominance of clayey quartz sand (clasts rarely larger than a few millimeters). Numbers at top of each segment indicates drill depth at top of segment.

Fig. 6.17. Whole (*A, C, D*) and split (*B, E, F*) sections of core from Exmore corehole, showing angular clasts (*AC*) and rounded clasts (*RC*) within glauconite/quartz matrix (*GM*) of Exmore breccia. Numbers at top of each segment indicate drill depth at top of segment.

Fig. 6.18. Split sections of core from Exmore corehole, showing inclined contacts between clasts and matrix within Exmore breccia and mud rims on clasts (arrows on *C, D, E*). Numbers at top of each segment indicate drill depth at top of segment.

Fig. 6.19. Split sections of core from Exmore corehole (*A, B, C, D*) and whole section from North corehole (*E*), showing complex plastic deformation of soft-sediment clasts within Exmore breccia. Numbers at top of each segment indicate drill depth at top of segment.

Fig. 6.20. Split sections of core from Exmore corehole, showing squeeze-outs (arrows) in clay clasts within Exmore breccia. Numbers at top of each segment indicate drill depth at top of segment.

Fig. 6.21. Whole and split sections of core from Exmore breccia, showing flame structures (arrows) in which one lithic unit has been injected into another lithic unit. *A* Bayside core; *B*, *C*, *D* North core. Numbers at top of each segment indicate drill depth at top of segment.

Fig. 6.22. *A* whole segment of NASA Langley core, showing transition from Exmore breccia to dead zone. Dashed line is contact between sand matrix of Exmore breccia and silt-rich layer, which contains coarse-grained burrow-fills, pyrite lattices with spherical pores, nodular concentrations of framboidal pyrite, and reworked specimens of foraminifera. Dotted straight lines are boundaries of fallout layer. Black rectangles indicate sample locations. *B* vertically split segment of NASA Langley core, showing concentrations of framboidal pyrite in upper part of silt-rich layer (arrows indicate position of this segment in *A*). *C* horizontally split segment of NASA Langley core, showing complex microlithologies (micaceous silt, dark clay band, coarse-grained burrow-fill, nodular pyrite concentrations) of silt-rich layer just above contact with Exmore breccia; thin, micaceous, white laminae contain benthic foraminifera reworked from Exmore breccia. *D* Vertically split segment of NASA Langley core, showing irregular contact between sand matrix of Exmore breccia and overlying silt-rich layer. Datum for vertical scale is top of fallout layer.

Fig. 6.23. *A* whole-core section from North corehole, showing uphole changes in stratal geometry in silt-rich layer. *B,C* two whole-core sections from Bayside corehole, showing inclined stratification in silt-rich layer; sparsely scattered clasts shown by arrows. Silt-rich layer represents flowin depositional facies discussed in Chapter 11.

Fig. 6.25. Split (*A*) and whole (*B*) core sections from Exmore corehole, showing vertical squeeze deformation and drag folds in clast of Lower Cretaceous laminated, organic-rich silt within Exmore breccia. Tracings (*A', B'*) show interpreted sense of motion on principal faults (solid lines) and trace of main fold axis (dashed line). Numbers at top of each segment indicate drill depth at top of segment.

Fig. 6.26. Whole core sections, showing boulders (continuous core) of scaly clay within Exmore breccia in Windmill Point corehole [*A* 0.76 m (2.5 ft) thick] and NASA Langley core [*B* 0.37 m (1.2 ft) thick]. Numbers at top of segments indicate drill depth at top of segments.

Fig. 6.27. Five whole-core sections (*B, C, D, E, F*) and one split-core section (*A*), showing variety of small, angular, crystalline basement clasts within Exmore breccia from Exmore corehole (*Ex*) and Windmill Point corehole (*WP*). Numbers at top of segments indicate drill depth at top of segments

Fig. 6.28. Thin sections (*A*, *D* plane-polarized light; *B*, *C* crossed polarizers), showing typical fracture patterns resulting from low-pressure (~8 GPa) shock metamorphism in clasts of crystalline basement extracted from Exmore breccia (Exmore corehole). *A* typical shock fractures in quartz (shocked to ≤8 GPa) within granitoid fragment or vein, width of field 1.1 mm; *B* shocked quartz fragment with fracture patterns similar to those of Hospital Hill quartzite (South Africa; shocked to ≤8 GPa), width of field 3.4 mm; *C* quartz with possible shock fractures, width of field 2.75 mm; *D* typical shock fractures in feldspar, width of field 2.2 mm.

Fig. 6.29. Thin sections (plane-polarized light), showing PDFs (planar deformation features) resulting from shock metamorphism (20−30 GPa) in clasts of crystalline basement (*A*−*D*) and in individual quartz grains (*E, F*) extracted from Exmore breccia. *A* densely spaced multiple sets of PDFs in K-feldspar grain, width of field 220 µm; *B* K-feldspar grain with dense pattern of multiple PDFs, width of field 355 µm; *C* multiple sets of PDFs in K-feldspar grain, width of field 335 µm; *D* multiple sets of PDFs in quartz grain from granitoid fragment, width of field 565 µm; *E* and *F* individual quartz grains from matrix of Exmore breccia (cross-polarized light), each showing two sets of PDFs, width of field ~1 mm. *Ex* = Exmore corehole; *NL* = NASA Langley corehole; *K* = Kiptopeke corehole.

Fig. 6.31. Thin sections (all with crossed polarizers), showing melt features resulting from shock metamorphism (35−60 GPa) in clasts of crystalline basement extracted from Exmore breccia. *A* nearly completely melted/annealed quartz grain; width of field 3.4 mm; *B* breccia pocket with apparent presence of melt matrix; crossed polarizers; width of field 3.6 mm; *C* granite fragment with annealed melt vein; crossed polarizers; width of field 3.4 mm; *D* aphanitic impact melt with K-feldspar clasts; crossed polarizers; width of field 3.4 mm. *Ex* = from Exmore corehole.

Fig. 6.32. Thin sections, showing glass microspherules from Exmore breccia. Microspherules indicate shock-melting of sedimentary target rocks at Chesapeake Bay crater. *A* chert fragment and chloritized fragment, both indented by glass microspherule; parallel polarizers; width of field 2.75 mm; *B* same glass microspherule as in *A* (crossed polarizers); *C* glass microspherule attached to and indenting strongly altered fragment with silicic matrix and granite-derived clasts; parallel polarizers; height of field 2.5 mm high; *D* glass microspherule firmly attached to glass splash on clast of fine-grained particle of meta-quartzite; parallel polarizers; width of field 4.5 mm; *E* same glass microspherule as in *D* (crossed polarizers). *NN* = Newport News corehole; *Ex* = Exmore corehole.

Fig. 7.3. Core segments in dead zone from NASA Langley corehole. *A* vertically split segment, showing contact with overlying dense clay of Chickahominy Formation; *B* horizontal split of segment *A*, showing complex laminar lithologies at contact with Chickahominy; *C* horizontal split of segment *A* taken 0.6 cm below *C*, showing laminae and burrow; *D* vertically split segment, showing uniform distribution of repetitious, horizontal laminae (sand, silt, clay). Approximate depths shown at tops of segments.

Fig. 7.4. Lithic characteristics of Chickahominy Formation. *A* laminar surface of horizontally split fresh core segment, showing needle-like echinoid spines distributed parallel to laminae and scattered white spots representing benthic foraminiferal tests (from NASA Langley corehole); *B* laminar surface of horizontally split fresh core segment, showing echinoid spines, thin-shelled clams, and foraminifera (from NASA Langley corehole); *C* segment of vertically split core (photographed after ten years of dry storage), showing laminated interval within Chickahominy Formation (from Windmill Point corehole).

Fig. 7.5. Core segments, showing burrows in upper and lower parts of Chickahominy Formation. *A* intensely burrowed clay (light-colored) in fresh whole core of upper part of Chickahominy Formation at NASA Langley core site. Burrows filled with greenish-black, glauconitic quartz sand derived from overlying Delmarva beds (lower Oligocene); *B* burrows (arrows) in dried out clay of lower part of Chickahominy Formation (vertically split weathered core) at Windmill Point core site. Sand in burrows derived from underlying Exmore breccia; *C* well-defined sand-filled burrow parallel to bedding plane (horizontal) in lower part of Chickahominy Formation (whole fresh core) at NASA Langley core site; burrow-fill derived from underlying Exmore breccia.

Fig. 7.6. Weathered split core segments from Chickahominy Formation overlying Exmore breccia at Exmore core site. *A*, *B* segments typical of hard, finely laminated clay that makes up bulk of Chickahominy at this site; *C*, *D* segments displaying sand-filled burrows (arrows) near base of Chickahominy at this site; burrows cause weathered cores to fracture and crumble.

Fig. 7.10. Core segment, showing minor branch of postimpact compaction fault system, which cuts Chickahominy Formation at 229.9 m (754.4 ft) in NASA Langley corehole. Hanging wall and foot wall separated by 1.5-cm-thick layer of pyrite-rich fault gouge.

Fig. 9.5. Seafloor outcrops of intensely fractured middle and lower Eocene pelagic limestones on New Jersey Continental Slope adjacent to Toms Canyon crater and ~300 km northeast of Chesapeake Bay crater. *A* fractured limestone beds form near-vertical cliff in upper half of photograph (arrow). *B* terrace of highly fractured limestone (arrows mark fractures. *C* talus of angular limestone clasts at base of cliff. Photographs from submersible dive courtesy of David C. Twichell

Fig. 12.4. 2-D computer simulation of Chesapeake Bay bolide impact, showing five postimpact time slices (10s, 30s, 60s, 120s, 170s). Simulation generated by D.A. Crawford, Sandia National Laboratories.

Fig. 12.5. 3-D rendering of four of time slices shown in Fig. 12.4 (10s, 30s, 60s, 170s) derived from computer-assisted video animation prepared by NHK (Japanese Broadcasting Company). Illustrations courtesy of Toshihiro Matsumoto, NHK.

Fig. 13.2. Stratigraphic range chart for benthic foraminifera in Chickahominy Formation at Kiptopeke core site. Broad shading indicates nominate taxa for principal benthic foraminiferal subassemblages that constitute *Cibicidoides pippeni* Assemblage. Heavy black lines indicate agglutinated species. Small open circles indicate reworked specimens found in dead zone.

Fig. 14.7. Suffolk Scarp, which is modern topographic expression of the outer rim of Chesapeake Bay impact crater. Topographic relief at this location is ~14 m (arrow). Location is on west side of Virginia State Highway 14, between the towns of Gloucester and James Store, ~0.5 km north of Mt. Zion Church.