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Structure, tectonics and metamorphic development of the Sancti Spiritus Dome (eastern Escambray massif, Central Cuba)

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ABSTRACT

The Sancti Spiritus Dome of the eastern Escambray (Cuba) represents a metamorphic fold and thrust structure which was part of the Cretaceous subduction-accretion complex of the Greater Antillean Arc. On the basis of structural data and pressure-temperature-time evolution the metamorphic complex can be subdivided into four units interpretable as nappes: a high-grade greenschist-facies unit (Pitajones unit), a high-pressure tectonic mélange (Gavilanes unit), high-pressure amphibolites (Yayabo unit) and – tectonically overlying - low-pressure metagabbros of the Greater Antillean Arc (Mabujina unit). The oldest rock fabrics are preserved in eclogite- and blueschist-facies rocks of the Gavilanes unit, indicating arc-parallel extension. Maximum metamorphic conditions are recorded in eclogites (16-20 kbar, 580-630 °C) and garnet-mica schists (16-23 kbar, 530-610 °C) of the Gavilanes unit. Field observations and fabric studies show that greenschist-facies dynamic indicators are dominated by top-to-NE tectonic transport in the lowermost nappes. The greenschist-facies shear zone between the Yayabo unit and the Mabujina unit is viewed as the main detachment zone between the subduction complex and the overlying arc complex. Active subduction ceased at about 70 Ma, followed by rapid uplift, exhumation and thrusting to the north.

KEYWORDS **Subduction-accretion complex. Metamorphism. Tectonics. Petrology. Geochronology. Greater Antillean Arc.**

INTRODUCTION

A major conspicuous element of the northern boundary of the northwestern Caribbean area (Fig. 1) is the suture zone marking the collision between the Cretaceous Greater Antilles island arc (GAA) and its associated subduction-accretion complex with the southern edge of North America (Yucatán and Bahamas platform; Iturralde-Vinent, 1994). The original structure of this Northern Caribbean Suture Zone (NCSZ) is preserved in excellent fashion along the north coast of Cuba, due to the Late Eocene jump of the plate boundary from the southern edge of the Bahamas platform to its present position along the Cayman trough. Concurrently the eastern part of the NCSZ was displaced eastward together with the present-day Caribbean plate, leaving behind the oceanic Yucatán basin as a fault-bounded triangular tectonic unit (Pindell et al., 2005). The age of the collision is dated by the folding and thrusting of the Bahamas carbonate sequences and the overlying olistostromes as Paleogene, no younger than Early Late Eocene (Iturralde-Vinent, 1996).

In spite of many modeling attempts, the collision between the GAA and the southern margin of the Yucatán/Bahamas platform is still not well understood. Introducing comprehensive data sets for the subduction-accretion complex in Central Cuba would allow the timing and the mechanism of the collision to be reconstructed in more detail. Here we summarize new structural, petrological and geochronological data for the western part of the NCSZ, the Escambray metamorphic complex of central Cuba, which traces the Early Cretaceous to Early Tertiary tectonic history of the Caribbean plate. The data indicate that subduction in this section of the GAA lasted about 30 Ma, involving crustal elements from the Yucatán block, and consuming proto-Atlantic crust. Collision initially involved top-to-the-north imbricated deformation of the GAA. Subsequently, the tectonically

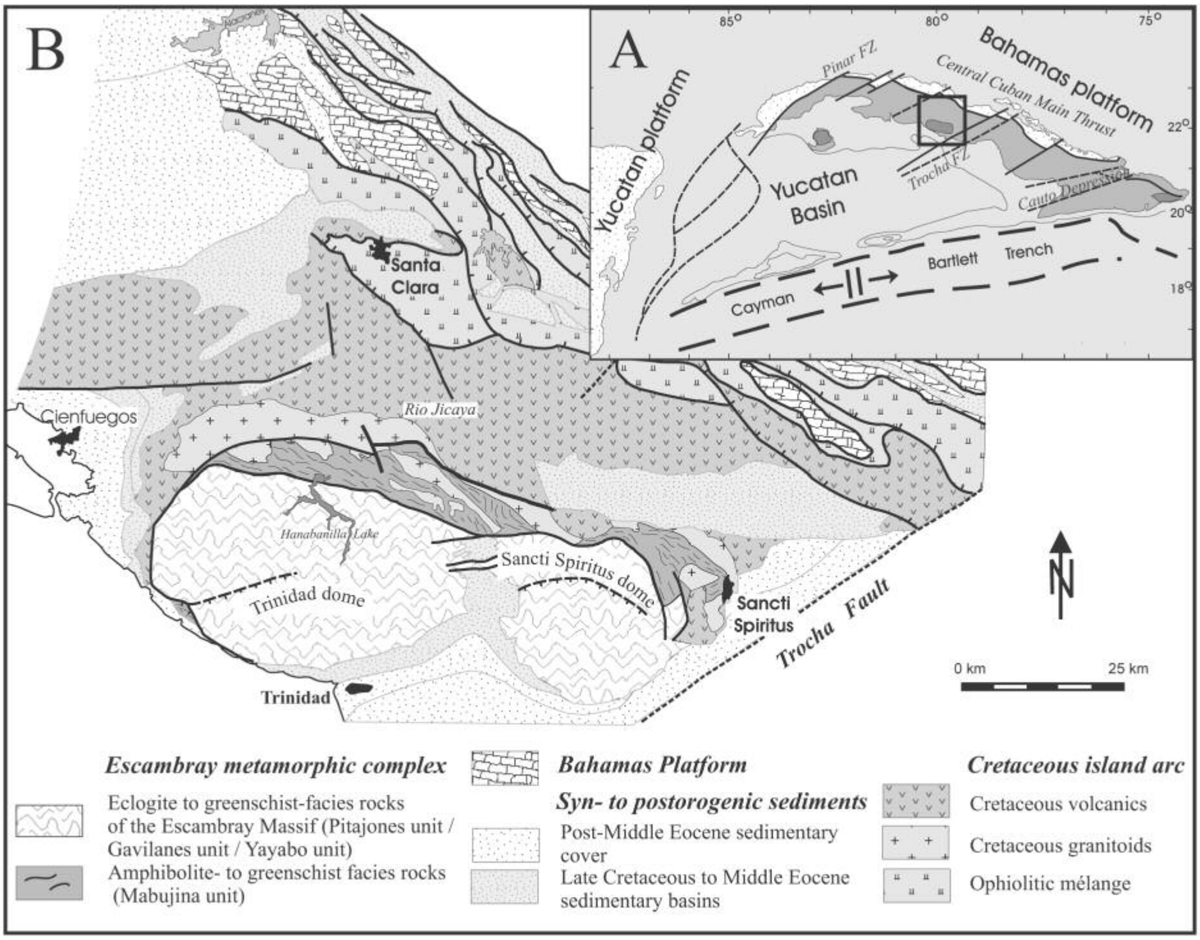


FIGURE 1 | **A) Tectonic sketch of the Yucatán basin with the NCSZ and the position of the Escambray metamorphic complex. Light grey areas indicate the allochthonous island-arc sequences, dark grey areas the metamorphic complexes (Isla de la Juventud, Escambray, Sierra Purial from west to east). B) Overview of the geologic units of Las Villas (Central Cuba), modified after Stanek (2000).**

thinned arc and fore-arc complex were thrust onto the southern shoulder of the Bahamas platform.

TECTONIC SETTING OF CENTRAL CUBA

The northwestern part of the North Caribbean Suture Zone consists of three structural domains (Fig. 1A). In the western domain (Guaniguanico Mountains west of the Pinar Fault Zone), sediments from the continental margin east of Yucatán have been thrust to the north (Pszczólkowski et al., 1975; Pszczólkowski, 1999). The top of the nappe pile consists of geological units with remnants of the fore-arc ophiolite and island arc of the GAA. With the exception of the Cangre metamorphic belt, these nappes show only a very weak metamorphic overprint (Hutson et al., 1998). In the eastern domain (southeast of the Cauto Depression), the Oriente ophiolite is thrust onto the metamorphosed Cretaceous GAA (Purial complex); both are covered to the south by a short-lived Paleogene island arc in the Sierra Maestra (Gyarmati, 1983; Cobiella et al., 1984).

The Central Cuban domain is bounded by the Pinar Fault Zone and the Cauto Depression (Fig. 1A); here the Central Cuban Main Thrust represents the western part of the NCSZ, separating the oceanic Cretaceous GAA and the thinned continental crust of the southern Bahamas platform. The Central Cuban Main Thrust comprises the Las Villas Fault (Hatten et al., 1988) and the Cubitas Fault (Iturralde Vinent and Roque, 1982) and their extensions to west (Matanzas) and east (Holguin); it represents the main thrust plane in Central Cuba in the sense of Wassal (1956), Shaposhnikova (1974) and Somin and Millán (1981); it is not an equivalent of the "Falla Cubana Axial" of Bush and Sherbakova (1986). In Las Villas, both the thrusted arc rocks and the folded platform sediments are cut by the NE-trending La Trocha Fault Zone. West of the La Trocha Fault Zone, postcollisional uplift and erosion has exhumed a complete profile through the GAA and the associated subduction-collision complex (Iturralde-Vinent, 1994; Stanek et al., 2000) (Fig. 1B).

The ophiolitic mélange that crops out between Lake Alacranes reservoir in the northwest via the city of Santa Clara to the La Trocha Fault Zone in the east (Fig. 1B), represents the basement of the Cretaceous GAA (Somin and Millán, 1981; Hatten et al., 1988). The island-arc rocks form a megasyncline, exposing the lower, pre-Aptian part of the volcanic sequence as well as the Middle to Upper Cretaceous volcanoclastic and igneous suites (Pardo, 1975). South of the megasyncline of the allochthonous island-arc rocks, the Escambray metamorphic complex is exposed in a tectonic window. In the Early Paleogene, the exhumation and uplift of the Escambray metamorphic complex was accompanied by the formation of flanking sedimentary basins, which were filled by detritus from metamorphic rocks (Kantchev, 1978).

Two principal goals guided the interdisciplinary investigations carried out by our team and summarized here: 1) to determine the tectonic structure and direction of tectonic transport during the evolving dynamic history of the Escambray nappe complex, and 2) to delineate the contrasting pressure-temperature-time paths of the various elements of the Escambray nappe structure

GEOLOGICAL SETTING OF THE ESCAMBRAY

The Escambray metamorphic complex extends for about 1800 km^2 and is thus the largest metamorphic complex along the northern Caribbean Plate boundary. The geomorphological gradient between the top of the mountain range and the adjacent Yucatán basin to the south is one of the most prominent in the northern Caribbean. The Escambray Mountains are divided by the Trinidad basin and the valley of the Agabama River into the western Trinidad dome and the eastern Sancti Spiritus dome (SSD) (Fig. 1B). The geomorphologically well-exposed metasedimentary sequences of the Escambray complex are surrounded and separated by tectonic contacts from a series of amphibolites, metagabbros and gneisses of the Mabujina complex (Somin and Millán, 1976).

The rock suites of the Escambray massif have been petrographically described in considerable detail by Somin and Millán (1974, 1977, 1981), Somin et al. (1975), Millán and Somin (1985a) and Millán (1988). According to these authors, the metamorphic rocks can be divided into two main groups. The dominant rock types of the Escambray complex are monotonous carbonate- and quartz-mica schists, locally intercalated with massive metacarbonates. On the basis of rare remnants of fossils the protolith ages of these metasedimentary rocks have been suggested to be Upper Jurassic to Lower Cretaceous, comparable to the stratigraphic profile in western Cuba (Millán and Myczcinski, 1978; Somin et al., 1992). The second group comprises massive dark-grey to black metacarbonates and marbles, with tectonic slivers of metagabbro, greenschist, massive sulfide bodies and serpentinite. Various bodies up to several tens of meters in size of eclogite, blueschist, garnetiferous mica schist, serpentinite and metaquartzite form mélange-like zones within the carbonate- and quartz-mica schists. In the northeastern part of the Escambray, garnetiferous amphibolites are also exposed. A number of lithostratigraphic, tectonic and metamorphic models have been proposed in the past to subdivide the Escambray complex into manageable and meaningful units (Fig. 2). These various

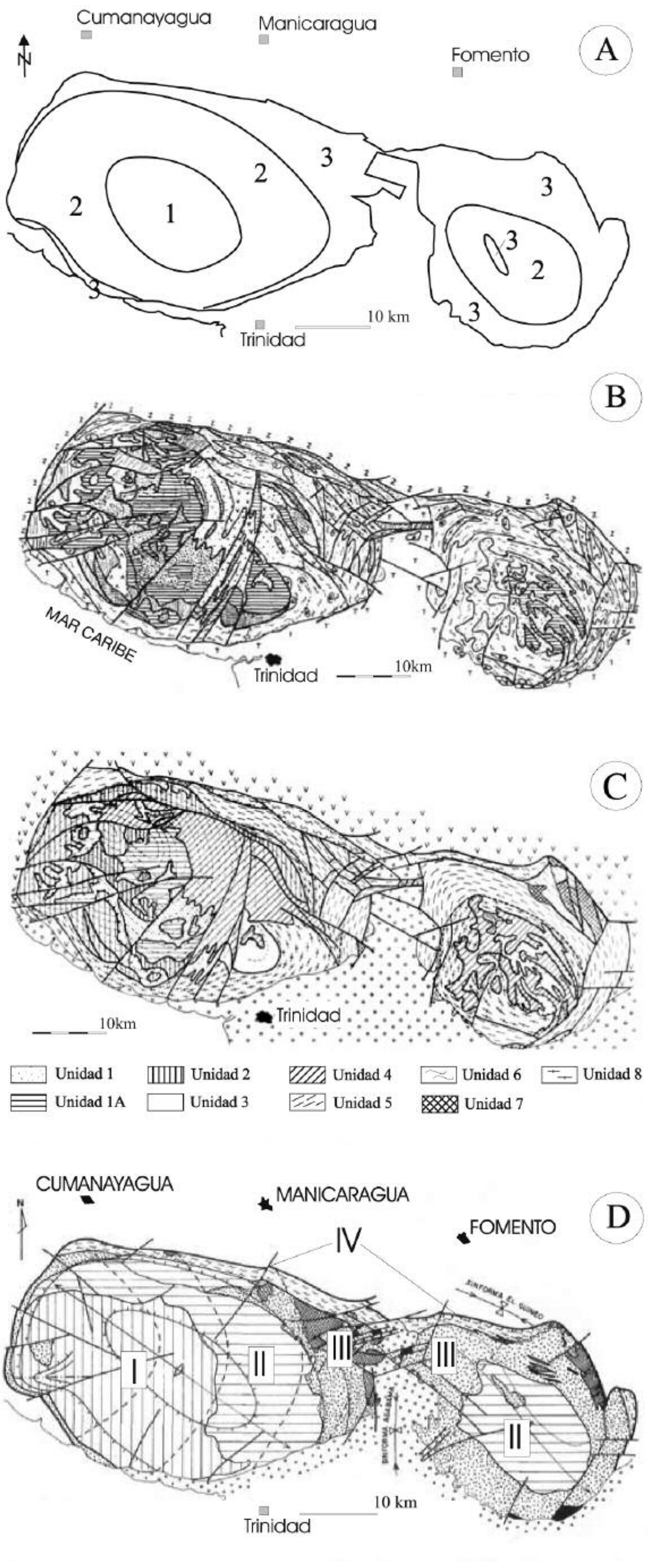


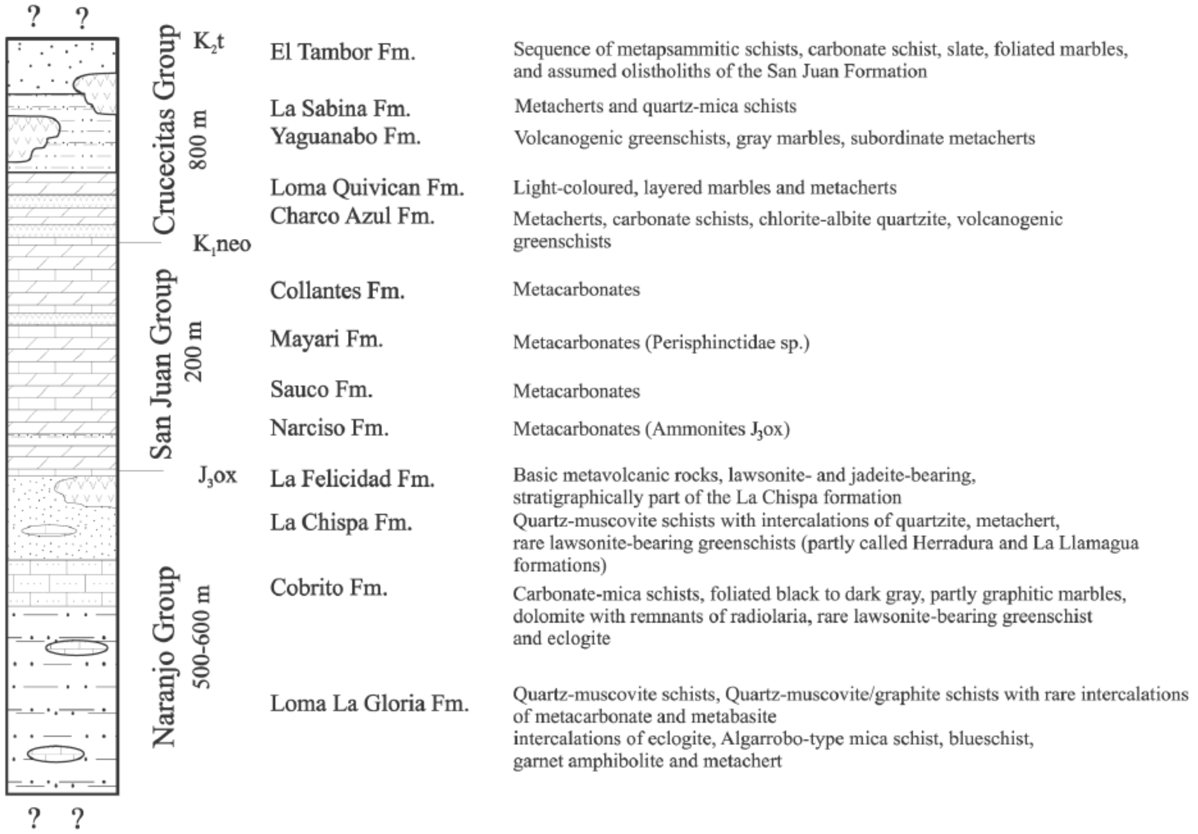
FIGURE 2 | **Comparison of published models of the tectonic, metamorphic and lithologic subdivision of the Escambray massif, south-central Cuba. A) Metamorphic zonation of the Escambray massif by Somin and Millán (1981). B) Lithostratigraphic subdivision of the Escambray massif by Millán and Somin (1985a). C) Subdivision of the Escambray massif into 8 tectonic units by Millán and Somin (1985b). D) Tectonic super units of the Escambray massif by Millán Trujillo (1997). Contacts between the super units are exaggerated for clarifying. Bold numbers correspond to the numbers of the super units (see text for further information).**

schemes reflect the evolution of our understanding of metamorphic nappe structures; they have also led to unfortunate misunderstandings that obscure the important story told by these rocks. To clarify this point, a short summary on previous work on the Escambray massif is offered here.

The first complete description of the Escambray metamorphic complex was published by Somin and Millán (1981), based on detailed field work and petrographic investigations. These authors distinguished groups of metamorphic rocks on the basis of characteristic mineral associations and identified three metamorphic zones: a low-grade zone in the core of the Trinidad dome (zone 1) as an uppermost unit (already described as a "nappe" by Somin and Millán, 1981), surrounded by greenschist-facies rocks (zone 2) and high-grade rocks (zone 3) along the periphery of the two domes (Fig. 2A).

The model of Millán and Somin (1985a) divided the metamorphic complex into at least 12 lithostratigraphic formations (Figs. 2B and 3), necessitating the definition of stratigraphic contacts according to the definition of lithostratigraphic formations (Boggs, 1987). Such a contact was discussed only for the boundaries between the Loma La Gloria and the Cobrito Fms, which together comprise the largest outcrop area in the Escambray massif. The proposed stratigraphy of the Escambray complex (Fig. 3) is based on rare observations of fossil remnants (Millán and Myshinzski, 1978; Somin and Millán, 1981; Stanik et al., 1981), and on lithological correlation and equation with the non-metamorphic stratigraphic section of western Cuba (Pszczólkowski, 1978, 1999).

The third model (Millán and Somin, 1985b) dealt tentatively with tectonic units in combination with three metamorphic zones (Fig. 2C). Concepts of tectonic nappes and thrusts (already mentioned by Somin and Millán, 1981) were introduced, without further detailed description. Mélange zones with metamorphosed ultrabasic rocks masking the limits between different tectonic units were described. According to the definition given, a tectonic unit was considered to comprise various lithostratigraphic formations and rocks of different metamorphic overprint. For example, in the Sancti Spiritus dome the unit 5 consists of both the Loma La Gloria Fm and parts of the Cobrito Fm, together with the stratigraphic contact assumed between them. The outer part of unit 5 corresponds to metamorphic zone 3 and the inner part to zone 2. The combination of greenschist- and eclogite-facies rocks in one tectonic unit was assumed to be caused by post-metamorphic thrusting and nappe formation.



El Tambor Fm.	Sequence of metapsammitic schists, carbonate schist, slate, foliated marbles, and assumed olistholiths of the San Juan Formation
La Sabina Fm.	Metacherts and quartz-mica schists
Yaguanabo Fm.	Volcanogenic greenschists, gray marbles, subordinate metacherts
Loma Quivican Fm.	Light-coloured, layered marbles and metacherts
Charco Azul Fm.	Metacherts, carbonate schists, chlorite-albite quartzite, volcanogenic greenschists
Collantes Fm.	Metacarbonates
Mayari Fm.	Metacarbonates (Perisphinctidae sp.)
Sauco Fm.	Metacarbonates
Narciso Fm.	Metacarbonates (Ammonites J_3ox)
La Felicidad Fm.	Basic metavolcanic rocks, lawsonite- and jadeite-bearing, stratigraphically part of the La Chispa formation
La Chispa Fm.	Quartz-muscovite schists with intercalations of quartzite, metachert, rare lawsonite-bearing greenschists (partly called Herradura and La Llamagua formations)
Cobrito Fm.	Carbonate-mica schists, foliated black to dark gray, partly graphitic marbles, dolomite with remnants of radiolaria, rare lawsonite-bearing greenschist and eclogite
Loma La Gloria Fm.	Quartz-muscovite schists, Quartz-muscovite/graphite schists with rare intercalations of metacarbonate and metabasite intercalations of eclogite, Algarrobo-type mica schist, blueschist, garnet amphibolite and metachert

FIGURE 3 | **The lithostratigraphic profile of the Escambray following the stratigraphic profile of western Cuba, summarized after Millán and Somin (1985b) and Dublan and Álvarez (1986).**

The fourth model (Millán Trujillo, 1997) combines metamorphic zones, lithostratigraphic formations and tectonic units into four tectonic *super units*, consisting of different nappes and thrust sheets (Fig. 2D). The first super unit ("primera unidad tectónica de orden principal") comprises rock suites of Cretaceous protolith age affected only by greenschist-facies metamorphism. The outcrop area of this first super unit is localized in the center of the Trinidad dome. This super unit consists of metasandstones (La Llamagua Fm), marble (San Juan Group), garnet-bearing metacherts (La Sabina Fm), basic metavolcanics (Yaguanabo Fm) and greenschist-facies metaterrigenous schists (El Tambor Fm). This first super unit is not exposed in the Sancti Spiritus dome.

The second super unit ("segunda unidad tectónica de orden principal") is located in the central part of the Sancti Spiritus dome. The rocks of this second unit have undergone HP/LT metamorphic conditions. The unit consists of graphite-bearing carbonate micaschists and marbles (Cobrito Fm), albite-bearing metasandstones alternating with metapelites, metavolcanics and marbles (La Chispa Fm), basic metavolcanics with jadeitic clinopyroxene and lawsonite ("esquistos verdes Felicidad") and different types of marbles (San Juan Group). The protolith age is assumed to be Jurassic. In addition to the above-mentioned protolith rock types, all protoliths of the first unit may also be exposed in the second unit.

The third super unit ("tercera unidad tectónica de orden principal") is exposed as a rim around the two dome-like structures of the Escambray, tectonically overlying the first and second unit. The rocks have been overprinted under HP/LT conditions. The retrograde metamorphic path is characterized by greenschist-facies conditions. The main rock types are quartz-mica schist (Loma La Gloria Fm) and carbonate-mica schist with intercalations of marble (Cobrito Fm). The mica schist suite includes bodies of eclogite, serpentinite, garnet schist of the Algarrobo type and garnet amphibolites of the Yayabo type. The unit has the appearance of a tectonic mélange containing high-grade rocks as tectonic slivers or boudins.

The fourth unit ("cuarta unidad tectónica de orden principal") is found only along the northern edge of the twin-dome structure. Although the rocks of this unit are not considered to have undergone HP-metamorphism, some metacherts do contain glaucophane and garnet.

All tectonic super units have undergone multiple folding and thrusting. In the proposed N-vergent mega-anticline (Millán Trujillo, 1997), the fourth super unit forms the uppermost nappe of the Sancti Spiritus dome.

A modified subdivision of the Sancti Spiritus dome into three metamorphic zones was later introduced by Schneider et al. (2004). These zones were correlated with the P-T-data provided by Grevel (2000). Thus the lowermost Unit I comprises greenschist-facies rocks. In Unit II the metasediments include lawsonite-blueschist facies metabasites, and in Unit III metabasites with an eclogite-facies overprint occur.

The evolution of ideas on the Escambray complex outlined here highlights the difficulties associated with finding meaningful subdivisions for heterogeneous nappe piles of metamorphic rocks. Modern concepts indicate that pressure-temperature-time (P-T-t) analyses are indispensable for reconstructing rock series with similar metamorphic histories into manageable units and for differentiating these from units with contrasting histories. Nevertheless, a multi-parameter, interdisciplinary study must accompany this approach. Protolith characterization is required because rocks with quite diverse origins may have been amalgamated at an early stage and therefore show similar metamorphic histories. By contrast, rocks with similar origins may have followed quite different P-T-paths during subduction, accretion and exhumation. Problems of scale and of P-T-t accuracy complicate all these efforts. Recognizable large-scale units may in themselves be critically heterogeneous, and the scale of a tectonic discontinuity may be difficult to ascertain, especially if rocks of similar protolith type and metamorphic grade happen to be juxtaposed.

GEOLOGY AND TECTONIC STRUCTURE OF THE EASTERN ESCAMBRAY

Geology of the nappe units of the Sancti Spiritus Dome

We commenced field work in the eastern part of the Escambray in 1994 together with G. Millán Trujillo of the Instituto de Geología y Paleontología in Havana and encountered considerable difficulties in identifying *in outcrop* the lithostratigraphic limits, tectonic units and metamorphic zones defined previously. Together we established a redefinition of the metamorphic suite of the Sancti Spiritus dome and the adjacent areas into five major structural elements, interpretable as nappes, on the basis of new structural and petrologic data evolving from our study. G.M.T. chose to pursue a different tectonic interpretation of the evolving data and presented his version independently in Millán Trujillo (1997), as summarized in Fig. 2D of this paper.

The tectonically lower three nappes, as defined by us (Pitajones, Gavilanes, Yayabo) are part of the traditional

Escambray metamorphic complex, whereas the upper two nappes are thought to represent parts of the Cretaceous GAA. These latter nappes are the Mabujina unit, which represents part of the metamorphosed basal part of the GAA, and an unnamed uppermost nappe composed of unmetamorphosed island-arc rocks. The following description is based on this originally mutually developed scheme. Neutral designations based on geographical names have been introduced to avoid confusion with previous subdivisional systems and to avoid undesirable connotations of source and evolution. It is important to keep in mind that further and more detailed study may lead to a further, more detailed breakdown of this nappe system.

Pitajones nappe

The tectonically lowermost nappe, called the Pitajones unit (Fig. 4, see Fig. 5 for locations) after typical sections near the village of Pitajones in the southwestern part of the SSD, comprises monotonous carbonate and quartz-mica schists with intercalations of massive metacarbonates in its lower part (Cobrito, Boquerones and Herradura Fms of Millán and Somin, 1985a). The upper part of the Pitajones nappe exhibits thinly foliated carbonate-mica schists with tectonic slivers or boudins of green schists and metagabbros, massive black and grey marbles (La Chispa Fm, los esquistos verdes Felicidad, the San Juan marbles of Millán, 1988; Dublan and Alvarez, 1986; Millán and Somin, 1985a). The boundary to the overlying nappe is marked by strongly deformed greenschists and carbonate-mica schists. Typical sections of the Pitajones unit can be found along the road from Fidel Claro to the mountains north of the settlement Veinte y Tres and in the upper valley of the Río Higuanojo.

Gavilanes nappe

The tectonically overlying Gavilanes unit (Fig 4; named after the hill of the same name south of the settlement of Gavilanes) forms stretched bands of quartz- and

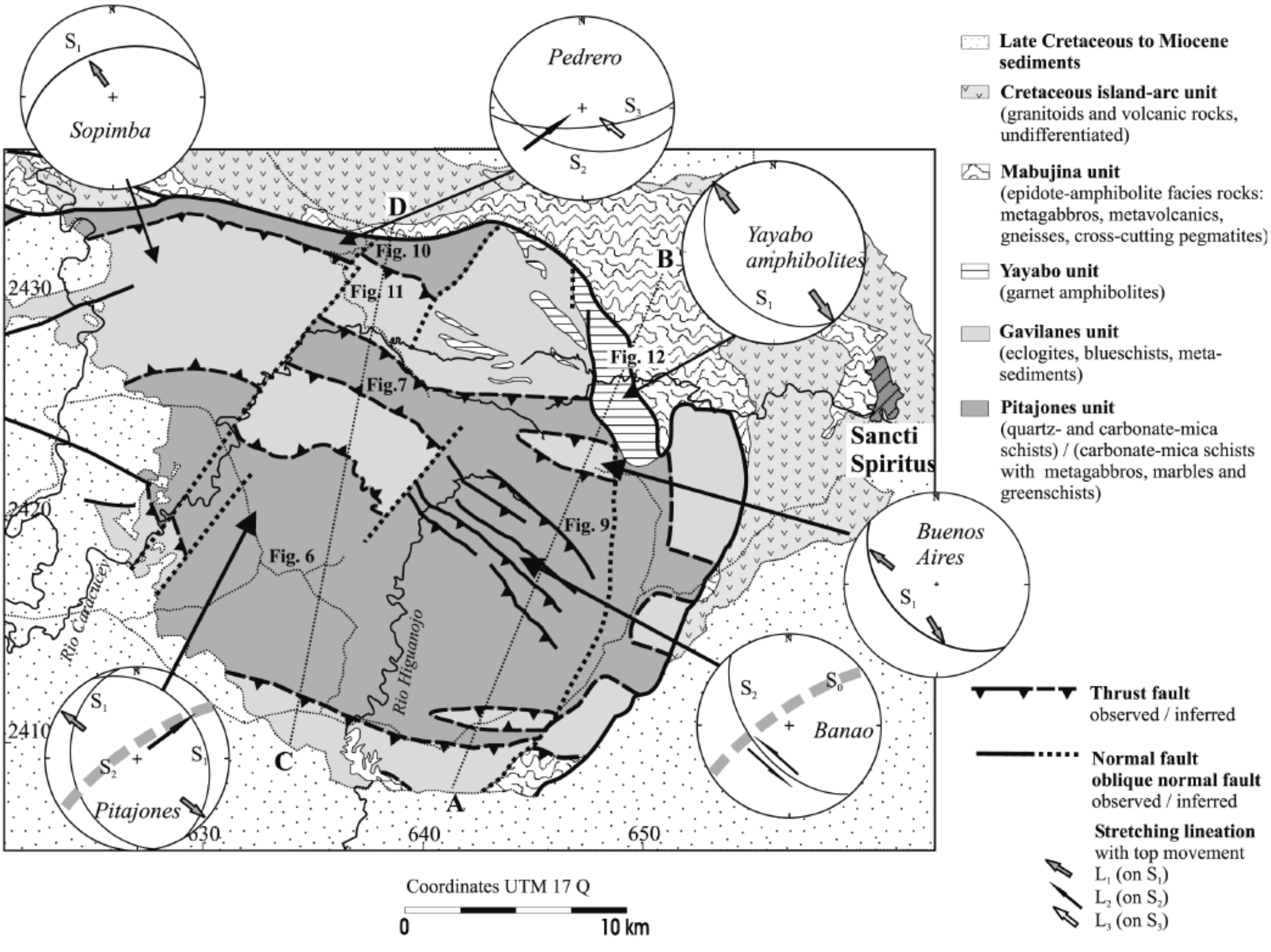


FIGURE 4 | **Tectonic structure of the SSD; diagrams use the lower hemisphere of Schmidt, indicating the spatial position of the metamorphic foliation and stretching lineation (grey bands are great circles, i.e. ¶-circles of the main foliation). Geologic base map compiled after Stanik et al. (1981) and Millán Trujillo (1996c, unpublished). For profiles "A - B" and "C – D" see Fig. 8.**

carbonate-mica schists with tectonic intercalations of HP-facies rocks like eclogite, blueschist, marble, metachert (Loma La Gloria Fm of Somin and Millán, 1981), garnet-mica schist ("Algarrobo type" rocks) and high-grade serpentinites (Auzende et al., 2002). In some places serpentinites and talcose rocks coat the tectonic slivers of HP-rocks. The outcrops of the HP-rocks extend from the northwestern edge of the SSD (Sopimba) to the east toward Buenos Aires and Loma del Obispo, as well as along the southern border of the SSD. The occurrence of HP-rocks in the core of the SSD is indicated by the occurrence of sodic amphibole and jadeite in metagrabbro. Typical sections of the Gavilanes unit can be found along the road 2 km south of Pedrero to Gavilanes and along the ridge crest of Sopimba.

Yayabo nappe

In the northeastern SSD (Fig. 4), a distinct series of garnet-bearing amphibolites with minor intercalations of serpentinites and metasediments were named the Yayabo suite by Somin and Millán (1974, 1976, 1981) and Millán and Somin (1976). The type outcrop is located in the valley of the Yayabo River, 12 km west of the city of Sancti Spiritus. The observed contact between the Yayabo rocks and the other units is a brittle fault zone in the Yayabo valley (see also Fig. 9). However, Yayabo-like rocks are also sheared into carbonate- and quartz-mica schists of the Gavilanes unit in the northeastern part of the SSD; the foliation of these rocks is tectonically concordant with the host rocks. The tectonic orientation of the main fabrics in the amphibolites and the carbonate-mica schists is described as more or less parallel. For this reason, and because of the high-grade amphibolite mineralogy, Somin and Millán (1981) inferred a common history for the Escambray complex and the Yayabo unit.

Towards the northeast, the Yayabo rocks dip below epidote-amphibolite-facies rocks of the Mabujina unit. The contact between the Mabujina and Yayabo units has been described both as brittle faults with lens-like bodies

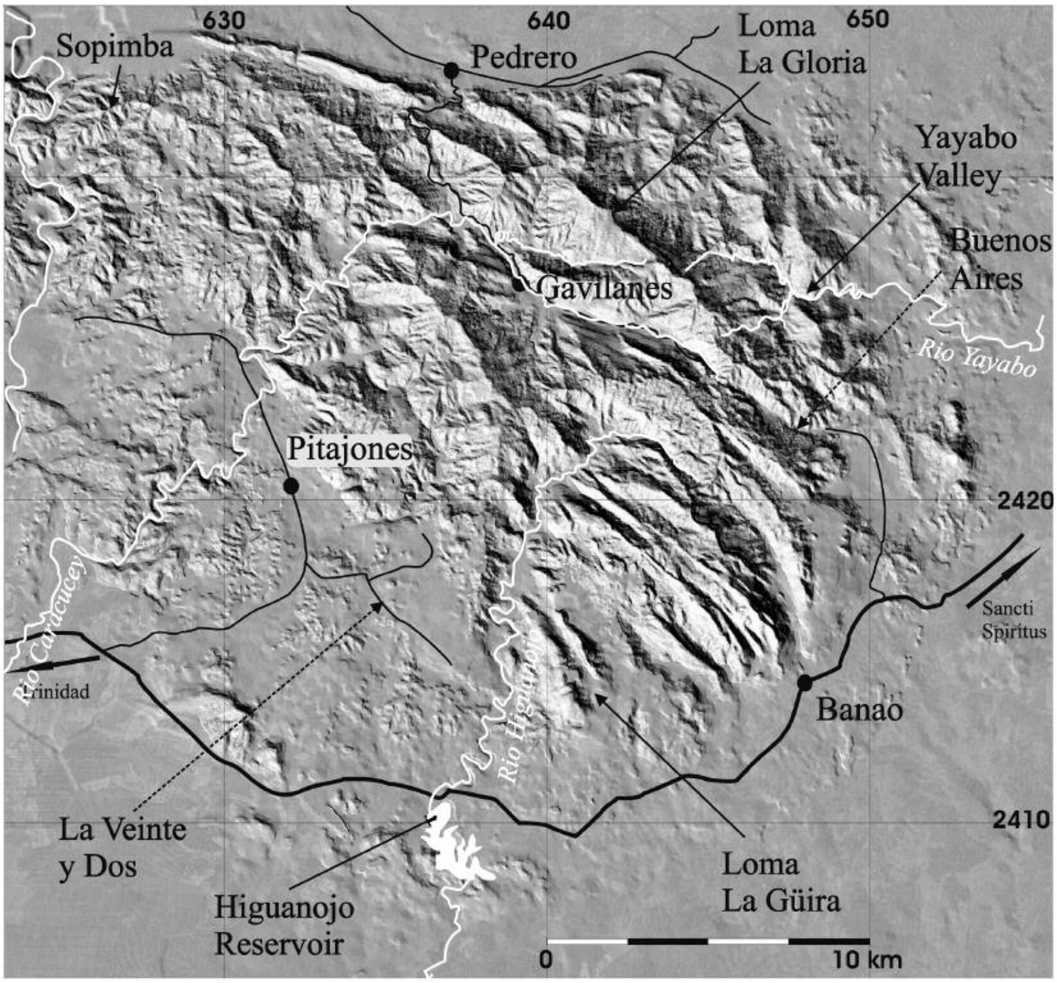


FIGURE 5 | **Shaded relief map on the basis of a digital elevation model of the Sancti Spiritus dome (coordinate reference UTM 17Q). The main roads and rivers in the SSD are indicated.**

of serpentinite and as semiductile mylonitic shear zones (Somin and Millán, 1981). In some localities, like the Camino Quemado in the eastern border of the Sancti Spiritus dome, both units are represented by garnetiferous amphibolites, and there is no obvious lithological difference between them (Somin and Millán, 1981).

Internal structure of the nappe pile of the Sancti Spiritus dome

The geomorphology of the SSD (Fig. 5) reflects the main tectonic structures of the dome. The flat southern and western parts of the SSD near Pitajones are remnants of a mid-Eocene transgression surface. The features of paleo-coastal erosion in the mica schists have been cut by the roads from Pitajones to south and west. Northwest and north of Pitajones Village, marbles, carbonate-mica schists and metabasites form a steep scarp. To the NW this scarp gives way to a hilly terrain which is underlain by series of flat-lying, foliated HP-metamorphic rocks. The eastern part of the dome west of Banao consists of several sharply linear, SE-trending mountain ranges which end abruptly along an assumed NE-trending fault. In the northern part of the SSD, the morphological SE-NW trend continues. Here the highest hills (Lomas la Gloria) reach more than 700 m. To the NE the mountain ranges decrease down to 300 m and pass into a rough hilly terrane, the outcrop area of the Yayabo amphibolites. In the north, the metamorphic rocks have been cut by young E-W trending normal faults, accompanied by remarkable slope steepening.

The different morphological features are caused by different tectonic structures (Fig. 4). In the western and northwestern part of the SSD, the Gavilanes unit lies on top of the Pitajones unit, and both exhibit a gently dipping main foliation (Sopimba). In the east and north, the linear mountain ranges indicate stacking and imbrication of mica schists with lenses of greenschist and marble.

Pitajones nappe

The main fabric element of the Pitajones unit is a penetrative foliation (S_2) marked by the growth of white mica. Older rock fabrics are represented by compositional layering, quartz rods with relic fold hinges, as well as folds in microlithons. A ductile S_1 foliation has also been preserved in sheath folds of marbles; metagabbros show transitions from only weakly deformed magmatic textures to greenschist-facies mylonitic textures. The structural thickness of the nappe unit can be estimated to be between 3 and 4 km.

In the type outcrops around the settlement of Pitajones (Fig. 4), the S_2 (main) foliation in the monotonous series of quartz and carbonate-mica schists dips gently in south-

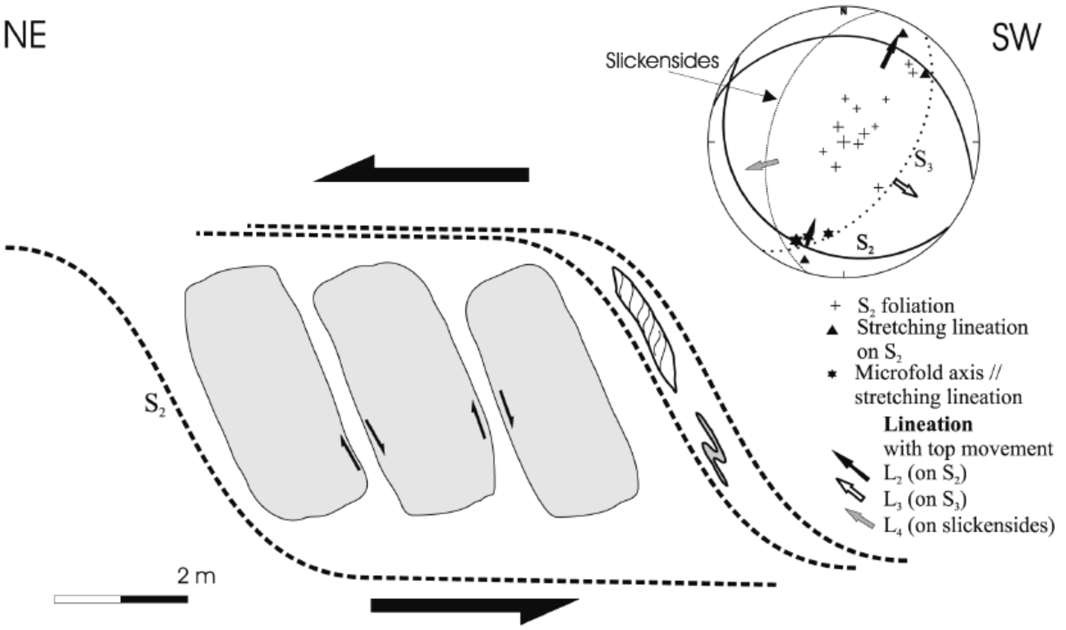


FIGURE 6 | **Bookshelf rotation (domino structure) of a greenschist boudin in a matrix of greenschist and carbonate-mica schist (length of the outcrop is 10-12 m). Tectonic transport during S_2 deformation is top to NE. Abandoned quarry 1 km west of the settlement of La Veinte y Dos (see Figs. 4 and 5).**

westerly and northeasterly directions, forming flat undulating asymmetric SE-trending folds. The axial planes of the folds and the SW-dipping stretching lineation, as well as mica fishes in thin sections, indicate a top-to-NE movement in most cases. The gently north- or south-dipping lineation is interpreted as the intersection of the S_2 and the steep west-dipping S_3 (extensional) foliation. A similar structural style of the mica schists can be observed along the road east of the Higuanojo reservoir (Fig. 4). In the upper part of the Pitajones unit the uniformity of the foliation has been disturbed by intercalation of boudins and tectonic slivers of marbles and greenschists. These intercalations can range from several meters up to several tens of meters in size. The direction of tectonic transport can be identified in outcrop scale as top to the NNE by striations on marble rods and by the rotation of marble and greenschist megaboudins (Fig. 6).

In the core of the SSD (Fig. 4), a Pitajones-like rock suite has been folded in both SW and NE vergent directions as a result of the compression between a large serpentinite body in the south and a main thrust fault in the NE (Fig. 7). In this case, the orientation of the S_3 (axial plane) schistosity coincides exactly with the direction of NE-SW compression. Depending on the orientation of the section seen in outcrop, two alternative directions for tectonic transport could be proposed.

Another instructive profile for structural studies of the Pitajones nappe is located in the upper valley of the Río Higuanojo (Fig. 4) west of Banao. Here the Río Higuanojo cuts a lithologic succession of the Pitajones unit which has been repeated several times due to reverse faulting (Fig. 8). In a profile from SW to NE, the main foliation is seen to be more or less horizontal in the south (Loma La Güira), parallel to the lithologic boundaries between the carbonate-mica schists, metacherts and massive dark marbles at the top. To the NE, the main foliation becomes steeper and the lithology also includes greenschists and metagabbros. In rare cases the carbonate-mica schists show a first folding of the sedimentary layering, asymmetric folds with SW-dipping axial planes, cut by an S_2

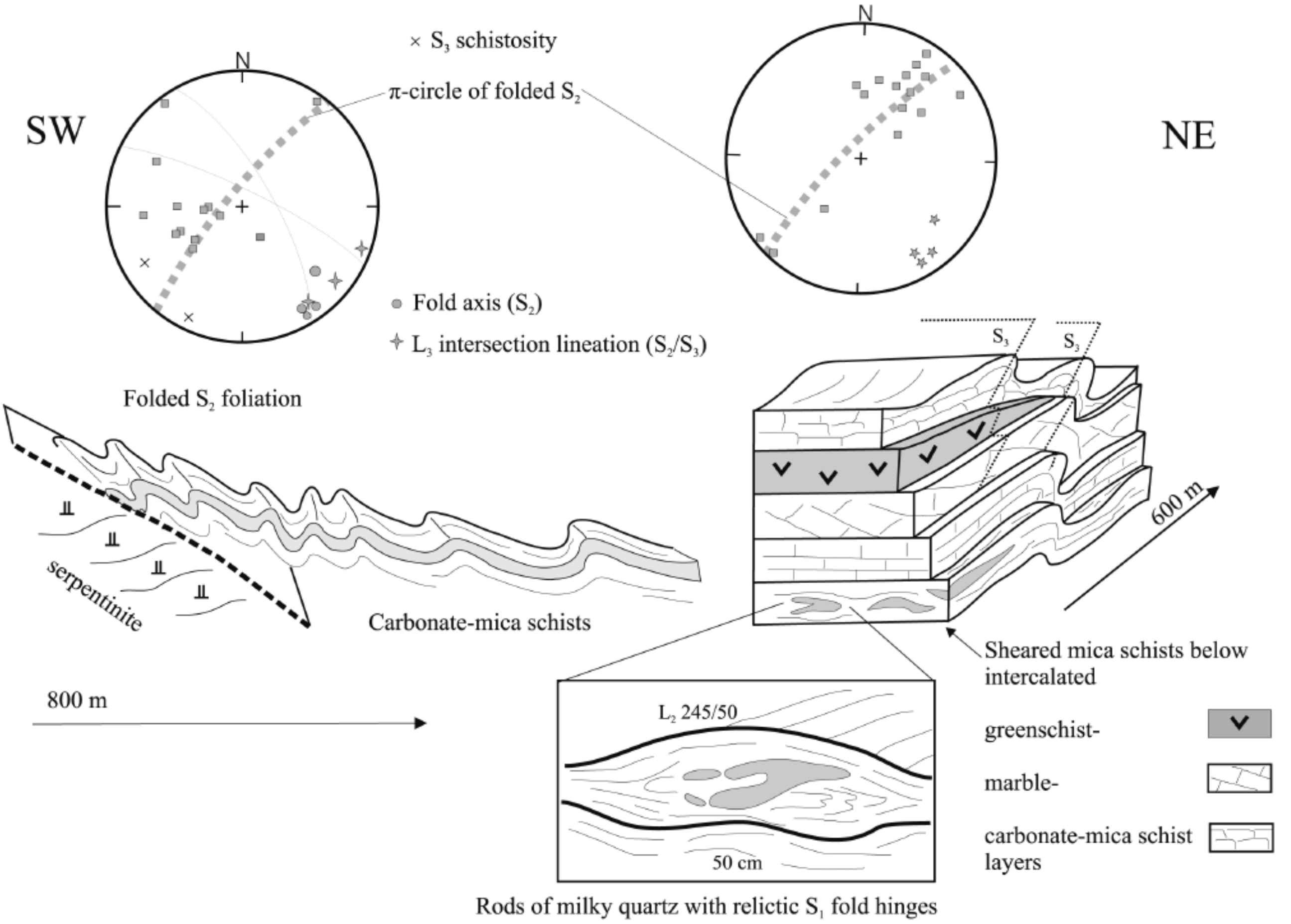


FIGURE 7 | **Structural sketch of the central part of the SSD (south of Gavilanes, see Fig. 4). SW- and NE-vergent, folded S_2 foliation at the top of a shear zone within the Pitajones unit (length of the profile is about 3 km). The S_2 main foliation has been cut by an axial- plane-parallel S_3 schistosity. The southern part of the profile is suggested to be a back thrust.**

(axial-plane) foliation (Fig. 9). The S_2 foliation has been overprinted by an S_4 crenulation cleavage which indicates normal (extensional) movement top to east (see Fig. 9, for example). The stretching lineations on the main foliation as well as sheath folds in marbles indicate an oblique reverse movement with a strong sinistral component under ductile conditions. Up to now there is no proof of a HP-mineral association here, so the main deformation in the Higuanojo area must be assumed to have taken place under greenschist-facies temperatures. The sinistral oblique reverse faults are thought to be the major tectonic element responsible for crustal thickening and exhumation of the Escambray complex during the latest period of subduction and the beginning collision.

The northern realm of the SSD (Pedrero, Fig. 4) shows a distinctive structural style. The S_2 deformation is very similar to that in other areas of the Pitajones-type rock suite, in that the series of carbonate- (in part graphite-rich) and quartz-mica schists have a characteristic SW dipping main foliation. The S_2 textures have been overprinted by a steeply dipping S_3 cleavage with an oblique dextral movement. In some places, folded S_2 textures with vertical fold axis can be observed (Fig. 10). These features indicate late semiductile thrusting to the north and dextral strike-slip movement in the extensional direction.

Gavilanes nappe

At the top of the Pitajones unit, HP-rocks occur both in the southern and in the northern part of the SSD. The poorly defined contact between both units involves strongly deformed greenschist-facies mylonites and thin foliated metacarbonates. In the Gavilanes unit, tectonic slivers or blocks of high-grade rocks, varying in size between tens to hundreds of meters, are embedded in a matrix of strongly foliated mica schists. A characteristic feature of the cores of the high-grade blocks is the random growth of amphibole (glaucophane), pyroxene (omphacite) and/or garnet in a foliation outlined by white mica. These fabrics are found not only in eclogite and blueschist, but also in metaquartzite and garnet-mica schist (Algarrobo-type). It can be concluded that these metasediments also underwent HP-conditions (Grevel et al., in review). Auzende et al. (2002) also suggest that the serpentinites of the Gavilanes unit were overprinted under high-grade metamorphic conditions. At the scale of the tectonic blocks, the primary texture has often been replaced by a retrograde foliation parallel to the foliation in the surrounding mica schists. At the map scale, the Gavilanes unit represents a tectonic mélange of HP-rocks in a matrix of mica schists. The structural thickness of the mélange unit can be estimated to be 500 to 800 m.

In the southern part of the SSD, eclogite, blueschist and serpentinite bodies have been exposed by erosion, but the tropical weathering precludes large outcrops suitable for structural work. In the northern part, the Caracucey River and its tributary creeks cut the Gavilanes unit; one of the best outcrops can be found along the gravel road from Pedrero to Gavilanes (Fig. 11, see also Fig. 4). The Gavilanes unit is limited to the north by a semiductile,

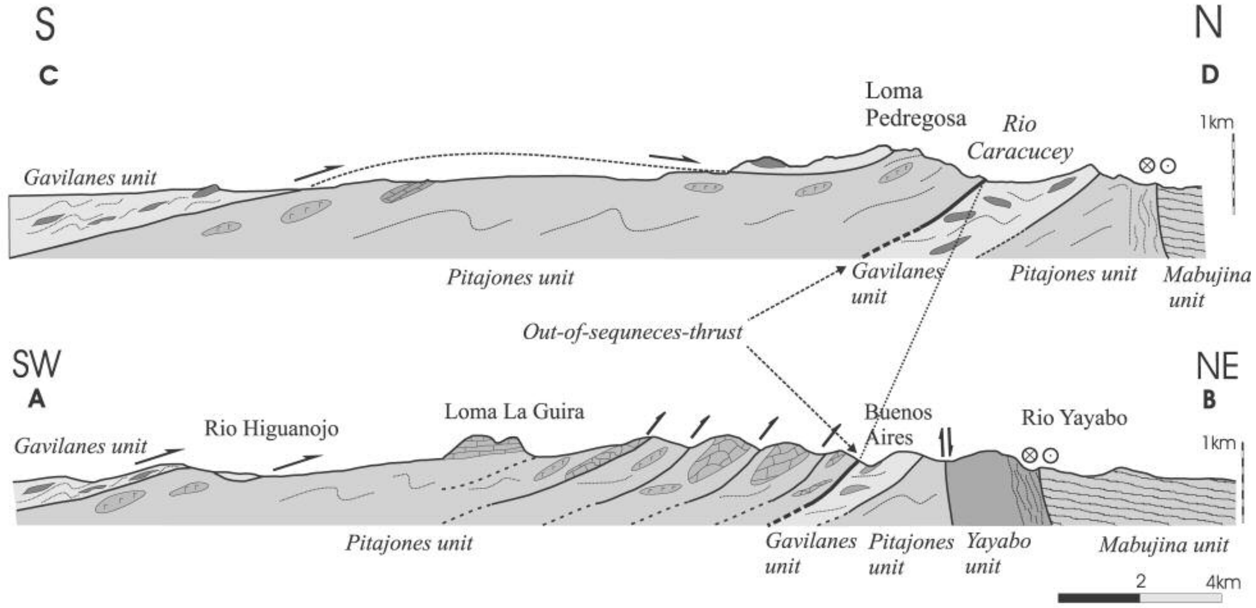


FIGURE 8 **Generalized SW-NE tectonic profile of the eastern part of the SSD (vertical exaggeration x2). In the south, thrust planes and the main foliation dip gently to the south; in the central part, the Pitajones unit forms a stacked structure. The contact between the Yayabo unit and the Mabujina unit is represent by a dextral mylonitic shear zone, overprinted by a brittle normal fault.**

top-to-north reverse fault. The hanging-wall rocks of the fault are characterized by isolated serpentinite lenses containing a large number of different types of blocks, such as garnet-mica schist, blueschist and talc schist. Towards the south into the valley of the Caracucey River (Fig. 11) blocks of eclogite, blueschist and metachert are embedded in carbonate-mica schists of the tectonic mélange. The s-c fabrics and stretching lineation in the mica schist indicate a dominant top-to-northeast movement. Further downhill a large eclogite body enclosed in a serpentinite matrix has been cut by the road (grey section in Fig. 11). This eclogite occurrence is one of the traditional sampling locations for HP-metamorphic rocks in the SSD (Schneider et al., 2004). It exhibits typical high-pressure-related textures in which the compositional layering is randomly overgrown by white mica and omphacite, in turn cross-cut by high-temperature shear zones. The eclogite body is also cross-cut by retrograde, antigorite-bearing shear zones with top-to-south movement. A similar direction of tectonic transport can be observed in semibrittle normal faults dipping gently to the south (S_4).

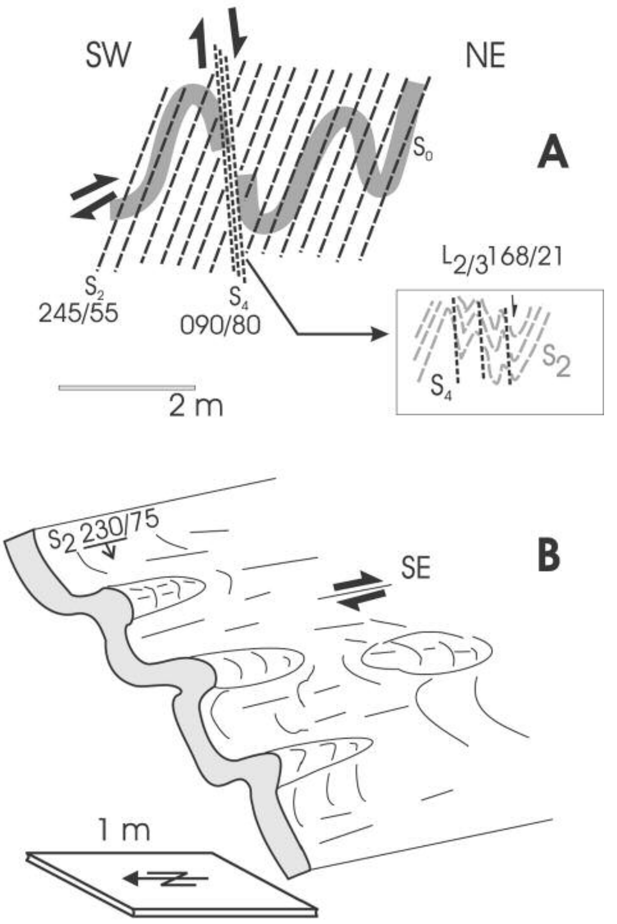


FIGURE 9 **Structural style of the Pitajones unit in the Banao - Río Higuanojo area (see Figs. 4 and 5). A) Carbonate-mica schists with folded sedimentary layering (NE-vergent) and cross-cutting S_2 foliation. S_4 is a younger semiductile extensional crenulation cleavage, which occurs in suitable rocks (Río Banao Valley, about 3 km north of Banao). B) Packages of marbles and pelitic schists show sheath folds in various sizes, with movement generally top-to-SE. (Río Higuanojo Valley, outcrops near Charco de Oro in the Cuchillas del Purial, about 6 km north of the Loma La Guira, see also Fig. 8).**

Beyond the section of Fig. 11, several blocks of eclogite and blueschist-facies rocks crop out in the road to the Gavilanes settlement. In the ford of the Caracucey River, eclogite lenses are embedded in highly sheared dark-grey marbles (Lithofacies Caracucey of Somin et al., 1992). The stretching lineation and sheath folds indicate a strong sinistral movement along this fault, interpreted as an out-of-sequence-fault (see Fig. 8). Black marble rods in the dark grey marble contain remnants of Radiolaria (Somin et al., 1992). The succession of dark grey marbles continues to the southeast towards Buenos Aires, where marbles with sheath folds and folded eclogite lenses and blueschist-facies quartzites are exposed in a wild-water creek. As in the Caracucey ford, the stretching lineation of the high-grade rocks yields an oblique sinistral movement (top to E – SE). The marbles are embedded in greenschists with a southwest dipping S_2 foliation.

In the valley of the Caracucey River west of Gavilanes (Fig. 5), the sheared tectonic contact between the Pitajones unit and the Gavilanes unit is exposed. At several localities along these shear zones, metapelitic schists occur. The thinly foliated, phyllitic texture with post-S_2 crenulation cleavage has been randomly overgrown by chloritoid (Grevel, 2000). Millán has also reported kyanite together with chloritoid and rutile (Millán, 1988).

Yayabo nappe

At the northeastern margin of the SSD, mainly along the Yayabo River valley, the contacts between the Gavilanes nappe and the tectonically overlying Yayabo and Mabujina nappes are exposed (see Fig. 12). In the western Yayabo valley, the high-temperature metamorphic contact between metasediments of the Gavilanes unit and the garnet amphibolites has been overprinted by a steeply dipping N-trending brittle fault. The metasediments comprise carbonate-mica schists, metaquarzites (in some places garnet-bearing), talc schist and rare garnet-mica schist. The carbonate-mica schists and metaquartzites have been folded with northeastern vergence, the fabrics of the rocks indicating a top-to-NE translation. The presence of HP-rocks in the metasediments of the western Yayabo valley (found only as boulders in the creek) suggests that these can be considered as belonging to the Gavilanes unit. Slivers of garnet amphibolites included in these Gavilanes-like rocks have been mapped by Somin and Millán (1976, 1981) and Stanik et al. (1981). Somin et al. (1992) also mentioned the occurrence of Yayabo-like amphibolites at the southern margin of the SSD. The contacts of these slivers are not

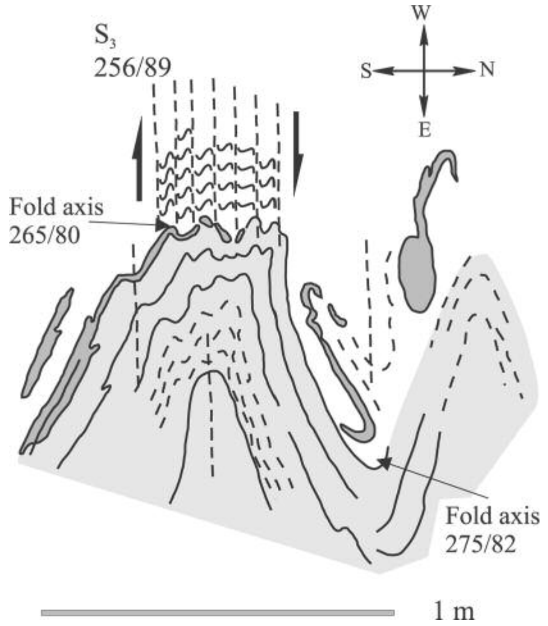


FIGURE 10 **Northern Pitajones unit, outcrop 200 m south of Pedrero (see Figs. 4 and 5). Map view of folded S_2 foliation of quartz-mica schist (grey) with quartz segregations (dark) and graphite-rich carbonate-mica schist with nearly vertical fold axis. The fold-related schistosity indicates dextral movement.**

clearly exposed, but tectonic contacts have been assumed. Somin and Millán (1981) have also mentioned rare eclogite-facies mineral associations in the Yayabo amphibolites.

The garnet amphibolites in the Yayabo valley represent a suite of amphibolites (Yayabo unit) with different proportions of garnet, zoisite and white mica. Grain size and texture can vary from coarse-grained, garnet-zoisite-rich amphibolites to fine-grained amphibolites with white mica. Zoisite needles several cm long and amphibole crystals form typical L-tectonites. The foliation is marked by the growth of white mica. Along the profile in Fig. 12 the foliation dips gently to SW, whereas the preferred orientation of zoisite and amphibole has a northwesterly trend. The rotation of garnet implies a main direction of tectonic transport top-to-NW. In rare cases sheath folds can be observed. To the east, metasediments and serpentinite bodies are tectonically intercalated with the garnet amphibolites. The appearance of serpentinite lenses marks a textural change between the garnet amphibolites and the mylonitic amphibolites.

In the eastern valley of the Yayabo River, the garnet amphibolites are in contact with blastomylonites and mylonites of a N-S trending major shear zone with a greenschist-facies overprint. The thickness of this zone is about 400-500 m. The mylonite zone includes sheared lenses of garnet amphibolites from the Yayabo unit as well as metagabbros from the overlying Mabujina unit. The fabric of the mylonites is produced by amphibole, white mica, rare zoisite, albite and quartz; garnet is gene-

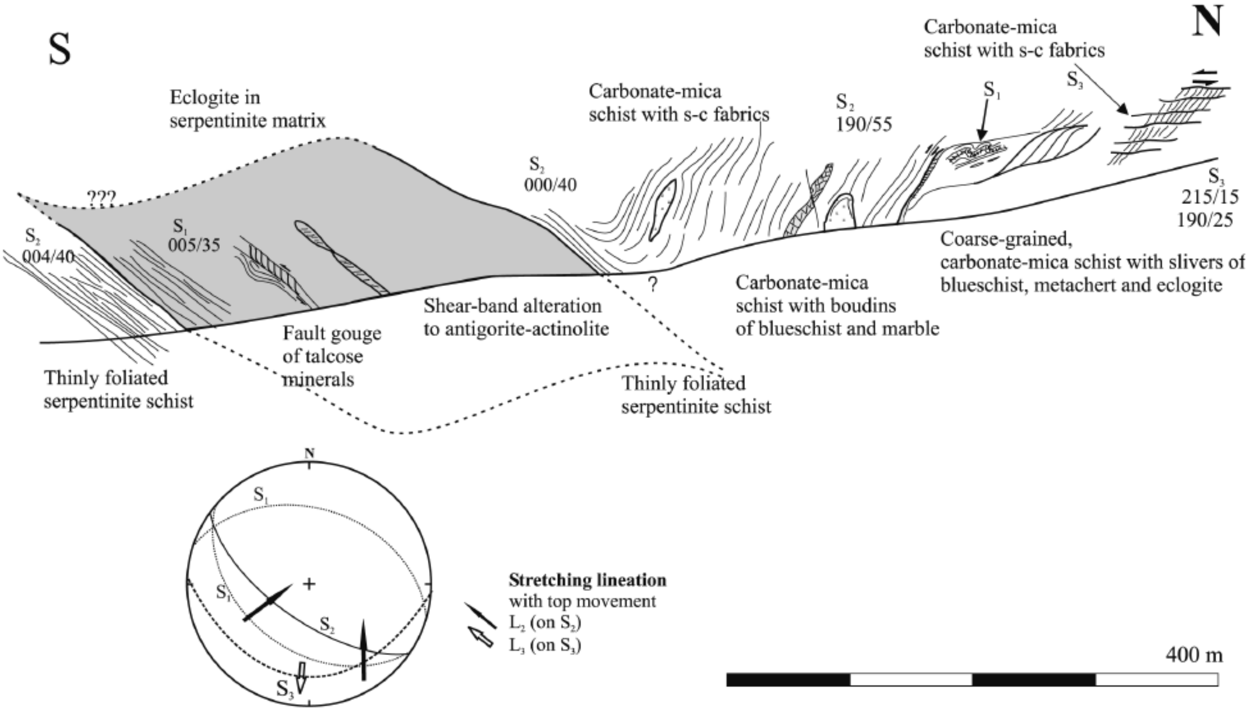


FIGURE 11 **Cross-section of the Gavilanes unit (tectonic mélange) south of Pedrero (see Figs. 4 and 5). The eclogite, metaquartzite and marble boudins preserve HP-fabrics (S_1). The matrix consists of carbonate-mica schists. Gently south-dipping semiductile to brittle shear zones mark the S_3 planes (the black line indicates the slope surface).**

rally absent. The mylonitic foliation dips steeply east; the mineral lineation dips gently to the N-NE. Dextral movement predominates in the mylonites. In the east, the mylonites are cut by normal brittle faults; producing a 5 m wide contact zone to tectonically overlying unaffected rocks of the Mabujina unit (Fig. 12). The mylonite zone between the Yayabo unit and the Mabujina unit is the most prominent shear zone in the eastern Escambray, and can be considered as the main detachment between the lower plate rocks (Escambray metamorphic complex as part of the subduction-accretionary complex) and the upper plate rocks (Mabujina unit as part of the tectonically overriding volcanic arc).

MABUJINA UNIT - THE NAPPE AT THE TOP OF THE ESCAMBRAY COMPLEX

Low-grade amphibolites in southern Central Cuba were first described by Thiadens (1937). Somin and Millán (1976) called them the Mabujina complex. Dublan and Alvarez (1986) subdivided the Mabujina complex into the amphibolite-facies Mabujina Fm and the greenschist-facies Porvenir Fm to the north of the Mabujina Fm. The Mabujina Fm or nappe frames the tectonic window of the Escambray complex as an erosional remnant.

The protolith rocks of the Mabujina amphibolites are interpreted as basement of the GAA, associated gneisses and metavolcanics as belonging to the lower part of the Cretaceous GAA, both now forming an allochthonous unit at the top of the Escambray complex (Somin and Millán, 1974, 1976, 1981; Boyanov et al., 1975; Dublan and Alvarez, 1986; Millán Trujillo, 1996b). This suggestion was taken up by Iturralde-Vinent (1994) and Kerr et al. (1999). The age of the protolith of the Mabujina Fm has been estimated paleobotanically from spores and pollen as Upper Jurassic to Lower Cretaceous (Dublan et al., 1988). A preliminary age determination on gneisses gave 90-130 Ma (Bibikova et al., 1988), and recent SHRIMP zircon dating has yielded 132 Ma (Rojas-Agramonte et al., 2005). On the basis of geochemical and isotopic data, the igneous protoliths of the Mabujina unit are interpreted as island-arc rocks derived from a depleted mantle source with sedimentary contamination (Blein et al., 2003).

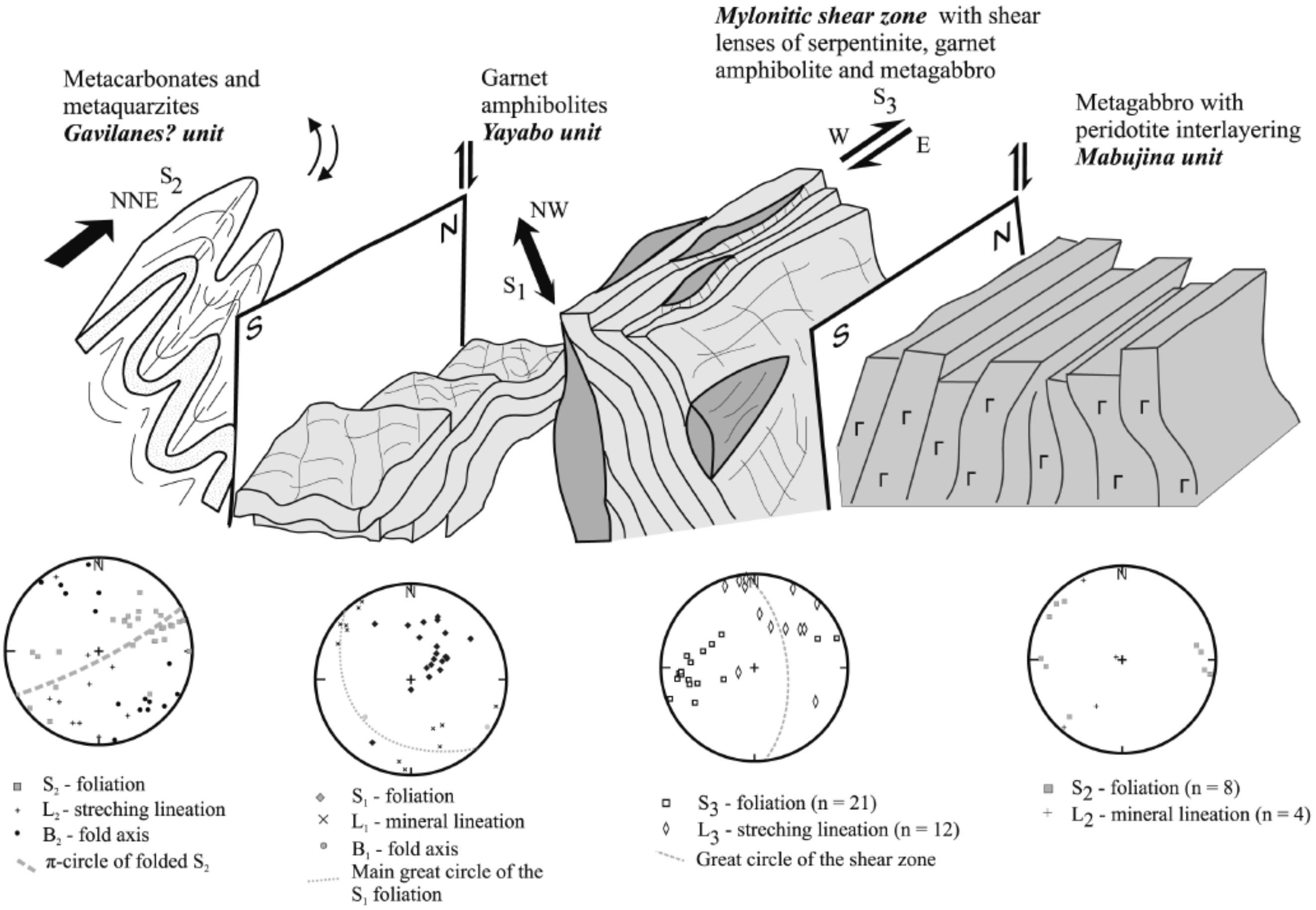


FIGURE 12 | **Generalized cross section (see Figs. 4 and 5) of the Yayabo unit along the Río Yayabo Valley (the section is about 2 km long).**

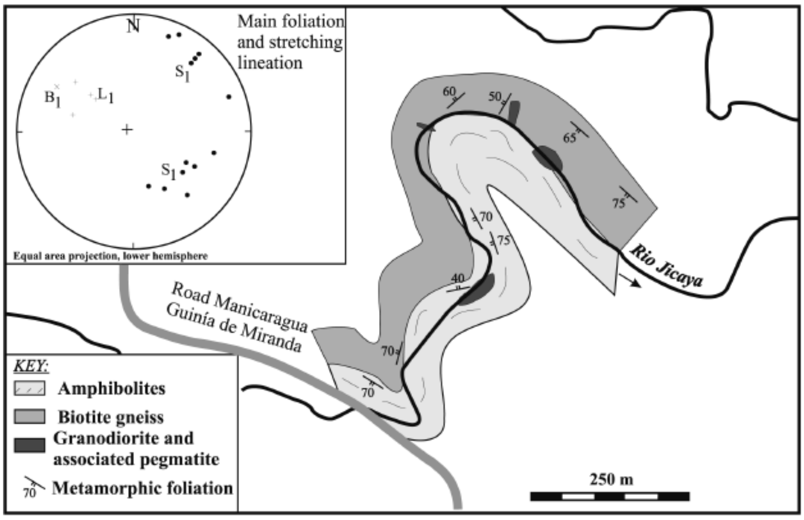


FIGURE 13 | **Structure of the Mabujina unit in the Río Jicaya Valley (see Fig. 1) west of Güinía de Miranda.**

The fifth and uppermost unnamed nappe unit incorporates all volcanogenic and plutonic rocks of the GAA which have undergone little or only very weak metamorphic overprinting. These rocks have been folded and thrust to the north. They are not the subject of this paper.

We have only few structural data on the overlying Mabujina unit itself. At the northeastern edge of the SSD, the Mabujina unit consists of monotonous metagabbros and pyroxenites, as well as rare garnet-bearing metagabbros. In other localities like the valley of the Rio Jicaya (see Fig. 1), amphibolites, biotite gneiss and plagiogranite gneiss predominate (Fig. 13). There the sequence is folded, the NW plunge of the fold axes coinciding with the trend of the stretching lineation in the gneisses.

Both the Mabujina as well as the Yayabo units have been intruded by quartz-feldspar-muscovite pegmatites up to several tens of meters thick, as well as veins of coarse-grained quartz-mica and milky quartz. Four localities - on the road from Manicaragua to Jibacoa, in the Río Jicaya valley, in the Yayabo quarry and an old quarry 2 km west of the Yayabo quarry - were studied and dated by Grafe et al. (2001). A similar pegmatite cross-cutting the Gavilanes-like rocks in the northeastern part of the Escambray has been described by Somin and Millán (1981). These pegmatitic rocks did not undergo ductile deformation like their amphibolite-facies host rocks. Thus the ages of 88-80 Ma determined by Grafe et al. (2001) on these small intrusions mark the minimum age of HP-metamorphism in the subduction-accretion complex of the GAA and of the ductile deformation in the lower part of the GAA itself.

PRESSURE-TEMPERATURE-TIME PATHS IN THE SANCTI SPIRITUS DOME

Pressure-temperature determinations

In conjunction with the basic structural observations outlined above and summarized in Table 1, the P-T-paths of the metamorphic rocks of the eastern Escambray represent critical constraints for the tectono-metamorphic subdivision discussed here. Grevel (2000) used a combination of classical thermobarometers as well as multivariant equilibria calculations to estimate pressure-temperature conditions. Her results are summarized here (Table 2 and

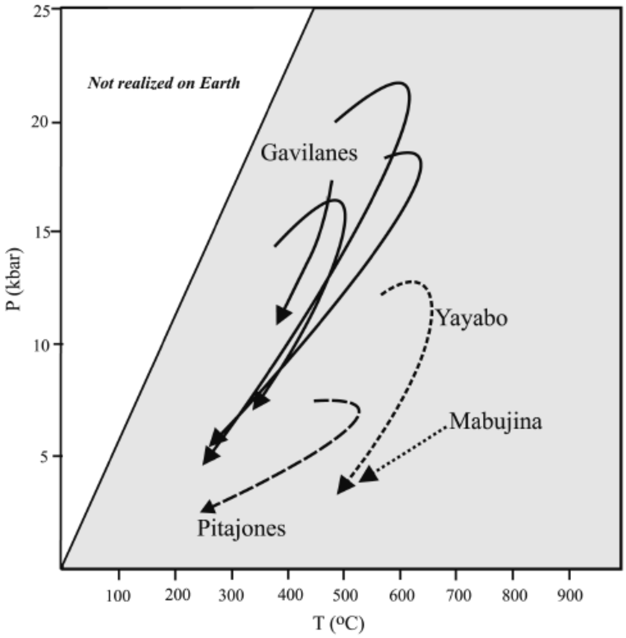


FIGURE 14 | **Exemplary P-T paths of the different nappe units of the eastern Escambray (modified from Grevel, 2000, and Grevel et al., in review).**

TABLE 1 **Deformation stages in the Escambray metamorphic complex (Pitajones, Gavilanes, Yayabo unit) and the overlaying island arc unit (Mabujina unit).**

Deformation stage	***Pitajones unit***	***Gavilanes unit (tectonic mélange)***	***Yayabo unit***	***Mabujina unit***
D0 Protolith	Relict sedimentary layering at the eastern margin of the SSD			
D1 Subduction-related	Relict first generation folds (F_1 preserved in remaining quartz rods) and sheath folds in marbles	HP-related fabrics with random growth of sodic blue amphibole, omphacite, deerite, white mica in the schistosity plane (S_1), preserved in boudins of HP-rocks; sheath folds in marble and metasediments	HT-HP related fabrics of amphibole, zoisite and white mica (S_1) (top to NW)	HT-fabrics (S_1 main schistisity) in metagabbros and gneisses; F_1 fold axis and stretching lineation indicate tectonic movement top to NW or SE
D2 Subduction and collision	Penetrative main schistosity (S_2) in carbonate-mica and quartz-mica schists as well as greenschists (top to N – NE); S_3 axial plane foliation of folded s_2 foliation	Penetrative main schistosity (S_2) in carbonate-mica and quartz-mica schists (matrix of the tectonic mélange); greenschist-facies schistosity in HP rocks (top to N – NE)	Mylonitic greenschist-facies shear zones with steeply dipping foliations marked by white mica.	Mylonitic greenschist-facies shear zones with steeply dipping foliations marked by white mica.
	Thickening, stacking and exhumation by (sinistral) oblique thrust faults (top to E – SE)			
D3 Thrusting and exhumation	Semi-brittle to brittle shear zones (top to S), W- and E-dipping S_4 (extensional crenulation) foliation; brittle faults		Semi-brittle to brittle shear zones (top to SE); brittle faults	brittle faults
D4 Neotectonics	Large-scale normal faults at the northern margin of the SSD, asymmetric uplift of the SSD; Suggested NE-trending normal faults parallel to the Trocha fault system			

Fig. 14). Grevel's (2000) estimate of the contrasting maximum metamorphic conditions reached in each nappe unit underscores the structural interpretation presented in this paper. The mineral assemblages of the Pitajones unit record 7-8 kbar at temperatures of 410-520°C. Although such conditions mirror fairly cool geotherms, there is no record of any rocks in this unit actually having reached conditions of the blueschist or eclogite facies. This is in clear contrast to the overlying mélange of the Gavilanes unit, where omphacite- and glaucophane-bearing garnet-mica schists, eclogites and deerite-bearing metacherts record clear evidence of HP/LT metamorphic conditions (Table 2). Very similar results were obtained by Schneider et al. (2004), who estimated 15-16 kbar and 600-650°C for three eclogite samples from Gavilanes-type rocks, although these estimates are generally somewhat lower in pressure and somewhat higher in temperature (Table 2). Pressure-temperature estimates of the high-variance metabasic assemblages of the Yayabo and Mabujina units are fraught with the traditional considerable difficulties. Nevertheless, the pressures of 12-14 kbar at temperatures of 580-650ºC estimated by Grevel (2000) for the Yayabo unit are in accord with the barroisitic nature of the rock-forming amphiboles found (Maresch and Abraham, 1981). Although the stability field of omphacite was obviously not reached, a HP/LT metamophic history is clearly indicated. Metagabbro samples from the Mabujina unit adjacent to the Yayabo unit of the NE boundary of the Escambray indicate maxi-

TABLE 2 **Maximum pressure-temperature conditions estimated for the metamorphic units of the eastern Escambray (Grevel, 2000; Grevel et al., in review).**

Metamorphic unit	*Rock type*	*Maximum conditions preserved*
Pitajones unit	metagabbros carbonate-mica schists	7-8 kbar, 410-520ºC 7-8 kbar, 480-520ºC
Gavilanes unit	garnet-mica schists, blueschists deerite metaquartzite eclogites	16-23 kbar, 530-610ºC >15 kbar, 470°C 16-20 kbar, 580-630 ºC
Yayabo unit	garnet amphibolites	12-14 kbar, 580-650ºC
Mabujina unit	metagabbros	≈ 7 kbar, 620-700ºC

mum temperatures of 620-700ºC at pressures of 7 kbar, in accord with the regional temperature estimates proposed by Somin and Millán (1981).

Figure 14 summarizes some typical P-T-paths for rocks from the various nappe units, again underlining contrasting structural and metamorphic evolution. The best P-T control is available for rocks from the Gavilanes unit. In keeping with the interpretation of a mélange, as well as the range of maximum P-T-conditions summarized in Table 2, individual samples may show distinct P-T-paths. Nevertheless, all these paths mirror steep P/T gradients typical. All paths converge at pressures of 5 to 10 kbar. As noted by Grevel et al. (in review) in their analysis of deerite-bearing metacherts of the Gavilanes nappe, subduction must still have been active during the exhumation of the structural components of this unit.

The P-T-paths of the Pitajones, Yayabo and Mabujina nappes are distinctly different. However Grevel's (2000) study indicates that the retrograde paths of the Mabujina and Yayabo units converged at ca. 4 kbar and 510-540°C. These P-T conditions can be interpreted as indicating the exhumation level at which the Mabujina and the Yayabo units were juxtaposed, with the formation of the greenschist-facies mylonite zone between them.

DISCUSSION AND CONCLUDING REMARKS

Several major conclusions can be drawn from Fig. 15. Subduction began at least as far back as the Albian/Aptian, and at least ~30 Ma of GAA-magmatic activity until at least 80 Ma are definitely indicated. However, as indicated in Fig. 15, there are clear indications (Schneider et al., 2004; Grevel et al., in review) that the exhumation path of the Gavilanes unit followed a "cold" P-T path, indicating that subduction was still active during the onset of exhumation at ca. 70 Ma. It is not entirely clear at present whether the Yayabo nappe originated from the subducting plate or whether it represents a part of the original "hanging wall" that became entrained in the subduction process. Nevertheless, although the Mabujina unit of the GAA basement and the Yayabo unit of the subducting plate were already welded together by 90 Ma, the Escambray nappe pile was not complete until the Early Maastrichtian i.e. during the last stages of subduction. The geochronological data of the Gavilanes unit reflect rapid cooling, most probably by underthrusting of sediments of the Bahamas margin and contemporaneous uplift (Fig. 15).

During the last stages of subduction-related metamorphism and the onset of final exhumation, especially of the Gavilanes unit, the island arc of the GAA was already being deeply eroded (Iturralde-Vinent, 1996). ^{40}Ar/^{39}Ar data from granitoids in eastern Central Cuba give a uniform 75-70 Ma peak (Hall et al., 2004). Fission track data of a diorite north of the Escambray (Fig. 15) supports the onset of uplift in the island arc at about 75 Ma. During the Late Campanian and Maastrichtian the island arc was covered by clastic sediments and platform-like carbonates (Kantchev, 1978). Not until about 65 Ma did thrusting of the metamorphic subduction-accretionary complex and the island arc onto the southern margin of the Bahamas platform begin to take place, and cooling may have been assisted by extensional tectonic unroofing (Pindell et al., 2005). This "65 Ma event", clearly seen in the P-t paths of Fig. 15, is the reason for the predominance of 75-65 Ma K/Ar "ages" in the early report of Somin and Millán (1981) in the metamorphic rocks of the Escambray. During this thrusting, subduction-complex buoyancy forces and slab rebound helped to uplift and exhume the metamorphic complex. This unroofing led to the sedimentary

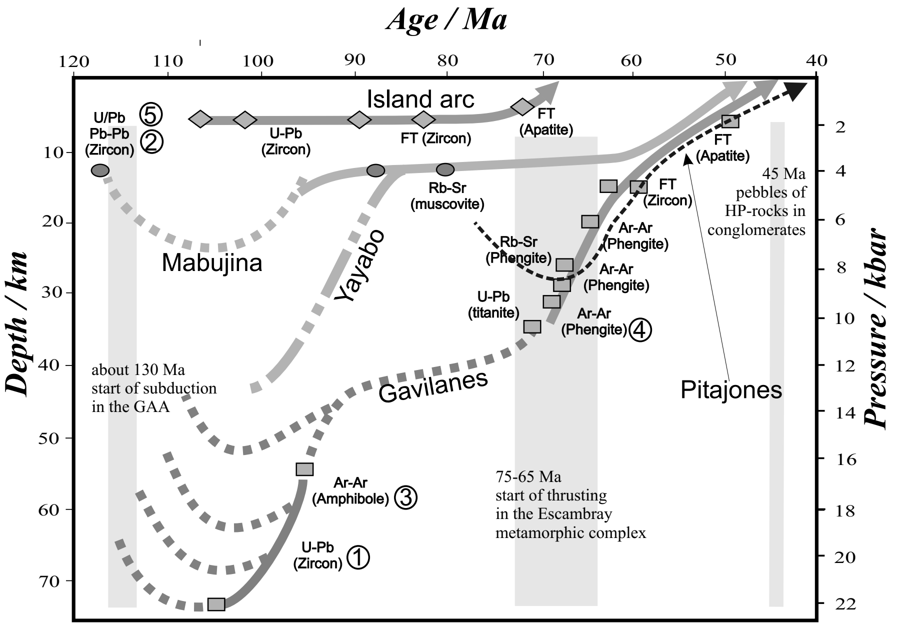


FIGURE 15 | **P-t paths of the nappe units of western Central Cuba. The sketch is based on data by Grafe (2001), as well as Hatten et al. (1988) (=1), Bibikova et al. (1988) (=2), Renne (in Draper and Nagle, 1991) (=3), Schneider et al. (2004) (=4), Rojas-Agramonte et al. (2005) (=5).**

basins filled by cover sediments and arc-related rocks now surrounding the Escambray complex. The first pebbles of HP-metamorphic rocks in the sedimentary record occur at about 45 Ma (Kantchev, 1978). All tectonic units had been exhumed and were being eroded by mid-Eocene time.

The structural development of the eastern Escambray correlates well with the P-t paths in Fig. 15. The SSD represents a fold and thrust structure formed at different crustal levels. The oldest rock fabrics are preserved in eclogite- and blueschist-facies rocks of the Gavilanes unit. NW-trending mineral lineations and sheath folds are suggested to represent the arc-parallel extensional direction during the subduction stage. Suggested tectonic erosion of the fore-arc wedge could lead to inclusion of parts of the basement of the island arc into the HP-mélange as the Yayabo unit; another protolith for the Yayabo amphibolites could be remnants of the subducted Protocaribbean crust. These rocks preserve the textures and the metamorphic overprint of an early subduction stage. In the Late Cretaceous, sedimentary and volcanic rocks of the Bahamas/Yucatán margins were being involved in the down-going slab. We suggest that the input of “cold” continental margin sediments led to a shallowing of the subduction angle and a thickening of the accretionary wedge. The volcanic front was shifted away from the arc axis and the magmatism in the island arc ceased. The subducted continental margin sediments underwent a high greenschist-facies metamorphic overprint with only a minor discernible shift to steepened P/T gradients (i.e. ca. 16 – 20°C/km). These rocks now represent the Pitajones unit.

In present exposures the Yayabo unit and the tectonically overlying Mabujina unit are separated by a brittle fault zone that cuts an earlier ductile shear zone. In terms of thrust tectonics, the Yayabo amphibolites were part of the lower plate (Escambray metamorphic complex) and the Mabujina unit was part of the overriding upper plate. We propose that the shear zone between the Yayabo unit and the Mabujina unit acted as the main detachment between the subduction-accretion complex and the overlying arc complex in a mid-crustal level.

Our interpretation agrees with the model of a south-dipping subduction zone (Pindell et al., 2005; for additional references see there). In this model the collision of the GAA with the Bahamas was the consequence of the subduction of Proto-Caribbean crust beneath the Caribbean microplate. In the southern part of western Cuba, seismic records show a narrow belt of “thin transitional crust” which extends eastward to Holguín (Moreno, 2003). This 20-30 km thick crust could be interpreted as continental crust thermally thinned during the opening of the Protocaribbean. Most of the tectono-metamorphic features in the Escambray complex-accretion, tectono-metamorphic overprint, structural thickness and uplift can be explained in terms of the collision of a north-facing island arc and its related subduction-accretion complex with the southern edge of the North American continental margin during the Late Cretaceous. The early stages of the development of the GAA and the subduction-accretion complex still remain problematic and will be the object of further investigations.

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