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HISTORY OF TERMINOLOGY AND CORRELATIONS OF THE BASAL CRETACEOUS FORMATIONS OF THE CAROLINAS

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Introduction

Several years ago the author undertook a study of the stratigraphy of the outcropping basal Cretaceous formations as exposed in an area between Fayetteville, North Carolina, and McBee, South Carolina. As a part of this project the literature concerning the basal Cretaceous formations of the Carolinas and adjacent states was reviewed and a composite correlation chart prepared (Chart I). This information is presented here as an illustration of the complexity of terminology, and to show the various stages in the history of the correlations. In addition a selected bibliography of the important work done on the Coastal Plain deposits of the Carolinas is included. Many references concerning the downdip portions of the basal Cretaceous have been omitted.

History of Terminology and Correlations

Prior to 1900, there were no serious attempts to describe and subdivide the Coastal Plain formations of the Carolinas. Local descriptions and correlations were made by various writers. Fontaine (1890, p. 174) described supposed Potomac strata near Haywood, North Carolina. Holmes (1894, p. 33-34) described the Cretaceous deposits of the North Carolina Sandhills and the "Potomac" clays on the Cape Fear River, (1896, p. 934). Darton (1896) wrote about

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THE BASAL COASTAL PLAIN FORMATIONS IN SOUTH CAROLINA. THESE PAPERS WERE MERELY SHORT DESCRIPTIONS OF ECONOMIC MATERIALS OR DESCRIPTIONS OF YOUNGER CRETACEOUS MARINE FOSSILS.

FUNDAMENTAL DESCRIPTIVE WORK ON THE BASAL CRETACEOUS BEDS IN SOUTH CAROLINA BEGAN WITH A SERIES OF PUBLICATIONS BY SLOAN (1904, 1907, 1908). THE NORTH CAROLINA FORMATIONS WERE DESCRIBED IN GREAT DETAIL BY STEPHENSON IN 1912[B], AFTER A SHORT PRELIMINARY REPORT IN 1907. SLOAN SUBDIVIDED THE BASAL CRETACEOUS OF SOUTH CAROLINA INTO THE HAMBURG, MIDDENDORF, AND BLACK CREEK "PHASES." STEPHENSON (1907, P. 95) NAMED THE BASAL COASTAL PLAIN FORMATION OF NORTH CAROLINA THE CAPE FEAR AND THE NEXT YOUNGER FORMATION THE BLADEN. HE REFERRED THE CAPE FEAR TO THE JURASSIC (?) AND THE BLADEN TO THE CRETACEOUS. THESE BEDS WERE DESIGNATED BY STEPHENSON IN 1912[B] (P. 83-144) AS THE PATUXENT AND BLACK CREEK FORMATIONS. HE THOUGHT THE PATUXENT WAS THE SOUTHWARD EXTENSION OF THE LOWER CRETACEOUS BEDS OF VIRGINIA, ALTHOUGH LITHOLOGY AND STRATIGRAPHIC POSITION WERE THE ONLY MEANS HE HAD OF CORRELATION (STEPHENSON, 1912[B], P. 83). THE BLACK CREEK WAS DESIGNATED AS THE NORTHWARD EXTENSION OF THE UPPER CRETACEOUS BLACK CREEK "PHASE" OF SLOAN.

BERRY (1914) REPORTED ON THE FLORA OF THE CRETACEOUS BEDS OF THE CAROLINAS. HE REGARDED SLOAN'S MIDDENDORF "PHASE" AS A MEMBER OF THE BLACK CREEK FORMATION AND SAID THAT IT OVERLIES THE LOWER CRETACEOUS "HAMBURG FORMATION." THE MIDDENDORF WAS CORRELATED WITH THE BLACK CREEK FORMATION BECAUSE OF THE SIMILARITY OF LARGE FLORA. BERRY THOUGHT THE UNDERLYING HAMBURG WAS

THE SOUTHWARD CONTINUATION OF THE NORTH CAROLINA PATUXENT FORMATION AND ASSIGNED A LOWER CRETACEOUS AGE TO IT (1914, P.7). STEPHENSON (1923) CONTINUED THE NAMES PATUXENT AND BLACK CREEK FOR THE NORTH CAROLINA AREA, BUT HE CALLED THE UPPERMOST BLACK CREEK BEDS THE SNOW HILL CALCAREOUS MEMBER OF THE BLACK CREEK FORMATION. HE ACCEPTED THE MIDDENDORF AS A LOWER MEMBER OF THE BLACK CREEK BEDS OF SOUTH CAROLINA (1923, P.7), AND HE REFERRED THE HAMBURG BEDS TO THE LOWER CRETACEOUS PATUXENT FORMATION (1923, P.2).

THUS THE BASAL CRETACEOUS ROCKS OF NORTH AND SOUTH CAROLINA WERE CLASSIFIED AS LOWER CRETACEOUS, AND THE NAME PATUXENT WAS EXTENDED SOUTHWARD FROM VIRGINIA. MEANWHILE, THE LOWEST CRETACEOUS BEDS NEAR TUSCALOOSA, ALABAMA (TUSCALOOSA FORMATION) WERE ASSIGNED TO THE UPPER CRETACEOUS BECAUSE OF A LARGE UPPER CRETACEOUS FLORA, MOSTLY DESCRIBED BY BERRY (1919). STEPHENSON DESCRIBED SUPPOSED LOWER CRETACEOUS BEDS EXTENDING "FROM THE ALABAMA RIVER VALLEY, NORTH OF MONTGOMERY, ALABAMA, EASTWARD THROUGH ALABAMA TO THE CHATTAHOOCHEE RIVER VALLEY, AT AND IMMEDIATELY SOUTH OF COLUMBUS, GEORGIA, AND THENCE NORTHEASTWARD THROUGH GEORGIA, INTERSECTING THE SAVANNAH RIVER VALLEY AT AND SOUTH OF AUGUSTA, GEORGIA." (STEPHENSON, 1914, P. 20). THESE BEDS WERE BURIED UNCONFORMABLY BY THE TUSCALOOSA FORMATION A SHORT DISTANCE WEST OF THE ALABAMA RIVER AND WERE TENTATIVELY CLASSIFIED AS LOWER CRETACEOUS BY BERRY (IN CLARK, 1911, STEPHENSON, 1912A, AND 1914) ON THE BASIS OF A VERY SCANTY SUPPOSED LOWER CRETACEOUS FLORA. THE "LOWER CRETACEOUS" BEDS OF GEORGIA AND ALABAMA WERE NOT DESIGNATED AS PATUXENT BECAUSE OF THE POSSIBILITY THAT THEY WERE NOT THE ACTUAL CONTINUATION OF THE

Patuxent found south of Virginia in the Carolinas, and were in fact "younger than the Patuxent formation of the Potomac group" (Stephenson, 1914, p.39) of Virginia and Maryland.

Further collections from the one fossil plant locality of the Alabama "Lower Cretaceous" were said by Berry (1923, p.434) to be Upper Cretaceous. On this note, Cooke (1926) revised the terminology and correlation of the basal Cretaceous beds of the Carolinas. He raised the Middendorf to formational rank and lowered its base so as to include the Patuxent (Hamburg) formation of South Carolina and the beds previously called Lower Cretaceous found east of the Flint River in Georgia. Cooke discarded the name Patuxent in North Carolina and replaced it by Stephenson's name, Cape Fear. Both the Cape Fear and Middendorf were correlated with the Tuscaloosa formation and were considered to be basal Upper Cretaceous.

As to the Patuxent or Hamburg of South Carolina, Cooke wrote:

> There seems to be no valid distinction between the so-called Lower Cretaceous or 'Hamburg beds' of Sloan and the typical Middendorf beds, which contain a large flora of Upper Cretaceous age. Middendorf lies in the midst of uniform sand hills that extend from the North Carolina line along the southeastern border Piedmont upland to the valley of Congaree River at Columbia. No one has succeeded in separating the 'Hamburg' from the Middendorf in this area ... the 'Hamburg' is .... obviously the continuation of the so-called Lower Cretaceous of Georgia (Cooke, 1926, p. 138).

Cooke discounted Berry's correlation of the Middendorf with the Black Creek and stated that "in my opinion the difference in the floras are more significant than the resemblances" (p. 138). He added that the lithology of the Black Creek and Middendorf contrast sharply, the two are separated by a pronounced unconformity, the area of outcrop of the Middendorf is greater than that of the Black Creek, and the type of the Middendorf is 20 miles from the nearest exposed Black Creek.

Cooke regarded the Cape Fear and Middendorf as very similar in age, but he was reluctant to extend the name Middendorf into North Carolina because of Stephenson's belief that the Cape Fear may include beds older than the Middendorf of South Carolina; however, he felt that the name Middendorf would eventually be applied in the North Carolina area.

In 1936, Cooke dropped the term Middendorf in favor of Tuscaloosa because:

> Field work done in Georgia in 1930 shows that the Middendorf there is quite different from the Eutaw formation, but apparently identical with the Tuscaloosa. A local name for the beds in Georgia and South Carolina is therefore unnecessary....(Cooke, 1936, p. 17).

(In this connection, it is interesting to note that Eargle [1955, p. 83-84] believes that most of the beds in eastern Georgia mapped as Tuscaloosa are actually of a much younger Cretaceous age). Cooke extended the Tuscaloosa into North Carolina with the reservation that the Tuscaloosa of North Carolina

MIGHT ACTUALLY CONTAIN BEDS OLDER THAN THE TYPICAL TUSCALOOSA.

THE CORRELATION CHART FOR THE OUTCROPPING CRETACEOUS OF THE ATLANTIC AND GULF COASTS PREPARED BY THE COMMITTEE ON STRATIGRAPHY OF THE NATIONAL RESEARCH COUNCIL (STEPHENSON ET AL., 1942) RAISED THE BASE OF THE BLACK CREEK FORMATION IN NORTH CAROLINA AND SOUTH CAROLINA TO SLIGHTLY ABOVE THE BASE OF THE TAYLOR (BASE OF COMPANIAN). ALMOST ALL PREVIOUS AUTHORS HAD REFERRED THE LOWER BLACK CREEK TO THE AUSTIN (TURONIAN OR LOWER SENONIAN). NO REASON FOR THIS CHANGE WAS MENTIONED IN THE TEXT. SPANGLER AND PETERSON (1950) CORRELATED THE TUSCALOOSA BEDS OF NORTH CAROLINA WITH THEIR COMBINED POTOMAC-RARITAN BEDS OF MARYLAND AND DELAWARE AND WITH THE RARITAN FORMATION OF NEW JERSEY. THE PATUXENT FORMATION WAS CORRELATED WITH THE LOWER PART OF THE NORTH CAROLINA TUSCALOOSA. THE LATTER WAS CONSIDERED TO BE IN PART LOWER CRETACEOUS AND IN PART UPPER CRETACEOUS (SPANGLER AND PETERSON, 1950, P.69 AND 8). THEY BELIEVE THAT IT IS NOT POSSIBLE TO JUSTIFY A TUSCALOOSA FORMATION IN NORTH CAROLINA ENTIRELY OF UPPER CRETACEOUS AGE WITH A LOWER CRETACEOUS PATUXENT FORMATION IN VIRGINIA, BECAUSE THE TWO FORMATIONS OCCUPY THE SAME STRATIGRAPHIC POSITION; IN FACT, TO SATISFY SUCH A CORRELATION:

> ... IT BECOMES NECESSARY ARBITRARILY TO PINCH OUT THE NON-MARINE UPPER CRETACEOUS UNIT NORTHWARD IN ORDER TO ALLOW AN IDENTICAL NON-MARINE UNIT OF LOWER CRETACEOUS AGE TO APPEAR.... TO ACCEPT THIS INTERPRETATION... AS BEING CORRECT INVOLVES THE ADJUSTMENTS OF THE COASTAL PLAIN DURING LOWER AND EARLY UPPER CRETACEOUS TIME:...IF THIS EXPLANATION IS CORRECT IT MUST BE BASED EN-

> TIRELY ON FLORAL DETERMINATION.... THE PROBLEM CAN NOT BE SOLVED BY SAYING THE SEDIMENTS WERE DEPOSITED IN A TRANSGRESSING SEA BECAUSE THEY ARE ALL NON-MARINE.... THIS LEAVES TWO POSSIBLE ANSWERS.... THERE ARE TWO IDENTICAL UNITS OF DIFFERENT AGE, OR THE AGE DETERMINATIONS BY BERRY AND OTHERS ARE MISLEADING AND ONLY ONE UNIT EXISTS.... (SPANGLER AND PETERSON, P. 69).

SPANGLER (1950) WROTE ABOUT THE INFORMATION OBTAINED FROM SEVERAL DEEP OIL TESTS IN EASTERN NORTH CAROLINA. ABOUT THE BEDS OF LOWER CRETACEOUS IN THE SUBSURFACE SPANGLER SAID:

> ... THE SEDIMENTS IN OUTCROP THAT PREVIOUSLY HAVE BEEN REFERRED TO THE TUSCALOOSA FORMATION ARE THOUGHT TO CONTAIN, AT THEIR BASE, BEDS OF LOWER CRETACEOUS AGE. THESE UPPER AND LOWER CRETACEOUS BEDS CAN NOT BE DIFFERENTIATED IN THE EXPOSURES. HOWEVER, IN THE SUBSURFACE, WHERE THEY CAN BE SEPARATED, THE NAME TUSCALOOSA IS APPLIED ONLY TO THE BEDS OF EAGLE FORD-WOODBINE AGE (SPANGLER, 1950, P. 123 AND 130).

IN EASTERN NORTH CAROLINA THE BEDS EQUIVALENT TO THE LOWER UNNAMED MEMBER OF THE BLACK CREEK FORMATION ARE DESIGNATED BY SPANGLER (P. 130) AS THE EUTAW FORMATION AND CORRELATED WITH THE AUSTIN OF TEXAS BECAUSE OF THE CONTAINED AUSTIN FORAMINIFERA. HE COMMENTED THAT "HERETOFORE, BEDS REPRESENTATIVE OF AUSTIN AGE WERE BELIEVED TO BE ABSENT IN NORTH CAROLINA" (P. 130). BUT EVERY AUTHOR PRIOR TO SPANGLER, EXCEPT STEPHENSON ET AL, CORRELATION CHART (1942), HAD REFERRED THE LOWER UNNAMED MEMBER OF THE BLACK CREEK EITHER DIRECTLY OR INDIRECTLY TO THE AUSTIN

OR PART OF THE AUSTIN.

SPANGLER (1950, P.130) RESTRICTED THE NAME BLACK CREEK TO THOSE BEDS IN EASTERN NORTH CAROLINA OF TAYLOR AGE AND EQUIVALENT TO THE SNOW HILL MEMBER AT OUTCROP.

THE CORRELATIONS AND INTERPRETATIONS OF STEPHENSON (1942), SPANGLER (1950), AND COOKE (1925, 1936) WERE ANALYZED AND CRITICIZED BY DORF (1952). HE FOUND THAT THE WIDER TIME INTERVAL BETWEEN THE TUSCALOOSA OF SOUTH CAROLINA AND THE LOWER UNNAMED MEMBER OF THE BLACK CREEK AS PROPOSED BY STEPHENSON ET AL. (1942) IS UNJUSTIFIED, BECAUSE THE PALEOBOTANICAL EVIDENCE SUPPORTS "THE ESSENTIAL AGE EQUIVALENCE" (DORF, 1952, P. 2183) OF THE TWO. DORF RESURRECTED THE MIDDENDORF MEMBER OF THE BLACK CREEK FORMATION FOR SOUTH CAROLINA. HE SUGGESTS THAT THE SUBSURFACE DEPOSITS OF EAGLE FORD AGE (REFERRED BY SPANGLER TO A PART OF THE OUTCROPPING TUSCALOOSA FORMATION) ARE EQUIVALENT TO THE PLANT-BEARING BEDS OF THE LOWER BLACK CREEK. ABOUT THE LOWER CRETACEOUS DORF SAID:

> THE SUBSURFACE BEDS REFERRED TO THE 'LOWER CRETACEOUS' BY SPANGLER ARE. ... MORE LIKELY THE EQUIVALENT OF COOKE'S 'TUSCALOOSA' FORMATION, WHICH IN NORTH CAROLINA INCLUDES ONLY THE BEDS PREVIOUSLY CALLED THE 'PATUXENT' OR 'CAPE FEAR' FORMATION. SINCE THESE BEDS HAVE NOT YIELDED DATABLE FOSSILS THEIR REFERENCE TO THE LOWER CRETACEOUS IS HERE QUERIED... THE LOWER PART OF COOKE'S TUSCALOOSA FORMATION (SOUTH CAROLINA) IS HERE REFERRED TO AS 'LOWER CRETACEOUS?' (UNDIFFERENTIATED), AS PREVIOUSLY DESIGNATED BY STEPHENSON (DORF, 1952, P. 2184).

A GENERALIZED GEOLOGIC MAP OF THE NORTH CAROLINA COASTAL PLAIN PUBLISHED IN A GUIDEBOOK BY LEGRAND AND BROWN (1955) SHOWS SOME REVISIONS OF THE BLACK CREEK AND TUSCALOOSA CONTACTS. IN GENERAL THE BLACK CREEK-TUSCALOOSA CONTACT IS PUSHED WESTWARD AT THE EXPENSE OF THE TUSCALOOSA. BEDS ALONG CONTENTNEA CREEK AND TAR RIVER CALLED PATUXENT BY STEPHENSON, AND TUSCALOOSA BY MOST AUTHORS WRITING AFTER 1936, ARE NOT SHOWN OR ELSE ARE IN PART INCLUDED WITHIN THE BLACK CREEK FORMATION. THE CORRELATIONS GIVEN (LEGRAND AND BROWN, 1955, BETWEEN P.5 AND 6) ESSENTIALLY AGREE WITH THOSE OF SPANGLER (1950), EXCEPT THAT THE TUSCALOOSA FORMATION IS RESTRICTED TO THE UPPER CRETACEOUS. THE LOWER CRETACEOUS IS REFERRED TO DEEP WELLS ONLY. IN THE SAME GUIDEBOOK, THE AUTHOR, REPORTED THE DISCOVERY OF "MICRO-FOSSILS IN WELL CUTTINGS DEEPER THAN 100 FEET" (LEGRAND AND BROWN, 1955, P. 6) WITHIN THE LOWER UNNAMED MEMBER OF THE BLACK CREEK FORMATION.

SIPLE, BROWN, AND LEGRAND (1956, P. 1757,1758) REPORTED THE DISCOVERY OF THE FIRST MICROFAUNA FROM THE OUTCROPPING TUSCALOOSA FORMATION OF SOUTH CAROLINA (IN FACT, "THE FIRST MICROFAUNA FROM OUTCROPPING BASAL CRETACEOUS STRATA EAST OF THE MISSISSIPPI," P. 1757). ALL OF THE SPECIES ARE FORAMINIFERA AND APPEAR TO BE NEW, BUT THE AUTHORS BELIEVE THAT THEY "INDICATE STRATA OF EITHER BASAL AUSTIN OR EAGLE FORD AND WOODBINE AGE" (SIPLE, BROWN, AND LEGRAND, 1956, P. 1757). IN A PERSONAL COMMUNICATION (1955), BROWN SUGGESTED THAT THE FOSSILS INDICATE AN EARLY AUSTIN OR PRE-AUSTIN AGE.

THE GEOLOGIC MAP OF NORTH CAROLINA (STUCKEY AND OTHERS, 1958) REFERS THE BASAL COASTAL PLAIN BEDS TO THE TUSCALOOSA FORMATION. THE OVERLYING CRETACEOUS BEDS ARE

are called Black Creek.

The author's views regarding the correlation and stratigraphic interpretation of the basal Cretaceous beds in the outcrop area of the Cape Fear and Peedee Rivers are given in the last two columns of Chart 1. This is based largely on work as yet unpublished (Heron, 1958). No attempt to justify these interpretations will be presented here. Stephenson's (1907, p. 95) term "Bladen" is here applied to the lower unnamed member of the Black Creek formation. He coined the name "Bladen formation" for "exposures ... in the bluffs of the Cape Fear River in Bladen County" (1907, p. 98). He included the uppermost "transition beds" in the Bladen formation, but those beds are now excluded by virtue of Stephenson's later designation of the "transition beds" as the Snow Hill member (1923, p. 9).

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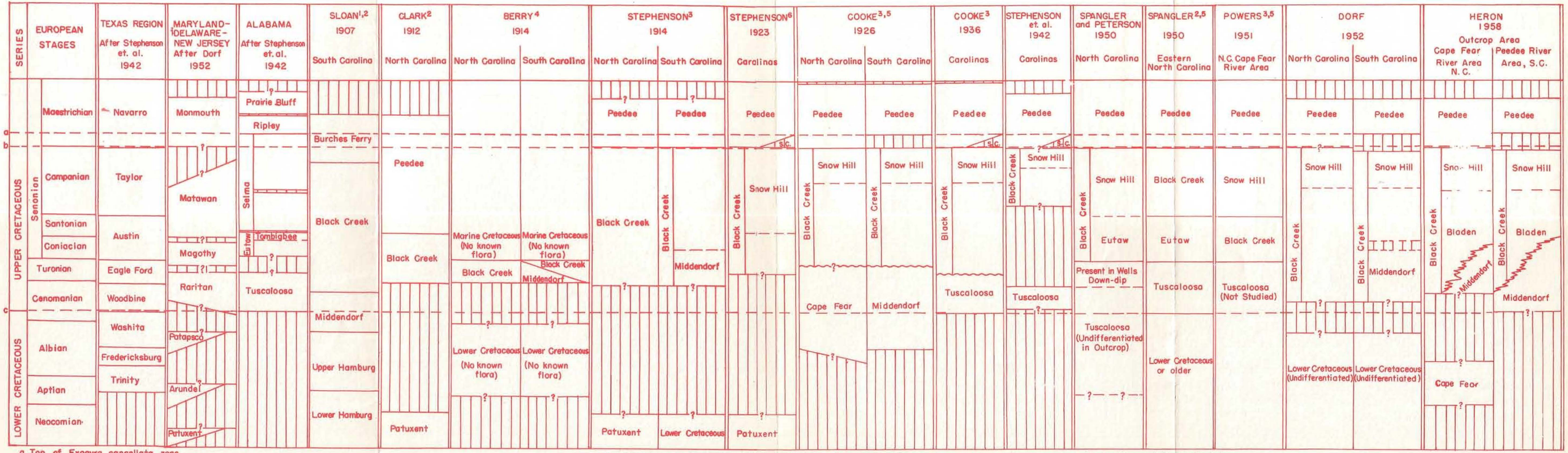
CHART I. – CRETACEOUS TERMINOLOGY AND CORRELATION USED BY VARIOUS WORKERS IN THE COASTAL PLAIN OF NORTH AND SOUTH CAROLINA



a. Top of Exogyra cancellata zone.
b. Top of Exogyra ponderosa zone. – Bottom of Exogyra cancellata and E. costata zones.
c. Boundary between the Lower and Upper Cretaceous.
NOTE – These boundaries after Stephenson et. al. 1942. Their position is not necessarily given or agreed to by other workers.

1. No European and only approximate Gulf Coast or northern Coastal Plain equivalents given.
2. Exact position of contacts was not clearly indicated.
3. No European correlation indicated.
4. No Gulf Coast correlation indicated.
5. No northern Coastal Plain correlation indicated.
6. Middendorf Member not indicated.

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