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Geology of the Camagüey Region, Central Cuba – Evolution of a Collisional Margin in the Northern Caribbean

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ABSTRACT

Mapping and prospecting activities of the Joint Cuban-German Geological Expedition (1981–1990) in the central part of the Province of Camagüey yielded a background knowledge of the geological structure and development of this region outlined here. Outstanding rock units are the ophiolite of Camagüey and the volcanic island arc, prospected for chromitites and disseminated porphyry ores. The ophiolite lies allochthonously above the Jurassic and Cretaceous rocks belonging to the passive continental margin of the North American plate. Reaches of the Cretaceous volcanic arc with a remarkable predominance of potassium were overthrust to the north over the ophiolite. The detritus of the pre-Upper Paleocene rocks are located in synorogenic deformed foreland and piggy-back basins, covered by postorogenic basins filled with sediments from the late Upper Eocene to the Present.

RESUMEN

El conocimiento de la constitución y evolución geológica de la parte central de la Provincia de Camagüey se ha profundizado como resultado de los trabajos de mapeo y de prospección ejecutados por la Expedición Geológica Conjunta Cuba-República Democrática Alemana entre 1981 y 1990. Las unidades litológicas más destacadas son la ofiolita de Camagüey y el arco volcánico, que fueron prospectadas por cromitita y mena diseminada porfírica. La ofiolita yace alóctona sobre las rocas de edades Jurásico y Cretácico pertenecientes al margen continental de la placa norteamericana. Secciones del arco volcánico Cretácico, caracterizadas por un notable contenido de potasio, están sobrecorridas hacia el norte sobre la ofiolita. Los détritos de las rocas pre-Paleoceno Superior yacen en cuencas sinorogénicas deformadas de tipo antepaís y en cuencas del tipo "piggy-back", las que a su vez están cubiertas por cuencas postorogénicas que contienen sedimentos del Eoceno Superior tardío hasta el Reciente.

Introduction

■ Central Cuba consists of three different terranes which display the essential stages of the evolution of the contact between the North American and the Caribbean plate: the southern margin of the North American plate (Bahamas), the ophiolite complex and the island arc (Fig. 1). They have been merged as a result of collisional and north-facing overthrusting processes. The Bahamas platform and the ophiolite are separated by the E-W striking Cuban main thrust. This suture zone is subdivided by NE trending fault zones (e.g. Trocha fault), which separate crustal segments with different tectonic structures. West of the Trocha fault, in Las Villas, the rock units are strongly deformed and overprinted by thrusting and uplift of the Escambray metamorphic complex. In contrast, east of the Trocha fault, in the Camagüey region, the sedimentary rocks of the

Bahamas platform and the island arc exhibit only a weak overprint by thrust-fault tectonics and metamorphism.

From 1981 to 1990 the Joint Cuban-German Geological Expedition carried out geophysical, structural, geochemical, petrological and exploratory works within the scope of a complex geological mapping at the scale of 1:50,000 over 8,000 km² of the central part of the Camagüey Province. The cooperation based on a geological mapping and prospecting COMECON-project (CAME III) endorsed by the governments of Cuba and the former German Democratic Republic (ITURRALDE-VINENT et al. 1987, PIÑERO et al. 1990).

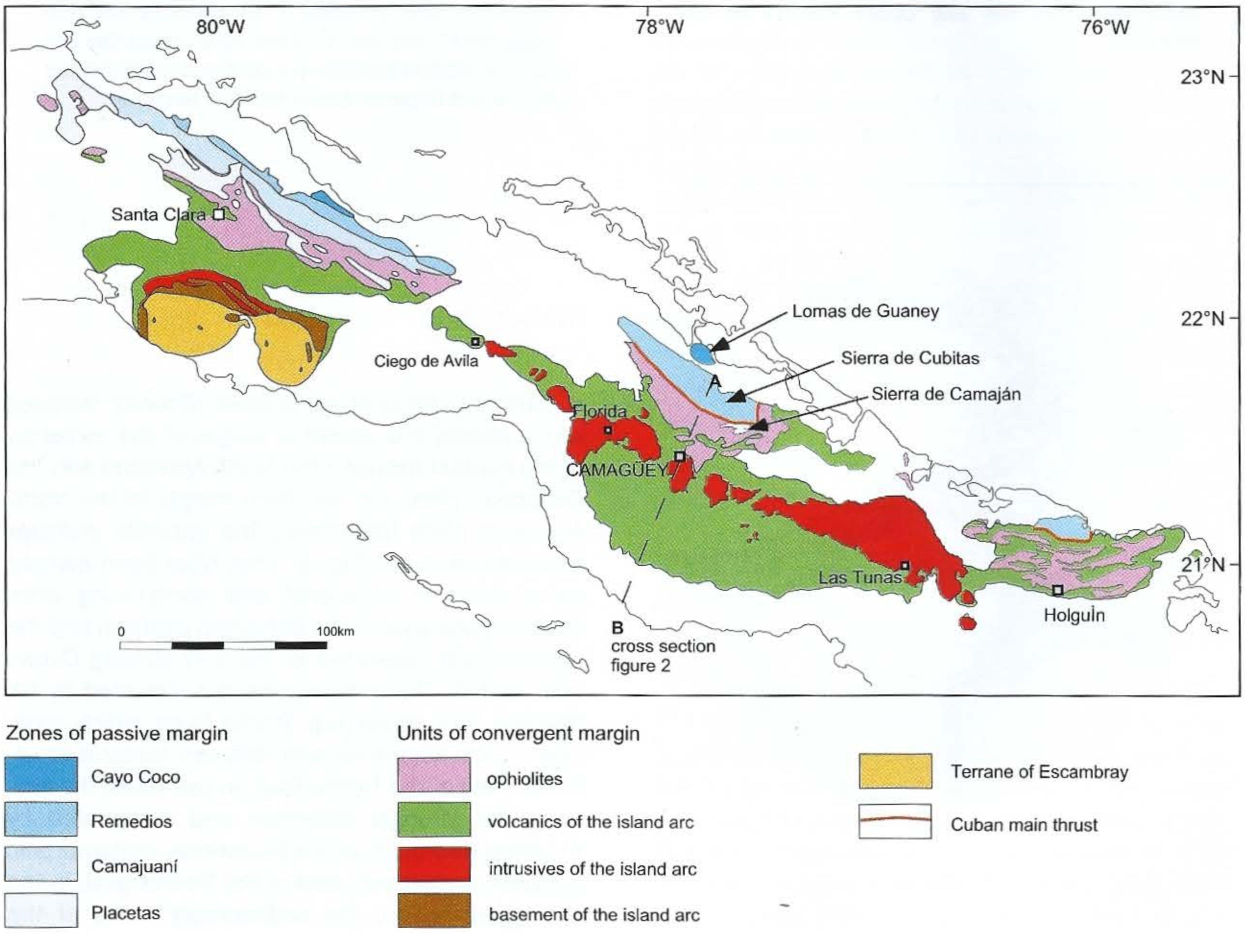
The North American plate – the passive margin

Jurassic and Cretaceous sediments of the passive North American plate margin have been mapped in the Sierra de Cubitas, the Sierra de Camaján and the Guaney Hills. The sediments belong to different tectono-sedimentary facies of the continental margin, which comprises a stratigraphic section from the Upper Jurassic to the Maastrichtian.

Albian to Maastrichtian sequences of the Bahamas carbonate platform, the so-called Remedios zone, crop out in the Sierra de Cubitas north of Camagüey. Their sediments are strongly folded with the folds showing NE vergence. Shallow-marine carbonate grainstone, wackestone and mudstone dominate in this stratigraphic section.

Fig. 1:

Schematic map of the Mesozoic units of Central Cuba.



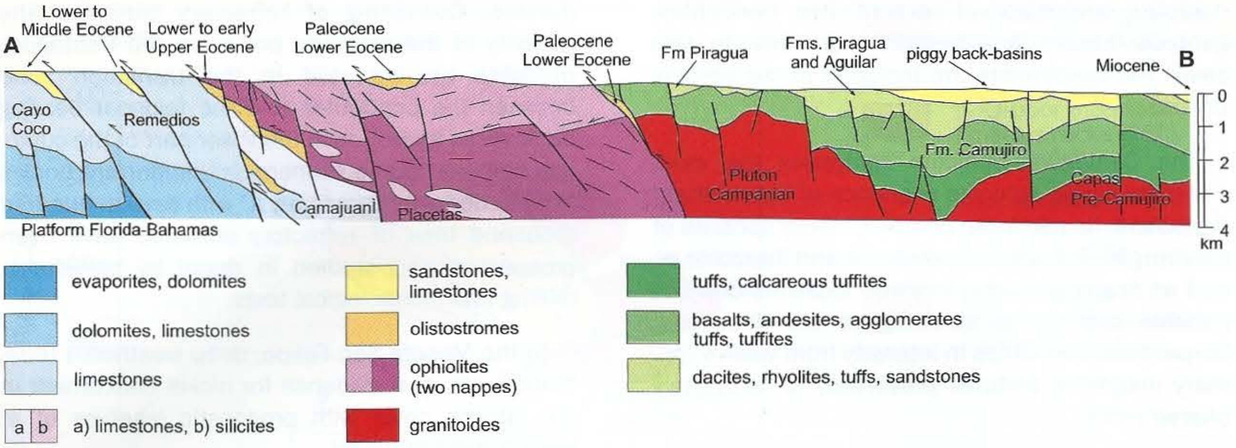


Fig. 2:

Schematic geological cross section of the central region of the Province of Camagüey (location see Fig. 1).

Two rudist banks in the Cenomanian and Maastrichtian are observed. During the Cenomanian, the carbonate platform was drowned, indicated by fine laminated hemipelagic mudstones. Sediments of the Turonian to Santonian have not been observed, the time gap probably forms a disconformity in the sedimentary record of the Sierra de Cubitas.

Marginal slope sediments of the Bahamas platform (Camajuaní zone) are presumably detected by seismic profiling below the ophiolite complex. A large, scale-shaped tectonic block of the intensely deformed distal slope up to the basin sediments of the Placetas facies zone occurs within the ophiolitic melange south of the Cuban main thrust in the Sierra de Camaján. The stratigraphic section starts with hyaloclastic basalts of Tithonian age, which are overlain by carbonates, cherts, sand- and siltstones. Interrupted during Turonian to Campanian times, the stratigraphic succession is continued by a 35 m thick series of Maastrichtian clastic carbonate rocks. The rocks of the Sierra de Camaján locally exhibit a schistosity and are strongly folded, with the grade of folding and deformation decreasing to NE from the slope sediments to the Bahamas carbonate platform.

The Camagüey ophiolite

The Camagüey ophiolite forms an arc-shaped belt of about 1,000 km². Drill holes and gravimetric data show that the thickness of the ultrabasic rocks increases up to at least 5 km in the south near Camagüey. The thrust plane dips with 30° to 45° to the SW; towards the south the dipping angle increases up to an almost vertical position (Fig. 2). Final thrusting of the ophiolite onto the Bahamas carbonate platform started in the Paleocene and lasted until the Upper Eocene (ITURRALDE-VINENT et al. 1987; ITURRALDE-VINENT 1996).

Above the Mesozoic carbonates of the passive margin, there is a section of Paleocene-Eocene sedimentary rocks and an olistostrome of early Upper Eocene age (Senado formation). The ophiolite tectonically overlies the former sections.

In the south, the ophiolite is covered by klippen-like bodies of arc volcanics, which are thrust upon a Paleocene to Lower Eocene olistostrome and upon the ophiolite.

The Camagüey ophiolite represents a tectonic melange consisting of two nappe structures with the lower one containing tectonic inclusions of sediments. Their most prominent one is the Sierra de Camaján rock unit. Both nappes show a similar

ophiolitic succession of serpentinites, peridotites, gabbros, basalts and pelagic sediments. In rare cases metasediments are included in the serpentinites.

The Camagüey ophiolite comprises the most complete alpine ophiolite sequence of the northern Caribbean. Its peridotite complex mainly consists of harzburgite, but also of websterite and lherzolite as well as scarcely dunite. In some localities dikes of gabbros cutting the harzburgites are described. Serpentinization varies in intensity from weakly (primary magmatic textures preserved) to completely altered rocks.

The cumulate complex is the best developed complex in the Camagüey ophiolite. Olivine gabbro, norite, troctolite, as well as anorthosite form large bodies with magmatic layering textures. In the lower parts of the complex, ultramafic rocks like lherzolite, websterite, harzburgite and few dunites occur within the cumulates. Cross-cutting dikes of gabbros, plagioclasites, plagiogranites and chromitite veins in the gabbros have been observed.

Between the peridotite and the cumulate complex, there is a transition zone. The ultramafics contain irregular bodies and dikes of gabbro and plagioclasite. In some places rodingite occurs.

There are only scarcely scattered outcrops of the dike complex. In the area west of Minas, dikes of basalt and dolerite occur, giving the impression of "sheeted dikes".

The volcano-sedimentary complex of the ophiolite sequence has been found in tectonic scale-shaped blocks in several locations. A section of ?Albian- ?Cenomanian-basalts, hyaloclastites, radiolarian cherts and siltstones – the Albaiza formation – crops out in isolated blocks of several square kilometers south of the Sierra de Camaján. In the northwestern part near Esmeralda, slices of hemipelagic limestones and metacherts are included into the serpentinite (Mate Prieto formation). In the NE of Camagüey a large tectonic slice of green schists, quartz mica schists, metacarbonates and carbon rich mica schists (La Suncia formation) is exposed.

Podiform chromitite bodies are widespread in the north of Camagüey. The chromitite bodies, some of which are medium-grade chromite ore deposits (about 30% Cr_2O_3 on the average), are related to different structural levels of the ophiolite. Host rocks of the metallurgical chromite are peridotites and dunites. Consisting of refractory chromite, the majority of the cromitite bodies in the Camagüey ophiolite are situated in the transition zone between the peridotites and the feldspar bearing basic rocks as well as in the lower part of the cumulate complex. Some economically important bodies like the deposit "Camagüey II" with several hundred thousand tons of refractory chromite have been prospected and studied in detail by gravimetry, drilling and technological tests.

In the Meseta San Felipe, deep weathered ultramafic rocks give evidence for nickel enrichment in the lateritic cover with prognostic reserves of at least 3 mio t of nickel.

The Cretaceous island arc

In the Camagüey region, the exposures of the Cretaceous island-arc complex extend over more than 80 km with an ESE strike. The NE trending Camagüey fault (Fig. 1) subdivides the island arc into two areas with different erosional levels: the downdropped western part of the island arc is partially covered by Tertiary sediments, whereas in the uplifted eastern part the volcanics are well exposed.

Similar island arc units have been found in Las Villas, eastern Cuba, and on the other islands of the eastern Greater Antilles. In Central Cuba, the island arc has been inactive since the late Cretaceous due to the collision with the Bahamas. The volcanics are disconformly covered by Upper Campanian and younger sediments. In contrast to the tectonic structure of Las Villas, the island arc unit of Camagüey is less deformed. The spatial relation between the different igneous complexes is well established by geological and geophysical mapping. However, still a matter of discussion is the intrusion age of the plutonic rocks. There are some contradictory K/Ar data, which indicate a general cooling of the island arc in the Campanian, whereas geological evidence suggests a Middle Campanian age (ITURRALDE-VINENT 1996).

The igneous island arc rocks of the Camagüey region can be subdivided by geological and geochemical features into three volcano-plutonic sequences: the pre-Albian, the Albian-Turonian and the Santonian-Campanian events (ITURRALDE-VINENT et al. 1987; ITURRALDE-VINENT 1996; STANEK 1996).

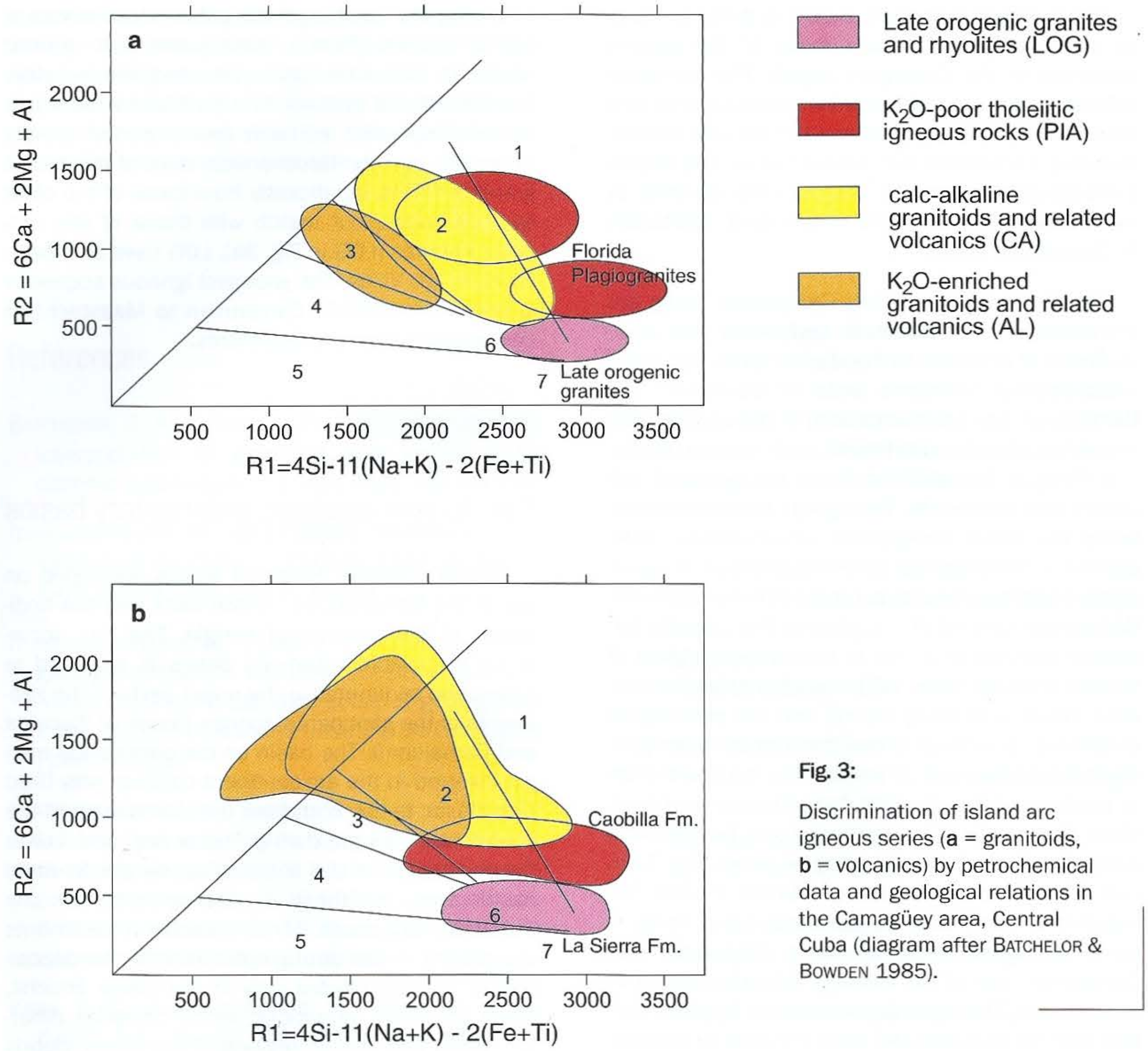


Fig. 3:

Discrimination of island arc igneous series (**a** = granitoids, **b** = volcanics) by petrochemical data and geological relations in the Camagüey area, Central Cuba (diagram after BATCHELOR & BOWDEN 1985).

In Las Villas and in the eastern Greater Antilles, the first appearance of island arc magmatism has been interpreted as primitive island arc magmatism (PIA, Fig. 3a, b). The pre-Albian age of these rocks is based on geochronological and biostratigraphic data. PIA-like rocks found in several localities of the Camagüey region are represented by the sedimentary-volcanic series of "Pre-Camujiro", which unconformly underlies the younger sections.

The second volcano-plutonic sequence developed from Albian to Turonian, its plutons dominated calc-alkaline fine- to mediumgrained diorites and granodiorites, forming large bodies like the massif SW of Florida village. A second group of plutonites consists of K-rich, syenitic and monzonitic rocks. Its K-rich plutons are intimately associated with gabbros like in the Camagüey massif. The syenites of the Camagüey and the Ignacio massifs were submitted to intensive metasomatic alterations with the replacement of plagioclase by K-feldspar, chloritization and formation of disseminated sulfides. Apart from other K-rich igneous rocks in the northern Caribbean, Central Cuba comprises the largest occurrence of K-rich plutonic and volcanic rocks within the Greater Antilles. Some porphyry copper-like mineralizations are related to the alkaline part of the intrusions.

The Camujiro formation (3,000 m thick) comprises all volcano-sedimentary rocks of the second sequence in the Camagüey region. The formation consists of basaltic, shoshonitic, trachybasaltic and trachyandesitic lavas, tuffs and tuffites with intercalations of carbonates with Albian fossils. The Middle Cretaceous sequence is disconformly covered by volcano-sedimentary rocks of the third, Santonian to Campanian sequence.

The Santonian and Early Campanian rocks are dominated by volcanoclastic sediments with intercalations of andesitic to rhyodacitic lavas. Two main rudist-bearing limestone units of Santonian and Campanian age are intercalated in the section. The sequence can be subdivided into various facies. The Piragua formation contains the proximal volcanics and sediments, the Aguilar formation represents the distal fine-grained volcanoclastic redeposited sediments. Age determinations (K/Ar) gave some dispersed results, but most of them represent Campanian cooling of the plutons.The Caobilla formation consists of dacitic to plagiorhyolitic lavas of various textures, tuffs, tuffites and only few carbonates. There is no fossil record, and the petrological evidences capable to reveal the formation environment are ambiguous. Therefore, the magma-tectonic position of the Caobilla formation is controversially discussed. The petrological and geochemical data of both plutonic and volcanic rocks (Fig. 3a,b) can be compared with the pre-Albian PIA-like formations of Las Villas. On the other hand, there is some geological evidence for a Coniacian(?) to Campanian age of the Caobilla formation (KERR et al. in press). The volcanic rocks are in tectonic contact with the ophiolite and were intruded by plutons. The intrusive bodies show a characteristic zonation of plagiogranites, tonalites and trondhjemites in the central part, surrounded by diorite and gabbro (Florida plagiogranites of Fig. 3a). They form a northern magmatic belt. Biostratigraphically defined contacts of base and hanging part of volcanics are unknown. Pebbles of plagiogranite have been found in Upper Cretaceous conglomerates in a drill hole east of Camagüey. The most characteristic feature of these plutons is the bimodal formation of Na-rich, K-poor mafic and felsic magmas with an affinity to tholeiites, contrasting to all the other igneous complexes of the Cretaceous island arc. Occasionally occurring magnetite skarns are related to the plutons.

During the last magmatic pulse, small stocks of biotite granite (Florida, Maraguan) and rhyolitic necks (La Sierra formation) intruded into the older formations and plutons. The La Mulata lavas presumably represent the basic counterpart of the last magmatic activity. Geochemical data of the biotite granites differs significantly from those of the older igneous suites, but match with those of late orogenic granites (LOG in Fig. 3a). LOG have also been found in Las Villas. The youngest igneous sequence is covered by Middle Campanian to Maastrichtian clastic and carbonate sediments.

Syn- to post-orogenic sedimentary basins

Foreland basins: Foreland basins developed on top of the Bahamas carbonate bank and the sediments of the continental margin. The first occurrence of ophiolitic and arc debris is recorded in Paleocene sediments in the upper parts of the sediments of the continental margin (zones of Placetas and Camajuaní). The basin on the continental margin involved in the arc-continent collision was filled with clastic debris both from the island arc and the continental margin during Paleocene and Lower Eocene times. In the Middle Eocene the foreland basins were overthrust by the ophiolite. On the Bahamas carbonate bank, Paleocene sediments are absent in the stratigraphic record, the deposition of clastics started only in the Lower Eocene. There are three formations, which comprise different facies and source regions of the clastic debris involved in the basin filling. The depositions terminated in the Upper Eocene; at this time the olistostromes (Senado formation) were overthrust by the ophiolite.

On top of the allochthonous units, several Paleocene-Eocene piggy-back basins evolved, composed of clastic and clastic-carbonate rocks. Some of these basins located above the ophiolites were strongly deformed during the late Middle and Upper Eocene.

Post-orogenic basins: Since the Upper Eocene, post-orogenic basins formed on top of the deformed basement of the island arc terrane. Three deposition cycles can be distinguished: from Upper Eocene to Oligocene, from Lower Miocene to Upper Miocene, and from Pliocene to Present times. Each cycle started with a transgression and the deposi-

tion of clastic sediments, the final sediments consisting of shallow-marine carbonates. With the cycles growing younger, depth and areal extension of the basins became smaller, until the studied geological record ended with the total uplift of the Camagüey region in the Holocene.

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