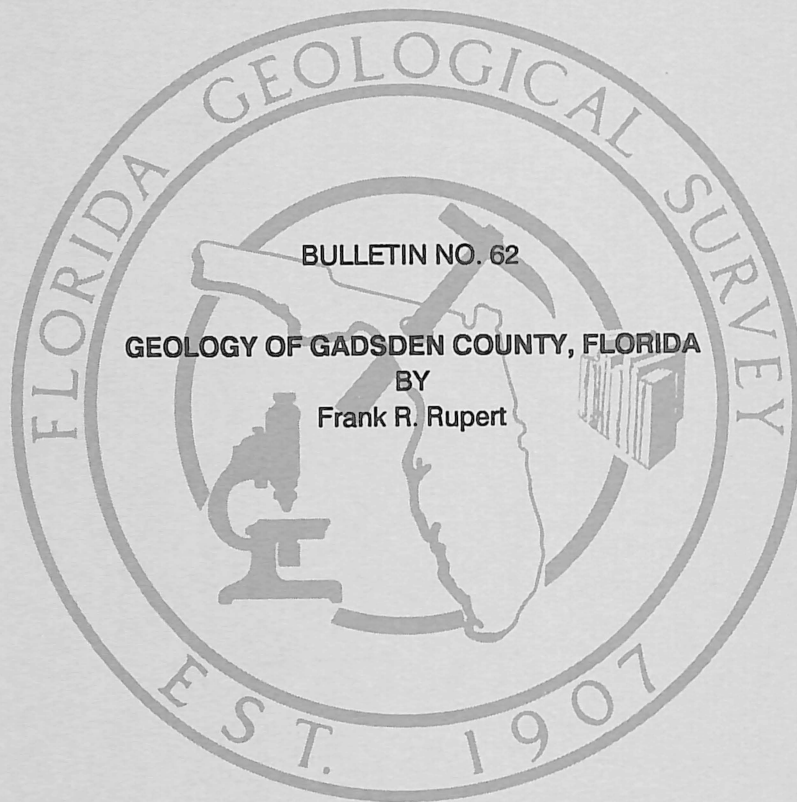


STATE OF FLORIDA
DEPARTMENT OF NATURAL RESOURCES
Tom Gardner, Executive Director

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FLORIDA GEOLOGICAL SURVEY
Walter Schmidt, State Geologist and Chief



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BULLETIN NO. 62

GEOLOGY OF GADSDEN COUNTY, FLORIDA
BY
Frank R. Rupert

Published for the

FLORIDA GEOLOGICAL SURVEY
Tallahassee
1990

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LETTER OF TRANSMITTAL



Florida Geological Survey

June 1990

Governor Bob Martinez, Chairman
Florida Department of Natural Resources
Tallahassee, Florida 32301

Dear Governor Martinez:

The Florida Geological Survey, Division of Resource Management, Department of Natural Resources, is publishing as its Bulletin No. 62, *Geology of Gadsden County, Florida*, prepared by Frank R. Rupert, P.G. No. 149. This report fulfills a need for information on the stratigraphy of Gadsden County, which is fundamental to ground-water resource investigations and land use planning. Information on mineral resources is also presented, along with data helpful to other agencies, planners, and the citizens of Florida.

Respectfully yours,

Walter Schmidt, Ph.D.
State Geologist and Chief
Florida Geological Survey

Printed for the
Florida Geological Survey

Tallahassee
1990

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GEOLOGY OF GADSDEN COUNTY, FLORIDA

by

Frank R. Rupert, P.G. No. 149

INTRODUCTION

Purpose

Florida's projected rapid population growth through the year 2000 dictates the need for an understanding of the geological parameters affecting intelligent growth planning. Previous research has provided a good geologic data base for much of Florida, but published information on many of the state's less-populous counties is lacking. In an attempt to synthesize existing geologic data into publicly usable information, the Florida Geological Survey is currently undertaking a series of geological studies of Florida's less-populous counties. The purpose of this report is to present a general overview of the geology and mineral resources of Gadsden County based on existing literature and well data on file at the Florida Geological Survey.

LOCATION AND EXTENT

Gadsden County is situated in the Big Bend Area of the Florida Panhandle (Figure 1). It is bounded on the west by Jackson and Liberty Counties, on the north by the State of Georgia, and on the east and south by Leon County.

Gadsden County is irregular in shape, spanning about 38 miles at its widest east-west dimension, and 22 miles at its greatest north-south dimension. The total land area is approximately 512 square miles. Population in 1989 was 46,400 (Smith and Bayya, 1989).

PREVIOUS INVESTIGATIONS

A number of authors have addressed the geology and paleontology of Gadsden County. The earliest studies included descriptions of the geology and stratigraphy of the area by Langdon (1891), Dall and Harris (1892), Dall (1892), and Dall and Stanley-Brown (1894). Sellards (1910, 1914, 1916

and 1917) included brief descriptions of the history, botany, geology, geomorphology, springs, and mineral resources of Gadsden and nearby counties. Harper (1914), described the vegetation and Sellards and Gunter (1918) discussed the geology of the area between the Apalachicola and Ochlockonee Rivers. Matson and Clapp (1909), Cooke and Mossom (1929), Cooke (1945) and Puri and Vernon (1959, 1964), included the Big Bend Area in their works on the geology of Florida. Bridge and Berdan (1952) and Rainwater (1971) investigated the petroleum prospects of the Big Bend area. An excellent series of articles by Applin and Applin (1944, 1947), Applin (1951) and Applin (1955) provided useful data on panhandle stratigraphy and paleontology. Cole (1944) reported on the microfauna in one Gadsden County well, and Puri (1953), Puri and Vernon (1956) and Banks and Hunter (1973) studied Miocene stratigraphy and paleontology of the Florida panhandle. Hendry and Yon (1958) provided a synopsis of the geology around the Jim Woodruff dam near Chattahoochee in Gadsden County, and Gremillion (1964, 1966) related the geology to the fuller's earth deposits of Gadsden County. The economic clay deposits were described in studies by Vaughn (1902, 1903), Sellards (1908, 1909), Sellards and Gunter (1909), Bell (1924), Calver (1949, 1957), McClellan (1964), Ogden (1978) Patterson (1974) and Spencer et al., (1989, in press). Bridges and Davis (1972) discussed the hydrologic effects of the 1969 flood in Gadsden County, and Pascale and Wagner (1982) included a portion of Gadsden County in their report on the hydrology of the Ochlockonee River basin. MacNeil (1944), Vernon (1952) and Doering (1960) included Gadsden and surrounding counties in their stratigraphic studies, and Schmidt (1979) detailed the surficial geology of Gadsden County in an environmental geology map. Yon (1953) and most recently, Scott (1988) reviewed the stratigraphy and extent of the Hawthorn Group sediments in the Big Bend area. Johnson (1989a) redescribed and illustrated the Chattahoochee Formation type section at Jim Woodruff Dam, north of

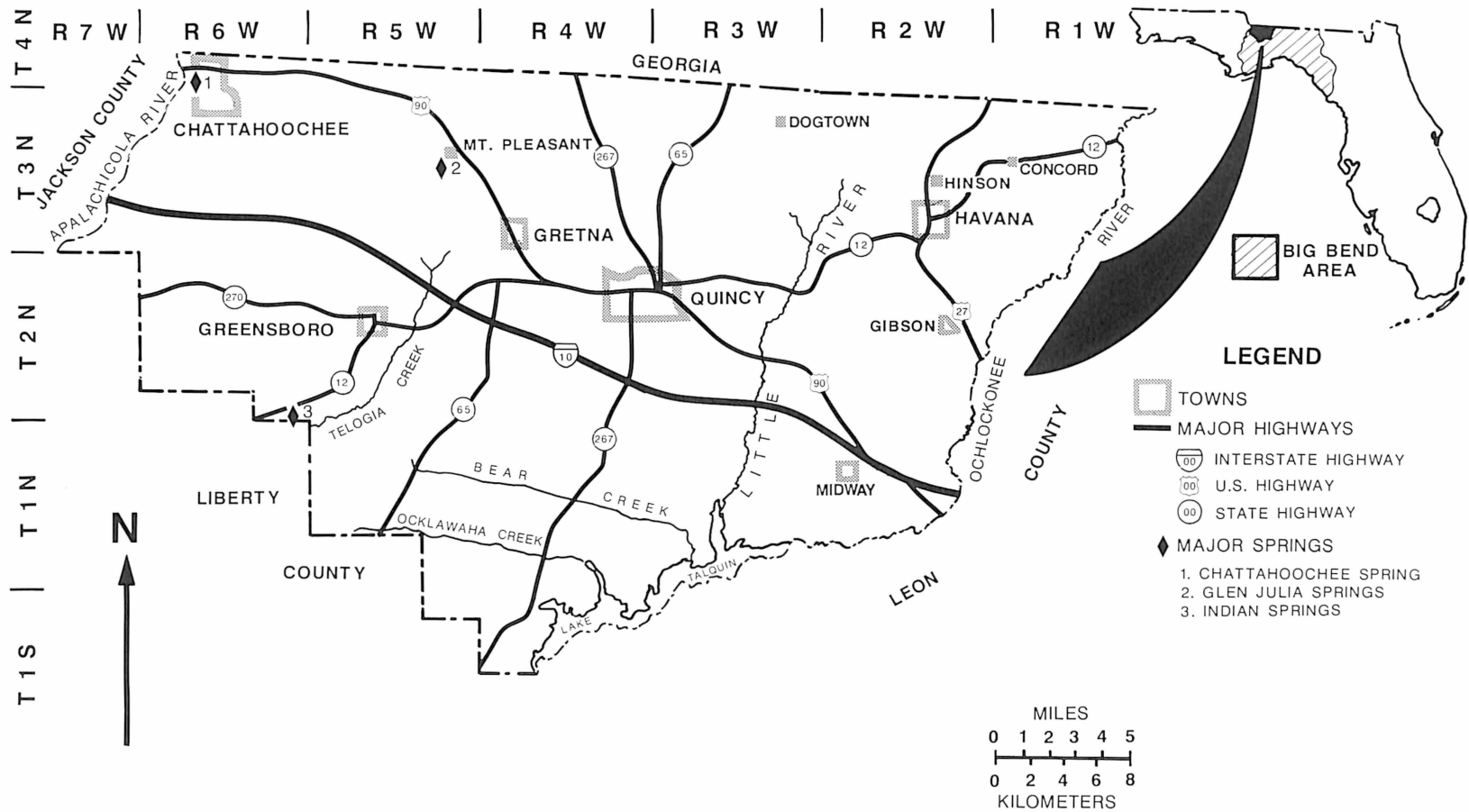


Figure 1. Gadsden County location map.

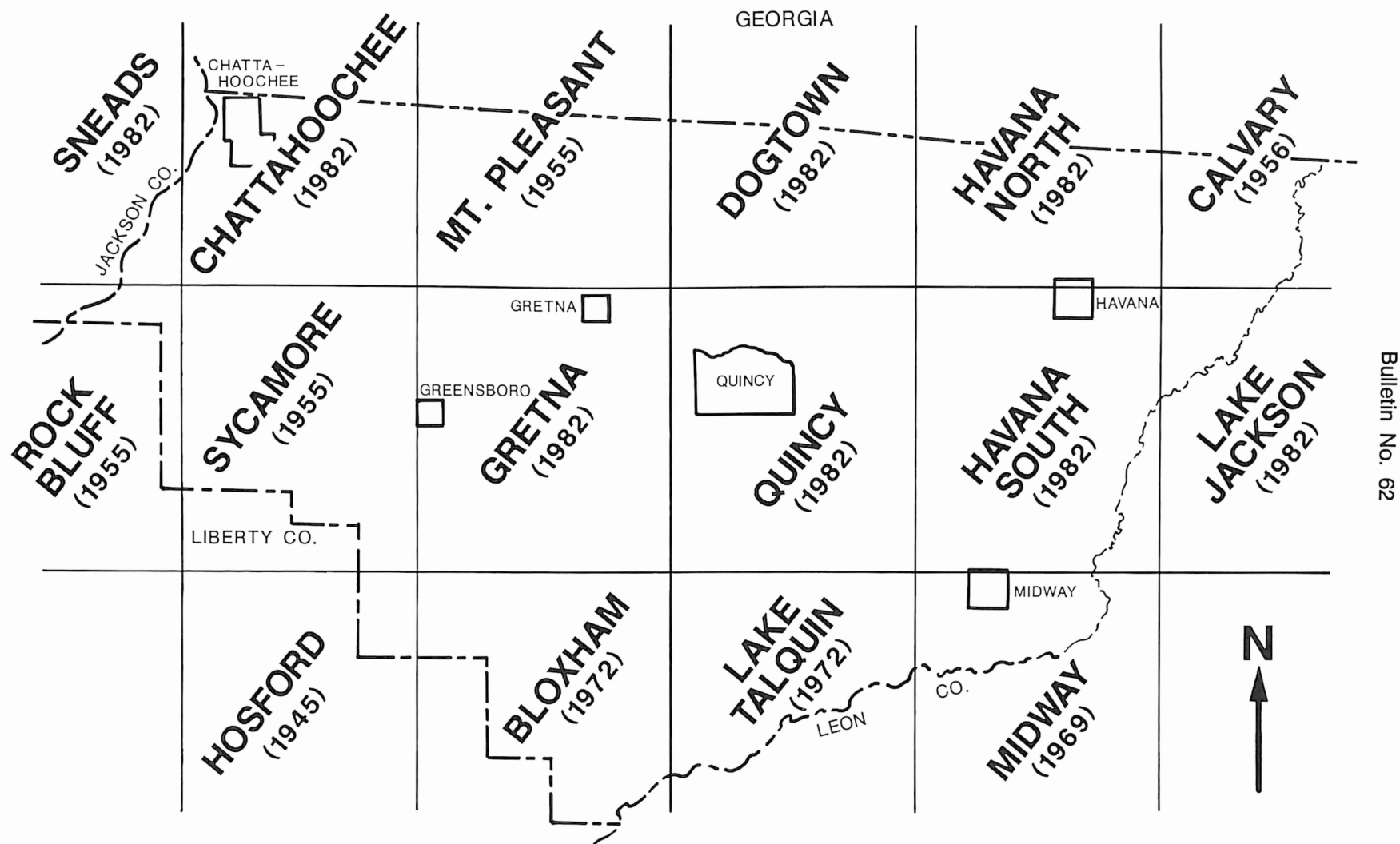


Figure 2. Index to U.S. Geological Survey 7 1/2 minute topographic quadrangle map coverage of Gadsden County.

Chattahoochee, and Johnson (1989b) provided a gamma-log of the same section.

MAPS

Surface contour information and cross-section profiles were obtained from the United States Geological Survey 7.5 minute topographic quadrangle maps. Figure 2 illustrates the topographic map coverage of Gadsden County. Base maps were derived from the Florida Department of Transportation General Highway map for Gadsden County. The surface lithology is covered by the Florida Geological Survey Map Series No. 90 (Schmidt, 1979).

WELL AND LOCALITY NUMBERING SYSTEM

The well numbering system in this study is that of the Florida Geological Survey well filing system. Each well is identified with a "W", a dash, and a one-to-five digit accession number unique to that well.

Wells and locations within the county are plotted according to the township, range, and section rectangular system. The location coordinates assigned to each well consist of five parts: the township number, the range number, the section number, and two letters representing the quarter/quarter location within the section. The basic unit of this coordinate system is the township, which is six miles square (Figure 3). Townships are numbered consecutively in tiers both north and south of the Florida Base Line, an east-west survey line passing through Tallahassee. The township rectangle is also numbered both east and west of the Principal Meridian, a north-south survey line also passing through Tallahassee. Each township square is equally divided into 36 square-mile pieces called sections. Sections are numbered 1 through 36 as shown on Figure 3. The sections are in turn divided into four quarters labeled a through d, and each quarter is further divided into quarters labeled

a through d in a similar fashion. Figure 3 provides an example of a well located according to this system. Table 1 is a list of the wells referred to in this report, with their elevations, depths, and locations.

METRIC CONVERSION FACTORS

In order to prevent awkward duplication of parenthetical conversion of units in the text of reports, the Florida Geological Survey has adopted the practice of inserting a tabular listing of conversion factors. For readers who prefer metric units to the customary U. S. units used in this report, the following conversion factors are provided:

<u>MULTIPLY</u>	<u>BY</u>	<u>TO OBTAIN</u>
acres	0.4047	hectares
acres	4047.0	sq. meters
cubic yards	0.7646	cu. meters
feet	0.3048	meters
inches	2.540	centimeters
inches	0.0254	meters
miles	1.609	kilometers
sq. miles	2.590	sq. km.
cub. ft. per sec.	0.646	cu. m. sec.
cub. ft. per sec.	448.8	gal. per min.
short tons	0.908	metric tons

GEOLGY GEOMORPHOLOGY

Gadsden County lies within the Northern Zone of Puri and Vernon (1964). The Northern Zone is characteristically a high broad upland including the northernmost Florida peninsula and all of the panhandle. Puri and Vernon (1964) recognize two major subdivisions of the Northern Zone in the Big Bend Area, the Northern Highlands and the Gulf Coastal Lowlands. Figure 4 is a generalized geomorphic map of Gadsden County.

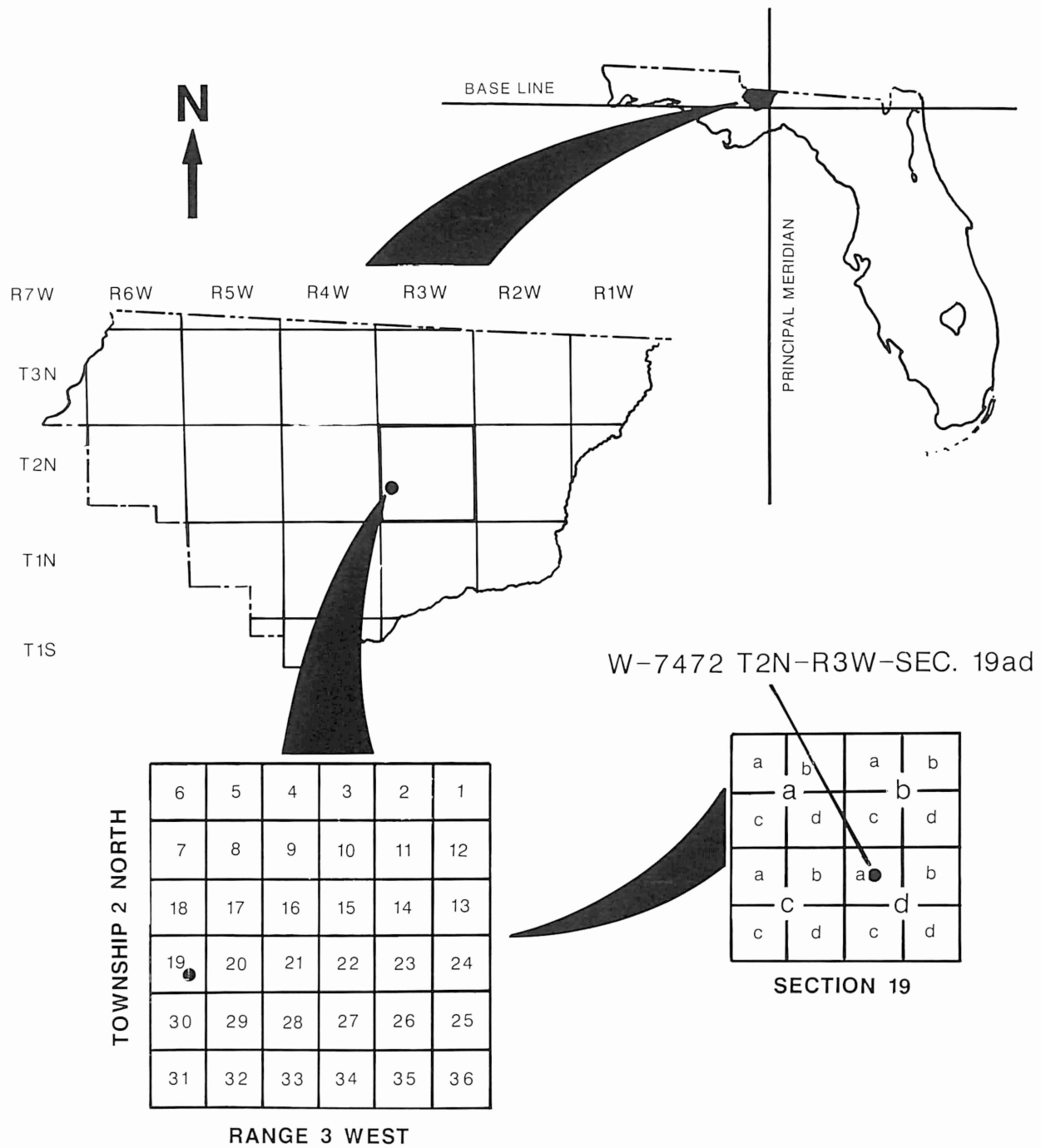


Figure 3. Well and locality numbering system.

Florida Geological Survey

Table 1. Wells referenced in text and cross-sections

<u>County</u>	<u>Well Number</u>	<u>Location (T R S 1/4-1/4)</u>	<u>Land surface elevation (feet MSL)</u>	<u>Total depth (feet below land surface)</u>
Gadsden	W-4	2N 3W 6ac	149.75	898
	W-329	3N 6W 4ab	116.0	200
	W-545	2N 2W 11a	268.0	368
	W-861	3N 2W 27ba	240.5	425
	W-1467	3N 1W 30cc	235.0	4010
	W-1478	4N 6W 32cc	40.2	121
	W-1768	2N 3W 35ba	200.0	4240
	W-1786	2N 5W 7aa	284.0	4222
	W-2482	3N 6W 15ab	288.0	216
	W-3078	2N 4W 6dd	277.0	360
	W-3482	3N 6W 4ab	146.53	239
	W-3577	2N 6W 19ba	245.0	4022
	W-4915	3N 4W 10bc	293.0	280
	W-4925	2N 4W 23ba	216.6	4185
	W-5201	2N 4W 5ab	288.17	467
	W-6217	2N 3W 29ac	201.0	7028
	W-7458	2N 5W 30ac	255.0	462
	W-7472	2N 3W 19ad	255.0	472
	W-7528	2N 2W 9dd	215.0	442
	W-7537	1N 3W 23dd	110.0	154
	W-7539	2N 4W 32aa	265.0	475
	W-15468	3N 2W 11ac	210.0	447
	W-15795	1N 2W 6bb	200.0	402
Jackson	W-1777	4N 7W 36cb	87.4	75
	W-1886	5N 11W 8ab	128.0	9243
Leon	W-6599	1S 4W 21aa	61.0	400
	W-6902	1N 1W 3a	80.0	158
	W-7180	2N 1W 1ad	279.0	302
	W-7536	1S 3W 1ad	148.0	215
Liberty	W-6611	2N 7W 23db	259.0	295
	W-7535	1S 6W 13dd	110.0	62
Wakulla	W-12114	2S 3W 27da	85.0	11100

Northern Highlands

The Northern Highlands geomorphic subzone is a portion of a nearly continuous series of topographically high uplands stretching from western Duval County, Florida, westward to the Florida-Alabama state line. These highlands are thought to be dissected remnants of a once much larger and continuous highlands area that stretched from southern Georgia southward into the Florida panhandle (Puri and Vernon, 1964). Stream valleys partition the Northern Highlands into a series of local geomorphic subzones. The Tallahassee Hills is the geomorphic subzone of the Northern Highlands comprising most of Gadsden County.

Tallahassee Hills

Tallahassee Hills was the name proposed by Cooke (1939) for the series of topographic hills in Florida delineated by the Georgia state line on the north, the coastal terraces to the south, the Withlacoochee River on the east, and the Apalachicola River on the west. In Gadsden County, the Tallahassee Hills extend southward from the Georgia state line to the edge of the Gulf Coastal Lowlands geomorphic zone. The Tallahassee Hills comprise nearly all of Gadsden County, with the exception of the southernmost tip of the county south of Ocklawaha Creek.

The sediments comprising the Tallahassee Hills may be deltaic or shallow marine in origin, with the hill tops composed largely of resistant clayey sands, silts, and clays. The modern hilly topography is the result of post-depositional dissection and erosion by running water. Elevations vary from approximately 100 feet above mean sea level (MSL) in the southern portion of Gadsden County to nearly 330 feet MSL near the Florida-Georgia State line.

Numerous streams dissect the hills in a dendritic pattern, and commonly form deeply-incised valleys and ravines. Telogia Creek, which originates northwest of Quincy, is a major creek flowing southwestward out of Gadsden County in a well-defined valley; it ultimately flows into the Ochlockonee River

to the south in Liberty County.

The Apalachicola River forms the westernmost boundary of the Tallahassee Hills geomorphic zone as well as being the western county boundary between Gadsden and Jackson Counties. Here, the Tallahassee Hills end rather abruptly at the edge of a flat, half-mile-wide floodplain on the east bank of the Apalachicola River. The steep bluffs formed at the edge of the Apalachicola River commonly stand between 150 to 200 feet above the floodplain and expose Miocene to Holocene age strata. Excellent examples are Jones Bluff and the east Jim Woodruff Dam bluff north of Chattahoochee. At these locations, over 100 feet of Lower Miocene to Holocene age sediments may be observed in the bluff face overlooking the river.

The dry sandy uplands eastward of the bluffs typically contain a flora of long leaf pine, scrub oak, and low woody shrubs. Interestingly, the bluffs appear to support a different and unique microclimate, with numerous magnolia, beech, white oak, holly, and sugar maple trees (Clewell, 1971).

The Ochlockonee River, flowing southwestward out of Georgia to the Gulf of Mexico, forms the eastern boundary of Gadsden County. Between the Georgia state line and the southern tip of Gadsden County, the river gradient averages 1.5 feet per mile (Hendry and Sproul, 1966). A hydroelectric dam, situated on the river a few hundred yards north of State Road 20, forms Lake Talquin at the southeastern edge of Gadsden County.

Numerous dendritic creeks drain into Lake Talquin south of Quincy. Lake Talquin occupies most of the floodplain of the Ochlockonee River in this portion of the county.

North of the lake, a discernible alluvial terrace, trending parallel to the river at approximately the 100 feet MSL contour, defines a low, semi-swampy area containing fluvial sediments. This zone bordering the Ochlockonee River was named the Ochlockonee River Valley Lowlands by Hendry and Sproul (1966). In Gadsden County, this geomorphic subzone averages about two miles wide as it stretches from the northeastern tip of Lake Talquin to the U. S. Highway 27 bridge. North of Highway

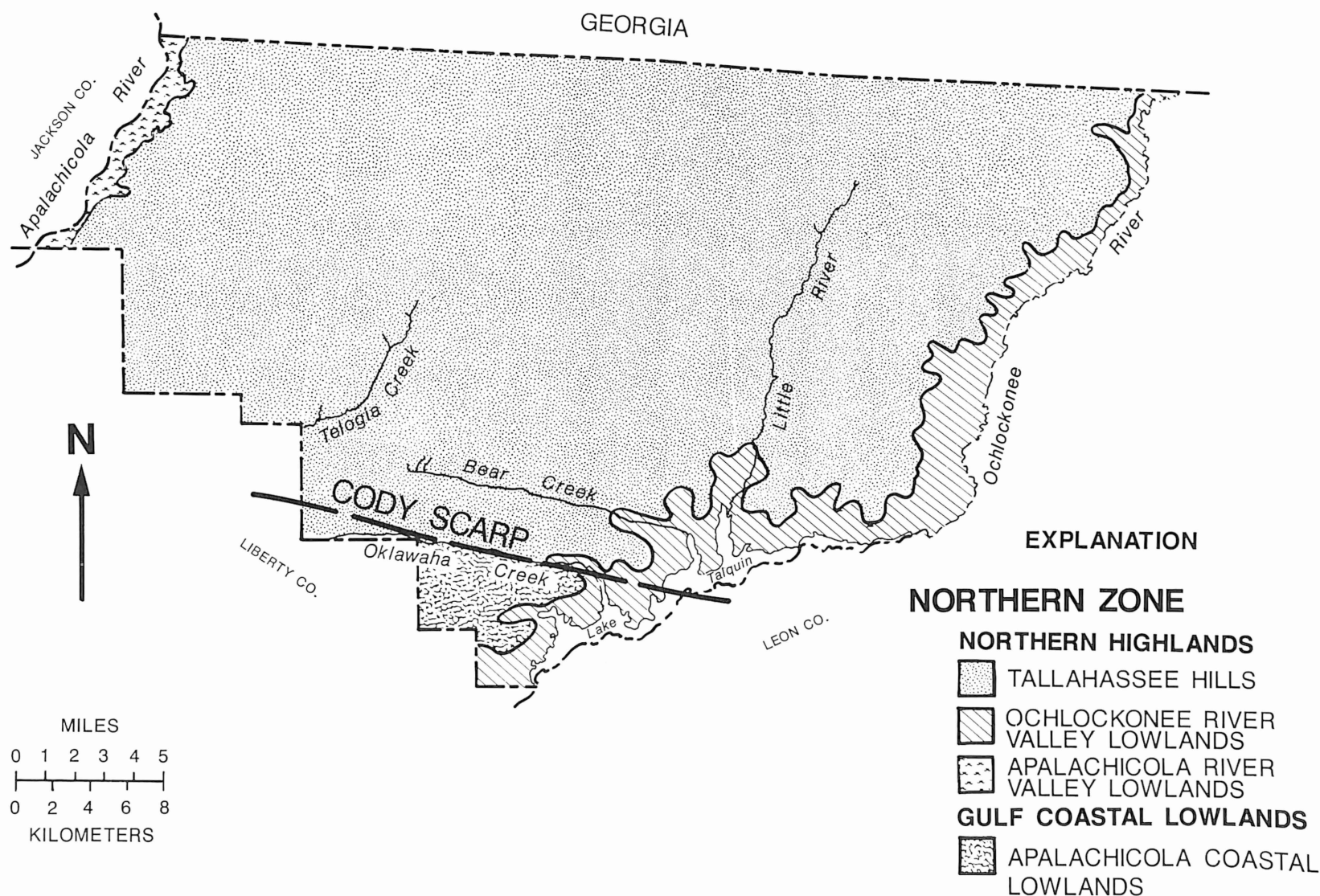


Figure 4. Geomorphic map of Gadsden County.

27, the Ochlockonee River Valley Lowlands become less than a mile wide as the river valley becomes more deeply incised in the Tallahassee Hills (Figure 4).

The Little River forms at the confluence of Wel-lacoochee Creek and Attapulcus Creek in north-eastern Gadsden County. This small river flows southward in a narrow valley roughly defined by the 100 feet MSL elevation line, and empties into an arm of Lake Talquin. Fluvial erosion by the Little River and its numerous tributaries has removed most of the reddish siliciclastic sediments of the Tallahassee Hills in the immediate vicinity of the river. The valley floors of the Little River and its larger tributaries consist largely of a thin layer of Holocene alluvium directly overlying sandy clay of the Hawthorn Group (Gremillion, 1964).

At the southern edge of the Tallahassee Hills, the east-west trending Cody Scarp forms the boundary between the Tallahassee Hills and the Gulf Coastal Lowlands of Puri and Vernon (1964). The name Cody Scarp was applied by Puri and Vernon (1959) to a distinct relict marine escarpment traceable at various elevations in the Florida Panhandle. In Gadsden County, the Cody Scarp trends east-west across the southern tip of the county, roughly bounded by Bear Creek to the north (approximately 220 feet MSL crest elevation) and by Ocklawaha Creek on the south (elevation approximately 200 feet MSL). The Gulf Coastal Lowlands geomorphic zone lies south of the Cody escarpment (Puri and Vernon, 1964).

Gulf Coastal Lowlands

The Gulf Coastal Lowlands geomorphic zone contains the relatively flat-lying lowlands in the panhandle stretching from the Cody Scarp southward to the Gulf of Mexico (Puri and Vernon, 1964). Pleistocene sea level fluctuations imposed a series of gently seaward-sloping marine terraces on the Gulf Coastal Lowlands, and the present-day topography of flat, sandy, frequently swampy terrain reflects this marine origin. Flora consists largely of long leaf pine, saw palmetto, wire grass, gall berry,

titi, and sweetbay (Clewell, 1971). Hendry and Sproul (1966) proposed the name Apalachicola Coastal Lowlands for the flat, sandy subzone of the Gulf Coastal Lowlands underlain by thick siliciclastic deposits in western Leon County. This terrain type is traceable into southernmost Gadsden County, and therefore the terminology of Hendry and Sproul (1966) is adopted in this report.

Apalachicola Coastal Lowlands

South of the toe of the Cody Scarp, approximated by Ocklawaha Creek, the topographic relief begins to flatten somewhat, losing the steep, deeply incised nature of the Tallahassee Hills to the north. Elevations range from about 50 feet MSL in the south near the Gadsden-Leon County line to about 200 feet MSL at the toe of the Cody Scarp. Thick sands and clayey sands underlie most of the Apalachicola Coastal Lowlands in Gadsden County. At the southernmost tip of the county, near Lake Talquin, unconsolidated surficial sands of fluvial and marine terrace origin become predominant, extending out of Gadsden County to the Gulf of Mexico. The portion of the Apalachicola Coastal Lowlands stretching southward from the toe of the Cody Scarp to approximately the 100 foot contour line has been called the Beacon Slope by earlier workers (Puri and Vernon, 1964).

Marine Terraces

An integral part of the present-day geomorphology of Gadsden County is a series of relict marine terraces. These terraces are step-like surfaces of erosion representing shorelines developed by advances and retreats of the sea during the Pleistocene Epoch. Healy (1975) recognizes five marine terraces based on elevation in Gadsden County. In order of descending elevation (and age), these shorelines are the Hazelhurst, the Coharie, the Sunderland-Okefenokee, the Wicomico, and the Penholoway Terraces. Figure 5 illustrates the extent of each terrace in Gadsden County.

Most of northern and western Gadsden County

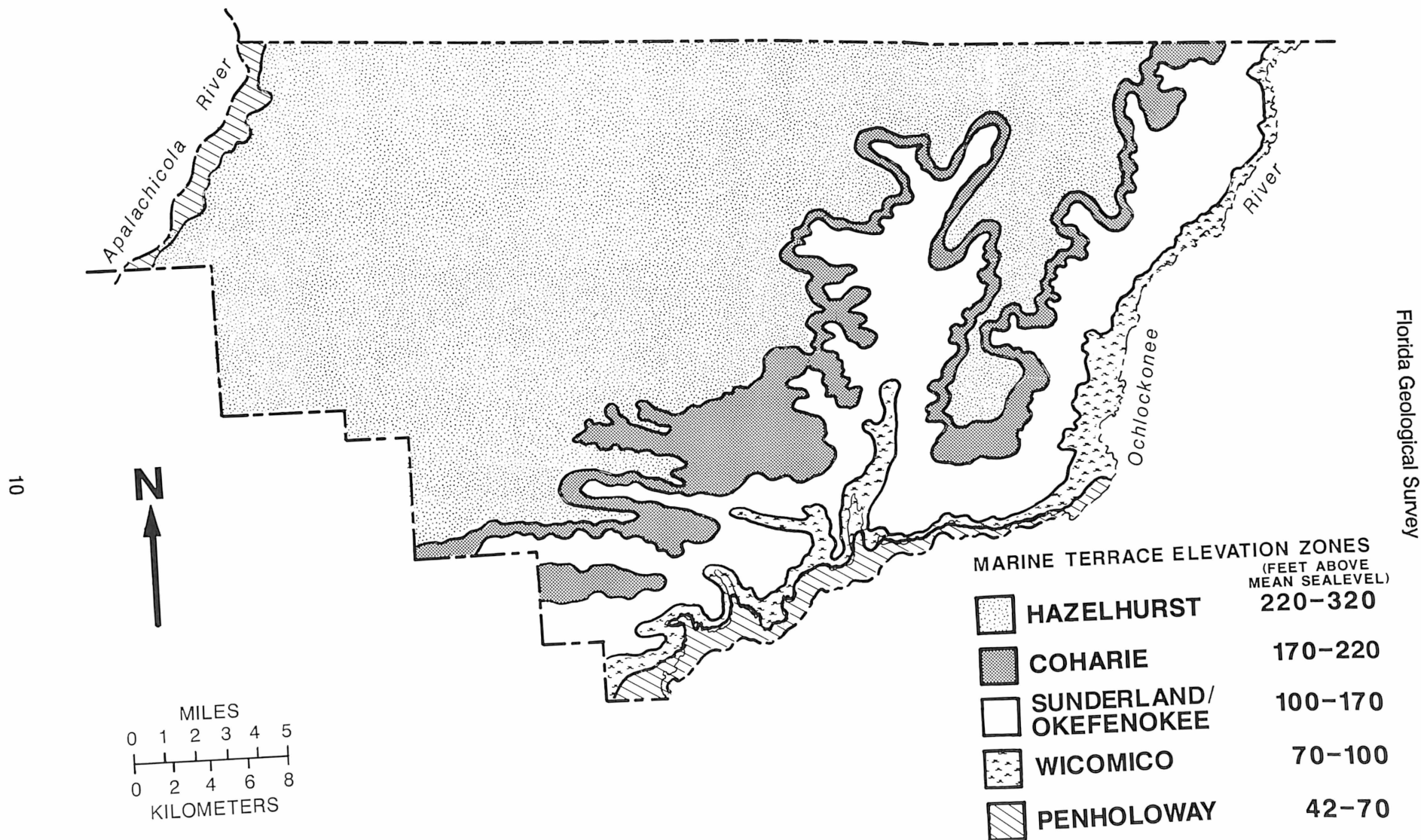


Figure 5. Marine terrace elevation zones of Gadsden County (modified from Healy, 1975).

is part of the Hazelhurst Terrace (Cooke, 1939), which is the highest Pleistocene terrace recognized in Florida (Healy, 1975). The Hazelhurst Terrace includes the Brandywine Terrace of Clark (1915), as well as the Coastwise delta plain of Vernon (1942) and the high Pliocene delta of MacNeil (1950). Lower limits of the Hazelhurst occur at approximately 220 feet MSL; the upper limits in Gadsden County occur at the 320 feet MSL elevation. MacNeil (1950) stated that the Gadsden County portion is a remnant of a once continuous highlands stretching from Mississippi eastward through Alabama, west Florida, and Georgia. The modern Tallahassee Hills appear to be a stream dissected remnant of this once flat terrace surface. Fluvial erosion associated with the Ochlockonee and Little Rivers has truncated the eastern edges of the Hazelhurst and successively lower terraces in Gadsden County (Figure 5).

The Coharie Terrace spans southern and eastern Gadsden County in a three-mile-wide band delineated by the 170 to 220 feet MSL contour lines. The Cody Scarp, which may be associated with the Coharie sea level stand, trends east-west across southern Gadsden County between Bear and Ocklawaha Creeks. These creeks display an east-west trending trellis drainage pattern, indicating that the creeks along the toe and crest of the Cody Scarp probably post-date terrace development (Gremillion, 1964).

As used in this report, the Sunderland Terrace includes the Sunderland Terrace of Cooke (1939) and the Okefenokee terrace of MacNeil (1950). The Sunderland Terrace lies between 100 and 170 feet MSL. It occurs as a narrow band across southern and eastern Gadsden County, paralleling the valleys of Bear and Ocklawaha Creeks and the Ochlockonee River.

The Wicomico Terrace occurs in a narrow band bordering the northern shore of Lake Talquin, trending up the valleys of the tributary creeks to the lake, and following the valley of the Ochlockonee River northeastward into Georgia. This terrace lies between the 70 feet MSL to 100 feet MSL elevations.

The youngest terrace in Gadsden County is the

Penholoway, which lies between 42 and 70 feet MSL. The valley of the Apalachicola River, the southeastern portion of the county, including the Lake Talquin area, and a portion of the Ochlockonee River valley (Figure 5) locally occupy the Penholoway Terrace (Healy, 1975).

Springs

Springs are waters discharged as natural leakage or overflow from an aquifer through a natural opening in the ground. Three of the larger springs in Gadsden County (Figure 1) have been developed as recreational areas. They are briefly described below, using data taken from Rosenau, et al. (1977).

Chattahoochee Spring

Chattahoochee Spring is located in the western part of the town of Chattahoochee, T4N, R6W, sec. 33ac, about 0.5 mile south of Highway 90 in a county park. The area has very high topographic relief, and the spring flow is from seeps in the hillside. Water discharges through a swimming pool and overflow rivulet to the Apalachicola River. Discharge measured 0.018 cubic feet per second (cfs) on October 26, 1972. Water temperature and pH were 19.5°C and 7.8, respectively on the same date.

Glen Julia Springs

Glen Julia Springs is located one mile southwest of Mount Pleasant in Glen Julia County Park, T3N, R5W, sec 14cd. A pool, 100 by 200 feet, receives water from multiple seeps in the clay banks of the pool and nearby ravine. The pool is dammed at its northern end, and overflow from the pool is piped through the base of the dam into South Mosquito Creek, a tributary to the Apalachicola River. Discharge on October 26, 1972 measured 0.57 cfs; water temperature was 19°C and pH was 5.3 on the same day.

Indian Springs

Indian Springs is a privately operated recreational facility about 2.5 miles southwest of Greensboro, T2N, R6W, sec 36bc. Spring flow is from seeps at the head of a small, steep-sided valley. The spring pool is about 75 by 300 feet, and varies from 2 to 14-feet deep. An earthen dam forms the south end of the pool and a concrete block wall encloses the north end. Discharge water drains through a grate at a southeast corner of the pool and runs 0.5 mile to Telogia Creek. Volume of discharge measured July 17, 1975 was 0.69 cfs; water temperature and pH recorded on the same day were 25°C and 5.2, respectively.

STRATIGRAPHY

The known sediments underlying Gadsden County range in age from Mesozoic to Recent. The oldest rocks that crop out in the county are sediments of the Early Miocene Chattahoochee Formation. Recent terrace sands and alluvium are the youngest. Figure 6 is a generalized stratigraphic section in Gadsden County. The Florida Geological Survey follows stratigraphic nomenclature of the COSUNA (Correlation Of Stratigraphic Units of North America) correlation program (Braunstein et al., 1988).

The subsurface data discussed in this report was derived from lithologic logs of water and oil well cuttings and cores. Figure 7 is a Mesozoic cross section derived from oil test well logs. Figure 8 shows the well and cross-section locations for a series of geologic cross-sections (Figures 9 through 13). Figures 9 and 10 are east-west Cenozoic cross-sections across Gadsden County. Figures 11, 12 and 13 are north-south Cenozoic cross sections.

Paleozoic Erathem

Paleozoic age sedimentary rocks have been penetrated by numerous oil test wells in Florida

(Applin, 1951). To date, however, no wells in Gadsden County have penetrated sediments older than Cretaceous age. Oil test wells in Jefferson County to the east and to the south in Wakulla County have penetrated what are considered to be Ordovician and Silurian sandstones and shales (Barnett, 1975). A Wakulla County well (W-12114) and well W-1866 to the west in Jackson County also penetrated Paleozoic age basalt sills and dikes at or near their respective total depths of 12,424 and 9,245 feet below land surface. Various basement rock maps (Applin, 1951; Chowns and Williams, 1983; Thomas et al., 1987; Dallmeyer, 1987; and Arthur, 1988) indicate that Paleozoic strata underlies Gadsden County at depths in excess of 7,000 feet.

Mesozoic Erathem

Eight oil test wells penetrated Mesozoic sediments in Gadsden County. Figure 8 shows the oil well locations and illustrates the deep stratigraphy of Gadsden County in a geologic cross-section. The sediments encountered range from Upper Cretaceous unnamed chalky limestones to Lower Cretaceous red bed siliciclastics.

Lower Cretaceous

The oldest sediments penetrated by oil test wells in Gadsden County are Lower Cretaceous siliciclastic red beds. These sediments are typically sparsely fossiliferous shales and quartz sands ranging in color from red to purple to light green in color, and containing sporadic lenses of limestone and calcareous sandstone (Applin and Applin, 1944). Well W-6217 drilled 2,941 feet of Lower Cretaceous sand and shale from a depth of -3,879 feet MSL to its total depth at -6,820 feet MSL (Florida Geological Survey, unpublished well log). Due to the massive nature of the Lower Cretaceous section, formations were not distinguished. The Lower Cretaceous sediments are overlain unconformably by Upper Cretaceous siliciclastics of the Atkinson Formation.

ERATHEM	SYSTEM	SERIES	UNIT	
			WEST	EAST
CENOZOIC	QUATERNARY	HOLOCENE	UNDIFFERENTIATED SAND AND CLAY	
		PLEISTOCENE		
	TERTIARY	PLIO-CENE	UPPER	CITRONELLE FM. MICCOSUKEE FM.
			LOWER	JACKSON BLUFF FM.
		MIOCENE	UPPER	
			MIDDLE	
			LOWER	HAWTHORN GROUP-TORREYA FM.
				CHATTAHOOCHEE FM. ST. MARKS FM.
		OLIGO-CENE	UPPER	
			LOWER	SUWANNEE LIMESTONE
		EOCENE	UPPER	OCALA GROUP
			MIDDLE	AVON PARK FORMATION
			LOWER	WILCOX GROUP UNDIFFERENTIATED
		PALEO-CENE	UPPER	WILCOX GROUP UNDIFFERENTIATED
			LOWER	
MESOZOIC	CRETACEOUS	UPPER	UNNAMED CHALK AND LIMESTONE	
			ATKINSON FORMATION	
		LOWER	UNNAMED SANDSTONE AND SHALE	

FM. = FORMATION

 ABSENT IN WELLS

Figure 6. East-West diagrammatic stratigraphic section in Gadsden County.

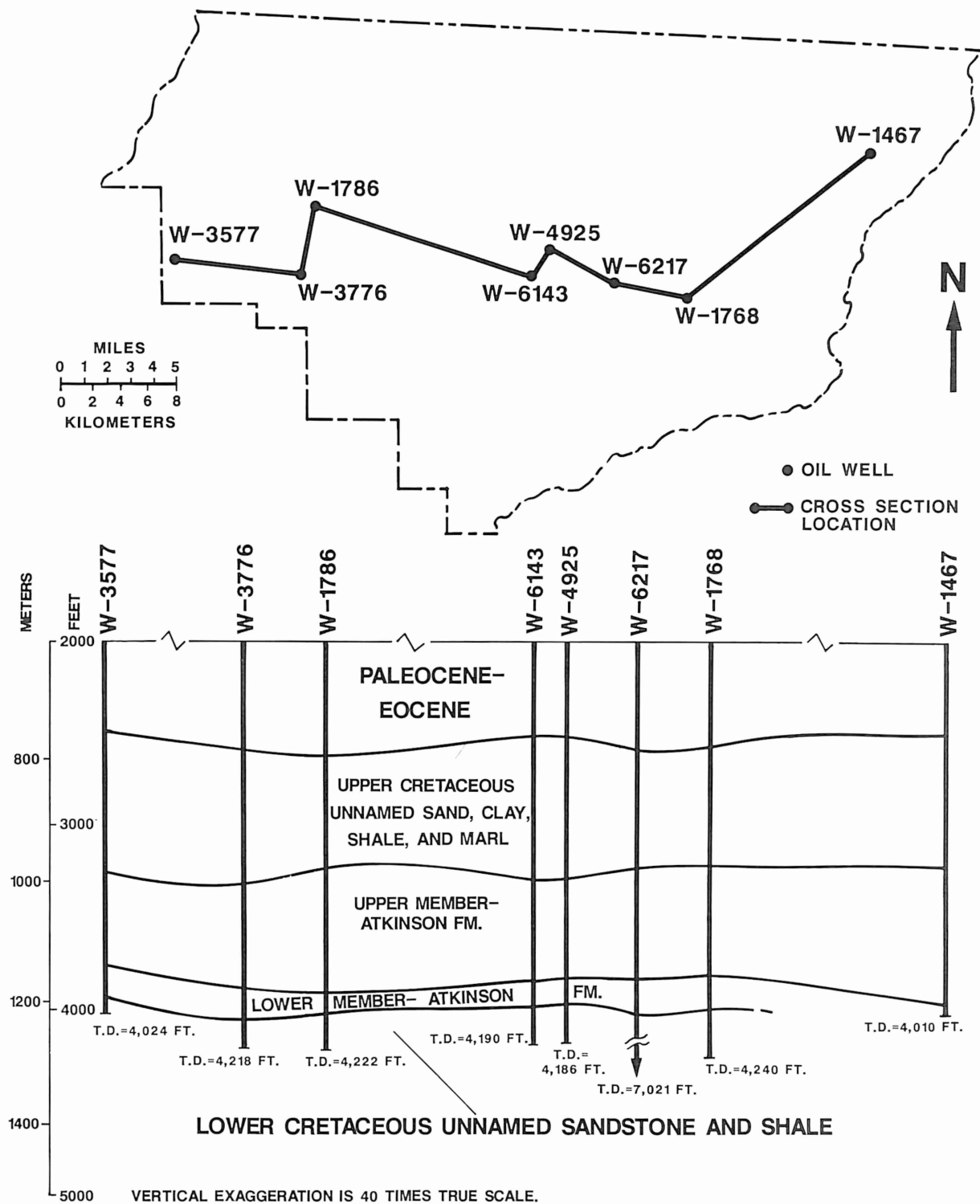


Figure 7. Mesozoic geologic cross-section.

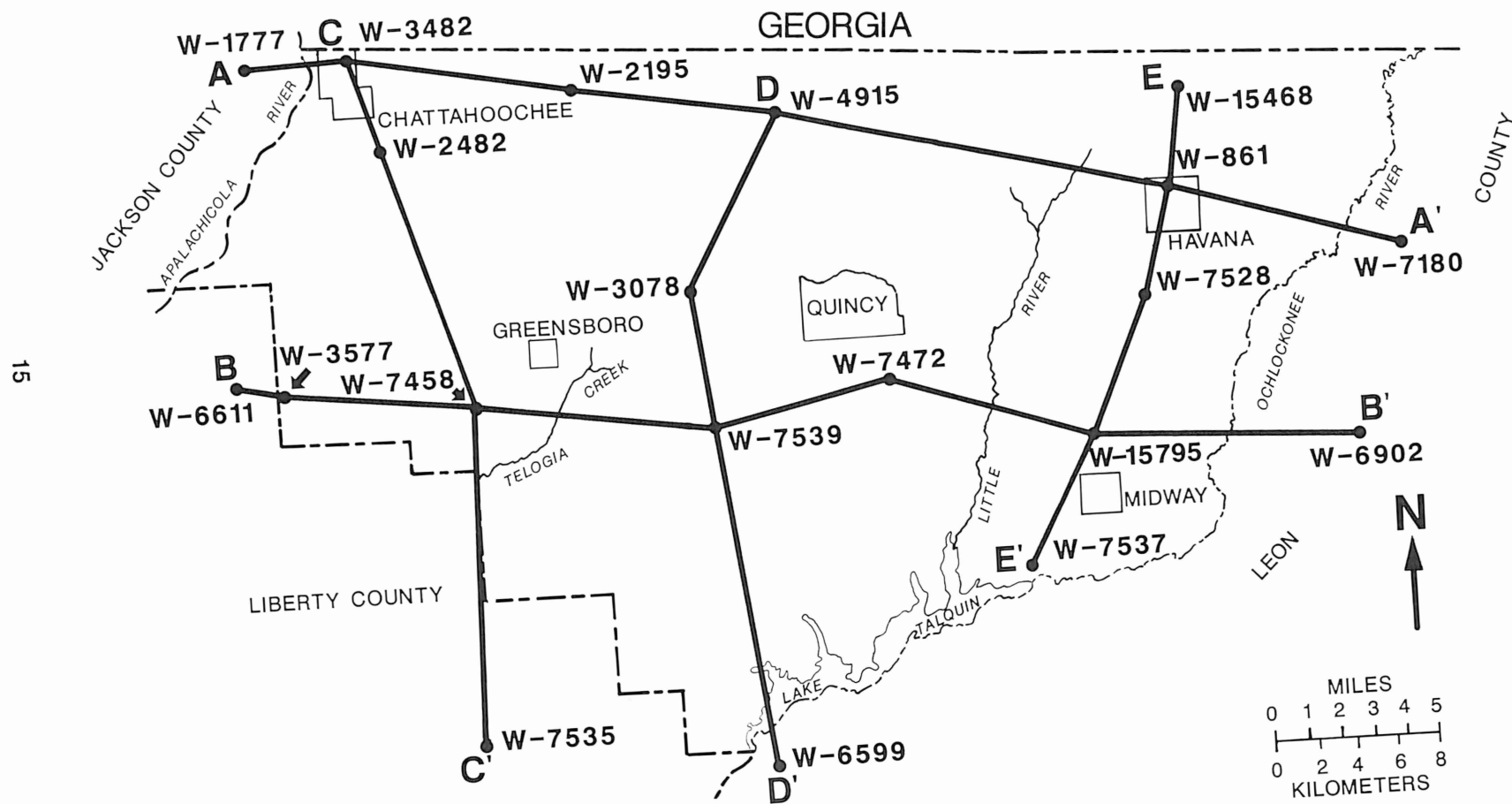


Figure 8. Geologic cross-section location map.

Florida Geological Survey

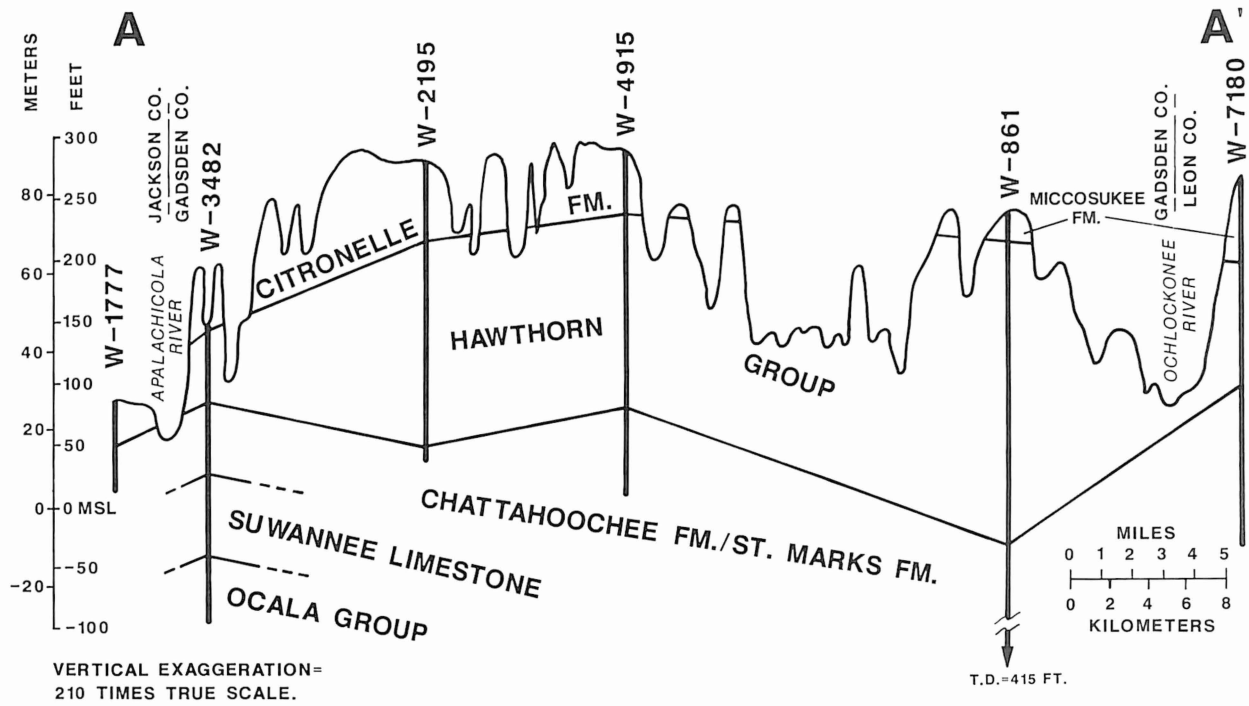


Figure 9. Geologic cross-section A-A'.

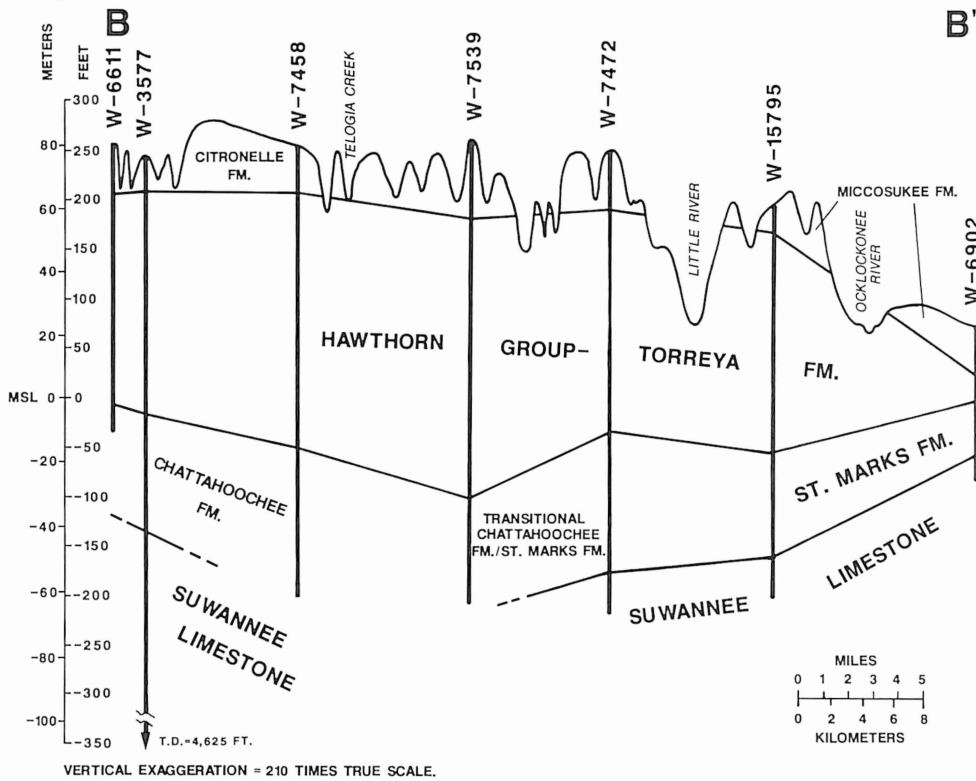


Figure 10. Geologic cross-section B-B'.

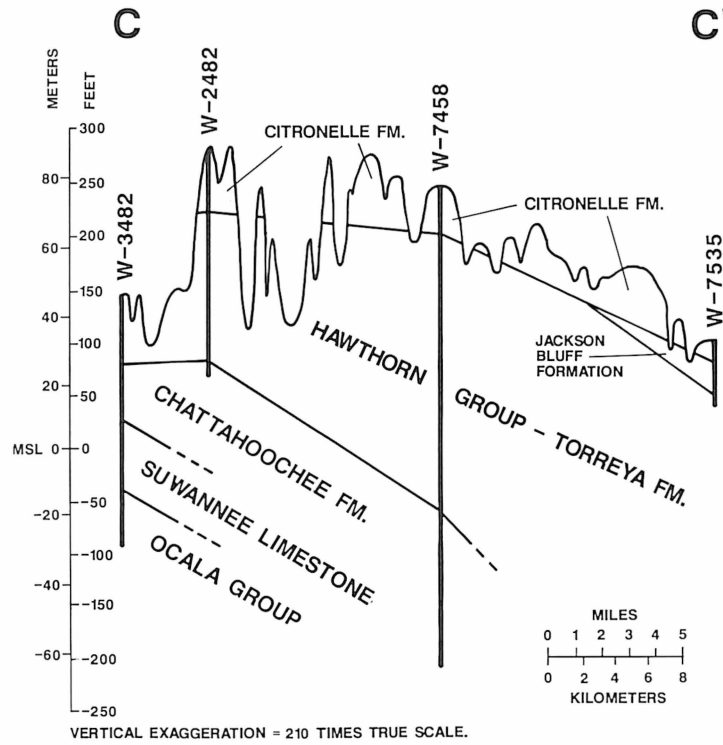


Figure 11. Geologic cross-section C-C'.

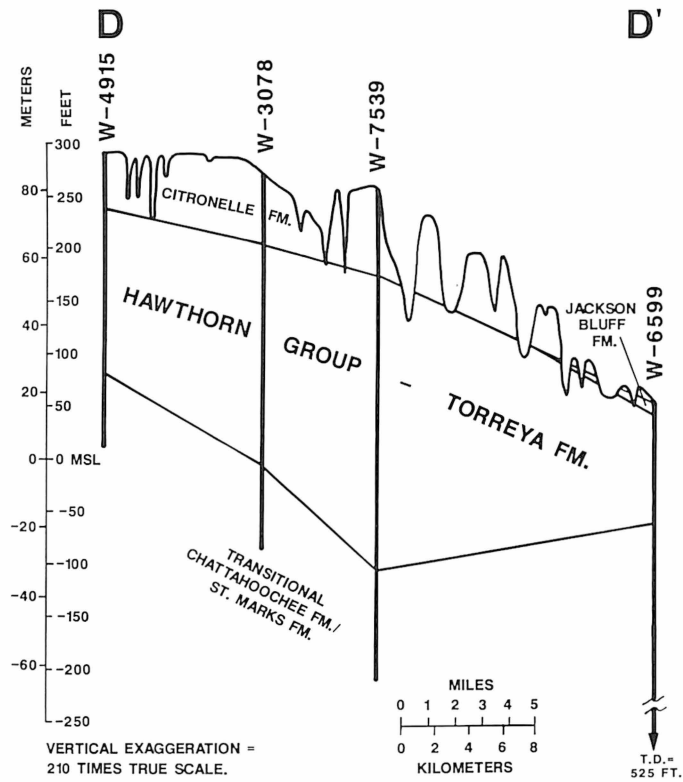


Figure 12. Geologic cross-section D-D'.

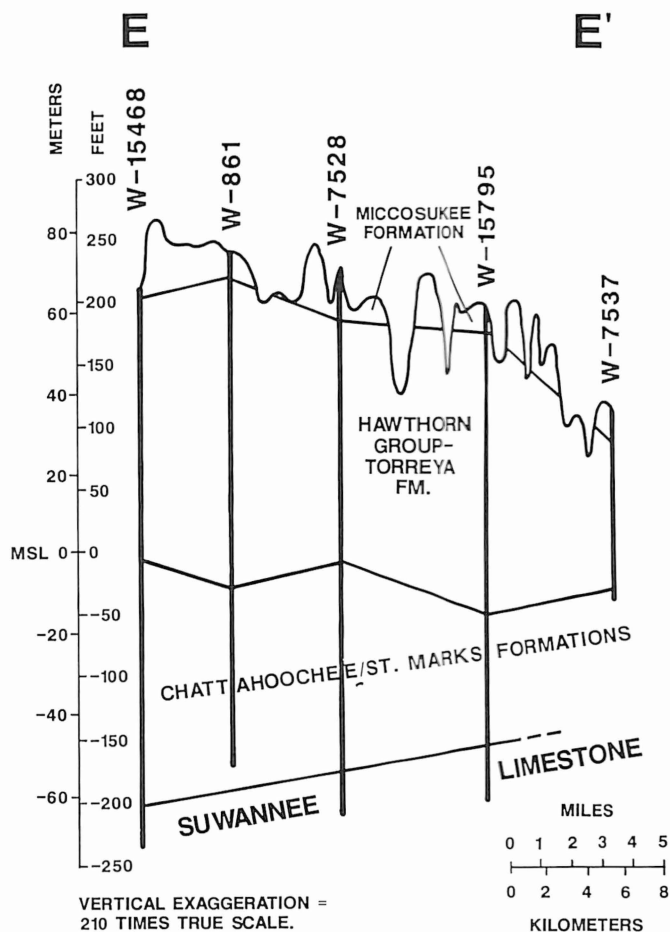


Figure 13. Geologic cross-section E-E'.

Upper Cretaceous Atkinson Formation

Applin and Applin (1947) applied the name Atkinson Formation to the Upper Cretaceous sediments of the Florida panhandle which were previously referred (Applin and Applin, 1944) to the Tuscaloosa Formation. In the western and central panhandle, the Atkinson Formation is divided into three informal members: the lower, middle, and upper (Applin and Applin, 1947). Only the upper and lower members are discernible in the eastern Florida panhandle.

Eight oil test wells penetrated Atkinson Formation sediments in Gadsden County (Figure 8). The lower member is a distinct, massive quartz sand, frequently interbedded with varicolored shales; depths to the top of this unit vary between -3,800 feet and -4,000 feet MSL. Although Applin and Applin (1947) indicated the presence of the middle member of the Atkinson Formation under the Gadsden County area, it can not be differentiated on lithologic or electric logs. The top of the upper member falls between -3,200 and -3,350 feet MSL under Gadsden County. Its lithology is comprised predominantly of gray and lignitic shales with interbedded sand (Florida Geological Survey, unpublished well log), and is most likely of marine origin (Hendry and Sproul, 1966). Immediately overlying the Atkinson Formation in Gadsden County is a series of unnamed, Upper Cretaceous siliciclastic and calcareous sediments.

Unnamed Upper Cretaceous Beds

A generally undifferentiated series of Upper Cretaceous gray to greenish-gray, marly shales, argillaceous sandstones, sandy and micaceous clays, and occasional limestones, overlie the Atkinson Formation in Gadsden County. These sediments, or portions of them, have been referred to under various names, including Austin Chalk, Selma Chalk, and Beds of Taylor Age (Applin and Applin, 1944; Hendry and Sproul, 1966; Yon, 1966). In Gadsden County, these unnamed sediments are present in eight oil test wells at a depth of approximately $-2,200 \pm 100$ feet MSL. Thickness of these sediments is a consistent 700 ± 50 feet in all wells. The top of these beds is the top of the Cretaceous in Gadsden County. Age determination for these sediments has been largely through paleontological dating. A sidewall core from well W-1467 in northeastern Gadsden County yielded a definitive Late Cretaceous microfossil assemblage including *Globotruncana arca*, at a depth of -2,281 feet MSL (Florida Geological Survey, unpublished well log).

CENOZOIC ERATHEM
Tertiary System
Paleocene and Eocene Series

Upper Paleocene to Lower Eocene Wilcox Group
Undifferentiated

Applin (1964) placed the siliciclastic sediments of the Florida panhandle containing a diagnostic foraminiferal fauna, similar to that of the Velasco Formation of Mexico, into the Lower Paleocene Midway Group. Reevaluations of the planktonic foraminifera present in Applin's logs indicate that the faunas are actually Late Paleocene, Thanetian Stage to Early Eocene, Ypresian Stage. Therefore, the Midway beds of Applin (1964) are herein considered to actually be sediments of the lower Wilcox Group (Braunstein et al., 1988).

Three oil test wells in Gadsden County penetrated sediments correlative to the lower Wilcox Group: well W-1467 (-1,839 feet to -1,994 feet MSL), well W-1768 (-2,100 feet to -2,330 feet MSL) and well W-3577 (-1,910 feet to -2,325 feet MSL) (Florida Geological Survey, unpublished well logs). These sediments occur as green to gray calcareous shales alternating with white to light brown, chalky limestone. No fossils were noted in the lithologic logs of these wells. However, a characteristic foraminiferal assemblage, the Tamesi fauna (Applin, 1964), occurs in stratigraphically correlative sections in Leon, Wakulla, and Jefferson County oil wells. This assemblage is composed of *Globorotalia velascoensis*, *Globorotalia angulata*, *Globorotalia pseudomenardii*, *Globigerina velascoensis*, and *Eponides cf. exigua*.

Undifferentiated Lower Eocene Wilcox Group sediments are present in three oil test wells in Gadsden County. Well W-1467 penetrated Wilcox Group sand from -1,425 feet to -1,839 feet MSL. Wells W-1768 and W-3577 encountered lithologically similar intervals from -1,545 to -2,100 feet MSL and -1,495 to -1,910 feet MSL, respectively. As they occur in Gadsden County, the Wilcox Group sediments are typically poorly fossiliferous, glauconitic and calcareous quartz sandstones, varying from greenish-gray to gray in color. As with the Paleocene Wilcox Group sediments, fossils were

sparse or absent in these intervals, and a lithologic correlation to nearby wells was used for age estimate.

Middle Eocene
Avon Park Formation

Miller (1986) grouped the lithologically similar Avon Park Limestone and Lake City Limestone of Applin and Applin (1944) into a single unit, the Avon Park Formation. The Avon Park Formation includes the Middle Eocene age carbonates occurring in northern and peninsular Florida, and is age equivalent to the Lisbon Formation (Smith, 1907) and Tallahatta Formation (Dall, 1898) of the western panhandle of Florida.

Gadsden County lies in a transitional area of the panhandle where the traditional highly fossiliferous cream to white to brown marine limestone and dolomite of the Avon Park Formation grades laterally into the more glauconitic, sandy, and clayey limestones and sands of the Lisbon and Tallahatta Formations to the west. Consequently, the Middle Eocene sediments underlying Gadsden County contain lithologic constituents characteristic of both the eastern and western facies; the assignment of these sediments to a specific lithologic formation is difficult. Pascale and Wagner (1982) lump these transitional sediments into unnamed rocks of Claiborne age. However, Hendry and Sproul (1966) recognize the Avon Park Formation in wells in western Leon County, and lithologic logs of three deep wells in Gadsden County (Florida Geological Survey, unpublished well log) indicate that the Middle Eocene sediments underlying most of the county still retain sufficient Avon Park Formation lithologic character to place them in this unit. Well W-3577, in the western portion of the county, penetrated Avon Park Formation section from -530 feet MSL to -1,495 feet MSL. The general lithology consisted of alternating grayish-brown to dark brown dolomites and crystalline to chalky limestones. From a depth of -840 feet MSL to -1,495 feet MSL, the limestones and dolomites contain up to 20 percent sand and glauconite, displaying an affinity to the siliciclastic Middle Eocene sediments

to the west. Well preserved fossils are rare in this section, but the foraminifera *Operculinoides* sp. is common at -1,315 feet MSL in W-3577. Wells W-1467 and W-1768 also contain similar Avon Park Formation lithologies at depths of -380 to -1,365 feet MSL and -485 to -1,545 feet MSL, respectively.

Upper Eocene
Ocala Group

Dall (1892) proposed the name Ocala Limestone for calcareous sediments exposed in the vicinity of Ocala, Marion County, Florida. Since this initial usage, the term Ocala Limestone has been redefined by numerous authors. An excellent historical review is provided by Puri (1957).

The nomenclature proposed in Puri (1957) is generally used today by the Florida Geological Survey. He raised the Ocala to group rank, with three subdivisions; in ascending order, these are: the Inglis Formation, the Williston Formation, and the Crystal River Formation.

The Ocala Group is known from well data to underlie most of Florida. Statewide, elevations of the top of these sediments range from greater than 100 feet above MSL in west-central peninsular Florida and the northern panhandle to over -1,200 feet MSL in south Florida, in the Apalachicola Embayment, and near Pensacola in the westernmost panhandle of Florida (Applin and Applin, 1944; Puri, 1957). Limestones of the Ocala Group are components of the Floridan aquifer system, an important fresh water aquifer.

In Gadsden County, the Ocala Group lies below the depth attained by most water wells. Eight oil test wells penetrated the top of the Ocala Group section at depths ranging from -266 feet MSL to -633 feet MSL. Well W-4 drilled 380 feet of typical Ocala Group sediments from -500 feet MSL to -880 feet MSL. The lithology is comprised of cream colored, highly fossiliferous, crystalline limestone containing abundant benthonic foraminifera and bryozoans. Foraminifera present are *Lepidocyclina ocalana*, *Operculinoides* cf. *wilcoxi*, *Eponides* sp., *Operculinoides* cf. *moodybranchensis*, and *Discorbis jacksonensis*. Similarly, in eastern Gadsden County, well W-3577 penetrated 540 feet of Ocala Group sediments from -305 feet MSL to -845 feet MSL. As in the other wells that penetrated Ocala section, the lithology in well W-3577 was typically a white to yellowish-gray to grayish-brown, chalky to crystalline, fossiliferous limestone, containing varying amounts of quartz sand, dolomite, and clay. Mollusks, bryozoa, echinoids, and benthonic foraminifera of the genera *Lepidocyclina* and *Operculinoides* are the most abundant fossils in this interval. Well W-3482, in Chattahoochee, penetrated Ocala Group sediments from -34 feet MSL to its total depth of -93 feet MSL.

Due to the massive, frequently recrystallized nature and lack of definitive index fossils in the Ocala Group sediments encountered in the Gadsden County wells, formational picks were not made in any of the wells. Puri and Vernon (1959, 1964) indicated that all three formations are probably present under the Big Bend area, with the Crystal River Formation comprising approximately the upper two-thirds of the Ocala Group section in the vicinity of Gadsden County. Schmidt and Coe (1978) however, in their study of nearby Jackson County, felt that these formations could not be differentiated, and called the sequence Ocala Group Undifferentiated.

Oligocene Series
Lower Oligocene
Suwannee Limestone

Cooke and Mansfield (1936) proposed the name Suwannee Limestone for the fossiliferous limestones which crop out on the Suwannee River between the towns of White Springs (Hamilton County) and Ellaville (Suwannee County). Vernon (1942) and Cooke (1945) give good nomenclatural histories for this unit. The Suwannee Limestone underlies much of Florida with the exception of the northern and eastern portions of the peninsula.

The Suwannee Limestone was encountered in eight oil tests and a number of fresh water wells in Gadsden County. This formation is also a com-

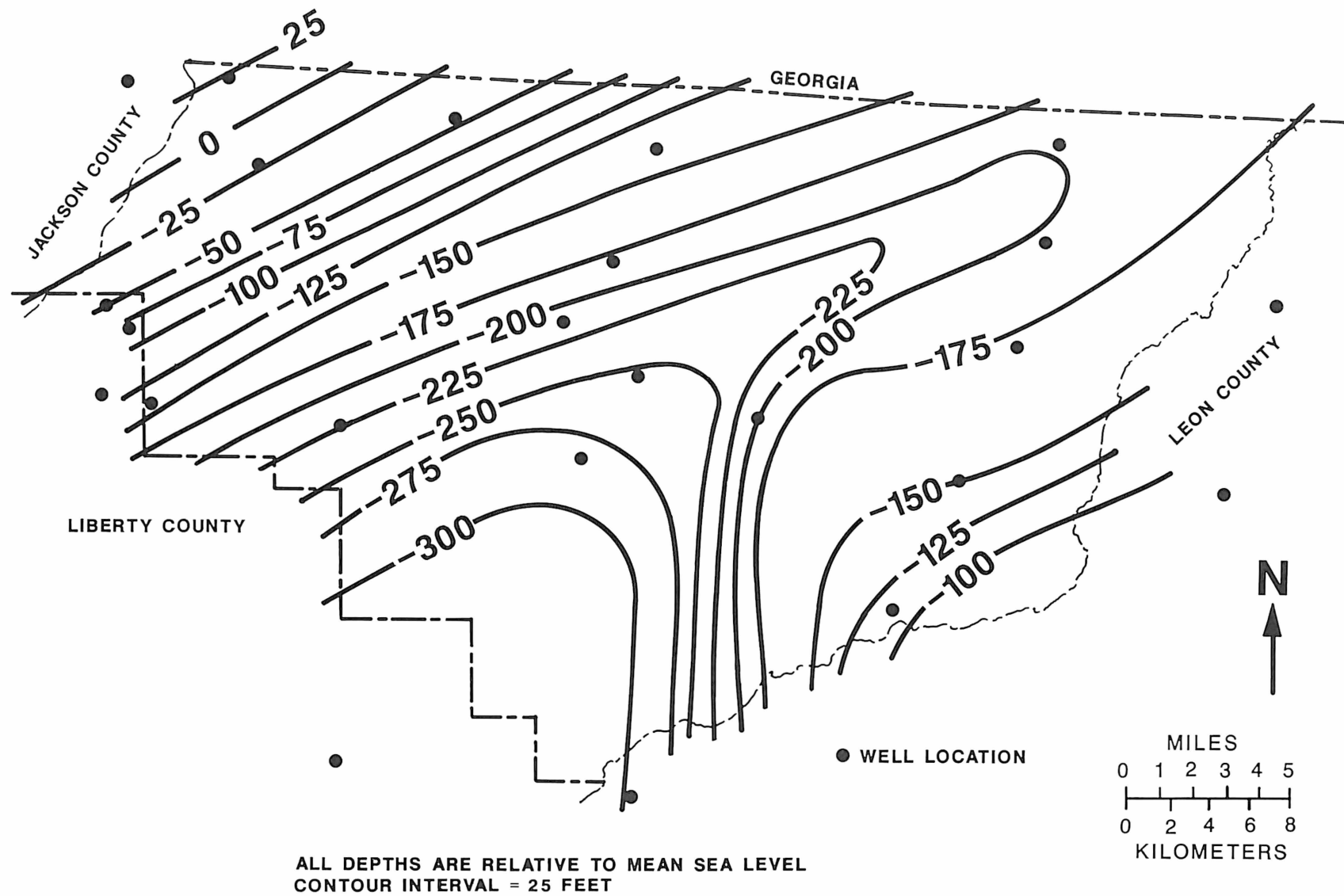


Figure 14. Structure contour map of the top of the Suwannee Limestone in Gadsden County.

ponent of the Floridan aquifer system, and is a source of potable water in the northern peninsula and panhandle of Florida. Lithologic sample logs from the wells indicate that the typical Suwannee Limestone lithology is a white to cream to light olive gray colored fossiliferous micritic to crystalline limestone, frequently containing brown dolomite and minor sand. Predominant fossils include mollusks and benthonic foraminifera. Well W-4 encountered Suwannee Limestone from -235 feet MSL to -400 feet MSL and contains a relatively abundant foraminiferal fauna. The foraminiferal assemblage in this well is composed of *Rotalia mexicana* var. *mecatepecensis*, *Eponides byramensis*, *Asterigerina* cf. *choctawensis*, *Operculinoides* cf. *forresti*, *Operculinoides* cf. *dia*, *Lepidocyclina* cf. *undosa*, *L. favosa*, *L. mantelli*, *L. supera*, *Rotalia choctawensis*, and *Gypsina globula*; mollusks noted were *Pecten* sp. and *Ostrea* sp. (Florida Geological Survey, unpublished well logs).

Figure 14 is a contour map on the top of the Suwannee Limestone in Gadsden County. The irregular surface of the Suwannee Limestone is unconformable with the overlying Lower Miocene St. Marks and Chattahoochee Formations, and varies in elevation from 25 feet MSL in well W-1478 to -286 feet MSL in well W-1786. Total thickness of this formation in the wells studied varies from 19 feet (well W-545) to 480 feet (well W-4925).

Miocene Series
Lower Miocene

St. Marks Formation and Chattahoochee
Formation

Johnson (1888) first applied the term Tampa Formation to Lower Miocene sediments exposed in the vicinity of Tampa, Hillsborough County, Florida. Over the years, many authors have attempted to redefine and divide this unit. Vernon (1942) included all sediments lying above the Suwannee Limestone and below the Alum Bluff Group (Middle Miocene) in the Tampa Formation. Puri (1953) placed all sediments previously assigned to the

Tampa Formation in the Tampa Stage, and erected two lithologic subdivisions in the panhandle: the St. Marks (Finch, 1823) facies and the Chattahoochee (Langdon, 1889) facies. These facies were raised to formation status by Puri and Vernon (1964).

The St. Marks Formation includes the offshore, calcareous, downdip facies of the Lower Miocene, while the Chattahoochee Formation is comprised of the updip, generally silty, clayey, and more dolomitic terrigenous and shallow water sediments of the same age (Puri, 1953). Gadsden County lies in a transitional area of the Big Bend where the calcareous St. Marks Formation on the east and south interfingers with the more siliciclastic and dolomitic Chattahoochee Formation in the west. The area of interfingering occupies much of central and eastern Gadsden County, and corresponds approximately to the axis of the Gulf Trough (Scott, 1986).

The typical lithology of the St. Marks Formation is a white to very light gray, fossiliferous, micritic limestone. It may contain minor amounts of clay and quartz sand (generally five percent or less). The most abundant fossils are mollusk molds and benthic foraminifera of the genera *Sorites*, *Elphidium*, *Archaias*, and *Puteolina*.

In contrast, the Chattahoochee Formation is generally a silty to sandy dolomite, with occasional occurrences of limestone. Well W-329, southeast of Chattahoochee, drilled 200 feet of Chattahoochee Formation. The upper 130 feet is comprised of a white, unfossiliferous sandy limestone (15 to 20 percent quartz sand); the lower 70 feet is a light orange to grayish orange, unfossiliferous dolomite.

The original type locality for the Chattahoochee Formation was located at Chattahoochee Landing on the Apalachicola River at Chattahoochee (Dall and Stanley-Brown, 1894; Matson and Clapp, 1909). However, the precise location of a type section relative to the river was not described. Exposures of limestone in this original type area are still visible along the access road to the old Victory Bridge, south of U.S. Highway 90. Puri and Vernon (1959;1964) proposed an alternate type locality for the Chattahoochee Formation located along the

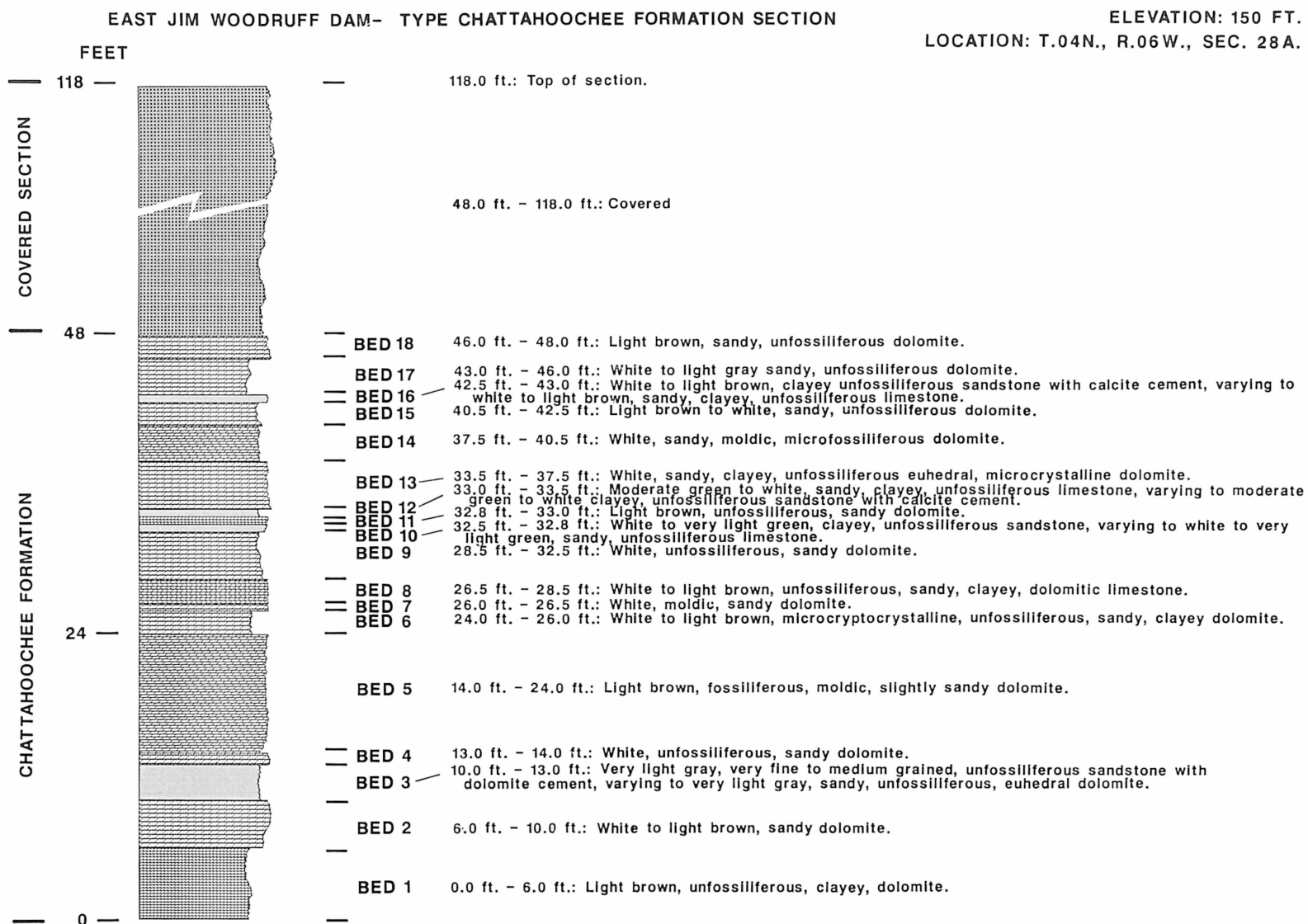


Figure 15. Columnar section of the type locality of the Chattahoochee Formation, east Jim Woodruff Dam, Decatur County, Georgia (after Johnson, 1989a).



Figure 16. Photograph showing the Chattahoochee Formation exposed along the Jim Woodruff Dam access road (T4N, R6W, sec. 28), 1988.

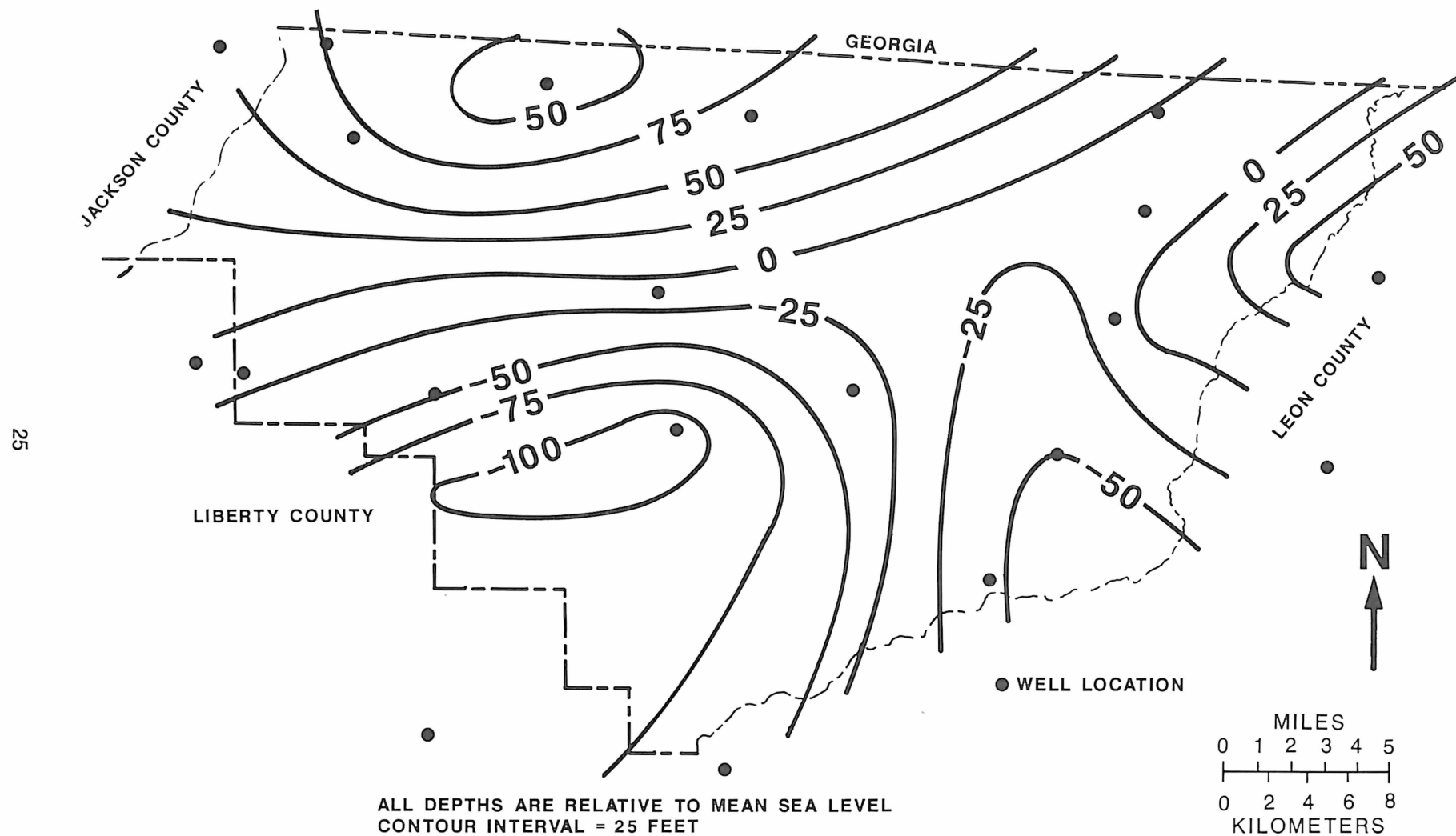


Figure 17. Structure contour map of the top of the Lower Miocene carbonates in Gadsden County.

access road to Jim Woodruff Dam just north of the town of Chattahoochee (T4N, R6W, sec. 28a, Decatur County, Georgia). Figure 15 shows a graphic diagram of the section at this location. Figure 16 is a photograph of the Chattahoochee Formation exposure along the Jim Woodruff Dam road.

Wells in central and eastern Gadsden County often show an interbedded St. Marks/Chattahoochee Formation relationship. Well W-4 in central Gadsden County penetrated 200 feet of Lower Miocene Chattahoochee/St. Marks Formation section from -40 to -240 feet. The lithology is comprised of white, hard to chalky limestones containing molds of gastropods, *Archaias sp.*, and *Sorites sp.*, interspersed and alternating with unfossiliferous sandy limestones and lenses of green to gray clay and sandy clay, (Florida Geological Survey, unpublished well log). Well W-7528, a core in eastern Gadsden County, penetrated 256 feet of undifferentiated Chattahoochee/St. Marks Formation sediments between 62 and -194 feet MSL. These sediments are comprised of sandy, clayey, dolomitic, moldic, fossiliferous, calcilutitic limestone and dolomite (Johnson, 1986). Formational picks were not made due to the interbedded nature of the lithologies.

The Chattahoochee/St. Marks Formation sediments overlie the Oligocene Suwannee Limestone, and are in turn overlain unconformably by siliciclastic sediments of the Lower Miocene Hawthorn Group. Figure 17 shows structure contours of the top of the Lower Miocene St. Marks and Chattahoochee Formations in Gadsden County.

Hawthorn Group Torreya Formation

The name Hawthorn was first proposed by Dall and Harris (1892) for Middle Miocene sediments exposed near the town of Hawthorne, Alachua County, Florida. An excellent historical review of the numerous redefinitions of these sediments is given by Scott (1988). Huddleston (1988) raised the Hawthorn to group status, and Scott (1988) has

extended existing formations of the Hawthorn Group from Georgia into Florida and erected several new formations within the group statewide. Banks and Hunter (1973) proposed the name Torreya Formation for the Early Miocene deposits in the eastern Florida panhandle. Huddleston and Hunter (1982) later suggested placing all deposits previously referred to the Hawthorn Formation in the western Florida panhandle into the Torreya Formation of the Hawthorn Group. The designated type section is located at Rock Bluff, Torreya State Park, in Liberty County, Florida (Banks and Hunter, 1973).

The Torreya Formation is characteristically a siliciclastic unit, consisting of a white to light olive-gray, very fine-to-medium grained clayey sand to sandy, silty clay, and frequently contains variable amounts of limestone, dolomite, and phosphate grains. Carbonate content generally increases in the basal portion of the section. The carbonate portions usually consist of quartz-sandy, clayey limestone or dolomitic limestone.

Clays are frequently an important component of the upper Torreya Formation. The dominant clay minerals are palygorskite and smectite, with minor amounts of sepiolite, kaolinite, and illite (Weaver and Beck, 1977). Fuller's earth, a commercial palygorskite clay, is mined from Torreya Formation sediments near Quincy and Midway and northward into Georgia.

Torreya Formation sediments underlie all of Gadsden County (Gremillion, 1964; Scott, 1988). The characteristic lithologies consist of occasionally fossiliferous and phosphatic sands and fuller's earth (palygorskite) clay, montmorillonite and kaolin clay interfingering with thin limestones and dolomites. The basal portion of the Torreya Formation is predominantly limestone. Oyster reefs comprised of *Ostrea normalis* and gastropod molds are often associated with the carbonate units, and marine diatoms have been noted in some of the clay (Gremillion, 1964; Ogden, 1978). Foraminifera are generally rare or absent; Applin (Florida Geological Survey, unpublished well log) notes only *Rotalia beccarii* at 9.75 feet MSL in well W-4. The fuller's earth mines near Quincy have yielded fossil trees

(Figure 18) and vertebrate remains, including skeletons of the extinct dugong *Hesperosiren cratagensis* (Figure 19).

The Torreya Formation crops out in bluffs along the east bank of the Apalachicola River. West of the river, it is absent. Sporadic exposures of Torreya along the Ochlockonee River in eastern Gadsden County have also been recorded by Gremillion (1964).

Depth to the top of the Torreya varies from 279 feet MSL in well W-5201 in west-central Gadsden County, to -18.5 feet MSL in core W-7539. Thickness ranges from approximately 100 feet in the western portion of the county to about 230 feet near Quincy.

Figure 20 is a structure contour map of the top of the Torreya Formation in Gadsden County. The surface of these sediments dips gradually in all directions from a high in the north-central part of the county. Sediments of the Citronelle and Miccosukee Formations, and in some areas the Jackson Bluff Formation, unconformably overlie the Torreya Formation.

Pliocene Series
Upper Pliocene
Jackson Bluff Formation

Puri and Vernon (1964) combined the Upper Miocene *Ecphora* and *Cancellaria* mollusk facies of Puri (1953) into the Jackson Bluff Formation, named after Jackson Bluff on the Ochlockonee River in western Leon County. Puri and Vernon (1964) placed the Jackson Bluff Formation unconformably above the Middle Miocene sediments, and below the Miccosukee Formation and younger deposits. Based on a reexamination of the planktonic foraminifera and calcareous nannofossils present in samples from several Jackson Bluff Formation outcrops, Akers (1972) and Huddlestun (1976) reassigned this formation to the Upper Pliocene.

The Jackson Bluff Formation has not been recognized in any wells in Gadsden County. It is recorded in wells and outcrop samples in Liberty County to the south (Schmidt, 1984), and in south-western Leon County (Hendry and Sproul, 1966).

Gremillion (1964) found no evidence of the Jackson Bluff Formation in his study of Gadsden County; he did, however, indicate the probable presence of covered Jackson Bluff Formation sediments along the north shore of Lake Talquin, stretching from Liberty County northeastward to Bear Creek in Gadsden County. Since the Jackson Bluff Formation sediments are not recognized in wells to the north and west of Lake Talquin, the formation most likely pinches out southeast of Highway 267 in the south-central tip of Gadsden County, or grades laterally into an unfossiliferous facies.

The lithology of the Jackson Bluff Formation, as it occurs in Leon County, is typically a greenish-gray to brown, very macrofossiliferous clayey sand and sandy clay. Mollusk shells of the genera *Busycon*, *Ecphora*, *Turritella*, *Cancellaria*, *Pecten*, *Strombus*, *Conus*, *Vermicularia*, and *Ostrea* are common to abundant in beds throughout the Jackson Bluff section (Puri and Vernon, 1964). A neritic zone benthonic foraminiferal assemblage comprised of species of *Quinqueloculina*, *Spiroloculina*, *Virgulina*, *Uvigerina*, *Textularia*, *Masilina*, *Triloculina* and others (Puri and Vernon, 1964) as well as time correlative planktonic forms such as *Globorotaloides hexagona hexagona*, *Globorotalia margaritae*, *Globorotalia cultrata menardii*, and *Globorotalia multicamerata* have been reported in outcrop samples of Jackson Bluff Formation in the panhandle area of Florida (Akers, 1972).

The late Pliocene age of the Jackson Bluff Formation suggests that it may locally be contemporaneous with the overlying Citronelle and Miccosukee Formations (Schmidt, 1984; Huddlestun, 1988). Throughout most of the Florida panhandle, however, the Jackson Bluff sediments are unconformably overlain by the clayey sands and gravels of the Citronelle and Miccosukee Formations.

Citronelle Formation

Matson (1916) gave the name Citronelle Formation to the orange and red sands, clays, and gravels



Figure 18a. Fossil Miocene cypress tree unearthed at the Engelhard Company Midway Mine, shortly after its discovery in 1963 (photo courtesy of Jack Williamson, Engelhard Company).



Figure 18b. Fossil cypress tree cleaned and on display at the Florida Geological Survey office in Tallahassee.

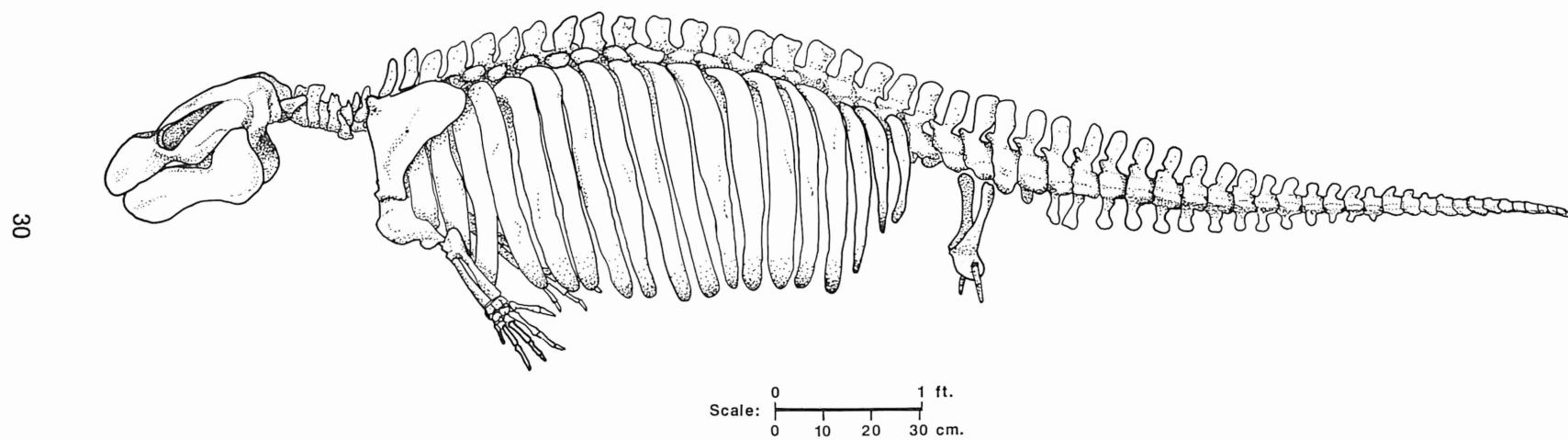


Figure 19. Miocene dugong *Hesperosiren cratagensis* found in the Floridin Company Quincy Mine in 1929.

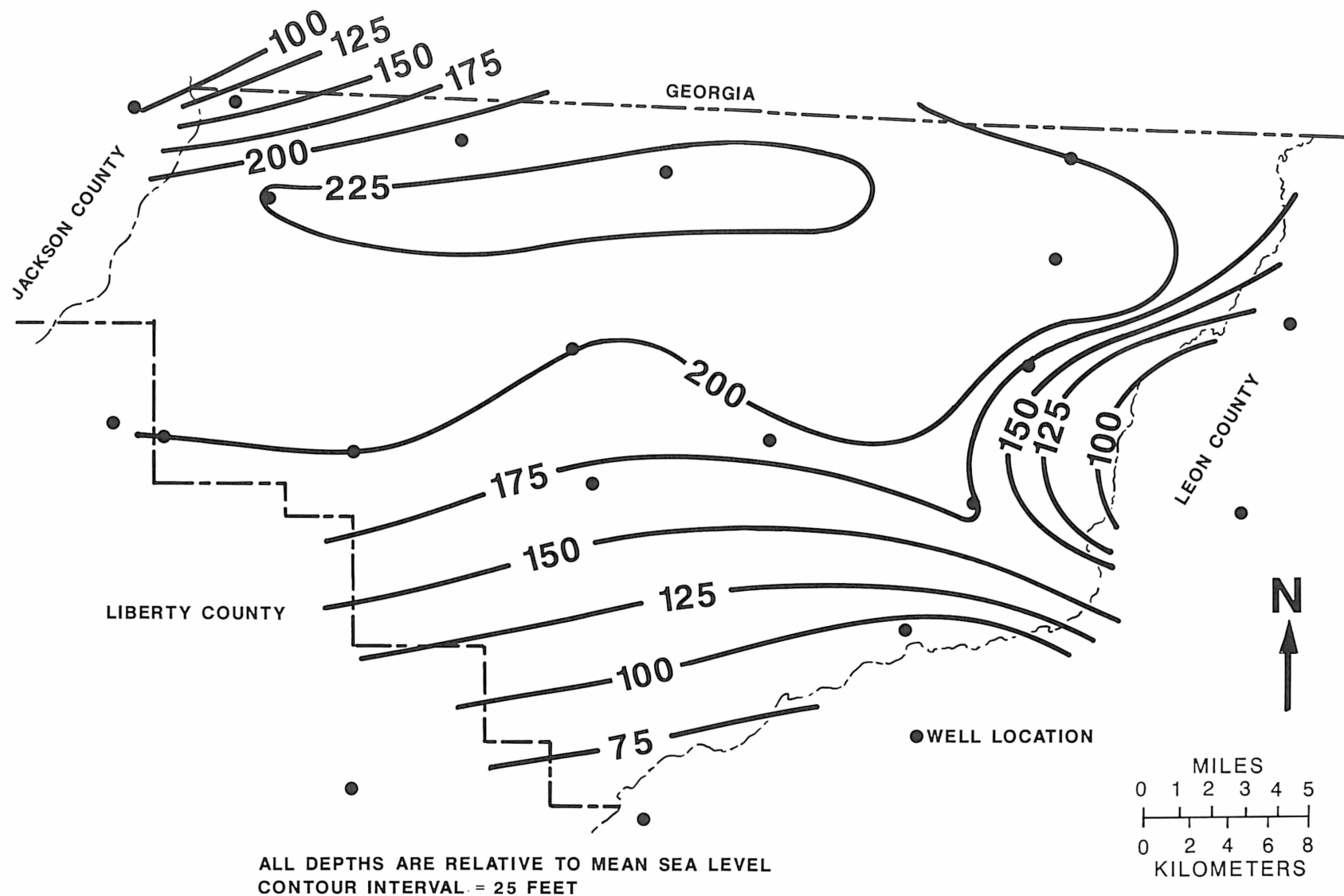


Figure 20. Structure contour map of the top of the Hawthorn Group - Torreya Formation in Gadsden County.

exposed near Citronelle, Mobile County, Alabama, and mapped its areal occurrence as far east as Okaloosa County in the Florida panhandle. Cooke and Mossom (1929) extended the eastern limit of the Citronelle Formation to near the town of Quincy in Gadsden County.

The age of the Citronelle Formation has been a source of debate for years. Berry (1916) assigned the Citronelle to the Late Pliocene based on terrestrial plant fossils in Alabama. Later authors (Doering, 1935; Roy, 1939) disputed this age, primarily because the plant fossils were in beds below the actual Citronelle sediments. Doering (1956) placed the Citronelle in the early (pre-glacial) Pleistocene based on the discovery of Pleistocene *Equus* teeth by Deussen (1914) in Citronelle sediments in Texas. Stringfield and LaMoreaux (1957) reevaluated a second Citronelle outcrop section originally collected by Matson (1916) in Alabama and found Late Pliocene plant fossils similar to those described by Berry (1916) contained within definite Citronelle sediments. As further evidence for a Pliocene age, Stringfield and LaMoreaux (1957) argue that the oldest Pleistocene marine terraces in Florida overlie Citronelle Formation deposits. Doering (1960) countered by citing the discovery of the Lower Pleistocene foraminifera *Hyalinea balthica* and *Globigerina (Globorotalia) inflata* in Citronelle-equivalent section in an offshore Louisiana oil exploration well. The disagreement has not been resolved. An absence of locally-correlatable index fossils in most of the Citronelle Formation precludes accurate age dating of the unit. For the purpose of this report, the modern consensus (Braunstein et al., 1988) that the Citronelle Formation is most likely Late Pliocene in age is herein adopted.

Sediments of the Citronelle Formation blanket most of western Gadsden County from Dogtown and Quincy westward. It caps many of the hills in the county, and lies unconformably upon sediments of the Hawthorn Group. Citronelle Formation sediments extend eastward to just west of the valley of the Little River. Here erosion has removed most Citronelle sediments, and the valley is blanketed by Pleistocene and Holocene clays and

sands. East of the Little River, the reddish siliciclastics are lithologically more similar to the Miccosukee Formation (Figure 9).

The general lithology of the Citronelle Formation in Gadsden County is orange to red, clayey, medium to coarse-grained quartz sands, with occasional clay lenses and beds of friable quartz pebbles. Cross-bedding is present in many exposures. The original thickness of the formation is uncertain, as erosion has removed the upper portion over much of the county. In most wells and outcrops, it is the uppermost unit, and generally varies from about 20-feet thick just east of Quincy to nearly 100 feet in western Gadsden County south of Chattahoochee (Figure 21).

Miccosukee Formation

Hendry and Yon (1967) gave the name Miccosukee Formation to the interbedded clays, silts, sands and gravels lying above the Hawthorn Group sediments and below the Pleistocene to Holocene age sediments in the Big Bend area of north Florida. In eastern Gadsden County, Miccosukee Formation sediments are somewhat similar in overall lithology to the Citronelle Formation. However, the Miccosukee Formation is generally comprised of fine-to-medium grained clayey sands. Gravel is less common than in the Citronelle, and the clays occur primarily in thin, discontinuous beds or in thin laminae.

Debate exists as to where in the county the transition from Miccosukee to Citronelle occurs. Many of the exposures in pits and in the fuller's earth mines appear to be transitional between typical Citronelle Formation lithology and Miccosukee Formation. As previously discussed, the Little River, with some exceptions, may be an arbitrary transition line between the two formations. Miccosukee Formation lithology is found in a few locations west of the river, however, particularly in road cuts along S.R. 12 and U.S. Highway 90 just east of Quincy.

As with the Citronelle Formation, age dating the Miccosukee accurately is not possible due to a lack of definitive index fossils. In Leon County, this



Figure 21. Photograph of Citronelle Formation sediments exposed in the Gadsden County Road Department Walker Pit (T3N, R6W, sec. 28c), 1983.

formation overlies the upper Pliocene age Jackson Bluff Formation. Originally placed in the Late Miocene (Hendry and Yon, 1967) the Miccosukee Formation is now considered to be age equivalent to the upper Pliocene Citronelle Formation (Braunstein et al., 1988).

In Gadsden County, the Miccosukee Formation sediments cap the topographically high areas east of the Little River. These sediments occur in a band trending northeastward into Georgia, and lie unconformably on Miocene Torreja Formation deposits. From eastern Gadsden County, the Miccosukee extends eastward through Leon and Jefferson counties, to eventually pinch out in eastern Madison County (Hendry and Sproul, 1966; Yon, 1966; and Hoenstine and Spencer, in preparation).

Core W-7537 in southeastern Gadsden County encountered 28 feet of Miccosukee Formation from 82 feet MSL to 110 feet MSL. The lithology was comprised of poorly indurated, grayish-orange, clayey, quartz sand. Further to the north, core W-7528 penetrated Miccosukee Formation from surface to 43.5 feet (230 feet MSL to 186.5 feet MSL); the lithology was a poorly indurated, light yellowish-orange to grayish-orange, mottled clayey, quartz sand and sandy clay. Figure 22 shows a roadcut exposure of Miccosukee Formation just east of Havana on U.S. 90. Throughout eastern Gadsden County, the Miccosukee Formation comprises the surficial sediment layer. In a few areas, especially along the Ochlockonee River and Lake Talquin, undifferentiated Pleistocene and Holocene sands unconformably overlie the Miccosukee.

Pleistocene and Holocene Series

Pleistocene and Holocene undifferentiated quartz sand and clay comprise the surficial sediments in several areas of Gadsden County (Schmidt, 1979). Most Pleistocene sediments are marine terrace deposits lying unconformably on the Citronelle, Miccosukee, Torreja or Chattahoochee Formations. Holocene alluvial deposits are concentrated along the major rivers, streams and creeks and are

often difficult to differentiate from the Pleistocene sediments.

STRUCTURE

The subsurface structure of Gadsden County has been influenced by several regional structural features. Figure 23 illustrates the location and orientation of these features.

Peninsular Arch

The Peninsular Arch forms the axis of peninsular Florida (Applin, 1951). It is a southeast-trending structural high in pre-Mesozoic sediments. Although no direct structural relationships are known to exist between the arch and the Tertiary sediments of Gadsden County, the downwarped western flank of the Peninsular Arch extends beneath the Big Bend area (Hendry and Sproul, 1966).

Apalachicola Embayment

Gadsden County is situated on or near the axis of a broad sedimentary basin known as the Apalachicola Embayment. Pressler (1947) estimated its size as approximately 30,000 square miles. Schmidt (1984) provides an excellent interpretive and nomenclatural history of this feature. Oil test wells have shown the sediment fill of the basin to be about 13,000 feet of Triassic to Holocene-age deposits, all resting on Paleozoic age metamorphic rocks (Applegate, et al., 1978; Schmidt and Clark, 1980).

Chattahoochee Anticline

North and northwest of the Apalachicola Embayment is a minor structural high called the Chattahoochee Anticline (Veach and Stephenson, 1911; Puri and Vernon, 1964). This structure is an elongate anticline trending northeast-southwest. Oligocene and Eocene rocks are exposed at the



Figure 22. Photograph of Miccosukee Formation sediments exposed in a road cut along U.S. 90 (T2N, R3W, sec. 16dc) east of Quincy, 1989.

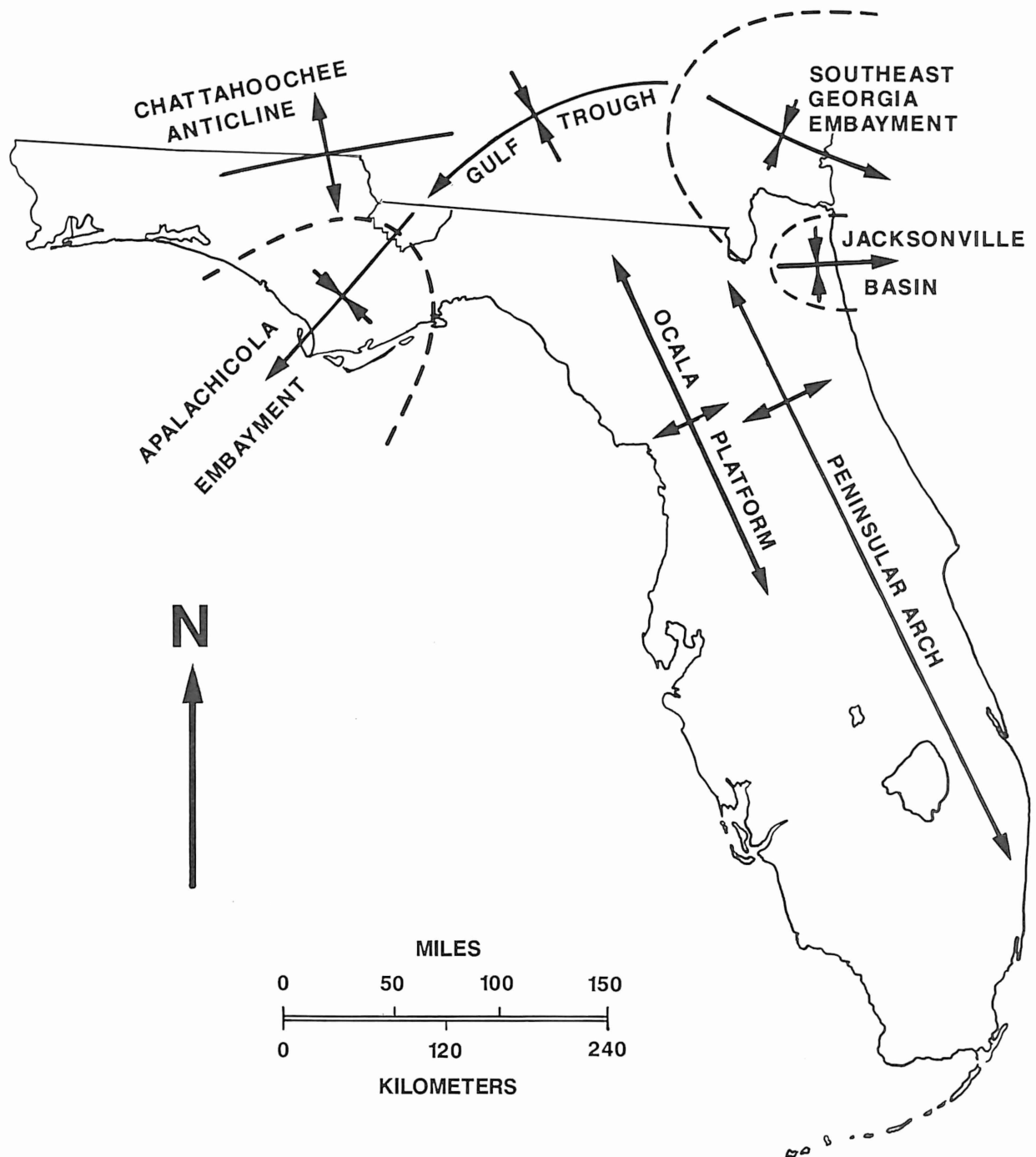


Figure 23. Principal subsurface structures of north Florida.

surface in the vicinity of the crest. Oligocene and younger sediments erosionally pinch out or are truncated against it (Schmidt, 1984).

Gulf Trough

Gadsden County lies in a transitional area between the carbonate-evaporite facies to the southeast and the terrigenous siliciclastic facies to the north and west. Dall and Harris (1892) proposed the existence of a channel-like area of erosion separating the continental border from the Eocene and Miocene islands of the Florida peninsula. Later authors, including Veach and Stephenson (1911), Applin and Applin (1944), Pressler (1947), and Jordan (1954) recognized a structural channel or trough, possibly a graben, in older sediments extending from southeast Georgia southwestward to the Big Bend area. Much of the early literature, which considered the trough to be a marine erosional feature, referred to it as the Suwannee Straits. Schmidt (1984) reviewed the structural history of the Gulf Trough. During Late Cretaceous through Oligocene time, this elongate structure connected the Southeast Georgia Embayment with the Apalachicola Embayment (Pressler, 1947). Structure maps on different stratigraphic horizons indicate the axis of the trough migrated over time. In the Late Mesozoic, the trough axis moved southeastward to the vicinity of western Taylor and Madison Counties; the direction reversed in the Early Tertiary and the trough moved northwestward to the present Gadsden/Liberty County area (Schmidt, 1984). The influence of the trough is apparent on the structure contour map of the Oligocene age Suwannee Limestone (Figure 14); the contour lines on the top of this formation trend northeastward into Georgia, defining the relative Oligocene position of the trough within Gadsden County. Throughout its existence as an open connection between the embayments, the trough was an area of slow deposition or non-deposition. Chen (1965) believed that strong, scouring marine currents in the trough formed both a lithologic and biologic facies barrier during almost

the entire Paleocene through Eocene time. Although its influence as a sediment barrier apparently waned by the end of the Oligocene, wells drilled in Oligocene and younger sediments over the trough show a sediment thickening which may be related to post-Eocene downwarping in the trough (Hendry and Sproul, 1966).

Ocala Platform

The Ocala Platform is a gentle, post-Oligocene flexure in west-central peninsular Florida. This structural high has an axis parallel to that of the Peninsular Arch, but the two features are unrelated (Applin, 1951). The platform exposes the Ocala Group and Avon Park Formation near its crest; Oligocene and younger sediments are erosionally truncated against the flanks of the structure (Applin, 1951).

GEOLOGIC HAZARDS

Gadsden County is situated in a geologically stable region of North America. The probability of the occurrence of a serious geologic hazard, such as a major earthquake, is low. Localized geologic hazards are more likely to affect small portions of the county. These include seasonal flooding, landslides, and sinkholes.

Flooding

The low-permeability of the surficial clayey sediments covering much of northern and central Gadsden County results in high precipitation runoff into the numerous drainage streams in the county. During periods of heavy or sustained rainfall, the streams and creeks may fill to capacity, eventually overflowing onto the surrounding land and filling topographically-low areas. Serious flooding has affected the county on at least two occasions in recent times. In early April of 1948, heavy showers caused major flooding throughout much of northern Florida. Figure 24 shows the flooded main street of River Junction on April 2, 1948. Heavy precipitation associated with a tropical storm in

September of 1969 also caused extensive flooding of low-lying areas throughout the county (Bridges and Davis, 1972). In this flood, several highway bridges were inundated, and some were damaged by raging waters.

The Pitt Landslide

Gadsden County's most notable landslide occurred on April 1, 1948, about three miles northwest of Greensboro (T3N, R5W, sec 32 dc) on the farm of Mr. D. W. Pitt. The slide opened a semicircular, 500-foot diameter pit (Figure 25), with soil flow to the northeast into Flat Creek. While the history of the slide is not well documented, flood-swollen Flat Creek probably initiated the sliding at the northeastern edge of the pit. Such landslides are not commonplace in Gadsden County. Similar slumping processes are known to occur on a smaller scale at the heads of drainage ravines, resulting in the "steepheads" common in Northern Florida.

Sinkholes

Sinkholes typically occur in areas underlain by karstic limestone with a thin, porous sediment veneer. Slightly acidic ground waters slowly dissolve subsurface caverns in the limestone, which may ultimately collapse under the weight of the surficial sediments, forming sinkholes. Limestone underlies much of Gadsden County, but is protected by variable thicknesses of low-permeability clays and clayey sands of the Citronelle and Miccosukee Formations. These clays retard downward percolation of water, and reduce the dissolution of the underlying limestone. The probability of sinkhole formation is therefore low for most of northern and central Gadsden County. Areas of the county with the highest probabilities of sinkholes are characterized by shallow-lying limestone or thin or absent clayey overburden sediments. These areas include northwestern Gadsden County, where the Chattahoochee Formation nears the surface, and at the southern tip of the county, south of the Cody Scarp, where the low permeability clays are thin or absent.

GROUND WATER

Ground water is water that fills the pores and interstitial spaces in the rocks and sediments beneath the surface of the earth. Most of Gadsden County's ground water is derived from precipitation within the county, in neighboring Florida counties and in south Georgia. A portion of the precipitation leaves the area by surface runoff in stream flow or by evapotranspiration. The remainder soaks into the ground and some moves downward into the porous zone of saturation. The top of the zone of saturation is known as the water table. Once in the zone of saturation, the water moves under the influence of gravity towards discharge points such as wells, seeps, springs, or eventually the Gulf of Mexico. Some of the water seeps into the deeper aquifer units, providing recharge to them.

In Gadsden County, three primary ground-water units are present. These are the surficial aquifer system, the intermediate confining unit, and the Floridan aquifer system (Southeastern Geological Society Ad Hoc Committee, 1986).

Surficial Aquifer System

Water in the shallow Plio-Pleistocene sand and clay units above the Hawthorn Group sediments is not confined and the water level is free to rise and fall. This unconfined water comprises the surficial aquifer system, and is not used extensively for public consumption (Pascale and Wagner, 1982). Most wells tapping the surficial aquifer system are dug wells, and yield less than five gallons per minute (gpm) (Wagner, 1983).

Intermediate Confining Unit

Sediments of the Hawthorn Group underlie the surficial aquifer in Gadsden County, and comprise an intermediate confining unit for the deeper Floridan aquifer system (Wagner, 1983). The clays, sandy clays, and marls of the upper part of this unit are generally of low permeability. In the lower half of the intermediate confining unit, thin carbonate



Figure 24. Photograph of the flooded Main Street in River Junction, Gadsden County, April 2, 1948.



Figure 25a. Aerial photograph of the Pitt landslide, April 2, 1948, T3N, R5W, sec 32 dc (photo by Tallahassee Aircraft Corporation).



Figure 25b. Photograph looking southwest at the scarp formed by the Pitt landslide (photo by R.O. Vernon, April 5, 1948).

beds are interbedded with the clays, and these create minor water-bearing zones generally yielding less than 10 gpm (Wagner, 1983). Leakage in the form of seeps frequently occurs from these minor aquifers in areas where rivers and streams dissect the water-bearing zones of the Hawthorn Group. The low permeability sediments within the intermediate confining unit also create an artesian aquifer in the underlying carbonates of the Floridan aquifer system.

Floridan Aquifer System

The name Floridan Aquifer was originally proposed by Parker, et al. (1955) for the artesian aquifer including all or parts of formations from Middle Eocene age to Middle Miocene age. The unit name was formally modified to Floridan aquifer system by the Southeastern Geological Society Ad Hoc Committee (1986). In Gadsden County, the St. Marks and Chattahoochee Formations comprise the upper portion of the Floridan aquifer system. Most public supply wells draw water from the upper Floridan aquifer system limestones at depths ranging from 120 to 300 feet below land surface. The Suwannee Limestone, the Ocala Group, and the Avon Park Formation comprise the lower units of the Floridan aquifer system in north Florida (Pascale and Wagner, 1982).

Two zones of differing hydrologic character are present within the Floridan aquifer system underlying Gadsden County (Wagner, 1983). One zone, occurring only in the northwest corner of the county near Chattahoochee, yields water in excess of 1000 gpm. Sediments within this zone are largely porous limestones, with solution-enlarged fissures or joints and well developed secondary porosity. In addition, this zone occurs immediately adjacent to the extensive recharge areas of eastern Jackson County, where porous surficial sediments directly overlie the Floridan aquifer system. Conductivity within this zone is estimated to be as high as 450 ft/day, with transmissivities exceeding 50,000 ft²/day (Wagner, 1983).

The second zone, which comprises the Floridan

aquifer system in the remainder of Gadsden County, is strikingly different. Thick, low-permeability sediments of the Hawthorn Group overlie the Floridan in this region. There is no direct recharge area present, and the porosity of the limestones within this area has not been increased by the acidizing effects of rainwater (Wagner, 1983). Recharge depends on leakage through the overlying confining unit sediments. As a result, maximum well yields are about 300 gpm near Quincy; hydraulic conductivity and transmissivity values are also low, at 25 ft/day and 5000 ft²/day, respectively (Wagner, 1983).

Potentiometric Surface

Water confined within an artesian aquifer is generally under a pressure greater than atmospheric, resulting in a positive static head. The height to which water rises in tightly cased wells penetrating an artesian aquifer forms an imaginary surface called the potentiometric surface. If the land elevation of a well is below the level of the potentiometric surface, the well will flow.

Figure 26 shows the potentiometric surface contours for the upper Floridan aquifer system in Gadsden County. The potentiometric surface varies from less than 40 feet MSL in southwest Gadsden County to over 70 feet above MSL in the extreme northwest corner of the county. Water flow in the aquifer is generally perpendicular to the contours, in this case, to the southeast.

MINERAL RESOURCES

The following discussion provides a general overview of the near-surface mineral commodities and petroleum resource potential for Gadsden County. Table 2 is a listing of the present mineral producers in Gadsden County.

CLAY

Clay occurs as a major constituent of the Citronelle and Miccosukee Formations and the

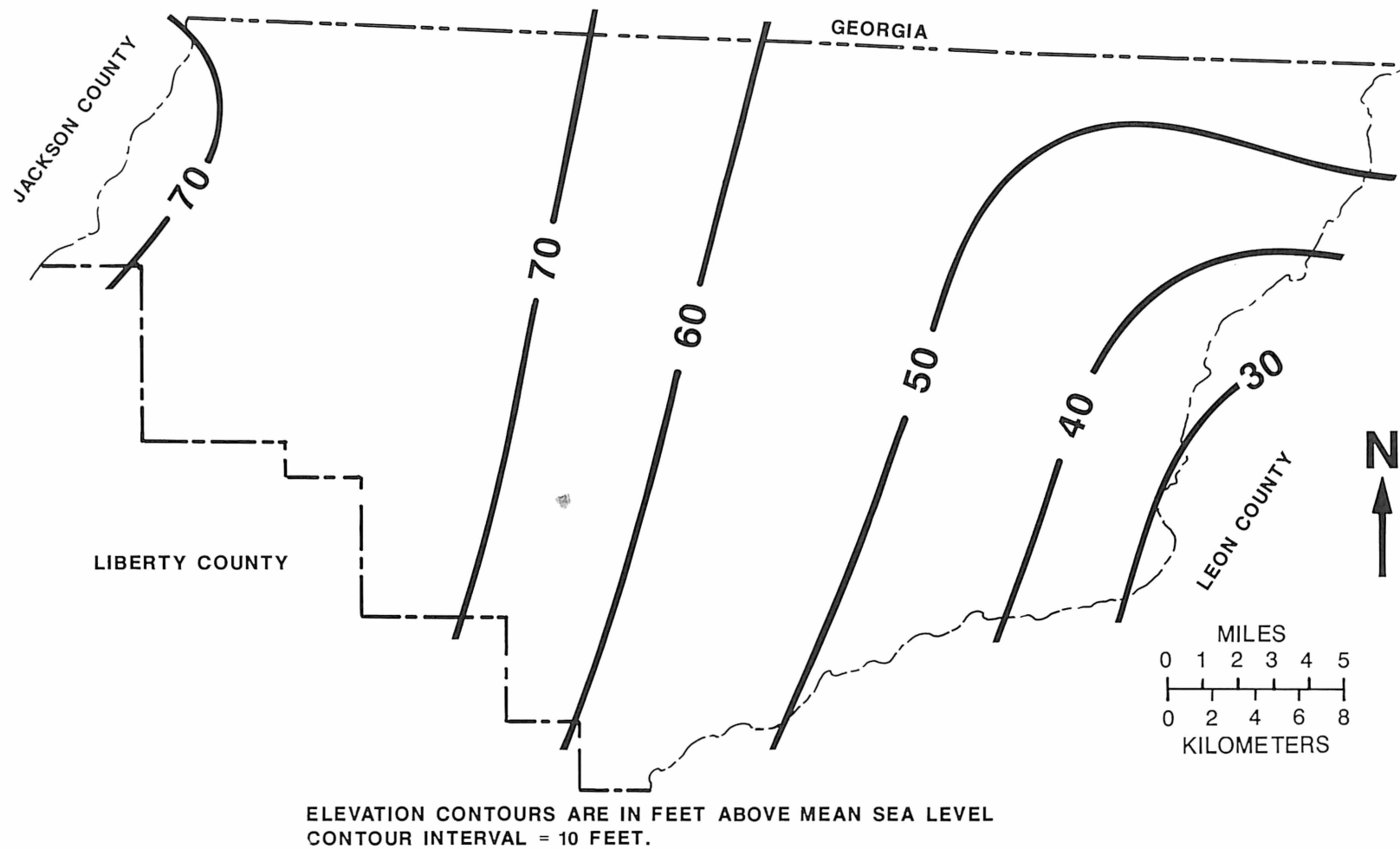


Figure 26. Potentiometric surface map of the Floridan aquifer system in Gadsden County.

Florida Geological Survey

Table 2. Mineral Producers by Commodity in Gadsden County (from Spencer, 1989)

CLAY	
<u>Company</u>	<u>Mine Location(T.R.S)</u>
Apalachee Correctional Institute P.O. Box 699 Sneads, FL 32460	Chattahoochee Pit 3N, 6W, sec. 8
FULLER'S EARTH	
Engelhard Corporation P.O. Box 220 Attapulgus, GA 31715	LaCamelia/Swisher Mines: 3N, 3W, multiple Midway Mine: 1N, 2W, multiple
Floridin P.O. Box 510 Quincy, FL 32351	Complex A Mine: 3N, 3W, multiple Complex B Mine: 3N, 3W, sec. 17 Complex C Mine: 3N, 3W, sec. 35
Milwhite Co., Inc. P.O. Box 96 Attapulgus, GA 31715	McCall Mine: 3N, 3W, sec. 4
Oil Dri P.O. Box 200A Ochlocknee, GA 31773	Fletcher McGinnis Mine: 3N, 3W, secs. 29,30,31,32
SAND	
Capital Asphalt P.O. Box 5767 Tallahassee, FL 32314	Davis Pit: 1N, 2W, sec. 21 Capital Asphalt Pit: 1N, 4W, sec. 21
Dravo Basic Material, Inc. P.O. Box 1685 Mobile, AL 36601	Chattahoochee River Plant 3N, 6W, sec. 5
Gadsden County Road Department P.O. Box 951 Quincy, FL 32351	Clark Pit: 2N, 6W, secs. 12,13 Fletcher Bar Pit: 2N, 6W, sec. 16 St. Hebron Pit: 2N, 3W, sec. 3 Walker Pit: 3N, 6W, sec. 28
River Bend Sand Company P.O. Box 1220 Quincy, FL 32351	River Bend Pit 1N, 4W, sec. 20

Hawthorn Group in Gadsden County. For the most part, the clays in the Citronelle and Miccosukee Formations are intermixed with varying proportions of quartz sand and gravel or occur as very thin discontinuous beds. Although these formations occur over much of Gadsden County, the impure, thinly-bedded nature of the contained clays precludes extensive utilization for fired products. However, the Apalachee Correctional Institution has, in the past, mined clay from its Chattahoochee Pit (T3N,R6W, sec. 8) for the local manufacture of brick. Bell (1924) provided physical property test results from what was probably a Chattahoochee Formation clay sample taken near the State Hospital at Chattahoochee:

Plasticity, judged by feel.....	Fair
Water of plasticity.....	21.40%
Pore water.....	0.10%
Shrinkage water.....	21.30%
Linear air shrinkage.....	6.40%
Volume air shrinkage.....	17.90%
Modulus of rupture, avg.....	84.5 pds /in ²
Slaking test.....	36 hours

Bell (1924) also listed test results from a second Citronelle Formation sample taken on the Key Plantation, three miles southeast of Quincy, which contained numerous limonite concretions:

Plasticity, judged by feel.....	Excellent
Water of plasticity.....	42.75%
Pore water.....	0.27%
Shrinkage water.....	24.48%
Linear air shrinkage.....	5.70%
Volume air shrinkage.....	15.75%
Modulus of rupture, avg.....	92.5 pd/in ²
Slaking test.....	24 hours
Overfires at cone 5.	

This sample had good plasticity and drying properties, but had low transverse strength and was of no

value for making fired products.

Alluvial clays associated with the Apalachicola and Ochlockonee Rivers have been mined in the past in Gadsden County for use in brick and tile making. One clay deposit located on what was then the State Hospital Farm, one mile northwest of Chattahoochee, was mined in the early 1920's for brick manufacture (Bell, 1924). This deposit reportedly exceeded 5 or 6 feet thick and covered an area of 60 to 80 acres in northwest Gadsden County and southwest Georgia. The following physical properties are recorded in Bell (1924):

Plasticity, judged by feel.....	Poor
Water of plasticity.....	32.25%
Pore water.....	5.40%
Shrinkage water.....	29.85%
Linear air shrinkage.....	17.50%
Volume air shrinkage.....	45.75%
Steel hard at cone 010.	

Bell (1924) also reported two alluvial clay mining operations in eastern Gadsden County. The Ochlockonee Brick Company mined a five-foot thick Ochlockonee River floodplain clay near Lawrence for use in common brick manufacture (Figure 27). This deposit was reportedly suitable for the manufacture of an excellent grade of common brick, hollow brick ware, and drain tile. The following table from Bell (1924) summarizes the physical properties of this clay:

Plasticity, judged by feel.....	Excellent
Water of plasticity.....	26.00%
Pore water.....	0.52%
Shrinkage water	25.48%
Linear air shrinkage.....	12.20%
Volume air shrinkage.....	33.20%
Modulus of rupture, avg.....	988.0 pds/in ²
Slaking test.....	2 days
Steel hard at cone 010.	

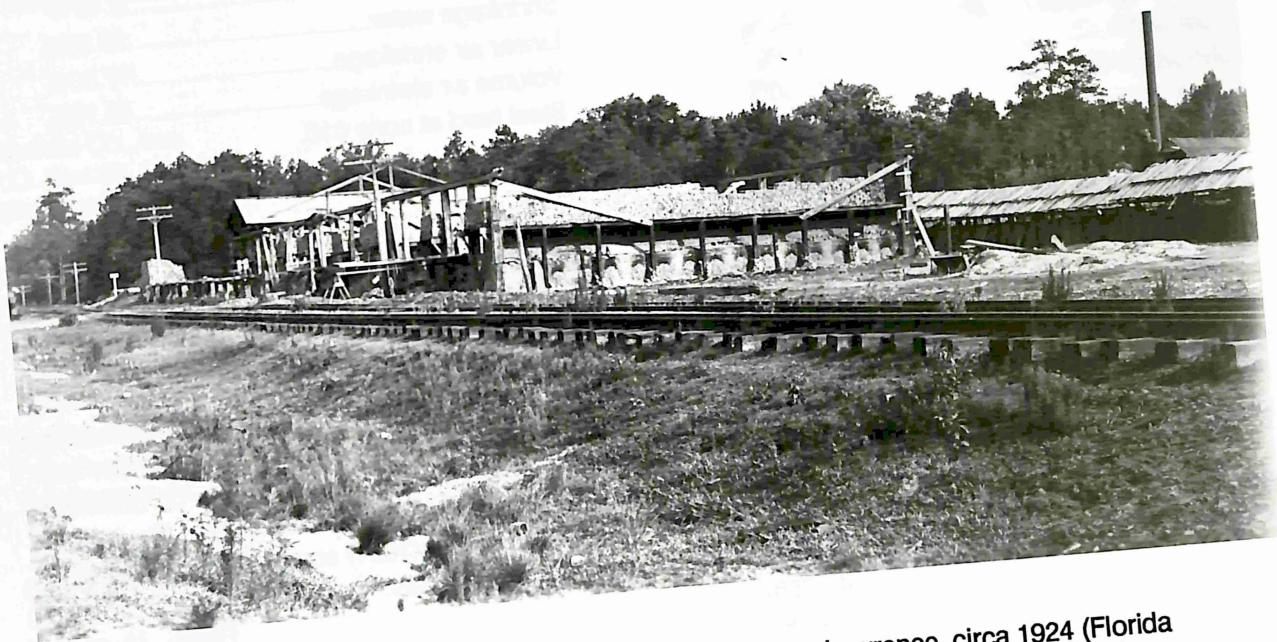


Figure 27. Photograph of the Ochlocknee Brick Company Plant at Lawrence, circa 1924 (Florida Geological Survey photo archives).

The Tallahassee Pressed Brick Company mined a second five feet thick alluvial clay deposit at an unrecorded location on the Ochlockonee River upstream from Lawrence. From this clay the company produced building brick, fireproofing, hollow blocks, and drain tile at its Havana plant during the 1920's. The following physical properties are reported by Bell (1924):

Plasticity, judged by feel.....	Excellent
Water of plasticity.....	25.65%
Linear air shrinkage.....	10.3%
Volume air shrinkage.....	27.8%
Modulus of rupture, avg.....	498.4 pds/in ²
Slaking test.....	48 hours
Steel hard at cone 010.	

Residual clays from the Chattahoochee Formation are generally calcareous, with high shrinkage and poor plasticity (Bell, 1924). Most of these clays are of no value in manufacturing. One exception was noted by Bell (1924) at the northeast edge of River Junction, where a variably thick Chattahoochee Formation clay was mined for construction brick in 1907. Several buildings in River Junction and Chattahoochee were reportedly constructed of bricks made from this clay deposit which underlies a small valley at River Junction, and in places, approached 15 feet in thickness. Bell (1924) reported the following physical properties for this clay:

Plasticity, judged by feel.....	Excellent
Water of plasticity.....	28.45%
Pore water.....	1.66%
Shrinkage water.....	26.79%
Linear air shrinkage.....	11.7%
Volume air shrinkage.....	29.4%
Modulus of rupture, avg.....	451.8 pds/in ²
Slaking test.....	2 minutes

Miocene clays associated with the Hawthorn Group sediments (considered by Bell (1924) to be clays of the Alum Bluff Group) have been mined for brick manufacture at various locations in Gadsden County. Bell (1924) noted the existence of plants at Hinson, circa 1859, and at Mount Pleasant, Grana, Quincy, and Chattahoochee during other unspecified periods prior to his 1924 publication. The Quincy plant extracted clays from the overburden removed during Fuller's earth mining. Bell (1924) provided the following physical properties for an overburden clay sample from the Quincy location:

Plasticity, judged by feel.....	Excellent
Water of plasticity.....	25.65%
Pore water.....	0.50%
Shrinkage water.....	25.15%
Linear air shrinkage.....	12.20%
Volume air shrinkage.....	36.82%
Modulus of rupture, avg.....	315.7 pds/in ²
Slaking test.....	2 minutes
Steel hard at cone 5.	

Fuller's Earth

Commercial deposits of fuller's earth, a Hawthorn Group palygorskite (attapulgitite) clay, occur in northern Gadsden County. These deposits were apparently formed in shallow Miocene lagoons or tidal flats, and trend in a northeasterly direction into south Georgia, approximately parallel to the axis of the Gulf Trough (Weaver and Beck, 1977).

The name fuller's earth dates back to ancient times when fine-grained sediments were used in the process of fulling, or increasing the weight and bulk of woolen cloth. Since biblical times, fuller's earth has been used as an absorbent cleaning material for cloth.

Fuller's earth is primarily composed of the clay mineral palygorskite (attapulgitite), and has been mined in the Gadsden County area since 1895 (Calver, 1957). The Floridin Company is currently mining palygorskite in several areas north and north

east of Quincy (Table 2). Two commercial grades of clay are produced from these mines: high yield grade and general purpose grade. High yield grade is nearly pure palygorskite, and exhibits excellent thixotropic (gelling) properties; uses of the high grade include drilling mud, no-carbon copy papers, liquid fertilizer suspenders, drugs, and paint thickeners (Kirk, 1983). General purpose grade clay is a mixture of palygorskite and montmorillonite. Due to its high absorbency, this product is used as an oil and grease absorbent, cat litter, and as insecticide carrier (Kirk, 1983). In addition to the Floridin Company, three other companies currently mine fuller's earth in Gadsden County. The Engelhard Corporation operates the LaCamelia and Swisher mines northeast of Quincy in T3N, R3W, and the Midway Mine in T1N, R2W. The Milwhite Company operates the McCall mine in T3N, R3W, section 4. Oil Dri recently began mining at the Fletcher McGinnis Mine No. 1, situated at the intersection of sections 29, 30, 31 and 32 of T3N, R3W (Schmidt et al., 1979; Campbell, 1986; Spencer, 1989).

In Gadsden County the mineable fuller's earth clay occurs in irregular, lenticular units and discontinuous beds within a variable series of fine to medium sands, silt, clay, minor carbonates, and occasional phosphate (Campbell, 1986). The ore is typically a blue to bluish-gray to grayish-green palygorskite clay, occurring in two distinct beds. The upper bed ranges up to eight-feet thick, and is mined only if it is substantially free of siliciclastics and carbonate impurities; the lower unit varies between 2 and 16-feet thick and is the primary commercial bed (Kirk, 1983). These units are generally separated by a variably thick, gray, clayey sand bed, which frequently contains carbonate beds, mollusks, vertebrate fossils and fossil wood. Figure 28 illustrates the stratigraphic section at the Engelhard Swisher Mine located north of Quincy, Florida. In this mine, the upper clay bed is quartz sandy and calcareous, and is not economical to mine. Only the lower grayish-blue palygorskite bed is mined. Figure 29 shows the lower fuller's earth bed at the Swisher Mine.

Mining of fuller's earth is accomplished primarily by earth-moving heavy equipment. Bulldozers and

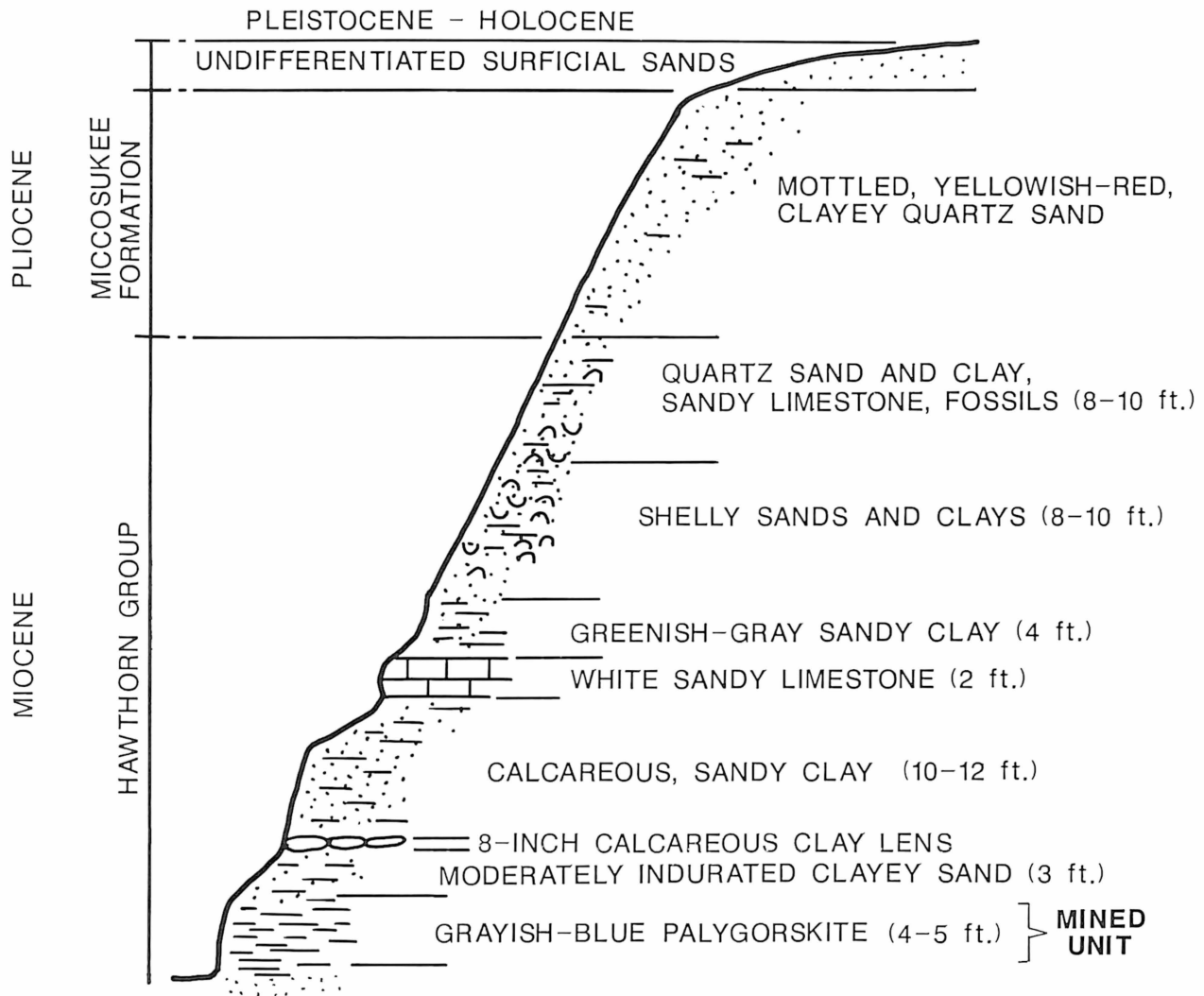
scrapers are used to remove the overburden, which consists of poorly consolidated to occasionally cemented sands, clays, and gravels of the Citronelle and Miccosukee Formations. Thickness of this overburden material averages 75 feet in northern Gadsden County, but may vary between a few feet and 100 feet (Patterson, 1974). Once the overburden is removed, the fuller's earth is stripped and loaded onto trucks by dragline (Figure 30). Trucks then haul the mined material to processing plants where impurities are extracted and the clay is dried, size graded, and packaged.

The fuller's earth mines in Gadsden County fall within the Meigs-Attapulugus-Quincy district of Florida and Georgia (Patterson, 1974; Spencer et al., 1989). Historically, this district has produced the bulk of the fuller's earth mined in the United States since 1895. Over 995,000 short tons, worth 6.5 million dollars, were mined in the district in 1986 (U. S. Bureau of Mines, 1986).

Limestone and Dolomite

Miocene limestone (CaCO_3) and dolomite ($\text{CaMg}(\text{CO}_3)_2$) belonging to the Chattahoochee Formation occur in near-surface deposits in northwestern Gadsden County. There are presently no active quarries in the county. Small-scale quarrying operations have existed near Chattahoochee in the past. One quarry south of Chattahoochee near River Junction, circa 1898, produced material used for cement, mortar and building stone; around 1925 small quantities of dolomitic limestone were dug one-half mile east of Florida State Hospital in Chattahoochee for use in a local dam (Cummings, 1899; Mossom, 1925). The following compositional analysis of the limestone obtained for the dam construction was given in Mossom(1925):

<u>Component</u>	<u>Percentage Composition</u>
Silica (SiO_2)	20.40
Iron and Alumina (Fe, Al)	3.74
Calcium carbonate (CaCO_3)	41.39
Magnesium carbonate (MgCO_3)	35.47



GENERALIZED GEOLOGIC SECTION ENGELHARD SWISHER MINE

Figure 28. Stratigraphic section at the Engelhard Swisher Mine north of Quincy, T3N, R3W (from Spencer et al., 1989).



Figure 29. Hawthorn Group fuller's earth sediments exposed at the Engelhard Swisher Mine (T3N, R3W), 1988.



Figure 30. Dragline mining at the Engelhard Swisher Mine (T3N, R3W), Gadsden County, 1988.

Most of the limerock derived from the Chattahoochee Formation occurs in thin, impure beds which are not economical for large scale mining, and additionally has the undesirable characteristic of being too soft for use as road base (Patterson, 1974).

Mossom (1925) and Schmidt et al. (1979) indicated a small area of limestone outcrop in the northeastern corner of Gadsden County, along the Ochlockonee River. The formational affinity of this limestone has not, to this writer's knowledge, been stated in the literature. Based on the local stratigraphy, it is tentatively assigned to the Torrey Formation of the Hawthorn Group. Mossom (1925) provides the following compositional analysis of a sample of this limestone taken at Ponto Springs, T3N, R1W, sec 10:

<u>Component</u>	<u>Percentage Composition</u>
Silica (SiO ₂)	49.58
Iron and Alumina (Fe, Al)	1.96
Calcium carbonate (CaCO ₃)	44.30
Magnesium carbonate (MgCO ₃)	---
Undetermined	5.16

Although unproven, the high quartz sand content, as well as the soft nature of most Hawthorn Group limestones, suggest that this limestone is not of commercial quality.

Sand and Gravel

Quartz sand and gravel (SiO₂) occur in abundance over most of Gadsden County. It is a principal component of the Holocene alluvial deposits and the relict Plio-Pleistocene marine deposits, as well as the Citronelle and Miccosukee Formations which cap the Tallahassee Hills. Much of this sand occurs interbedded and consolidated with clays and silts, and washing is required to extract the sand. Martens (1928) analyzed a sample from the Citronelle Formation, taken one mile southwest of Concord, Gadsden County, with the following results:

<u>Percentage Passing Each Sieve</u>							<u>Silt and Clay</u>
<u>1/4 inch</u>	<u>10</u>	<u>20</u>	<u>50</u>	<u>100</u>	<u>200</u>		<u>(Elutriation Loss)</u>
46.1	---	95.0	85.5	61.9	50.5		41.2

Sand and gravels occurring in river banks, bars, and beds are generally clean and require little processing before use. Hendry and Sproul (1966) report that sands have been mined from the Leon County side of the Ochlockonee River. In Gadsden County, sand has been extracted from the Ochlockonee River east of the town of Gibson, for use in construction and in the manufacture of concrete-bonded brick. Martens (1928) reported similar operations by the Tallahassee Pressed Brick Company, and presented the following analysis of sand collected from an Ochlockonee River bar southeast of Havana:

<u>Percentage Passing Each Sieve</u>						
<u>1/4 inch</u>	<u>10</u>	<u>20</u>	<u>50</u>	<u>80</u>	<u>100</u>	<u>200</u>
100	---	91.5	28.4	---	3.7	3.0

Dravo Basic Materials Incorporated currently dredges sand and gravel from the Apalachicola River at their Chattahoochee River plant, T3N, R6W, sec. 5. A sample collected by Martens (1928) at the Chattahoochee mining location yielded the following results:

<u>Percentage Passing Each Sieve</u>						
<u>1/4 inch</u>	<u>10</u>	<u>20</u>	<u>50</u>	<u>80</u>	<u>100</u>	<u>200</u>
---	100	60.6	13.1	---	1.7	0.5

Capital Asphalt Company maintains sand operations at the Davis Pit (T1N, R2W, sec. 21) and the Capital Asphalt Pit, off Highway 267 (T1N, R4W, sec. 21). The primary use for this sand is road construction and asphalt additive.

River Bend Sand Company also operates a sand mine near S.R. 267 south of Quincy (T1N, R4W, sec.

20). This mine produces primarily concrete and masonry sand.

The Gadsden County Road Department presently operates four borrow pits in undifferentiated and Citronelle Formation sediments (see Table 2). These sands and clayey sands are utilized as road base and fill by the county.

The abundance of sand and gravel within Gadsden County makes impure construction and fill grade sand-mining potential relatively high. Due to the lack of demand, however, development of this industry on a large-scale basis remains unlikely.

Phosphate

Phosphatic sand and granules occur in most of the Hawthorn Group sediments and in portions of the Chattahoochee Formation in Gadsden County. Some phosphatic material also occurs as reworked Miocene sediments in Plio-Pleistocene deposits. Analysis of well cuttings from Gadsden County reveals that phosphate concentrations are generally less than 10 percent in sediments throughout the county. Phosphate exploration samples taken by mining companies in nearby Leon and Wakulla Counties showed a maximum phosphorite (P_2O_5) concentration of only 5.45 percent (Patterson et al.,

1986). Since modern phosphate mining requires a minimum P_2O_5 content of 28 percent (Cathcart and Patterson, 1983), commercial phosphate potential for Gadsden County and the Big Bend Area as a whole is low.

Petroleum

The current production of oil in Florida occurs from Mesozoic age sediments in two major areas of Florida. In south Florida, a number of fields are situated along the Sunniland Trend, and produce from the Lower Cretaceous Sunniland Formation; in northwestern Florida, a series of fields in northern Santa Rosa County produce oil from the Jurassic Smackover and Norphlet Formations (Applegate and Lloyd, 1985).

Various companies have drilled a total of nine oil test wells in Gadsden County, ranging in depth from 1,750 feet below land surface (bls) to 7,021 feet bls (Figure 8). None of the wells encountered oil or gas, and were all plugged and abandoned as dry holes. Although none of the wells reached Jurassic section, the position of Gadsden County updip of the productive Smackover and Norphlet Formation pinchouts precludes a high petroleum potential for the area (Applegate et al., 1978).

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FLORIDA GEOLOGICAL SURVEY**

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