CHATTANOOGA SHALE AND RELATED ROCKS OF CENTRAL TENNESSEE AND NEARBY AREAS— AN ABSTRACT

By Louis C. Conant and Vernon E. Swanson

Trace Elements Investigations Report 682

UNITED STATES DEPARTMENT OF THE INTERIOR

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	46

CONTENTS

CHATTANOOGA SHALE AND RELATED ROCKS OF CENTRAL TENNESSEE AND NEARBY AREAS—An Abstract

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INTRODUCTION

The Chattanooga shale and Maury formation, which typically have a combined thickness of about 30 to 35 feet, crop out on the steep slope between the Nashville Basin and the surrounding Highland Rim; outside the Basin they are present in several river valleys and in folded areas. Throughout most of the area studied these rocks are nearly flat lying, but in the southeastern part they have been involved in the Appalachian folding and are commonly contorted and sheared.

These investigations were supported largely by the Atomic Energy Commission because of the small but significant amount of uranium known to be present in the black shale.

CHATTANOOGA SHALE

The Chattanooga shale, now considered to be of Late Devonian age, lies unconformably on many formations ranging in age from Middle Ordovician to Middle Devonian. It is overlain, with probable local disconformity, by the Maury formation, chiefly of Mississippian age, and this is overlain conformably by the Fort Payne chert and related rocks. Recent studies of the conodonts by Hass have established the ages of the Chattanooga and the Maury, and studies of bones and plant remains have verified the age of the Chattanooga.

Following is the stratigraphic classification used in this report, and approximate typical thicknesses of the units:

	Approximate thickness (feet)
Maury formation	3.
Chattanooga shale	30.
Gassaway member	15.
Upper, middle, and lower units recognized (Locally the Bransford sandstone bed is at the base.)	
Dowelltown member	15.
Upper and lower units recognized (The Center Hill bentonite bed is in the upper unit.)	
Basal sandstone	0.1
Hardin sandstone member (present only locally)	0-15.

The Hardin sandstone member is a quartzitic, slightly phosphatic, essentially unfossiliferous unit present only in the southwestern part of the area studied. In a complete section the Hardin grades upward into black shale of the Dowelltown member, but locally it is overlain abruptly by black shale of the Gassaway member and in a few places by the Maury formation. These relations suggest a short period of erosion at the end of Dowelltown time, and either a local absence of sedimentation during Gassaway time or another erosion interval of local extent after Gassaway time.

A thin sandstone that is present nearly everywhere at the base of the Chattanooga shale has often been called the "Hardin sandstone," but such usage is unwarranted as the sandstone is quite unlike the

Hardin in both lithologic character and age. The basal sandstone of the Chattanooga, commonly an inch or less thick, ranges widely in age depending on the time that the sea first inundated an area. In the Swan Creek phosphate area the 'blue phosphate" is an unusually thick and phosphatic manifestation of the basal sandstone of late Chattanooga and probably even of early Maury age.

The Dowelltown member has a pronounced two-fold division east of the Nashville Basin: the lower unit is essentially black shale, the upper unit is alternating gray claystone and black shale. The lower shale unit is commonly less massive than the shale of the Gassaway member. Black shale lies immediately above the basal sandstone, locally is interbedded with the sandstone, and in some places is at the extreme base of the formation. The shale unit locally has many thin beds or films of fine sandstone.

The upper unit of the Dowelltown, because of its abundant beds of gray claystone, is the most easily recognized subdivision of the Chattanooga shale. Near the top is the distinctive Center Hill bentonite bed, about 1 inch thick, that can be traced over a wide area in east-central Tennessee. The gray beds are believed to represent times of sufficient aeration of the stagnant sea to partially oxidize the organic matter over wide areas, whereas the black shale results from reducing conditions in which sulfurous bottom water prevented oxidation of the organic matter. The cause of these supposed aerations is unknown. Toward the north the gray claystone beds diminish in number; the lowest beds disappear first. No unconformity separates the lower and upper units of the Dowelltown, so it is believed that the lower gray beds are less widespread because the supposed aerating agency did not extend northward at first as far as it did later. A slight diastem seems to separate the Dowelltown from the overlying Gassaway member, at least locally.

The Dowelltown member is absent over much of the area west of the Nashville Basin. Where it is present in that area, the two lithologic subdivisions cannot be identified, and the Dowelltown is essentially a massive unit of dark-gray shale having a thin basal sandstone. The member is also not a recognizable lithologic unit south of Tennessee.

The Gassaway member can be divided in part of the area into three units because of the presence of a 2- to 3-foot middle unit that contains a few thin beds of distinctive gray siltstone and claystone. Along the Northern Highland Rim a sandstone at the base of the Gassaway is termed the Bransford sandstone bed, an adaptation of usage by Campbell (1946)_/.

_/Campbell, Guy, 1946, New Albany shale: Geol. Soc. America Bull., v. 57, p. 829-908.

A unique "varved" bed marks the base of the middle unit but is not thought to represent annual layering. Except for the thin middle unit, the entire Gassaway is a nearly homogeneous succession of massive black shale. In the northern part of the area the upper unit of the member is thicker, and in its upper part consists of a phosphate-nodule-bearing shale that is younger than the upper part of the shale elsewhere.

The black shale of the Chattanooga contains about 20 to 25 percent quartz, 25 to 30 percent clay and mica, 10 percent feldspar, 10 to 15 percent pyrite, 15 to 20 percent organic matter, and 5 percent of miscellaneous constituents. Most of the quartz ranges from clay-size particles to grains about 0.02 mm in greatest diameter. The black shale is minutely and well laminated, and this lamination causes the fissility of the rock upon weathering.

The gray claystone has, by contrast, a somewhat larger proportion of clay minerals, finer grained quartz and mica, only scattered fine particles of organic matter and pyrite, and much coarser stratification.

MAURY FORMATION

The Maury formation consists chiefly of greenish mudstone, or glauconitic sandstone, and in most places has a conspicuous layer of phosphate nodules at or near its base. In some areas black shale is also present in the formation. The Maury is commonly only about 1 to 4 feet thick and is believed to represent most of Kinderhook (Early Mississippian) time. Its lower contact is fairly sharp at most places; its upper contact is commonly knife sharp where overlain by the Fort Payne chert but is gradational where overlain by the New Providence formation and its equivalents. Little physical evidence has been seen of any unconformity associated with the Maury formation.

The phosphate nodules are present chiefly as nodules, balls, and plates of many shapes and sizes. Most of them are concentrated in a single layer and are embedded in black shale, glauconitic sandstone, or claystone. The nodules commonly range in size from 1 inch to a foot or more, but some of the plates are several feet long. The bed of nodules is a distinctive feature of the Maury formation over most of the area and is known to range in thickness from an inch to 2 feet within a horizontal distance of 50 feet. The nodules seem to have accumulated during a time of extremely slow deposition, as in places known on the ocean floor today.

DEPOSITION OF THE ROCKS

The Chattanooga shale is part of a blanket of black shale and other marine rocks that were deposited in a sea that covered large parts of North America in Late Devonian time. In Tennessee this sea covered most of what is now the Nashville dome, but a few areas appear to have been islands during Chattanooga time.

A shallow-water origin for the Chattanooga shale is indicated by several circumstances. Any deep-water hypothesis encounters serious difficulties, and the evidence commonly cited in its support is thought to be inapplicable. Most of the black mud that formed the Chattanooga shale is believed to have accumulated in water 100 feet deep or less--some apparently accumulated close to shorelines in water only a few feet deep. The sediment is believed to have been transported by sea-bottom traction, suspension, and by wind. The water-borne part probably came from land areas far to the east and northeast, and from island and other land areas in and near central Tennessee. Sedimentation appears to have been phenomenally slow, 30 feet of shale representing deposition during most of Late Devonian time.

Repeated gentle agitation of the water by waves and currents probably shifted the muds continuously, so that they were well sorted and spread smoothly over the bottom. The fine laminations, which are typically irregular and discontinuous, are thought to result from this repeated reworking of the sediments over a long period of time. No varves representing annual or other regular cycles of deposition have been recognized. Locally the muds were slightly channeled, and in at least one area more than a foot of sediment seems to have been stripped away by submarine planation.

The Flynn Creek cryptoexplosive structure, a small area of highly disturbed Ordovician rocks, is of especial interest because an abnormal thickness of some 200 feet of Chattanooga shale is present in a basin above the structure. Apparently the depression did not exist over this disturbed area at the beginning of Chattanooga time as commonly supposed, but the area sank slowly as the black muds accumulated, and the subsiding basin was kept filled by black mud that moved along the sea bottom for considerable distances.

The Maury formation probably represents a long time of transition between the shallow black-mud sea of Late Devonian time and the more widespread, well aerated, and presumably deeper sea of Mississippian time. The fairly abrupt lithologic changes between the Maury and the adjacent formations, and even within the formation, may have taken place slowly, but also at a time of extremely slow sedimentation.

ECONOMIC POSSIBILITIES OF THE CHATTANOOGA SHALE

Economically the rocks of the Chattanooga shale and Maury formation have thus far been of little importance. Several possibilities exist for utilizing the rocks in the future, especially by combining the by-product possibilities. The oil yield of the shale is on the order of 10 gallons per ton, which is much below the yield of shales currently considered for oil extraction. Among the other products that might be obtained from it are phosphate, black pigment, sulfuric acid, uranium, and light-weight aggregate for concrete.

Each of the five stratigraphic units of the shale has a different amount of uranium, which varies only slightly over large areas, but the three units of the Gassaway member are consistently the richest. For about 50 miles along the Eastern Highland Rim, from DeKalb County to Coffee County, shale approximately 15 feet thick contains an average of about 0.006 percent uranium, equivalent to about 1,800 tons of metallic uranium per square mile. The grade normally decreases where the thickness increases greatly or wherever the shale contains phosphate nodules. The grade decreases northward into Kentucky, westward along the northern Highland Rim, and southward into Alabama. Widely scattered information suggests that the grade increases slightly eastward toward the Sequatchie anticline, where the uranium content appears to be slightly higher.

The uranium is thought to have been removed from the sea water by plant particles on the sea bottom, and the relative richness to have resulted from the extremely slow sedimentation.