Muchos saludos

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Tectono-magmatic development of Central Cuba

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With 5 figures in the text

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Abstract: During the Cretaceous, at the northern margin of the Proto-Caribbean plate, a magmatic arc complex evolved, which today occupies large areas of Camagüey and Las Villas in Central Cuba. The island arc magmatites are stratigraphically, geochemically and according to their metallogenetic specialization subdivided into three volcano-plutonic cycles. As a result of the beginning subduction tholeiitic, sodic bimodal magmas rose in the Neocomian, followed by calcalkaline andesitic volcanics in the Aptian to Albian. In the Late Cretaceous calcalkaline and potassium-rich plutonic rocks prevailed. The magmatic development came to a halt during the collision of the island arc and the Bahama platform in the Campanian.

Zusammenfassung: Am Nordrand der Protokaribischen Platte entwickelte sich in der Kreide ein magmatogener Inselbogen-Komplex, der in Kuba hauptsächlich in den Gebieten von Las Villas und Camagüey aufgeschlossen ist. Die Inselbogen-Magmatite können stratigrafisch, geochemisch und metallogenetisch in drei vulkano-plutonische Zyklen gegliedert werden. Im Neokom ist die beginnende Subduktion durch die Bildung Na-betonter, tholeiitischer bimodaler Magmenserien charakterisiert. Im Apt und Alb dringen vor allem kalkalkalische andesitische Vulkanite auf. Nach einem Hiatus in der Magmenförderung am Ende der Unterkreide dominieren in der Oberkreide kalkalkalische und K-betonte Intrusiva. Die magmatische Entwicklung endet im Campan infolge der Kollision des Inselbogens mit der Bahama-Plattform.

Resumen: En el margen septentrional de la placa Protocaribeña un complejo de arco magmático se formó durante el Cretácico, en el presente aflorando sobre todo en las áreas de Camagüey y Las Villas de Cuba Central. Las rocas magmáticas del arco insular se pueden subdividir en tres ciclos vulcano-plutónicos tanto estratigráficamente como geoquímicamente y en su especialización metalogénica. En el Neocomiano la subducción inicial provocó la formación de un arco primitivo con un magma-

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tismo sódico-toleítico bimodal. Durante el Aptiano y Albiano subieron rocas vulcanógenas andesíticas, principalmente calcoalcalinas. Después de un híato magmático en el Albiano Superior cuerpos intrusivos tanto calco-alcalinos como rocas ricas en potasio predominaron. El desarrollo magmático finalizó en el Campaniano por la colisión del arco insular y la plataforma Bahámica.

Introduction

The geological structure of Central Cuba was created when the Proto-Caribbean plate collided with the southern margin of the North American plate, and the North Caribbean island arc was thrust onto the Bahama platform in the Late Cretaceous - Tertiary. In Central Cuba three Mesozoic tectono-stratigraphic units can be distinguished. In the northern coastal edge the "autochthonous" marine carbonate and chert series of the Bahama platform are situated. These sediments comprise a complete stratigraphic column from the Upper Jurassic to Maastrichtian and were

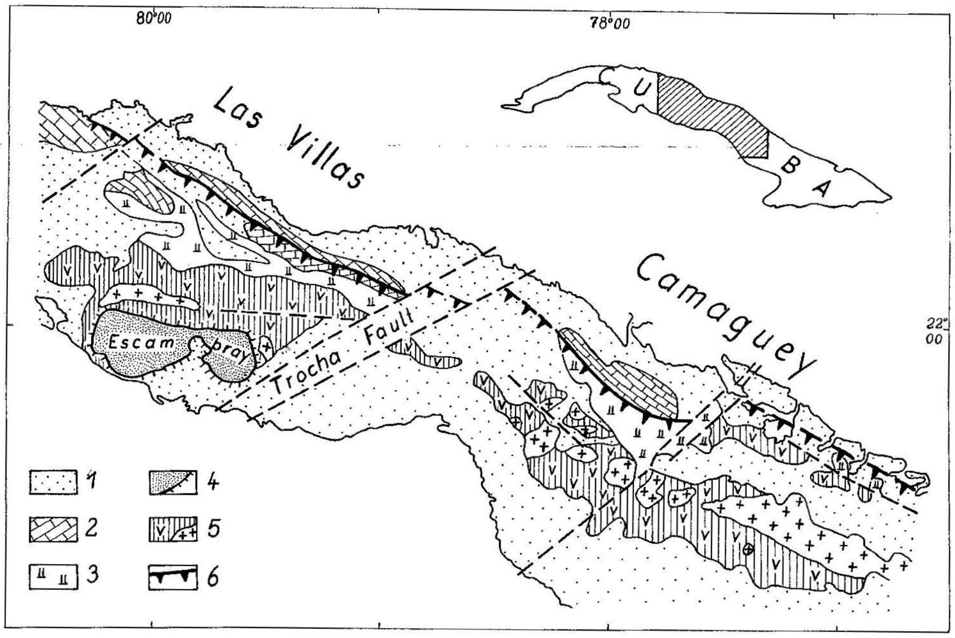

Fig. 1. Outcrop distribution of Meso-Cenozoic tectono-stratigraphic units in Central Cuba. Autochthonous units: 1 - undifferentiated Posteocene sedimentary cover; 2 - Jurassic to Cretaceous carbonates of the Bahama platform. Allochthonous units: 3 - ophiolite complex; 4 - metamorphic complex of the Escambray; 5 - volcanics and plutonics of the Cretaceous island arc assemblage; 6 - Central Cuban main thrust.

folded with northern vergency in the Early Tertiary (KNIPPER & CABRERA 1974). To the south, the Central Cuban main thrust bounds the marine sediments against the "allochthonous" units, the ophiolite complex and the Cretaceous island arc.

The present paper concentrates mainly on the magmatic development in the Cretaceous island arc (CIA) in Central Cuba (Fig. 1). In the past ten years, the magmatic rocks of the CIA were the subject of various geological investigations and field parties. In Las Villas, basic geological mapping was done by two Cuban-Czechoslovakian expeditions (STANIK et al. 1981, DUBLAN & ALVAREZ et al. 1986) and a Cuban-Bulgarian expedition (VASILIEV & ARCIAL 1989), whereas in Camagüey this was done by a Cuban-German field group (ITURRALDE-VINENT & THIEKE et al. 1987).

Tectonic structure of the Cretaceous island arc

Rocks of the CIA assemblage crop out in two areas of Central Cuba: Las Villas and Camagüey, which are separated from each other by the NE-SW trending Cenozoic Trocha fault. The Trocha fault acts like a boundary between different structural stages in the CIA (Fig. 2).

East of the Trocha fault, in the Camagüey area, the rocks of the CIA are mainly preserved in "parautochthonous" weakly folded and imbricated thrust sheets, forming a megamonoclinal structure. Particularly in the southern part of Camagüey, NW-SE trending volcano-sedimentary basins can be reconstructed on the basis of aerial photographs. The main magmatic axis of the CIA is marked by both syenitic to monzonitic and gabbroic to granitic intrusive bodies, which are accompanied by smaller

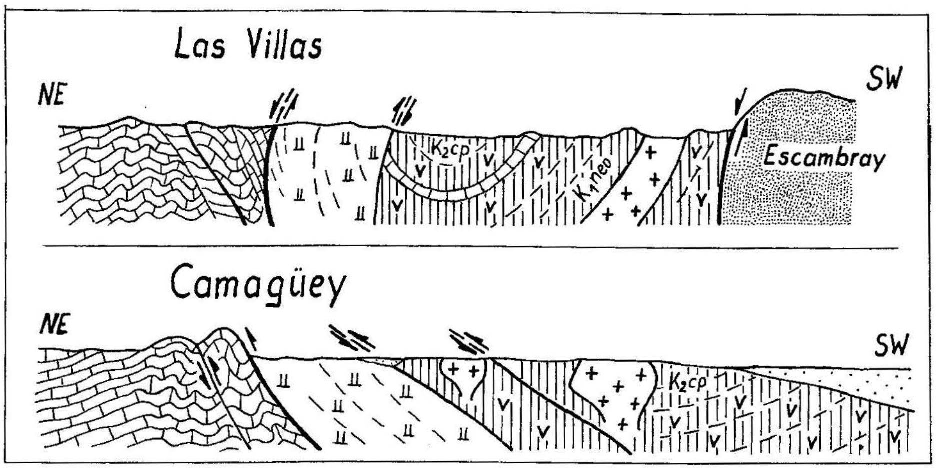

Fig. 2. Schematic cross-sections of the Cretaceous island arc in Central Cuba, showing a megasynclinal structure in the western part and a megamonoclinal position of the island arc east of the Trocha fault (for symbols see Fig. 1).

granitoid stocks in regular distance in the southern "back-arc area". Sodic, bimodal magmatic rocks are widespread north of the main magmatic axis south of the Central Cuban main thrust. The intrusive bodies of these sodic magmatites show a typical zonation with a plagiogranitic core and mafic marginal parts.

The megasynclinal structure of the island arc in Las Villas is probably caused both by thrusting during the obduction and the isostatic uplift of the subducted, metasedimentary Escambray complex in the south. Near the contact to the Escambray complex, the lowermost part of the CIA (Mabujina amphibolites) is intensely sheared and cataclastically deformed; in contact-parallel striking faults mylonized and serpentinized lens-shaped ultramafic bodies preferentially occur. To the north the intensity of deformation decreases, the Cretaceous volcanics and volcanoclastics generally dip NE to the WNW-ESE trending syncline of Seibabo. The megasynclinal structure of the CIA in Las Villas allows an almost complete reconstruction of the stratigraphic column (LILAVATTI & DILLA 1985).

Stratigraphic overview

In Central Cuba the island arc assemblage can be subdivided in three volcano-plutonic cycles (VPC) which differ with regard to their type of magmatism and petrochemical characteristics.

The probably lowermost formations of the CIA crop out north of the Escambray complex and comprise the so-called Mabujina amphibolites, chloritized and amphibolized basaltic volcanics and mafic intrusives (SOMIN & MILLAN 1981). In low-grade metamorphic sediments and volcanoclastics Middle to Late Mesozoic sporomorphs are found (DUBLAN & ALVAREZ et al. 1986); i. e. a postulated pre-Mesozoic metamorphic basement does probably not exist in the southern part of Central Cuba. The upper part of the first VPC consists of bimodal rock series (LILAVATTI 1988). These rock series comprise an alternation of basaltic and plagiorhyolitic volcanics and pyroclastics, intruded by mafic and plagiogranitic plutonites. At the top of the first VPC subaerial felsic pyroclastics and shallow-marine carbonates occur both in Las Villas and Camagüey. Biostratigraphic data are still lacking, only rare K-Ar age determinations of plutonites indicate an Early Cretaceous age of the bimodal sodic magmatites (ITURRALDE-VINENT et al. 1989, own unpubl. data). In comparison with the "primitive island arc"-volcanics (PIA) of Puerto Rico (DONELLY & ROGERS 1980), the Duarte, Maimon and Amina formations of Hispaniola (BOWIN 1975, SOLER & CHEILLETZ 1985), we assume a Neocomian age for the first VPC.

In the Aptian the volcanics of the second VPC followed concordantly over the sodic, bimodal series. The widespread submarine basaltic to andesitic lava flows and volcanoclastics mark a change in the geochemical trend from tholeiitic to calcalkaline in the second cycle. Plutonic rocks are observed very rarely. A characteristic sequence of biogenic, clastic and shallow-marine carbonates and volcanomictic sandstones and conglomerates forms the top of the second VPC. The Upper Albian carbonates show similarities to those of Hispaniola (Hatillo limestone; BOURDON 1985) and the Río Matón limestone in Puerto Rico (KERDRAON 1985).

In the Cenomanian the third VPC began with extrusions both of calc-alkaline and high-potassium volcanics, ranging in composition from basaltic to felsic and to "shoshonitic" rocks. In general, pyroclastics and sediments in shallow-water to subaerial environments dominated over lava flows. In comparison with the older VPC the plutonic activity expanded and reached the climax in the Coniacian to Lower Campanian. At this time the main magmatic axis of the CIA was marked by multiple intrusions both of calcalkaline and high-potassium igneous rocks. In the Campanian the magmatic development of the CIA came to an end with the emplacement of felsic lava flows and necks, and the intrusion of small granitic bodies.

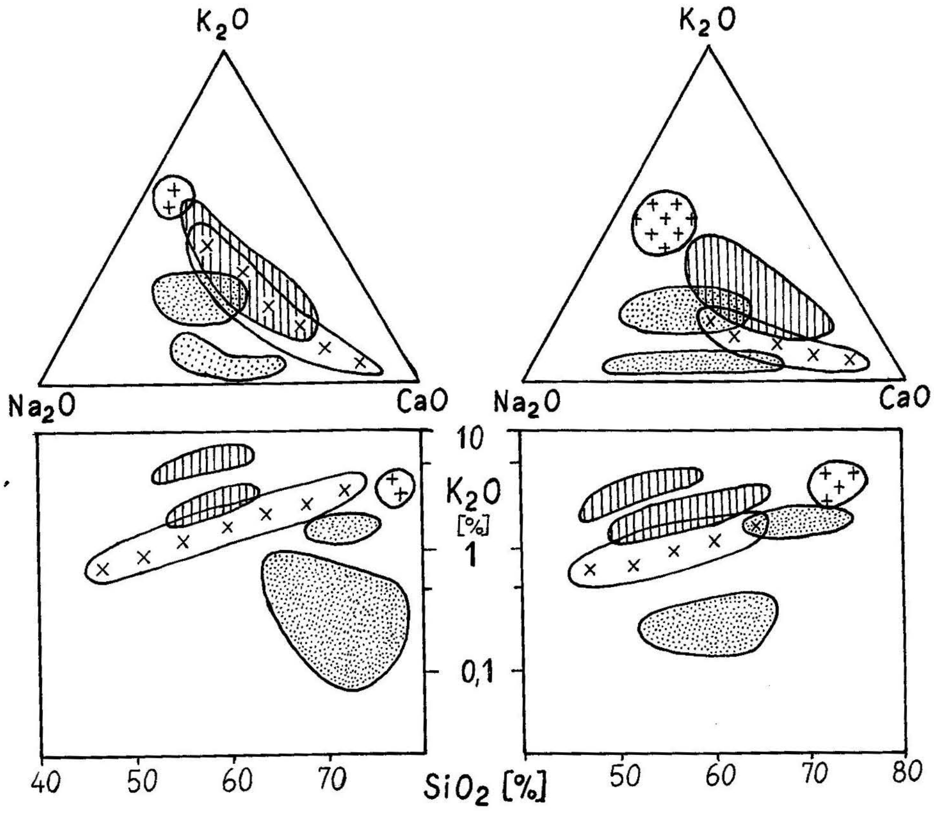

Fig. 3. Alkali and K_2O/SiO_2 diagrams of Central Cuban island arc plutonics (left) and volcanics (right). Dashed: Lower Cretaceous sodic bimodal rocks; lines: Lower to Upper Cretaceous calcalkaline rocks; X: Upper Cretaceous K-rich ("alkaline") rocks; +: uppermost Cretaceous low-Fe granites and rhyolites.

Geochemical characteristics

Major element data mainly exist from the volcanics and plutonics of Camagüey (about 350 samples), however trace element data are still mostly lacking for this area. In Las Villas, a geochemical subdivision of the island arc volcanic rocks was made by LILAVATTI (1988). Petrology, field relations and the petrochemical data indicate a 3-group classification of the CIA magmatism (see Figs. 3 and 4).

The first group includes both volcanic and plutonic rocks of the sodic bimodal series; the geochemical characteristics are chiefly tholeiitic. In Las Villas, the volcanics of the Los Pasos formation show a well limited distribution of mafic and felsic members in the SiO_2 histogram. The most distinctive characteristics of the first group in relation to similar calc-alkaline and alkaline rocks are the low K_2O contents of the intermediate and siliceous rocks (Fig. 3). The magmatites of the first group are comparable to the PIA suite of DONELLY & ROGERS (1980).

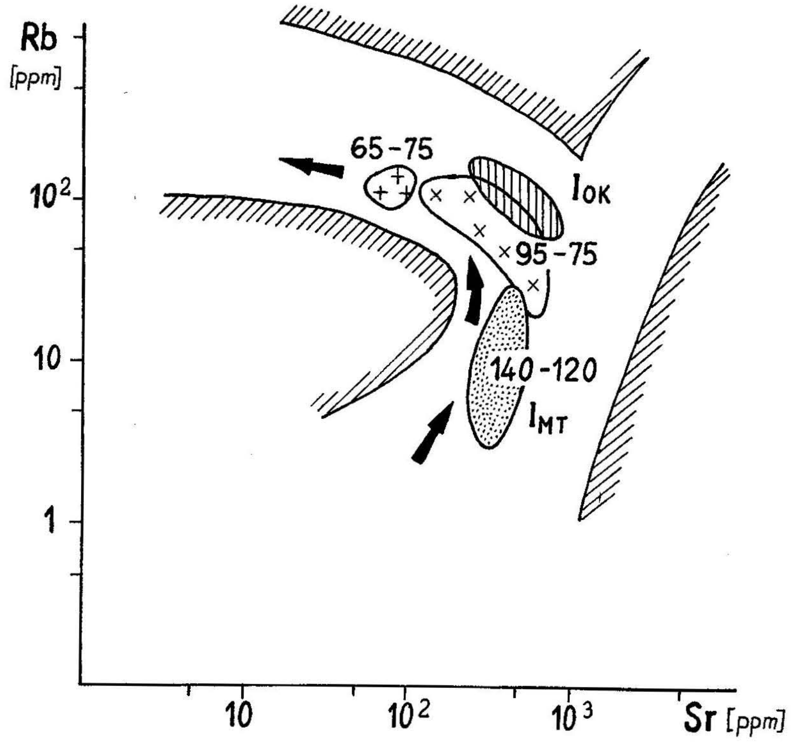

Fig. 4. Rb/Sr distribution of Central Cuban island arc igneous rocks and related K/Ar data, showing the trend of "active plate boundaries" by TISCHENDORF & PÄLCHEN (1985), from Lower Cretaceous sodic to Upper Cretaceous calcalkaline and "alkaline" rocks (for symbols see Fig. 3 and the text).

The second group comprises the calcalkaline and potassium-rich igneous rocks of Late Cretaceous age, and great parts of the mafic to intermediate volcanics of the Aptian and Albian. On the AFM diagram the second group follows the same general trend as the first group. Up to now we do not have sufficient data to separate genetically the "alkaline" rocks from the calcalkaline ones. The only difference is apparently the higher K_2O content in the "alkaline" rocks. This is why both calcalkaline and potassium-rich rocks are united in one geochemical group.

The third group contains some Campanian felsic volcanics and granitic stocks. These siliceous rocks are low in Fe and are lacking intermediate and mafic members.

A genetical classification by TISCHENDORF & PÄLCHEN (1985) is shown in Fig. 4. The Rb/Sr relation of volcanic and plutonic rocks, combined with the available K-Ar data indicate a trend from a Neocomian tholeiitic bimodal magmatism (I_{MT} - "Intrusive mantle granitoids of the tholeiitic series") to Upper Cretaceous calcalkaline and potassium-rich igneous rocks (I_{OK} - "Intrusive granitoids of the ocean crust" by the above mentioned authors) at active convergent plate margins. The low Fe granites and rhyolites of the third group occupy a distinct position in the diagram.

This classification is in good agreement with the metallogenetic specialization of the magmatic series (CABRERA 1986, ITURRALDE-VINENT & THIEKE et al. 1987):

- a sodic, bimodal, tholeiitic series with Fe-specialization (massive pyritic sulfide deposits and magnetitic skarns),
- a calcalkaline and potassium-rich series with Cu-Au specialization (porphyry copper type deposits).

Plate-tectonic model

The North Caribbean island arc evolved at the boundary between two lithospheric plates: the Proto-Caribbean plate of oceanic crust and the North American plate. On the basis of present data, we agree with models as proposed by authors from MALFAIT & DINKELMANN (1972) to HAYDOUTOV (1986) and ROSS & SCOTESE (1988) who suggest a southwest-dipping subduction zone at the northern border of a "Pacific" oceanic plate segment, which consumed the oceanic crust formed by rifting between North and South America. The plate-tectonic reconstruction of the island arc development in Central Cuba comprises four stages (Fig. 5).

Neocomian (?): Start of subduction along a hypothetical transform fault, which separated the "Pacific" and "Atlantic" oceanic plate segments. A temporal extensional tectonic regime during the beginning subduction, the passage of the snout of the northern slab below the later arc allowed the formation of sodic, bimodal tholeiitic magmas and caused the isostatic uplift of the evolving arc in the Upper Neocomian.

Aptian to Albian: The ongoing subduction formed a submarine magmatic arc with basaltic to andesitic volcanism. The zone of maximum magmatic activity migrated inward to the south. In the Late Albian the volcanism came to a halt and widespread shallow-marine carbonates occurred.

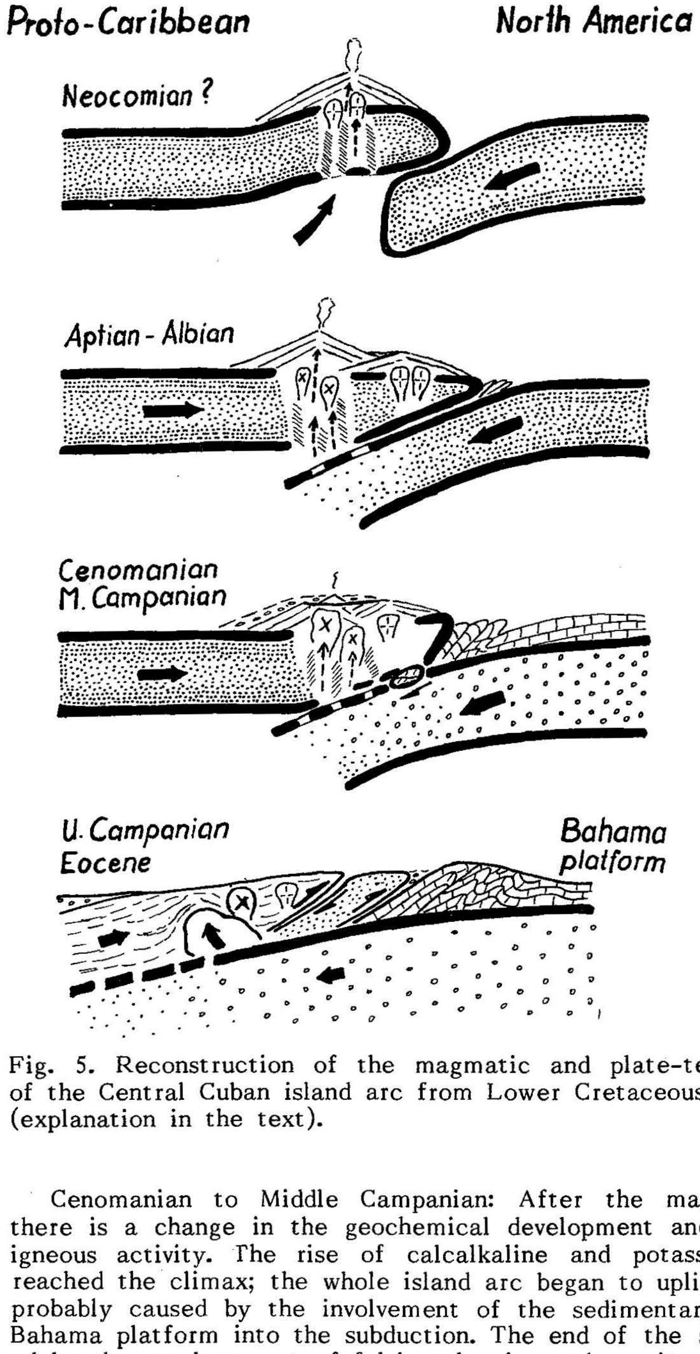

Fig. 5. Reconstruction of the magmatic and plate-tectonic development of the Central Cuban island arc from Lower Cretaceous to Lower Tertiary (explanation in the text).

Cenomanian to Middle Campanian: After the magmatic interruption there is a change in the geochemical development and characteristics of igneous activity. The rise of calcalkaline and potassium-rich plutonites reached the climax; the whole island arc began to uplift. This process was probably caused by the involvement of the sedimentary fan south of the Bahama platform into the subduction. The end of the subduction is marked by the emplacement of felsic volcanics and granites.

Late Campanian to Middle Eocene: Obduction of the island arc and the fore-arc limb onto the southern edge of the Bahama platform. Structure-forming process in the CIA by thrusting (in Camagüey) and by isostatic uplift of a subducted metasedimentary complex (in Las Villas).

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