

# **Thermal Maturity of the U.S. Atlantic Coastal Plain Based on Legacy Exploration and Stratigraphic Test Wells, Including Hatteras Light Esso #1\***

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## **Introduction**

Recent vitrinite reflectance study of the Chesapeake Bay impact structure (CBIS) (Malinconico et al., 2009), Virginia, USA, highlighted the dearth of U.S. Atlantic Coastal Plain maturity data available for background thermal framework studies, despite numerous deep exploration wells drilled from 1944 to the 1970's. For the CBIS study, comparative background maturities were calculated from two modern equilibrated downhole temperature studies, including the Virginia Tech Crisfield geothermal test well in Maryland. The goal of the current study is to collect downhole vitrinite reflectance data from several mid-to-late 20th century exploration and stratigraphic test wells, including the Hatteras Light Esso #1, in order to fill the void in maturity information on the ocean edge of the coastal plain from New Jersey to North Carolina. The study is testing hypotheses on the coastal plain/Outer Continental Shelf (OCS) depth to the oil window (0.6%Ro), whether thermal trends are regionally similar, and, if possible, whether pre-Cretaceous Mesozoic strata are Triassic or post-rift Jurassic in age.

## **Well Data**

Initial data ([Table 1](#)) are available from Standard Oil of New Jersey Hatteras Light Esso #1, Cape Hatteras, North Carolina; J&J Enterprises E.G. Taylor #1-G, Delmarva Peninsula, Virginia; Standard Oil of New Jersey Maryland Esso #1, Ocean City, Maryland; and Socony-Vaccum J.T. Bethards #1, southwest of Ocean City ([Figure 1](#)).

Hatteras Light Esso #1 is the deepest and easternmost of the coastal plain wells; its location is about 65 km southwest of the Manteo Exploration Unit, North Carolina OCS, an undrilled high-risk offshore prospect ([Figure 1](#)). The well reached basement at 9,853 ft and had a total depth of 10,054 ft. Cretaceous and younger marine and terrestrial coastal plain sediments extend to 9,145 ft, where reflectance is ~0.51% Ro. Between 9,145 ft and basement are sediments that have previously been called Triassic ("Newarkian") (drillsite lithologic logs), Lower Cretaceous (Spangler, 1950), or Upper Jurassic(?) (Perry et al., 1975). We assign these strata to the Upper Jurassic. Reflectance in these pre-Cretaceous

sediments is 0.60%, generally continuous with the reflectance trend in overlying strata. This lack of an abrupt downhole increase in maturity precludes the use of reflectance data to draw any conclusions on age or hiatuses for these pre-Cretaceous strata.

The Taylor #1-G well reached basement at 6,272 ft. Reflectance at 6,005 ft near the base of the coastal-plain section is 0.39%. Cuttings from 6,070-6,180 ft, variably designated Triassic (Onushak, 1972) or Lower Cretaceous/Upper Jurassic (Perry et al., 1975), are 0.47-0.51% Ro. This increase is insufficient, however, given noise in overlying data, to confirm the strata as lower Mesozoic.

Maryland (Ocean City) Esso #1 was drilled about 4 miles north of Ocean City, Maryland, to 7,710 feet depth, but did not reach basement or pre-Cretaceous strata (Anderson et al., 1948). Measured reflectance in Maryland Esso #1 at 7,585 ft is 0.46%.

The Bethards #1 well was drilled about 15 miles southwest of Ocean City. Total depth was 7,178 feet; basement was reached at 7,130 feet. Anderson et al. (1948) stated that lithologic changes within the interval 6,500-6,700 feet are “highly suggestive” of Triassic age strata, and the top of the “Triassic” was placed at 6,566 feet. However, Perry et al. (1975) reassigned these strata to the Lower Cretaceous/Upper Jurassic based on lithologic correlation to similar spore-pollen-bearing beds in Taylor #1. Reflectance of 0.45% at 7,125 feet in our study is continuous with the overlying maturity trend (Table 1).

The reflectance trends from the coastal plain wells are similar to that of the Baltimore Canyon COST B-2 (far shelf) OCS well (Smith et al., 1976, Scholle, 1977) ([Figure 2](#)), suggesting comparable regional thermal gradients and depth to the onset of oil generation (0.6% Ro) at 10,000-11,000 ft (~3,200 m).

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| <b>Hatteras Esso #1, NC</b> |       |           | <b>Taylor #1-G, Accomack County, VA</b> |       |           |
|-----------------------------|-------|-----------|---|-------|-----------|
| Depth (ft)                  | %Ro   | Depth (m) | Depth (ft)                              | %Ro   | Depth (m) |
| 815.0                       | 0.302 | 248.4     | 775                                     | 0.251 | 236.2     |
| 1745.0                      | 0.281 | 531.9     | 1335                                    | 0.294 | 413       |
| 7710.0                      | 0.478 | 1233.5    | 1465                                    | 0.312 | 446.5     |
| 7710.0                      | 0.478 | 2350.0    | 1625                                    | 0.264 | 495.3     |
| 7771.0                      | 0.474 | 2368.6    | 1655                                    | 0.373 | 504.4     |
| 8285.0                      | 0.473 | 2525.3    | 1695                                    | 0.335 | 516.6     |
| 8505.0                      | 0.455 | 2592.3    | 2065                                    | 0.365 | 629.4     |
| 8919.5                      | 0.510 | 2718.7    | 2085                                    | 0.325 | 635.5     |
| 9185.0                      | 0.607 | 2799.6    | 3575                                    | 0.366 | 992.1     |
| 9805.0                      | 0.596 | 2988.6    | 3575                                    | 0.298 | 1089.7    |
|                             |       |           | 4895                                    | 0.378 | 1492.0    |
|                             |       |           | 5255                                    | 0.367 | 1601.7    |
|                             |       |           | 5535                                    | 0.405 | 1687.1    |
|                             |       |           | 5935                                    | 0.351 | 1809.0    |
|                             |       |           | 6005                                    | 0.387 | 1830.3    |
|                             |       |           | 6095                                    | 0.472 | 1857.8    |
|                             |       |           | 6155                                    | 0.507 | 1876.0    |
| <b>Bethards #1, MD</b>      |       |           | <b>Ocean City Esso #1, MD</b>           |       |           |
| Depth (ft)                  | %Ro   | Depth (m) | Depth (ft)                              | %Ro   | Depth (m) |
| 3175                        | 0.378 | 967.7     | 1365                                    | 0.252 | 416.1     |
| 3305                        | 0.361 | 1007.4    | 1700                                    | 0.294 | 518.2     |
| 3685                        | 0.401 | 1123.2    | 2145                                    | 0.292 | 653.8     |
| 3735                        | 0.366 | 1138.4    | 2225                                    | 0.303 | 678.2     |
| 4575                        | 0.330 | 1394.5    | 6675                                    | 0.483 | 2034.5    |
| 4625                        | 0.329 | 1409.7    | 6705                                    | 0.459 | 2043.7    |
| 5385                        | 0.433 | 1641.3    | 7435                                    | 0.405 | 2266.2    |
| 5840                        | 0.386 | 1780.0    | 7585                                    | 0.455 | 2311.9    |
| 5935                        | 0.454 | 1809.0    |   |       |           |
| 7125                        | 0.450 | 2171.7    |   |       |           |

Table 1: Vitrinite reflectance data from legacy Atlantic Coastal Plain exploration and stratigraphic test wells.

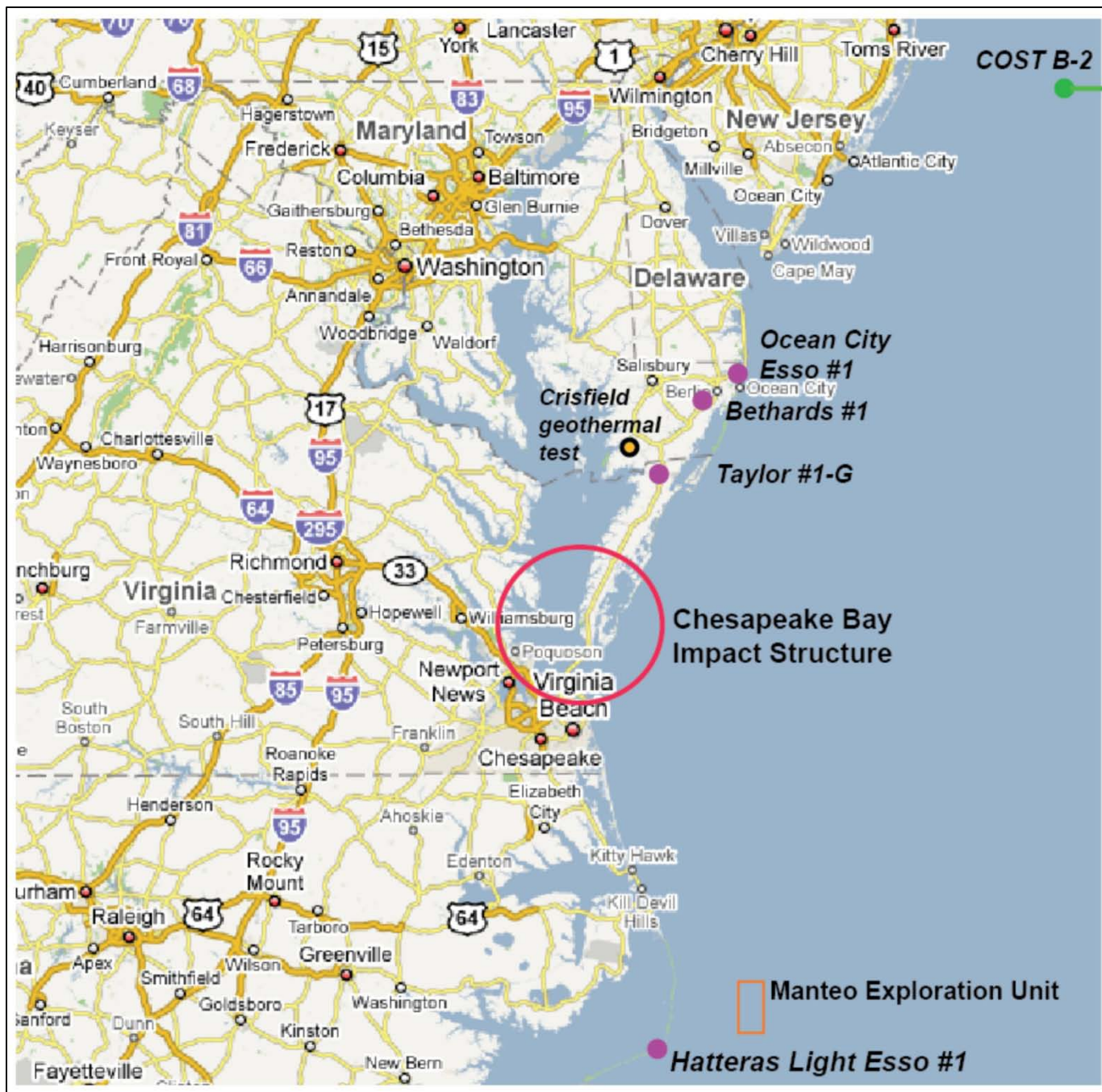


Figure 1: Location map for Atlantic Coastal Plain wells and other features used or referenced in this study.

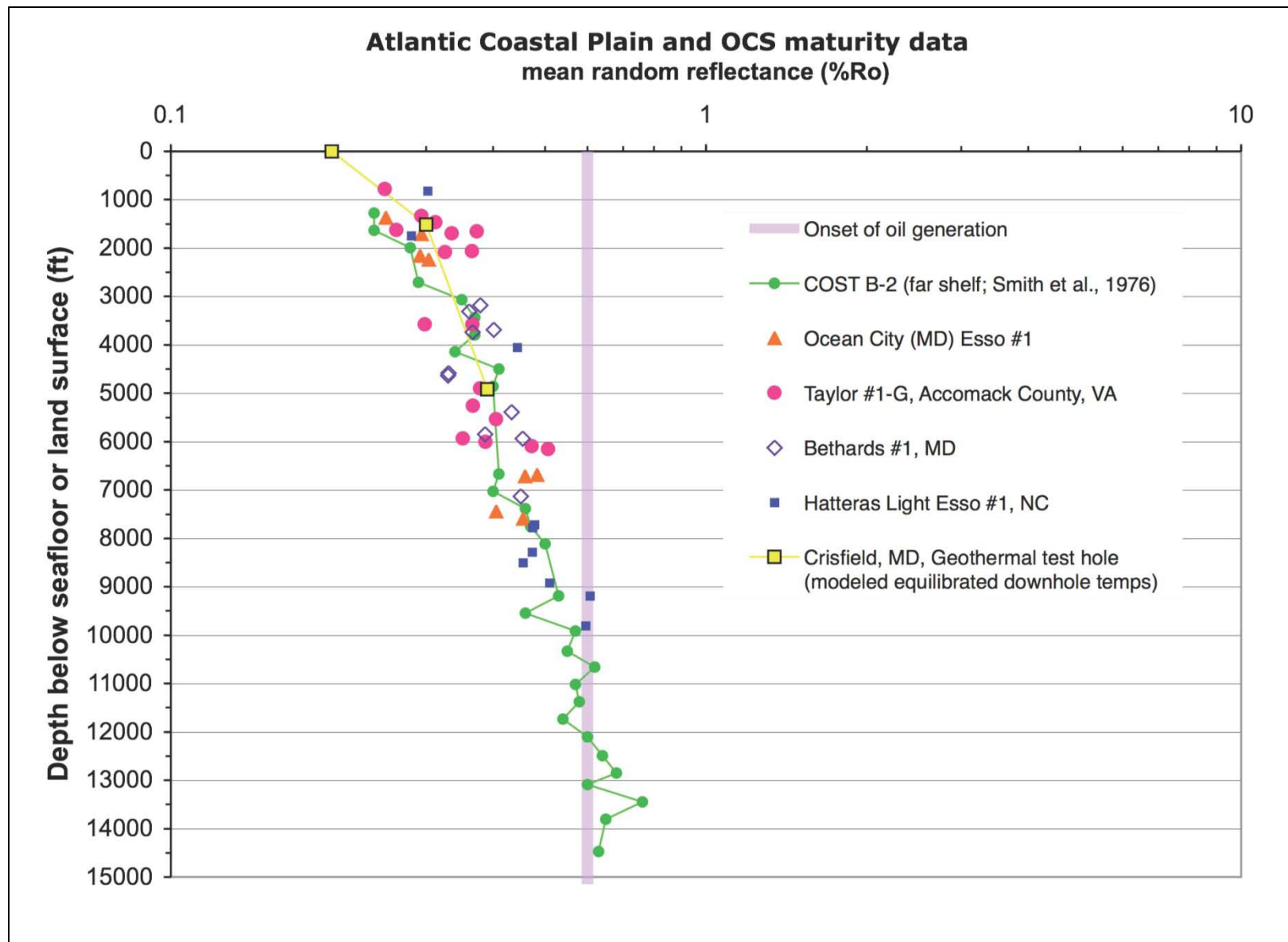


Figure 2: Plot of legacy well vitrinite reflectance data from this study compared to COST B-2 data and modeled values from equilibrated downhole temperature data (<http://geothermal.geol.vt.edu/CrisfieldDeepGeothermalTest.html>), Crisfield geothermal test well, Maryland.