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TECTONIC CONTROLS ON LOWER DEVONIAN SANDSTONE DISTRIBUTION, ALABAMA

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ABSTRACT OF THESIS

TECTONIC CONTROLS ON LOWER DEVONIAN SANDSTONE DISTRIBUTION, ALABAMA

The Devonian Frog Mountain Formation thickens abruptly eastward across the Eastern Coosa thrust fault from <12 m on the west to >70 m on the east. The thin Frog Mountain on the west unconformably overlies the Cambrian-Ordovician Knox Group. The thin Frog Mountain (mostly shale) is overlain by the Mississippian Maury Shale (~1 m thick) and Fort Payne Chert (~50 m thick). The thick Frog Mountain on the east rests on the Middle Ordovician Athens Shale, a black shale >150 m thick. The Athens overlies the Knox Group. The thick Frog Mountain is nearly all sandstone and is overlain by Fort Payne Chert which is only ~1 m thick

In the Eastern Coosa hanging wall, an upper-level out-of-the-syncline thrust fault with thick Frog Mountain in the hanging wall cuts more than 290 m stratigraphically down section from Athens to lower Knox in the footwall. The upper-level Frog Mountain thrust sheet crosses over the Eastern Coosa fault, and truncates folds in the Eastern Coosa footwall, moving ~2 km.

The thick Frog Mountain Formation associated with the Eastern Coosa thrust sheet has been transported ~100 km cratonward. The Frog Mountain Formation was deposited over a low topographic high, which was in the location of the Blountian peripheral foreland bulge.

KEYWORDS: Lower Devonian Frog Mountain Formation, Eastern Coosa thrust sheet, out-of-the-syncline thrust, Blountian peripheral foreland bulge, Alabama

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TECTONIC CONTROLS ON LOWER DEVONIAN SANDSTONE DISTRIBUTION, ALABAMA

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THESIS

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The Graduate School

University of Kentucky

2010

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THESIS

A Thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Arts and Sciences
at the University of Kentucky

By

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To Neil C. Solis

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CHAPTER 1: INTRODUCTION

General

In the Appalachian thrust belt in Alabama, the basal décollement is generally in Lower to Middle Cambrian starta, and the immediately overlying Upper Cambrian to Lower Ordovician Knox Group carbonates constitute a regional stiff layer that controls the structure of large-scale thrust sheets (Thomas and Bayona 2005). In much of the thrust belt, the basal décollement is in the Middle to lower Upper Cambrian Conasauga Formation; however, around the field area, older beds (Lower Cambrian Chilhowee, Shady, and Rome strata) are included in the hanging walls of large thrust faults. The strata above the Knox Group stiff layer were generally transported passively on the thrust sheets; however, in some thrust sheets upper-level detachments imbricate parts of the post-Knox succession (Thomas and Drahovzal, 1974). In the field area, the post-Knox succession exhibits abrupt variations, suggesting both local and/or larger scale faults.

In Alabama, the stratigraphic succession between the top of the Knox Group (top of the Lower Ordovician) and the top of the Fort Payne Chert (near the top of the Lower Mississippian) includes four regional unconformities and encompasses significant variations in thickness and facies between the unconformities (Thomas and Osborne, 1995). The stratigraphic variations are explained by gradual changes along strike within some thrust sheets, and contrasts between thrust sheets indicate tectonic shortening of the stratigraphic gradient. Within one thrust sheet (the Coosa thrust sheet), as mapped by Osborne and others (1988), an abrupt along-strike boundary between two strongly contrasting post-Knox successions is unexplained. Current mapping of the area (Thomas and Bayona, 2005) demonstrates a large regional-scale thrust fault, the Eastern Coosa fault, which translates the contrasting successions into close proximity.

Purpose

To better understand to nature of the Eastern Coosa fault, a field study was conducted. The map area was chosen because it contains the junction of the Eastern Coosa and Western Coosa faults. The Field area is where the two contrasting post-Knox successions are in very close proximity. Field mapping, structural analysis of field area, Ever since the Frog Mountain Formation was first identified (Hayes, 1894 1902) it was been a chronostrigraphic unit rather than a lithostratigraphic unit (Butts, 1926). Any unit identufied as early Devonian in age was mapped as Frog Mountain. Thus the Frog Mountain Formation consists of several facies, but is dominated by a thick nearly all sandy facies, and a thin mostly shale facies. Comprehensive studies of the Frog Mountain Formation (Kiefer, 1970; Ferrill, 1984) have better identified age appropriate early Devonian strata, and have demonstrated that at the base of the Lower Devonian Frog Mountain Formation, there are as many as three regional unconformities merging. The top of the Frog Mountain formation is also marked by a regional unconformity. Alleghanian juxtaposition and erosion destroyed much of the Frog Mountain Formation facies relationships. Incorpoating conclusions from mapping, previous workers data, and a palinspastic restored thrust sheet map (Thomas and Bayona, 2005), some conclusion can be drawn about the distribution of Lower Devonian Frog Mountain Formation.

Field area

The field area is in the southeastern Appalachian thrust belt in the Ellisville and Piedmont 7.5-minute quadrangles, Cherokee County, Alabama (Figure 1.1; Plate 1). The area has been mapped previously by Hayes (1894, 1902), Cloud (1967), Bearce and others (1977), and Osborne and others (1988, 1989).

As currently mapped, the field area comprises the juncture of four thrust sheets: Rome, Western Coosa, Eastern Coosa, and Jacksonville. The Rome, the Western Coosa, and the Eastern Coosa thrust sheets have strongly contrasting stratigraphic successions, whereas the Eastern Coosa and Jacksonville thrust sheets share similar stratigraphy. In general, rock units in the area include the Lower Cambrian Shady Dolomite, Lower Cambrian Rome Formation, Middle to lower Upper Cambrian Conasauga Formation, Upper Cambrian to Lower Ordovician Knox Group, Middle Ordovician Athens Shale, Lower Devonian Frog Mountain Formation, Lower Mississpippian Maury Shale, Middle Mississippian Fort Payne Chert, and Upper Mississippian Bangor Limestone and Floyd Shale.

Topography

The field area lies in the Appalachian Valley and Ridge Province (Plate 1). The topography is dominated by ridges capped with relatively erosional resistant strata, and valleys are floored with strata more erosionally susceptible. Terrapin Creek is a prominent erosional feature which meanders from south to north, bisecting a number of ridges through the field area. In general, the valleys and ridges trend northeast-southwest. Low hills in the northern part of the field area are lined with the Conasauga Formation. To the west, these hills are broken by Coloma Mountain, an easterly trending ridge with the Shady Dolomite at the base, and the Rome Formation at the crest. Coloma Mountain ridge ends to the east. A relatively small valley in the Conasauga Formation, cut by drains that flow into Terrapin Creek, separate Coloma Mountain from the next set of dominant ridges to the south. A nearly continuous ridgeline capped with the Knox Group traverses the field area. Roberts Mountain, Freeman Hill, and Craig Mountain are prominent features along the Knox capped ridgeline. The south side of the Knox Group ridgeline is a dip-slope. To the west, a set of three northerly striking ridges have Frog Mountain Formation at the crest and are separated by valleys floored with Floyd Shale and/or Bangor Limestone. These ridges culminate to the north in an irregularly shaped ridge capped with sandstone. In the central part of the field area, a dominant ridge of Frog Mountain Formation strikes northeast. This ridge includes Casey Hill, Frog Mountain proper, and Brown Mountain. The Frog Mountain Formation ridge as a whole will be referred to as Frog Mountain ridge herein. To the south of Frog Mountain ridge is a low valley lined with Athens Shale. Farther southeast, a low ridge of Knox Group strikes northeastward. Farther south, a low ridge of Rome traverses the field area. Another valley floored with the Consauga Group separates the Rome ridge from several low northeast-striking ridges of the Knox Group.

Regional Stratigraphy

Lower Cambrian Shady Dolomite

The Shady Dolomite was described by Cloud (1967) as thinly laminated, light to dark-gray, fine- to medium-grained dolostone, which is locally siliceous and silty. He described the upper 45 m as maroon, yellow, and mauve silty clay and clayey siltstone that grades upward into the overlying Rome Formation. Cloud (1967) estimated the Shady to be 113 m thick in Cherokee County. In Cherokee County, Cloud (1967) did not observe the Shady in place but mapped it on the basis of residuum and topography.

The Shady Dolomite is part of a transgressive succession that records deposition on a shallow continental shelf (Thomas and others, 2000). The Chilhowee Group, which underlies the

Shady, marks the beginning of the transgression. This transgression continued through the deposition of the Shady Dolomite. The Chilhowee-Shady transgressive sequence records the early post-rift subsidence along the Blue Ridge rift (Thomas and others, 2000).

Lower Cambrian Rome Formation

The Rome Formation consists of interbedded sandstone, siltstone, and shale. Minor amounts of carbonate are reported, and anhydrite is preserved in the subsurface (Thomas and Drahovzal, 1973; Thomas and others, 2000; Thomas and others 2001). Cloud (1967) estimated the Rome have a thickness of 304 m. The Rome Formation is gradational with the overlying Conasauga Formation.

The Rome Formation indicates an influx of siliciclastic sediment that was episodically exposed subaerially. The sudden influx of clastic sediment interrupted deposition of the Shady dolomite, and indicates a new source for detritus (Thomas and others, 2000). The initial deposition of the Rome Formation closely corresponds to Ouachita rifting, suggesting the influx of sediment is related to crustal extension (Thomas and others, 2000). The rift-related sediment supply continued through the Middle Cambrian.

Middle to Lower Upper Cambrian Conasauga Formation

The Conasauga Formation exhibits four distinct facies in the Western Coosa and Rome thrust sheets as identified by Cloud (1967) and Thomas and Drahovzal (1973). Conasauga exposed in the Western Coosa thrust sheet constists of a lower interbedded shale/limestone facies and an upper oolitc calcarenite facies. The lower Conasauga within the Rome thrust sheet is dominantly interbedded fine-grained clastic rocks, whereas the upper Conasauga is a ribbon-bedded argillaceous limestone.

The basal clastic-rich Conasauga represents the continued supply of clastic sediment related to Ouachita rifting (Thomas and others, 2000). The Conasauga is an intermediate unit between the underlying clastic-dominated Rome Formation and the overlying carbonate-dominated Knox Group.

Upper Cambrian to Lower Ordovician Knox Group

The Knox Group consists of Copper Ridge Dolomite, Chepultepec Dolomite, Longview Limestone, and Newala Limestone in ascending order. The Knox Group ranges in thickness from 800 m to 1100 m (Thomas and Drahovzal, 1973). The lower part of the Knox Group consists of light-colored siliceous dolostone, which is overlain by fine- to coarse-grained limestones in the upper part of the group. The Longview Limestone and Newala Limestone were mapped together by Cloud (1967). Cloud (1967) estimated a combined thickness of 243 m, which is consistent with outcrop width. The Knox Group is bound by an unconformity at the top.

The Knox Group was deposited on a huge carbonate platform on the Laurentian craton (Raymond, 1993). During Knox deposition, Laurentia straddled the equator, and much of what is now the southern United States was in the Southern Trade Wind belt (Scotese, 1990). The Copper Ridge Dolomite and the Chepultepec Dolomite of the Knox represent overall trangressive sequences followed by an abrupt deepening (Raymond, 1993). The post-Knox unconformity marks the Early and Middle Ordovician boundary (Sloss, 1988).

Middle Ordovician Athens Shale

The Athens Shale is an organic-rich black shale with local dark-gray limestone and sandstone interbeds (Thomas and Osborne, 1995). Cloud (1967) estimated the thickness of the Athens Shale to be 30 m to 122 m. The Athens Shale represents the flysch-like deposits commonly found in the Appalachian basin, in a flexural-foreland basin model (Bayona and Thomas, 2003). The Athens Shale is part of the Taconic clastic wedge (Thomas and Osborne, 1995).

Lower Devonian Frog Mountain Formation

Hayes (1894, 1902) originally recognized and named the Frog Mountain Formation for outcrops at the southwestern end of Frog Mountain ridge (Plate 1). Frog Mountain lies in the Eastern Coosa thrust sheet where the Devonian Frog Mountain Formation is abnormally thick, and nearly all sandstone. Hayes estimated 244 m to 366 m of thickness, whereas Ulrich (1909) measured 107 m of Frog Mountain Formation. Cloud (1967) estimated 152 m of Frog Mountain, and Kiefer (1970) measured 71 m. Drahovzal and Thomas (1977) measured 78 m at the type section locality. Ulrich’s (1909) measured section includes the siliceous dolomitic limestone exposed at the base of the Frog Mountain Formation at the type locality. Cloud (1967) and Drahovzal and Thomas (1977) mapped the siliceous dolomite as Ordovician. The variation in thicknesses of previous workers is probably a result of the structural complexity of the type section locality. Kiefer’s measured section is the most detailed estimate of the true thickness of the Frog Mountain Formation in the Eastern Coosa thrust sheet, and this section follows:

			Meters
MISSISSIPPIAN SYSTEM			
Fort Payne Chert or Floyd Shale (7.6+ m)			
	13.	Cover, shaley chert float	7.6
	12.	Chert, irregularly bedded, fossiliferous	0.9
DEVONIAN SYSTEM			
Frog Mountain Formation (71+ m)			
	11.	Shale, thin to irregularly bedded, highly arenaceous, cherty	1.5
	10.	Sandstone, medium to thick bedded, coarse-grained, massive	4.0
	9.	Sandstone, thin to medium bedded, medium-grained	2.7
	8.	Sandstone, very thin to thin bedded, medium-grained	1.5
	7.	Sandstone, thin to medium bedded, medium- to coarse-grained	4.3
	6.	Sandstone, very thin to medium bedded, occasionally irregularly bedded, medium-grained, cross-bedded	17.3
	5.	Covered, calcareous coarse-grained sandstone float.	15.2

	4.	Sandstone, thick bedded, medium-grained	0.6
	3.	Sandstone, very thin to medium bedded, medium-grained	3.7
	2.	Covered, arenaceous limestone or calcareous sandstone float	20+
ORDOVICIAN SYSTEM			
Newala Limestone (7.6+ m)			
	1.	Limestone, thick to very thick bedded, finely crystalline, sparsely fossilliferous	7.6+

On the southern side of Frog Mountain ridge, the base of the Frog Mountain Formation is above the Middle Ordovician Athens Shale. On the northern side of Frog Mountain ridge, the base of the Frog Mountain Formation is above the Upper Cambrian to Lower Ordovician Knox Group (Plate 1). The thick, sandy, Frog Mountain Formation is mainly known from outcrops in the vicinity of Frog Mountain ridge. Another Athens–Frog Mountain Formation–Fort Payne succession; however, is exposed near Anniston, Alabama, within the Coosa deformed belt (Thomas and Drahovzal, 1974), where 30 m of Frog Mountain Formation ovelies the Athen Shale. Approximately 3 m to 5 m of Fort Payne Chert overlies the thick Frog Mountain.

The thick Frog Mountain Formation was deposited in a marginal-marine environment (Butts, 1926; Kiefer, 1970). The unconformity at the base of the Frog Mountain represents the merging of two regional unconformities at the top of the Ordovician System, and at the top of the Silurian System (Ferril and Thomas, 1988).

North and west of the Eastern Coosa fault in the Western Coosa thrust sheet, typical thickness of the Frog Mountain Formation is less than 12 m on the basis of outcrop width and measured sections. In general, only the upper third of the Frog Mountain Formation is sandstone. In the Western Coosa thrust sheet, the Frog Mountain Formation is exposed as isolated thin beds or pebbly float. Complete sections of Frog Mountain are scarce. Thomas and Drahovzal (1977) measured 11 m at a road cut on Alabama highway 9 (Plate 1, NE 1/4, NE 1/4, sec. 18, T 12 S, R10 E). The dominant lithology of the Frog Mountain Formation is shale:

MISSISSIPPIAN SYSTEM		Meters
Fort Payne Chert		
DEVONIAN SYSTEM		
Frog Mountain Formation		
6.	Sandstone, fine-grained	0.6
5.	Claystone	1.8
4.	Sandstone, fine- to coarse-grained	0.9
3.	Claystone and chert interbedded	2.7
2.	Claystone and chert interbedded	3.0
1.	Sandstone, fine- to medium-grained	0.9
Covered		

The site of this section is now covered, but the description is consistent with outcrops in road cuts along continuous ridges that extend outside the field area. The outcrop trend of the Frog Mountain is along northerly striking ridges. Cloud (1967) mapped these narrow ridges as late Devonian or early Mississippian, and noted that the sandstone rests unconformably on Early Ordovician Newala Limestone. Cloud (1967) suggested that transgressive Mississippian seas reworked the Devonian sediments.

Lower Mississippian Maury Shale

The Maury Shale is not exposed in the field area, but is exposed above the Frog Mountain Formation at nearby locations (Kiefer, 1970). The Maury Shale is no more than 3 m to only several centimeters thick. The shale is greenish-gray, contains phosphate nodules and glauconite, and represents most of Kinderhookian time (Conant and Swanson, 1961; Kiefer, 1970; Thomas, 1972, 1977; Pashin, 1993).

Middle Mississippian Fort Payne Chert

The Fort Payne Chert was originally undifferentiated from the Mississippian Floyd Shale and Bangor Limestone by Cloud (1967), but later was mapped as undifferentiated Devonian Frog Mountain Formation and Fort Payne Chert because the units are relatively thin (Bearce and others, 1977). The Fort Payne Chert is estimated to be 50 m thick in the Western Coosa thrust sheet. In the Eastern Coosa thrust sheet, the Fort Payne was reported to be ~1 m by previous workers (Kieffer, 1970; Thomas and Drahovzal, 1977).

The Fort Payne represents the lower part of a carbonate ramp (Thomas, 1972). The abundant crinoids in the lower ramp indicate that it was relatively rich in oxygen and nutrients caused by upwelling of cold nutrient-rich water from the Ouachita embayment (Gutschick and Sandberg, 1983).

Upper Mississippian Bangor Limestone and Floyd Shale

The Bangor Limestone in Northern Alabama ranges from 130 m to 180 m thick (Thomas, 1972). To west, the Bangor thins and grades into the Floyd Shale. To the southeast, in the fold-trust belt, the Bangor thins and grades westward (along-strike of regional structures) to a clastic facies, as well. In northwestern Georgia, the Bangor is as much as 200 m thick (Thomas, 1979). In Georgia, the Bangor Limestone grades southeastward into and intertounges with the Floyd Shale, and the Bangor tongue includes many clastic interbeds of clay shale and sandstone. The Bangor Limestone with the sandstone and shale interbeds indicate intertoguing of the carbonate and clastic facies.

The Floyd Shale in Alabama grades upward into the Bangor Limestone and Parkwood Formation (Thomas, 1979). In northeastern Alabama, the Floyd-Parkwood contact rises above the Bangor Limestone, and the Bangor is a massive carbonate tongue within the Floyd Shale. In Georgia, the Floyd Shale is as much as 290 m thick and is overlain by a tongue of Bangor.

In the field area, intensely folded and weathered Bangor Limestone is surrounded by Floyd Shale within the Western Coosa thrust sheet. The exact Bangor-Floyd relationship is unknown, because of poor exposure; however, the Bangor Limestone in the field area marks the southernmost extent of Bangor Limestone, apparently as a tongue within the Floyd Shale.

Echinoderm and foraminifera establish a Chesterian age for the Bangor Limestone (Rich 1980). The Bangor signifies the development of carbonate bank cratonward of the Laurentian continental margin (Pashin, 1993), and the limestone intertoungues with the Floyd Shale. The Floyd Shale represents a prodelta facies which prograded to the northwest in Georgia.

Previous Structural Interpretations

Previous mappers recognized the irregular relationship of the Lower Devonian Frog Mountain Formation and the underlying Ordovician strata. Cloud (1967) noted the thick Frog Mountain Formation along Frog Mountain ridge overlies the Knox Group (Chepultepec Dolomite, Longview Limestone, Newala Limestone), and Athens Shale and suggested a Taconic disturbance and an angular unconformity beneath the Frog Mountain Formation. Drahovzal and Thomas (1977) traced the thick Frog Mountain Formation west to two Frog Mountain Formation outliers along Terrapin Creek. Drahovzal and Thomas (1977) noted the Knox Group/Athens Shale/Frog Mountain Formation outcrop relationship. They also recognized abrupt structural changes within the Frog Mountain Formation outcrop belt, and a sandstone breccia commonly filled with limonite associated with the thick Frog Mountain Formation. Drahovzal and Thomas (1977) suggested a detachment surface at the base of the Frog Mountain Formation rather than a pre-Devonian angular unconformity, and the Frog Mountain outliers are thrust klippen.

Hayes (1894, 1902) initially mapped the Coosa fault as an extensive regional fault that extends through the field area. Cloud (1967) noted outliers of the Knox Group resting on thin expressions of the Conasauga Formation near the Coosa fault and suggested the Providence Church fault: a steep, south-dipping normal fault which overprinted part of the Coosa fault. Drahovzal and Thomas (1977) included parts of the Providence Church fault but did not recognize it as structure that obliterated the Coosa fault. Subsequent regional mappers (Osborne and others, 1988; 1989) did not recognize the Providence Church fault, but mapped the Coosa fault. Thomas and Bayona (2005) recognized the Western Coosa and Eastern Coosa faults. Both faults have a similar detachment level, but contrasting post-Knox strata.

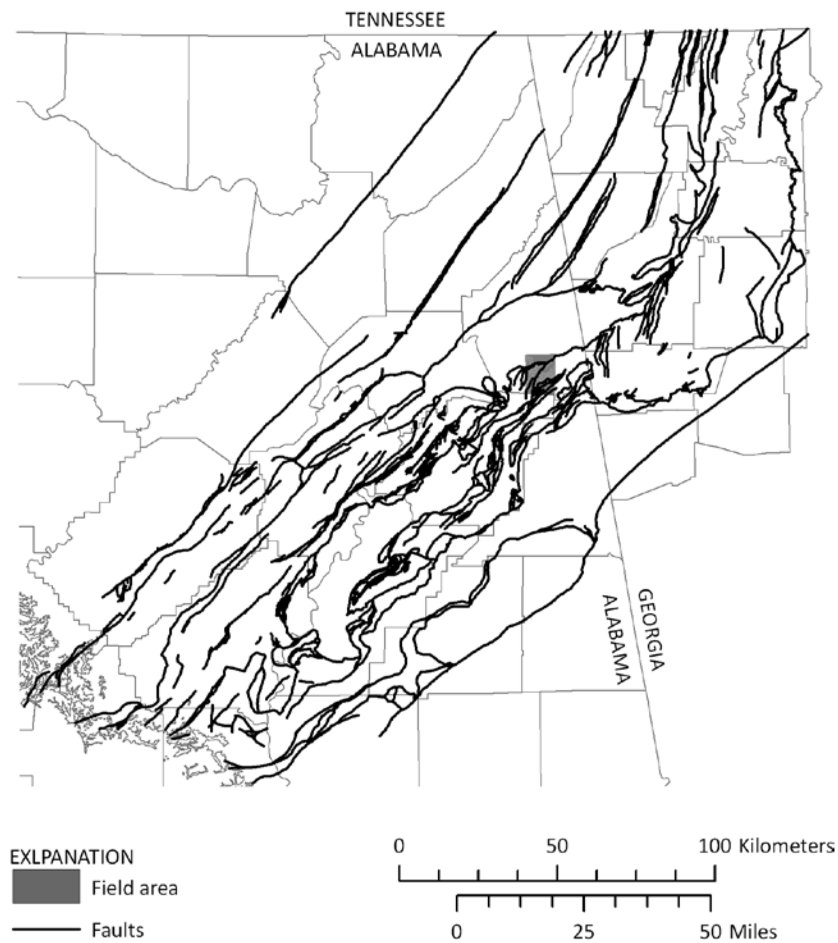

Figure 1.1. Field area location denoted by black polygon. Birmingham, Alabama marked by large black circle. Piedmont, Alabama marked by small black circle. Thrust faults are red.

CHAPTER 2: STRATIGRAPHY OF THE ROME THRUST SHEET

Conasauga Formation

In the field area, no strata younger than Conasauga are exposed in the Rome thrust sheet. Two of the four Conasauga regional facies are exposed (Plate 1 and Figure 2.1). The lower part is predominantly light- to dark-gray and olive shale, siltstone, and sandstone with sparse interbeds of dark-gray to black calcisiltite. Isolated outcrops of the lower Conasauga are in the low hills of the Rome thrust sheet. The upper part of the locally exposed Conasauga is buff to medium-gray, ribbon-bedded, argillaceous calcisiltite to calcilutite. A good exposure of the upper part of Conasauga facies is at Ellisville west of the water tank, on Alabama Highway 9, where it crosses Terrapin Creek (NW ¼, Sec 20, T 11 S, R 10 E, Plate 1). The true thickness of the Conasauga north of the Western Coosa thrust fault is difficult to estimate because of intense deformation within the Rome thrust sheet.

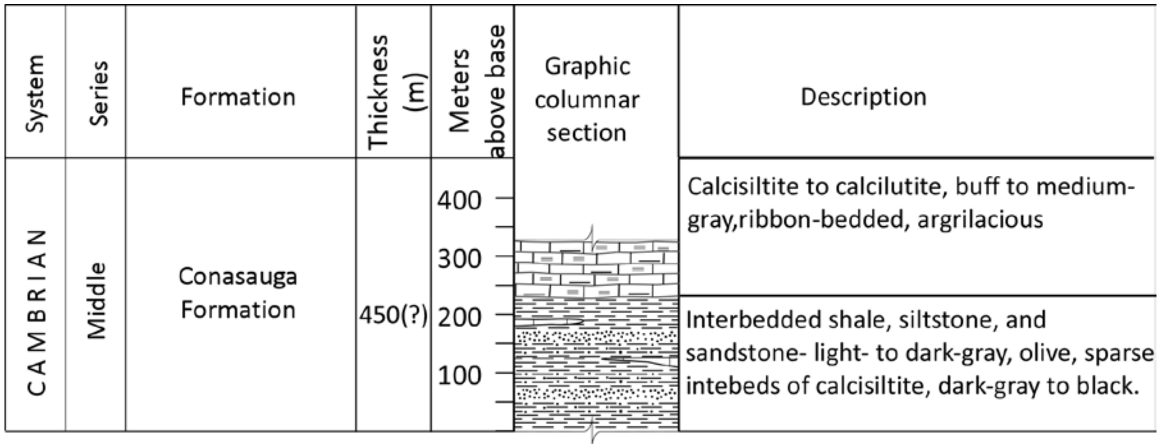

Figure 2.1. Compiled columnar section of Conasauga Formation exposed in the Rome thrust sheet.

CHAPTER 3: STRATIGRAPHY OF THE WESTERN COOSA THRUST SHEET

The Paleozoic strata exposed in the Western Coosa thrust sheet range in age from Early Cambrian to Late(?) Mississippian. The hanging wall of the Western Coosa thrust fault juxtaposes Lower Cambrian Shady Dolomite onto Middle to lower Upper Cambrian Conasauga Formation in the Rome thrust sheet. The Rome Formation overlies the Shady Dolomite in the Western Coosa hanging wall, and in places, the fault cuts up section into the lower Rome. The Middle and lower Upper Cambrian Conasauga Formation, overlying the Rome, consists of two distinct facies. The Upper Cambrian to Lower Ordovician Knox Group overlies the Conasauga Formation in the Western Coosa thrust sheet. The Lower Devonian Frog Mountain Formation unconformably overlies the Knox Group. The Mississippian Maury Shale, Fort Payne Chert, Floyd Shale, and Bangor Limestone, in succession, overlie the Frog Mountain Formation.

Lower Cambrian Shady Dolomite

The Shady Dolomite within Cherokee County is mostly covered except for a few thin discontinuous ribs of black to very dark-gray, hummocky, laminated, dolosiltite, which grades into the overlying Rome Formation (N ½, Sec 32, T 11 S, R 10 E, Plate 1). The contact with the overlying Rome Formation is covered, and the bottom is faulted. The estimated thickness is 146 m (Figure 3.1).

Lower Cambrian Rome Formation

The Rome Formation crops out along the Coloma Mountain ridge in the Western Coosa thrust sheet (Plate 1, NW 1/4, Sec 32; SE 1/4, Sec 28; SW 1/4, NE1/4, Sec 27, T 11 S, R 10 E). The Rome Formation consists of interbedded sandstone, siltstone, and shale. Both sandstone and siltstone are maroon to dark-brown or yellow, and are thin-bedded to laminated (Figure 3.1). The shale is purple to red, and buff to green. On the basis of outcrop width (Plate 1), the Rome is estimated at 274 m thick. The Rome Formation is gradational with the overlying Conasauga Formation.

Middle to Lower Upper Cambrian Conasauga Formation

In the Western Coosa thrust sheet, the Conasauga is conformable with the underlying Rome Formation and overlying Knox Group (Figure 3.1). A nearly complete section is exposed along Alabama Highway 9 and Terrapin creek (SE ¼, Sec 31, T 11 S, R 10 E and NE ¼, Sec 6, T 12

S, R 10 E, Plate 1). The lower part of the Conasauga is interbedded shale, limestone, and dolomitic limestone, approximately 35 m thick. The dominant lithology of the Conasauga in the hanging wall of the Western Coosa fault is oolitc calcarenite. The calcarenite is light to medium gray, and thin to medium bedded with some shaly partings. Some of the calcarenite is crossbedded. The upper part of the Conasauga is 390 m thick. The total thickness of the Conasauga in the Western Coosa thrust sheet is 425 m. The contact with the overlying Knox Group is sharp where exposed (Center, SE ¼, Sec 32, T 11 S, R 10 E, Plate 1). Much of the Conasauga is highly weathered, and is represented by residual chert float on slopes. Characteristic Conasauga chert float is commonly drusy or oolitic.

Upper Cambrian to Lower Ordovician Knox Group

The Knox Group consists of Copper Ridge Dolomite, Chepultepec Dolomite, Longview Limestone, and Newala Limestone. The Knox Group is poorly exposed, and it is not practical to separate the individual formations in mapping as Cloud (1967) did. Various stratigraphic markers such as a sandstone body at the base of the Chepultepec Dolomite cannot be traced very far from local outcrops (SE ¼, Sec 5, T 12 S, R 10 E, Plate 1). Outcrops of the upper Knox units (Longview Limestone and Newala Limestone) are not laterally continuous; therefore, the Knox Group is mapped as undifferentiated.

The base of the Knox in the area is marked by a stromatolitic chert, which overlies the oolitic facies of the Conasauga Formation (Center, SE ¼, Sec 32, T 11 S, R10 E, Plate 1; Figure 3.1) (Cloud, 1967). The stromatolitic chert is composed of mottled white and black interdigitated chert. Where exposed, the Conasauga/Knox contact is easily recognized and consistent throughout the mapped area. The Copper Ridge Dolomite is exposed as ledges in Terrapin Creek (Center, NE 1/4, Sec 5, T 12 S, R 10 E, Plate 1). Only 30 m of Copper Ridge is exposed; and it is light-gray, chert-bearing, dolomitic calcisiltite. The best outcrop of lower Knox Group (Copper Ridge Dolomite and Chepultepec Dolomite) is along an abandoned meander of Terrapin Creek (SE ¼, Sec 5, T 12 S, R 10 E, Plate 1). Approximately 61 m of Chepultepec Dolomite are exposed. The Chepultepec is composed of medium- to dark-gray doloarenite with yellow chert nodules. The lower Knox generally is exposed as chert residuum float. The chert generally has dolomite-rhomb molds.

The Longview Limestone and Newala Limestone are very poorly exposed in the map area. Sandy dolostone is indicative of the Longview Limestone (Cloud 1967). Several sandy dolostone float blocks on slopes below Frog Mountain Formation at the crest of a low ridge (SE ¼, Sec 8, T 12 S, R 10 E, Plate 1) may represent the Longview Limestone. Newala Limestone was not observed in outcrop in the Western Coosa thrust sheet. The total thickness of the Knox Group is approximately 1150 m (Figure 3.1).

Lower Devonian Frog Mountain Formation

The basal Frog Mountain Formation consists of interbedded greenish-gray shale and yellowish-brown chert (Figure 3.2). The shale yields brachiopods, corals, gastropods, and cephalopods (Kiefer, 1970). The upper sandstone of the Frog Mountain is medium- to light-gray, thin- to medium-bedded, and fine- to coarse-grained; and it contains some brachiopods.

The predominant lithology of the thin Frog Mountain within the Western Coosa thrust sheet is the basal shale that rests unconformably on the Newala Limestone of the Knox Group. The sandstone of the Frog Mountain is relatively thin and is unconformably overlain by the Early Mississippian Maury Shale or Fort Payne Chert.

Lower Mississippian Maury Shale

The Maury Shale is not exposed in the field area, but has been measured at nearby locations (Kiefer, 1970). The Maury Shale is, generally, very thin, and may be covered in the Western Coosa thrust sheet.

Middle Mississippian Fort Payne Chert

The Fort Payne Chert generally crops out as crinoid-bearing chert float in 1- to 5-cm long blocks. The Fort Payne is exposed in place at only a few localities (NE ¼, Sec 19, T 12 S, R 10 E; NE ¼, Sec 17, T 12 S, R 10 E, Plate 1), where it is yellowish-tan to white, thin-bedded chert with shaly partings (Figure 3.2).

Upper Mississippian Bangor Limestone and Floyd Shale

Bangor Limestone in the field area is of unknown thickness. It is tightly folded, and bedding is nearly vertical. The best exposures of the Bangor are in the N ½, Sec 20, T 12 S, R 10 E (Plate 1), where it is dark- to light-gray, laminated to thinly bedded, argillaceous calcisiltite to calcarenite (Figure 3.2). Some of the limestone is weathered to a shale-like residue with crinoid columnal and brachiopod molds.

The Floyd Shale in the field area forms valley floors in the Western Coosa thrust sheet. Exposure of the Floyd Shale is poor (SE ¼, Sec 18; SE ¼, Sec 19; NE ¼, Sec 20, T 12 S, R 10 E, Plate 1). Where it is exposed, it is slightly silty to clay shale (Figure 3.2). The Floyd is fissile and has blocky fracture.

The Bangor Limestone in the field area is dipping nearly vertically; however, the Floyd Shale surrounds the Bangor Limestone. This suggests the Bangor and the Floyd have an intertounging relationship in the field area. Because of intense small-scale folding, thickness is uncertain.

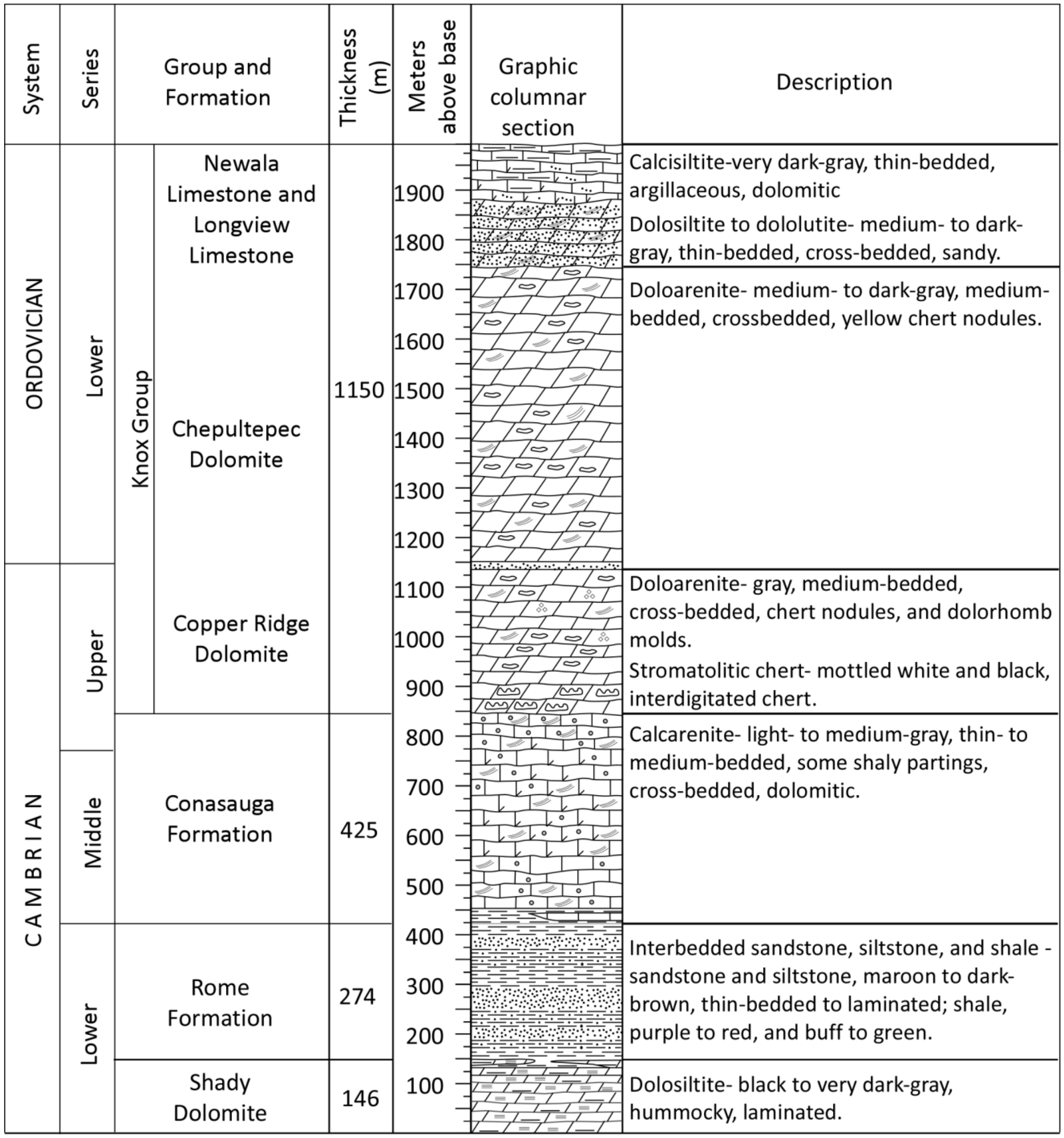

Figure 3.1. Compiled columnar section of lower Paleozoic strata exposed in the Western Coosa thrust sheet.

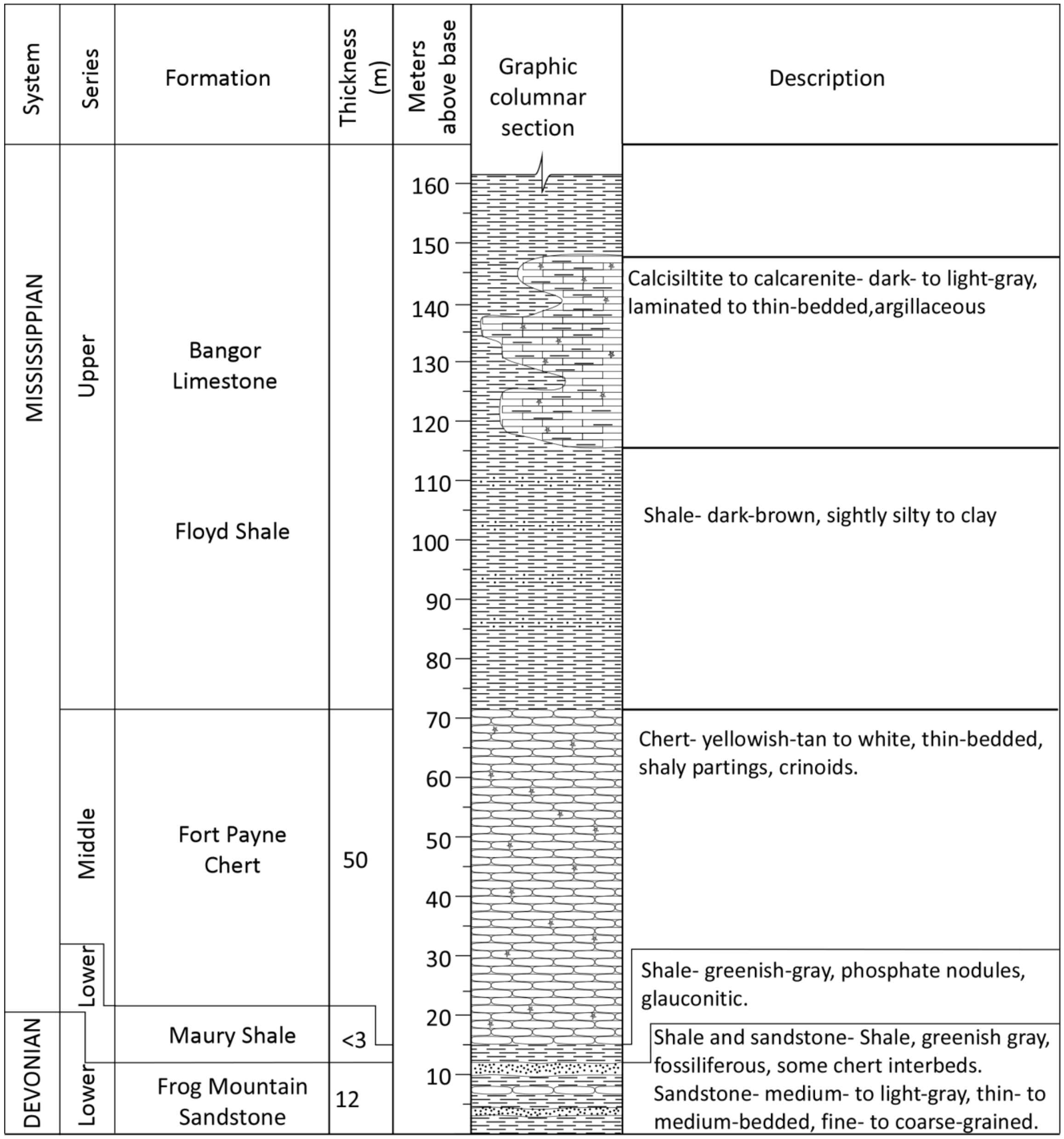

Figure 3.2. Compiled columnar section of upper Paleozoic strata exposed in the Western Coosa thrust sheet.

CHAPTER 4: STRATIGRAPHY OF THE EASTERN COOSA THRUST SHEET

The stratigraphic section exposed southeast of the Eastern Coosa thrust fault includes formations from Early Cambrian to Middle Mississippian in age (Plate 1). The Lower Cambrian Rome Formation is the oldest exposed unit in the hanging wall of the Eastern Coosa thrust fault, and is overlain by the Middle to lower Upper Cambrian Consauga Formation. The Conasauga is overlain by the Upper Cambrian to Early Ordovician Knox Group. The Middle Ordovician Athens Shale unconformably overlies the Knox Group in the Eastern Coosa thrust sheet. The Lower Devonian Frog Mountain Formation overlies both the Athens Shale and the Knox Group. The contact relationships between the Knox Group, Athens Shale, and Frog Mountain Formation greatly affect both structural and stratigraphic interpretations within the Appalachian foreland. The Frog Mountain Formation is overlain by the Middle Mississippian Fort Payne Chert.

Lower Cambrian Rome Formation

Rome Formation is exposed in the hanging wall of the Eastern Coosa fault (SE ¼, Sec 24, T 11 S, R 10 E, Plate 1). The Rome Formation consists of very thin- to medium-bedded, maroon siltstone, and maroon, gray, and tan, silty to clay shale (Figure 4.1).

Middle to Lower Upper Cambrian Conasauga Formation

The Middle to lower Upper Cambrian Conasauga Formation is very poorly exposed in the Eastern Coosa thrust sheet. Oolitic chert-residuum is common along the trace of the Eastern Coosa thrust fault. Approximately 6 m of peloidal and oolitic calcarenite is observed in place northeast of Craig Mountain (NW ¼, Sec 35, T 11 S, R10 E, Plate 1 and Figure 4.1). This outcrop is located very close to the contact of the Conasauga Formation with the Knox Group.

Upper Cambrian to Lower Ordovician Knox Group

The Upper Cambrian to Lower Ordovician Knox Group is poorly exposed in the Eastern Coosa thrust sheet, although a basal biostromal layer is observed as mottled chert residuum float. The Copper Ridge Dolomite is well exposed southwest of Craig Mountain (NE ¼, Sec 3, T 12 S, R10 E, Plate 1 and Figure 4.1) in the Eastern Coosa thrust sheet. The Chepultepec Dolomite is not well exposed in the Eastern Coosa thrust sheet. Cloud (1967) was able to separate the Cooper Ridge from the Chepultepec, but any visible stratigraphic markers are no longer evident.

The poor exposure and structural complexity in the field area make it difficult to determine the separate thicknesses of the Longview and Newala Limestones. Longview Limestone is well exposed at two locations north of Casey Hill. The best exposure is along Cherokee County Highway 33 (NW ¼, Sec 10, T 12 S, R 10 E, Plate 1). The Longview Limestone is medium- to dark-gray, thinly bedded, cross-bedded, sandy doloarenite or calcarenite with minor amounts of dark-gray, very thin-bedded to laminated dolosiltite and dololutite. Another exposure of Longview Limestone is located in a sinkhole north of Casey Hill (NW ¼, Sec 10, T 12 S, R 10 E, Plate 1). The dolostone at this location is medium to dark-gray, wavy-bedded, cross-bedded and sandy. These units of the Knox Group are exposed only in the Eastern Coosa thrust sheet.

Middle Ordovician Athens Shale

The Athens Shale is poorly exposed in the mapping area. The best exposures are along the southern edge of the Frog Mountain ridge (Plate 1). On the basis of outcrop width, the estimated thickness of the Athens Shale is 152 m. The Athens Shale in the field area is tightly folded with the Newala Limestone; thus, an accurate thickness is difficult to estimate. The Athens Shale at outcrop ranges from gray to black, fissile to blocky, silty shale (Figure 4.1). Graptolites are reported locally (Thomas and Drahovzal, 1977). The contact of the Middle Ordovician Athens Shale with the underlying Upper Cambrian to Lower Ordovician Knox Group is unconformable. The contact between the base of the Lower Devonian Frog Mountain Formation and the top of the Athens Shale is apparently parallel with bedding, but the outcrop pattern of the Frog Mountain Formation throughout the field area indicates a discordant contact between the Athens Shale and overlying Frog Mountain Formation.

Lower Devonian Frog Mountain Formation

The thick Frog Mountain Formation of the Eastern Coosa thrust sheet is relatively well exposed as a dominant easterly trending ridge, Frog Mountain ridge (Plate 1, Sec 10, 11, 12, and 1; T 12 S, R 10 E). The Frog Mountain Formation type section is located at the western end of this ridge (NW ¼, SW ¼, Sec 10, T 12 S, R 10 E) (Hayes, 1894; 1902). This section is so poorly exposed today that it is not practical to measure it. At Frog Mountain ridge, the base of the Frog Mountain Formation is above the Middle Ordovician Athens Shale at the southern side of Frog Mountain and above the Late Cambrian to Early Ordovician Knox Group along the northern side of Frog Mountain (Plate 1).

The Frog Mountain Formation is buff, tan, light- to medium-gray, and light-red, mostly fine-grained with local coarse-grained sandstone, and is locally bimodal with sparse coarse sand grains in a fine-grained bed (Figure 4.1). It is generally thin- to medium-bedded, wavy, and internally massive; although there are local cross-beds and scours. The Frog Mountain is well cemented, but locally friable. The basal Frog Mountain Formation is hematitic and has abundant coral molds and brachiopods (NE ¼, NW ¼, Sec 12; Center, NW¼, Sec 11, T 12 S, R 10 E). Toward the top of the Frog Mountain Formation, rare crinoid molds are evident (SE ¼, SW ¼, Sec 10; NW ¼, SW ¼, Sec 9, T 12 S, R 10 E).

Middle Mississippian Fort Payne Chert

At the type section of the Frog Mountain Formation, Kiefer (1970) measured 0.9 m of Fort Payne Chert, and observed 7.6 m of chert float. Thomas and Drahovzal (1977) measured approximately 1 m of Fort Payne Chert. The Fort Payne Chert outcrop is not visible today, and no higher strata crop out in the Eastern Coosa thrust sheet (Figure 4.1).

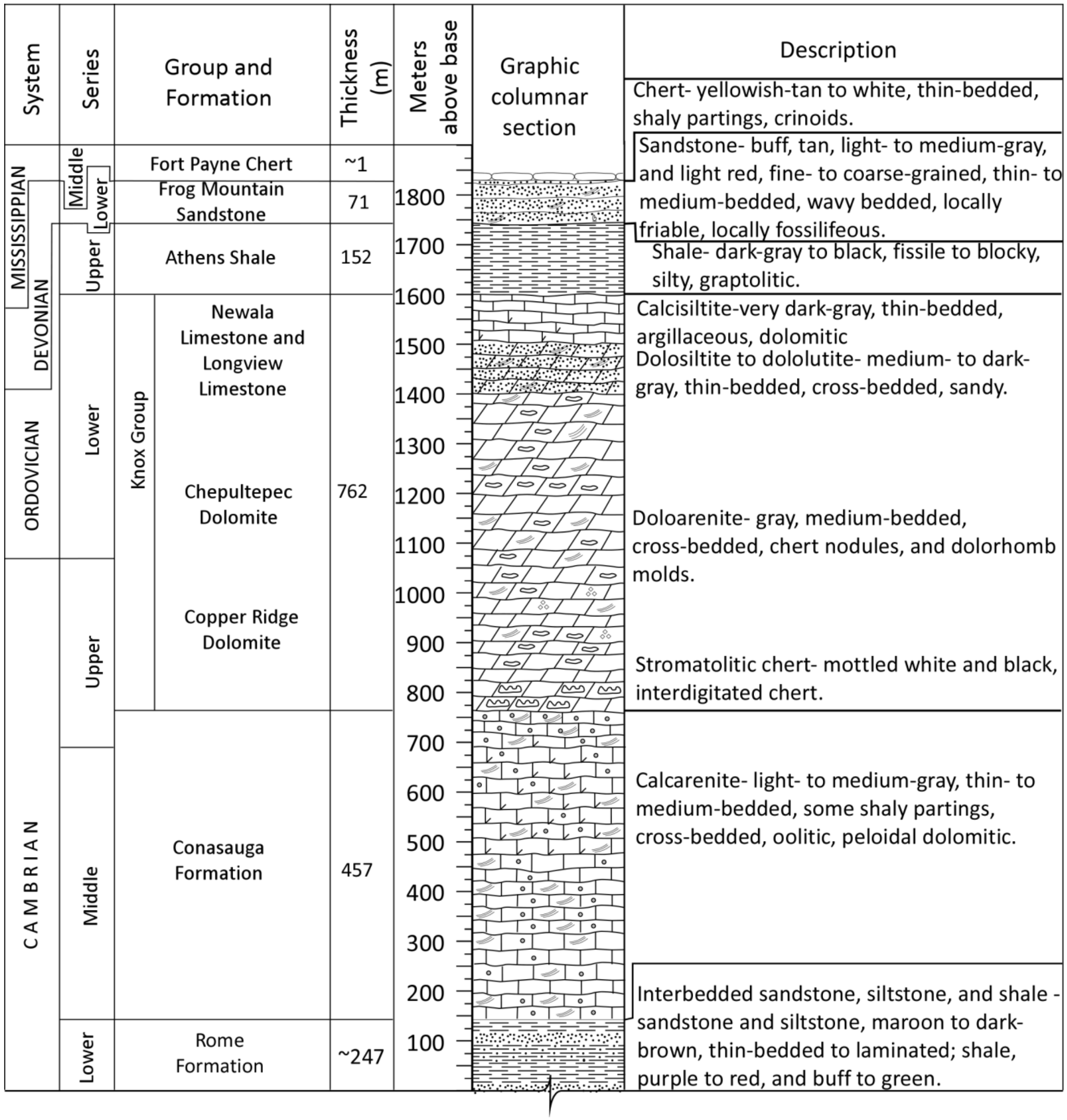

Figure 4.1. Compiled columnar section of Paleozoic strata exposed in the Eastern Coosa thrust sheet. The Jacksonville thrust sheet is stratigraphically similar, but no beds younger than Chepultepec Dolomite are included within the Jacksonville thrust sheet.

CHAPTER 5: STRATIGRAPHY OF THE JACKSONVILLE THRUST SHEET

The Lower Cambrian Rome Formation is the oldest exposed unit a in the hanging wall of the Jacksonville thrust fault and is overlain by the Middle to lower Upper Cambrian Conasauga Formation. The Consauga is overlain by the Upper Cambrian to Lower Ordovician Knox Group. The Knox Group is the youngest formation preserved south of the Jacksonville fault, within the map area (Figure 4.1).

Lower Cambrian Rome Formation

Rome Formation is exposed in the hanging wall of the Jacksonville thrust sheet at McFrey Crossroads (SW ¼, Sec 22, T 12 S, R 10 E, Plate 1) and in a road cut at the NW ¼, Sec 28, T 12 S, R10 E (Plate 1). The Rome Formation at both locations consists of very thin- to medium-bedded, maroon to red siltstone, and maroon, gray, and tan, silty to clay shale (Figure 4.1). The underlying Shady Dolomite and the overlying Conasauga Formation are not exposed at either of these outcrops.

Middle to Lower Upper Cambrian Conasauga Formation

In the Jacksonville thrust sheet, an exposure of oolitic wavy-bedded dolomitic calcarenite of the Conasauga Formation crops out near Spring Garden School (SW¼, Sec 13, T 12 S, R 10 E, Plate 1 and Figure 4.1). This outcrop is very close to the contact with the overlying Knox Group. In the southeast corner of the field area near La Garde Lake, within the Jacksonville thrust sheet, the Conasauga Formation outcrop consists of oolitic chert float.

Upper Cambrian to Lower Ordovician Knox Group

In the Jacksonville thrust sheet, near La Garde Lake, the basal layer of the Knox Group is mottled dololutite. The Conasauga Formation and Knox Group contact is relatively easy to identify because of the contrast between the calcarenite of the Conasauga and the mottled dololutite and chert of the Knox. In the Jacksonville thrust sheet, Cooper Ridge Dolomite and Chepultepec Dolomite are indistinguishable because of poor exposure. No younger beds are identified in the Jacksonville thrust sheet (Figure 4.1).

CHAPTER 6: TALLADEGA SLATE BELT EQUIVALENTS OF PRE-MISSISSIPPIAN STRATA EXPOSED IN THE FIELD AREA

The Lower Devonian Frog Mountain Formation in the Eastern Coosa thrust sheet is at least 71 m thick, whereas, throughout much of fold-thrust belt in Alabama, the Lower Devonian Frog Mountain is less than 20 m thick (Ferrill, 1984). The Frog Mountain Formation in the fold-thrust belt unconformably overlies Lower Ordovician to Silurian strata (Kiefer, 1970; Ferrill, 1984). The only other succession of Lower Devonian strata in the region is south of the fold-thrust belt, in the Talladega slate belt (Figure 6.1); however, the Lower Devonian succession in the Talladega slate belt is much thicker than the Lower Devonian succession in the fold-thrust belt. The Talladega slate belt contains the Talladega Group, a thick secession of Silurian(?) to Lower Mississippian strata. The Talladega Group overlies Cambrian to Lower Ordovician strata (Tull, 1998; 2002). The pre-Mississippian succession in the Talladega slate belt includes the Kahatchee Mountain Group, the Sylacauga Marble Group, and the Talladega Group in ascending order (Figure 6.2).

Lower Cambrian Kahatchee Mountain Group

The Kahatchee Mountain Group consists of the Waxahatchee Slate, Brewer Phyllite, Stumps Creek Formation, and the Wash Creek Slate in ascending order (Guthrie, 1989). These units represent the distal Laurentian margin, and the Kahatchee Mountain Group is equivalent to the Chilhowee Group of the fold-thrust belt (Tull, 1998). The Kahatchee Mountain Group is composed of dark metapelite, metasandstone, quartz-pebble metaconglomerates, and sandy marble; it is more than 2 km thick (Tull and Guthrie, 1985). No Chilhowee Group is mapped in the field area, but the Chilhowe Group (Wiesner Formation) is exposed in the hanging wall of the Western Coosa thrust fault west of the field area. The Kahatchee Mountain Group is overlain by the Sylacauga Marble Group.

Lower Cambrian to Lower Ordovician Sylacauga Marble Group

The Sylacauga Marble Group consists of the Jumbo Dolomite, Fayetteville Phyllite, Shelvin Rock Church Formation, Gooch Branch Chert, and Gantts Quarry Formation in ascending order (Tull and others, 1988; Guthrie, 1989). The Sylacauga Marble Group is 2550 m thick (Tull, 1998) and is equivalent to the Lower Cambrian Shady Dolomite through the Upper Cambrian to Lower Ordovician Knox Group (Tull and others, 1988) (Figure 6.2).

The Jumbo Dolomite (equivalent to the Shady Dolomite) is light- to medium-gray, thin- to thick-bedded dolomitic marble, which is locally sandy (Osborne and others, 1988). The Jumbo Dolomite ranges in thickness generally from 15- to 65 m, but is locally as thick as 220 m (Guthrie, 1989). The contact between the Wash Creek Slate and the Jumbo Dolomite is gradational. The Jumbo Dolomite is overlain by the Fayetteville Phyllite.

The Fayetteville Phyllite is equivalent to both the Lower Cambrian Rome Formation, and the lower part of the Middle to lower Upper Cambrian Conasauga Formation (Guthrie, 1989). The Fayetteville Phyllite is red to gray phyllite and slate, interlayered with light-brown to light-gray metasiltstone, fine-grained metasandstone, and dolomite marble. The Fayetteville Phyllite is 150 m thick (Tull, 1998). The upper Conasauga is correlated to the Shelvin Rock Church Formation (Tull and others, 1988). The Shelvin Rock Church Formation is moderate-pink to light-gray calcite and locally dolomite marble, and is 1000 m thick (Tull, 1998).

Equivalents to the Upper Cambrian to Lower Ordovician Knox Group are recognized in the Talladega slate belt (Tull and others, 1988; Guthrie, 1989). The Copper Ridge Dolomite, Longview Limestone, and Chepultepec Dolomite are correlated to the Gooch Branch Chert. The Gooch Branch Chert is 150 m thick (Tull, 1998), and consists of light-gray to light-brown marble with abundant light-gray to white foliated metachert. The Newala Limestone is correlated to the Gantts Quarry Formation (Tull and others, 1988). The Gantts Quarry Formation is white to light-gray calcite marble with interlayered dolomite marble and thin phyllite layers, and is 600 m thick (Tull, 1998).

The Kahatchee Mountain and Sylacauga Marble Groups are unconformably overlain by the Silurian(?) to Lower Mississippian Talladega Group (Tull, 2002). The unconformity is angular and reported to be as great as 8.5^{o}.

Silurian(?) to Lower Mississippian Talladega Group

The Talladega Group is Silurian(?) to earliest Mississippian in age, and is more than 2.5 km thick. The Talladega Group consists of the Lay Dam Formation, Cheaha/Butting Ram Quartzite, and Jemison Chert (Tull, 2002). The Lay Dam Formation unconformably overlies the Sylacauga Marble and Kahatchee Mountain Group. It is greater than 2 km thick and consists of metaturbidite, arkosic conglomerate, and thick olistostromal beds. The olistostromal beds contain boulder- to sand-sized carbonate rock, metachert, metasandstone, and metasiltstone typical of the underlying Sylacauga marble and Kahatchee Mountain Group. The olistotrmal beds also contain fragments of granite and granitic gneiss, which have a Grenville age (Telle and others, 1979). The olistostromal units near Jemison, where the Lay Dam Formation is ~1250 m thick, represent proximal submarine fan facies (Tull and Telle, 1989), whereas the ~2400 m thick Lay Dam Formation northeastward beneath the Erin Slate represents distal turbidite facies (Tull and Telle, 1989; Lim, 1998). The immature clasts within the olistostromal beds indicate rapid and steep uplift, and unusually fast deposition (Tull, 2002). The age of the Lay Dam Formation is defined by the following: 1.) the youngest underlying rocks of the Sylacauga Marble group contain Early Ordovician conodonts (Tull and others, 1988); 2.) the overlying Butting Ram Quartzite and Jemison Chert contain Early to Middle Devonian fauna (Butts, 1926; Carrington, 1973); 3.) the upper Lay Dam contains conodonts with a Silurian to Pennsylvanian age range (Tull and others, 1988). The Lay Dam is bracketed between a Silurian to Early Devonian age.

The Butting Ram Quartzite and the northeastern equivalent, the Cheaha Quartzite, overlie the Lay Dam Formation (Tull, 2002). The Butting Ram and Cheaha Quartzite is a thick succession of metasandstones and metaconglomerates. The Butting Ram and Cheaha Quartzites range from ~200 m to ~380 m thick (Carter, 1985), but locally are as much as 850 m thick (Tull, 1979). Shallow-marine fossil assemblages within the Butting Ram Quartzite indicate but are not definitive of an Early Devonian age (Carrington, 1973). The Butting Ram and Cheaha Quartzites grade upward into the Jemison Chert.

The Jemison Chert is as much as 400 m thick, and consists of grayish-white to yellowish-orange, massive, thick-bedded, fine-grained, locally argillaceous, locally fossiliferous, metachert, and light- to dark-gray, fine- to medium-grained, fissile quartz-sericite-chlorite phyllite, and schist (Szabo and others, 1988). The age of the Jemison Chert is restricted to late Early Devonian or older, but not younger than early Late Devonian (Tull, 2002).

Given rapid sediment accumulation, an Early Devonian age is allowable for the Lay Dam Formation (Tull and Telle, 1986; Ferrill and Thomas, 1988; Tull, 2002). With an Early Devonian age for the Butting Ram Quartzite and Jemison Chert, the Talladega Group is age correlated to the Lower Devonian Frog Mountain Formation. Furthermore, the Butting Ram Quartzite and Frog Mountain Formation both contain feldspars derived from a granitic-gneiss cratonic basement source (Ferrill and Thomas, 1988).

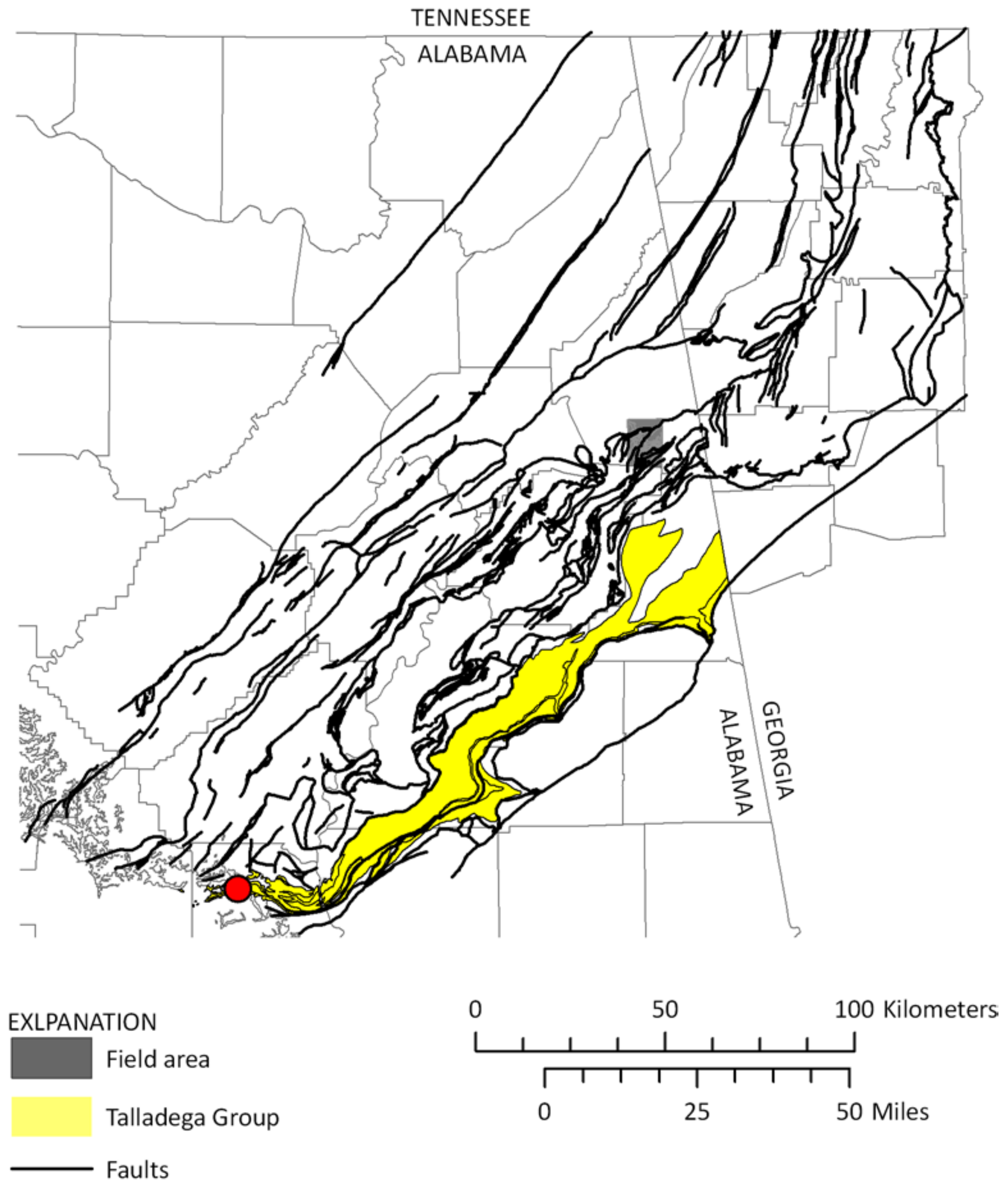

Figure 6.1. Location of the Talladega Group in Alabama (red circle marks Jemison, Alabama).

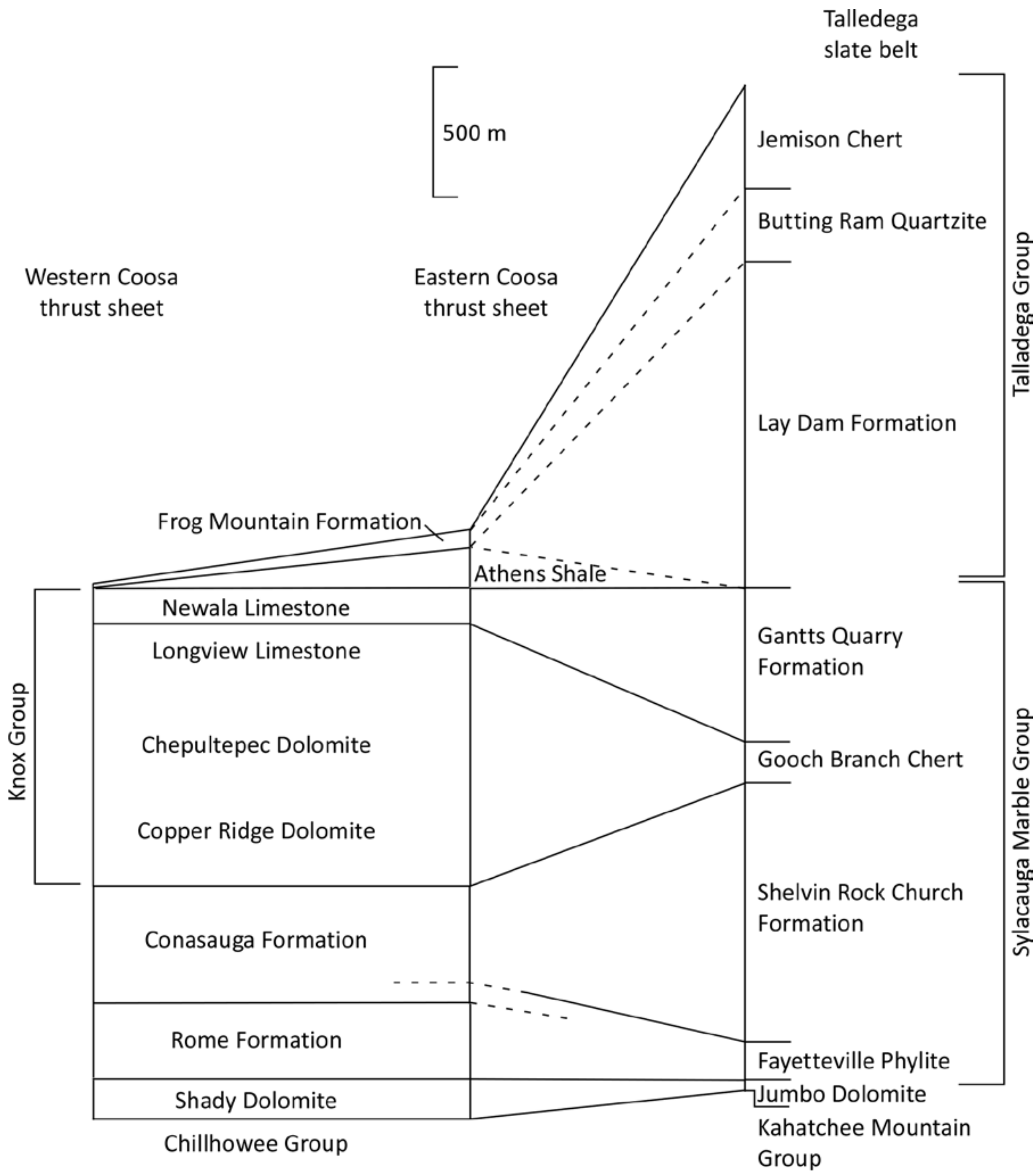

Figure 6.2. Correlations between the stratigraphic successions within the Western Coosa thrust sheet, the Eastern Coosa thrust sheet, and the Talladega Slate belt. Thicknesses of the Sylacauga Marble Group and the Talladega Group are from Tull (1998). No horizontal scale.

CHAPTER 7: STRUCTURE OF THE ROME THRUST SHEET

Regional

The trailing edge of the regionally extensive Rome thrust sheet is in the northern part of the field area (Figure 7.1). Strata in the thrust sheet are limited to the Conasauga Group (Osborn and others, 1988; Thomas and Bayona, 2005). The leading edge of the Rome thrust sheet is in the upper Conasauga; whereas the lower Conasauga crops out at the trailing edge. Northwest of the field area, the Rome thrust fault parallels strike with the Dunaway Mountain and Peavine thrust sheets (Figure 7.1). East of the Peavine thrust sheet, the Rome fault cuts more easterly across the Kingston, Chattooga, and Rocky Mountain thrust sheets. Northeast of the field area, the fault trace is highly irregular where it cuts across the Horseleg thrust sheet. The trailing edge of the Rome thrust sheet is truncated by the Helena, Western Coosa, and Eastern Coosa thrust faults along strike (Figure 7.1). The Rome thrust sheet is apparently very thin and shallow. The upper and lower Conasauga at the leading and trailing edges of the thrust sheet, respectively, indicate a very low dip on the Rome fault. A lack of seismic imaging and loss of resolution of the structure because of surface noise also indicate a thin shallow thrust sheet (Thomas and Bayona 2005). As further evidence of a shallow, thin, thrust sheet, where the Rome fault cuts across the Horseleg thrust sheet, the map trace of the Rome fault is highly irregular, following topographic contours, indicating a nearly flat surface which truncates folds in the footwall (Cressler 1970; Georgia Geological Survey, 1976). The Rome fault is folded by the footwall folds (Thomas and Bayona, 2005).

Field Area

In the field area, the trailing edge of the Rome thrust sheet is truncated by segments of the Western and Eastern Coosa thrust faults (Plate 1). The Western Coosa thrust fault juxtaposes Shady Dolomite onto the Conasauga Formation of the trailing edge of the Rome thrust sheet. The Western Coosa fault cuts up section to the east where the map trace merges with that of the Eastern Coosa thrust fault. Although the Eastern Coosa fault brings Conasauga in the hanging wall onto Conasauga of the Rome thrust sheet, a distinct difference in facies helps to delineate the Eastern Coosa fault trace. South of the fault, although outcrop is rare in the Conasauga, oolitic and peliodal chert float can be found. North of the fault, an interbedded siltstone and shale facies of the Conasauga is exposed in scattered outcrops in the Rome thrust sheet.

The mean bedding attitude of Conasauga in the Rome thrust sheet is N52^{o}E 56^{o}SE (Figure 7.2); however, outcrops nearest the Eastern and Western Coosa faults show the greatest range of attitudes within the Rome thrust sheet. The thrust sheet contains open and closed folds. The axes of these folds are sub-parallel to the mean strike. A mapped fold, near Ellisville (W ½ Sec 20 T 11 S, R 10 E, Plate 1), is one of the best exposed folds in the Rome thrust sheet in the field area, and helps illustrate the style of folding in the thrust sheet. The fold plunges at S74^{o}W 5^{o} (oblique to regional strike). It is a closed, asymmetric fold with an amplitude of 394 m and wavelength of 1842 m (A-A', Plate 1; Plate 2). Other mapped folds in the area are open and plunge nearly parallel to strike, in contrast to the fold in cross section A-A' (Plate 1 and Plate 2).

Beds in the Rome thrust sheet nearest to the Western and Eastern Coosa thrust faults strike from N70^{o}W to N40^{o}E and have an average dip of 18^{o} SE to SW. Outcrop and map-scale folds are common close to the trailing edge of the Rome thrust sheet (SE ¼ Sec 30 and NW ¼ Sec 27 T 11 S, R 10 E, Plate 1). These tight, isoclinals folds plunge nearly perpendicular to the Western and Eastern Coosa faults and indicate east-west shortening of the thrust sheet. Overall, the variability of strike and the relatively low dip angles, along with the regional evidence, suggests that the Rome thrust sheet is relatively flat but includes local folds (F-F', Plate 1; Plate 2).

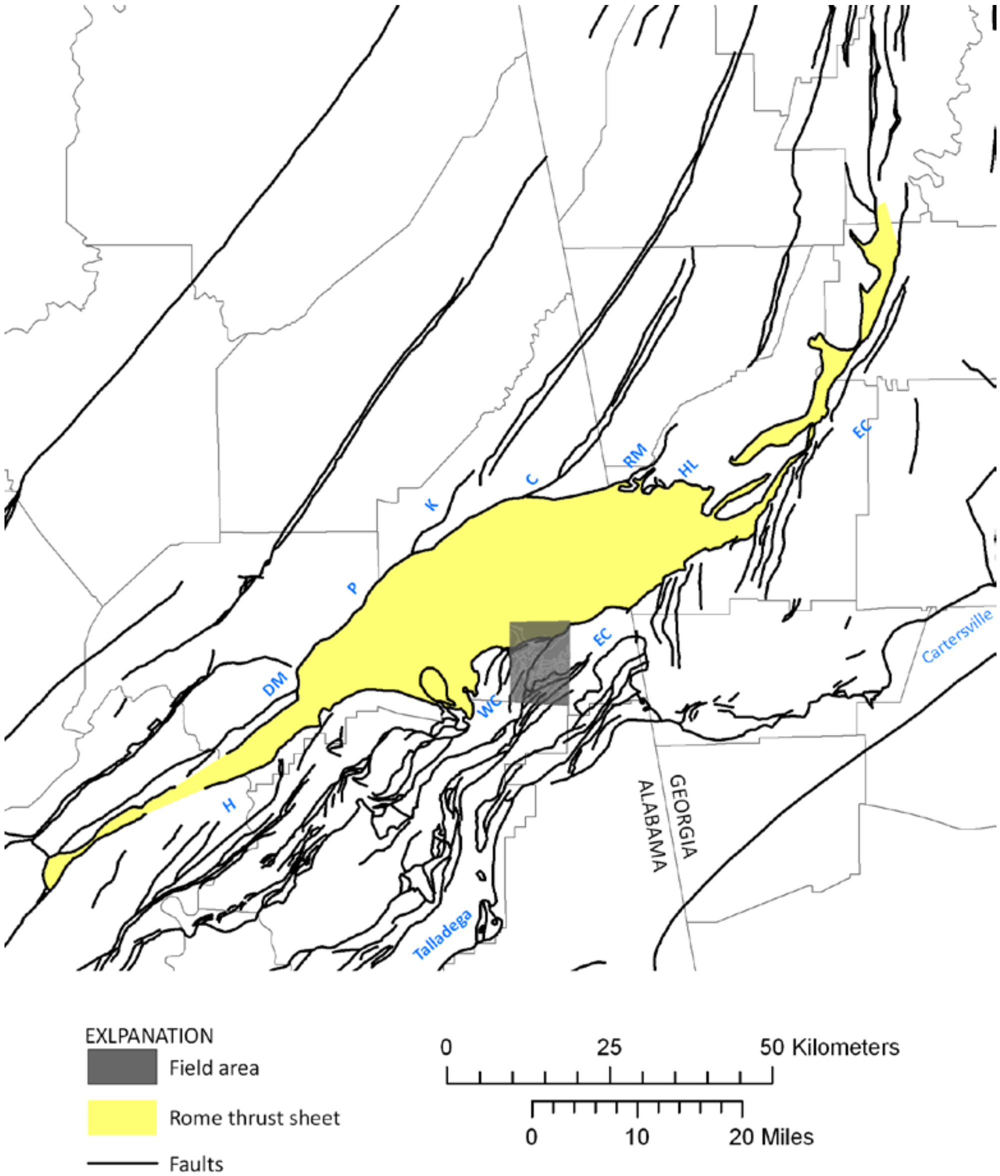

Figure 7.1. Location of the Rome thrust sheet in relation to the field area (DM = Dunaway Mountain, P= Peavine, K = Kingston, C = Chattooga, RM = Rocky Mountain, HL = Horseleg, H = Helena, WC = Western Coosa, and EC = Eastern Coosa faults).

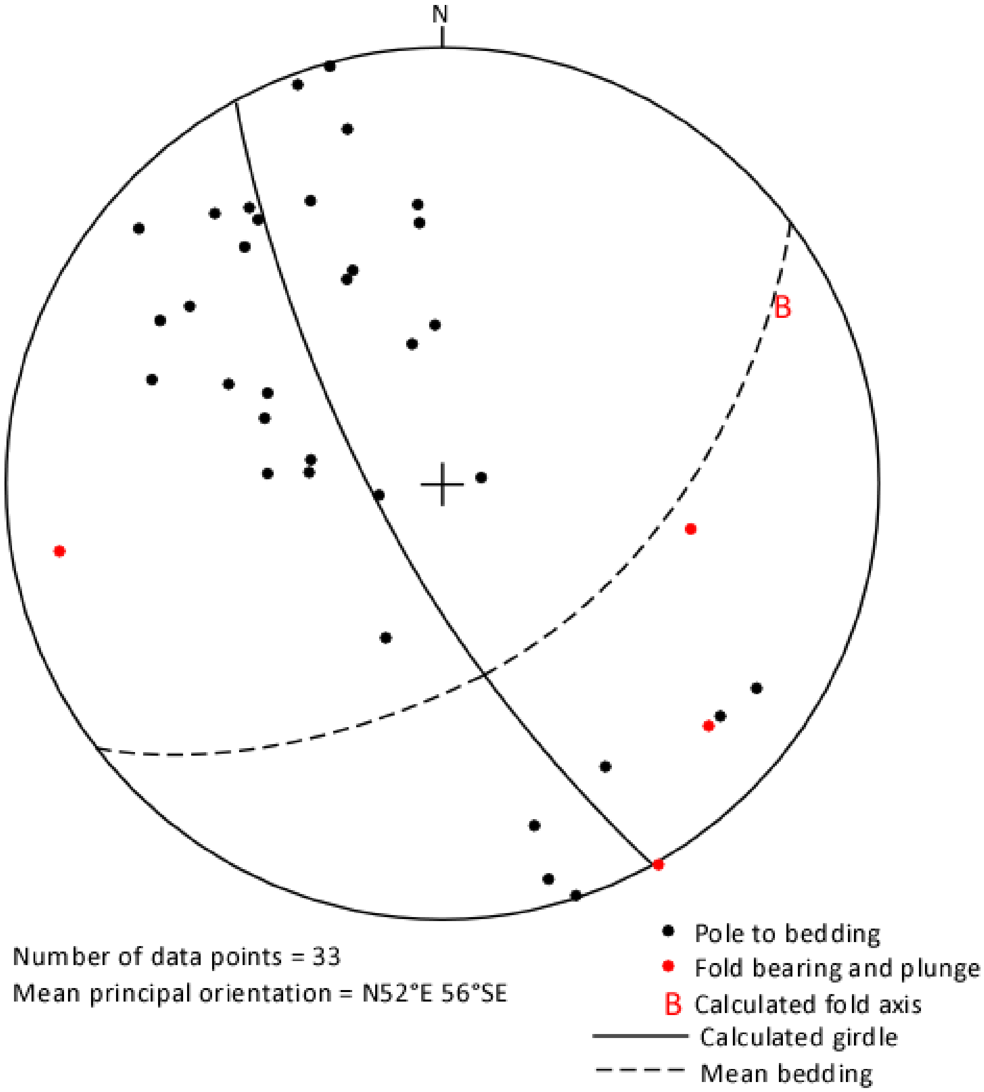

Figure 7.2. Stereonet plot of poles to bedding attitudes within the Rome thrust sheet, which includes attitudes north of the field area. Scattered poles in the southern hemisphere reflect bedding at the trailing edge of the Rome thrust sheet.

CHAPTER 8: STUCTURE OF THE WESTERN COOSA THRUST SHEET

Regional

The Western Coosa thrust sheet includes strata from the Lower Cambrian Chilhowee Group to the Upper Mississippian Bangor Limestone and Floyd Shale (Osborne and others, 1988, Thomas and Bayona, 2005). The Western Coosa thrust sheet is bound by the Rome thrust sheet to the north and west (where the Western Coosa fault curves to the south near Weisner Mountain) (Figure 8.1). The Western Coosa fault curves abruptly in strike, trending east-west, where it is bound by the Helena thrust sheet to the north. Farther west, the Western Coosa Fault curves in strike to more nearly northeast-southwest, where it truncates the Angel block. The Angel block overrides part of the Coosa deformed belt. The Coosa deformed belt is a set of thrust sheets arranged in three strike-parallel tiers (Thomas and Drahovzal, 1974). The thrust sheets within each tier (frontal, intermediate, and interior) have contrasting thickness and successions of strata. Faults and folds from the intermediate tier of the Coosa deformed belt extend into the Angel block and into the Western Coosa thrust sheet (Thomas and Bayon, 2005). The trailing edge of the Western Coosa thrust sheet is bound by the Pell City fault to the south and west, and by the Jacksonville fault and the Eastern Coosa fault to the east.

Field Area

In the mapped area, the Western Coosa thrust sheet consists of the Shady Dolomite, Rome Formation, Conasauga Formation, Knox Group, Frog Mountain Formation, Fort Payne Chert, Floyd Shale, and Bangor Limestone (Figure 3.1, Figure 3.2, Plate 1). The Western Coosa thrust fault extends northeast through the mapped area, parallel to Coloma Mountain ridge, juxtaposing Shady Dolomite onto the Conasauga Formation in the Rome thrust sheet. Eastward, the fault cuts up section, in the hanging wall, through the Rome Formation into the Conasauga Formation and map trace of the Western Coosa thrust fault merges with the Eastern Coosa thrust fault (SW ¼, Sec 26, T 11 S, R 10 E, Plate 1). The trailing edge of the Western Coosa thrust sheet is truncated by the Eastern Coosa thrust fault, and trends north-northeast. Near the point where the two faults merge, the Eastern Coosa thrust fault brings the Conasauga Formation onto Conasauga and Knox of the Western Coosa thrust sheet. The Eastern Coosa fault cuts up section in both the hanging wall and footwall toward the southwest, and places Athens Shale in the hanging wall onto the Bangor Limestone and Floyd Shale in the Western Coosa thrust sheet.

Internally, attitudes and fold axes generally parallel the trend of the trace of the Western Coosa thrust fault. The mean bedding attitude is N48^{o}E 38^{o}SE (Figure 8.2). Knox outcrops in the area where the Eastern and Western Coosa faults merge suggest tight fold hinges nearly perpendicular to the trace of the Western Coosa fault (Sec 33 and Sec 34, T 11 S, R 10 E, Plate 1).

An outlier of the Knox Group near Coloma Mountain rests on a thin expression of the Conasauga (SW ¼, Sec 32, T 11 S, R 10 E, Plate 1). The outcrop relationships suggest that the Knox is a small klippe (B-B', Plate 1; Plate 2). If the Knox is a klippe, then Conasauga-Knox contact must be part of a downward cutting fault that places lower Knox onto lower Conasauga.

To the southeast, away from the trace of the Western Coosa fault, several ridges with a more northerly trend contain up-plunge structures of the northeastern part of the Coosa deformed belt and are capped with hematitic sandstone breccia (Plate 1). These ridges have thrust-imbricated sections of Frog Mountain Formation, Fort Payne Chert, Floyd Shale, and Bangor Limestone. The valleys between these ridges are synclinal folds which plunge to the south. At the northern (structurally up plunge) end of these ridges (Sec 8, T 12 S, R10 E; C-C', Plate 1; Plate 2), a small syncline, cored with Floyd Shale, has the eastern limb truncated by a fault which has the Knox Group in the hanging wall. Cross section D-D' (Plate 1; Plate 2) illustrates the along-strike southward continuation of the same syncline with the fault-truncated eastern limb. Farther down-plunge, cross section E-E' (Plate 1; Plate 2) illustrates this westernmost syncline; however, the eastern limb of the syncline is preserved.

In the hanging wall of the previously described fault, the Knox Group is in both the footwall and hanging wall (C-C', Plate 1; Plate 2). Farther down plunge, to the south, tightly folded Frog Mountain and Fort Payne are preserved in the hanging wall (NE ¼, Sec 17, T 12 S, R 10 E, Plate 1; D-D', Plate 1; Plate 2). To the southwest, cross section E-E' illustrates the down-plunge form of the fault and folds. The fault cuts up southwestward to Fort Payne in the footwall and Frog Mountain in the hanging wall. The tight folds illustrated in cross section D-D' plunge southwestward into a more open asymmetric syncline cored with Floyd Shale and Bangor Limestone. The eastern limb of the eastern syncline is truncated by the Eastern Coosa fault. Wave length and amplitude vary along strike, but comparing the folds illustrated in cross section E-E'; the westernmost folds have a wave length of 334 m and an amplitude of 111 m, while the eastern folds have a wave length of 2333 m and an amplitude of 244 m. In the field area, fold axes in the southwest part of the Western Coosa thrust sheet are sub-parallel to the Eastern Coosa fault (Figure 8.2). These folds are generally open and plunge to the south.

Irregularly shaped ridges along cross sections C-C’, D-D’, and E-E’ (Plate 1; Plate 2) are capped with hematitic sandstone breccia float. Although the float is generally sparse, prospect pits with the sandstone breccia and relatively thick blocks of sandstone are found throughout the area. This float can be traced directly east, across the Eastern Coosa fault to a continuous ridge of Frog Mountain Formation (Sec 8 and Sec 9, T 12 S, R10 E, Plate 1). The stratigraphy of the Frog Mountain Formation in the Western Coosa thrust sheet is strikingly different from that in the Eastern Coosa thrust sheet (Figure 3.2 and Figure 4.1). A hematitic sandstone breccia is common along the northern edge of a large area of Frog Mountain outcrops in the Eastern Coosa thrust sheet. Outcrop patterns and attitudes of the Frog Mountain Formation in the Western Coosa thrust sheet indicate that the stratigraphically thin Frog Mountain Formation (characteristic of the Western Coosa thrust sheet) is underneath the thicker Frog Mountain Formation like that of the Eastern Coosa thrust sheet, suggesting the that thick Frog Mountain Formation on the Western Coosa thrust sheet is allocthonous.

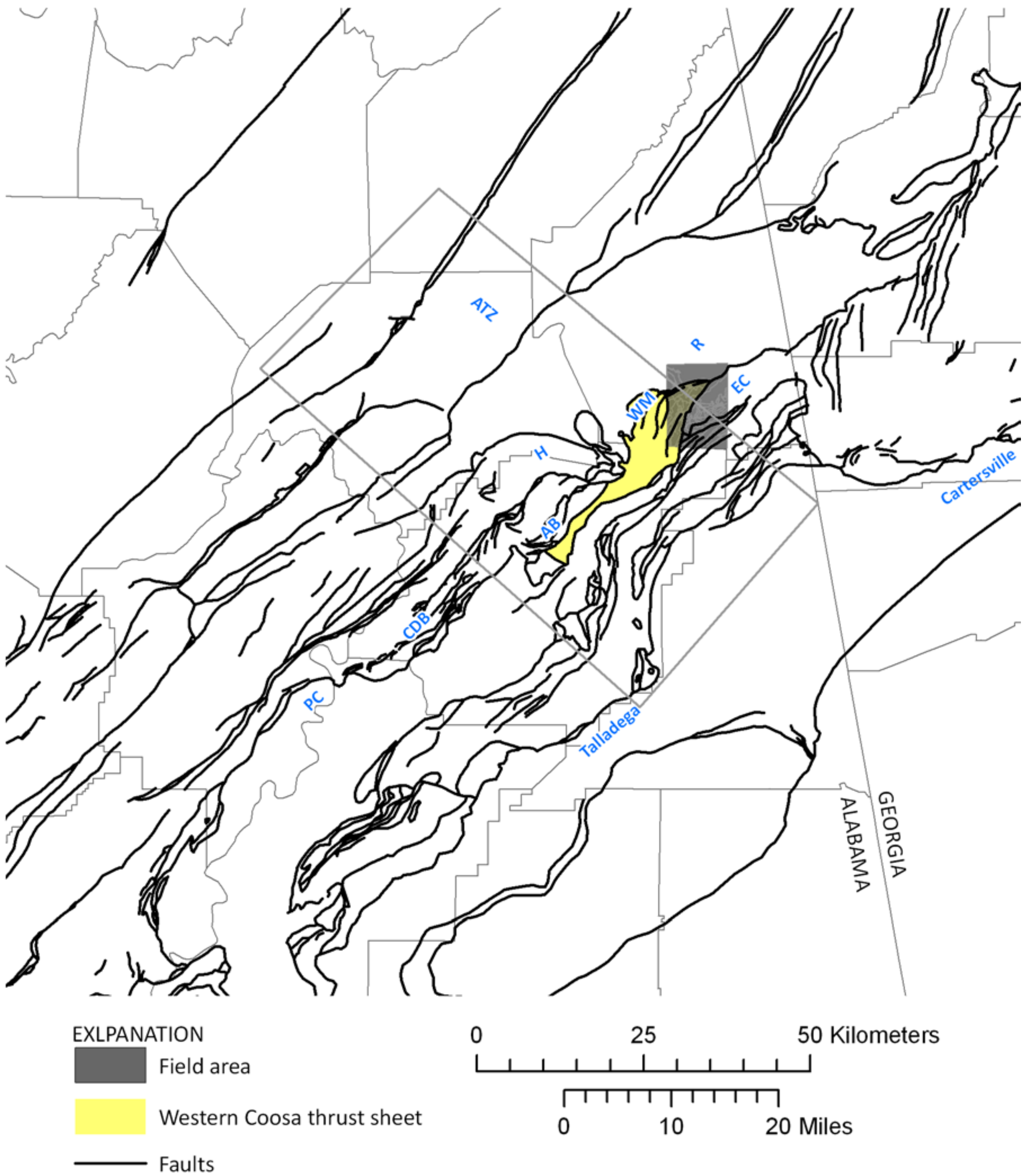

Figure 8.1. Location of the Western Coosa thrust sheet in relation to the field area (R = Rome fault; WM = Wiesner Mountain; H = Helena fault; PC= Pell City fault; ATZ = Anniston transverse zone, shown by outline; AB = Angel block; CDB = Coosa deformed belt; EC = Eastern Coosa fault).

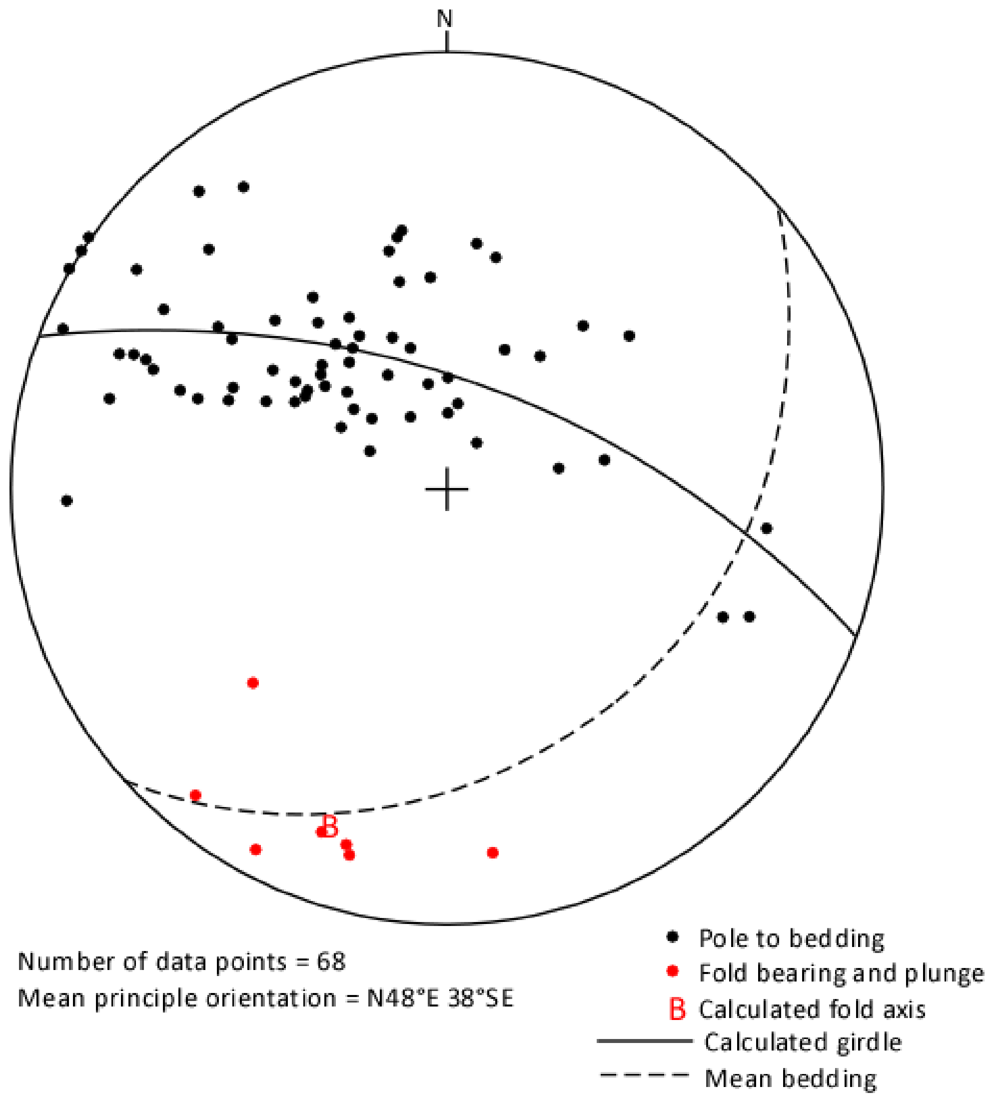

Figure 8.2. Stereonet plot of poles to all bedding attitudes and plunges of folds within the Western Coosa thrust sheet.

CHAPTER 9: STRUCTURE OF THE EASTERN COOSA THRUST SHEET

Regional

The Eastern Coosa thrust sheet is an expansive thrust sheet in Georgia and Alabama (Figure 9.1). In northwestern Georgia, the Eastern Coosa thrust sheet is bound by the Dalton thrust sheet in the footwall to the west (Thomas and Bayona, 2005). To the south, along strike, the Rome thrust sheet bounds the Eastern Coosa thrust fault in the footwall. In northwestern Georgia, the Eastern Coosa fault bends westward, and extends westward with the Rome thrust sheet in the footwall (Osborne and others, 1988; Thomas and Bayona, 2005). In eastern Alabama within the field area, the Eastern Coosa fault curves in strike to more southerly, and truncates the Western Coosa thrust sheet. To the south, the Eastern Coosa fault is truncated by the Jacksonville fault. The Jacksonville fault ends eastward, and the trailing edge of the Eastern Coosa thrust sheet is truncated by the Indian Mountain thrust fault which strikes northeast, but curves abruptly to the southeast, and ends eastward in westernmost Georgia (Figure 9.1). Farther east, the Cartersville and Great Smoky faults truncate the trailing edge of the Eastern Coosa thrust sheet.

The Eastern Coosa thrust sheet contains Lower Cambrian Rome Formation, Middle to lower Upper Cambrian Conasauga Formation, Upper Cambrian to Lower Ordovician Knox Group, Middle Ordovician Athens Shale, a thick succession of Lower Devonian Frog Mountain Formation, and a thin Middle Mississippian Fort Payne Chert (Figure 4.1).

Field Area

In the field area, the Eastern Coosa thrust sheet is bounded on the north by the Rome thrust sheet, on west by the Western Coosa thrust sheet, and on the south by Jacksonville thrust sheet (Plate 1). The Eastern Coosa fault to the northeast of the field area cuts down eastward to the Rome Formation, but it abruptly cuts up section westward juxtaposing the Eastern Coosa oolitic facies of the Conasauga Formation onto the shale and siltstone facies of the Conasauga in the Rome thrust sheet. In the field area, the Western Coosa thrust fault diverges southwestward from the Eastern Coosa fault, and the Eastern Coosa fault takes a more southerly trace. The Eastern Coosa fault cuts up section very gradually southwestward along strike. South of the intersection of the two faults, Conasauga Formation in the Eastern Coosa is thrust onto Conasauga of the Western Coosa thrust sheet; to the south, Knox is faulted onto Knox. Farther southwest, the Eastern Coosa fault brings Middle Ordovician Athens Shale onto Upper Mississippian Bangor Limestone. An internal fault diverges eastward from the Eastern Coosa thrust fault, and continues as a trailing splay. Farther south, the Eastern Coosa fault is truncated by the leading edge of the Jacksonville thrust fault.

The leading edge of the thrust sheet places the oolitic and peloidal carbonate facies of the Conasauga on to the clastic-dominated Conasauga facies of the Rome thrust sheet (Plate 1, Figure 2.1, and Figure 4.1). Topographically, the northern part of the thrust sheet is dominated by a northeast-trending ridge of Knox Group (SE 1/4, Sec 34, T 11 S, R 10 E, Plate 1). Although, Terrapin Creek cuts across the ridge, a ridge continuing south of the creek matches the trend of Eastern Coosa fault. The fault gradually cuts up section through the Knox Group to the Devonian Frog Mountain Formation (Sec 9 and Sec 17, T 12 S, R 10E, Plate 1), which is in a complex shallow thrust sheet. Farther southeast, the Eastern Coosa fault cuts through the Middle Ordovician Athens Shale in the hanging wall (SE ¼, Sec 17, T 12 S, R 10 E, Plate 1).

The dominant fold in the Eastern Coosa thrust sheet, a syncline cored with Athens Shale, is sub-parallel to the east-northeast striking Eastern Coosa fault (Plate 1). The northern limb of the syncline has upper Knox, Athens Shale, and a thick succession of Frog Mountain Formation; the beds dip gently to the southeast (F-F’, Plate 1; Plate 2). The southern limb of the syncline has upper Knox Group and Athens Shale. The Athens is generally vertical; although, some steep to overturned beds are evident (Plate 1). The western part of the syncline has lower Knox chert on the southeast resting on Athens Shale, indicating that the southern limb of the fold is truncated by a southeast-dipping fault with Knox in the hanging wall. To the east, this fault places lower Knox onto Newala Limestone (upper Knox). Furthermore, the Newala Limestone outcrop shows tight folding of the upper Knox Group and the Athens Shale, and the fold is fault-truncated by the lower Knox (Sec 11, T 12 S, R 10 E, Plate 1).

On the east, the irregular outcrop pattern of the thick Frog Mountain Formation shows that it lies discordantly on the Chepultepec Dolomite (Sec 1 and Sec 2, T 12 S, R 10 E, Plate 1). On the west, outliers of the thick Frog Mountain are on both sides of the Eastern Coosa fault (Figure 9.2; Sec 8 and Sec 9, T 12 S, R 10 E, Plate 1). The cross-cutting relationship of the Eastern Coosa fault and the outcrop patterns of the Knox Group, Athens Shale, and Frog Mountain Formation make it difficult to discern stratigraphic and structural relationships within the Eastern Coosa thrust sheet.

Internally, the mean bedding attitude in the Eastern Coosa thrust sheet is N58°E 28°SE, which roughly matches the northeasterly trend of the Eastern Coosa fault (Plate 1, Figure 9.3). The scatter of poles to bedding, however, displays a high degree of variance within the thrust sheet (Figure 9.3). Folds in the thrust sheet are open on average; however, they plunge southward, nearly perpendicular to average bedding. The fold plunge is approximately parallel to the more north-south trending section of the Eastern Coosa fault. Most of the fold data are from the dominant ridge of Frog Mountain Formation containing the dominant topography of the Frog Mountain ridge (Figure 9.2; SE ¼, Sec 10, T 12 S, R 10E, Plate 1).

An irregular, northeast-trending belt of thick Frog Mountain Formation extends through the field area along a topographic ridge called Frog Mountain ridge (area 1, Figure 9.2; Plate 1). The westernmost outcrops of the Frog Mountain Formation adjacent to the Eastern Coosa thrust sheet are in a ridge parallel to the Eastern Coosa fault (areas 2 and 3, Figure 9.2). The southernmost Frog Mountain overlies the Athens Shale (area 2, Figure 9.2; SE ¼, Sec 17, T 12 S, R 10 E, Plate 1). The westernmost outcrops of Frog Mountain Formation extend onto the Western Coosa thrust sheet (area 4, Figure 9.2).

The Frog Mountain Formation at the western end of Frog Mountain ridge (area 1a, Figure 9.2; SW ¼, Sec 10, T 12 S, R 10 E, Plate 1) is apparently concordant with the dip of the underlying Knox Group on the north. To the east, on the north side of Frog Mountain ridge, the Knox Group and Frog Mountain Formation are concordant as well (area 1b, Figure 9.2; NE 1/4 , Sec 10, T 12 S, R 10 E, Plate 1). The ridge continues eastward, and bifurcates around a topographically low spot in the ridge, where siliceous dolomite indicative of the upper Knox Group is found (area 1c, Figure 9.2; NE ¼, Sec 11, T 12 S, R 10 E, Plate 1). This low area in the ridge is surrounded by Frog Mountain Formation. Farther east, the ridge forks to the north, where the Frog Mountain Formation outcrop pattern shows that the Frog Mountain Formation rests on the Chepultepec Dolomite of the Knox Group (area 1d, Figure 9.2; Sec 2 and Sec 1, T 12 S, R 10 E, Plate 1). Where the southern fork of Frog Mountain ridge continues to the northeast, Athens Shale crops out on both the north side and the south side of the ridge adjacent to the Frog Mountain Formation (area 1e, Figure 9.2; SW ¼, Sec 1, T 12 S, R 10 E, Plate 1). The base of the Frog Mountain Formation along the north side of the Frog Mountain ridge is dominated by a hematitic sandstone breccia, which can be used to trace the Frog Mountain Formation westward from Frog Mountain ridge across the Eastern Coosa fault (areas 2, 3, and 4, Figure 9.2; Sec 8, T 12 S, R 10 E, Plate 1).

On the southern side of the Frog Mountain ridge (area 1, Figure 9.2), the Frog Mountain Formation rests mostly on the Middle Ordovician Athens Shale, except at the western end of the ridge where the Frog Mountain rests on the Newala Limestone of the Knox Group. The strike of the Athens Shale bedding is nearly parallel to the strike of Frog Mountain bedding; however, the Athens dips, on average, are vertical to overturned, and generally steeper than Frog Mountain Formation dips (Sec 11, T 12 S, R 10 E, Plate 1). The Frog Mountain Formation close to the contact of the Athens Shale has the appearance of quartzite.

Tracing the thick Frog Mountain Formation west of Frog Mountain ridge, two isolated ridges of Frog Mountain Formation crop out. The southern ridge overlies the Athens Shale (area 2, Figure 9.2). The southeastern face of this ridge dips steeply to the southeast. An anticline hinge crops out at the southern end of the ridge with a bearing and plunge of S45^{o}W 37^{o} (Figure 9.4). The Frog Mountain Formation on the northern ridge (area 3, Figure 9.2NE ¼ Sec 17 and SW ¼, Sec 9, T 12 S, R 10 E, Plate 1) overlies the Knox Group, and also dips steeply to the east (Figure 9.5).

Tracing the hematitic sandstone breccias farther to the west shows the Frog Mountain Formation discordantly overlying the folded and faulted stratigraphic succession of the Western Coosa thrust sheet (area 4, Figure 9.2). Although thick Frog Mountain Formation outcrop is rare (SE ¼, Sec 8, T 12 S, R 10 E, Plate 1), blocks of sandstone float thicker than the Western Coosa Frog Mountain Formation sandstone facies are found on the irregularly shaped ridges of the Western Coosa thrust sheet.

Isolating the bedding attitudes in the Frog Mountain Formation on a stereonet plot reveals scattered bedding orientations; however, dominant northeast-striking beds dip relatively gently to the southeast (Figure 9.6). A secondary trend on the plot is of bedding striking northwest and dipping to the southwest. The average attitude for the Frog Mountain Formation is N71^{o}E 22^{o}SE. The plot for all units except Frog Mountain in the Eastern Coosa thrust sheet (Figure 9.7) is less noisy with an average attitude of N43^{o}E 38^{o}SE.

In summary, the base of the Frog Mountain Formation is above the Middle Ordovician Athens Shale at the southern side of Frog Maintain ridge and above the Upper Cambrian to

Lower Ordovician Knox Group along the northern side of Frog Mountain ridge (Plate 1). Previous mappers recognized this relationship and suggested (1.) a Taconic disturbance and an angular unconformity beneath the Frog Mountain Formation (Cloud, 1967); or (2.) the Frog Mountain ridge is a thrust klippe as inferred from the outcrop pattern and internal structure (Bearce and others, 1977). The Frog Mountain Formation on the south side of the ridge is in contact with the Athens Shale, and is relatively quartzite-like; and individual grains are difficult to impossible to discern. The Frog Mountain on the northern side of the ridge is in contact with the Knox Group, and is characterized by hematitic sandstone breccia. The rock fabrics of the Frog Mountain suggest structural deformation along the base, indicating that the contact of the Frog Mountain Formation with the Athens Shale and Knox Group is a fault. Therefore, the thick Frog Mountain Formation ridge is interpreted to be a thrust klippe that has been transported northward, and the original depositional contact was with the Athens Shale. The Frog Mountain fault cut downward stratigraphically in the footwall in the direction of transportation.

Regionally, the lower Devonian Frog Mountain Formation is known to unconformably overlie the Red Mountain Formation, the Chickamauga Limestone, the Athens Shale, the Little Oak Limestone, and the Newala Limestone; but it is not known to rest on any rocks older than the Newala Limestone (Keifer, 1970). Distribution of Frog Mountain Formation in the field area shows the Frog Mountain rests not only on the Newala Limestone, but on the Chepultepec Dolomite of the Knox Group as well, supporting the idea of a downward cutting fault at the base of the Frog Mountain Formation, and the Frog Mountain in the field area is a thrust sheet (NE ¼ Sec 1 T 12 S, R 10 E, Plate 1).

To the west of the Frog Mountain ridge, outliers of the Frog Mountain thrust sheet are truncated folds in the Eastern Coosa hanging wall (area 2 and area 3, Figure 9.2). Furthermore, the thick Frog Mountain Formation can be traced across the Eastern Coosa fault, where it truncates folds and faults in the Western Coosa thrust sheet which is the Eastern Coosa footwall (cross sections C-C’, D-D’, and E-E’, Plate 1; Plate 2).

Frog Mountain Fault Mechanism

From the geologic map of the field area (Plate 1), a translational distance of ~2 km for the fault at the base of the Frog Mountain Formation can be derived by measuring from the Knox Group/Athens Shale contact in the Eastern Coosa thrust sheet (NE ¼, Sec 16, T 12 S, R 10 E, Plate 1) to the northernmost Frog Mountain Formation outlier in the Western Coosa thrust sheet (NE ¼, Sec 8, T 12 S, R 10 E, Plate 1). A translational distance of ~1.2 km is measured from the Athens Shale/Knox Group contact in SW ¼, Sec 1, T 12 S, R 10 E (Plate 1) to the Frog Mountain Formation in the NW ¼, Sec 1, T 12 S, R 10 E (Plate 1). Using part of cross section F-F' (Plate 2) a sequence of events can explain the stratigraphically downward cutting fault at the base of the Frog Mountain Formation which truncates structures within the Western Coosa thrust sheet (Plate 3). A model for the Frog Mountain fault (Plate 3) was developed using a stiff/weak-layer model and an out-of-the-syncline thrust (Butler, 1982).

After emplacement of Western Coosa thrust sheet, movement begins on the Eastern Coosa thrust fault (I, Plate 3). A fault-bend fold develops in the hanging wall at the frontal ramp of the Eastern Coosa fault (I, Plate 3). Later faults are shown in Plate 3; hanging wall/footwall cutoffs are shown (A_0, B_0, and C_0 in Plate 3).

As strain increases in the Eastern Coosa thrust sheet, a break-back splay thrust fault develops and begins to propagate through the Knox Group, but does not break through the Knox Group (stiff layer) (II, Plate 3). As shortening in the Athens Shale (weak layer) and underlying Knox Group continues, thrust separation and tectonic thickening and thinning in the Athens Shale accompanies ductile deformation and tight folding with the upper part of the underlying Knox Group, while the overlying Frog Mountain Formation (stiff layer) is not incorporated with folding. The area of ductile deformation of the Athens Shale is controlled by distance needed to transport the Frog Mountain Formation roughly 2 km, and is constrained by the location of the trailing Easter Coosa splay (Plate 1). Initial displacement of 640 m between A_0 and A_1, translates to shortening of the top of the Knox Group by 640 m as the top of the Knox Group is tightly folded with the Athens Shale. An out-of-the-syncline thrust at the base of the Frog Mountain Formation (stiff layer) develops over the tectonically shortened and thickened Athens Shale (II, Plate 3). This thrust, cuts stratigraphically down section in the footwall through the Athens Shale and truncates the fault-bend fold in the Eastern Coosa hanging wall. As the out-of the-syncline thrust continues to cut structurally higher, it incorporates Athens Shale in the hanging wall, and truncates the Eastern Coosa fault by 640 m, the distance between B_0 and B_1 (II, Plate 3).

Reactivation of the Eastern Coosa trailing splay emplaced Knox Group over the deformed Athens Shale and uppermost Knox Group. Break through at C_0, resulted in a final movement of ~360 m along the base of the Frog Mountain Formation (measuring the bed length of the base of the Frog Mountain Formation) (B_1 to B_2, III, Plate 3). A minimum net movement of 1 km has occurred at the base of the Frog Mountain Formation. Although the translation distance demonstrated in Plate 3 is not as great as illustrated on Plate 1, alterations to the Knox ramp could modify translational distance.

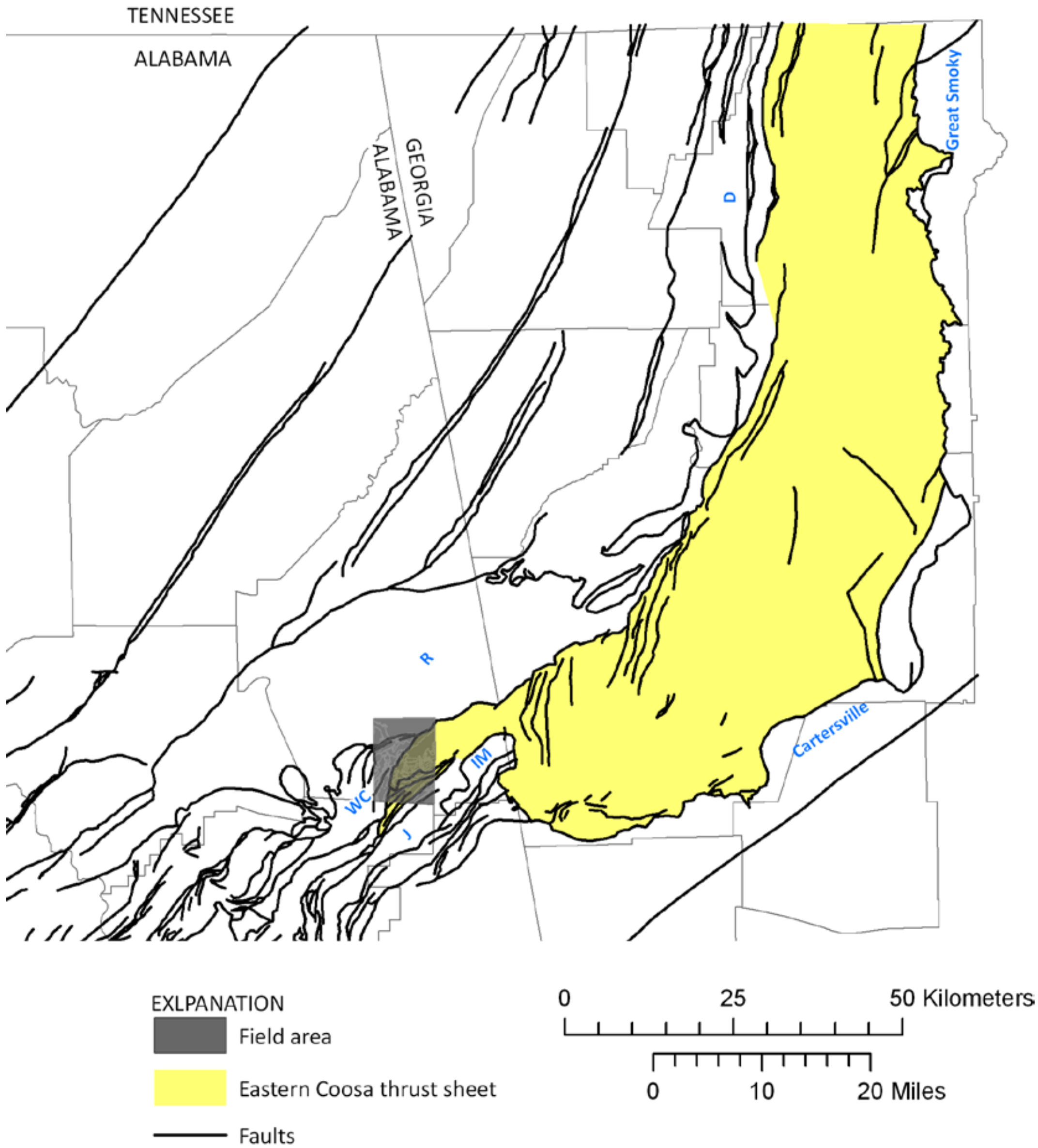

Figure 9.1. Location of the Eastern Coosa thrust sheet in relation to the field area (D = Dalton, R = Rome, WC = Western Coosa, J = Jacksonville, and IM = Indian Mountain faults).

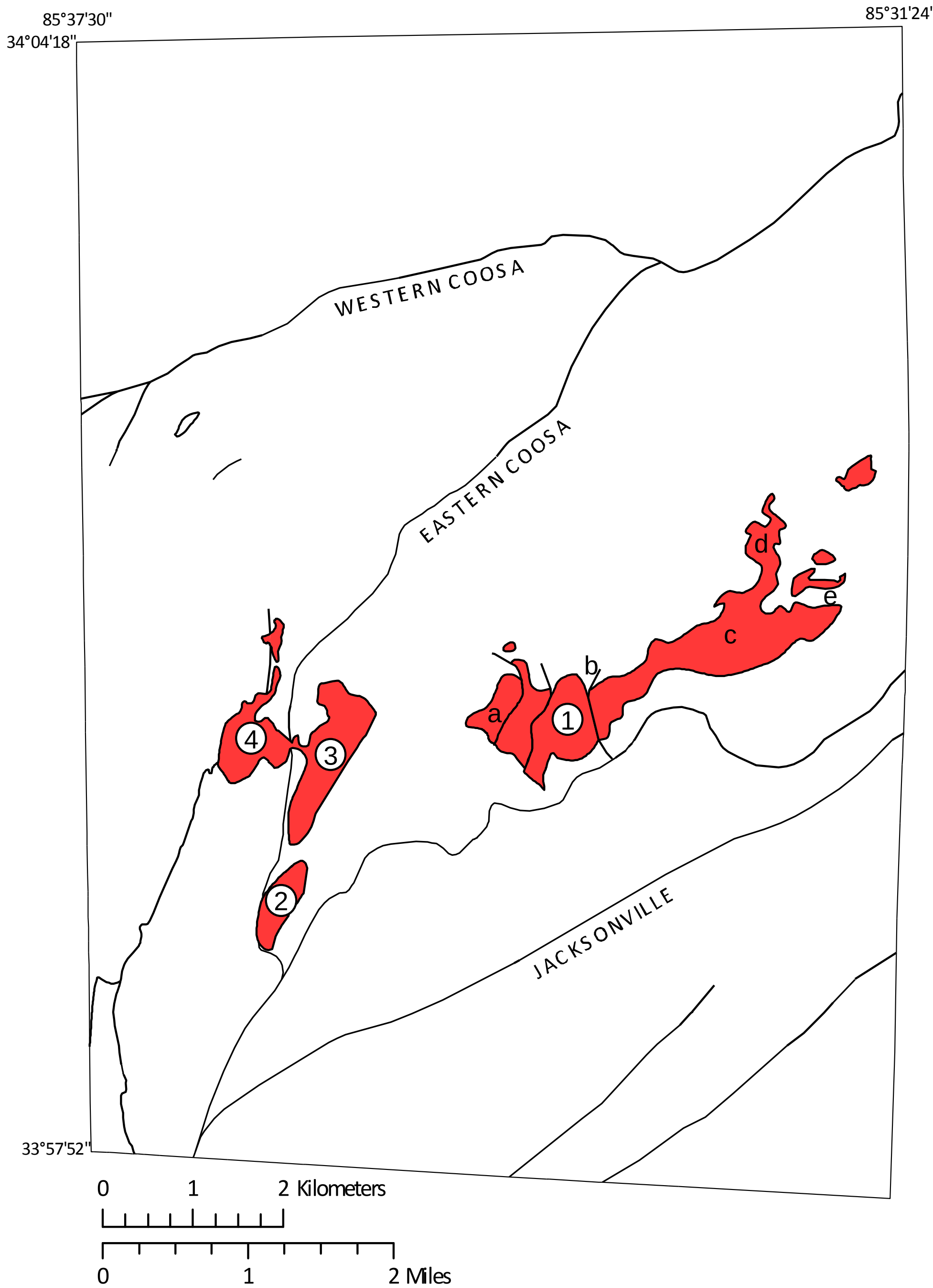

Figure 9.2. Outline map of faults and thick Frog Mountain Formation (red) labeled 1 through 4. Frog Mountain Formation in contact with the upper Knox Group at 1a through 1c. Frog Mountain Formation in contact with Chepultepec Dolomite of the Knox Group at 1d. The Frog Mountain Formation overlies the Athens shale at 1e.

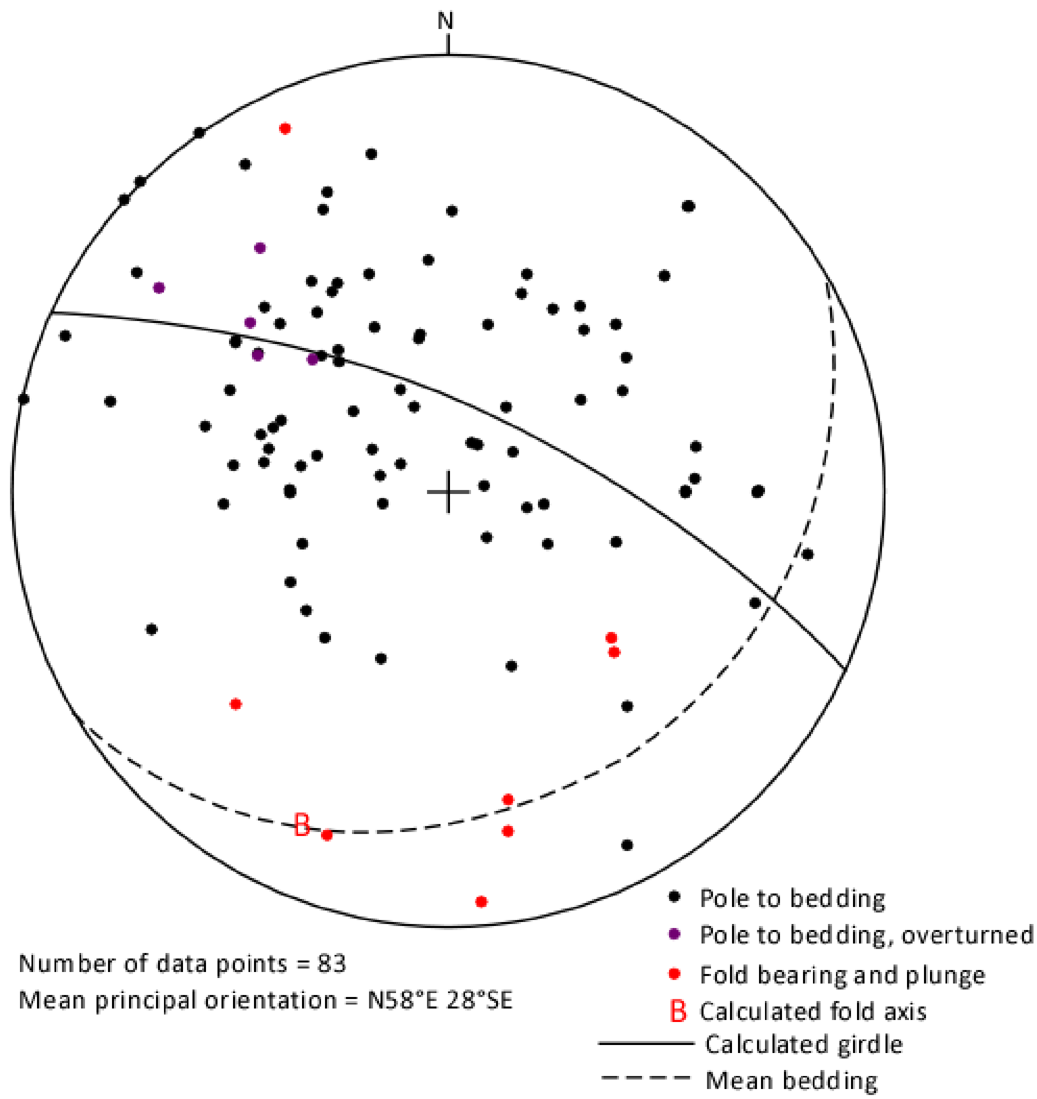

Figure 9.3. Stereonet plot of poles to all bedding attitudes within the Eastern Coosa thrust sheet.

Figure 9.4. Slumped fold hinge in the Frog Mountain Formation with a bearing and plunge of S45°W 37° (area 2, Figure 9.2)

Figure 9.5. Dip slope of Frog Mountain Formation (area 3, Figure 9.2).

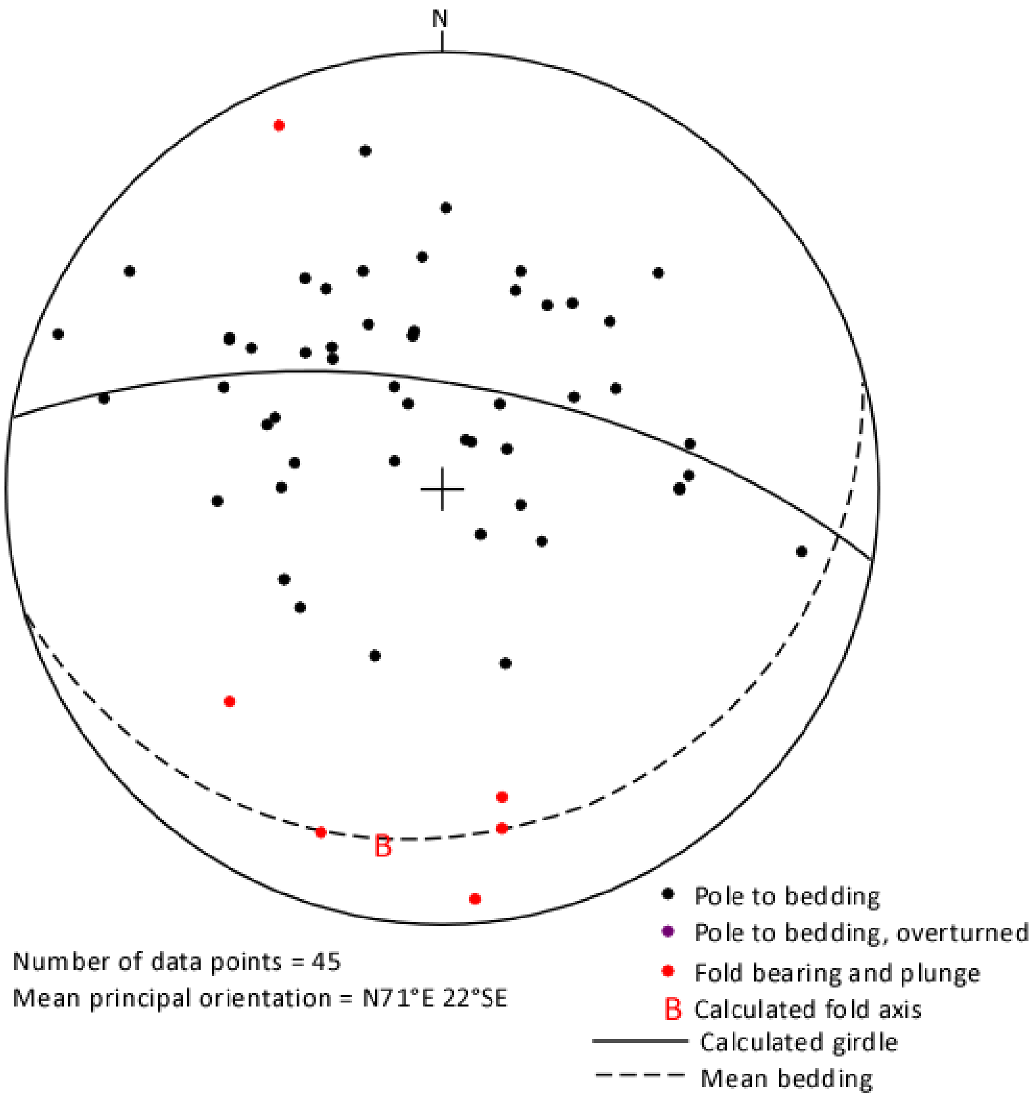

Figure 9.6. Stereonet plot of poles to bedding attitudes of the Frog Mountain Formation within the Eastern Coosa thrust sheet.

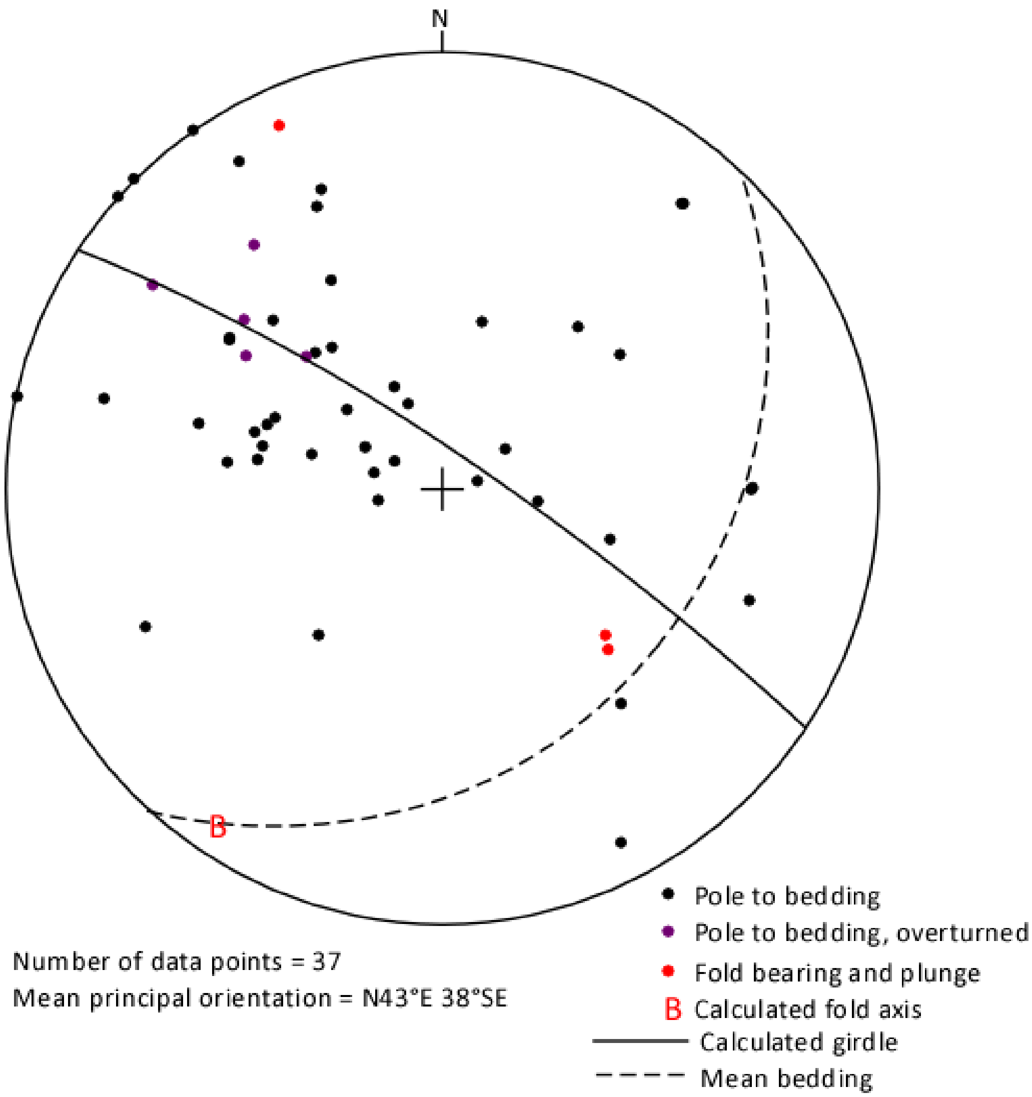

Figure 9.7. Stereonet plot of poles to bedding attitudes in the Eastern Coosa thrust sheet for all units other than the Frog Mountain Formation.

CHAPTER 10: STRUCTURE OF THE JACKSONVILLE THRUST SHEET

Regional

Splays of the Jacksonville thrust fault extend to the northwest into the Eastern Coosa thrust sheet (Figure 10.1), and the Jacksonville thrust sheet merges with the trailing part of the Eastern Coosa thrust sheet (Thomas and Bayona, 2005). To the southeast, the Jacksonville fault truncates the Eastern Coosa fault and truncates the trailing edge of the Western Coosa trust sheet. The Jacksonville fault abruptly strikes to the south, and it truncates the trailing edge of Pell City thrust sheet. Farther south, the Jacksonville fault changes strike, to a more westerly trend. To the southwest, the Jacksonville fault may merge with the Pell City fault (Cook and Thomas, 2009). The Sleeping Giants klippe to the southwest of the trace of the Jacksonville fault may be trailing imbricates of the Jacksonville fault. The trailing edge of the Jacksonville thrust sheet is truncated by the Talladega fault and the Indian Mountain fault.

Field Area

In the field area, outcrop data in the Jacksonville thrust sheet are sparse. Most of the surface structural relationships were mapped on the basis of float. The Jacksonville fault maintains an average strike of N60^{o}E, and on the basis of outcrop width and Conasauga-type float, places Conasauga of the Jacksonville thrust sheet onto Knox of the Eastern Coosa thrust sheet (Sec 13 and Sec 14, T 12 S, R10 E, Plate 1). The fault cuts down section along-strike southwestward in the hanging wall, placing Rome of the Jacksonville thrust sheet onto Knox of the Eastern Coosa thrust sheet. The Jacksonville fault bends to the south, and truncates the Eastern Coosa fault (Sec 29, T 12 S, R 10 E, Plate 1). An average attitude for bedding in and just south of the field area is N55^{o}E 44^{o}SE. Two splays off the Jacksonville fault repeat sections of Conasauga and Knox (cross section F-F'', Plate 1; Plate 2)

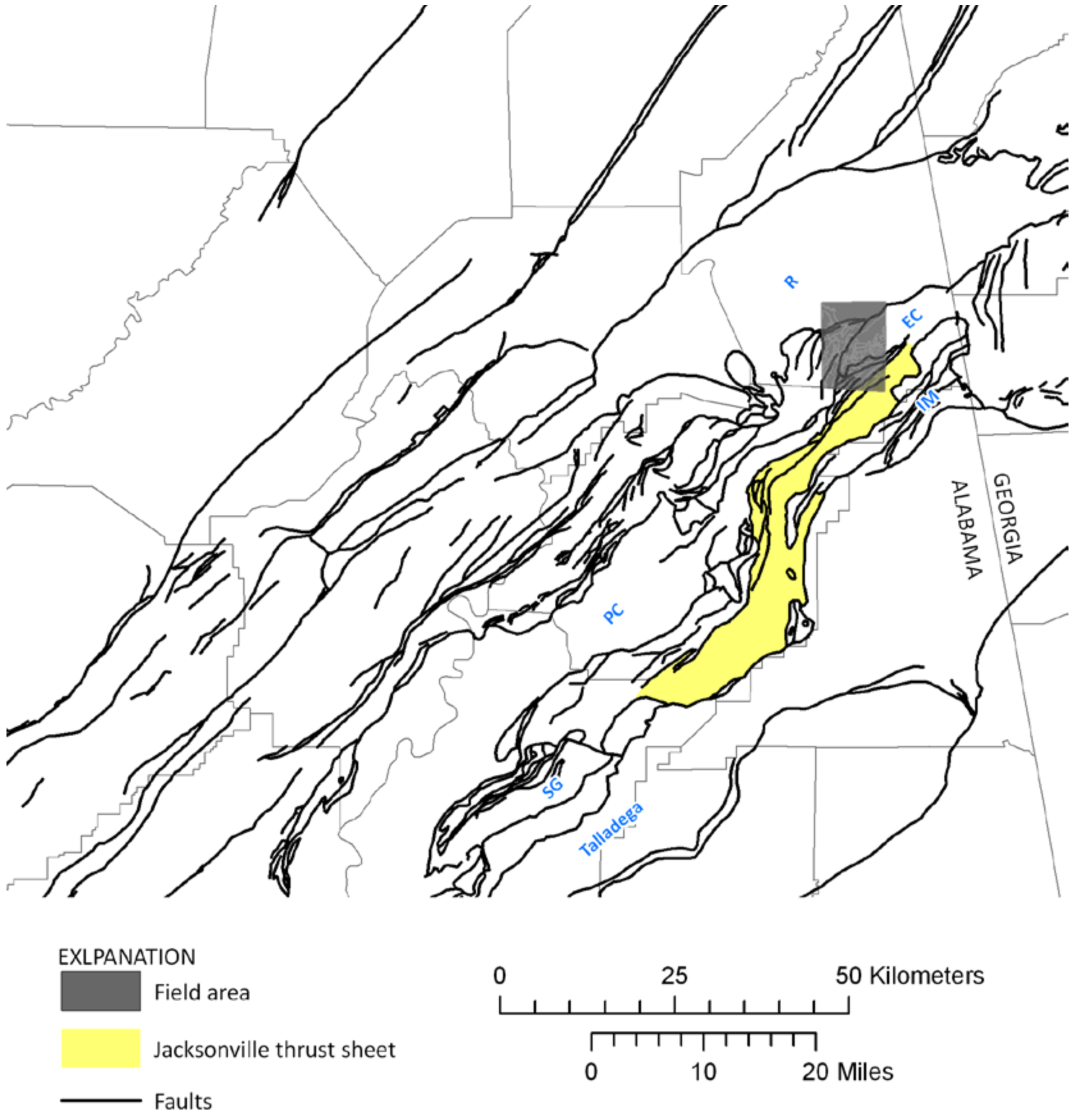

Figure 10.1. Location of the Jacksonville thrust sheet (EC = Eastern Coosa, PC = Pell City SG = Sleeping Giants, and IM = Indian Mountain faults).

CHAPTER 11: REGIONAL DISTRIBUTION OF FROG MOUNTAIN FORMATION

The Devonian Frog Mountain Formation in northern Alabama and northwestern Georgia is bounded above and below by unconformities. The pre-Frog Mountain Formation unconformity truncates strata from Siliruian (Red Mountain Formation) to Lower Ordovician (Newala Limestone of the Knox Group) in age.

Kiefer (1970) studied the Lower Devonian Frog Mountain Formation in eastern Alabama, and Ferrill (1984) studied the Frog Mountain in central Alabama. Kiefer (1970) based his interpretations on data from 66 measured sections, and palinspastic restorations of the thrust belt. By looking at the restored distribution of grain sizes, he concluded the Frog Mountain was derived from northern sources (i. e., the Nashville Dome). Isopachs created by Kiefer (1970) show a narrow linear trend of the Frog Mountain Formation, suggesting some possible thickness and facies control by northeast-southwest trending basement normal faults.

Ferrill (1984) measured 37 sections, mostly in the fold-and-thrust belt, but also some in the Talladega slate belt. Ferrill ruled out a northern source for the Frog Mountain Formation, but suggested the Frog Mountain Formation was partly reworked Silurian strata. The Frog Mountain Formation is more feldspathic than underlying sedimentary rocks, and the feldspars are the same type as those in the Butting Ram Quartzite of the Talladega Group, suggesting that the Butting Ram and Frog Mountain have a shared source.

The goal for this portion of the project is to develop a restored map of the outcrops using palinspastic restoration of thrust sheets in Alabama and Georgia by Thomas and Bayona (2005). The restoration was based on balanced structural cross sections, which used data from outcrops, deep wells, and seismic lines.

Method

Using shape files from the USGS, a base map of counties and Public Land Survey System (PLSS) for Alabama and Georgia was compiled. Measured-section locations of Kiefer (1970) and data from county reports published by the Georgia Geological Survey (Croft, 1964; Cressler, 1970, 1964a, b, 1963) were approximated using the PLSS and county information (Figure 11.1). The original measured sections were referenced using township and range in Alabama.

Measured sections in Georgia were located using geographic and thrust sheet loctions. Accurate location of outcrops points would have been aided by locations given in latitude/longitude.

The restoration of Frog Mountain outcrops is based on the restoration of the thrust belt in Alabama and Georgia (

Figure 11.2). The restored map of Thomas and Bayona (2005) was downloaded as a Portable Document File (PDF), cropped, and converted to a Tagged Image Format File (TIFF). The TIFF image contained information about the present location of thrust faults, cross section lines, the palinspastic position of the thrust faults, and locations of basement faults. Much of the geologic information was traced from the Alabama 1:250,000 Geologic Map (Osborne and others, 1988) which is in a polyconic projection, and the Georgia 1:500,000 Geologic Map (Lawton and others, 1976). The image was georeferenced in many different ways, trying not to distort the image too much (some distortion occurs when georeferencing an image). Large errors developed from the method of the primary data collectors (Township and Range), as well as error generated by georeferencing the image. The paper geologic maps were traced in pieces then assembled. Paper maps will stretch with time, and small offsets from the paper stretching will result in errors. When an image is registered, one pixel of the image is assigned coordinates. Errors will result if the pixels are not the correct distance apart. During rectification of the image, the image is stretched and compressed to match the coordinates given to the pixels. This results in a loss in accuracy, because pixels don't compress. Many attempts were made at georeferencing the image to a polyconic projection, but the projection could not be attained using Blue Marble Geographic Transformer 3, or ArcInfo 9.3, so the image was projected into UTM Zone 16N, NAD 1927 using ArcMap 9.3.1. UTM was chosen because it would result in rotation of the image rather than compressing it. Data from the image were then collected using ArcInfo 9.3, converted to ArcGIS shape files, and projected into decimal degree using ESRI's projection utility. Projecting vectors does not introduce much error, because vectors will readily compress and expand from one projection to the other. The resultant error is approximately 0.8 km at its largest (at any scale). No other techniques were used to mitigate this error.

The measured-section locations were projected on to a map of the top of the Cambrian Conasauga Formation, restored parallel to the balanced structural cross sections, and placed in palinspastic positions (Figure 11.3). The thickness of the Frog Mountain Formation was then contoured using ArcMap 9.3.1, and the initial isopach was then hand edited using ArcInfo 9.3 to create a final isopach (Figure 11.4).

Results

The initial restoration of the Frog Mountain points demonstrates the abnormally thick Frog Mountain type section is translated a distance of 100 km (Figure 11.3). Thus, the stratigraphic gradient has been greatly shortened. Isopach contours show thickening to the southeast. There is local thickening, as much as 29 m, in the northern area. Projection of known basement faults leads to the interpretation that there may indeed be some fault control on the northern depocenter of the Frog Mountain Formation. The local, abnormally thick section may have been deposited in a graben that had rotated down to the southwest, and preserved more of the Lower Devonian section (Figure 11.4). The thick southeastern Frog Mountain Formation, associated with the Eastern Coosa thrust sheet, restores closer to a southern source, closer to the Laurentian continental margin. The Frog Mountain Formation thins and pinches out cratonward.

Mapping the Frog Mountain subcrop illustrates that the Frog Mountain overlies rocks of Early Ordovician to Early Silurian in age (Figure 11.5). Four areas on the map stand out: (1.) the northern region where the Frog Mountain Formation generally is absent or where present, overlies the Lower Silurian Red Mountain Formation, (2.) a north-central region, where the Frog Mountain Formation overlies Middle Ordovician Little Oak Limestone and Chickamauga Limestone, (3.) a central region where the Frog Mountain Formation overlies the Lower Ordovician Newala Limestone of the Knox Group, and (4.) a southern region where the Frog Mountain Formation overlies the Middle Ordovician Athens Shale. The subcrop map displays four regional unconformities merging and diverging. The unconformities are at Early-Middle Ordovician, Late Ordovician-Early Silurian, Middle Silurian-Early Devonian, and Middle Devonian times (Figure 11.6). These unconformities bound varying successions of strata which record the tectonic history of the Laurentian margin near Alabama and Georgia.

The Athens Shale represents the flysch-like deposits of the Blountian synorogenic clastic wedge (Bayona and Thomas, 2003). As the peripheral foreland bulge migrated cratonward during the Blountian tectophase of the Taconic orogeny, preexisting basement faults were reactivated. This resulted in the inversion of the Birmingham graben (Figure 11.5) (Bayona and

Thomas, 2003). The Middle Ordovician Athens Shale lapped onto the Blountian peripheral foreland bulge (Figure 11.5 and Figure 11.6), the central region of Lower Ordovician Newala Limestone. Cratonward from the bulge, during Middle Ordovician time, the foreland was relatively stable, and carbonates continued to be deposited (the Little Oak Limestone and the Chickamauga Limestone) (Bayona and Thomas, 2003). The Lower Silurian Red Mountain Formation lapped onto the Middle Ordovician Chickamauga Limestone but pinched out southward, and did not lap down onto the Newala Limestone, suggesting the Blountian peripheral foreland bulge remained a topographic high during Early Silurian time. During the Acadian orogeny, oblique convergence and southwestward migration of the orogen occurred (Ettensohn 1985, 1987). Dextral transpression at the Alabama promontory resulted in basement uplifts and deposition of the Talladega Group (Ferrill and Thomas, 1988). Similarities between the Butting Ram Quartzite of the Talladega Group and sandstones of the Frog Mountain Formation suggest a shared provenance (Ferril, 1984; Ferrill and Thomas, 1988). The Frog Mountain Formation thins and pinches out cratonward (Figure 11.4). Where the Frog Mountain Formation overlies the Athens Shale, it is generally thicker and nearly all sand. Where the Frog Mountain Formation overlies the Newala Limestone it is generally thin and mostly shale. The facies relationships and subcrop pattern of the Frog Mountain Formation suggest that the Frog Mountain Formation was deposited over a low topographic high during Early Devonian time. The topographic high may have impeded dispersal of coarser clastic sediment cratonward. The low topographic high occupied the same area as the Blountian peripheral foreland bulge.

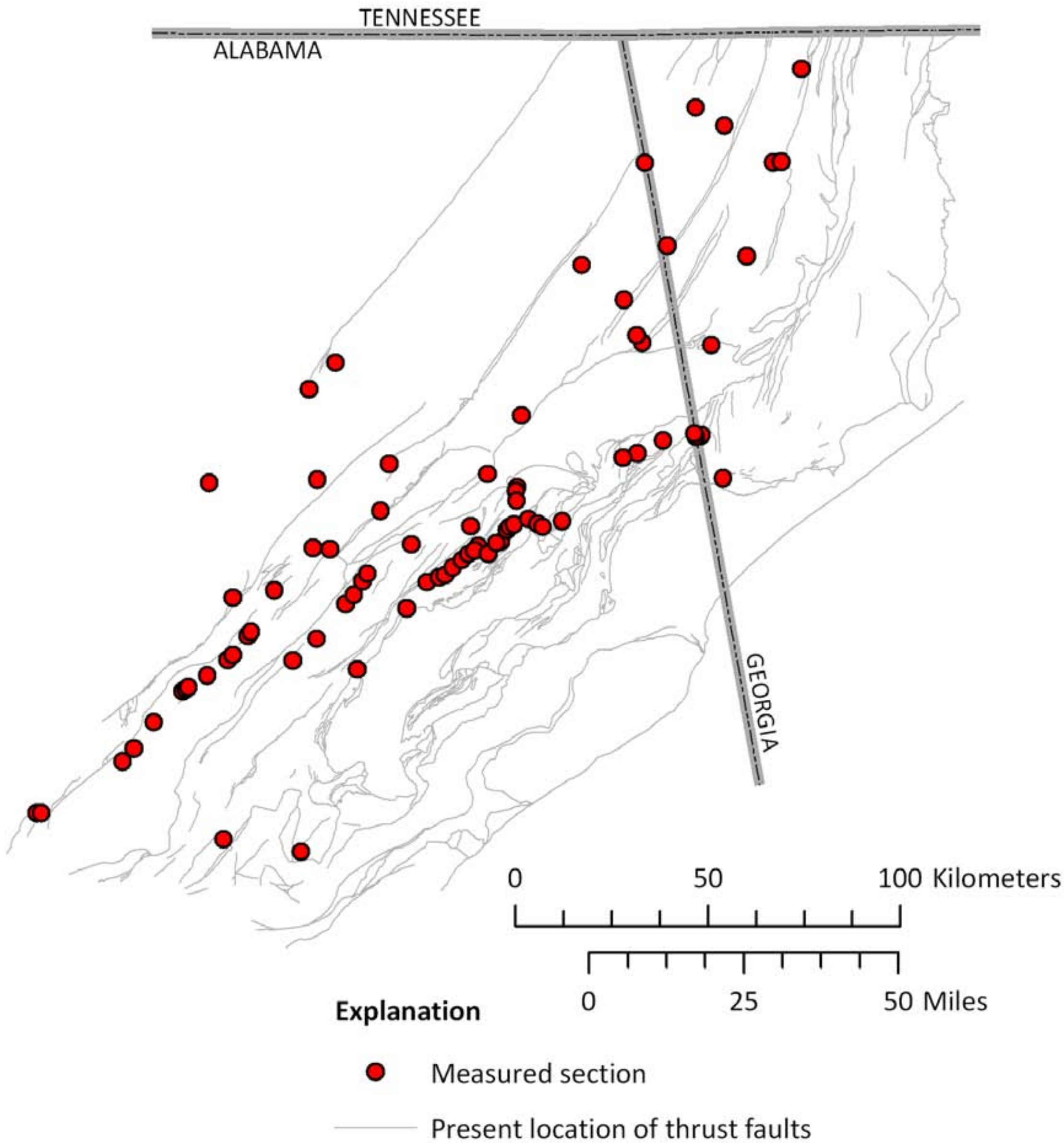

Figure 11.1. Measured sections located using Public Land Survey System and layered on thrust fault locations for Alabama and Georgia (Cressler, 1964a; 1964b; Kiefer, 1970)

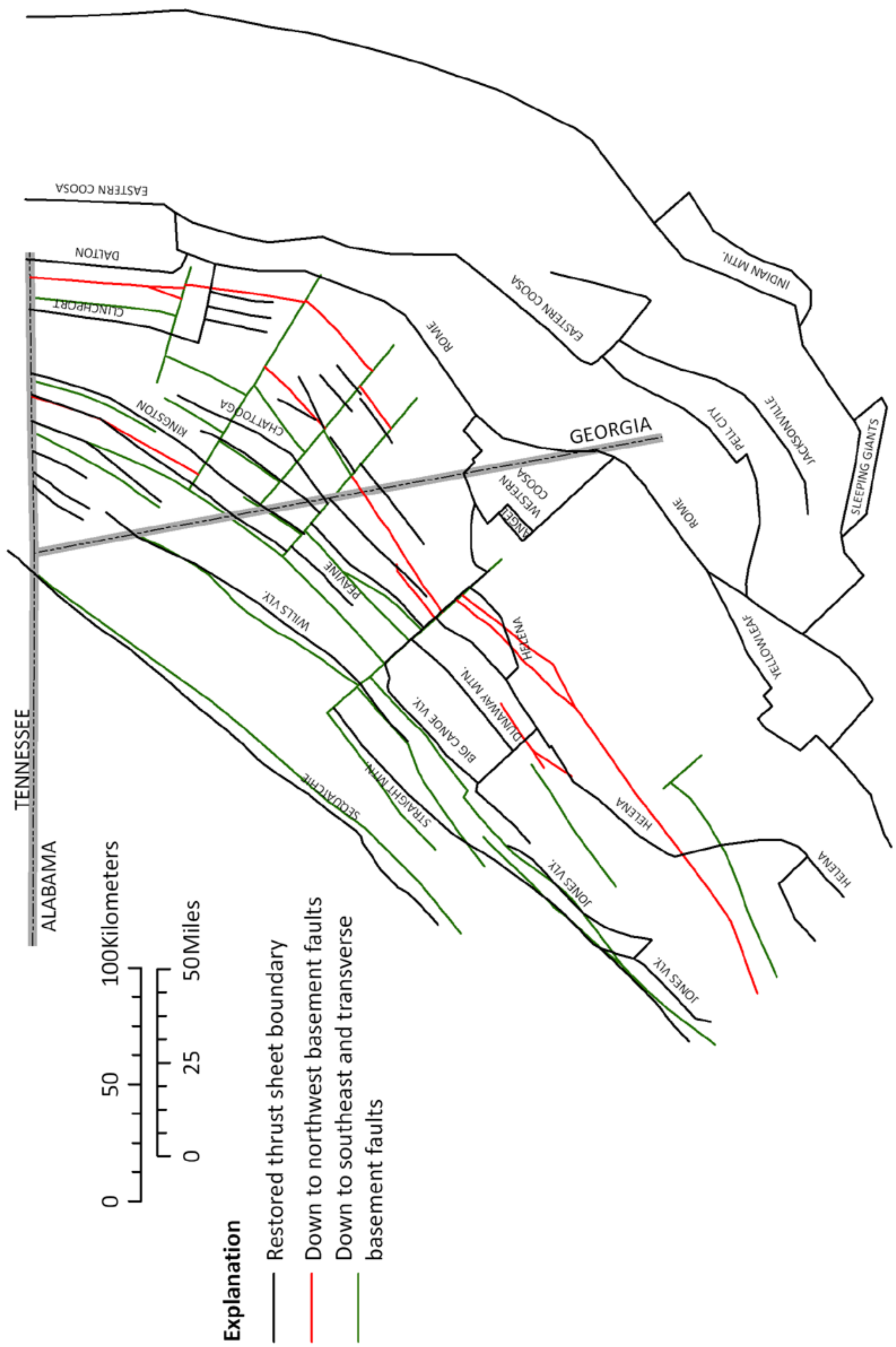

Figure 11.2. Palinspastic map from Thomas and Bayona (2005).

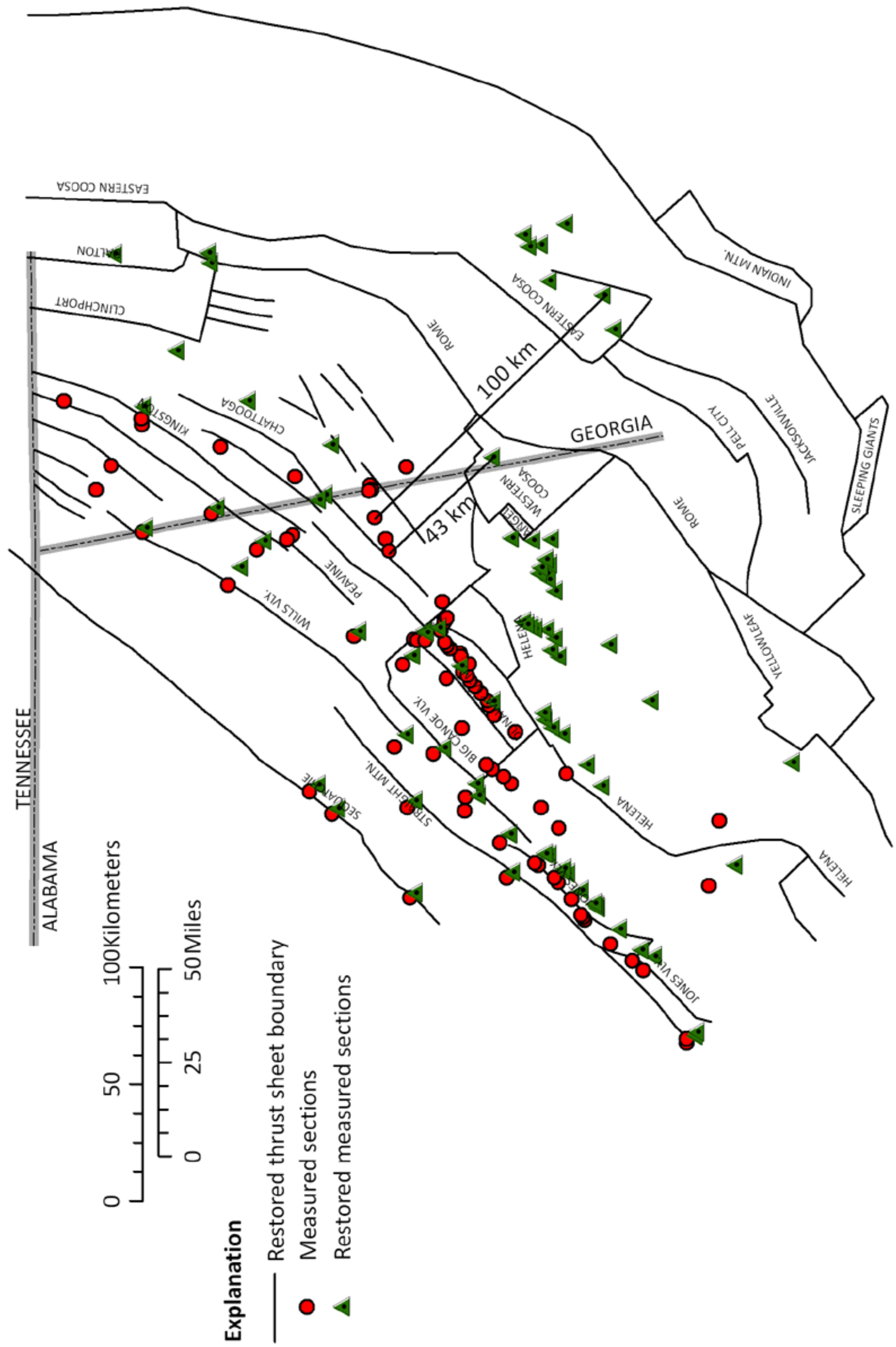

Figure 11.3. Measured sections of Frog Mountain Formation restored parallel to restored cross sections.

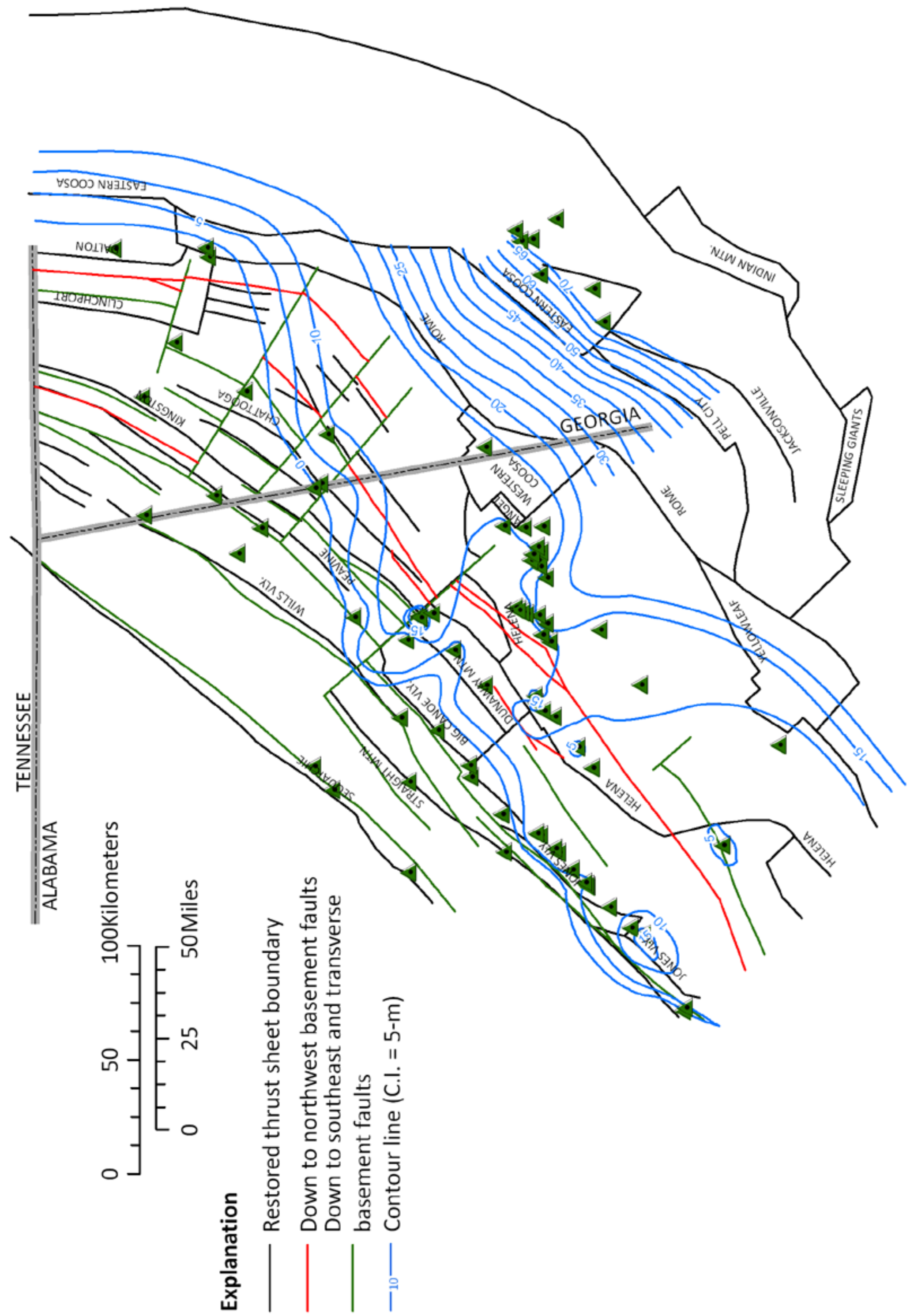

Figure 11.4. Isopach map of Frog Mountain Formation with locations of restored measured sections.

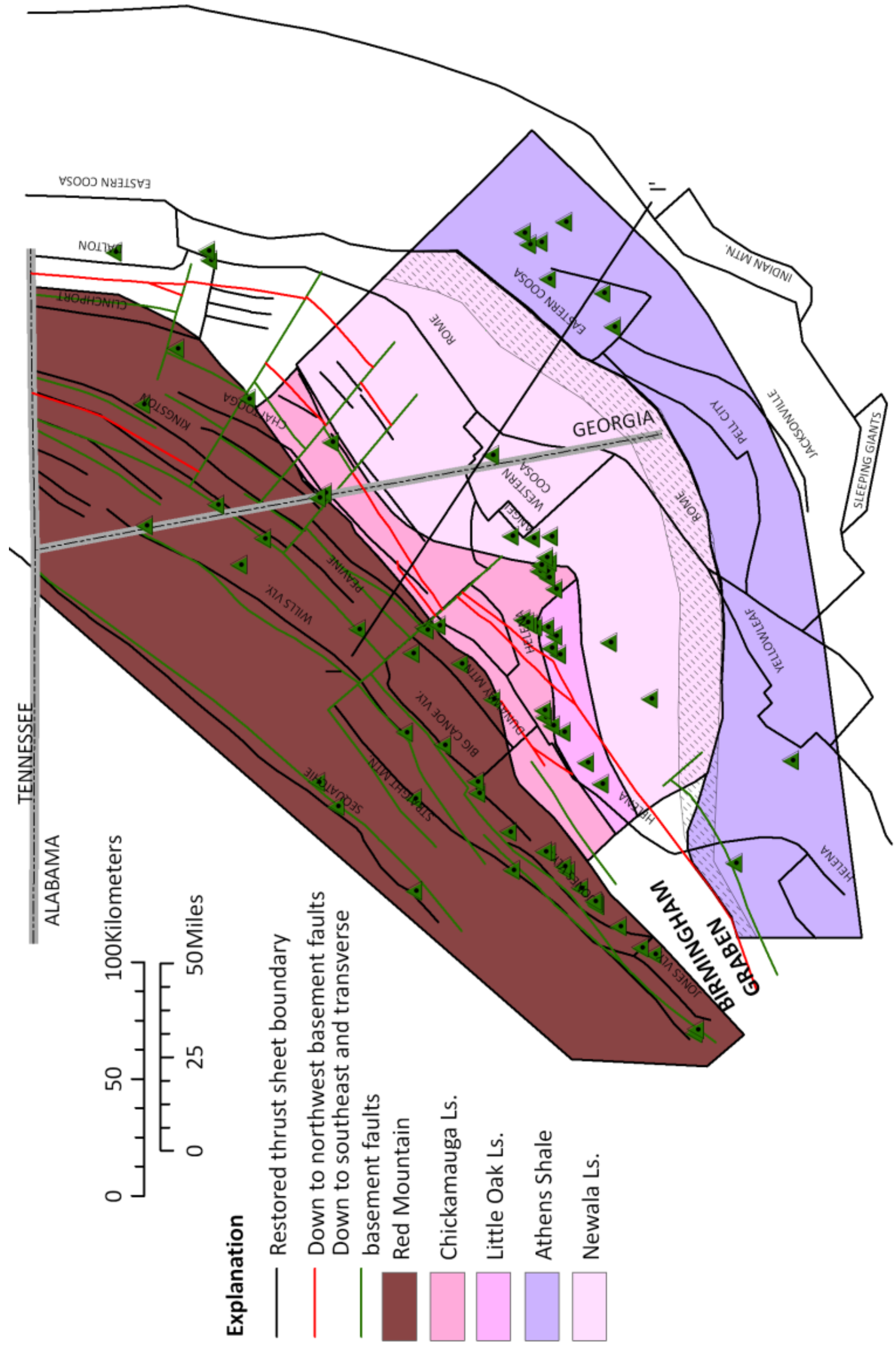

Figure 11.5. Subcrop below unconformable base of Frog Mountain Fromation, using locations of restored measured sections. The facies transition from shaly Frog Mountain Formation to sandy Frog Mountain Formation is shown by the hatchered polygon.

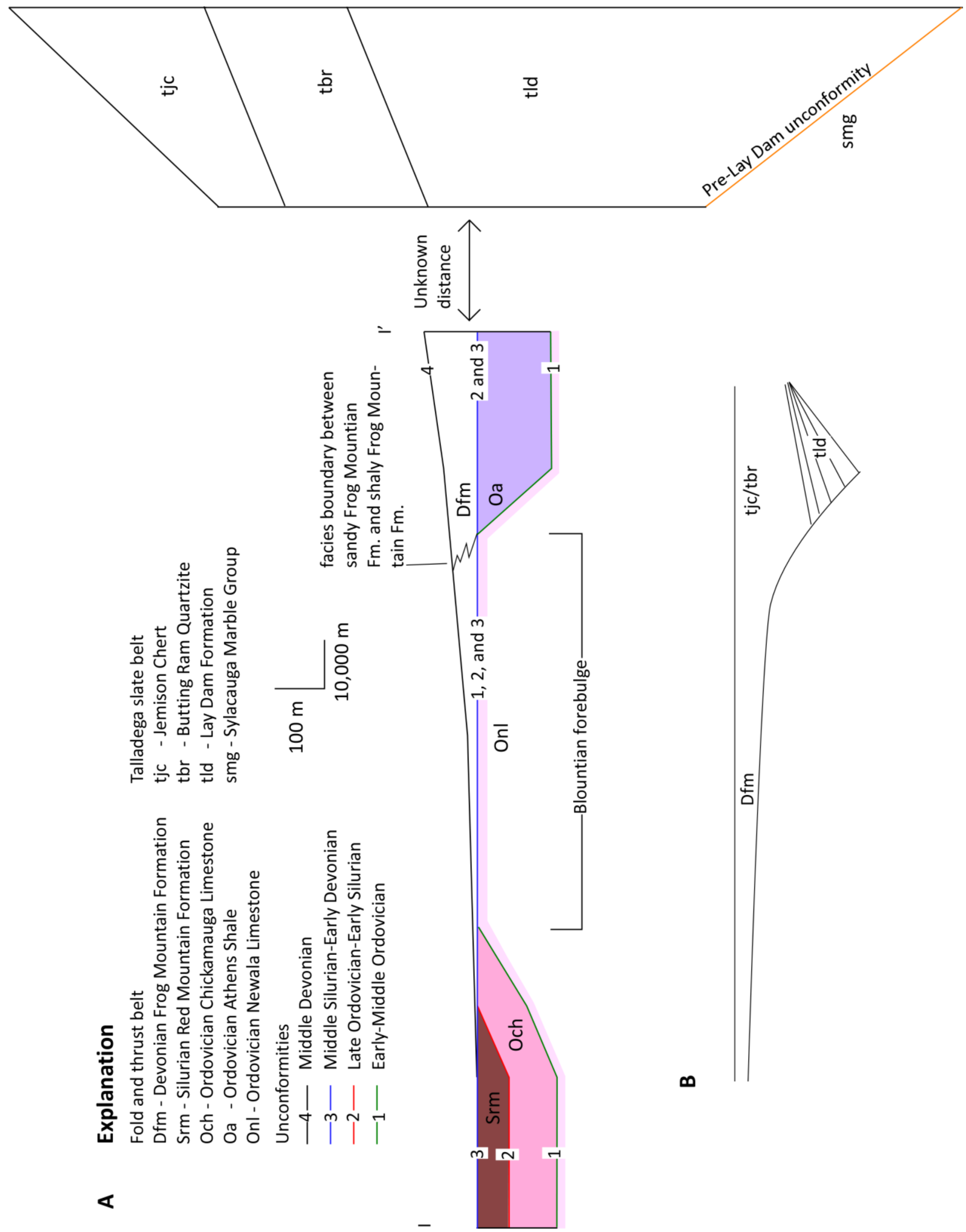

Figure 11.6. A.) Cross section illustrating stratigraphic relationships of the Frog Mountain Formation subcrop (datum) and Talladega Group Lower Devonian equivalents, as well as regional unconformities (cross section I-I', Figure 11.5). B.) Diagrammatic section illustrating Early Devonian stratigraphic relationships.

CHAPTER 12: CONCLUSIONS

- A sub-horizontal out-of-the-syncline thrust fault at the base of the stratigraphically thicker Frog Mountain Formation in the Eastern Coosa thrust sheet cuts down section stratigraphically in the direction of transportation from the Athens Shale to the Chepultepec Dolomite of the Knox Group. The fault also cuts across the Eastern Coosa fault onto the Western Coosa thrust sheet.

- Outliers of thick Frog Mountain Formation in the Western Coosa thrust sheet are allocthonous, and initially were part of the Eastern Coosa thrust sheet. The outliers of thick Frog Mountain overlie a folded succession that includes the stratigraphically thin Frog Mountain Formation in the Western Coosa thrust sheet. The Frog Mountain Formation allocthon has been transported a minimum of 1000 m.

- Crosscutting relationships in the field area demonstrate a break-back thrust history for all exposed thrust sheets. The stacking order is: (1.) the Rome thrust sheet, (2.) the Western Coosa thrust sheet, (3.) the Eastern Coosa thrust sheet (Frog Mountain thrust sheet), and (4.) Jacksonville thrust sheets. The anomalous outcrop pattern of the Frog Mountain Formation in the field area is a result of faulting during the Alleghanian orogeny

- The two different post-Knox successions within the Western Coosa thrust sheet and the Eastern Coosa thrust sheet were initially far apart. On the basis of the map of restored thrust sheets (Thomas and Bayona, 2005), Alleghenian thrusting translated the Eastern Coosa thrust sheet ~100 km to the present position.

- On the basis of the subcrop of the Lower Devonian Frog Mountain Formation, the Frog Mountain Formation was deposited over a regional low topographic high. The regional topographic high was in the same location as the Blountian peripheral foreland bulge.

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