Thompson Field Forum 2025, Cuba | 12–18 April 2025

Field Trip guide to

**“The Geology of Cuba: Key for the Tectonic Evolution of the Caribbean–North American Plates”**


**By**

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*Valle de Viñales, Pinar del Río Province, Western Cuba. Karstic relief on passive margin Upper Jurassic and Cretaceous limestones. The world-famous Cuban tobacco is grown in this valley. Cover of GSA Today, Volume 26, Number 10 (October 2016).*

## Introduction

The seven-day Thompson Field Forum 2025 “The Geology of Cuba: Key for the Tectonic Evolution of the Caribbean–North American Plates” will take place in western and central Cuba during April 12-18, 2025. In parallel, the Geological Society of Cuba organized the session “Geology and Geodynamic Evolution of Cuba and the Caribbean” as part of the activities offered by the XVI Cuban Geological Congress and the XI Cuban Earth Sciences Convention, to be held in Havana during April 7-11, 2025.

The Thompson Field Forum 2025 will start in the Pinar del Rio region of western Cuba. For the first two days, the group will visit localities around Viñales (a UNESCO World Heritage Site) in the Guaniguanico terrane. The group will then move to central Cuba for a traverse across the Cuban orogenic belt, spending three nights in Santa Clara and one in Trinidad (another UNESCO World Heritage Site and one of the best-preserved colonial cities in the Caribbean). Because Cuba records the geodynamic interactions of the Caribbean and North American plates since the Lower Cretaceous until the early Upper Eocene, its sedimentary, magmatic and metamorphic record is a major target of study. Like all Forums, this one is designed to capture the essence of exciting discoveries and controversial topics of Cuban geology through observations in the field for onsite discussions in the area, taking advantage of the opportunity to bring together various experts to exchange current knowledge, ideas, and theories in the field.

The field trip is planned to give an overview of the geologic architecture of the Mesozoic-Tertiary passive margin of North America and the Cretaceous active plate margin of the Caribbean, including latest-Cretaceous to Tertiary orogenic belt and associated basins in the region, with special focus on Jurassic limestones, K-T boundary and products of the Chicxulub impact, subducted high pressure complexes (tectonic blocks of serpentinite mélanges of the northern ophiolite belt, Escambray complex), obducted ophiolitic bodies (northern ophiolite belt), the Cretaceous oceanic volcanic arc and its metamorphic counterpart (Mabujina Amphibolite complex). The selection of outcrops has been based on several criteria, including: a) transportation in a large bus for 40 persons, b) accessibility and, importantly, c) road safety in a context of small roads with heavy traffic.

## Literature

The Earth Sciences literature on Cuba is full of papers published in sources that are not easily found, neither in libraries nor in internet. However, Yasmani Ceballos Izquierdo and Manuel Iturralde-Vinent have gathered since 2011 thousands of papers that are offered in pdf format in the "*Biblioteca Digital Cubana de Geociencias*", which is frequently actualized. Click here for inspection.

You can access to a selected list of references relevant for the field-trip in our TFF 2025 Cuba website.

For an overview of Cuban geology, take a look at:

Iturralde-Vinent, M.A., Garcia-Casco, A., Rojas-Agramonte, Y., Proenza, J.A., Murphy, J.B. and R.J. Stern (2016). The geology of Cuba: A brief overview and synthesis. GSA Today 26, 10, 4-10. DOI: 10.1130/GSATG296A.1.

and other field-trip guides:

Iturralde-Vinent (2018). Field Guide to Western Cuba Geology. Private publication.

Iturralde-Vinent (2006). Geology of the former Caribbean plate boundary, Camaguey, Central Cuba. Field trip organized by *IGCP 433 Caribbean Plate Tectonics.*

Garcia-Casco et al. (2009). Subduction and arc complexes of central Cuba. Field trip organized by *IGCP 546 Subduction Zones of the Caribbean*. https://www.ugr.es/~agcasco/igcp546/.

The following text is based on the results and introductions of the papers listed above. Only specific references are given where appropriate.

## The Geology of Cuba

The Cuban orogenic belt is part of the northeastern branch of the Caribbean belt (Figure 1A) that formed as a result of convergence between the North American and Caribbean plates in Mesozoic to Tertiary times. The process involved subduction, collision and accretion of large amount of Caribbean oceanic material, including ophiolites and intra-oceanic volcanic arc rocks, and passive margin sequences of North America, all tectonically imbricated along the belt (Figure 1B, and Figure 2).

The geodynamic evolution of the Caribbean region started with the rupture of Pangea during Jurassic times, which involved the inception of the Proto-Caribbean ridge (i.e. the westward extension of the Central Atlantic ridge in the intra-Pangean future Caribbean realm in between the Americas) and the inter-American transform in between the Proto-Caribbean realm and the Farallon plate, which largely controlled the drifting apart of the North and South American plates. The Proto-Caribbean basin started to subduct under the Farallon plate, probably favored by the inter-American transform, at ca. 135 Ma, forming backarc, forearc, arc and intra-arc units in the leading edge of the Farallon plate. Oceanic subduction of the Proto-Caribbean during the Cretaceous developed high-pressure serpentinite-matrix mélanges with tectonic blocks of eclogite, blueschist, high-pressure greenschist, garnet amphibolite, antigoritite, jadeitite and other high-pressure metasomatic rocks. Tectonic complexities in the forearc and the backarc led to mid Cretaceous local subduction events that created metamorphic soles associated with ophiolitic units and triggered subduction of forearc lithosphere. Continued subduction led to the collision of the NE leading segment of the Caribbean plate with the passive margin of North America (i.e. the Bahamas platform and the Maya block) during latest Cretaceous – Tertiary times, when ophiolite, subduction mélange and volcanic arc units were tectonically emplaced on the passive margin units. At the same time, syntectonic sedimentary basins developed and exhumation of previously subducted passive margin complexes (Caribeana terrane) took place (Figure 3). Ongoing collision and subduction with a strong strike-slip motion continues today in the eastern Dominican Republic and Puerto Rico-Virgin Islands, while more orthogonal subduction occurs in the Lesser Antilles.

The North American passive margin is represented in Cuba by 1) juxtaposed tectonic units of the fold-and-thrust belts of the Guaniguanico terrane, 2) the metamorphic (subducted) Caribeana terrane (both related to the Maya Block; Figure 3) and 3) the northern fold belt (related to the Bahamian borderlands and Proto-Caribbean crust), which consist of shallow to deep marine sediments and mafic extrusive, subvolcanic and intrusive rocks (Figure 4). Passive margin deposits date back to early Jurassic time. Van Hinsbergen et al. (2009) define non-metamorphic sedimentary slivers of 1-10 $km^2$ surrounded by foliated serpentinites belonging to the underriding proto-Caribbean crust (Placetas belt) that were accreted and incorporated in the serpentinite melange during underthrusting of the Placetas sediments, which, given their stratigraphic range, occurred after the Maastrichtian. There are rare outcrops of Grenvillian (ca. 900 Ma) basement (see sections "Western Cuba" and "Central Cuba" below for more details).

Ophiolitic units are tectonically emplaced above the passive margin units and above the volcanic arc in western (Bahía Honda) and Eastern Cuba. The most important ophiolitic assembly is the "northern ophiolite belt", a discontinuous belt of more than 1000 km in length composed of discrete, variously sized bodies exposed in the north of the island, from W to E, Cajálbana, Mariel-La Habana-Matanzas, Las Villas, Camagüey and Holguín (Figure 1B). Cajálbana (westward) and Mayarí-Moa-Baracoa (eastward) are emplaced above the Cretaceous volcanic arc. All these bodies were considered to represent a single geologic element formed within the same paleogeographic/paleotectonic setting during the Mesozoic. The bodies include ultramafic rocks (mostly, harzburgite, but also local dunite, lherzolite, pyroxenites, dunites and podiform chromitite bodies) serpentinized to varied extent plus layered and isotropic gabbros, diabase, basalt, and oceanic sediments. Oceanic transformations resulted in low-pressure chrysotile-lizardite serpentinization and ocean floor metamorphism reaching up to upper amphibolite facies conditions. Amphibolitic metamorphic soles at the base of the ultramafic section of ophiolites are only locally exposed in eastern Cuba (Lázaro et al., 2015).

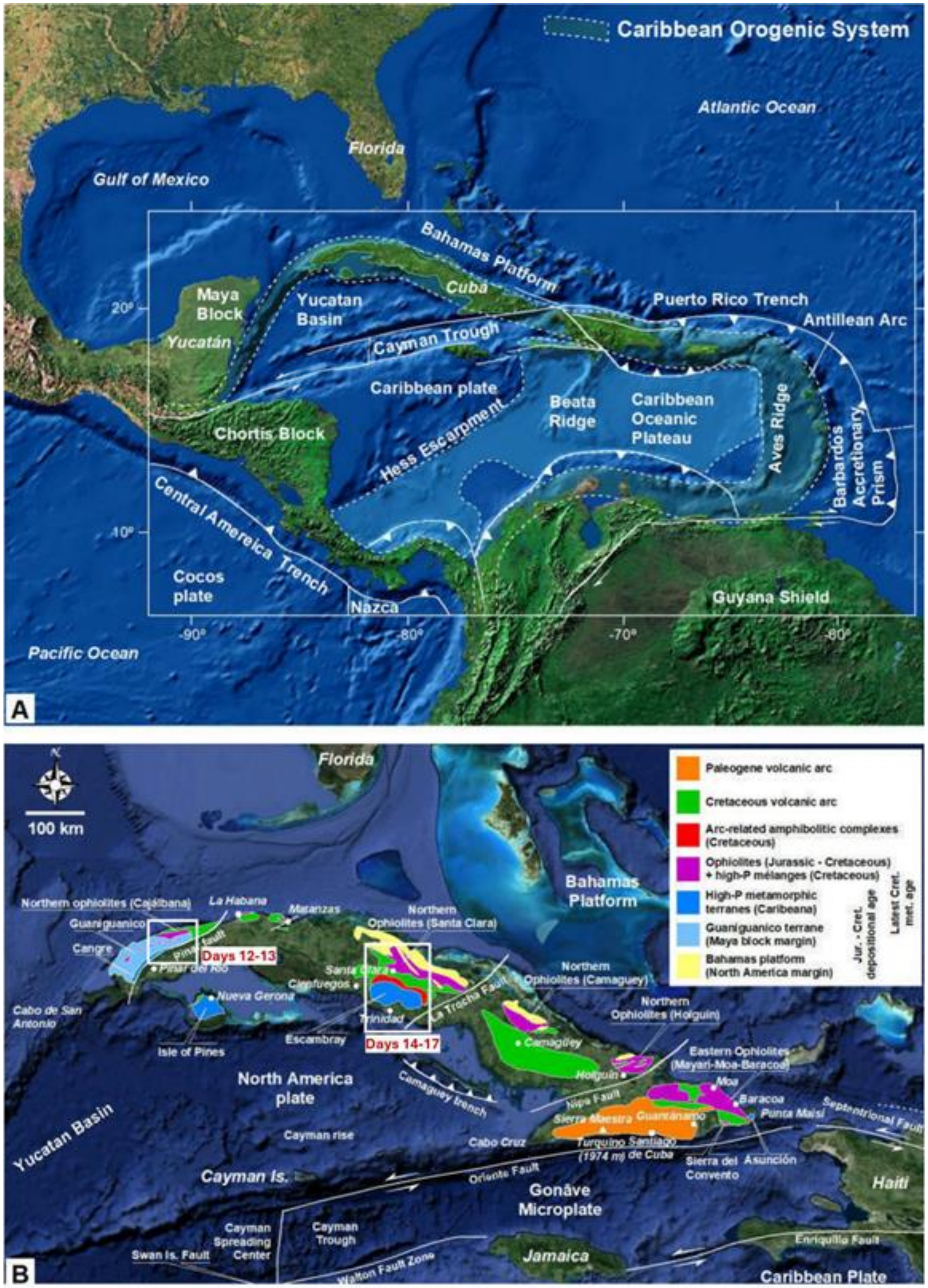


*Figure 1. A) Tectonic map of the northern Caribbean region. B) Generalized geologic-tectonic map of Cuba modified from Iturralde-Vinent et al. (2016) showing TFF2025 field areas.*


*Figure 2. Geological map of Cuba (1:250000) with insets showing TFF2025 field areas. Academia de Ciencias de Cuba (1988). Click here for a high-resolution version. Click here for legend.*

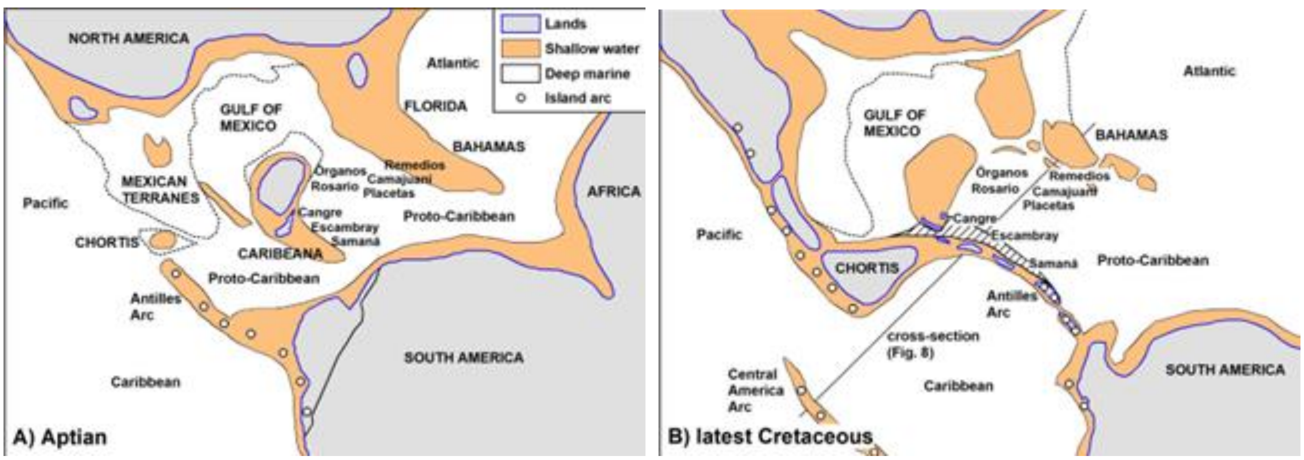


*Figure 3. Paleogeographic sketches of the Caribbean region for mid- and latest-Cretaceous times showing the inferred position of Caribeana (denoted by the Cangre, Escambray, and Samaná terranes) relative to the Mayan and Bahamian borderlands and the Greater Antilles arc. In B, Caribeana (hatched pattern) is in the process of subduction. The trace of cross-sections of Figure 5 is shown in B. After Garcia-Casco et al. (2008).*

Petrological and geochemical studies point to MORB, backarc basin basalt (BABB), forearc (FAB), transitional MORB-island arc tholeiitic (IAT), IAT and boninitic signatures that would imply formation in an early-to-late Cretaceous evolving suprasubduction environment. However, recent ideas consider most ophiolites as fragments of the forearc formed during subduction initiation in the early Cretaceous. The ophiolitic rocks of forearc setting are 135-130 Ma old (Rui et al., 2022 ; see also Niu et al., 2022 for early Cretaceous age in a back-arc setting). However, the earliest age of formation of the ophiolite belts in Cuba is allegedly constrained to be Upper Jurassic (Tithonian) based on paleontologically dated sediments that locally cover the basaltic crust of the Santa Clara ophiolite (Llanes-Castro et al., 1998). Middle-Upper Jurassic was the time of break-off of Pangea and the onset of formation of the Proto-Caribbean oceanic basin connected with the Atlantic. The basin opened until the Maastrichtian as the Americas drifted away. However, Jurassic ages for the ophiolitic crust is controversial, not only because it disagrees with isotopic dating in central and eastern Cuba (e.g., Niu et al., 2022 , Rui et al., 2022) but because the oceanic crust is of suprasubduction Caribbean forearc origin (Butjosa et al., 2024).

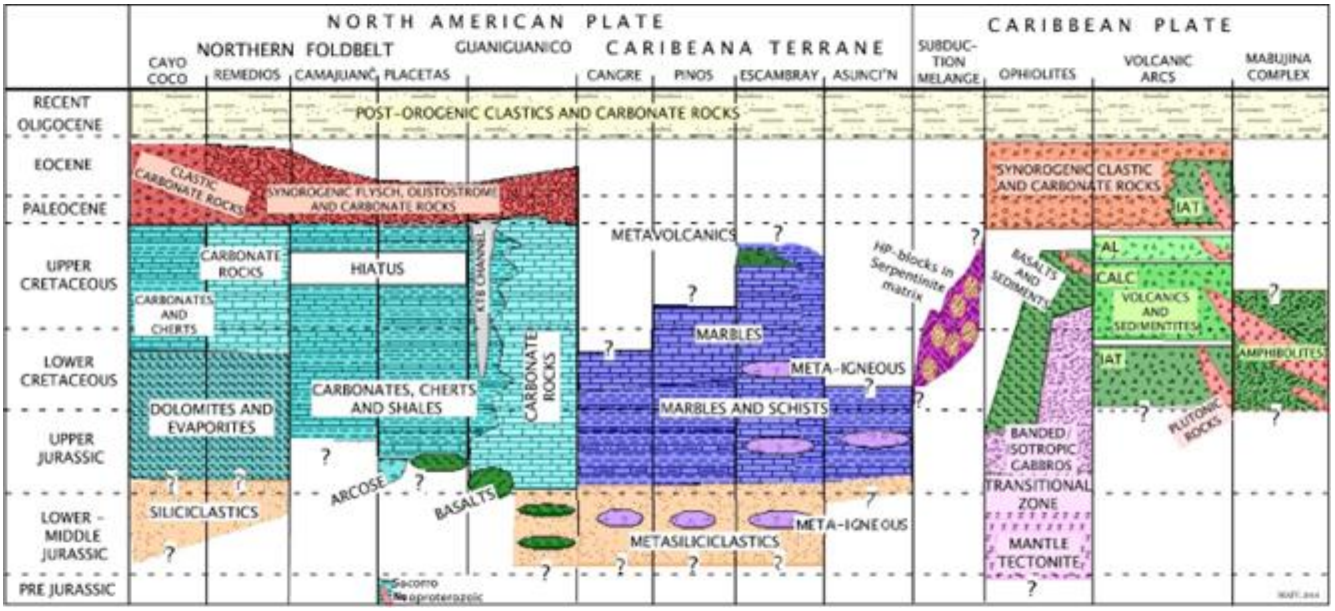


*Figure 4. Generalized tectonic-stratigraphic chart of Cuba. To the right under "volcanic arcs," abbreviations refer to island arc tholeiite (IAT), alkaline suites (AL), and calc-alkaline suites (CALC). KTB channel refers to a deep erosional channel cut due to the Cretaceous-Tertiary boundary mass flows from the platform margins due to the impact. (From Iturralde-Vinent et al., 2016).*

During their latest Cretaceous-Eocene tectonic accretion to the continental margin, the ophiolitic bodies were strongly sliced off, fractured and brecciated. In fact, most of them can be considered as tectonic serpentinite-matrix mélanges that contain, in addition to co-genetic igneous and sedimentary materials, exotic blocks incorporated from adjacent sedimentary sections, volcanic-arc and subduction complexes. In this regard, ophiolitic assemblies appear also as olistostromes and large olistoplates separated from the emplacing tectonic units and deposited in synorogenic late Maastrichtian-Tertiary basins (Figure 4).

Ophiolitic material metamorphosed to high-pressure is found as blocks within serpentinite-matrix mélanges in three different geological settings. 1) Most commonly, these high-pressure mélanges occur associated with, or mingled with, the ophiolitic units all along the northern ophiolite belt and eastern Cuba belt. 2) Blocks of serpentinite-matrix melanges also form, together with ophiolitic fragments, olistoliths within non-metamorphic Eocene olistostromes in western Cuba and late Maastrichtian/Danian in central and eastern Cuba. The blocks in both geological settings include eclogites, garnet amphibolites, blueschist and greenschist facies rocks, antigoritites, talc±amphibole±chlorite metasomatic rocks, tremolitite veins and jadeitites, the latter, only confirmed in eastern Cuba Sierra del Convento mélange (though eventually present in other mélanges). On the other hand, the Sierra del Convento and La Corea mélanges in eastern Cuba (see Figure 1B for location) stand out as a world-class examples of high-pressure mélange bearing trondhjemite due to partial melting of the subducted oceanic crust at 700-750 ºC, 1.5 GPa at ca. 120 Ma. It has been inferred that such a high thermal gradient (16 ºC/km) during subduction was due to subduction of the Proto-Caribbean mid-ocean ridge. High-pressure blocks within serpentinite-matrix subduction mélanges record long-lasting subduction since 130-125 Ma to ca. 70 Ma. 3) Ophiolitic material is also found in the Escambray and Mabujina complexes as slices of serpentinite. In the Escambray complex, the serpentinites contain antigorite, pointing to subduction under relatively high P-T conditions, in agreement with tectonic inclusions exotic blocks of MORB-like eclogite (75-70

Ma). In the Escambray, massive Yayabo garnet amphibolites are considered of oceanic origin accreted to the metamorphic pile.

A belt of tectonic units consisting of Cretaceous volcanic, volcanic-sedimentary and plutonic arc rocks of basic through acid composition all along the island (Figure 1B and Figure 2) documents an Early Cretaceous (Hauterivian? -mid Albian age) island arc of tholeiitic (IAT) affinity that developed into a voluminous calc-alkaline (CA) and high-K calc-alkaline magmatism (Albian-Campanian) (Iturralde-Vinent, 1996; Hu et al., 2022 and references therein). This general sequence of Cretaceous arc volcanism in Cuba is similar to that identified all along the Caribbean region (Great Arc of the Caribbean, Burke, 1988). These volcanic arc sequences are interrupted by unconformities followed by paleosoils, conglomerates and shallow marine limestones (Figure 4). The volcanic arc units tectonically overlie the passive margin sections, but they are also locally tectonically intercalated with ophiolitic rocks and distal Proto-Caribbean sediments (Placetas Belt). Cretaceous volcanic arc rocks underwent generalized zeolite-, subgreenschist- and greenschists-facies transformations in the volcanic arc environment. However, high-pressure blueschist- facies conditions are recorded in a distal section of the volcanic arc, in the El Purial complex of eastern Cuba (Figure 1B). The protoliths of the Purial complex are probably early Maastrichtian and older in age, but metamorphism took place within the late Maastrichtian/Danian, probably coeval with the detachment, exhumation and emplacement of mafic-ultramafic thrust-sheet bodies (Iturralde et al., 2006). A whole-rock K/Ar determination on mica-quartz schist yielded 75±5 Ma (Somin et al., 1992). The Cretaceous volcanic arc magmatic activity lasted ca. 60 Myr (135-130 - 70 Ma; Rojas-Agramonte et al., 2010, 2011), similar in range to high-pressure rocks all along the island. A metamorphosed fragment of the volcanic arc is found in the Mabujina Complex (Porvenir Fm and Mabujina Amphibolite Complex) that underlies the volcanic arc section (see below).

For the most part of the territory, passive margin deposition and volcanic arc activity ended during the latest Cretaceous (Figure 4), when fragments of the passive margin subducted (Caribeana, Figure 5), initiating the collision between the Caribbean plate and the margin of the North American plate. This collision triggered the emplacement of arc and ophiolitic units onto the passive margin and led to the formation of synorogenic basins (Maastrichtian/Paleocene olistostromes and flysch; Iturralde-Vinent, 2015). The architecture of the orogenic belt is different all along the island, with ophiolites+arc units above the passive margin sequences, but volcanic arc units occur either tectonically above (central Cuba) or below (western and eastern Cuba) the ophiolitic units. In eastern Cuba, mainly in the Sierra Maestra Mountains, subduction-related island arc tholeiitic magmatism with volcanic-sedimentary series developed after a Maastrichtian-Danian hiatus of volcanism (Iturralde-Vinent, 1995, 1996). These were intruded by Paleocene-mid Eocene plutonic rocks (60.5 ± 2.2 to 46.9 ± 0.1 Ma; Rojas-Agramonte et al., 2004; 2008) ;. In central and northeastern Cuba, fine grained tuffites occur interbedded with the Paleocene-Middle Eocene sedimentary rocks. Magmatism ended by early late Eocene time, when Cuba was fully accreted to, and made part of, the North American plate, and the active Caribbean-North American plate margin migrated to the South (proto-Oriente-Cayman ridge-Swan transform system).

**Tectonic events**

The Cuban thrust-and-fold belt was complexly assembled during latest Upper Cretaceous-early Upper Eocene times, when syn-tectonic basins developed above the ophiolitic and Cretaceous arc units, and a foredeep basin onto the continental margin units (Figure 4 and Figure 5). Collisional tectonics, ophiolite obduction and olistostrome formation relate to the insertion of the leading edge of the Caribbean plate (volcanic arc and ophiolites) into the Proto-Caribbean crust and the passive North American margin (Mayan and Bahamian margins) (Iturralde-Vinent et al., 2008). The Campanian termination of the volcanic arc and the Upper Cretaceous ages of high-pressure metamorphism in passive margin metamorphic terranes (Escambray, Isle of Pines) indicate onset of arc-continent collision in the Cuban segment of the Caribbean orogenic belt at ca. 70-75 Ma. The accretionary history of the orogen in Cuba encompassed this latest Campanian-early Maastrichtian event, but also latest Maastrichtian-early Danian, and Middle to early Upper Eocene events. As the Caribbean plate drifted eastward relative to the Americas, the leading edge of this plate collided first with the Caribeana terrane Garcia-

Casco et al. (2008), forming the metamorphic complexes of the Caribbean (e.g., Escambray complex). Later, during the Paleocene - late Middle to early Upper Eocene, the accretionary prism collided with the Mayan and Bahamian margins (Figure 5).

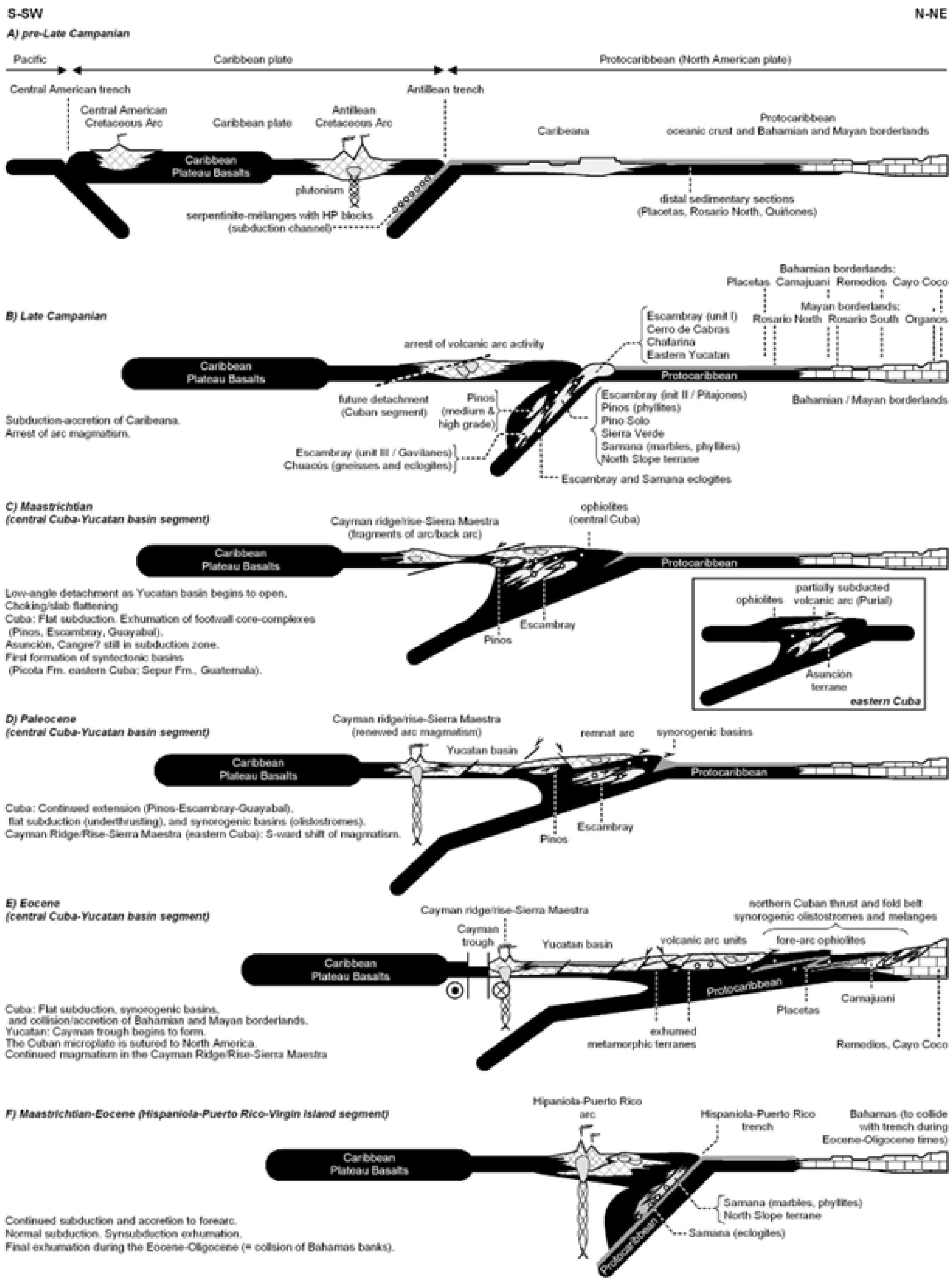


*Figure 5. Tectonic sketch cross-sections showing the evolution of the northern margin of the Caribbean plate, metamorphic terranes and Mayan/Bahamian borderlands, after Garcia-Casco et al. (2008). Click for larger view.*

## Western Cuba

Within the territory of western Cuba, the following tectonic elements can be distinguished from north to south:

- The Southern Gulf of Mexico lithotectonic unit.
- The Bahía Honda tectonic unit which includes mafic-ultramafic rocks, Cretaceous arc volcanics, and sedimentary rocks of latest Cretaceous and Tertiary age.
- The Guaniguanico terrane which includes Jurassic-Paleocene continental margin sequences and Paleogene foreland deposits.
- The Los Palacios basin which contains Upper Cretaceous and Tertiary sedimentary rocks
- The Guanal high which includes Miocene sedimentary rocks and a poorly known unexposed older section presumably consisting of serpentinites and mafic igneous rocks
- The La Coloma-Sabana Grande tectonic unit which contains Upper Cretaceous and Tertiary sedimentary rocks underlain by Cretaceous volcanic arc rocks
- The Pinos barrovian terrane which includes Mesozoic metasiliciclastics and marbles of continental margin origin.

The Southern Gulf of Mexico lithotectonic unit represent the autochthonous extended continental crust area between Yucatan, Florida and western Cuba, where concur the foldbelt, the Bahama-Florida basement, and the Gulf of Mexico basement with superimposed Paleogene and younger basins. This is a major hydrocarbons district within the Cuban offshore economic zone.

The Bahía Honda allochthonous unit is part of the Folded and thrusted belt represented by a lower, deformed ophiolite sheet, overlain by thrust sheets of Cretaceous calc-alkaline forearc volcanics, including basalts, pyroclastic and epiclastic deposits of Albian? to Campanian age. This unit was deformed late in the Campanian just after the extinction of the volcanic arc. The whole unit rest in tectonic contact above the Gulf of Mexico and the Guaniguanico terrane, being the highest tectonic element of the structural pile.

The volcanic forearc section in the Bahía Honda unit is unconformably overlain by upper Campanian and younger sedimentary rocks. Upper Campanian-Maastrichtian sedimentary rocks consist of deep-water flysch, claystone, and conglomerate of the Vía Blanca Fm. The clastic debris in these rocks is mostly derived from the erosion of an extinct volcanic arc including detrital quartz, rock fragments and biogenic clasts. KTB deposits are formed by a calcareous megaturbidite (Peñalver Fm, up to 200 meters thick), similar to coeval deposits of the Rosario belts (Cacarajicara Fm, up to 800 m thick). (Iturralde-Vinent, 1992; Katayama et al., 2000)

The Paleocene-Lower Eocene flyshoid section (Vibora Group) is represented by a well-stratified conglomerate, sandstone, siltstone and claystone beds, usually with slump beds and olistostromic intercalations, overlain by the Lower-Middle Eocene hemipelagic marl, radiolarian marl and marly limestone, with rare intercalations of fine grain clastic rocks toward the base (Universidad Fm). Unconformably above these units is present Late Eocene undeformed hemipelagic marl and marly limestone (Punta Brava Fm).

The upper Campanian-Eocene sedimentary basins that overlie the extinct arc in Cuba have been classified in general as "post-arc" or "superimposed onto the arc" because they evolved in the new structural fabric which arose after the extinction of the Cretaceous arc. Some of these basins, for example the Bahía Honda unit, evolved as a "piggy-back" basin during Paleocene-middle Eocene time. The mafic-ultramafics and Cretaceous volcanic rocks are intensely deformed, but show no signs of metamorphism. The Uppermost Cretaceous-Eocene sedimentary section is less deformed than the older rocks.

The Guaniguanico mountains can be subdivided into several tectono-stratigraphic sequences that show the evolution of Pangea into the Laurasian continental passive margin from Early(?)-Middle Jurassic to early Paleocene, facing the Proto-Caribbean sea to the southeast, before deformation took place between Paleocene and Late Eocene. The Lower Tertiary sedimentary rocks in Guaniguanico are related to the evolution of a foredeep basin, which will be characterized below.

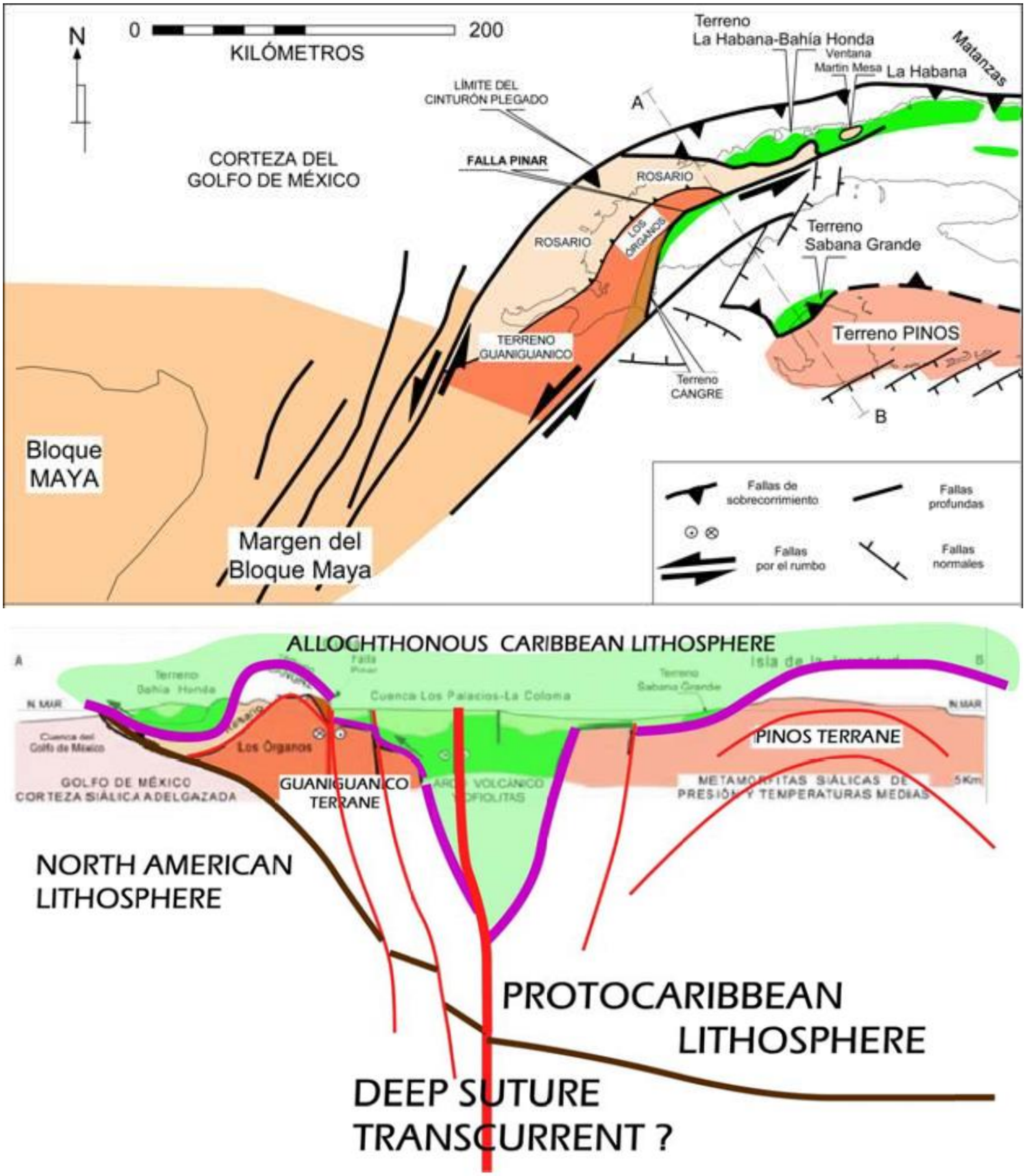


*Figure 6. General tectonic map and cross section of Western Cuba.*

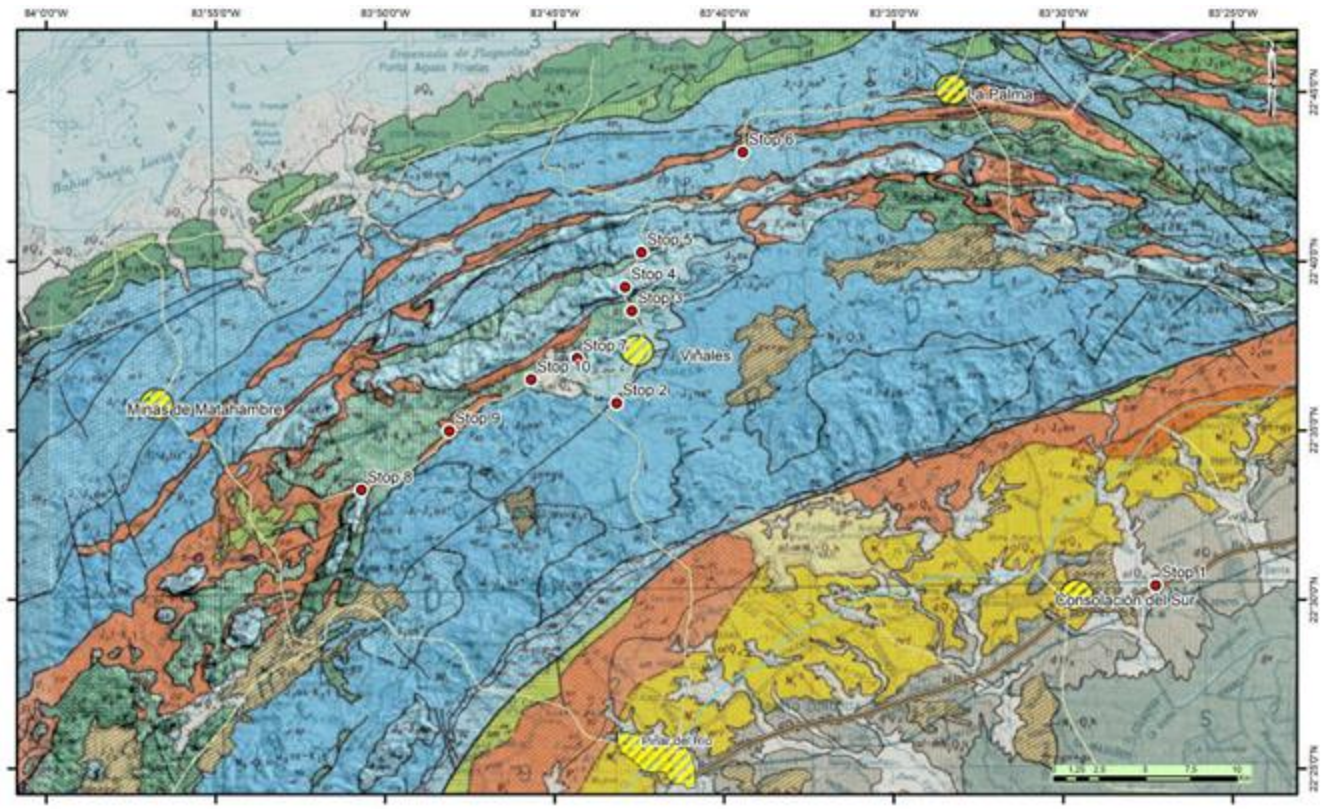


*Figure 7. Geological map of western Cuba (1:250000) with indication of TFF2025 stops. Academia de Ciencias de Cuba (1988). Click here for legend.*

## Central Cuba

The Villa Clara region in central Cuba displays a fairly well exposed N-S geological transect across the Island (Figure 1B and Figure 2). Here, the orogenic belt is subdivided (North-to-South) into the following elements (Figure 8 and Figure 9):

- The northern passive margin belts (Bahamas margin, slope and deep ocean –Proto-Caribbean- basin).
- The northern ophiolites (forearc) and associated high-pressure mélanges (subduction complex).
- The Cretaceous Volcanic arc.
- The Mabujina complex (volcanic arc metamorphosed during the mid Cretaceous).
- The Escambray complex (subducted passive margin of the Caribeana terrane).

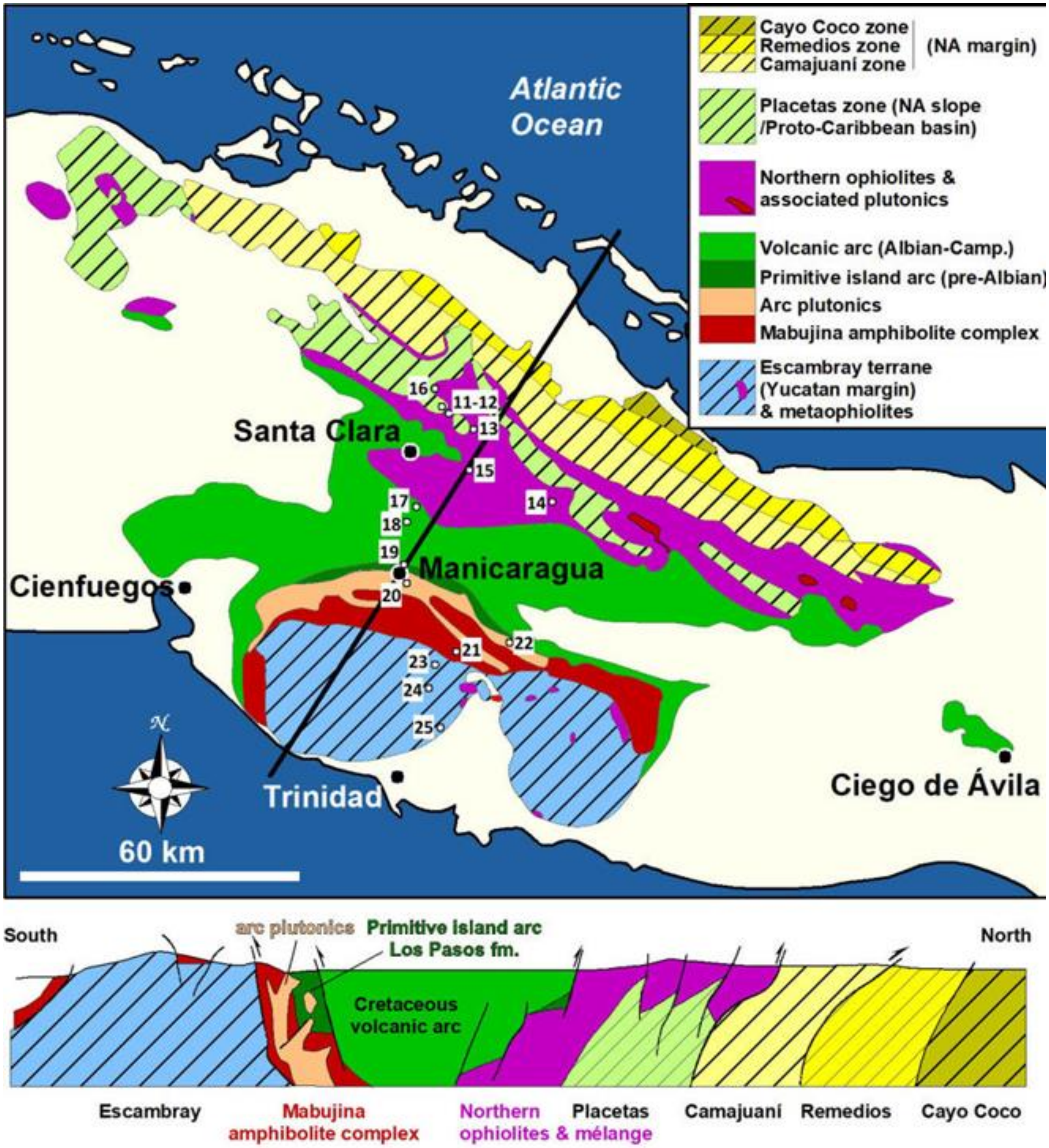


*Figure 8. Geological sketch-map and cross-section (black line) of central Cuba (based on Iturralde-Vinent, 1998) with indication of stops.*

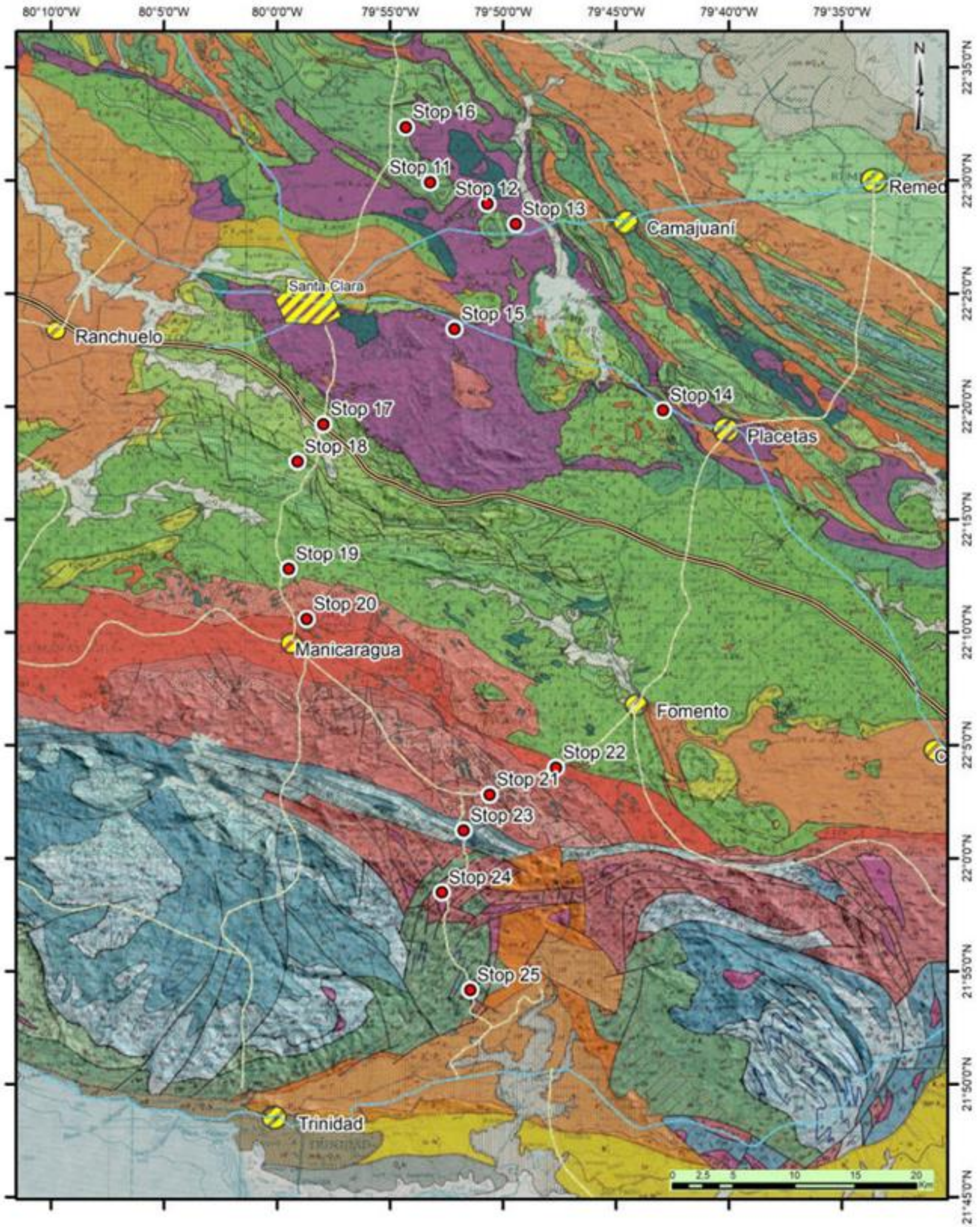


*Figure 9. Geological map of central Cuba (1:250000) with indication of TFF2025 stops. Academia de Ciencias de Cuba (1988). Click here for legend.*

**The northern sedimentary belts**

The *Northern Sedimentary Belts* embrace strongly deformed Mesozoic-early Cenozoic shallow to deep marine sedimentary deposits that tectonically underly the ophiolitic+volcanic arc bodies or form a series of elongated tectonic slivers. The rocks are grouped in "belts", formed in various paleotectonic and paleogeographic scenarios of the North American plate (Figure 10). These belts are, from northeast to southwest, Canal Viejo de Bahamas, Cayo Coco, Remedios, Camajuaní and Placetas. Within these belts can be distinguished the Mesozoic passive margin–oceanic basin sections and the Maastichtian-mid Eocene syn-orogenic foredeep basins above the overriding units (Figure 10). The Canal Viejo belt (Florida –Bahamas platform) is known only from oil wells. The oldest rocks are probably Triassic, resting upon a continental crust. The Cayo Coco belt of northern Cuba represents one of the intraplatform channels, while the Remedios belt represent the southernmost edge of the Florida-Bahamas carbonate platform. The Camajuaní and Placetas belts, on the other hand, represent the Late Jurassic to Late Cretaceous continental slope and Proto-Caribbean oceanic basin, respectively. The oldest rocks known southeastward are slivers of Precambrian marbles and Jurassic granites (Socorro Complex) at the base of the Late Jurassic–Cretaceous Placetas belt sequence. At the Camaján hills (Camaguey) occur Early Tithonian continental margin basalts, hyaloclastites and hemipelagic limestones. From Paleocene to early Upper Eocene, a foredeep basin and forebulge developed in the Proto-Caribbean and Bahamas margin. Deformations in the Northern Sedimentary Belts increase from northeast to southwest, from a slightly deformed section with local development of isolated linear folds in the Canal Viejo belt, up to very tight folds and thrust faulted lenticular bodies intermingled with serpentinites in the Placetas belt. These deformations are Paleocene to mid Eocene and reflect the syn-accretionary process of SW to NE collision of the leading edge of the Caribbean plate with the North America margin along the Florida-Bahamas borderland.

Of the different northern sedimentary belts, only the Placetas Belt will be visited during the TFF2025. This belt embraces a series of NW-SE elongated thrust and fold bodies, roughly lenticular, strongly deformed, partially foliated and intercalated within serpentinite melanges, which outcrop from Matanzas to Holguín in Northern Cuba. Along strike from NW to SE the Placetas tectonic lenses became increasingly detached from each other. These tectonic slivers are built by a stack of thin nappe units, which present some stratigraphic singularities. The Placetas section in NW Santa Clara overlies a late Proterozoic Grenvillan basement intruded by Middle Jurassic granites and covered by arkoses. This basement underlies Oxfordian?-Late Berriasian marine arkosic and polymictic sandstones with siltstones, conglomerates and limestones layers (Constancia Fm.) which is not recorded southeastward along the strike of the Belt. In Camaján hills, NE of Camaguey, the Placetas´s oldest unit is Lower Tithonian basalts with thin layers of hyaloclastites, laminated limestones and tuffites (Nueva María Fm). The Late Tithonian-Turonian sections of the Placetas Belt yield more similarities and is represented by well bedded pelagic limestones with intercalated beds of cherts, shales, sandstones and calcarenites. Within these strata occur the thick Aptian-Cenomanian well bedded cherts and silicified sandstones unit (Santa Teresa Fm). Above the Coniacian-Campanian hiatus occur calcirudites to calcarenites (Amaro and Camaján Fms), which may be either late Maastrichtian or K/T in age. In Central Cuba the foreland deposits associated to the Placetas Belt are Paleocene-Lower Eocene olistostromes (Vega Fm.), which yield clastic elements derived from the ophiolites and Cretaceous volcanics, and, in minor amounts, carbonate and chert fragments derived from the forebulge within the North American margin.

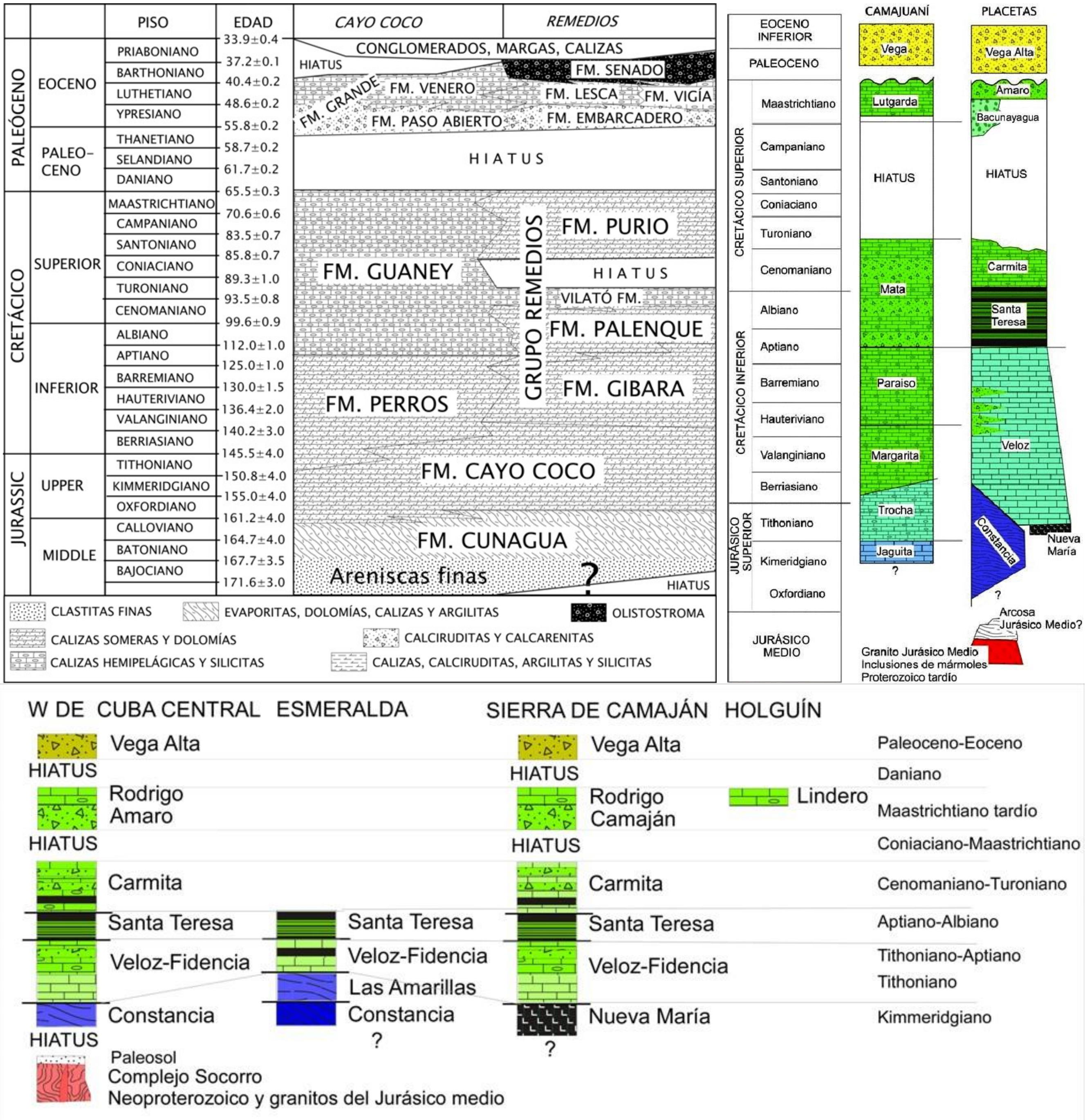


*Figure 10. Schematic stratigraphic sections of the Northern Sedimentary Belts of Cuba in central Cuba (Iturralde-Vinent, 2021).*

## The northern ophiolites and associated subduction mélanges.

Due to strong tectonic disruption and associated block-in-matrix relationships in large parts of the geological units, the term Villa Clara serpentinitic mélange (VCSM) has been used rather than the Villa Clara ophiolite. This tectonic mélange is characterized by metre- to kilometre-sized blocks/bodies of varied origins within a serpentinitic matrix (serpentinized peridotites and serpentinites s.s.). In addition to serpentinite/serpentinized peridotite blocks in mélange, the blocks include: a) dismembered ophiolitic mafic crust (basalts, diabase dykes and gabbros) whose igneous mineral assemblages are generally partially replaced by very low- to low-temperature alteration/metamorphic assemblages. Additionally, amphibolite- and greenschist-facies assemblages are present in breccified and massive bodies diabase/ microgabbro (up to several m-sized blocks)and, less intensely, in layered gabbro. The layered gabbro exhibits a coarse grain size and an orientation of mineral grains that indicates a cumulate character. It is locally intruded by diabase and microgabbro, indicating late-stage intrusion events) developed at low pressure (<2 kbar) under static conditions, b) exotic blocks of high-pressure metabasite (eclogite, blueschist, garnet amphibolite), metaultramafite (antigoritite), metasomatite (chloritite, actinolitite-tremolitite, commonly forming blackwalls around high-pressure rocks) and metasediments, c) non-metamorphic or slightly metamorphic (up to the greenschist facies) arc-derived volcanic and sedimentary rocks and d) non-metamorphic Bahamian borderland-derived sedimentary rocks of the Placetas belt. Late Cretaceous (70–85 Ma) volcanic arc-related granitoids intrude the serpentinites. However, even if they are late intrusive bodies, they were locally reworked (after 71 Ma) to form tectonic blocks. Available field (and more limited petrologic-, geochemical-, and geochronologic-based) relationships in central Cuba, including the lack of siliciclastic-matrix melanges, do not support mixing of different metamorphic grades in a mélange and mixing of materials that make up the matrix as a result of exhumation and sedimentation prior to later subduction and development of a deformational overprint.

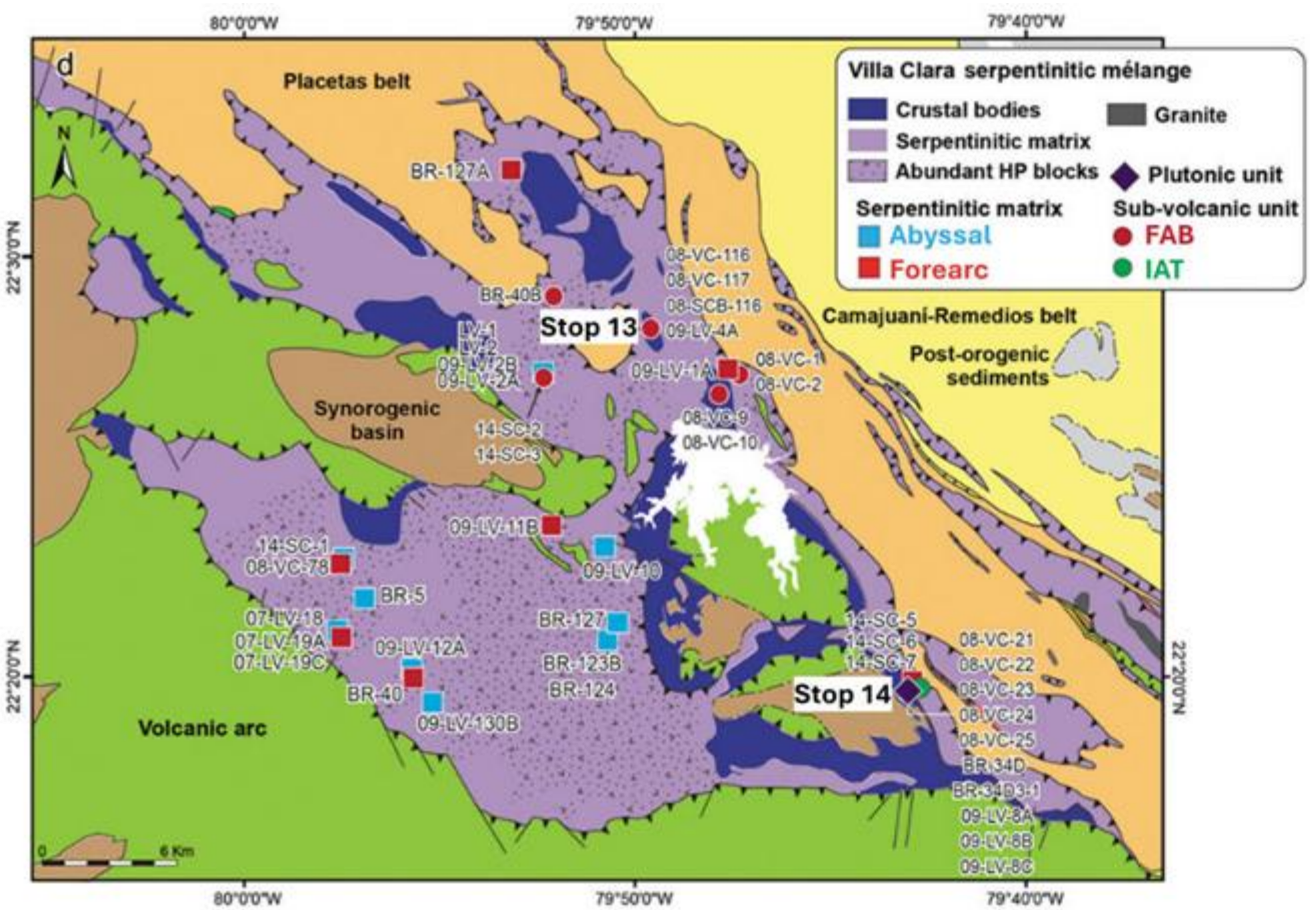


*Figure 11. Geologic map of central Cuba mélange (from Butjosa et al., 2024, compiled after Kantshev et al., 1978, 1480 pages; unpublished; part 1, part 2, part 3, Álvarez et al., 1991; unpublished and García Delgado et al., 1998, Mapa geológico de Cuba central (provincias Cienfuegos, Villa Clara y Sancti Spiritus) escala 1:100000, Instituto de Geología y Paleontología, La Habana).*

While most authors consider a rather unstructured mélange, Álvarez-Sánchez and Bernal-Rodríguez (2015) identified an ophiolitic complex above the Villa Clara Mélange Complex and subdivided the latter in two distinct serpentinite mélanges: the Descanso (above) and Santa Clara (below). The Descanso mélange contains low-P ophiolitic, volcanic-arc and sedimentary rocks from the North American passive margin and basin. In contrast, the Santa Clara mélange encloses high-pressure subduction-related rocks. The cross-section offered by Álvarez-Sánchez *et al*. (1992) suggests that the latter mélange reaches a few km in thickness, but as a result of reverse faults and piling of several smaller slices. Álvarez-Sánchez *et al*. (1992) and Álvarez-Sánchez and Bernal-Rodríguez (2015) recognize, however, that these two mélanges may occur mixed in the field, as long as low-P, high-P and unmetamorphosed blocks are found adjacent to (a few metres apart from) each other. For this reason, these authors emphasize the polygenic (i.e. heterogeneous block composition) and polyphasic (i.e. formed at various stages) nature of these rocks. In this regard, Garcia-Casco *et al*. (2002) and Garcia-Casco *et al*. (2006) pointed out that eclogite blocks exhumed from ca. 60 km within a serpentinitic subduction channel mélange at c. 110 Ma, indicating a first stage of mélange formation deep in the forearc (subduction channel) during the early Cretaceous. A second main stage of mélange formation occurred during arc-continent collision and ophiolite obduction starting at c. 70 Ma (Garcia- Casco *et al*. 2008), as indicated by the incorporation into the mélange of low-P ophiolitic and non-metamorphic volcanic-arc, granitoids and passive-margin blocks. This extreme reworking of HP and LP mélanges explains the close spatial presence of high-pressure, low-pressure and unmetamorphosed blocks locally, and may also explain the lack of correlation of the abyssal and forearc geochemical affinities of ultramafic rocks (Butjosa et al., 2024). Hence, the Villa Clara Serpenitnite Mélange is a composite mélange (polygenic polyphasic mélange) but, due to the aforementioned extreme reworking, it can be treated here as a single but complex geologic body made of high-pressure and low-pressure blocks within serpentinite and of serpentinite blocks-in-mélange.

The serpentinitic matrix of the mélange comprises serpentinized peridotites and serpentinites mostly of harzburgitic composition that show foliated, brecciated and massive unsheared fabrics. Brecciated fabric is characterized by slip planes/foliations with local penetrative foliation and mylonitization. Deformed and undeformed arrays of veins composed of serpentine group minerals are common. At the outcrop scale, both brecciated and massive serpentinized peridotites and serpentinites have a compact appearance, with green-dark grey to dark brown colour. A pseudomorphic texture is commonly characterized by lizardite. When present, relicts of primary mantle minerals are commonly oriented following a 'ghost' high-temperature mantle foliation. Though abyssal and forearc ultramafics are present and mixed in the mélange, they can be distinguished only by bulk-rock and mineral (relict olivine, orthopyroxene, clinopyroxene and spinel) chemical composition and not by regional distribution (Figure 11 and Figure 12). The occurrence of rocks of such contrasted geodynamic settings has been explained due to local preservation of former abyssal oceanic lithosphere during structuration of forearc lithosphere upon subduction initiation in the early Cretaceous (Butjosa et al., 2024).

The ophiolitic mafic rocks are layered gabbros, sub-volcanic bodies of diabase and microgabbros and generally altered basalts and hyaloclastites and radiolarian cherts. The lithological and textural features of the igneous rocks are characterized by plagioclase laths and augite magmatic relicts replaced by albite, epidote, hornblende (brown-green) and chlorite indicating low-pressure metamorphism after emplacement. Prehnite and pumpellyite occur in late veins. No foliation is apparent, despite the existence of foliation in the enclosing serpentinite. P-T paths are only retrograde (i.e., do not have prograde sections). Phase relations indicate low-P metamorphism in an oceanic context.

The age of ophiolitic assemblage has been considered of Tithonian-Lower Cretaceous age due to the presence of paleontologically-dated sediments intercalated with the basaltic rocks and hialoclastites (Llanes-Castro et al., 1998). One sample of metadiabase dike (probably, a block) yielded U-Pb LA–MC–ICP–MS zircon age of 135 Ma (Niu *et al*. 2022). These authors characterized the geochemical signature of the mafic bodies as intermediate between N-MORB and island arc tholeiite composition, and argue that they formed in a back-arc basin. Butjosa et al. (2024), however, consider that mafic rocks have forearc basalt (FAB) and island arc tholeiitic (IAT) composition (Figure 13) and that the FAB compositions formed in a forearc region during subduction initiation in the early Cretaceous. The IAT compositions formed later, as they have been detected only as intrusions in the plutonic section of the ophiolite (Butjosa et al., 2024), while FAB dominates as intrusions in ultramafics and as massive bodies associated with micrograbbros and locally heavily altered basalts, pointing to structuration of the oceanic lithosphere. The 135 Ma age and FAB composition of the mafic rocks of the ophiolites in central Cuba are similar to those of low-P metadiabase blocks within serpentinite in eastern Cuba (Lázaro et al., 2016). These blocks mark the subduction initiation in the Caribbean forearc during Valanginian time. Therefore, it is unlikely that this ophiolitic assemblage formed during the Jurassic oceanic expansion in the Proto-Caribbean.

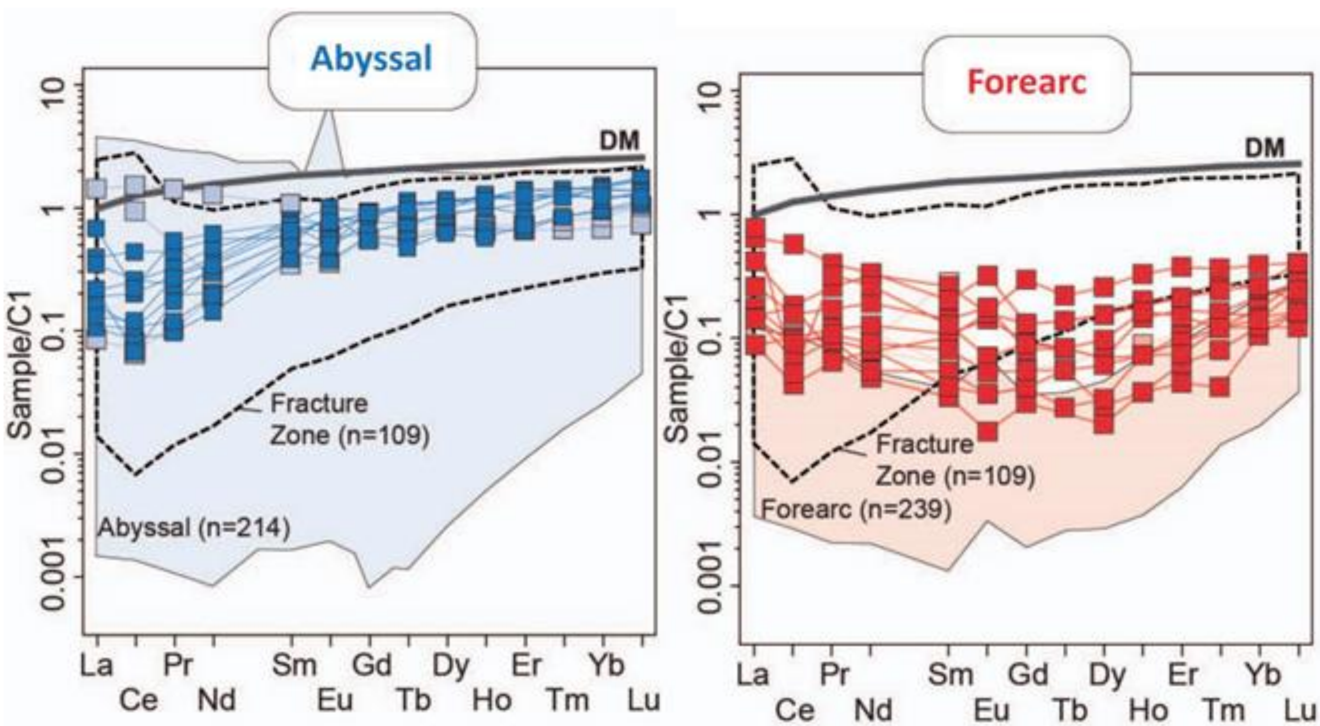


*Figure 12. REE patterns of ultramafics (Butjosa et al., 2024).*

Mélanges containing m- to dm-sized blocks of eclogite, garnet amphibolite (retrogressed eclogite), amphibolitite, blueschist-greenschist facies rocks, quartzite, metapelite and antigoritite occur within the northern ophiolite belt. Available K-Ar ages from samples of high-pressure (HP) blocks in the region range from 130 to 60 Ma, but data cluster about 110±10 Ma (Iturralde-Vinent et al., 1996) suggesting an Early Cretaceous age for the subduction zone; younger ages are inferred to represent reworking during Upper Cretaceous-Paleogene tectonism associated with collision. The abyssal and forearc serpentinitic matrix differ from the blocks of massive strongly foliated high-T high-P antigoritites with non-pseudomorphic interlocking texture that lack relict mantle mineralogy and (Butjosa *et al*. 2023). These rocks may locally contain blocks of eclogite, implying two steps in the mélange forming history. The exhumation P-T path followed by antigoritites and eclogites are similar, hence both forming part of the suite of exotic high-P blocks present in the mélange. These blocks of high-T, high P antigoritite will be visited during this TFF2025. The composition of eclogites and retrogressed eclogites indicates MOR basaltic composition (Figure 14), likely of the oceanic lithosphere of the Proto-Caribbean (Garcia-Casco et al., 2008), and P-T paths indicate prograde burial in a warm subduction zone reaching up to 20 kbar (Garcia-Casco et al., 2002; Garcia-Casco et al., 2006) or up to ca. 30 kbar (Rui et al. 2024), followed by strong decompression with minor cooling during amphibolitization. Age determinations in this and other eclogite blocks indicate protolith formation during the Hauterivian (126.3 ± 0.7 Ma U-Pb zircon, Rui et al. 2024) and Aptian subduction-related peak metamorphism and Albian exhumation and mélange formation (103.4 ± 1.4 Ma Ar/Ar amphibole, 115.0 ± 1.1 Ma Ar/Ar phengite, 118.2 ± 0.6 Ma Rb/Sr Ms-Omp-WR, Garcia-Casco et al., 2002; and 118.6 ± 1.6 U-

Pb zircon, Rui et al. 2024). The 7 Myr difference between the formation of the protolith in the oceanic ridge and subduction metamorphism would point to ridge subduction (Rui et al. 2024), even if partial melting of the slab in a hot subduction scenario triggered by ridge subduction was not achieved, as in eastern Cuba mélanges (Garcia-Casco et al., 2008b; Lázaro and García-Casco, 2008; Lázaro et al., 2009, 2011; Blanco-Quintero et al., 2010, 2011a, 2011b). Another potential problem for ridge subduction in central Cuba mélanges is that garnet porphyroblasts contain relict inclusions of glaucophane, pointing to cold-to-warm, but not hot, subduction.

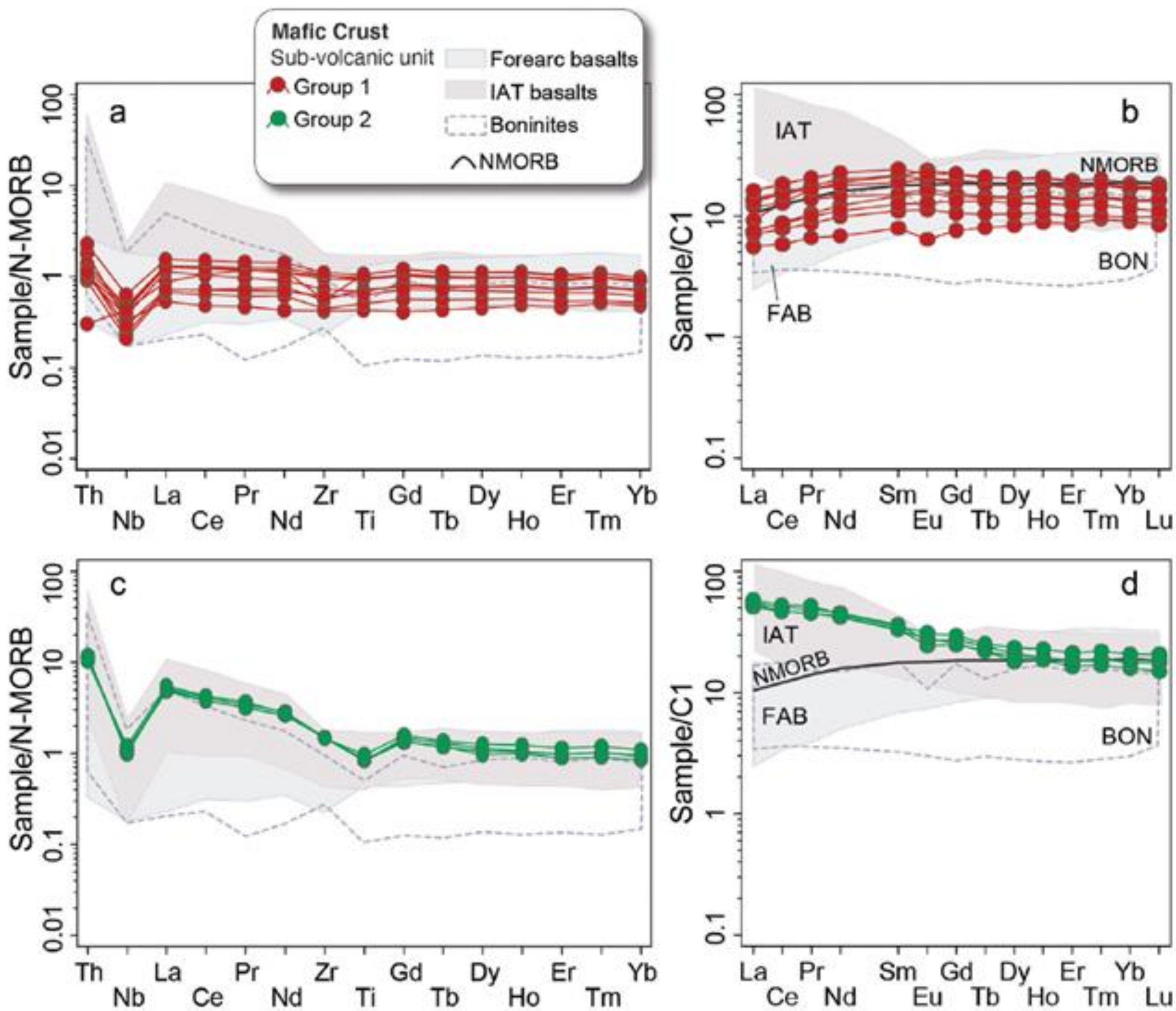


*Figure 13. REE patterns of FAB and IAT diabase (Butjosa et al., 2024).*

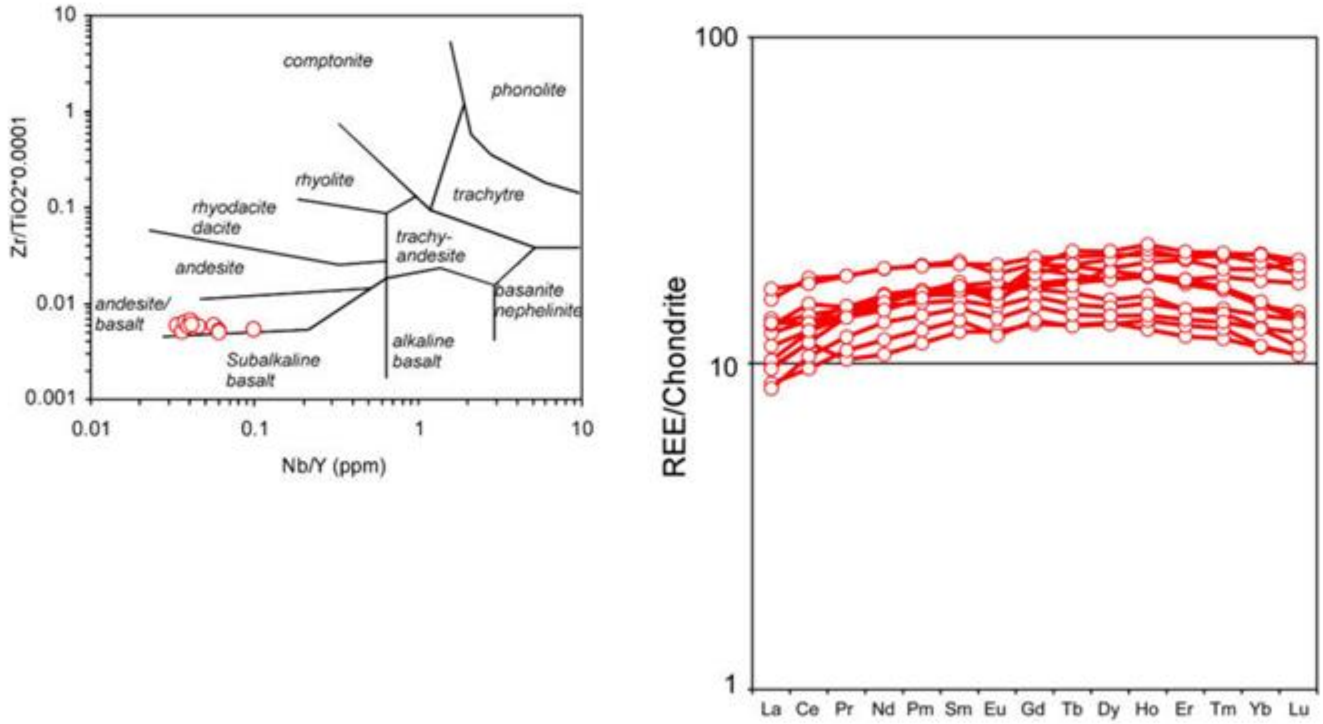


*Figure 14. Bulk-rock composition of eclogites and retrogressed eclogites from the central Cuba serpentinitic mélange (unpublished data).*

**The Volcanic arc**

Tectonically above the ophiolitic bodies, the Cretaceous volcanic arc units are formed by volcanic-sedimentary sequences that evolve from tholeiitic to calc-alkaline signatures dating from early Cretaceous (Hauterivian?) (Los Pasos Formation of the Primitive Island Arc) to Campanian times (Figure 15) and calc-alkaline plutonic rocks of mostly, mid-Cretaceous age (Manicaragua Batholith), intruding both the volcanic arc and the Mabujina Complex (see below).

In the Central Cuba Volcanic Arc, numerous lithostratigraphic units have been defined since the 1930s. A general description of the arc units to be visited during the TFF 2025 trip is provided below, while a detailed description of the stratigraphy of the Central Cuban Volcanic Arc can be found in Geología de Cuba. Compendio 2021 (Iturralde-Vinent, 2021) For more information see Kantshev et al. (1978a and b); Díaz de Villalvilla (1988); Díaz de Villalvilla et al.(1997; 2003unpublished); Iturralde-Vinent (1996); Sukar & Pérez (1997); Rojas-Agramonte et al. (2011), Torró et al. (2016), Dublan & Alvarez (1986, unpublished); Grafe et al. (2001).

The best-preserved sections of the Greater Antilles fossil convergent margin crop out in Central Cuba. The region has been studied to understand the magmatic evolution of the intra-oceanic convergent margin (IOCM) over its ~60-million-year lifespan. The arc section in Central Cuba is nearly complete, containing a quasi-continuous record of arc magmatism since pre-middle Hauterivian time (~133 Ma). The oldest arc-related rocks, found in the Santa Clara and Camagüey regions, consist of an unmetamorphosed primitive bimodal volcanic sequence, known as the Los Pasos Formation. This formation developed in a submarine environment, where bimodal lavas erupted, and associated massive sulfide ores were deposited. Geochemically, the basalts of the Los Pasos Formation include low-Ti island arc tholeiites (IAT), whereas felsic volcanics exhibit M-type, boninitic, and tholeiitic signatures. The Porvenir Formation, considered a metamorphic equivalent of the Los Pasos Formation, crops out as a narrow strip along the northern edge of the Mabujina Amphibolite Complex and is dominated by basalts, pyroclastics, and gabbros metamorphosed under greenschist facies conditions.

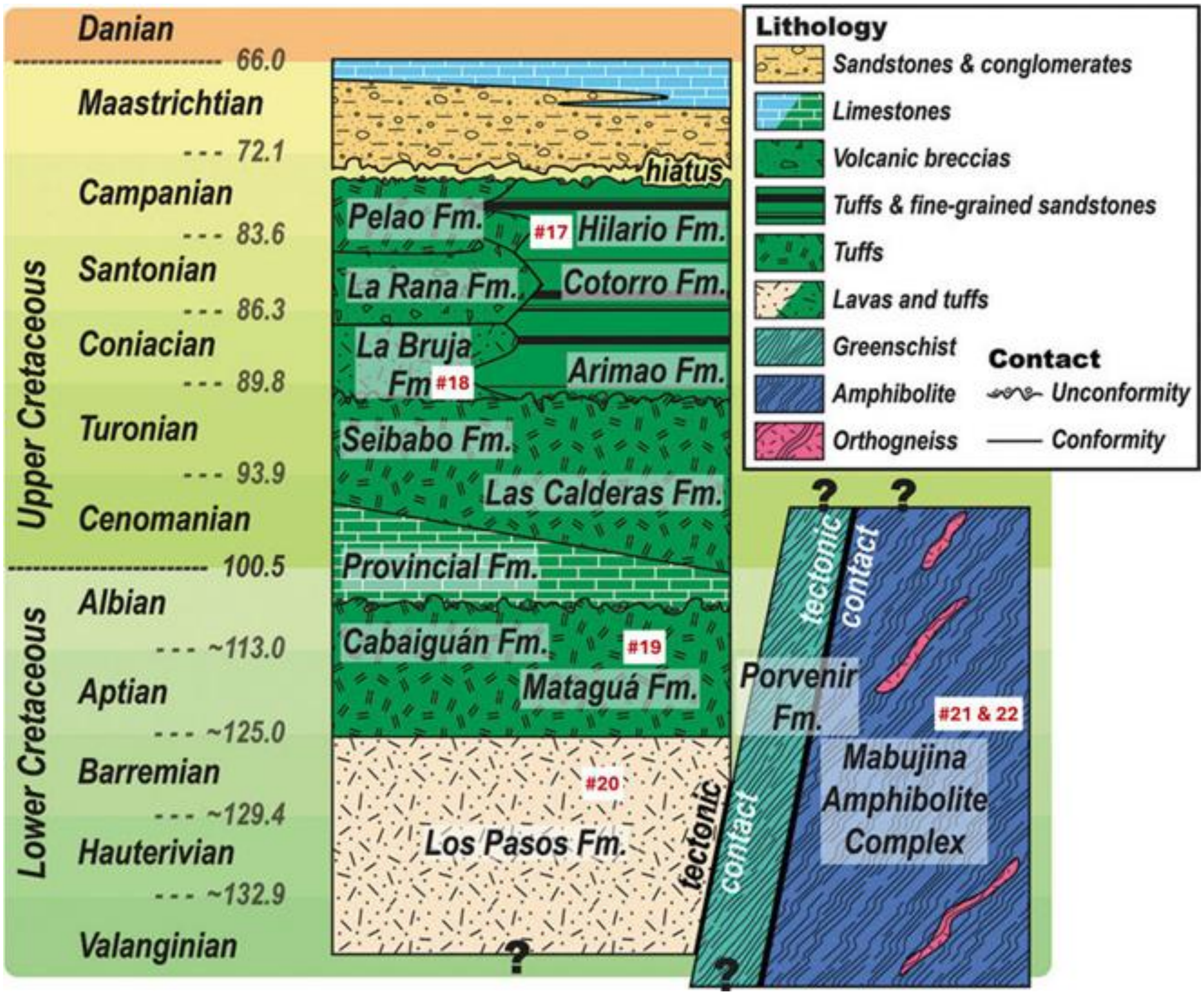


*Figure 15. Stratigraphy of the Cretaceous volcanic arc in Central Cuba and its relation to the underlying Mabujina Amphibolite complex (Hu et al., 2024, slightly modified from Iturralde-Vinent, 2021), with indication of stops.*

Several younger volcanic arc complexes and series unconformably overlie the Early Cretaceous IAT lavas. These include widespread Albian-Coniacian calc-alkaline volcanic rocks and Coniacian-Campanian high-K calc-alkaline volcanic rocks. The second stage of volcanism began with the Aptian-Lower Albian Mataguá Formation, which conformably overlies the Los Pasos Formation and represents the lowest section of the volumetric calc-alkaline sequences. An Albian angular unconformity, represented by conglomeratic rocks, separates the Mataguá Formation from the overlying Provincial Formation.

The Upper Cretaceous (Coniacian-Santonian) La Bruja Formation consists mainly of pyroxene andesite with a typical pearlitic texture, with dacites comprising about 70% of its volume. The formation also includes agglomeratic lava breccias, zeolitic tuffs, tuffites, sandstones, siltstones, and marls. It overlies the Cabaiguán, Mataguá, Provincial, and Seibabo Formations and is unconformably covered by the Cotorro and Hilario Formations.

The Hilario Formation, which unconformably overlies La Bruja, is composed predominantly of zeolitized tuffs along with marls, limestones, and sandstones. The tuffs, which are light green to greenish-gray when fresh and cream beige to brown when weathered, occur in strata ranging from a few centimeters to several meters thick. The lower portion of the unit contains tuff intercalations, suggesting a transitional relationship with the Cotorro Formation. Fossiliferous limestone layers within the Hilario Formation have yielded an early Campanian fossil assemblage (Furrazola Bermúdez et al., 2001), with an intercalated andesitic lava flow dated to 76 Ma (Hu et al., in prep).

The Manicaragua Batholith consists of granitoids exposed in the Villa Clara region, to the north and east of the MAC. These granitoids intrude both the Cretaceous volcano-sedimentary sequences and the Mabujina amphibolites, with smaller exposures southwest of the Escambray Massif. The granitoids exhibit a wide range of compositions, from quartz-diorite and granodiorite to diorite, quartz-monzodiorite, quartz-monzonite, tonalite, and trondhjemite, all following a consistent calc-alkaline trend. These rocks contain amphibolite xenoliths, while rare leucocratic granites intrude the more mafic granitoid facies. The granitoids are cross-cut by pegmatitic veins, which are subsequently intruded by granite porphyry dikes, porphyritic diorite, and lamprophyre. Zircon dating from weakly foliated and unfoliated granitoids within the Manicaragua Batholith indicates Turonian-Campanian ages (ca. 89–83 Ma).

**The Mabujina Complex**

The volcanic-arc units overlie the Mabujina Complex, composed of the Porvenir Fm. and the Mabujina lithothem (Millán-Trujillo, 1996), that should be considered two distinct tectonic units (Figure 15). The former is perhaps equivalent to the Los Pasos Fm. It consists of bimodal acid-basic volcanic sequence metamorphosed in the greenschist facies. The age of the formation is Berriasian?-Hauterivian?, based on correlation with Los Pasos Fm. The Mabujina lithothem, or Mabujina Amphibolite Complex (MAC), is the lower unit of the Mabujina complex and tectonically overlies (and surrounds) the dome-shaped high-pressure Escambray Complex. The Mabujina Complex is intruded by the mid-Cretaceous Manicaragua batholith. The oldest age of the batholith constraints the age of metamorphism to pre-89 Ma (Rojas-Agramonte et al., 2011; see also Grafe et al., 2001).

The MAC consists of intense to moderately deformed low-intermediate pressure amphibolites, metaporphyritic amphibolites, schistose and banded amphibolites, metagrabbroic amphibolites, metapyroxenites (hornblendites), intercalated metagranodioritic and granitic gneisses, discordant veins and bodies of tonalitic-trondhjemitic-granitic bodies and veins and locally metasilicites. Both the Porvenir Fm. and Mabujina Lith. are arc-derived (Millán-Trujillo, 1996) with island-arc tholeiitic and calc-alkaline signatures (Blein et al., 2003; Hu et al., 2023). U-Pb zircon dating by Rojas-Agramonte et al. (2011) indicates that the MAC developed during the early to middle Cretaceous . The oldest ages from tonalitic-trondhjemitic rocks, dating back to ca. 133 Ma, constrain the age of formation of the basaltic protoliths of the MAC to, at least, Valanginian time.

The origin of the Mabujina Complex metamorphic protolith has been debated (Hu et al., 2023, and references therein). Some researchers have proposed that the Mabujina Complex (Porvernir Fm. and MAC) represents the deepest metamorphosed section (root) of the Cretaceous volcanic arc and its oceanic (pre-arc) sole (Millán-Trujillo, 1996), while others have suggested it has an exotic origin. This latter view posits that a segment of the Pacific-related Early Cretaceous Mexican Guerrero volcanic arc was tectonically emplaced beneath the Caribbean arc (Blein et al., 2003). Recent whole-rock geochemical analyses indicate that the protoliths of the MAC form an island-arc sequence, characterized by less common island-arc tholeiitic mafic rocks, which are similar to the Early Cretaceous tholeiitic island arc of the Caribbean, and a dominant presence of transitional to calc-alkaline mafic and felsic igneous rocks, which closely resemble the Early to Late Cretaceous magmatism of the Caribbean arc (Figure 16; Hu et al., 2023).

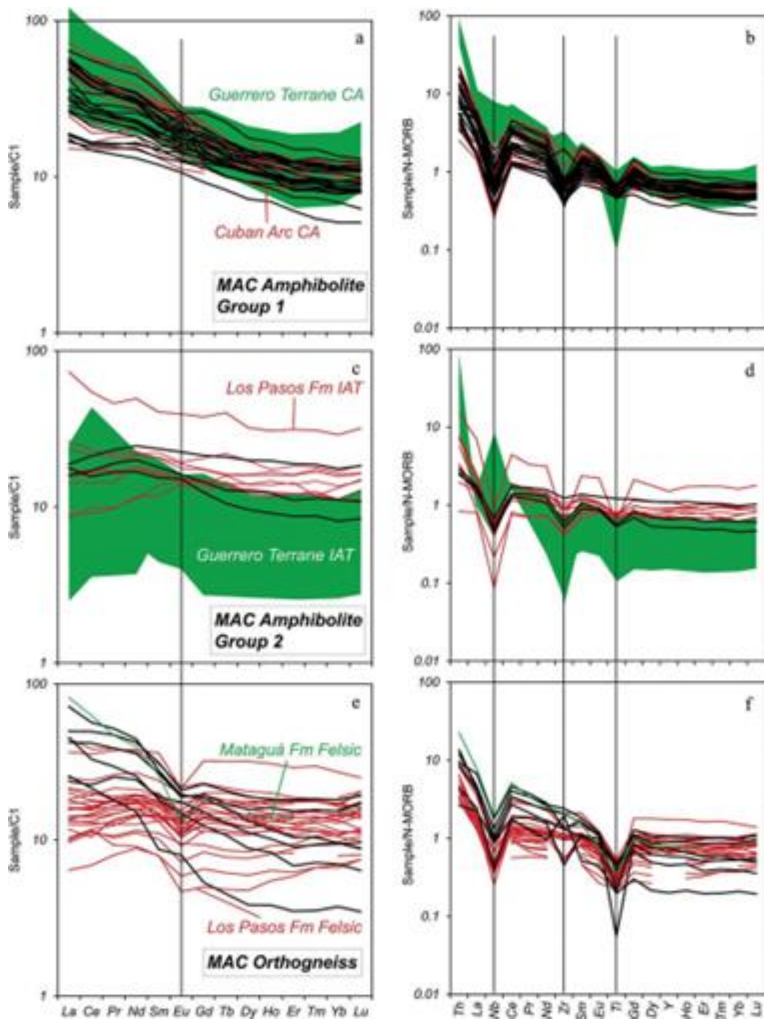


*Figure 16. Chondrite-normalized REE (a, c, e) and NMORB-normalized extended trace elements patterns (b, d, f) the MAC. Geochemical data of calc-alkaline rocks of the Cuban arc refer to the Mataguá, Cabaiguán, and Camujiro Formations (the latter in the Camaguey region, to the East of Santa Clara region) are from Hu et al. (2024) and Torró et al. (2020). Geochemical data of the Guerrero Terrane are from Mendoza and Suastegui (2000). Geochemical data of the Los Pasos Formation are from Hu et al. (2024).*

## The Escambray Complex

Emplaced from below, the Escambray Complex forms a two-dome tectonic window (Trinidad and Sancti Spiritus domes) below the metamorphosed arc-related Mabujina Complex that surrounds the domes (Figure 17). The complex is made of a thrust pile that includes a) metacarbonatic and metapsammopelitic rocks with local metabasite intercalations that represent passive margin sedimentation and magmatism (Figure 18) and b) tectonically intercalated metaophiolitic rocks represented by serpentinite-matrix melanges that host tectonic blocks of metamafic rocks (Millán-Trujillo, 1997a, 1997b; Schneider et al., 2004; Garcia-Casco et al., 2006, 2008; Stanek et al., 2006, 2019; Cruz-Gámez et al., 2016; Despaigne-Díaz et al., 2016, 2017). The sedimentary/metabasite section have been correlated with non-metamorphosed Jurassic-Cretaceous passive margin sequences in the Guaniguanico terrane of western Cuba that formed part of the borderland of the Maya block (Figure 18; Millán-Trujillo, 1997a, 1997b; Iturralde-Vinent, 2021). García-Casco et al. (2008) have considered these sections as a fragment of the so-called Caribeana terrane, a platform-like terrane projecting off the Maya block and located within the Proto-Caribbean ocean. Millán-Trujillo (1997a) subdivided the complex of strongly deformed tectonic slices into four major tectonic units (I to IV, numbered from bottom to top in the pile; Figure 17), each of which comprises a number of smaller tectonic units. The tectonic mélanges within the complex include serpentinites and blocks of eclogite and high-pressure calcareous schists. However, these rocks also occur as dispersed boudins within some lithodemes (i.e., "Esquistos Algarrobo" and "Esquistos Felicidad" in the Jurassic Loma la Gloria and earliest Cretaceous Cobrito lithodemes, Figure 18). This and other arguments has led to the idea that the upper part of the Escambray complex represents a mega-mélange (Gavilanes unit of Stanek et al. 2006, 2019), an idea disputed by Álvarez-Sánchez (2021). For a detailed review of the stratigraphy and geology of the Escambray complex, see Álvarez-Sánchez (2023), Álvarez-Sánchez and Bernal-Rodríguez (2023a; 2023b).

The conditions of metamorphism are varied, ranging from low grade at intermediate-P (greenschist facies) and high-P (blueschist facies) to medium grade at high-P (eclogite facies) (Figure 19 and Figure 20; Schneider et al., 2004, Garcia-Casco et al., 2006, Grevel et al., 2006; Stanek et al. 2006, 2019; Despaigne-Díaz et al., 2016, 2017). The internal deformation is intense and complex, with numerous tectonic-metamorphic inversions. The massif has a general inverted metamorphic zoning, with greenschist facies at the base in unit I, greenschist and lawsonite blueschist facies in unit II, and epidote-blueschist and eclogite facies at the top in unit III. The uppermost unit IV in contact with the overlying Mabujina complex diverges from this pattern (greenschist-blueschist facies).

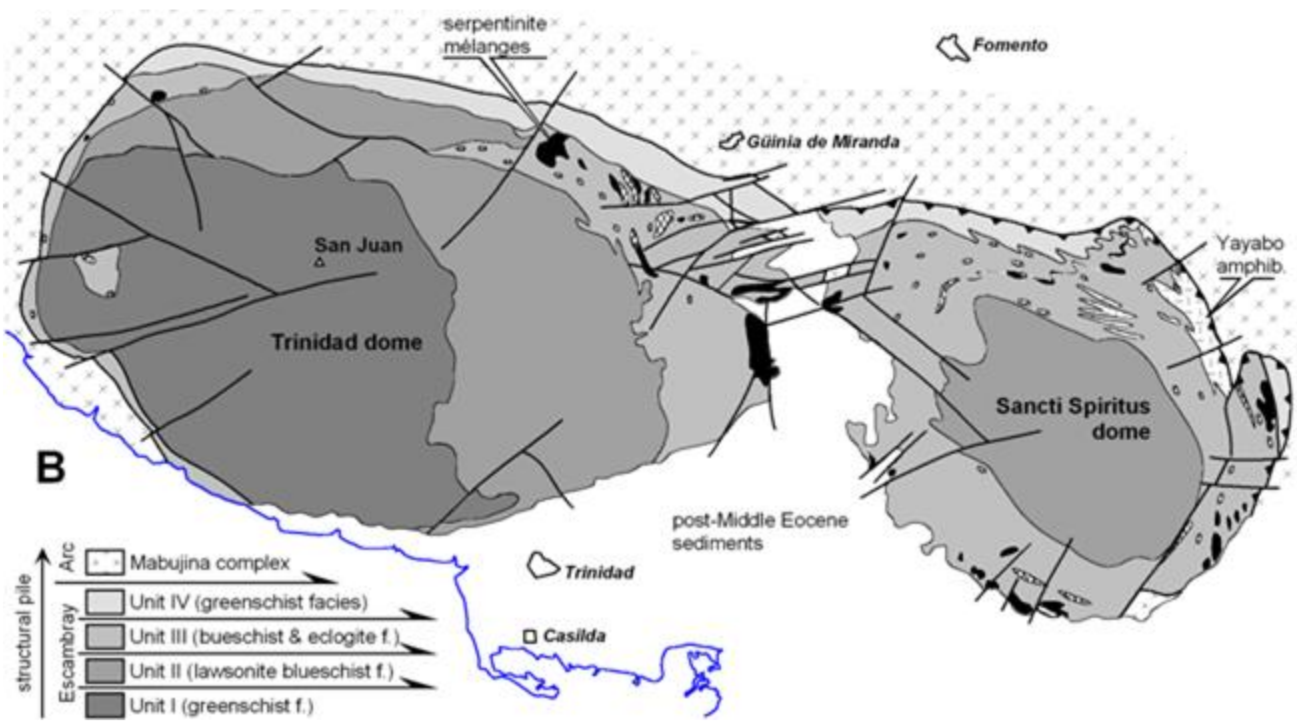


*Figure 17. Geologic map of the Escambray Complex (after Millán-Trujillo, 1997a, taken from Garcia-Casco et al., 2008) with indication of major tectonic units, serpentinite mélanges and eclogite bodies (only shown for unit III).*

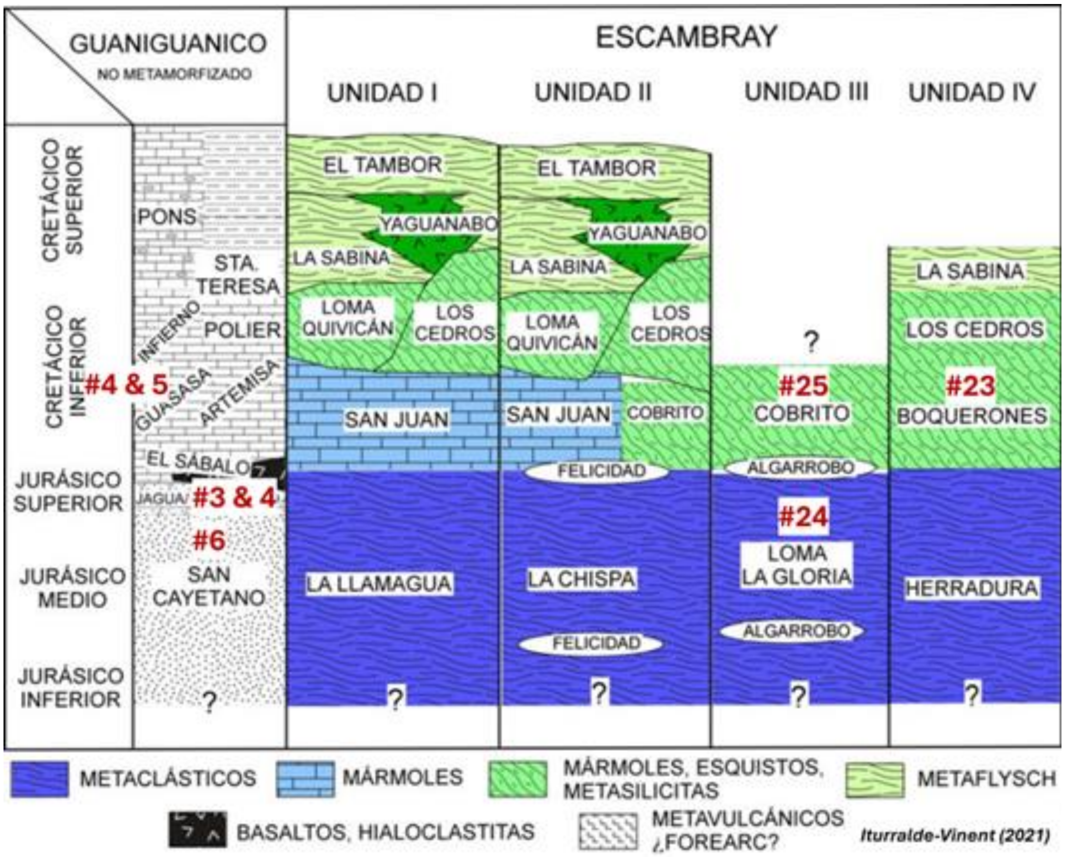


*Figure 18. Schematic stratigraphic sections of lithodems of Escambray units I-IV and their correlated formations in the Guaniguanico terrane of western Cuba. After Iturralde-Vinent (2021).*

High pressure conditions indicate subduction of the associated continental margin-like terrane. Subduction of oceanic lithosphere is also documented by serpentinite-matrix mélanges bearing high-pressure exotic blocks. Increasing the metamorphic grade up in the pile from the deepest greenschist unit I through blueschist unit II to the upper eclogite facies unit III, while unit IV culminating the pile contains retrograde greenschist facies rocks. Geochronologic data ($^{40}Ar/^{39}Ar$, Rb-Sr, Lu-Hf) indicates peak P-T conditions of metamorphism at 70-75 Ma in the eclogitic upper unit III and slightly younger time in units II (ca. 65 Ma) and I (ca. 60 Ma), indicating sequential subduction and accretion of the different units (Figure 19 and Figure 20; Somin et al, 1992; Schneider et al., 2004, Garcia-Casco et al., 2008, Despaigne-Diaz et al., 2017, Stanek et al., 2019, and references therein). That the eclogitic metamorphic peak of Unit III coincides with the vanishing of the Cretaceous volcanic arc in West-Central Cuba was one key observation for tectonic models involving the subduction and collision of the intra-Proto-Caribbean passive-margin terrane Caribeana (Fig. 4; Garcia-Casco et al., 2008).

Millán-Trujillo (1997a) reported that eclogite facies rocks of tectonic unit III underwent blueschist facies retrogression and related this overprinting to the low-grade high-pressure metamorphism of unit II. This type of blueschist retrogression is not common in the HP exotic blocks of the northern ophiolite belt from western-central Cuba, a fact that may relate to tectonic processes exclusive of the Upper Cretaceous subduction system where the Escambray complex impinged. Millán-Trujillo (1997a) and later other authors (Figure 19 and Figure 20; Schneider et al., 2004; Garcia-Casco et al., 2006, 2008; Stanek et al., 2006, 2019; Despaigne-Díaz et al., 2016, 2017) identified this blueschist retrogression as a result of syn-subduction exhumation. These authors also noted that the prograde metamorphic evolution of coherent eclogite samples (former passive margin magmatic rocks) present in the metasedimentary formations is more complex than that of the eclogite blocks of the tectonically intercalated strips of serpentinite-mélanges, but that their peak eclogite conditions and retrograde evolutions are similar, the latter characterized by substantial cooling upon exhumation. The syn-subduction exhumation process is characterized by sequential tectonic emplacement in the accretionary system of the different units in the course of the late Cretaceous-early Tertiary, starting with earlier and more deeply subducted unit III followed by units II and I (Figure 5).

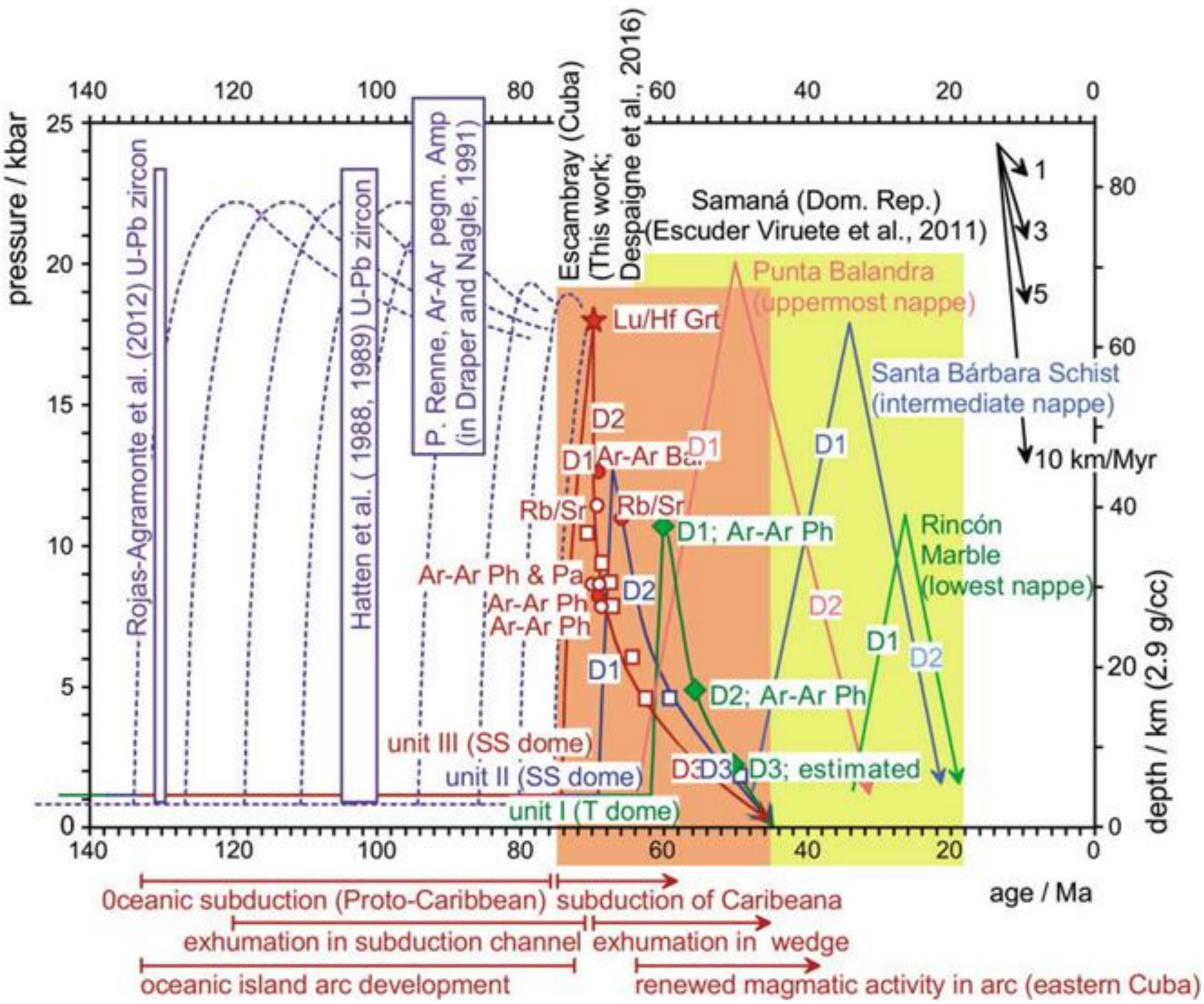


*Figure 19. (from Despaigne-Diaz et al., 2017). P-t path obtained using P-T, geochronological and petrological data for the Escambray complex. Data from the Sancti Spiritus dome from Schneider et al. (2004); Stanek et al. (2006) and Rojas-Agramonte et al. (2012). Results from the Trinidad dome from Despaigne-Díaz et al., 2016. Trajectories in red (Unit Ill) and blue (Unit II) are from the Sancti Spiritus dome and Unit I in green from the Trinidad dome. Data from the Samana complex main tectonic units (Escuder-Viruete et al., 2011a) have been included for comparison (see text for Discussion). D1, D2 and D3 are the different deformation events. Major tectonic events are represented as red lines below the main figure.*

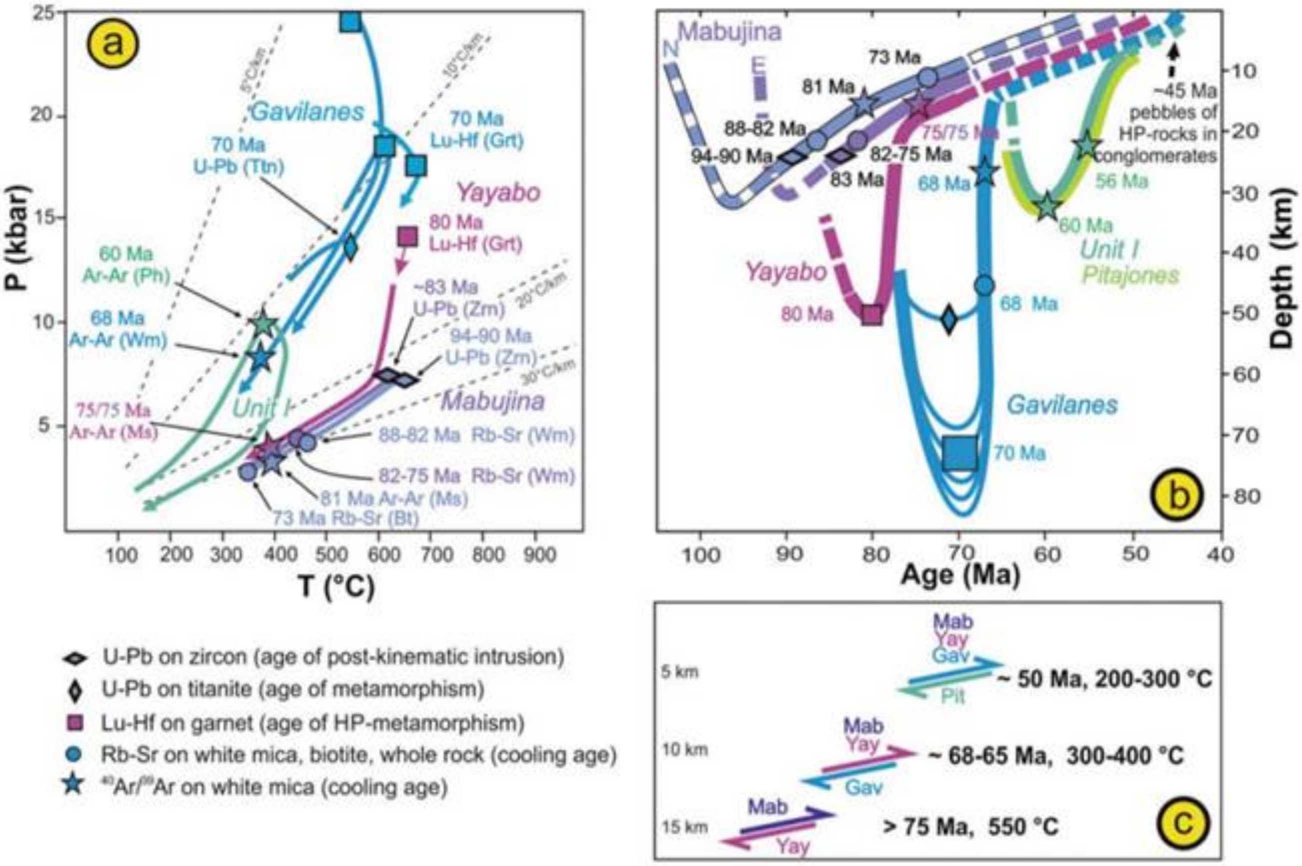


*Figure 20. (From Stanek et al., 2019, including the Mabujina complex). (a) P-T-(t) diagram with cooling paths from the mega-melange Gavilanes Unit (blue), the Yayabo Unit (purple), greenschist-facies units (bright green: Pitajones Unit; dark-green: La Sierrita nappe of Unit I from Despaigne-Díaz et al., 2016) and the MAC North and East (violet). (b) Depth-time trajectories for the various metamorphic units. (c) Schematic sequence of tectonic juxtaposition of the EC units and MAC in time.*

## Field trip stop by stop

**Links to the TFF2025 webpage**

Day 1, April 12. Leaving Havana (7.30 AM at street Línea in Vedado and at 8.00 AM at the Convention Center) and transfer to Viñales (Pinar del Rio) along the Havana-Pinar Highway. Arriving to Viñales at around 12.00 AM. Guaniguanico terrane (Mesozoic passive margin sequences).

April 12, stop 1. Parador las Barrigonas. 22°30'25.08"N, 83°27'16.43"W. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 12, stop 2. Viñales Geopark visitors center. 22°35'48.30"N, 83°43'10.99"W. Overview of the Viñales valley and general geology and geomorphology of the region. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 12, stop 3. Puerta de Ancón scenic view. 22°38'31.86"N, 83°42'43.97"W. Late Jurassic Jagua Fm and San Vicente member of the Guasasa Fm. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

April 12, stop 4. Palenque Cave area. 22°39'14.14"N, 83°42'55.60"W. Jurassic limestones. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

April 12, stop 5. El Indio Cave parking area. 22°40'15.53"N, 83°42'27.24"W. Jurassic-Cretaceous section. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

April 12, stop 6. Km 13 of the Viñales-La Palma road. 22°43'13.47"N, 83°39'27.44"W. San Cayetano sandstones and shales (Lower? To Upper Jurassic early Oxfordian). See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

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Day 2, April 13. Western Cuba. Guaniguanico terrane (Mesozoic passive margin sequences).

April 13, stop 7. Prehistoric Mural and Viñales Stonehenge. 22°37'7.59"N, 83°44'20.80"W. Scenic views. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 13, stop 8. Entronque Moncada section. 22°33'14.21"N, 83°50'42.66"W. K-Pg boundary. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 13, stop 9. Manacas Formation. 22°34'58.47"N, 83°48'6.93"W. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 13, stop 10. Ichthyosaur Cave. 22°36'30.02"N, 83°45'41.94"W. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

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Day 3, April 14. Leaving Pinar del Rio to Santa Clara, arriving at 2.00 pm. Central Cuba. Sedimentary sequences of the Mesozoic passive Bahamian margin and ophiolites.

April 14, stop 11. Santa Clara airport-Minerva road. 22°29'54.95"N, 79°53'14.13"W. Sediments of the Bahamian borderland. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 14, stop 12. Santa Clara airport-Minerva road. 22°28'58.23"N, 79°50'42.10"W. Serpentinite mélange with blocks of veined amphibolitized eclogite. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 14, stop 13. Santa Clara airport-Minerva road. 22°28'4.55"N, 79°49'26.84"W. Serpentinite mélange with tectonized low-P mafic intrusives (amphibolite). See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

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Day 4, April 15. Central Cuba. Ophiolites and high-pressure serpentinite-matrix mélange.

April 15, stop 14. Santa Clara-Placetas road. 22°19'49.99"N, 79°42'55.71"W. Banded gabbros of the oceanic lower crust, underlying serpentinized peridotites and late intrusive diabases. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 15, stop 15. Santa Clara-Placetas road. Pelo Malo Quarry. 22°23'25.89"N, 79°52'9.04"W. Ophiolite mélange. Megablock of HP foliated (±dolomite) antigoritite sorrounded by "normal" (regional) serpentinte. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

April 15, stop 16. Santa Clara-Encrucijada road road. Las Delicias. 22°32'21.98"N, 79°54'18.89"W. Ophiolitic mélange. Eclogite blocks within serpentinite. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

Day 5, April 16. Central Cuba. Cretaceous volcanic arc (from youngest to oldest formations).

April 16, stop 17. Hilario Formation. 22°19'13.05"N, 79°57'57.72"W. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

April 16, stop 18. Brujas Formation. 22°17'33.83"N 79°59'6.04"W. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

April 16, stop 19. Mataguá Formation. 22°12'48.69"N, 79°59'29.74"W. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

April 16, stop 20. Los Pasos Formation. 22°10'35.21"N, 79°58'42.06"W. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

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Day 6, April 17. Central Cuba. Low-to-intermediate pressure arc-related Mabujina Amphibolite Complex (MAC) below the Cretaceous arc, plutonic rocks of the Manicaragua batholith and subducted Mesozoic passive margin of the Escambray Complex below the MAC.

April 17, stop 21. Agabama River. 22° 2'49.20"N, 79°50'36.01"W. Amphibolite of the Mabujina Complex. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See age relation to stratigraphy of the Cretaceous volcanic arc.

April 17, stop 22. Agabama River. 22° 4'0.77"N, 79°47'39.89"W. Amphibolite and granitic rocks of the Mabujina Complex. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See age relation to stratigraphy of the Cretaceous volcanic arc.

April 17, stop 23. Carbonates of Boquerones lithodeme (Upper Jurassic) of the Escambray Complex. See on map. See on sketch map. See on Google Maps. See on stratigraphic chart.

April 17, stop 24. Güinia de Miranda-Trinidad road. El Algarrobo village. 21°58'29.50"N, 79°52'42.77"W. Graphitic schists and muscovite+calcite-bearing schists of the Loma La Gloria lithodeme (Jurassic) of the Escambray Complex. See on map. See on sketch map. See on Google Maps. See on stratigraphic chart.

April 17, stop 25. Güinia de Miranda-Trinidad road. 21°54'10.23"N, 79°51'27.00"W. Muscovite+calcite±graphite schists of the Cobrito lithodeme (Upper Jurassic-Lower Cretaceous) of the Escambray Complex. See on map. See on sketch map. See on Google Maps. See on stratigraphic chart

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Day 7, April 18. Farewell and back to Havana.

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**First day: Saturday 12.04.2025. Stops 1-6. Leaving Havana convention Center at 8.00 AM and transfer to Viñales (Pinar del Rio) along the Havana-Pinar Highway. Arriving to Viñales at around 12.00 AM.**

**Stop 1.** Las Barrigonas coffee shop and tourist stop. 22°30'25.08", N 83°27'16.43"W. 15 min. See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

The " barrigona palm tree" is endemic to western Cuba.


**Stop 2.** Viñales Geopark visitors center. 22°35'48.30"N, 83°43'10.99"W. Overview of the Viñales valley and general geology and geomorphology of the region (40 min). Lunch (40 min). Transfer to the next stop (30 min).

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

Here you can find important information about the Viñales UNESCO Cultural Reserve in the Visitor Center. The main exhibition hall presents posters in Spanish and English. Also, the center offers an excellent overview of the Viñales valley. On the northern side, you can see the Sierra de Guasasa and Sierra de Viñales kartsic mountains. This landscape represents a unique example of “tower karst”, with hills named “mogotes”, characterized by vertical walls at least in two of their sides and a rounded top. These mountains are almost hollow inside, as they contain huge spaces occupied by a network of fluvial-vadose caves.


*Figure 21. Viñales UNESCO Cultural Reserve. Visitors Center and main exhibition hall.*

*Figure 22. Overview of the Viñales valley.*

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**Stop 3.** Puerta de Ancón scenic view. 22°38'31.86"N, 83°42'43.97"W. Toward Valle de San Vicente, stop at the intersection with the road to Laguna de Piedra. In this scenic view can be seen the Late Jurassic Jagua Fm and San Vicente member of the Guasasa Fm. (30 min). Transfer to the next stop (40 min).

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.


*Figure 23. Main geologic units of the Sierra de Guasasa and Sierra de Viñales.*

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**Stop 4.** Palenque Cave. 22°39'14.14"N, 83°42'55.60"W. Inside the Valle de San Vicente, the Late Jurassic (Oxfordian) Jagua Formation features well-bedded shales with laminated fossiliferous limestone concretions (Jagua Vieja member) overlied by well-bedded limestones (Pimienta member). At the top of these limestones lies the Guasasa Formation, starting with a limestone breccia from an onlap event, followed by the San Vicente Member's limestones. These carbonate platform limestones, dated from the latest Oxfordian to earliest Tithonian, are unique to the Los Órganos mountains in western Cuba. They vary from massive to medium-bedded and are partially dolomitized. The lower section consists mainly of micritic limestones, transitioning to some calcarenites upward. Microfacies include various limestone types, though details are obscured by recrystallization, karstification, and weathering. (40 min). Transfer to the next stop (20 min).

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

*Figure 24. Overview of the mogote hill with the cave´s entrance.*

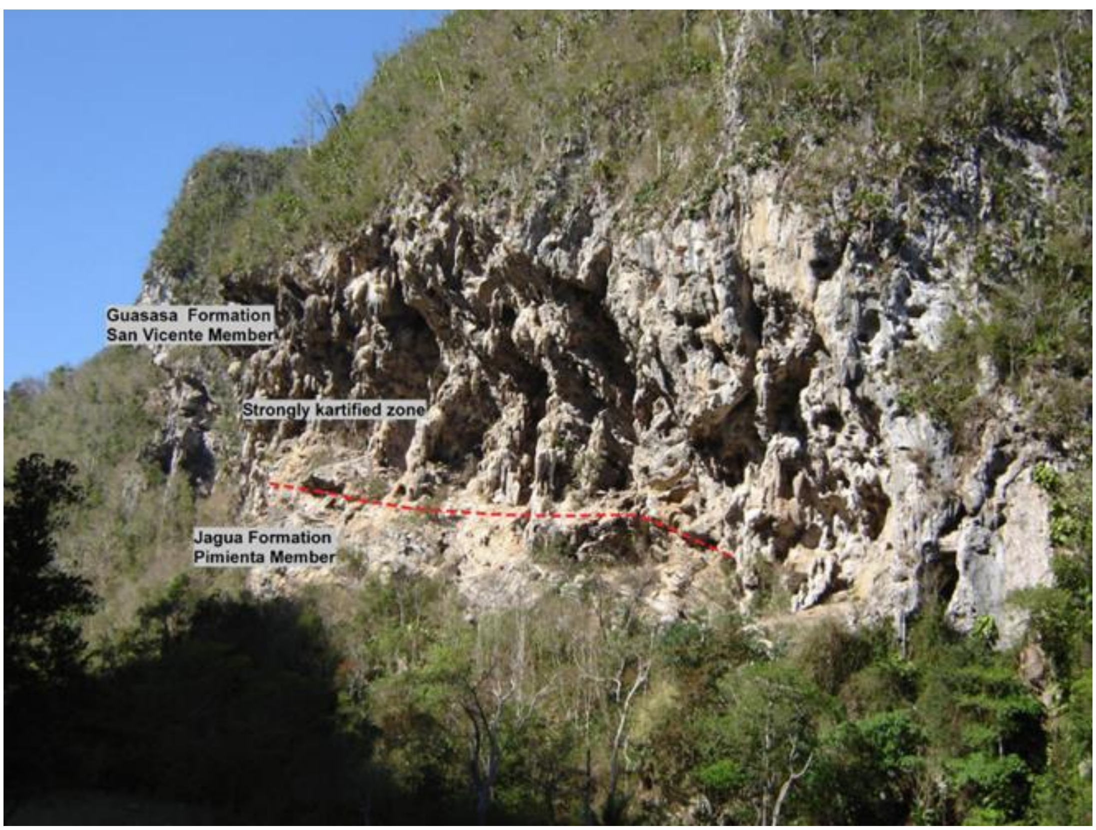


*Figure 25. Principal features observed at Stop 4, Palenque Cave.*

*Figure 26. Left: Calcirudite bed at the base of the San Vicente´s carbonate platform. Right: well bedded beds of the San Vicente platform carbonates*

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**Stop 5.** El Indio Cave parking area. 22°40'15.53"N, 83°42'27.24"W. Jurassic-Cretaceous section. El Americano, Tumbitas and Tumbadero Members of the Guasasa Fm marking the drowning and extinction of the San Vicente carbonate platform. These members consist of well-stratified limestone containing calpionellids, radiolaria, nannofossils, and occasionally, ammonites. The El Americano Member, up to 45 m thick, comprises dark-gray to black well-bedded limestones and dolostones, resting above the San Vicente Member. A minor unconformity separates El Americano from the Tumbadero Member, which consists of thin-bedded to laminated limestones with black chert intercalations, 20 to 50 m thick. The Tumbitas Member, 40 to 50 m thick, features thick-bedded, compact light-grey micritic limestones with darker limestone intercalations. The Jurassic-Cretaceous boundary lies around the El Americano-Tumbadero contact. (1 hour). Transfer to the next stop (1 hour).

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.


*Figure 27. Upper part of the Guasasa Fm with El Americano, Tumbadero and Tumbitas members. The transition between the carbonate platform and the deeper basin.*


*Figure 28. Left: Transition between El Americano and Tumbadero Mbs, circa J-K boundary. Right: Tumbadero Mb micrites with intercalated cherts. In Guaniguanico mountains cherts usually occur since the late Tithonian.*

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**Stop 6.** Km 13 of the Viñales-La Palma road. 22°43'13.47"N, 83°39'27.44"W. On both sides of the road outcrop the strongly folded San Cayetano sandstones and shales (Lower? To Upper Jurassic early Oxfordian). These folds are inverted (recumbent). The San Cayetano Formation is the oldest known deposits in the Guaniguanico mountains. It represents a sedimentary unit coeval with the early breakup of Pangea in the mesoamerican area, and it is locally cut by dikes and sills of basic igneous rocks. The lithology is sandstones, shales, and rare conglomerates deposited on Laurasian siliciclastic shelf and coastal plain environments. Very low grade metamorphism is present. Landward terrestrial deposits occur in Sierra de los Órganos belt, while more marine dominate the Sierra del Rosario sections. Shallow marine beds are found as intercalations which yield bivalves, and some ammonites to the top of the unit. (1 hour). Departing to the hotel.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

*Figure 29. San Cayetano´s recumbent folds.*


*Figure 30. Left: San Cayetano´s antiform fold. Right: San Cayetano´s folded section with tighter folds.*

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Arriving at hotel Rancho San Vicente and Casas particulares in Viñales at ca. 6 PM. Dinner at 7 PM. 8.30 PM, after dinner meeting to discuss the geology of the day.


**Second day: Sunday 13.04.2025. Stops 7-10. Leaving at 8 AM (1½ hour drive to the outcrop).**

**Stop 7.** Prehistoric Mural and Viñales Stonehenge. 22°37'7.59"N, 83°44'20.80"W. Scenic views. We won't get off here, we'll just look down from the bus. Transfer to the next stop (40 min).

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

*Figure 31. Mural at Valle de Dos Hermanas.*

*Figure 32. Tower karst mogote hills and carbonate breccia forming karstic pinnacles. Valle Dos Hermanas*

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**Stop 8.** Entronque Moncada section: K-Pg boundary (1½ hour). 22°33'14.21"N, 83°50'42.66"W. Transfer to the next stop (1 hour).

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

The section along the road displays an excellent example of the Guaniguanico K-Pg boundary and early Tertiary deposits, representing the transition from Proto-Caribbean basin (Pons-Moncada-Ancón Fms) into the foredeep basin sediments (Manacas Fm).

The section overly the Albian-Cenomanian well-bedded black micritic and biomicritic limestone with lens and irregular concretions of black cherts (Pons Fm). These limestones are separated by an erosional contact and a long hiatus from the K-Pg boundary Moncada Fm (an approximately 2-m-thick complex characterized by repetition of calcareous sandstone beds that show overall upward fining and thinning). The Moncada Formation contains abundant shocked quartz, altered vesicular impact-melt fragments, and altered and deformed greenish grains of possible impact glass origin. In addition, a high iridium (ca. 0.8 ppb) peak is identified at a clayish layer on top of the formation.

On top of the K-Pg boundary occurs the Paleocene to Middle Eocene section which consists of about 18 m of well-bedded, light reddish-violet-green micritic, slightly recrystalized to sublithographic limestone with interbedded shales of the Ancón Formation, which grades upward into shales and fine grained sandstones of the Pica Pica Mb of the Manacas Formation.


*Figure 33. Type locality of the Moncada K-Pg boundary unit.*


*Figure 34. Left: Slaty violet limestone of the Paleocene Ancón Fm. Right: Ancón Fm and the overlying Manacas Fm (Pica Pica Mb).*

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**Stop 9.** Manacas Formation (1 hour). 22°34'58.47"N, 83°48'6.93"W. Transfer to the next stop (20 min).

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

A small quarry on the south side of the Viñales-Moncada road exposes a deformed olistostrome (Vieja wildflysch) of the Manacas Formation. The olistostrome consists of a chaotic mix of clastic elements within a sandy-gravel, quartz-rich matrix. The proportion of the matrix and the composition of the clastic elements vary across different localities. The quarry contains clastic elements ranging from a few centimeters to 1-3 meters, composed of Mesozoic limestones and shales, deformed into slates and schists with a boudin-like shape and concentric foliation. The matrix constitutes a small part of the rock. The deformation likely relates to the detachment zones of thrust faults, with the Manacas Formation typically capping the stratigraphic sequence of each nappe, and underlying rocks showing no recrystallization.

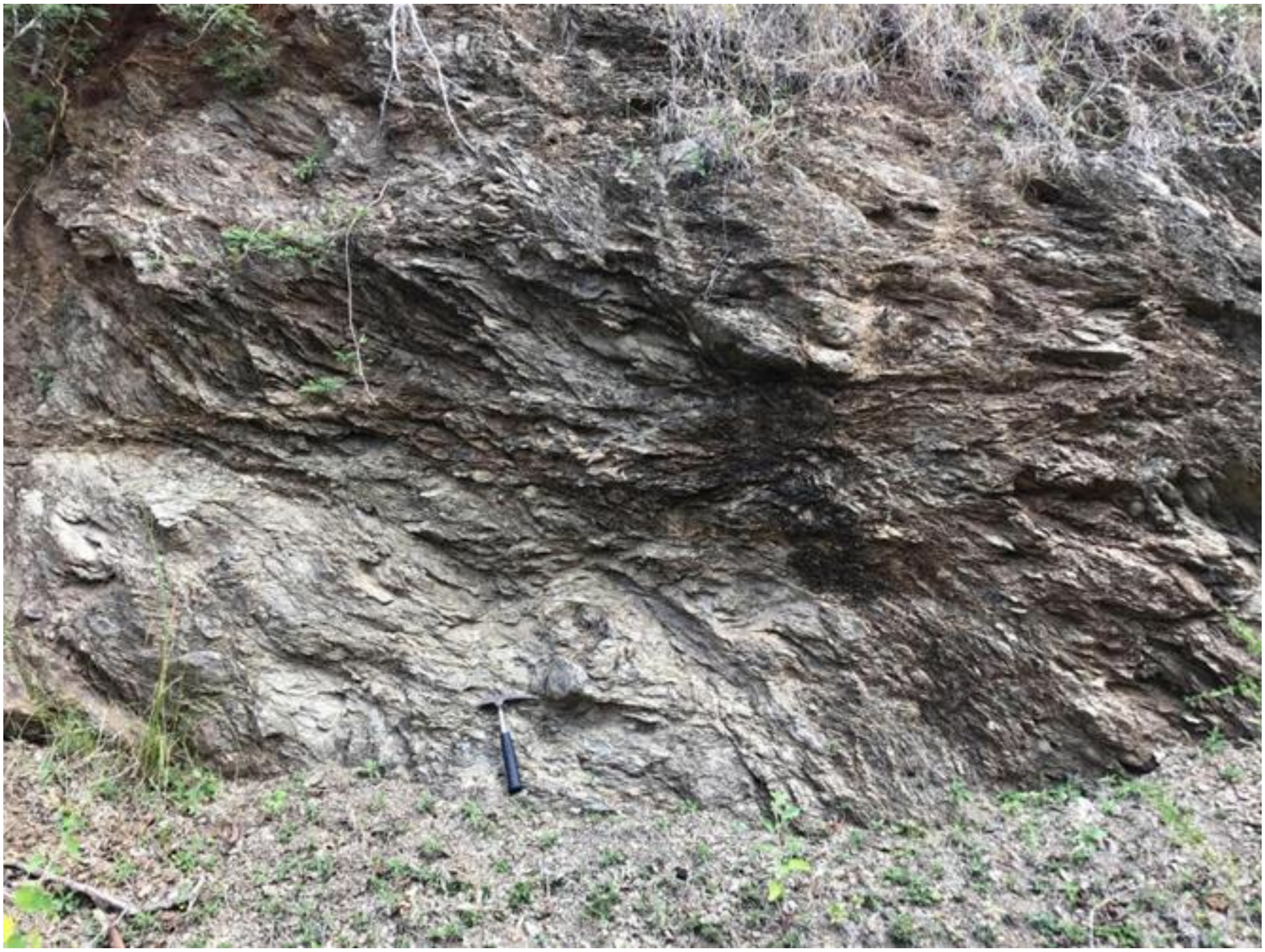

*Figure 35. Deformed foliated matrix of the Vieja Wildflysch (Olistostrome)*

*Figure 36. Subangular sandstone (left) and limestone (right) blocks in deformed matrix.*

*Figure 37. Deformed lenticular blocks (boudine) in deformed matrix.*

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**Stop 10.** Ichthyosaur Cave. 22°36'30.02"N, 83°45'41.94"W.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

The El Cuajaní is a beautiful small valley with very strong karst corrosion. The Late Tithonian El Americano member rocks here are represented by well-bedded black micritic and biomicritic limestones with lens and irregular concretions of black cherts. The partially articulated skeleton of an Ichthyosaur is exposed in the interior of the cave. Several samples recovered from the fossil-bearing slab contain a microfossil assemblage of the Tithonian Bonetilla boneti (or Boneti) Subzone, the upper part of the Chitinoidella Zone. The fossil bones are concentrated around the vertebral column, with a few ribs, isolated vertebrae, and one fin scattered nearby. The vertebral column is bent into a U-shape, with the caudal vertebrae positioned above the cervical vertebrae. Absent parts are the skull, girdle elements, both forefins, and one hindfin. The morphological pattern of the hindlimb resembles that of Late Jurassic Platypterygiinae ophthalmosaurids, such as Caypullisaurus bonapartei and Aegirosaurus leptospondylus (Iturralde-Vinent et al., in preparation) (2 hours). Transfer to Benito's tobacco house (30 min).

*Figure 38. Fluvial cave entrance, just above present day river. Open in well bedded micrites and biomicrites of the El Americano Member. Collapsed blocks illustrate the high level of karstic evolution.*

*Figure 39. Left: Ichthyosaurs hindfin. Right: Ichthyosaur vertebrae and ribs.*

**Stop at Tobacco plantation**. Visit to a tobacco family-run business (Benito's tobacco house) near Viñales town to get an insight into the traditional way of making cigars from tobacco drying house and rolling demonstration. In addition, you can have the opportunity to smoke an organic Cuban cigar. If time allows visit to Viñales Town (free walk).

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Arriving at hotel Rancho San Vicente and casas particulares in Viñales at ca. 6 PM. Dinner at 7 PM. 8.30 PM, after dinner meeting to discuss the geology of the day.

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**Third day: Monday 14.04.2025. Stops 11-13. Leaving Pinar del Rio to Santa Clara (central Cuba). Time of departure 7.30 AM, arriving at ca. 2.00 PM.**

**Stop 11.** Santa Clara airport-Minerva road. 22°29'54.95"N, 79°53'14.13"W. Sediments of the Bahamian borderland. Placetas belt (relative autochtonous of the ophiolitic mélange). Veloz Fm.: Thin to medium well stratified beds of slightly argillaceous micritic limestones with variable dolomitization degree and intercalated shales. Ammonites (*Haploceras aff. H. gallardoi*) and microfossils (*Calpionella alpina, C. elliptica, Tintinopsella sp., Calpionellopsis sp., Nannoconus spp.*) allow determining a Tithonian-Berriasian age. This formation documents platform sedimentation during the Jurassic-Early Cretaceous prior to the deepening of the Placetas basin during the Upper Cretaceous.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.


*Figure 40. Argillaceous limestones of the Veloz Fm. (Placetas belt of the Bahamian borderland).*

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**Stop 12.** Santa Clara airport-Minerva road. 22°28'58.23"N, 79°50'42.10"W. Looking from the bus, serpentinite mélange with blocks of veined amphibolitized eclogite.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

The eclogitic mineral assemblage consists of garnet, scarce omphacite, barroisite, epidote, paragonite, phengite and rutile overprinted by magnesiohornblende, albite, K-feldspar, epidote, chlorite and titanite. Garnet porhoyroblasts are relatively well preserved with nice prograde growth zoning. Reliect omphacite is essentially located within garnet porphyroblasts. Late epidote is coarse grained and is concentrated in thin veins that crosscut earlier structures and indicate infiltration of fluids. The phase relations suggest decompression and cooling during fluid infiltration. The chemical composition of the rocks indicates MOR basaltic composition. Fluid infiltration and associated amphibolitization and vein formation did not affect significantly the concentration of REE and other immobile trace elements.

*Figure 41. The knocker (surrounded by serpentinite).*


*Figure 42. Veined amphibolite (regrogressed eclogite) Relict garnet porphiroblasts in an amphibole-epidote-sodic plagioclase matrix.*

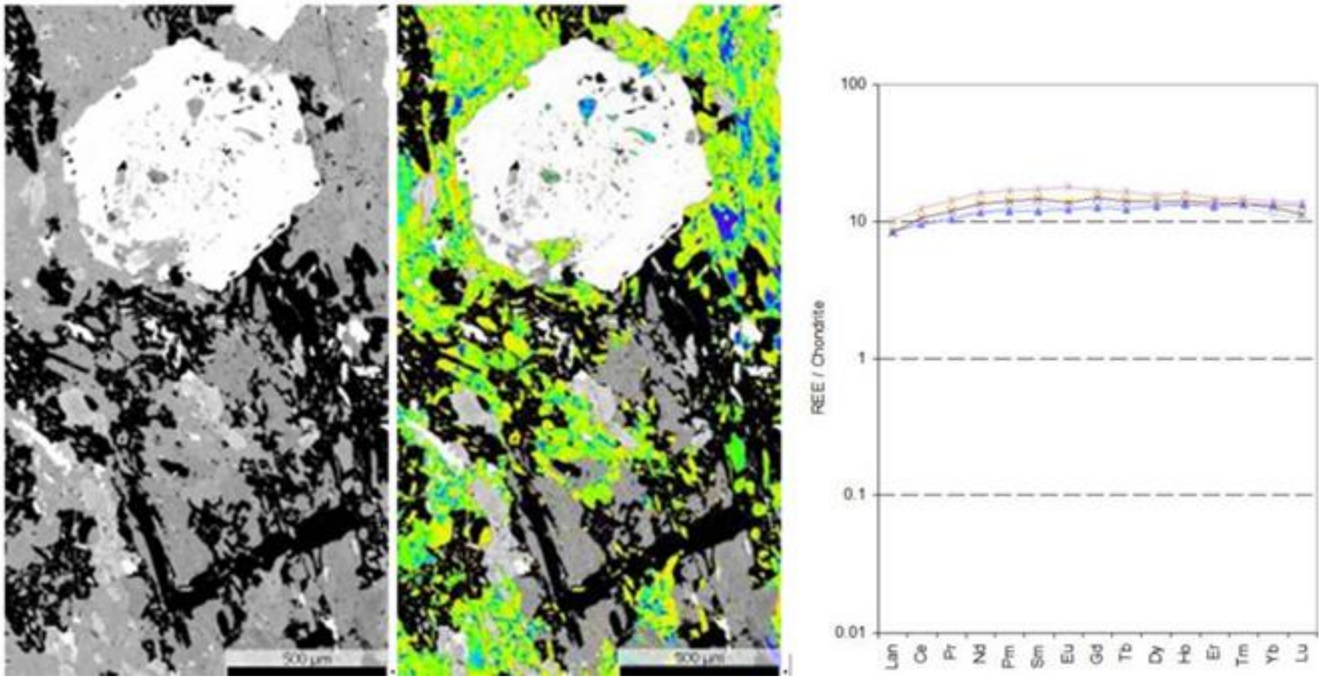


*Figure 43. Left: BSE and XR Al-Ka images of retrogressed eclogite (omphacite is preserved within garnet porphyroblast) with abundant albite and amphibole and epidote forming the matrix. The XR Al-Ka image shows the distribution of Al in amphibole on top of the BSE image. Right: REE / chondrite patterns retrogressed eclogites denoting MORB protolith.*

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**Stop 13.** Santa Clara airport-Minerva road. 22°28'4.55"N, 79°49'26.84"W. Serpentinite mélange with tectonized low-P mafic intrusives (amphibolite).

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

Former FAB dikes intruding the ultramafics now occur as blocks of diabase (Figure 45) within serpentinite (Figure 44). The diabases are not deformed and show magmatic relicts replaced by amphibolite-greenschist-subgreenschist facies assemblages containing albitic plagioclase, epidote, calcic amphibole ±chlorite ±prehnite (Figure 46).

*Figure 44. Field aspect of the ultramafic section.*

*Figure 45. Field aspect of blocks of diabase (former dikes) within serpentinite.*

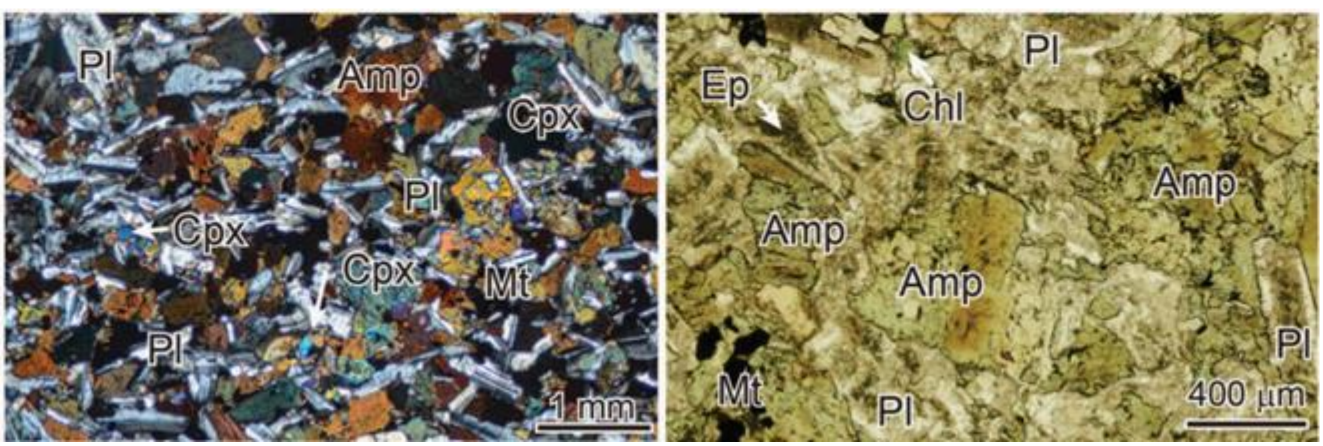


*Figure 46. Microscopic views of (meta)diabase ([Butjosa et al., 2024](#)). Note inverse zoning in amphibole, from brown-reddish (hornblendic) cores to green (actinolitic) rims denoting growth during cooling.*

Arriving at Hotel La Granjita and casas particulares in Santa Clara at ca. 6.30 PM   Dinner at 7.30 PM. 8.30 PM, after dinner meeting to discuss the geology of the day.

**Fourth day: Tuesday 15.04.2025. Stops 14-16. Santa Clara and surroundings: Ophiolitic mélange. Time of departure: 8.00 am.**

**Stop 14.** Santa Clara-Placetas road. Outcrop in the railway close to the road. 22°19'49.99"N, 79°42'55.71"W. Banded gabbros of the oceanic lower crust, underlying serpentinized peridotites and late intrusive diabases.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

The banded plutonics include gabbronorite, olivine gabbro, troctolite, quartz diorite, tonalite, plagiogranite-diorite (Figure 47). In this outcrop, a common lithology is (leuco)gabbronorite made of coarse grained un zoned plagioclase and clinopyroxene with typical cumulate texture (Figure 49). The rocks are amphibolitized, with tremolitic amphibole, chlorite, serpentine, magnetite, prehnite, pumpellyite, and calcite as typical alteration products (Figure 49). Some ultramafic rocks are strongly overprinted by serpentine, calcite, and opaque minerals. Diabase – microgabbro dykes and bodies crosscut the banded structure (Figure 48). In these rocks magmatic plagioclase and clinopyroxene are overprinted by brown-green hormblende (brown hornblende probably late magmatic), chlorite, prehnite, pumpellyite, clinozoisite, opaque minerals, and calcite.

The chondrite-normalized REE patterns of the gabbro-gabbronorites are characterized by LREE-depleted and relatively flat HREE segments, and positive Eu anomalies (Figure 50). These patterns indicate that these rocks are cumulates from variably fractionated MORB- or FAB-like melts. A FAB signature is strengthened by the forearc signature of the underlying ultramafic rocks (Figure 48; see location of stop 14 in Figure 11). The intrusive diabase-micrograbbro rocks significantly differ from those of layered cumulate rocks and other diabase rocks that intrude the mantle ultramafics. They display REE patterns characterized by LREE-enriched and HREE-depleted segments, typical of arc lavas. A slight negative Eu anomaly as a result of plagioclase fractionation is present, representative of evolved lavas with high REE contents. The REE patterns are similar to island arc tholeiites (Figure 51Figure 13).


*Figure 47. Banded gabbros.*

*Figure 48. Left: Serpentinites (towards viewer) below banded gabbros (away viewer). Right: Diabase intrusion in the banded gabbros.*

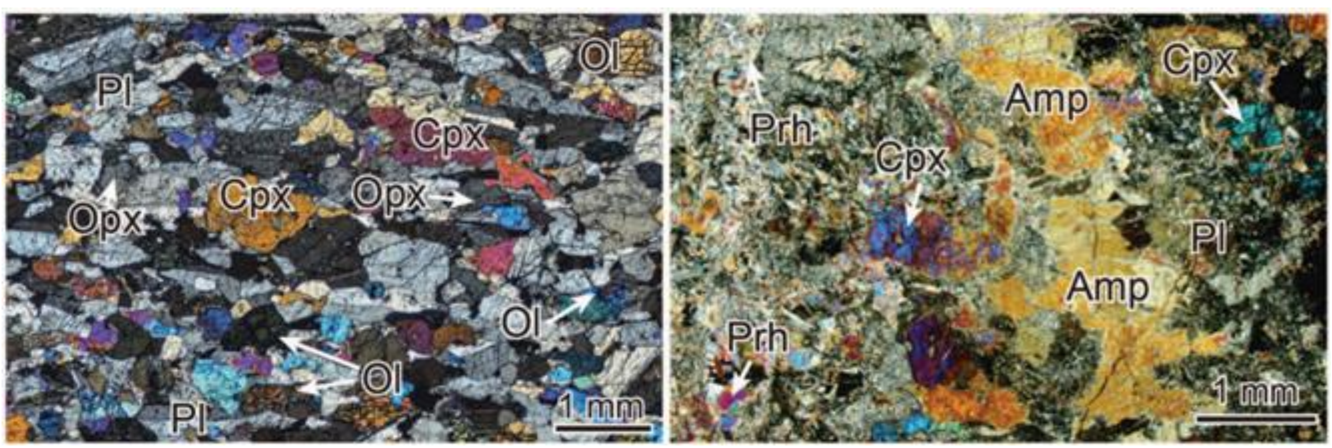


*Figure 49. Petrography of fresh and altered samples of gabbros.*

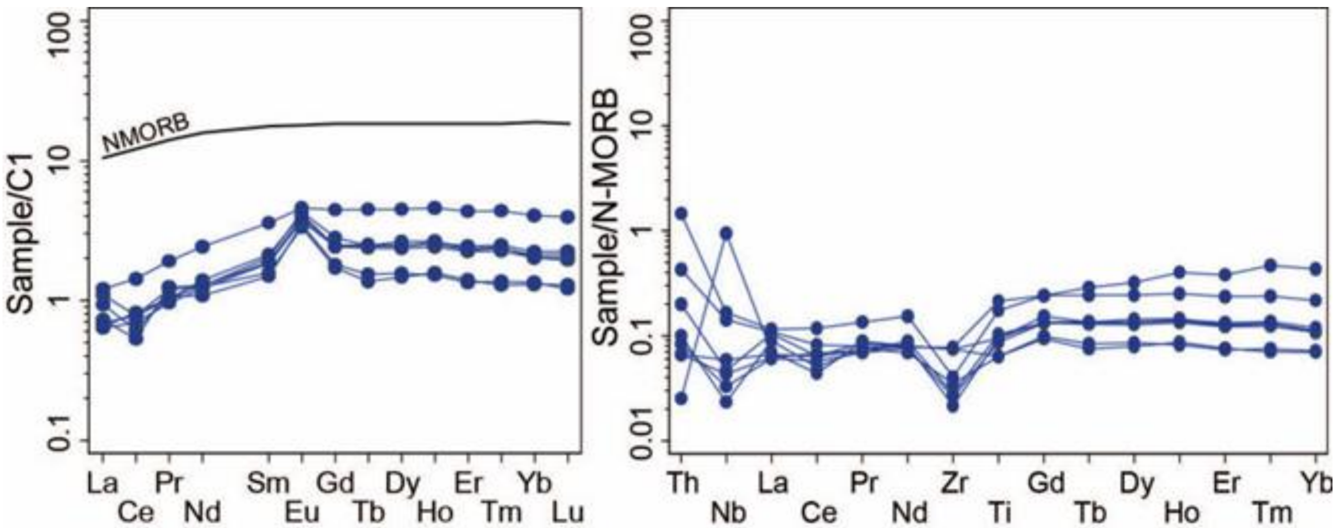


*Figure 50. Composition of banded gabbros (Butjosa et al., 2024).*

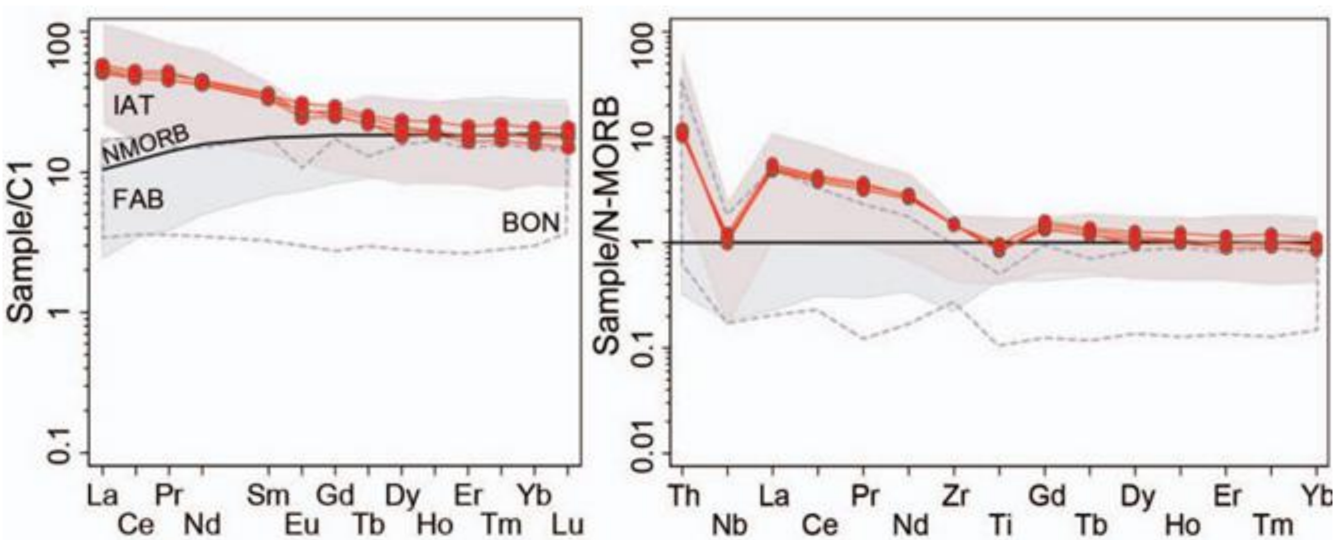


*Figure 51. Composition of diabases, IAT (Butjosa et al., 2024).*

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**Stop 15.** Santa Clara-Placetas road. Pelo Malo Quarry. 22°23'25.89"N, 79°52'9.04"W.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

The ophiolite mélange contains blocks of antigoritite that may enclose eclogite blocks. One excpecional case is the megablock of high-pressure massive foliated antigoritite sorrounded by "normal" (regional) low-P serpentinte (Figure 52, Figure 53, Figure 54). The rock represents abyssal mantle (Figure 55) that was transformed into antigoritite during subduction. Fluid-rock interaction is denoted by the local presence of dolomite, generally as elongated patches that indicate preferential fluid flow, and by coarse grained tremolite veins that document hydrofracturing deep in the subduction realm (Butjosa et al., 2023). The P-T conditions of tremolitite formation (ca. 450 ºC, 8 kbar) are consistent with a warm subduction gradient (Figure 55). The P-T path of one eclogite block located not far from the Pelo Malo block reached peak conditions of c. 20 kbar and c. 600 °C Garcia-Casco et al. (2002, 2006), compatible with the stability of antigorite. During decompression and cooling, this path intersects the conditions of tremolitite vein formation.

*Figure 52. Top: View of the Pelo Malo antigoritite mega-block. Bottom: Panoramic view from the hill.*

*Figure 53. Top: Aspect of sheared antigoritite in the abandoned quarry front. The browner regions are dolomite-bearing. Bottom surrounding "normal" brecciated serpentinite.*

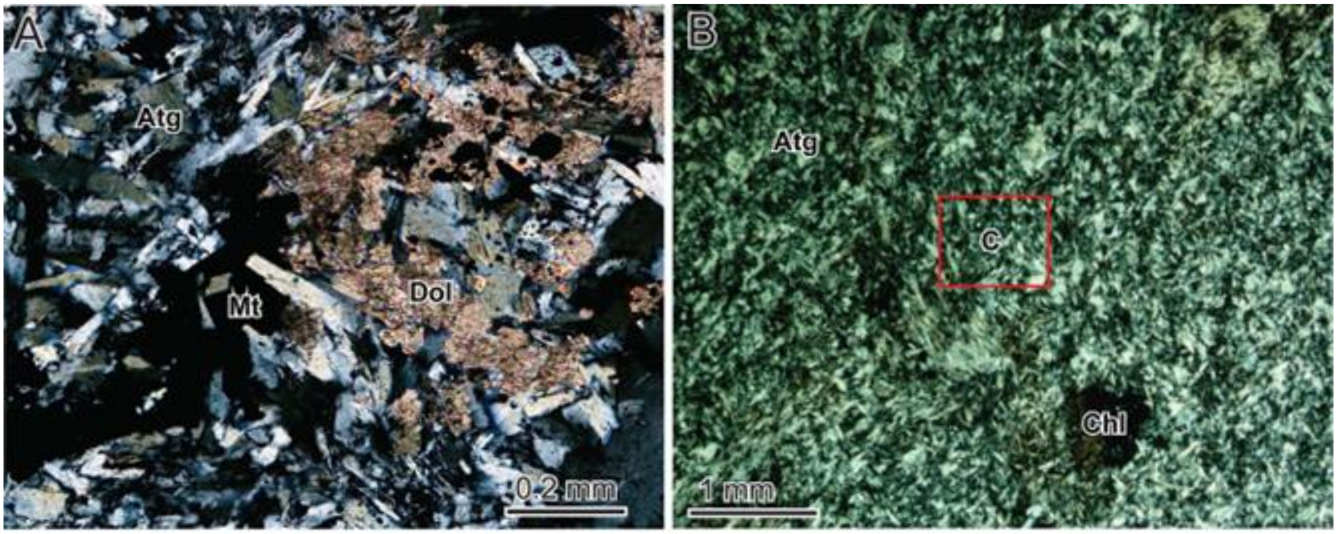


*Figure 54. Plane-polarized light (crossed polars) photomicrographs of antigoritite. A) Dolomite-bearing antigoritite showing antigorite-dolomite intergrowths. B) Antigoritite showing interpenetrating texture and chlorite blasts.*

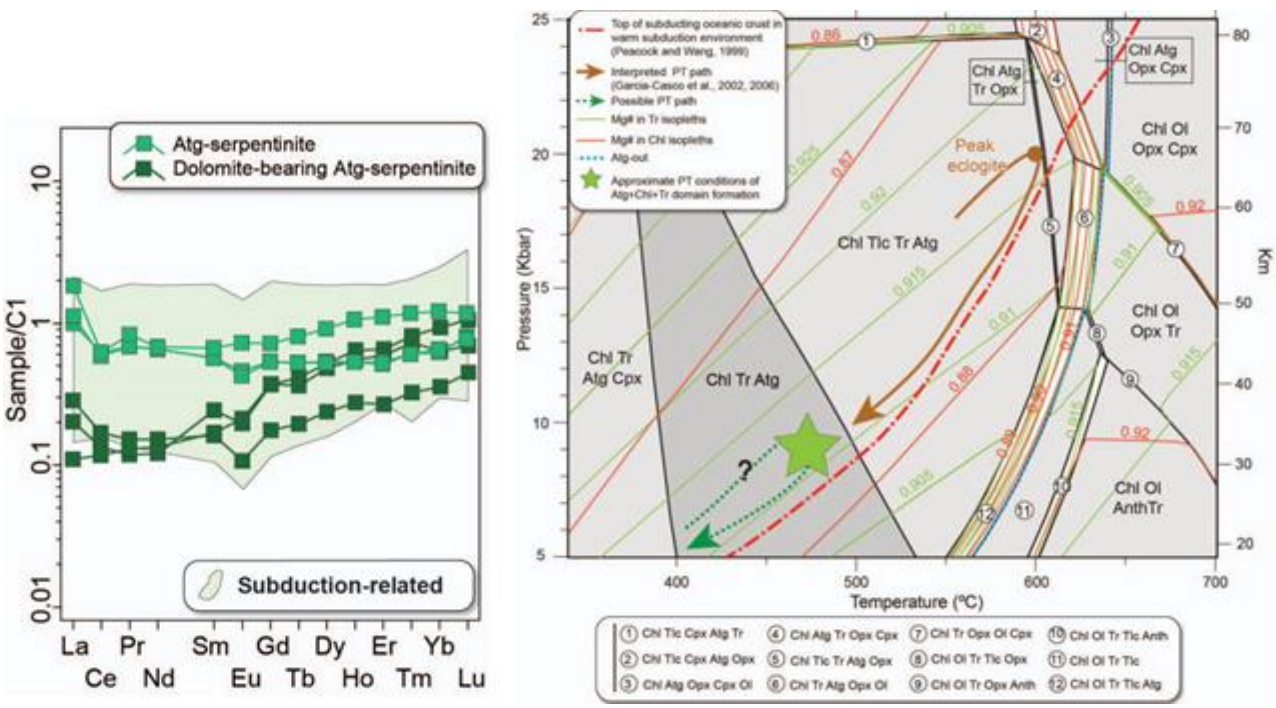


*Figure 55. Left: Composition of Pelo Malo antigoritites. Right: P-T conditions of tremolite-vein formation compared to the P-T path of eclogite blocks within the serpentinite mélange (Butjosa et al., 2023).*

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**Stop 16.** Santa Clara-Encrucijada road road. Las Delicias. 22°32'21.98"N, 79°54'18.89"W. Ophiolitic mélange. Eclogite block within serpentinite.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps.

The eclogite block (Figure 56) is made of garnet, omphacite, sodic-calcic amphibole (barroisite), epidote and rutile (Figure 57). The sodic-calcic amphibole retains prograde growth zoning, with cores of actinolite-magnesiohornblende. Garnet displays prograde and oscillatory zoning (Figure 58). Some retrogressed areas contain relicts of the eclogitic assemblages (but typically little or no omphacite) overprinted by sodic-calcic and calcic amphibole, albite, epidote, phengite, chlorite and titanite.

The composition of the eclogite block is of MORB composition (Figure 14), likely representing the oceanic lithosphere of the Proto-Caribbean (Garcia-Casco et al., 2008). The P-T paths indicate prograde burial in a warm subduction zone reaching up to 20 kbar (Garcia-Casco et al., 2002; Garcia-Casco et al., 2006) or up to ca. 30 kbar (Rui et al. 2024) followed by strong decompression with minor cooling during amphibolitization. Oscilatory zoning has been related to tectonic instabilities of the subducting slab (Garcia-Casco et al., 2002).

Age determinations in this and other eclogite blocks indicate protolith formation during the Hauterivian (126.3 ± 0.7 Ma U-Pb zircon, Rui et al. 2024) and Aptian subduction-related peak metamorphism and Albian exhumation and mélange formation (103.4 ± 1.4 Ma Ar/Ar amphibole, 115.0 ± 1.1 Ma Ar/Ar phengite, 118.2 ± 0.6 Ma Rb/Sr Ms-Omp-WR, Garcia-Casco et al., 2002; and 118.6 ± 1.6 U-Pb zircon, Rui et al. 2024). The 7 Myr difference between the formation of the protolith in the oceanic ridge and subduction metamorphism would point to ridge subduction (Rui et al. 2024), even if partial melting of the slab in a hot subduction scenario triggered by ridge subduction was not achieved, as in eastern Cuba mélanges (Garcia-Casco et al., 2008b; Lázaro and García-Casco, 2008; Lázaro et al., 2009, 2011; Blanco-Quintero et al., 2010, 2011a, 2011b). Another potential problem for ridge subduction in central Cuba mélanges is that garnet porphyroblasts contain relictic inclusions of glaucophane, pointing to cold-to-warm, but not hot, subduction.

*Figure 56. Field aspect and close up views of eclogite block. Greener regions are richer in omphacite while blackish regions are richer in Na-Ca amphibolte.*

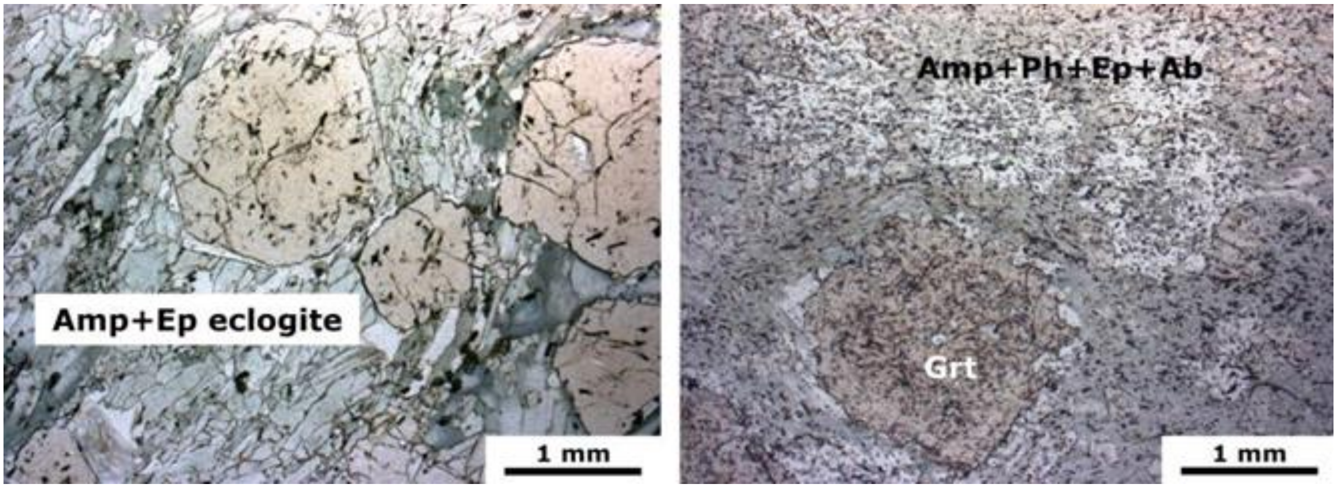


*Figure 57. Petrographic views of eclogite block. The peak paragenesis Grt+Omp+Na-Ca-Amp+Ep+Rt is overprinted by retrograde Na-Ca/Ca-Amp+Ep+Ab+Ph+Ttn±Chl.*

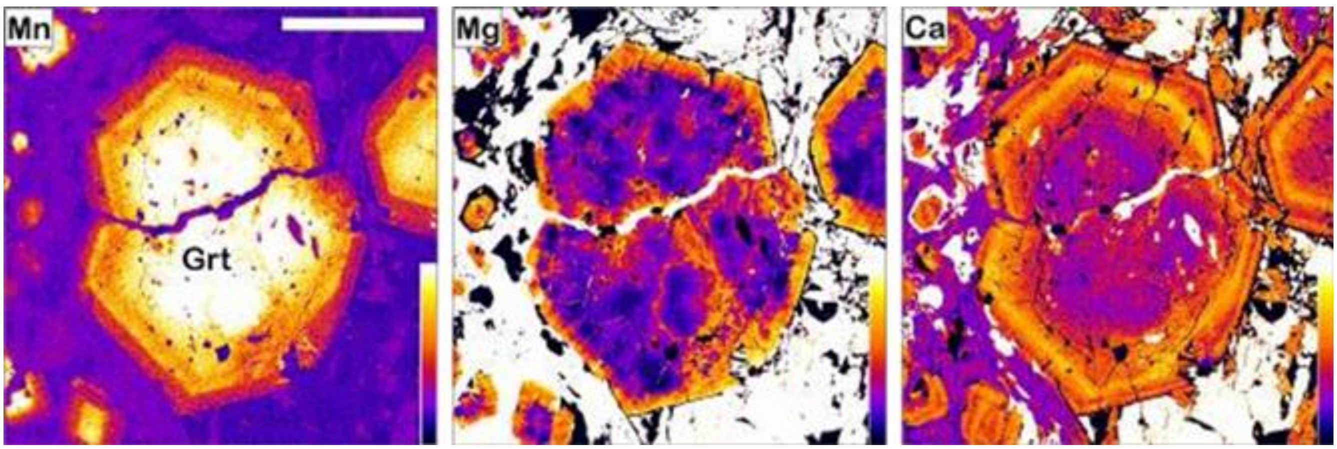


*Figure 58. Oscillatory and patchy (Mg) zoning of garnet.*

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Arriving at Hotel La Granjita and casas particulares in Santa Clara at ca. 6.30 PM Dinner at 7.30 PM. 8.30 PM, after dinner meeting to discuss the geology of the day.

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**Fifth day: Wednesday 16.04.2025. Stops 17-20. Cretaceous Volcanic Arc. Time of departure 8 AM.**

**Stop 17.** Hilario Formation (1 hour). 22°19'13.05"N, 79°57'57.72"W.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

Junction of the Manicaragua road with the national highway. The section exposes a volcano-sedimentary sequence consisting of tuffaceous sandstones, tuffs, volcanic breccias with tuffogenic matrix, polymictic sandstones and limestone. The tuffs are light green (zeolitized) to greenish grey (fresh) and cream beige to brown (weathered) in color. They form strata 2-3 cm to 1-5 m in thickness. Paleontological studies constrained the age of the Formation to the Campanian. Additionally, U-Pb dating of apatite from an andesitic lava sample east of central Cuba yielded an age of 76 Ma, confirming its Campanian age (Hu et al., in prep.). The dated andesitic flow is interbedded within a sequence of pyroclastic and terrigenous rocks (Hu et al., in prep). The Hilario Fm. lies unconformably on top of the La Bruja Fm. (next stop). Transfer to the next stop (30 min).


*Figure 59. Andesitic lava flow grey porphyritic andesite with plagioclase and amphibole phenocrysts (top panel, left) within a volcano-sedimentary sequence of tuff, conglomerate, tuffaceous shale and sandstone (top panel, right). Microphotograph of tuffaceous limestone with sub-angular crystals and lithic fragments (bottom).*

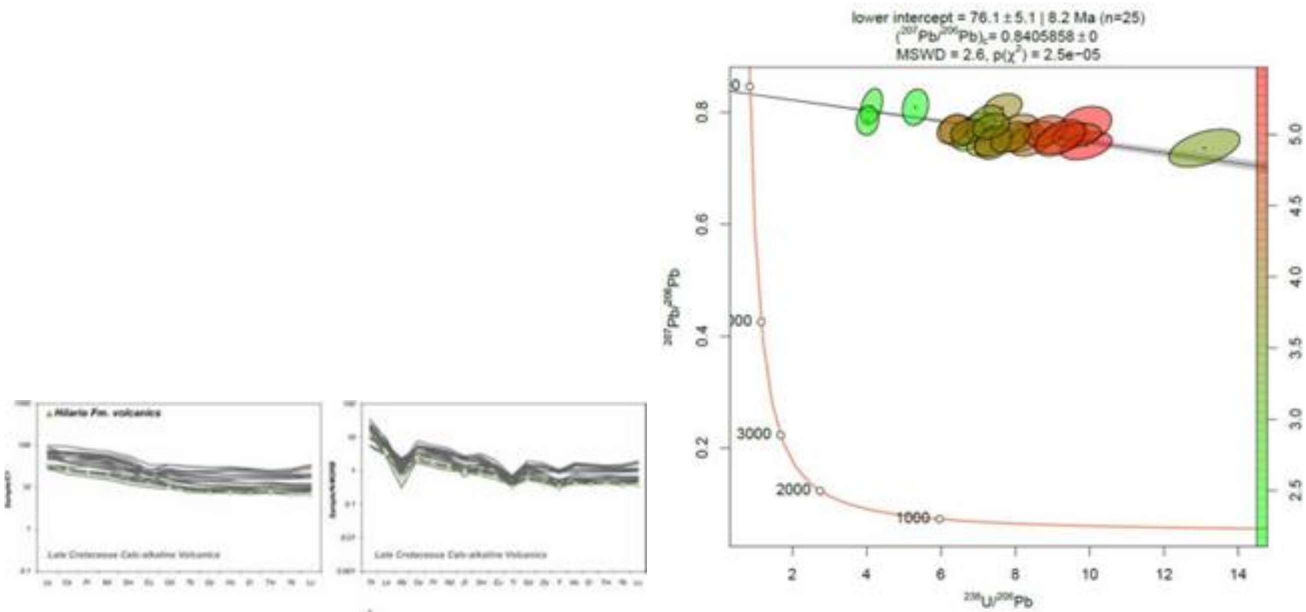


*Figure 60 Chemical composition and apatite U-Pb concordia plot from Hilario Fm (andesite sample 23LV41).*

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**Stop 18.** Brujas Formation (1 ½ hour). 22°17'33.83"N 79°59'6.04"W.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

North of Seibabo village, secondary road towards the El Brillante village. Volcano-sedimentary packages of stratified tuffs and agglomerates, flows of andesitic lavas with spheroidal weathering and coarse-grained tuffs with "onion skin" weathering. The age has been determined by its stratigraphic position as Upper Cretaceous, Coniacian-Santonian. However, new U-Pb data on apatite gives older ages of ca. 95 Ma (Hu et al., in prep).

A studied sample from this location was identified as a peperite. The sample is dominated by a mixture of elongated clasts of quartz and clay minerals, interpreted to represent fluidization and vesiculation of the host sediments as hot magma is violently injected. The sedimentary matrix is composed of quartz, clay minerals and carbonate. Crystal fragments of plagioclase and clinopyroxene are~ 20% of the rock. Fragments of plagioclase phenocrysts may show oscillatory zoning and coarse sieved texture. Augite fragments rarely present zoning and are free of alteration. Subangular to fluidal shaped glass represents basaltic melt of 300 to 800 microns in size.

*Figure 61. Peperite.*

*Figure 62. Clinopyroxene phenocryst (dark mineral in the volcanic clast) show an overgrowth rim similar to plagioclase phenocrysts.*

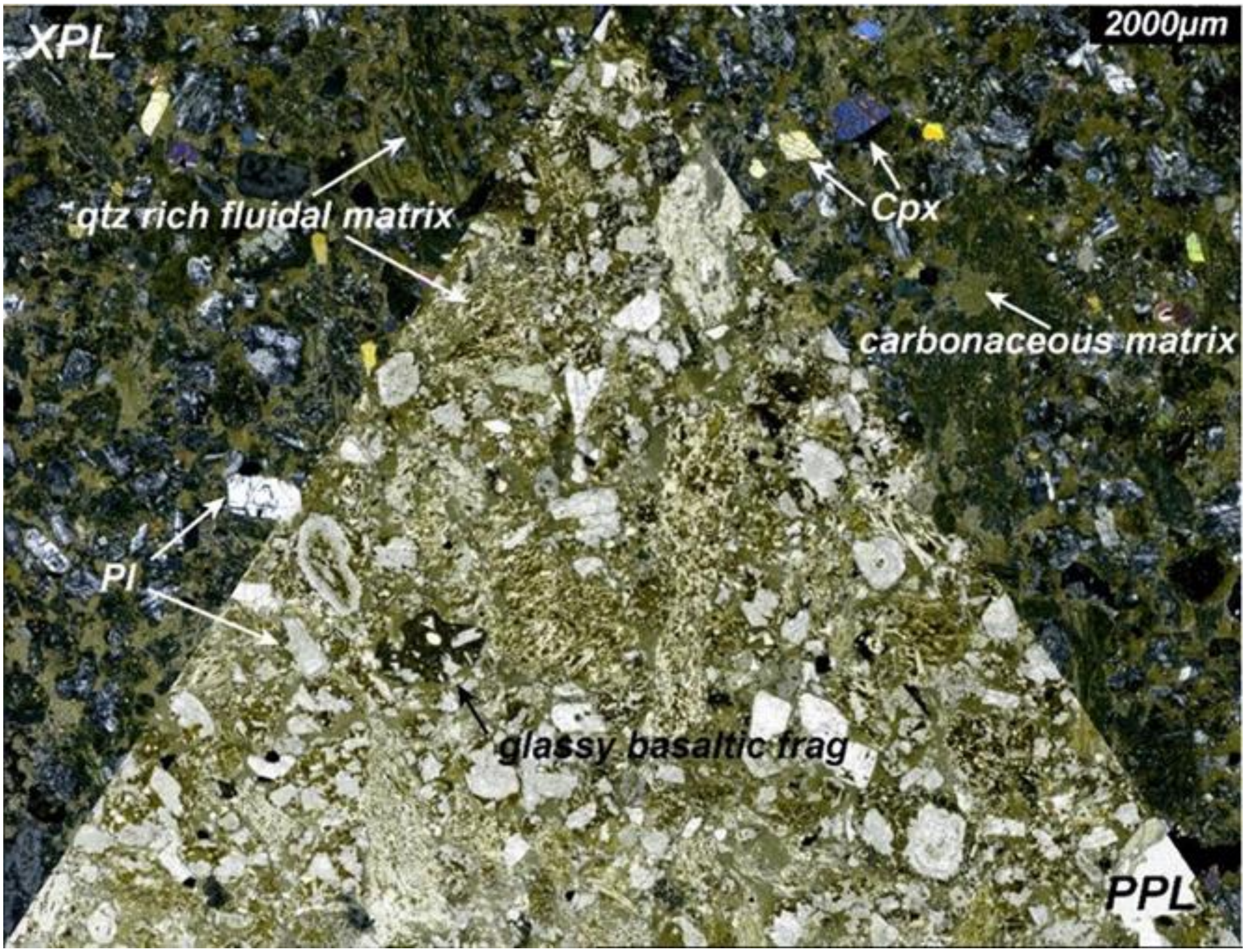


*Figure 63. Volcanic clast (porphyritic olivine basalt) embedded in a carbonate rich sediment. The sample contains a hypocrystalline matrix consisting of plagioclase and clinopyroxene laths and glass. Large plagioclase phenocrysts show a consistent texture with a coarse zoned core with glassy melt inclusions and an outer overgrowth. Olivine phenocrysts are completely replaced by pervasive secondary saponite.*

*Figure 64. Left: Altered volcanic bomb within coarse-grained tuff. Right: clast rich blocky peperite.*

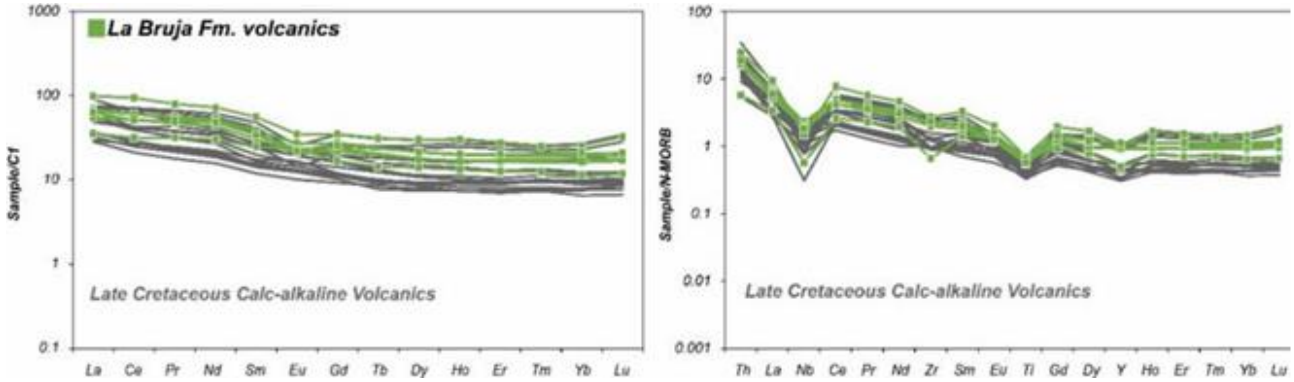


*Figure 65. Chemical composition of La Bruja volcanics.*

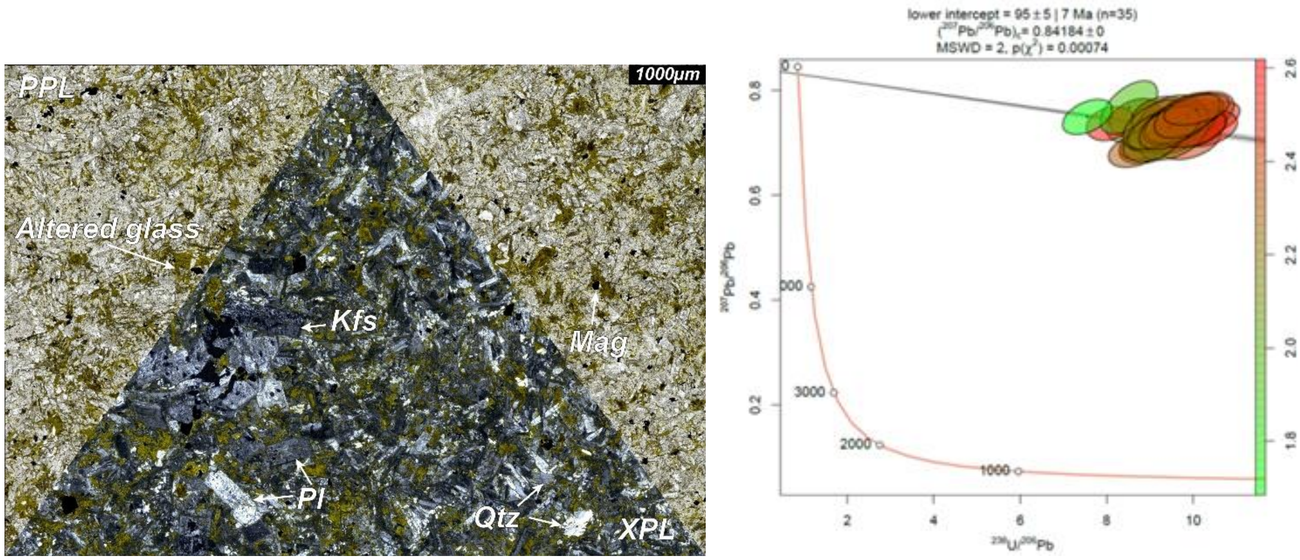


*Figure 66. Apatite U-Pb concordia plot from La Bruja Fm. sample 23LV10A, a highly altered seriate glomerophyric volcanic rock consisting mainly of feldspars.*

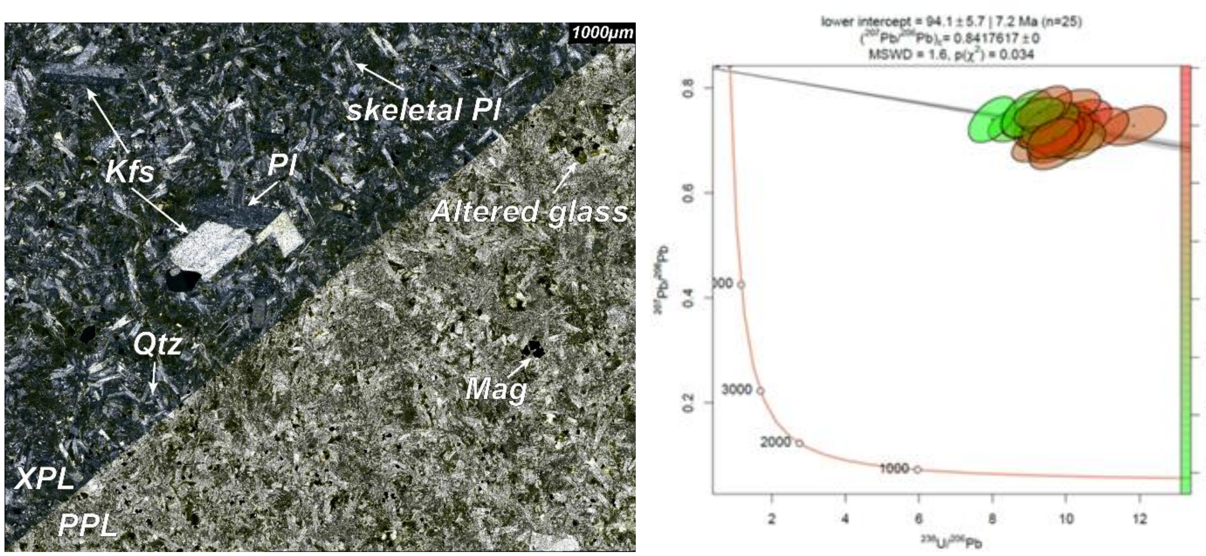


*Figure 67. Apatite U-Pb concordia plot from La Bruja Fm. sample 23LV10B, an altered massive coarse-grained seriate glomerophyric porphyritic andesite with plagioclase phenocrysts.*

In sample of Figure 66 the medium-grained tabular to elongated plagioclase feldspar (albite) and orthoclase of the matrix are randomly oriented and show intersertal texture, filled with fine grained quartz and glass (mostly altered in greenish brown color). A few large glomecrysts composed entirely of medium to coarse grained tabular orthoclase show perthitic texture. Apatite appears as inclusions in the feldspar phenocrysts.

The matrix of sample 23LV10B of Figure 67 consists of fine to medium grained intersertal elongated plagioclase laths and tabular orthoclase filled with fine-grained quartz. The plagioclase matrix shows shallow tails and skeletal texture, indicating fast cooling. Large glomerocrysts are composed entirely of medium to coarse grained orthoclase with perthitic texture. Apatite appears as inclusions in the feldspar phenocrysts.

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**Stop 19.** Mataguá Formation. (40 Min). 22°12'48.69"N, 79°59'29.74"W.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

Under the bridge of the Los Pasos River, on the Santa Clara-Manicaragua road. Volcanic sequence of amygdaloidal basalts, aphyric basalts, pyroclastic flow and volcanic breccias. In this outcrop, in the upper section the basalt shows flow banding, and lower sequence contain a pyroclastic sequence and volcanic breccias with fragment of variable size.

According to the geochemistry, the Matagua Fm. marks a transition from the tholeiitic to the calc-alkaline series, with a predominance of the latter. A Lower Cretaceous (Aptian-Albian) age is constrained by its stratigraphic position, concordant on top of the Los Pasos Fm. (next stop). A new U-Pb Apatite age from the unit give an age of ~121 Ma confirming the age of the unit.

*Figure 68. Overview of the outcrop at Los Pasos River.*

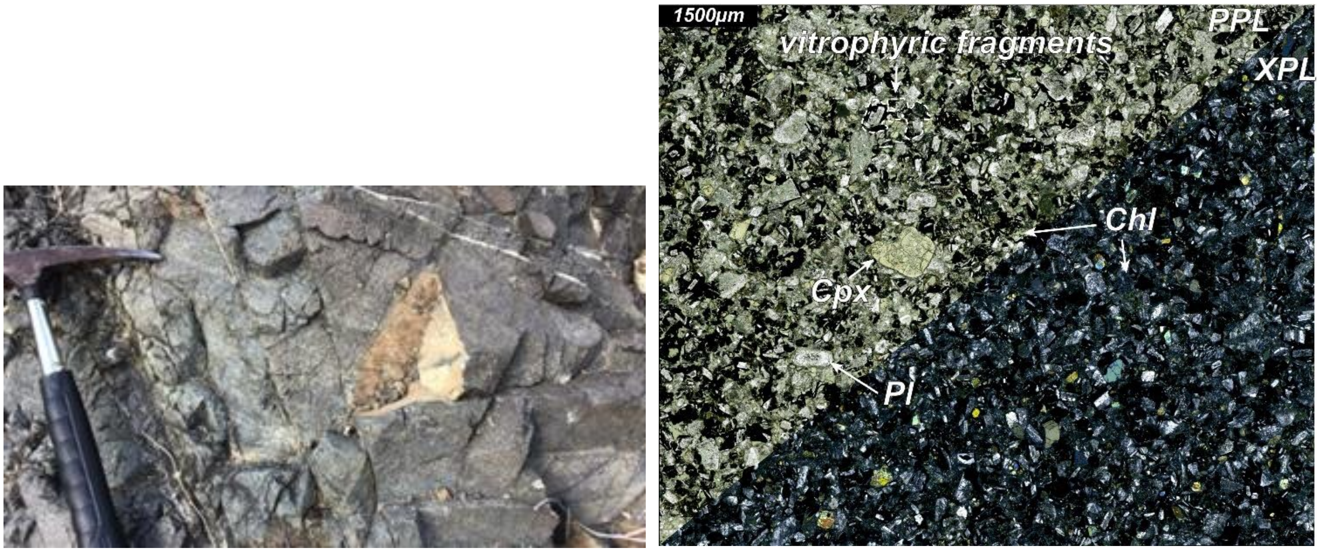


*Figure 69. Field microscopic aspect of black aphyric basalt with weakly flow banding. The rock is a fine- to medium-grained basaltic rock made up of vitrophyric lithic fragments and phenocrysts fragments of plagioclase and clinopyroxene. The glass is strongly altered, replaced by chlorite and palagonite. Lithic fragments are made up mostly of fine-grained plagioclase microliths and a few clinopyroxene grains embedded in strongly altered glass matrix. Medium-grained clinopyroxene are fresh and rarely present zonation.*

*Figure 70. Amygdaloidal basalt (left) and **v**olcanic breccias (right).*

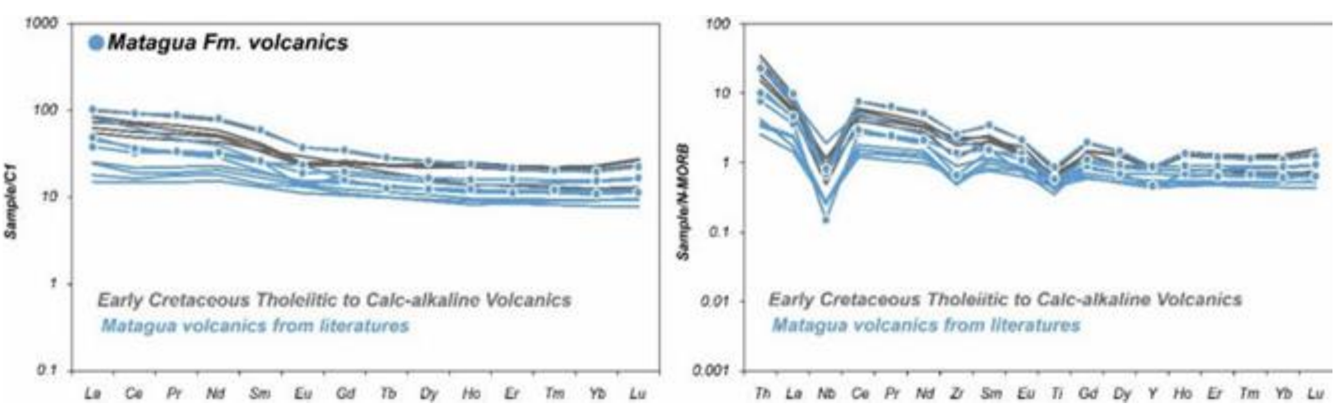


*Figure 71. Chemical composition of Mataguá Fm. volcanics.*

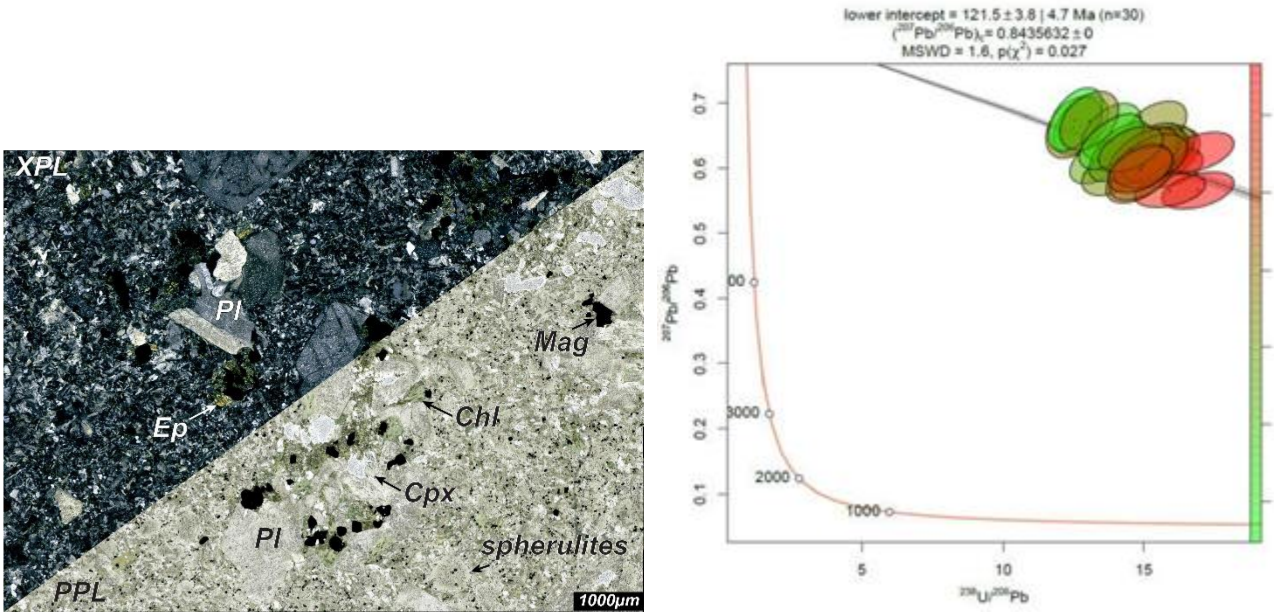


*Figure 72. Apatite U-Pb dating on sample 23LV45B (the location was marked as La Rosita Formation in the geological map of Central Cuba). Glomerophyric volcanic rocks consisting of phenocrysts, essentially of plagioclase and K-feldspar, and minor magnetite and clinopyroxene, in a spherulitic matrix. Plagioclase phenocrysts are strongly altered by saussarization and sericitization, locally zoned with inclusions now replaced by chlorite. Clinopyroxene glomerocrysts are mostly replaced by epidote and chlorite. The matrix is made up of fine-grained spherical plagioclase and minor anhedral quartz. The mafic phase in the matrix is completely replaced by chlorite and epidote. Fine-grained magnetite appears as accessory mineral in the matrix and forms needle shaped grains associated with spherical plagioclase. Euhedral apatite is present both in matrix and as inclusions in plagioclase phenocrysts. Secondary calcite replaces plagioclase.*

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**Stop 20.** Los Pasos Formation. (40 Min). 22°10'35.21"N, 79°58'42.06"W.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See on stratigraphic chart.

Quarry of massive light grey plagiorhyolites intruded by mafic dykes. In general, the Los Pasos Fm. consists of rhyolites, plagiorhyolites, rhyodacites, dacites, basalts, basaltic andesite and tuffs of felsic and mafic composition, subordinately andesite, as well as tuffites, breccias and agglomerates, sandstones, and siltstones. This bimodal volcanic assemblage is characterized by effusive and subvolcanic facies that predominate over explosive facies. Hydrothermal alteration is widespread, including propylitic with epidote-actinolite associations and chlorite alteration with actinolite, sericite, quartz, carbonate, prehnite-pumpellyite. Replacement of primary plagioclase by albite is commonly observed, also in veins.

Los Pasos formation is considered as an island arc tholeiitic series, although subordinate samples pertain to the calc-alkaline series. The lower contact is unknown since it is cut by a fault to the south or is intruded by the Manicaragua batholith. Its contact with the overlying Matagua Fm is covered, though their beddings are concordant.

The age is considered Lower Cretaceous (pre-Albian) due to its stratigraphic position and U/Pb zircon dating from unfoliated granodiorite intrusions yielding ages of 125 Ma (Rojas-Agramonte et al., 2011; Hu et al, in prep).

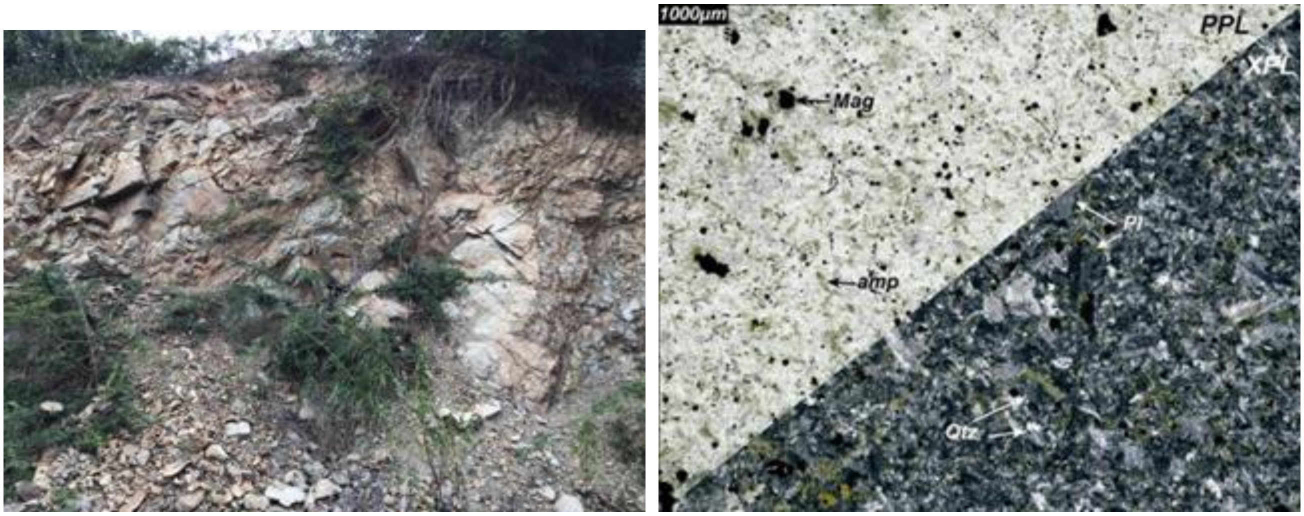


*Figure 73. Massive light grey plagiorhyolite. Fine- to medium-grained volcanic rock dominated by anhedral partly recrystallized medium-grained plagioclase (albite) phenocrysts, embedded in a matrix mainly composed of recrystallized fined-grained quartz. Fine-grained acicular actinolite present as mafic phase in this rock, in some parts showing radiating texture indicating secondary origin. Fine to medium-grained magnetite and tiny apatite rods appear as accessory minerals.*

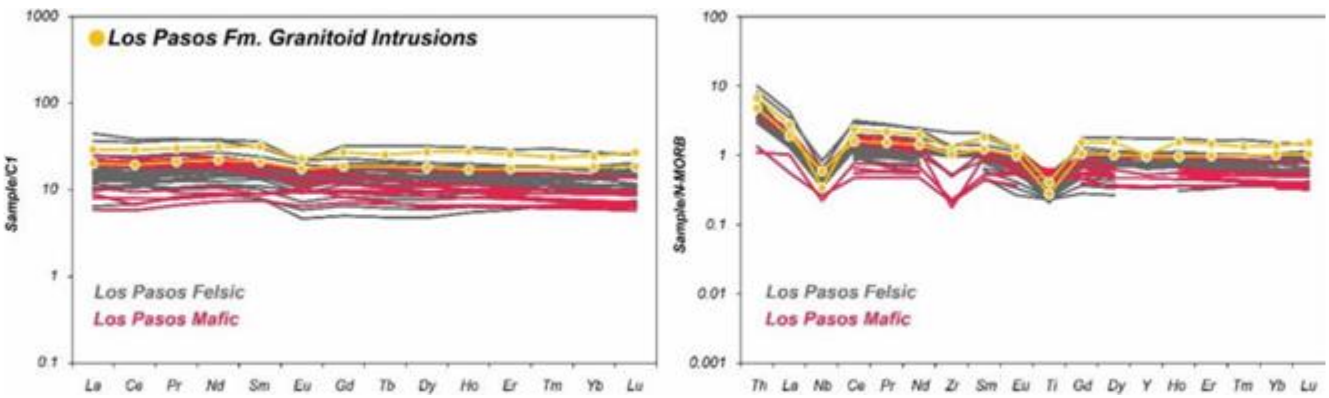


*Figure 74. Chemical composition of Los Pasos Fm.*

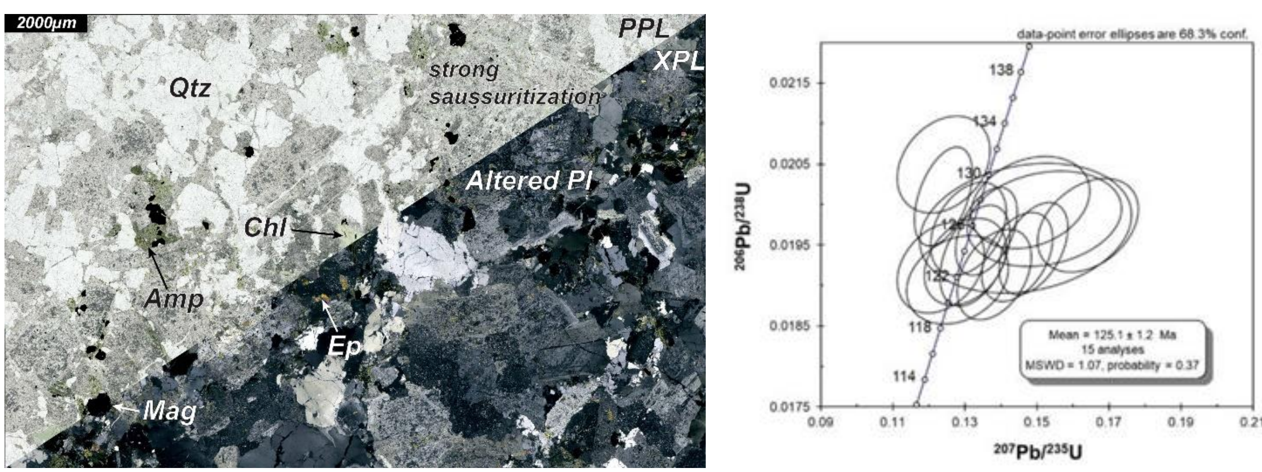


*Figure 75. Zircon U-Pb concordia diagram and petrography of of granitoid intrusion in Los Pasos Fm (sample 23LV-24). This coarse-grained granitoid (trondhjemite) consists of quartz and plagioclase with minor amphibole. Plagioclase crystals are commonly zoned and highly altered to saussurite, giving a cloudy appearance among the*

*weakly deformed quartz. Secondary epidote and chlorite replaced primary fine-grained acicular or medium-grained anhedral amphibole crystals. Few igneous grains of epidote may be present. Magnetite and zircon make up the accessory mineralogy.*

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Arriving at Hotel La Granjita and casas particulares in Santa Clara at ca. 6.30 PM. Dinner at 7.30 PM. 8.30 PM, after dinner meeting to discuss the geology of the day.

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**Sixth day: Thursday 17.04.2025. Stops 21-25. Breakfast 7.30 AM. Mabujina and Escambray complexes along the road Santa Clara-Güinía de Miranda-Trinidad. Time of departure 8 AM.**

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**Stop 21.** Amphibolite of the Mabujina Complex (40 min). 22° 2'49.20"N, 79°50'36.01"W.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See age relation to stratigraphy of the Cretaceous volcanic arc.

In the Agabama River, amphibolites of the Mabujina Amphibolite Complex (MAC) show a variable degree of metamorphism and deformation. Highly deformed amphibolites are well recrystallized and may display proto-mylonitic fabrics defined by amphibole and plagioclase (Grafe et al., 2001). Metatonalitic-metatrondhjemitic rocks alternate with the amphibolites showing a dominant foliation parallel to the main foliation of the amphibolites, thus indicating pre-metamorphic intrusion. Syn-metamorphic felsic layers, dykes, and veins occur parallel and crosscutting the main metamorphic foliation of the amphibolites. They contain small amphibolitic enclaves rich in hornblende interpreted as melanosomic material (i.e., restitic) within trondhjemitic leucosome produced after local partial melting of amphibolite. Locally, these leucocratic bodies are strongly deformed, showing a dynamic recrystallization process. According to their field occurrence related to the amphibolite, the granitoid rocks can be broadly visualized as a dominant group of concordant deformed granitoids and orthogneisses and a less abundant group of concordant to discordant felsic veins. The oldest ages of granitoids within the MAC date back to ca. 133 Ma suggesting that the basaltic protoliths of the MAC formed since at least Valanginian time (Rojas-Agramonte et al., 2011).

*Figure 76. Amphibolite and felsic dikes affected by deformation.*

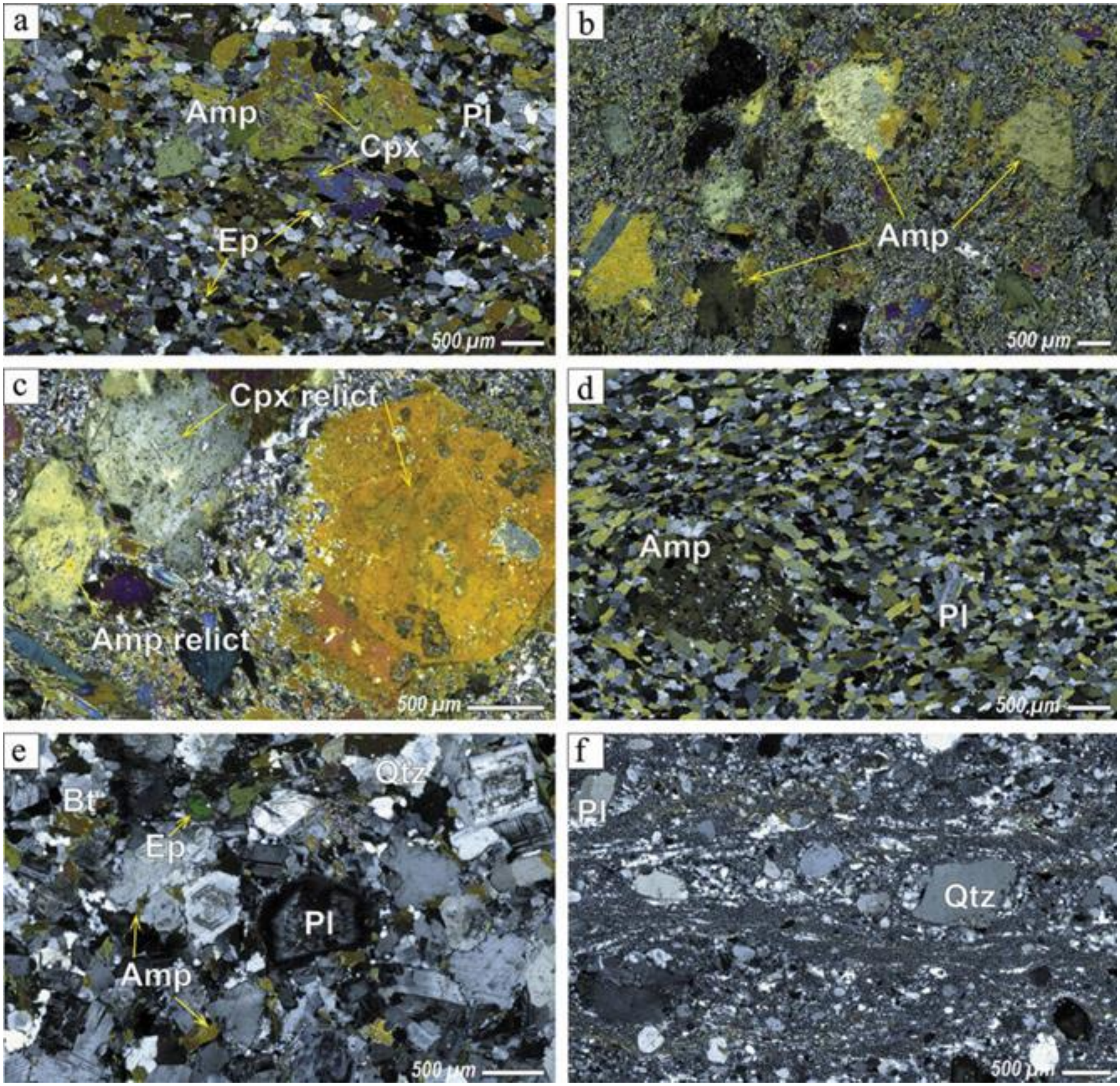


*Figure 77. Photomicrographs of igneous and metamorphic rocks from the Mabujina Amphibolite Complex. (a) Sample LV50: foliated epidote-amphibolite shows relics of magmatic clinopyroxenes. (b) Sample 7LV9: non-foliated amphibolite with remaining porphyritic subvolcanic texture from basaltic protolith. (c) Sample 7LV9: metamorphic amphiboles replacing igneous phenocrysts of clinopyroxene and amphibole. (d) Sample LV52: foliated amphibolite consisting of amphibole and plagioclase. Note porphyroblastic amphibole with small plagioclase inclusion. (e) Sample 8LV20B: medium-grained undeformed tonalite from the MAC with oscillatory-zoned plagioclase crystals. (f) Sample LV43A: concordant felsic vein from the MAC shows mylonitic texture, ribbons of quartz and plagioclase with pressure shadows. White bar indicates 500 µm. (g) Sample 8CF3: completely recrystallized quartz and deformed plagioclase with flame-shape twining in an orthogneiss from the MAC. Abbreviations: Amp: amphibole; Bt: biotite; Chl: chlorite; Cpx: clinopyroxene; Ep: epidote; Ms: muscovite; Pl: plagioclase; Qtz: quartz. (Hu et al., 2024).*

**Stop 22.** Amphibolite of the Mabujina Complex of and granitic rocks of the Manicaragua batholith (40 min). 22° 4'0.77"N, 79°47'39.89"W.

See on 1:250K geologic map. See on geologic sketch map. See on Google Maps. See age relation to stratigraphy of the Cretaceous volcanic arc.

The description of this outcrop in the Agabama River is very similar to Stop 21, although the granitoids of the Manicaragua batholith with enclaves of amphibolites can be observed. The batholith crosscuts the MAC mainly in the northern part, near the contact with the Cretaceous Volcanic Arc, and establishes an upper limit for the magmatic formation and metamorphism of the MAC at 89 Ma (Rojas-Agramonte et al., 2011).

*Figure 78. View of the outcrop in the Agabama River.*

*Figure 79. Granitoids with inclusions of amphibolites.*

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Stops 23-25 in the Trinidad dome of the Escambray Complex, tectonically below the Mabujina Amphibolite Complex (note green-colored rocks around the domes in the map below) are shown in (Figure 80)

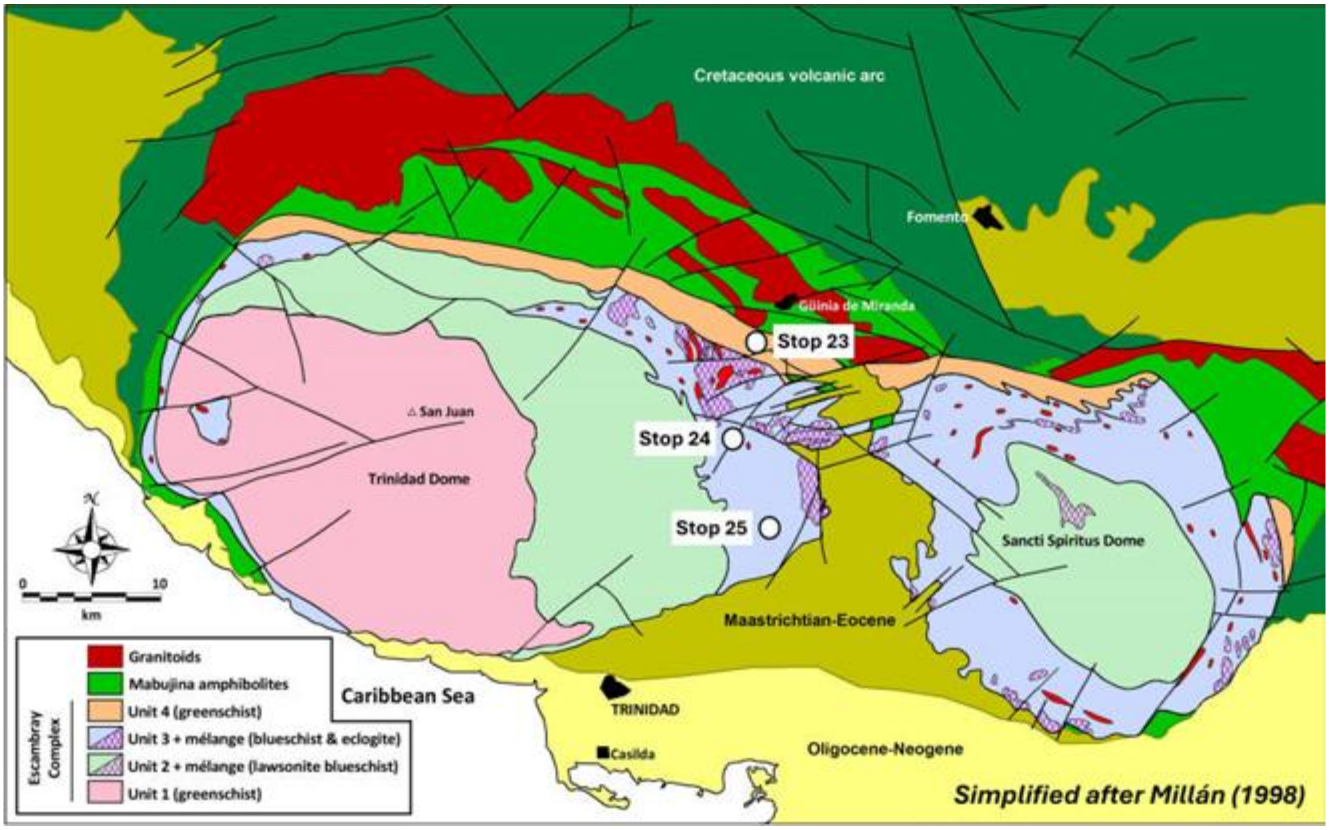


*Figure 80. Geologic map of the Escambray Complex (after Millán-Trujillo, 1997a, published in 1998) with indication of major tectonic units, serpentinite mélanges and eclogite bodies and location of stops 23-25.*

**Stop 23.** Carbonates of Boquerones lithodeme (Upper Jurassic-Lower Cretaceous) of Major Unit 4 (topmost in the structural pile) of the Escambray Complex. 22°01'13.72"N, 79°51'45.19"W.

See on map. See on sketch map. See on Google Maps. See on stratigraphic chart.

The Boquerones lithodeme is characterzed by thin strata of calcareous schists and marbles, normally graphitic, foliated, and rhythmic character. It contains some boudins of black microgranular dolomitic marbles with abundant radiolarians, including probably Messozoic *Nassellaria*. It also contains intercalations of metabasite (former dikes or intrusive bodies representative of passive margin magmatism). It seems that it overlies the Herradura lithodeme, made of probably Jurassic low-grade detrital graphitic metasediments correlated to the Loma La Gloria lithodeme of the Escambray Complex and the San Cayetano Fm. in Western Cuba (Figure 18).

*Figure 81. Metacarbonates of the Boquerones lithodeme (Escambray unit 4; Figure 80).*

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**Stop 24.** Güinia de Miranda-Trinidad road. El Algarrobo village. 21°58'29.50"N, 79°52'42.77"W. Graphitic schists and muscovite+calcite schists of the Loma La Gloria lithodeme (Jurassic) of the Escambray Complex (40 min). This lithodeme is correlated to detrital strata of the San Cayetano Fm. of Western Cuba.

See on map. See on sketch map. See on Google Maps. See on stratigraphic chart.

The Loma La Gloria lithodeme (200-400 m in thickness) is made of coarse-grained quartzitic and quartz-muscovite metasandstones, generally with abundant albite with frequent cm- to m-thick intercalations of generally graphitic metapelitic schits rich in muscovite and more local layers of foliated marbles. Locally, it contains boudins (tectonic blocks) of eclogites and serpentinites up to 10 m in thickness and of Algarrobo schists (strongly crystalline, commonly calcareous garnet-bearing schists of probable metamorphic-metasomatic origin). The origin of the lithodeme is debated (pseudostratigraphic relation vs. tectonic mélange). The Cobrito lithodeme lies above (Stop 25).

*Figure 82. Calcite-muscovite schist of Loma La Gloria lithodeme.*

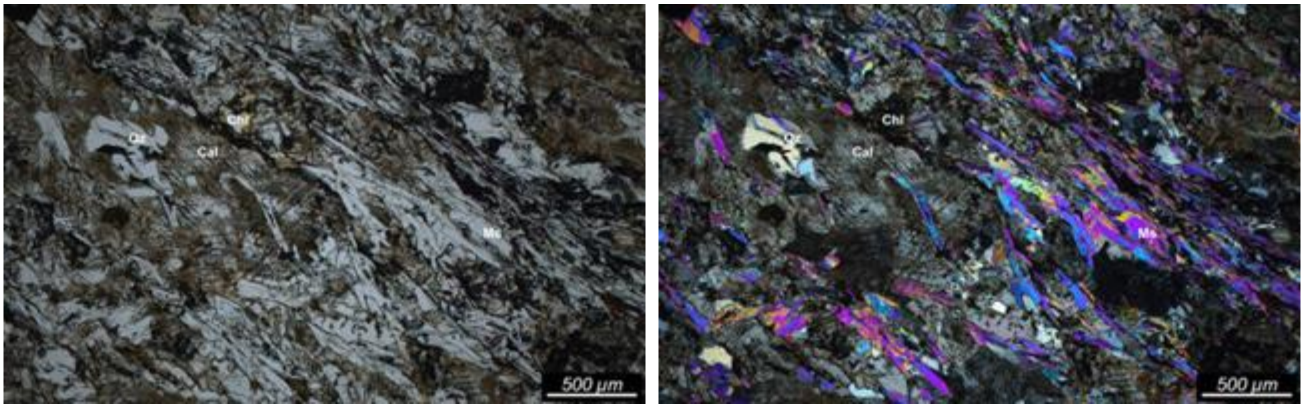


*Figure 83. Optical images of the calcite-muscovite-chlorite schist of this stop 24. It also contains rutile (not shown).*

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**Stop 25.** Güinia de Miranda-Trinidad road. 21°54'10.23"N, 79°51'27.00"W. Muscovite+calcite±graphite schists of the Cobrito lithodeme (Upper Jurassic-Lower Cretaceous) of the Escambray Complex (40 min).

See on map. See on sketch map. See on Google Maps. See on stratigraphic chart.

The schistose sequence of the Cobrito lithodeme contains fine strata of generally (graphitic) dark and, less frequently, light marbles. They may also appear as mm-to-cm sized boudins with Mesozoic radiolaria and other microfossils. Like Loma la Gloria lithodeme, it contains boudins of eclogitic and serpentinitic rocks (photos below) that may reach several meters in size. It rests above the Loma la Gloria lithodeme (Stop 24).

*Figure 84. Field aspect of the calcite-muscovite schists with boudins of the Cobrito lithodeme.*

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Arriving at Hotel Las Cuevas in Trinidad at ca. 5 PM. Dinner at 7.30 PM. 8.30 PM, after dinner concluding meeting of the Thomson Field Forum.

 

**Seventh day: Friday 18.04.2025. Return to Havana in the morning after breakfast. Arriving at the convention Center at 1.00 PM.**

Field trip leaders Yamirka, Manuel, Kenya, Haoyu and Antonio wish you enjoy the Thompson Field Forum 2025 "The Geology of Cuba: Key for the Tectonic Evolution of the Caribbean–North American Plates".



Granada, March, 2025.