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Open File Report 36

The Lithostratigraphy of the Hawthorn Group of peninsular Florida

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in

Phosphate Deposits of the World
Published by Cambridge University Press

by

William Burnett and S. R. Riggs

Florida Geological Survey
Tallahassee, Florida
1990

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The lithostratigraphy of the Hawthorn Group of peninsular Florida

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Abstract

The Hawthorn Group has been a problematic unit since it was named by Dall & Harris (1892). It is a complex unit consisting of interbedded and intermixed carbonate and siliciclastic sediments containing variable concentrations of phosphate. Scott (1988) upgraded the Hawthorn to group status in Florida and delineated its component formations.

The Hawthorn Group in northern Florida has been subdivided, in ascending order, into the Penney Farms, Marks Head, Coosawhatchie and Statenville Formations. These units range in age from Early Miocene (Aquitanian) to Middle Miocene (mid Serravalian) (Huddlestun, pers. comm., 1983). Lithologically, the Hawthorn Group in northern Florida is made up of a basal carbonate with interbedded siliciclastics (Penney Farms), a complexly interbedded siliciclastic–carbonate sequence (Marks Head), a siliclastic unit with variable concentrations of carbonate in the matrix and individual beds (Coosawhatchie), and a crossbedded, predominantly siliciclastic unit (Statenville). Phosphate grains are present throughout most of these sediments, varying in concentration from absent to as much as 60% of the sediment.

In southern Florida, the Hawthorn Group is comprised of, in ascending order, the Arcadia and Peace River Formations. The Tampa Formation or Limestone of former usage is included as a lower member of the Arcadia Formation due to the Tampa's limited areal extent, lithologic similarities and lateral relationship with the undifferentiated Arcadia. Similarly, the Bone Valley Formation of former usage is incorporated as a member in the Peace River Formation. The southern Florida Hawthorn Group sediments range in age from Early Miocene (Aquitanian) to Early Pliocene (Zanclean) (Hunter, pers. comm., 1985). Lithologically, the Arcadia Formation is composed of carbonate with varying amounts of included and interbedded siliciclastics which are most prevalent in the Nocatee Member (basal Arcadia). The Peace River Formation is predominantly a siliciclastic unit with some interbedded carbonates. The carbonates are often dolostone. Phosphate grains are virtually ubiquitous in the south Florida Hawthorn sediments with the exception of the Tampa Member where it is often absent.

The Hawthorn sediments of peninsular Florida reflect a series of sea-level events and phosphogenic episodes. These sediments are characterized as being deposited in inner shelf, nearshore environments. Erosion and reworking of pre-existing sediments played an important role in the development of the Miocene sediment packages.

Introduction

The sediments of the Hawthorn Group represent a dramatic change in sedimentation in Florida. From the end of the Mesozoic to the beginning of the Neogene, carbonate sediments with a very minor siliciclastic component dominated the depositional environments of peninsular Florida. During the Early Miocene, siliciclastics, derived from the southern Appalachians, filled the Gulf Trough and encroached into the carbonate-producing environments of peninsular Florida. The carbonate-producing environments were gradually pushed further south as siliciclastic deposition increased. During the Miocene, phosphogenesis became an important depositional–diagenetic process. Phosphate grains occur within the Hawthorn sediments in amounts ranging from trace to 60%. Palygorskite, sepiolite, smectite and minor illite are the clay minerals associated with the Hawthorn sediments.

The lithostratigraphy of the Hawthorn Group throughout peninsular Florida provides the regional framework for attempting to understand the complex nature of the phosphate-bearing Miocene sediments.

There have been numerous investigations of the Hawthorn sediments during the last century. Scott (1988) provides a lengthy discussion of these previous investigations and as such they will not be discussed in this paper.

Structure

The Hawthorn Group is present throughout much of peninsular Florida (Figs. 26.1, 26.2) except on top of the Ocala Platform and the Sanford High where it is missing due to erosion or non-deposition. The main structures which controlled the deposition and present distribution of the Hawthorn Group are shown on Figure 26.3. These features have been considered structural in origin; however, there is considerable discussion concerning their origin, whether they are depositional or structural. Nonetheless, the features were topographically expressed on the surface underlying the Hawthorn Group. The two major positive features were the Ocala Platform with the Central Florida Platform and the Sanford High with the St Johns and

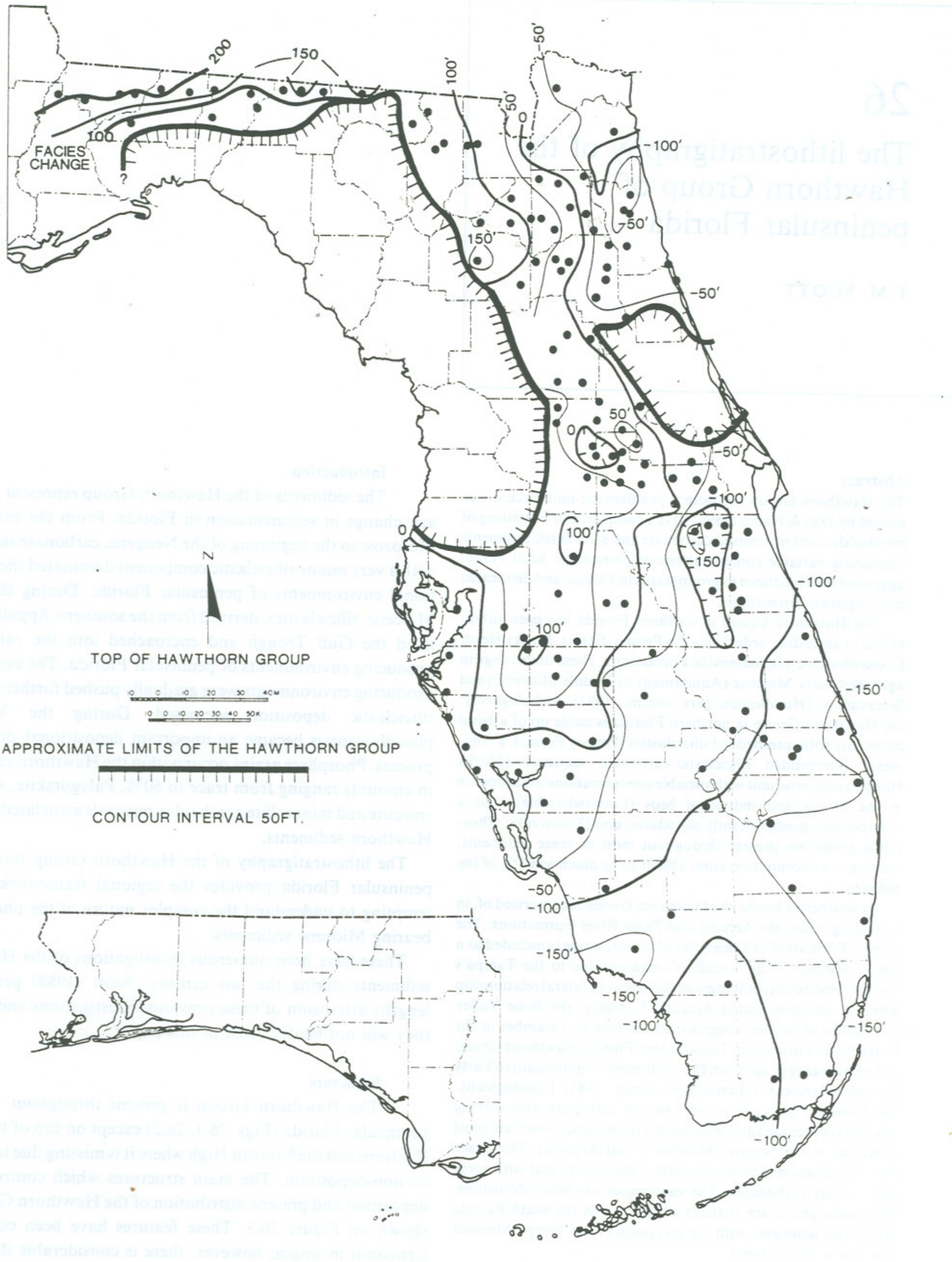

Fig. 26.1. Top of Hawthorn Group in Florida based on cores and well cuttings.

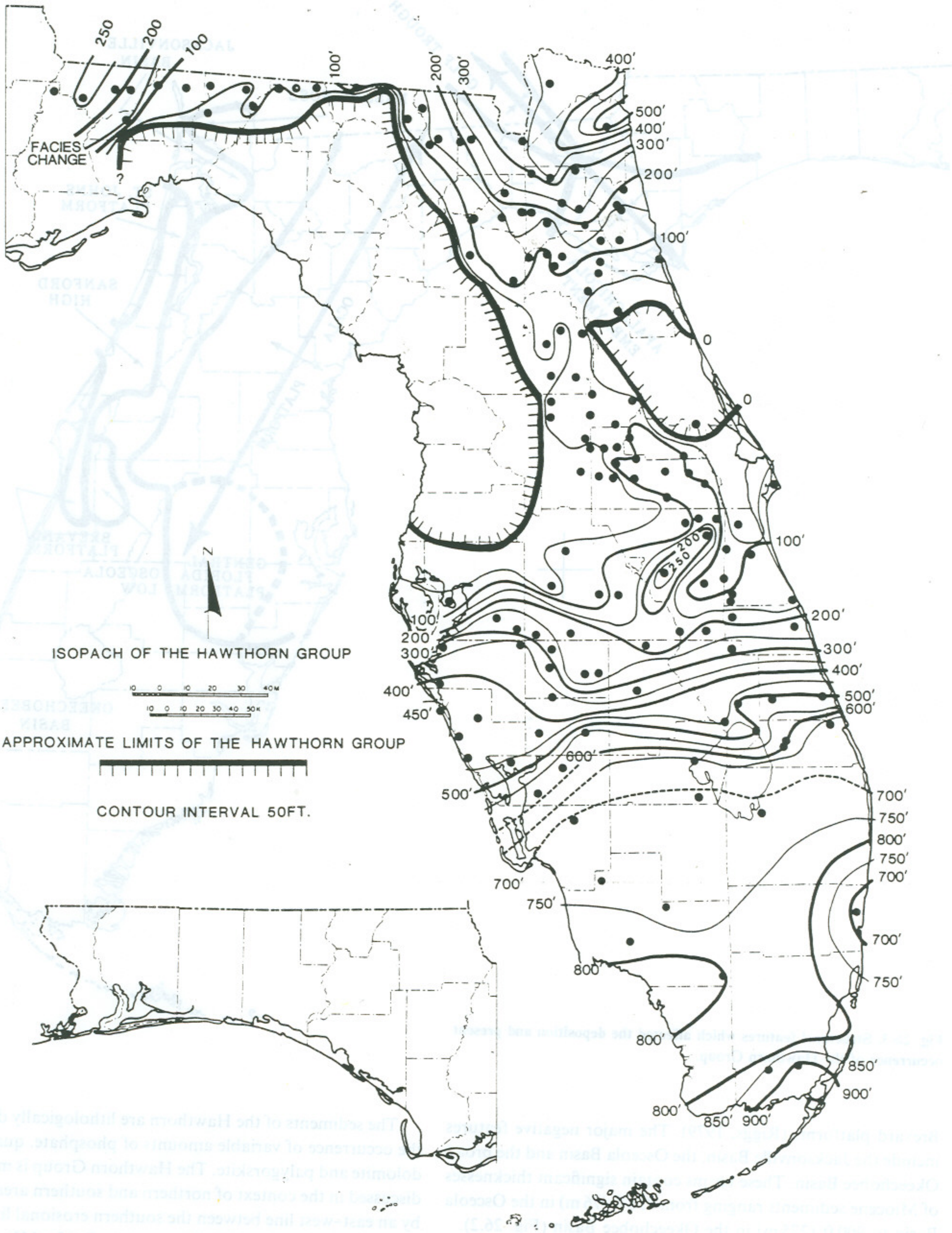

Fig. 26.2. Isopach of the Hawthorn Group in Florida based on cores and well cuttings.

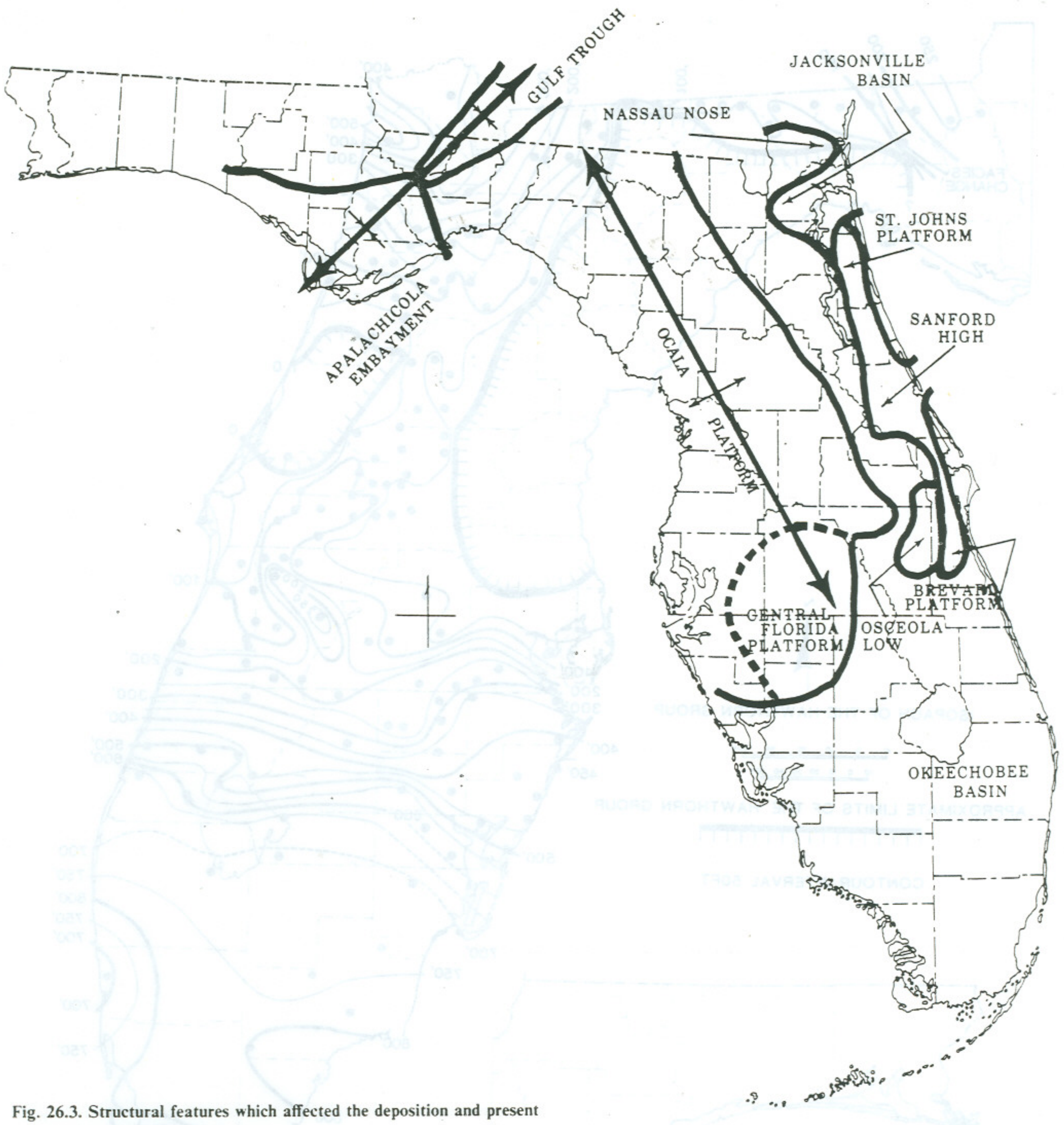

Fig. 26.3. Structural features which affected the deposition and present occurrence of the Hawthorn Group.

Brevard platforms (Riggs, 1979). The major negative features include the Jacksonville Basin, the Osceola Basin and the broad Okeechobee Basin. These basins contain significant thicknesses of Miocene sediments ranging from 250 ft (76 m) in the Osceola Basin to 900 ft (275 m) in the Okeechobee Basin (Fig. 26.2).

Lithostratigraphy

Previous investigations considered the Hawthorn sediments as a single formation which displayed great variability throughout Florida. The resulting confusion is evident in the literature. Elevating the Hawthorn to group status eliminates much of the confusion.

The sediments of the Hawthorn are lithologically defined by the occurrence of variable amounts of phosphate, quartz sand, dolomite and palygorskite. The Hawthorn Group is most easily discussed in the context of northern and southern areas divided by an east–west line between the southern erosional limit of the Hawthorn on the Ocala Platform and the Sanford High, respectively (see Fig. 26.4). Lateral and vertical variability is most pronounced in north Florida.

North Florida

The Hawthorn Group in north Florida contains significantly higher percentages of siliciclastic sediments than in south

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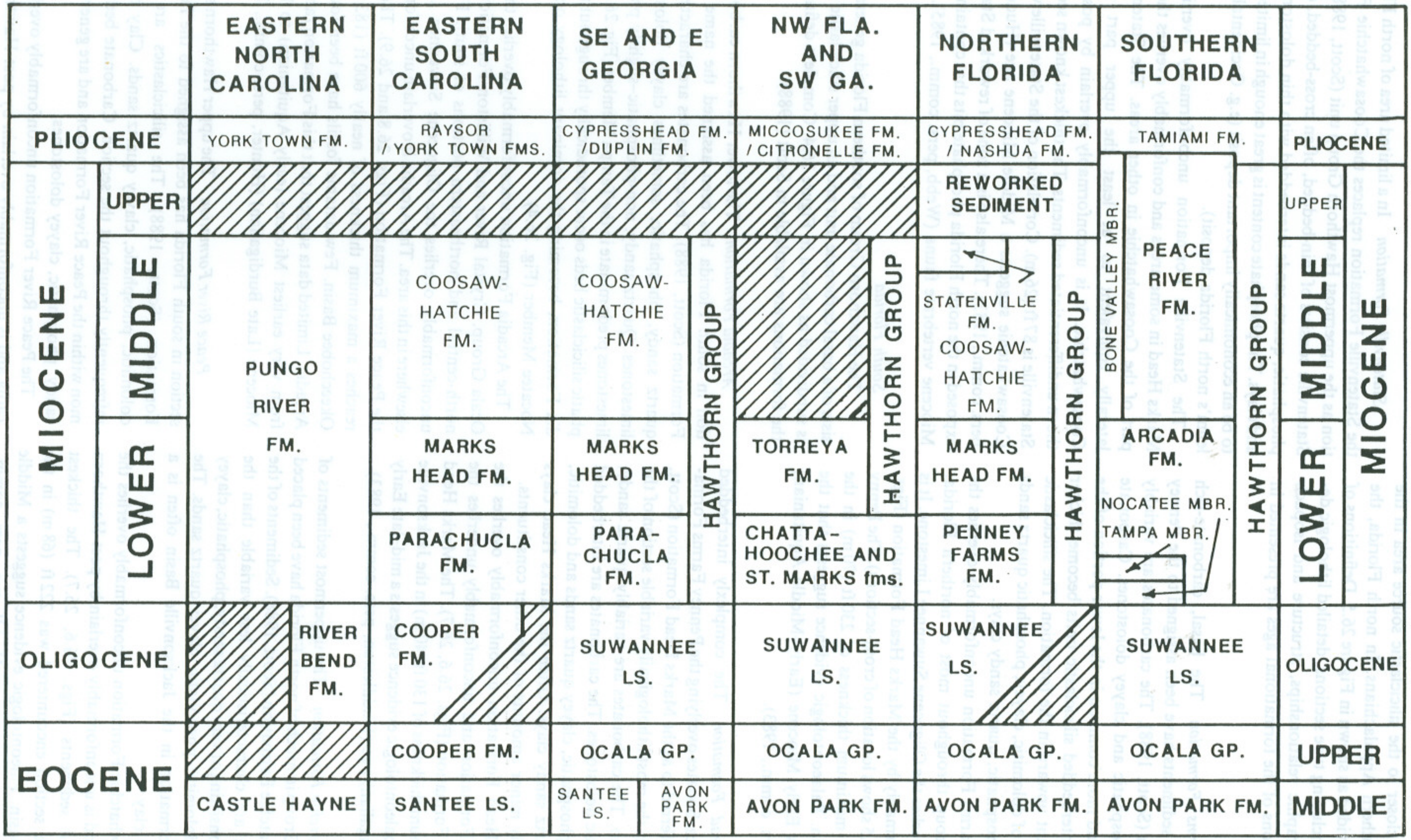

Fig. 26.4. Generalized stratigraphic correlations from Florida to North Carolina (modified from unpublished Gulf Coast COSUNA chart and Atlantic Coastal Plain chart, American Association of Petroleum Geologists, 1983).

Florida since it is closer to the siliciclastic source area in the Piedmont and southern Appalachians. In north Florida, the Hawthorn is subdivided as shown in Figure 26.5. Definitions of these formations including type sections, detailed lithologic descriptions, stratigraphic relationships, structure and isopach maps and discussions of the formational ages are presented in Scott (1988).

Penney Farms Formation The basal, carbonate-rich Hawthorn Group sediments have been assigned to the Penney Farms Formation (Scott, 1988). The carbonates are variably quartz sandy, phosphatic and clayey dolostones. Carbonate beds are thicker and more common in the lower portion of the Penney Farms. Interbedded siliciclastic units become thicker and more abundant upward in the formation. The siliciclastic sediments consist of dolomitic, clayey, phosphatic quartz sands and dolomitic, phosphatic, quartz sandy clays.

The Penney Farms Formation unconformably overlies the Eocene Ocala Group throughout most of northern Florida. Occasionally it overlies the Oligocene Suwannee Limestone. It is overlain unconformably by the Marks Head Formation (Figs. 26.6, 26.7; Fig. 26.5 shows location of cross-sections). The Penny Farms reaches a maximum thickness of 230 ft (70 m) in the Jacksonville Basin. Palaeontologic evidence suggests that the Penney Farms is Early Miocene (Early–Middle Aquitanian) (Huddlestun, pers. comm., 1983).

Marks Head Formation The complexly interbedded siliciclastics and carbonates overlying the Penney Farms Formation have been referred to as the Marks Head Formation (Scott, 1988). This unit is the most lithologically variable section of the Hawthorn Group. The carbonates are variably quartz sandy, clayey, phosphatic dolostones. The carbonates are interbedded with dolomitic, phosphatic, clayey quartz sands and dolomitic, phosphatic, quartz sandy clays. Often the Marks Head clays may contain only minor amounts of the other constituents.

The Marks Head Formation unconformably overlies the Penney Farms Formation and unconformably underlies the Coosawhatchie Formation (Figs. 26.6, 26.7). The Marks Head reaches a maximum thickness of 130 ft (40 m) in the Jacksonville Basin. Limited paleontologic evidence suggests a mid–late Early Miocene (Burdigalian) age (Huddlestun, pers. comm., 1983).

Coosawhatchie Formation The uppermost sediments of the Hawthorn Group in much of north Florida have been placed in the Coosawhatchie Formation (Scott, 1988). Sediments of the Coosawhatchie are characteristically less variable than the Marks Head, consisting of very quartz sandy, phosphatic, clayey dolostones to dolomitic, phosphatic, clayey quartz sands. The base of this formation in the Jacksonville Basin often is a dolomitic, silty clay.

The Coosawhatchie Formation unconformably overlies the Marks Head and is unconformably overlain by post-Hawthorn undifferentiated sediments (Figs. 26.6, 26.7). The thickest Coosawhatchie section encountered was 222 ft (68 m) in the Jacksonville Basin. Paleontologic evidence suggests a Middle Miocene (Early Serravalian) age (Huddlestun, pers. comm., 1983).

Statenville Formation In a limited area of north Florida, the Statenville Formation replaces the Coosawhatchie Formation as the uppermost Hawthorn Group unit (Scott, 1988). The Statenville consists of thin-bedded, often cross-bedded, clayey, phosphatic, quartz sands interbedded with thin dolostone beds and clays. The phosphate content is great enough in limited areas to be an economically important deposit (e.g. Occidental Petroleum's north Florida deposit).

The Statenville Formation unconformably overlies the Marks Head in some areas and conformably overlies the lower part of the Coosawhatchie in other areas. The Statenville is laterally equivalent to at least the upper part of the Coosawhatchie. It is unconformably overlain by post-Hawthorn undifferentiated sediments. The thickest known section of Statenville is 87 ft (26 m). Correlation of the Statenville with the Coosawhatchie suggests a Middle Miocene age (Huddlestun, pers. comm., 1983). There also is a zone of reworked Statenville exposed in the north Florida phosphate pits that contains a Late Miocene vertebrate fauna (Webb, pers. comm., 1985).

South Florida

The Hawthorn Group of southern Florida generally consists of a basal carbonate unit and an upper siliciclastic unit and is subdivided as shown in Figure 26.4. Complete definitions of the formations are available in Scott (1988).

Arcadia Formation The lower Hawthorn carbonate section in south Florida has been assigned the name Arcadia Formation (Scott, 1988). The carbonates are characteristically quartz sandy, phosphatic, sometimes clayey dolostones to limestones. Quartz sandy, non-phosphatic–slightly phosphatic limestones predominate in the Tampa Member (Fig. 26.4). Phosphatic siliciclastic beds occur sporadically throughout the Arcadia Formation, becoming the dominant lithology only in the Nocatee Member (Fig. 26.4).

The Arcadia Formation unconformably overlies the Eocene Ocala Group, Crystal River and Williston Formations, in the north-central and northeastern portions of south Florida. It unconformably overlies the Oligocene Suwannee Limestone elsewhere in this area. The Arcadia is overlain unconformably by the Peace River Formation (Figs. 26.8 and 26.9). The Arcadia reaches a maximum thickness of nearly 600 ft (183 m) in the Okeechobee Basin. Few datable fossils have been found in the Arcadia. Limited data suggest that this Formation ranges in age from very earliest Miocene (early Aquitanian) to late Early Miocene (Late Burdigalian) (Hunter, pers. comm., 1985).

Peace River Formation The upper Hawthorn siliciclastic section in south Florida has been assigned to the Peace River Formation (Scott, 1988). The siliciclastics are typically dolomitic, phosphatic, clayey quartz sands. Clay beds occur infrequently throughout the section. Carbonate beds are common within the Peace River Formation and are generally quartz sandy, phosphatic, clayey dolostones.

The Peace River Formation unconformably overlies the Arcadia and is unconformably overlain by post-Hawthorn undifferentiated sediments (Figs. 26.8 and 26.9). The Peace River

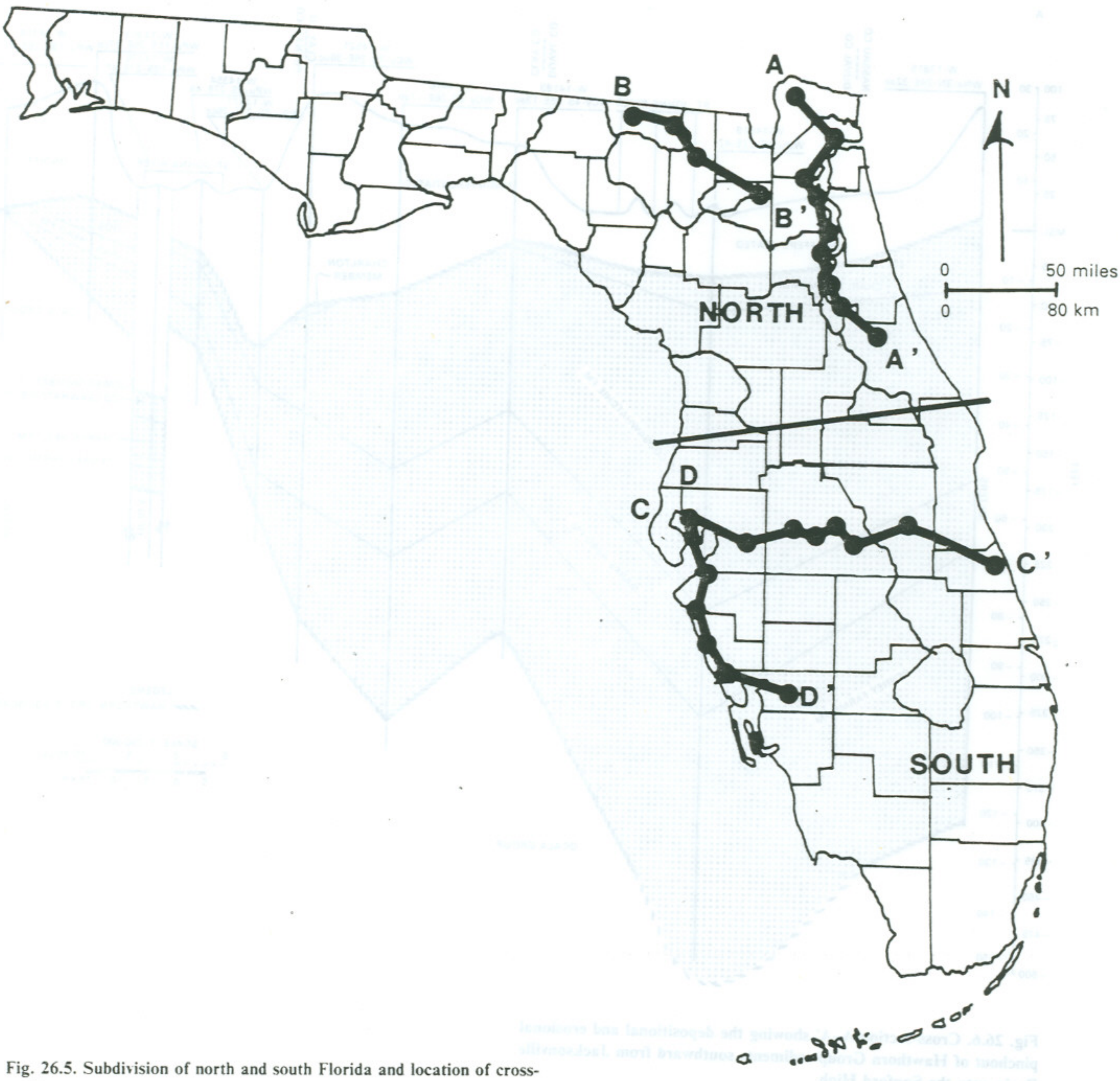

Fig. 26.5. Subdivision of north and south Florida and location of cross-sections.

Formation reaches a maximum known thickness of 650 ft (198 m) in the Okeechobee Basin. Faunal evidence suggests that the Peace River Formation ranges in age from Middle Miocene (Serravalian) to no younger than earliest Pliocene (earliest Zanclean) (Hunter, pers. comm., 1985).

Scott (1988) reduced the status of the former Bone Valley Formation to Member. The status reduction was due to the limited areal extent of this unit and the lithologic relationship and demonstrated time equivalence to the undifferentiated Peace River Formation. Lithologically, the most important factor for separating the Bone Valley from the remainder of the Peace River Formation is the occurrence of phosphate gravel in the Bone Valley Member. Phosphate gravel and sand are mixed with quartz sand and clay in proportions that vary from bed to bed vertically, and within beds laterally. This unit is the main phosphate-producing horizon in the Central Florida Phosphate District.

The boundaries of the Bone Valley Member are complex. In some areas of the district it unconformably overlies the Arcadia Formation while in other areas the Bone Valley conformably to unconformably overlies the undifferentiated Peace River Formation. The Bone Valley Member is unconformably overlain by post-Hawthorn undifferentiated sediments (Figs. 26.8 and 26.9). The maximum recognized thickness for this unit is approximately 50 ft (15 m). The age of the Bone Valley Member is derived entirely from vertebrate fossils collected from this until MacFadden & Webb (1982) and Webb & Crissinger (1983) suggest that the Member ranges in age from as old as latest Early Miocene (latest Burdigalian) to as young as Early Pliocene (Zanclean).

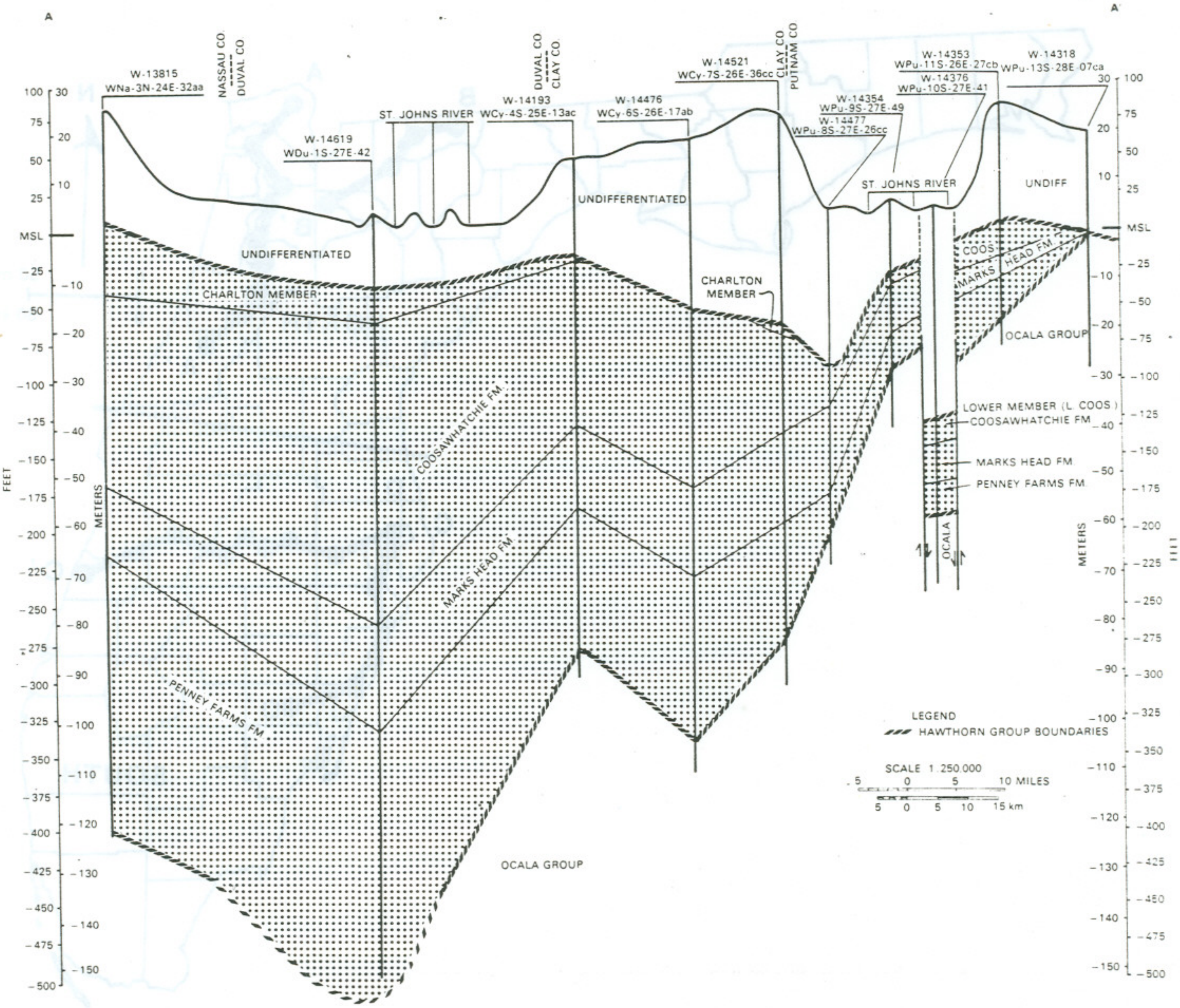

Fig. 26.6. Cross-section A–A′ showing the depositional and erosional pinchout of Hawthorn Group sediments southward from Jacksonville Basin onto the Sanford High.

Geologic history

During the Miocene, peninsular Florida was subjected to numerous major and minor sea-level fluctuations and periodically subaerially exposed. The sediments of the basal Hawthorn Group are the first record of Miocene transgressions upon the eroded, karstic, limestone surface of Florida. These sediments, carbonates and siliciclastics of the Penney Farms and lower Arcadia Formations, contain significant but not economically important amounts of apatite, indicating the Miocene phosphogenic episode had begun.

Carbonate sediments dominated deposition in the Early Miocene, although they contained a significant siliciclastic component. The siliciclastics present in the earliest Miocene represent the first recorded Cenozoic influx of siliciclastics onto the carbonate bank of peninsular Florida. This major shift in sedimentation may have been the result of eperiogenic uplift in the Appalachians, possibly coupled with a climatic change. The dramatic influx of siliciclastic sediments filled the Gulf Trough which had effectively isolated the carbonate bank from siliciclastic input from at least Early Paleocene through Late Oligocene. Siliciclastic deposition was very important in northern Florida in the Lower Miocene but did not dominate in southernmost Florida until possibly as late as early Late Miocene (Scott, 1983). Phosphate occurs as discrete apatite grains and as rims on and replacement of carbonate intraclasts. Sediments deposited during the early part of the Lower Miocene (Early Aquitanian) probably did not completely cover the Ocala Platform or the Sanford High.

Sediments deposited in the mid-Lower Miocene (Late Aquitanian–early Burdigalian) have not been recognized in

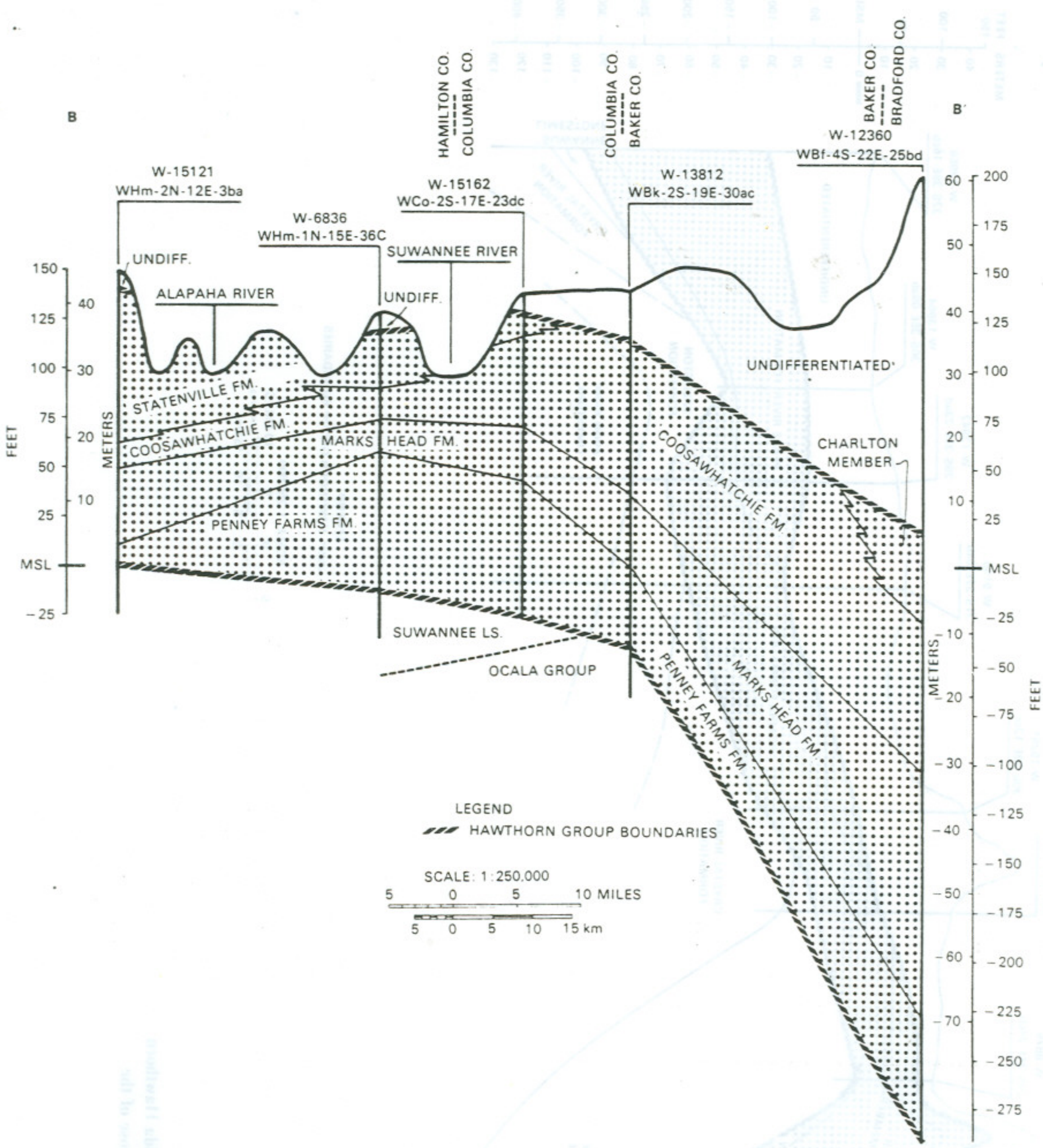

Fig. 26.7. Cross-section B–B′ showing the relationship of the Statenville Formation to the remainder of the Hawthorn Group in north Florida.

Florida. If sediments of this age are to be found onshore, it may be in the thick Arcadia Formation section in south Florida's Okeechobee Basin. It is not known whether the absence of these sediments is due to non-deposition or erosion, but it is helpful to note that they are not recognized in Georgia, South Carolina or North Carolina.

Lower Miocene (Mid-Burdigalian) sediments of the Marks Head and upper Arcadia formations were deposited on the mid-Lower Miocene unconformity. Siliciclastic sedimentation dominated in northern Florida while carbonate deposition, mixed with variable amounts of siliciclastics, continued in southern Florida. Once again apatite is present, but not in economically important quantities. In north Florida, the Lower Miocene sediments were probably not deposited over the Ocala Platform or the Sanford High. However, the present distribution and thickness of these sediments suggest that more of the structures were covered than earlier in the Early Miocene.

Middle Miocene sediments disconformably overlie the Lower Miocene throughout much of the State. The unconformity is often marked by a bored, phosphatized, well-lithified carbonate bed or a rubble resulting from the rip-up of this bed. Deposition of the mid-Miocene sediments may have begun as early as very early Middle Miocene (Langhian) (Snyder, pers. comm., 1985) to mid-Middle Miocene (Early Serravalian) (Huddlestun, pers. comm., 1985). The deposition of the Middle Miocene Hawthorn sediments covered the entire peninsula (Scott, 1988). There, sediments were later removed by erosion from the crest and upper flanks of the Ocala Platform,

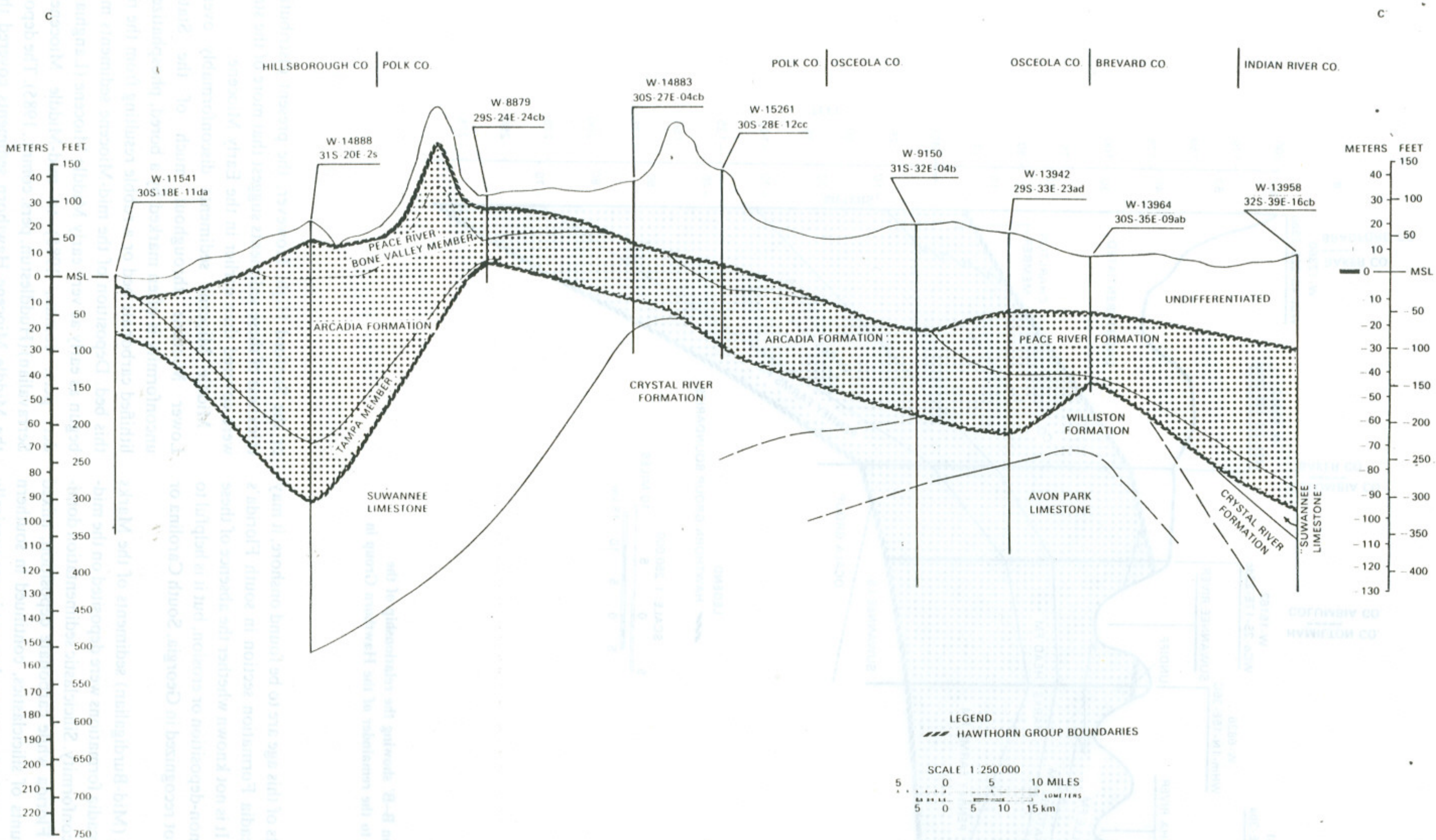

Fig. 26.8. Cross-section C–C′ showing the southern Florida Hawthorn Group sediments from west to east across the southern nose of the Ocala Platform to the Brevard Platform.

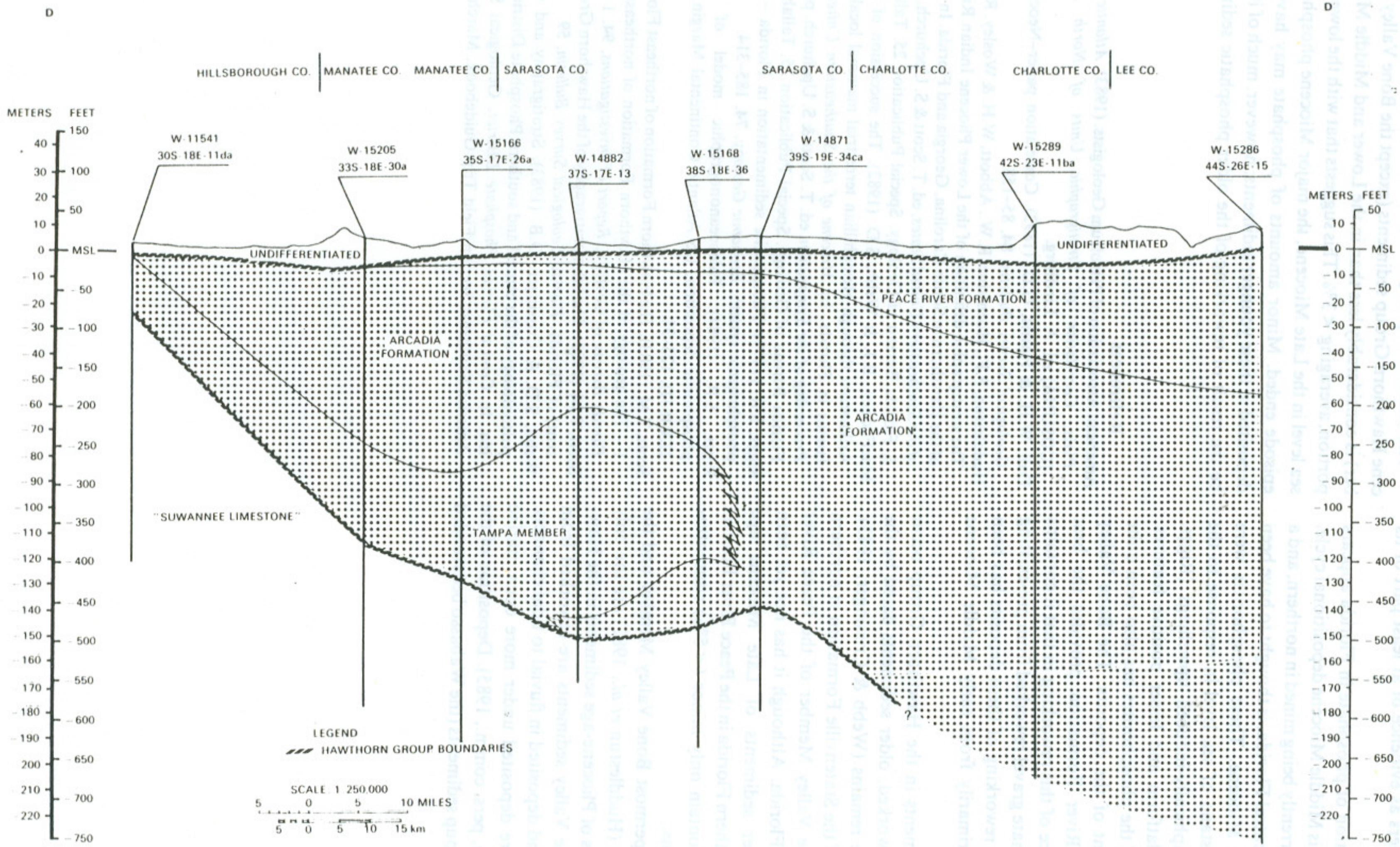

Fig. 26.9. Cross-section D–D′ showing thickening of the Hawthorn Group southward into the Okeechobee Basin.

leaving only isolated outliers as evidence of at least part of its former extent.

The greatest accumulation of phosphate in Florida appears to have occurred during this Middle Miocene depositional cycle. Much of the phosphate currently being mined in northern, and a portion of that mined in central Florida, is thought to have been deposited in the Middle Miocene. These phosphorites were deposited during a high stand of sea level in response to the impingement of topographically-induced upwellings (Riggs, 1984) onto the Ocala Platform and lesser positive features. Subsequent reworking of the phosphorites has also been quite important in development of the deposits. The Bone Valley Member of the Peace River Formation provides the best example of the importance of this reworking in that it contains large quantities of phosphate gravel reworked from pre-existing phosphate deposits. The reworking of these deposits has been multicyclic, occurring primarily from early Middle Miocene through Early Pliocene.

Upper Miocene sediments in the Hawthorn Group occur primarily as zones of reworked, older sediments dated by the occurrence of vertebrate remains (Webb & Crissinger, 1983). These occur at the top of the Statenville Formation in northern Florida and in the Bone Valley Member of the Peace River Formation in southern Florida. Although it has not yet been fully documented, other sediments of Late Miocene age (Tortonian) occur in southern Florida in the Peace River Formation. These sediments contain only minor (<5%) concentrations of phosphate grains.

Sediments of the uppermost Bone Valley Member and the informal Wabasso beds (Huddlestun *et al.*, 1982) are the only documented occurrences of Pliocene-age sediments in the Hawthorn Group. The Bone Valley sediments are reworked from older Hawthorn beds and deposited in fluvial to tidal channels. The Wabasso beds were deposited under more open marine conditions (Huddleston, pers. comm., 1985). Deposition of the youngest Hawthorn Group sediments (the Wabasso beds) ended in late Early Pliocene.

The amount of phosphate present in the post-Middle Miocene Hawthorn Group sediments (except the Bone Valley Member) is considerably less than in the Lower and Middle Miocene portion, averaging <3%. This suggests that with the lowering of sea level in the Late Miocene, the major Miocene phosphogenic episode ended. Minor amounts of phosphate may have been deposited in these younger sediments; however, much of it could be the result of reworking of the older phosphatic sediments.

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