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Project 433
Caribbean Plate

Caribbean Plate Tectonics

Duration and status: On going (2000-2004)

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1. Website address related to the project

www.ig.utexas.edu/CaribPlate/CaribPlate.html

The web site displays the information concerning the project, including project logo, project description, past events and reports, future meetings, Caribbean bibliography, Caribbean models comparison, interesting information, and forum. The FORUM section contains important papers and ppt presentations about the Caribbean Plate Tectonics. The site is regularly updated in order to keep the scientific community informed about the progress of the project.

2. Summary of major past achievements of the project

The scientific problems that have been debated in previous meetings of the Project 433 are of two categories: 1) General, concerning the basic tenants of the plate tectonic reconstructions 2) Local, related to the interpretation of particular areas.

General Problems

-The Galapagos hotspot and Caribbean plateau.
-The early opening of the Caribbean and Gulf of Mexico: an issue of time and space.
-The autochthonous vs. allochthonous origin of the Caribbean plate
-The problem of time and space in the reconstruction of tectonic terranes

<u>The Galapagos hotspot and Caribbean plateau</u>. As we made clear in last year's report, there are two fundamental points of view regarding the role of the Galapagos hotspot in the geology of the Caribbean, which were the subject of extensive debate in Stuttgart and Leicester. One group holds that the Galapagos hotspot has nothing to do with the ProtoCaribbean crust or the Caribbean Plateau basalts, because the hot spot was always positioned west of both of them, and, consequently, was not the source of the so-called Caribbean plateau basalts. The other interpretation holds that the Galapagos hotspot actually produced the Caribbean plateau basalts and the ridges within the Nazca and Cocos plates. Pindell and Kennan's (2002) newly published reconstructions do not agree with the point that the Galapagos hotspot produced the Caribbean plateau basalts. Trace element and isotopic geochemistry, however, do not rule it out (Leicester's meeting report).

<u>The problem of the early opening of the Caribbean and Gulf of Mexico: an issue of time and space</u>

Paleontologic data and biogeographic interpretations strongly suggest that probably since Hettangian, more certainly since Pliensbachian, there was a periodic marine biotic exchange between the western Tethys and the eastern Pacific across central Pangaea. This fact is hard to reconcile with the present models for the time and rate of the break-up of Pangaea. A possible solution is that this biotic exchange may have taken place along the latest Triassic--Jurassic rift valley system within present-day North America. This situation has to be further explored.

<u>Autochthonous vs. allochthonous origin of the Caribbean plate</u>

During every meeting there have been strong debates regarding this problem with authors placed on both ends. In the last meeting in Barbados James Keith championed the autochthonous position, but there are other authors which also follow this point of view, meaning that the allochthonous do not satisfy yet all the expectations.

Generally the allochthonous concept has gained momentum in the last years, but many problems remain with this type of model. Most of these problems are strongly related to the availability of hard data about some local areas in the region.

For example James Keith raised a group of questions regarding the allochthonous origin of the Caribbean Plate. Following are some of the points raised by James (FORUM www.ig.utexas.edu/CaribPlate/CaribPlate.html):

1. Jurassic rift directions on the Maya Block conform with regional extensional strain in North and South America and in the intervening area. They show that the Block has not rotated, a requirement of the allochthonous models.

2. The ocean crust in the Gulf of Mexico follows the same extensional trend and broadens somewhat to the east. If the Maya Block had rotated, this crust would broaden markedly to the west, which it does not.- It is geometrically impossible for a 3,000 kilometers long, straight arc to enter the Caribbean and assume its strongly curved configuration without intense compression of the Caribbean Plate, on which it sits. In fact the Caribbean Plate is highly extended.
3. It is geometrically impossible for the Chortis Block to migrate SE-wards into the Central American location at the same time as the CaribbeanPlate is supposed to be migrating northeastwards.
4. Northward transport of the (South America derived) Middle Eocene Scotland Group sands of Barbados was stopped by the Tiburón Rise, on top of which coeval sands occur (DSDP drilling results; drilling 19 km to the north did not find these sands). The Rise lies on the Atlantic Plate. The relationship shows that the Scotland Group accumulated close to its present location and not north of the Maracaibo area.
5. Coeval Maastrichtian - Middle Eocene clastics throughout Middle America record a regional convergence event that cannot be explained by the allochthonous model, which attributes diachronous flysch deposition to entry and passage of the plate.

Local Problems

- The nature, historic position and palinspastic reconstruction of tectonic terranes as Chortis, Andean, Piñón-Dagua, Guaniguanico, Escambray, Pinos.
- The nature and historic position of ophiolites and related terranes
- The Geometry of the Arcs
-The conception of a single Great Arc vs. Multiple Arc evolution of the volcanic terranes.
- The polarity and polarity flip of the volcanic arcs
- The time span of the arcs' magmatic activity

<u>The nature, historic position and palinspastic reconstruction of tectonic terranes as Chortis, Andean, Piñón-Dagua, Guaniguanico, Escambray, and Pinos</u>

Many early plate tectonic models of the Caribbean ignored the CSWT, but fortunately, they have been taken into account in more recent versions. However, as demonstrated by the lively discussion at the Havana meeting in March 2001, the geology of the CSWT is still too poorly known to be interpreted without ambiguity. More field and laboratory research focused on the petrology and internal structure of the Socorro (Grenvile), Escambray, Purial and Pinos metamorphic terrains, as well as on the stratigraphy and tectonic position of the Placetas and Rosario belts (terrains) are urgently required before a fair interpretation of the origin of these geologic units can be reached. Available P-t path studies, isotopic dating and geochemical data for the Escambray and Purial are still insufficient.

CHORTIS: During the meeting in Guatemala, there were several presentations to show that the basement of Chortis and the Mexican terranes are quite different, a fact difficult to reconcile with the alleged original position of Chortis in contact with the Mexican terranes. But in Austin P. Emmet presented new data about Chortis. Asked If there is direct evidence for the alleguedly large displacements along the Motagua-Polochic fault zone according to his research in Honduras he expressed that: "Today there are no (or not yet) evidence for the alleguedly large displacements along the Motagua-Polochic fault

But I hope that some evidence, perhaps indirect, may be forthcomming from my work. But as I see it, the big questions with regard to Chortis are:
a) Where did the Chortis block start out (let's say, prior to the Middle Jurassic time)?
b) Is there any direct evidence (paleomagnetic? correlation of basement terranes? pre-Cretaceous stratigraphic continuity?) to place Chortis unambiguously within a pre-Cretaceous reconstruction? I hope so, but I haven't done the work to demonstrate this (yet). I know that the same middle Jurassic (Bajocian) ammonites are found in Agua Fria strata in Honduras (Ritchie and Finch, 1985) as are found in Colombia (Bartok and others, 1985) and that lots of workers put these two 'blocks' close together in reconstructions for that time period (Dickinson and Lawton, 2001; Cediel and others, in press <AAPG volume in press on Caribbean>).
c) Since the early Cretaceous, what do stratigraphic facies relationships suggest regarding the relative positions of previously adjacent terranes (southern Mexico, Chortis, Colombia/N. South America)? Clearly this is also a question of paleomagnetic records within these strata (it might be true that the Jur-Cret-early Tertiary strata of Chortis have been significantly undersampled to be able to say with confidence what a polar wander pathway for the block should look like; is there more than one block?).
d) Is there any other explanation for the evolution of the Swan transform and Cayman trough basins that do not require large displacements along the M/P fault system?
P. Emmet also pointed out, concerning the different basement of Chortis and Mexican terranes the following: "I am quite sure that there are at least a few provinces within the Chortis block in which the basement characteristics are lithologically, mineralogically and magnetically distinct from one another. I do not have a problem visualizing how these distinct basement types might have evolved across an area the size of Chortis (collage tectonics along a convergent pre-Cretaceous margin?) and so I would imagine that the major basement heterogeneities predate the mid-Jurassic rifting of NOAM / SOAM and the dismemberment of Chortis and perhaps some other basement blocks (Maya, etc). It would seem reasonable to me to think that these basement heterogeneities might be correlated across a number of basement blocks in order to reconstruct the pre-Cretaceous location of the Chortis block. It must be kept in mind, however, that the magnetic character of basment may be easily overprinted later by igneous intrusions or by the tectonic emplacement of magnetic rocks (ophiolites). The most interesting observation from the country-wide aeromagnetic data base of Honduras (not illustrated in the data shown in my presentation to UTIG of 20 Sep 02 which focused only on the most eastern part of the country) is the distinction between highly magnetic basment in the north and weakly magnetic basement in the south. Clearly, it is problematic to distinguish the impact in the magnetics of the numerous igneous intrusions and volcanic flows in the north (Horne, 1976b; Manton and Manton, 1984) from the magnetic signature due only to the high(er) grade metamorphic basement (Horne and others, 1976a; Manton, 1996), as compared to the lower grade pelitic schists in the south (Fakundiny, 1970). But I suspect that careful work on documenting and distinguishing the basement rocks of the Chortis block would enable a comparison to the basement rocks of southern Mexico and/or Colombia in order to test proposed reconstructions. I don't think that this has yet been rigorously done."
CUBAN SOUTHWESTERN TERRANES: Despite the fact that we believe that these are allochthonous terranes, their original position is a matter of very different interpretations.

There is no way of rebuilding the early configuration of Pangeae if we do not solve this problem. This is an issue that now is a matter of research by dating and Pt path of metamorphic rocks, so we will soon have best data to address this problem.
PIÑON-DAGUA-SIQUISIQUE TERRANES: The original position of these terranes is a matter of very different interpretations and are poorly constrained. But the position of both the Siquisique and Penon-Dagua must be resolved in order to understand the evolution of the Caribbean.

Time and space constraints during the reconstruction of tectonic terranes

There is a regular problem in the treatment of time and size regarding the evolution of tectonic terranes in many plate tectonic reconstructions of the Caribbean region. For example, the size of the Jurassic and Cretaceous basins represented by the stratigraphic sections of the Guaniguanico terrane, went through a process of extension during the Mesozoic, and were compressed and piled as a stack of thrust sheets during the Early Cenozoic. Therefore, the present size of the Guaniguanico terrane can not be extrapolated to the Mesozoic. BUT, is a common method to keep present-day size when the terrane is re-located to its alleged original position. The same is true for the Escambray and Pinos terranes.

The nature and historic position of the Caribbean ophiolites

To understand the origin of the Caribbean, it is necessary to identify the nature and provenance of the ophiolites and related igneous complexes within the area. Latest petrological research has produced new data that strongly complicate our original views. In Cuba, the so-called northern ophiolite proved to be a tectonic mixture of several different tectonic units. The same complex picture arose in Guatemala, Dominican Republic and Puerto Rico. New data, being published in recent years, also follow the same trend of discovering complexity where simplest models were applied.

For example, a growing amount of data strongly suggest the occurrence of back arc magmatic rocks in the Cuban northern ophiolites, but also there are indications of the presence of suprasubduction magmatic rocks probably arc related. At the same time, there are indications of a minimum of two ocean crustal elements, probably due to two distinct stages of oceanic spreading. These issues have to be properly addresses in the future, as they have no place in present plate tectonic models.

Albian-Campanian arc in Central America

Another controversial subject is the existence of an active Albian-Campanian island arc in Central America. But growing evidence suggest that actually such Albian-Campanian island arc occur as part of present-day southern Central America. The presence of a Central American mid-Cretaceous arc surely reduced the rate of relative eastward movement of the Caribbean plate respect to North and South America.

The Geometry of the Arcs

During the meetings in Rio de Janeiro, Stuttgart, and Cuba the geometry of the arc was the subject of consideration. A debate arose concerning the characteristics of the Greater Antilles- Aves Ridge- Lesser Antilles Cretaceous-Paleogene volcano-sedimentary complexes and the fact that the components of the original arcs (backarc, axial arc, front arc, subduction suture) are not evident in any cross-section of the present-day islands. The issue is that the arcs have been deformed by combined thrusting, extension along the axis, and were subsequently subdivided into distinct terrains that were the subject of rotation and eastward transportation. Consequently, the original geometry of the arcs are no longer represented by today's outcrops and their elements can only be found along specific islands of the chain.

If there is a single arc evolving from Cretaceous to Recent, why f are there important unconformities and interruptions of the magmatic activity, why many reorientations of the axis of the arc? This is a problem that has not been properly addresses, and has been pending since the beginning of the project. This matter will be the subject of attention in several forthcoming meetings.

The Great Arc vs Multiple Arc concept. Pindell's Caribbean models show a single "Great Arc" evolving from Cretaceous to recent as the leading edge of the Caribbean plate progressively occupy the space created by the separation of North and South America. Another concept is that there were multiple arcs that evolved step by step from Cretaceous to Recent. The Multi Arc concept evolves from the following ideas:

a. The occurrence of several magmatic and stratigraphic gaps within the Greater Antilles-Lesser Antilles volcano-sedimentary sections and the presence of unconformities at different time intervals on the various islands.

b. Modification of the geochemistry of the arc magmatism after some of these gaps, especially in Cuba. However this does not apply to all of the tectonic breaks in Puerto Rico.

c. Modification of the orientation and geographic distribution of the arc magmatic axis after each gap, but especially after the earliest Cretaceous boninite and IAT arc, and after the Cretaceous arc.

The polarity of subduction of the Caribbean plate in Cretaceous time has been an intriguing topic since Mattson in 1979 proposed that a reversal in subduction direction occurred during plate development. A summary of the evidence relevant to a reversal and the possible timing of the event is given by Jolly et al (1998). Most models seemingly require a change in subduction direction. For example, Pindell proposed a flip in the polarity of the arc at about 120 Ma. However, several researchers consider that the polarity took place in different times. Those investigating the origin of the plateau basalts disagree because a thick buoyant oceanic plateau would be very difficult to subduct, and would therefore significantly affect the subduction polarity reversal. They cite the arrival of the buoyant and thick Caribbean plateau at the eastward dipping subduction zone as a mechanism for the flip, in a situation analagous to that seen in the Solomon Islands with the attempted subduction of the Ontong Java oceanic plateau. However, the Pindell and Kennan (2002) model suggests that the 120 Ma polarity reversal occurred before the bulk of the plateau was formed, on the basis of the following pieces of evidence:

a. Abundant evidence for a large tectonic event around that time.

b. Unconformities in many arc-related sequences at ca. 120 Ma.

c. P-T paths from high-pressure metamorphic rocks.

d. Change in geochemical character from PIA to CA in many circum-Caribbean arcs.

e. The earlier the flip occurred, the easier it would occur tectonically. At 120 Ma, the arc would have been short and straight and there was a powerful potential mechanism available (the acceleration of the opening of the Atlantic. At 75 Ma, the arc was ~2000km in length, and may have been very highly arcuate in shape, which would require huge internal deformation as the convex side changes from the SW to the SE. However, in the discussion at Leicester it was conceded that there is growing evidence for an earlier pulse of plateau magmatism around 130-120 Ma. If that is the case, an earlier plateau could have formed and caused the postulated subduction flip, and the later plateau building events (78, 90 Ma) could have represented the last pulses of magmatism. Other authors also disagree with the subduction reversal because this flip does not explain the geochemical evolution of the Cretaceous arc magmatism in Cuba (Iturralde-Vinent, A. Kerr), or the tectonics of north central Cuba. Iturralde-Vinent has postulated a major change in the geometry of the convergent plate boundary between latest Campanian and Paleocene, involving deformation and almost complete extinction of arc volcanism, modification of the trend of the arc axis, and a major change in the orientation and geochemistry of the arc.

The polarity of the Paleogene arc in eastern Cuba has been proposed to be both North dipping and South dipping. But the North to South dipping model is just ignored and not properly debated by those with a different interpretation. We will dedicate a field workshop to address this issue. Pindell, Mann and other Caribbean plate tectonic modelers hold the position that the subduction zone of the Paleogene arc was located north of the arc and with a dip to the south. Another group (Iturralde-Vinent, Sigurdson) presented evidence that the Paleogene subduction zone dipped north and was located south of the arc. Recent geochemical, geochronological and paleontological research in the area favor the subduction from the south model; the fact that the Paleogene arc developed after a Maastrichtian gap in the magmatic activity; and with a distinct orientation with respect to Cretaceous volcanism.

The time span of the arcs' magmatic activity

In general, arcs last just few tens of millions of years, for example in the western Pacific. The same picture arose if we measure the time elapsed between unconformities within the Cuban arc. The same unconformities found in Cuba during the Aptian-Albian, Santonian-Campanian, Maastrichtian-Paleocene and Middle Eocene have been described in Hispaniola, Puerto Rico and Jamaica. More attention has to be paid to these unconformities and their bearing in the evolution of the arcs. Also, data have been provided regarding the possibility of change not only in polarity, but also in trend of the axial part of the arc. The present set of "single arc" models do not fully account for these changes in orientation.

Questions to be addresses in future meetings:

Concluding, some of the problems that remain to be solved, or at least require further discussion and agreement, are:

(A) Is there one or several plateau basalts events in the Caribbean?

(B) If the Galapagos Hot Spot is unrelated to the origin of these plateau basalts, then how did the plateau basalts form?

(C) Is the thick Caribbean crust a result of a mantle plume, the result of plate superposition by subduction, or are there other causes?

(D) Is there a section of Lower Cretaceous volcanic arc rocks in southern Central America?

(E) What and where are the relicts of the original ProtoCaribbean crust?

(F) Are these relicts present within or adjacent to the ophiolite belts along the plate boundaries?

(G) Are the Aptian-Albian, Santonian-Campanian, Campanian-Maastrichtian, Lower Paleocene and Middle-Late Eocene unconformities in the volcanic arc sections of a single or of different origins?

(H) Is the prominent unconformity in the Aptian-Albian volcanic arc sections of regional extent and is it related to a change in arc polarity?
(I) Is there a single volcanic "Great Arc" since the Aptian-Albian to the Present, or there were several arcs evolving as in circum Pacific region?
(J) Are the Cuban Cretaceous and Paleogene volcanic arcs a single back arc (main Cuba)-axial arc (Sierra Maestra) couple as proposed by Pindell?
(K) Are they instead two distinct arcs, as suggested by geochemistry, petrology and classic regional geology?
(L) Is there any true axial arc section in the Paleogene rock suites of Hispaniola and Puerto Rico-Virgin Islands?
(M) Are the Paleogene igneous rock suites in Hispaniola and Puerto Rico-Virgin Islands of back arc or front arc instead of axial arc?
(N) Did the Yucatan basin actually open during the Paleogene?
(O) Did this proposed Paleogene event fracture and subdivide the Cuban volcanic arc igneous suites into two branches so that now one suite is the main Cuban island arc (back arc setting) and the other Sierra Maestra-Cayman ridge arc (axial arc setting)?
(P) Are the Cuban Southwestern allochthonous terranes (Guaniguanico, Pinos and Escambray) deformed crustal sections of the ancient margin of North America?
(Q) If so, where were their original locations and do they actually represent ancient basins that are now deformed and superimposed as a stack of thrust units?
(R) Why do some models show these terranes as being of the same size in both the Mesozoic and the Present?
(S) How and when were these terranes emplaced to their present position?
(T) Where they just dragged, according to the allochthonous model, as crustal fragments in front of the leading edge of the Caribbean Plate?
In fact, it is possible to add many more questions, but this can be a never ending exercise. We need, in future years, to start discussing some of these issues within the egroup, and by this method, bring our debate to a new level and to reasonable conclusions.
During the business meeting in Barbados, scheduled as the Annual Meeting for this year 2002, two major issues were evaluated: The need to start working on the preparation of the final memoir of the Project. In this regard, potential contributors are requested to start thinking about their papers in three lines:
1. Historical evaluation of Plate Tectonics in the Caribbean,
2. Caribbean Plate Tectonic Models,
3. Papers contributing with hard data bearing on the understanding of the Caribbean geological evolution.
The second subject was to remind all project members to acknowledge IGCP Project 433 membership in their papers. Unfortunately, even some major contributors to the project forget to add this line in their abstracts and papers.
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3. Achievements of the project Year 2002

3.1 List of countries involved in the project (countries active this year)*

At the present time there are about 200 scientist involved in the project, as in previous years, but with different degrees of participation. They belong to the following countries: Canada, USA*, Mexico*, Guatemala, Nicaragua, Costa Rica*, Panama, Perú, Venezuela*, Colombia*, Argentina*, Trinidad & Tobago, Barbados, Puerto Rico*, Jamaica*, Dominican Republic*, Cuba*, Poland, Hungary, Italy*, Germany*, France*, Spain*, United Kingdom*, Japan, New Zealand*.

3.2. General scientific achievements

This year we held scientific workshops and presentations and provided extra time for debates, with great success in terms of clarification of individual opinions and interpretations. Communication among Caribbean scientists have been very active, and successful. We have exchanged ideas, information and begun new projects. Also we have been able to incorporate a group of PhD students to investigate subjects related to Caribbean Plate tectonics.

Working groups were active as before. However, we have never emphasized them in the past, but they are listed on our web page and in the 2000-2001Annual Report.

The working group of Petrology and Geochronology was very active both in meetings and carrying out the following research projects: two Cuban-Spain projects, one Dominican Republic-Spain-France project, one US-Virgin Islands project, etc.). The working group of stratigraphy and paleontology presented and debated important papers in Havana (2003), and previously also in Havana (2001) and Barbados (2002); field research was carried out on Jurassic marine and terrestrial reptiles in Argentina and Cuba, supported by National Geographic Society, and investigations of Cretaceous rudist suported by NGO. The working group on Plate Tectonics Interpretation is very active. The group meets every year, and during 2003 they met in Havana, Freiberg and Barcelona. In the web page there is a section concerning plate models of the Caribbean, and 3 new models were added during 2003.

For different reasons, beyong the wish of the project's leaders, the meetings planned for Haiti and Venezuela were not held. A meeting was also held in Puerto Rico, but was outside the scope of the IGCP 433. In the other meetings held this year in Cuba, Freiberg,

Barcelona, and Granada, we concentrated the discussions on major problems selected previously that needed to be addressed during 2003 (see report for 2002). They are:
-Modeling the Caribbean Plate Tectonic history: The autochthonous vs allochthonous origin of the Caribbean
-The problem of space and time in the reconstruction of terranes
-The nature of the ophiolites and their historic possitions
-The conception of single vs multiple arc
-The Central American Arc
-Volcanic activy and possible volcanic hazards

The debate and discussion concerning these issues can be read in the meetings reports that are included in this Annual Report. Here we briefly summarize some of the main results.

Modeling the Caribbean Plate Tectonic History. The autochthonous vs allochthonous origin of the Caribbean

One would like to believe that such a fundamental issue as "did the Caribbean crust form in situ, or within the Pacific ocean" should have been resolved after many prior years of research. However the truth is that there is not yet an agreement on this topic among scientists. It is true that the majority follow the allochthonous model as originally posted by Malfait and Dinkelmann in 1971, but at the same time, well known scientists such as Frists, Meschede, James and others, do not accept this idea. They have some good points against the allochthonous model, points that have been discussed in previous reports. This problem was strongly debated in Brazil (2000), Barbados (2002) and Barcelona (2003). We shall have to continue the analysis of hard data and interpretations, until a consensus is reached. This year we posted the allochthonous model of Pindell and Kennan, as well as those of K. James and Giunta (visit www.ig.utexas.edu/CaribPlate/forum.htm)

The problem of space and time in the reconstruction of terranes. Their palinspastic reconstruction

This is another topic that may seem to have been previously well established and evident, and should not be a matter of much disagreement; however, the opposite is true. Further consideration makes it obvious that a complex terrane, formed by an amalgamation of distinct geologic units, representing various different paleogeographic scenarios, can not be interpreted in a simplistic manner. For example, the present tectonic reconstructions of complex terranes such as Escambray, Pinos or Guaniguanico in Cuba, are redraw for 20, 60 or 120 millions years ago, with the same shape and size as today. Any of these terranes, as for example the Escambray, contain fragments of continental margin, mafic-ultramafic bodies and volcanic arc. In any palinspastic reconstruction, for any time before the present, today's outline of the terrane has no meaning at all, mostly because the exposed area is only a fraction of the actual size of the deformed and amalgamated metamorphic terrane. This matter was debated in Boston (2001), Freiberg (2003), Granada (2003), and unfortunately, has not yet had sufficient impact in current plate models. We will have to continue working in this direction.

The nature of the ophiolites and their historic position

The natural association of ultramafic and mafic rock, usually interpreted as fragments of ocean crust, have been investigated during the project. Field and laboratory research is being done by the Italian-Latinoamerican group, two Cuban-Spaniard groups, and local Cuban researchers. We now understand that the various outcrops of mafic-ultramafic bodies cropping out in the foldbelts around the Caribbean, have very different composition and tectonic position, and the more this topic is being investigated, the more complex the situation is found to be. Many of the so-called "ophiolites" of Cuba are of suprasubduction origin, formed in conditions of arc and back arc environments. In addition, representatives of oceanic plateau basalts and subduction complexes have also been found. The main problem now is to identify the age of the protoliths, because the age of the metamorphism is generally understood. During the meeting in Granada we have evaluated the degree of complexity in the Greater Antilles mafic-ultramafic complexes, and as is outlined in the meeting's report, the tectonic and compositional diversity is evident. Another problem we are facing now, is to classify which mafic-ultramafic complexes are of true Caribbean origin, and which are of Pacific origin. It is clear that those mafic-ultramafic bodies older than the age of the Caribbean, such as Pliensbachian (Duarte Complex of Hispaniola) and Bathonian (Siquisique basalts in Venezuela), are the best candidates to be identified as Pacific crust. In other crustal sections the age of the protoliths is not yet well understood. The use of petrological technics will surely help in this undertaking, as several recent papers demonstrate.

The conception of single vs multiple arc

The debate of a single (Great Arc) vs. multiple arc evolution of the Caribbean has been active almost since the begining of the project, and still goes on. This problem was adddressed this year, as planned, at the scientific meetings in Havana, Freiberg, and Granada, and at the field trip to eastern Cuba. In Granada we concluded that the concept of a single arc evolving all the way from the mid Cretaceous to the Recent was not possible anymore. Especially during the workshop in Granada, new geochemical and geological data were presented in support of this interpretation (see meeting's report below).

The Central American Arc

This year the age and duration of the Central American arc was back in debate. Within the egroup and person-to-person mail there was an exchange of papers and opinions related with the Albian to Santonian arc activity. The very existence of the arc was questioned during the workshop in Stuttgart (see report), but facts piled up in favor of this possibility [Calvo, 2003, GSA Bull. 115(7)]. Next year we will have a field workshop in Costa Rica (March 1-7, 2004) in order to visit the Nicoya Peninsula and the igneous and sedimentary complexes related to the crust and arc sections.

Volcanic activity and possible volcanic hazards in the Caribbean

This year we have added to the web site a section dedicated to the volcanic activity in the Caribbean, with a list of the active volcanoes in the region, as well as a forecast about the year that it is possible that others may become active. This is in agreement with the relationships of the project with society. Visit the web page of the project (forum) and search for Trombley, R.B., 2003. "Holocene Volcanic Activity in the Caribbean Plate

Margins: Forecast and Risk Assessment." The document (updated to October 2003) is included in this report.

3.3. List of meetings with approximate attendance and number of countries
The meetings celebrated this year were held in Cuba, Germany, and Spain (Barcelona and Granada). The full reports of these meetings are included in this document.

LA HABANA, CUBA. March 24-28, 2003. The subject of the field workshop was: A single vs multiple arc interpretation of the Caribbean. The Field trip was organized to the Ophiolites, and to the Cretaceous and Paleogene arc terranes in eastern Cuba, in order to make detailed observations of the relationships between the ophiolites and the volcanic-arc rocks, as well as between the Cretaceous and Paleocene-Eocene volcanic arc sections. The meeting, held in Havana, also was concerned mainly in debating these issues. The report and abstracts of the presentations are available at http://www.ig.utexas.edu/CaribPlate/reports/cuba_2003.htm.
Participants: The persons and institutions attending the meeting were Antonio Garcia Casco and Joaquín Proenza (Spain), Percy Denyer and Teresita Aguilar (C. Rica), Wilson Ramírez (P. Rico), Giuseppe Giunta (Italy), Pedro Corona Chavez (Mexico), Walter Maresh and Peter K. Stanek (Germany), James Pindell (U. Kingdom), John Lewis (N. Zealand), Manuel Fundora Granda, Jose Luis Cuevas, Manuel iIurralde Vinent, Kenya Núñez Cambra, Jesus Blanco, Rafael Tenreyro, Jorge Cobiella (Cuba).
FREIBERG, GERMANY. April , 2003. During this scientific meeting there were presented key papers concerning the geology of the Caribbean. The project leader M. Iturralde-Vinent presented a key-note address about the status of the Project. This was an important opportunity to exchange with geologists working in Central and South America. Several presentations by non-members of the Project were extremely interesting, especially a series of reports about the study of the interactions between the Pacific plates and the SOAM-CARIB plates. New evidence was presented concerning infra-plate erosion taking place in several portions of the subduction zone in Central and South American trenches. These data additionally support the contention, by several authors, that the Nicoya complex of Costa Rica contains fragments of the Caribbean Plate. Abstracts of these presentations are available from Terra Nostra 2: 2003: 1-93. They may be found at: http://www.geo.tu-freiberg.de/dynamo/LAK_18/Tagungsband-gesamt-24-3-03-final.pdf and the IGCP report at http://www.ig.utexas.edu/CaribPlate/reports/freiberg_lak.htm
Participants: Walter Maresh and Peter K. Stanek (Germany), Manuel iIurralde Vinent, Kenya Núñez Cambra (Cuba), and many non-members from Central and South America. Some of them became members of the project after this meeting.
BARCELONA, SPAIN, September, 2003. This was a meeting of the working group of regional tectonics. During the meeting were presented examples of both the allochthonous and autochthonous Caribbean plate models. The session on the Caribbean comprised seven papers. They include regional papers on the Caribbean and Gulf of Mexico and progress to local focus on hydrocarbon aspects of Cuba and Trinidad. The oral session was complemented by a poster session with nine contributions. Extended abstracts of papers and posters are available on the conference CD, issued by theAAPG.

In the opening address James noted that geologically the Caribbean remains one of the world?s most highly debated areas. There are abundant models of plate migrations, hotspot and mantle plume activity, island arc development and disappearance, subduction reversals, opening of young oceanic basins, major block rotations and major plate migration.
Participants: F. Audemard (Venezuela), Giuseppe Giunta (Italy), James Pindell (U. Kingdom), Keith James (USA), J. Rosenfeld (USA), A. Vera E. (Spain), Miranda, J. Patino, I. Alor, A. Avarado, H. Alzaga, A. Cerón, R. dario, M. Espinosa, J. Granath, L. Hernandez, J. Hernandez, J. Jacobo, L. Kennan, M. Maldonado, A. Marin, A. Marino, J. Mendez, E. Pliego, A. Ramirez, G. Reyes, A. Chambers, P. Lukito, C. Solla Hach, S. Torrescusa Villaverde, C. Riaza Molina, H. Bachmann, P. Mullin, and D. Truempy.
GRANADA, SPAIN, September, 2003. This was a meeting of the working group on Petrology and Geochronology, and was celebrated with great success, including a field trip to outcrops of the Bethic subcontinental peridotites.
Participants: Edward Lidiak (USA), John Lewis (New Zealand), Antonio García Casco (Spain), Rafael Torres Roldan (Spain), Concepción Lázaro (Spain), Joaquín Proenza (Spain), Claudio Marchesi (Italy), Carlos Garrido (Spain), Fernando Gervilla (Spain), Kenya Núñez Cambra (Cuba), Manuel Iturralde-Vinent (Cuba).

3.4. Educational, training or capacity building activities
PhD students have been accomplishing associated research in this project, in regions as Sierra Maestra of Cuba (G. Kyzar), Sierra del Convento and Guira de Jauco of Cuba (K. Núñez), Sierra del Convento of Cuba (C. Lázaro), Cuban rudist-bearing rocks (R. Rojas), Ophiolites of northeastern Cuba (Claudio Marchesi), Ophiolites of Northern Venezuela (Elisa Padoa), Southwestern Puerto Rico (M. Martínez, D. Lao Davilla).

3.5. Participation of scientists from developing countries
At every meeting of the project the participation of scientists from developing countries is encouraged and supported by the project, especially when one of the leaders is from a developing country. We believe that there have been important participation, particularly because we have held one meeting in a developing country and three in Europe. Scientists, Ph.D and MSc students are participating from 11 developing countries.

3.6. List of most important publications

At the end of this report are listed publications, including some abstracts and extended abstracts. Important contributions in this year are the field guide to Eastern Cuba, the Abstract Volume of the Havana, Freiberg and Barcelona meetings, and the publications in December 2003 of the AAPG Memoir.

3.7. Activities involving other IGCP projects or the IUGS
N/A

4. Activities planned
4.1. General goals

The last year (2004) of the project is aimed toward the preparation of the SCIENTIFIC RESULTS of the project, as a memoir, to be published early in 2005 by *Geologica Acta*. We will also organize a Field meeting in Costa Rica to address in detail the geology of Central America. The final scientific meeting will be held as part of the 32 International Geological Congress in Florence, Italy.

4.2. Specific meetings and field trips (please indicate participation from developing countries)
In all the following meetings there will be participants from developing countries, partially supported by IGCP Project 433, partially by other sources.
Field workshop in Costa Rica. March 1-7, 2004
Geology of the Pacific Margin of the Caribbean Plate
Conveners: Dr. Percy Denyer and Dr. Peter Baumgartner (Escuela Centroamericana de Geología)
Contact person: P. Denyer pdenyer@geologia.ucr.ac.cr
Escuela Centroamericana de Geología de Costa Rica.
Apdo. 214-2060 UCR, San José, Costa Rica
March 1st. Scientific meeting. Presentations only about the Geology and Plate Tectonics of Central America.
March 2-7. Field trip. Visit to the Nicoya complex and related units.

32 International Geological Congress. August 2004. *Symposium G20.11. The Caribbean Plate Tectronics. State of the Art in the year 2004.* IGCP Project 433: Caribbean Plate Tectonics: a Step Forward
1. *Origin and Evolution of the Caribbean: The evolution of the ideas and models.* Papers to be included in this section will be concerned with evaluating the history of Caribbean interpretation from Geosynclinal to Plate Tectonics theories.
2. Second Part: *The conflict among data sets and their interpretation, with present-day models.*

5. Project funding requested
We request high funding, considering the third world involvement and the celebration of a Field Meeting in Costa Rica and the Final Meeting in Florence (Italy). Usually we carry part of the expenses from one year to the other, in order to be able to support meetings taking place before June/July that is the usual time when we receive the new year budget. But this year, the roll-over money we had from 2002 was deleted from the budget allocated for 2003. This procedure has left us without sufficient funding for the Field meeting of March 1-7th in Costa Rica. We would like to request an urgent allocation of the funding for Costa Rica.

6. Request for extension, on-extended-term-status, or intention to propose successor project
We believe that the project is turning into an important forum to keep a high level of communication among Caribbean scientists, has provided an umbrella for the development of multinational research projects with the goal of studying key areas of the Caribbean, has promoted the development of PhD studies in the area, and has proven that

the appropiate understanding of the origin and evolution of the Caribbean will require more time and exchange. For this purpose, we will prepare a follow-up project (2005-2009) to be presented next year along with the final report of the present one.

7. Attach any information you may consider relevant

7.1. REPORT OF THE MEETING IN CUBA
Report of the Field Workshop in Cuba, March 2003

By M. Iturralde-Vinent (Project co-leader)

During the period March 18-28, 2003, a field workshop of the IGCP Project 433 "Caribbean Plate Tectonics" was celebrated in Cuba, as part of the V Geological and Mining Congress of the Cuban Geological Society. The Field Workshop was attended by project members from Costa Rica (2), Cuba (6), Germany (2), Italy (1), Jamaica (1), Mexico (1), Spain (1), USA (2), and New Zealand (1). Additionally, non-members of the project, around 15 persons (from Cuba and USA), actively participated in the debates during the scientific meeting. The field workshop was subdivided into a field trip (March 18-23), a scientific meeting (March 27, with posters, oral presentations, and a round table), and the Project's Bussiness Meeting.

In the following paragraphs the most important results of the field workshop are briefly explained.

SCIENTIFIC MEETING
The meeting was held on the 27th of March and included posters, oral presentations and a round table discussion. The presentations where of great interest for a better understanding of the plate tectonic evolution of the Caribbean area, but at the same time, demonstrated that we are still far away from reaching an agreement concerning the interpretation of some key aspects of Caribbean geology. Some papers presented new information or new interpretations about different aspects of the Caribbean and the Gulf of Mexico (Cuevas, Fundora, Giunta, Bartolini, Maresch, Denyer). Concerning Cuba, it was clear from the presentations that the "northern ophiolites" of Cuba have been emplaced generally from South to North. The ophiolites of eastern Cuba, but including those of central and western Cuba, are probably poly-genetic and part of more than one tectonic event, being emplaced between the Maastrichtian and Paleocene-Late Eocene (Field trip and Nuñez). It also has become clear that these ophiolites have distinct compositions and origins, ranging from oceanic plateaus to suprasubduction environments. The study of the chromitites, the ultramafic-mafic bodies, and the metamorphic inclusions in the serpentinitic melanges provide information about the occurrence of Cretaceous crustal units of oceanic plateau and of suprasubduction environments (arc and back-arc) (García Casco, Proenza, Lewis, Iturralde-Vinent, 1996). The development of the Caribbean volcanic arcs was a subject of extensive discussion. As in previous meetings, new data was presented supporting the idea that the Paleocene-Eocene arc of Eastern Cuba is different from the Cretaceous arc (Stanek, field trip), but there was not agreement in this concern. Interesting also was the presentation of S.

Mitchell, who provided evidence for an important unconformity at the base of the Maastrichtian in Jamaica. M. Iturralde-Vinent indicated that such unconformity is well developed in Cuba, and also in Dominican Republic at the base of the Maastrichtian Don Juan conglomerates. According to J. Pindell this event records the collision of the Great Arc with Yucatan, while to M. Iturralde-Vinent it represents a shift in the stress direction. Later J. Pindell presented a revised version of his Caribbean Plate Tectonic Model that was the subject of interesting comments and some debate. He argued that the Cuban arc terrane derives from the inter-American Arc between Chortis (when Chortis lay adjacent to Guerrero, Mexico) and Ecuador, then was involved in the Aptian Caribbean "arc-polarity reversal" during which west-dipping subduction beneath the Caribbean Plate began, afterward underwent arc-parallel extension during middle and Late Cretaceous time, converged obliquely with southern Yucatán in the Maastrichtian, and finally migrated ahead of the Yucatán intra-arc basin during the Paleogene on its way to collision with the Bahamas. He also proposed that the Cuban "arc" terrane represents a forearc piece of the Great Caribbean Arc only, and should not be considered as an arc in itself. In other words, he proposed that the Sierra Maestra-Cayman rise belt represent the axial part of the Great Arc; that the Cretaceous volcano-plutonic rocks that outcrop in Cuba from northwest to southeast are a forearc suite; so the Yucatan basin is just an intra-arc basin. This conception produced some debate (Cobiella, Iturralde-Vinent), as it is contradictory with the arguments that the Cretaceous segment of the arc in Cuba is independent of the segment of Paleocene-Eocene age (see field trip below).

PROJECT'S BUSINESS MEETING

A brief evaluation of the present status of IGCP Project 433 was presented. It was considered that the project is fulfilling its goals.

FIELD TRIP TO EASTERN CUBA

The subject of the Field Trip.was to discuss the relationships between the ophiolites, the metamorphic terranes, the Cretaceous and the Paleocene-Eocene volcanic arcs in Eastern Cuba Took place during the days of April 18 (Havana to Moa), 19 (Moa to Sabaneta), 20 (Moa to Baracoa), 21 (Baracoa to Santiago and El Cobre mine), 22 (Santiago to Turquino area), and 23 (Santiago to Havana). (See map below).

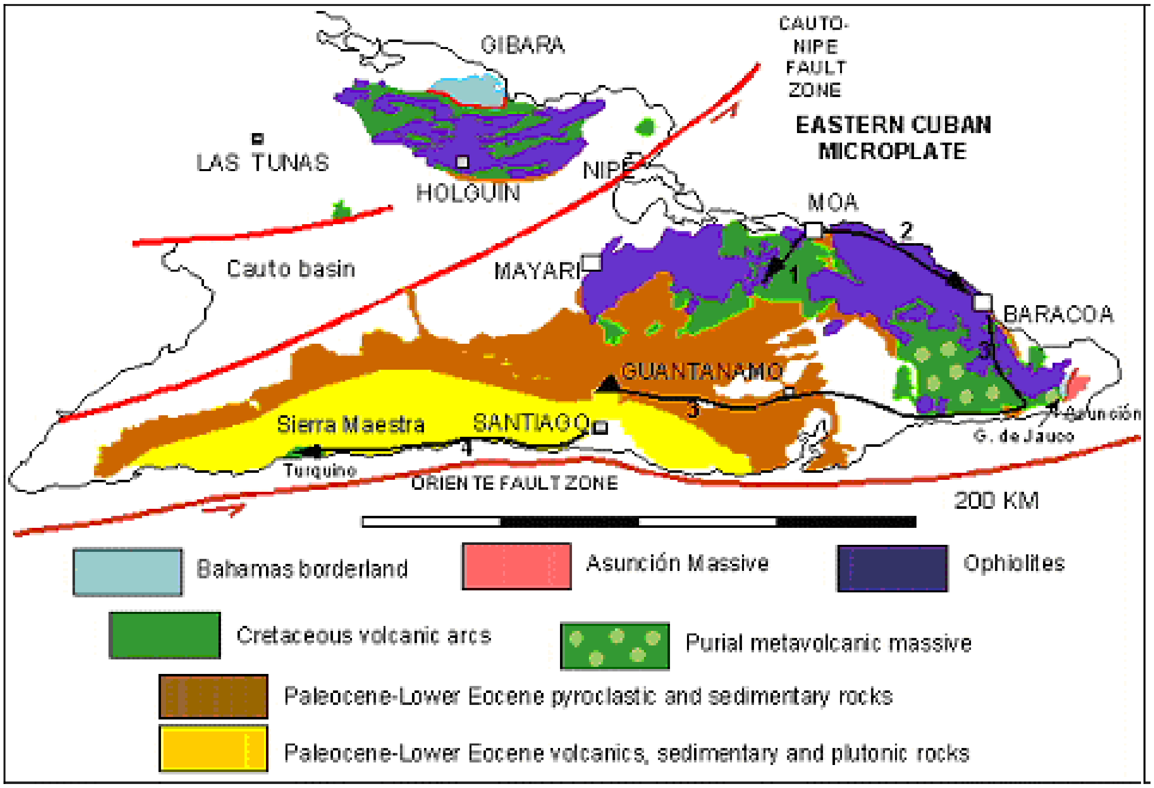

Figure 1. Simplified tectonic map of Eastern Cuba, where the black arrows with numbers indicates the route of each day.

In order to explain the origin of the Caribbean area, two major concepts are in dispute regarding the evolution of the volcanic activity. One is the concept of a single "Great Arc" evolving at the leading edge of the Caribbean Plate from Lower Cretaceous to the Present. An alternative concept is the Multiple Arc hypothesis, which maintains that during the evolution of the Caribbean realm several independent volcanic arcs have been active. The identified multiple arcs take into account several criteria: 1. Change in the trend of the axial part (volcano-plutonic core) of one arc with respect to the other; 2. Major unconformities, magmatic quiescence, and tectonic events separating one arc from the other; 3. A particular geochemistry of each arc's igneous suite; and 4. Simultaneous evolution of two or more independent arcs in distinct geographic areas. During the field trip exposures were visited in support of the Multiple Arc hypothesis.

The region of Eastern Cuba, eastward of the Cauto-Nipe Fault Zone, is very distinct with repect to other areas of the island. It is the only place in Cuba where the Bahamian (North American) borderland suite occur as metamorphic rocks (Asunción massive); and the only one where Cretaceous volcanic arc rocks are partially metamorphosed up to HP/LT assemblage(Purial massive). It is one of the few places where Cretaceous amphibolites occur as representatives of oceanic crustal elements (Guira de Jauco and Sierra del Convento amphibolites). Furthermore, it is the only place in Cuba where ophiolites bodies (the so called Mayarí-Moa-Baracoa allochthon) lies almost horizontal, and furthermore, where there is evidence to show that the emplacement of this body took place in the Maastrichtian due to a gravitational mechanism. It is the only place in Cuba where the Paleocene-Eocene volcanic arc rocks occur slightly deformed in two main environments, a back arc basin (North of Sierra Maestra-Cayman rise) and an axial arc system (Sierra Maestra-Cayman ridge).

During this field trip the Asunción, Güira de Jauco and Sierra de Convento areas will not be visited, but all the other elements will be evaluated from the scope of its tectonic position and relationship with the evolution of the Caribbean plate.

THE EASTERN CUBA MICROPLATE

Given the very unusual geological constitution of Eastern Cuba, it is probably the least understood area of Cuba, but at the same time represent a key element of the Caribbean plate tectonic puzzle. The fact is that the Eastern Cuban area represent a peculiar microplate within the Greater Antillean Orogen, which was deformed during the latest Cretaceous, and again during the Oligocene. The Latest Cretaceous deformation is very important, and probably was related with some interaction between the Caribbean plate (CARIB) and the North American plate (NOAM) . Such an event produced the extintion of the Late Cretaceous arc segment in Guatemala, Cuba, Hispaniola and Monta - as del Caribe (Venezuela). Regional metamorphism took place at the same time. Due to the fact that there is not deformation recorded in the Paleocene-Eocene within the Eastern Cuba Microplate, the relationships between the latest Cretaceous allochthonous units are better preserved in the area. It seems that during the Paleocene-Eocene, while other parts of the Greater Antillean Orogen were strongly deformed, the boundary faults of the Eastern Cuba Microplate diverted the stress, especially the Cauto-Nipe Fault Zone. Later in the Oligocene, strike slip movements along the Oriente fault, produced new deformation, mostly within a wide strip along the present southeastern Cuba and Northern Hispaniola.

Probably the lowest structural elements in the tectonic pile of Eastern Cuba are the Late Jurassic-Lower Cretaceous low degree HP/LT metasedimentary rocks (marbles and shales) of the Asunción massive. Tectonically emplaced above this unit are found the Güira de Jauco amphibolites, represented by deformed serpentinites and coarse to fine grained layered or massive amphibolites of low degree HP/LT metamorphism. The Purial massive is represented by Cretaceous metavolcanic rocks, including volcano-sedimentary, sedimentary and igneous protoliths. The sections located toward the southwest yield a higher degree of HP/LT metamorphism (blueshists), while those to the North vary from greenshists to a very low regional metamorphism. The relationships of the Purial metavolcanics are complex, as these rocks are found tectonically overlying the Güira de Jauco amphibolites, overlying or intermingled with non-metamorphosed Cretaceous volcanic rocks; and also overlain by the Sierra de Convento amphibolites and the Mayarí-Moa-Baracoa allochthon. Sedimentary rocks of Lower to Middle Eocene overlie the Purial massive. Above the area of the Purial metavolcanics are reported blocks of Maastrichtian limestones of the Cañas Formation, which may not be *in situ*. The Maastrichtian La Picota olistostrome and the Lower-Middle Eocene San Ignacio slope breccia with fragments of Purial's marbles and shists do occur above the Purial rocks. This relationships suggest that the metamorphism is pre-Maastrichtian, and that by Lower Eocene Purial was already uplifted. The origin of the Purial metamorphic massive is a real puzzle, because there is not any reasonable explanation for the HP/LT, maybe the emplacement of the ophiolites can be the cause, but such an idea is contradictory to present understanding of the origin of blueshist.

The Sierra del Convento massive is represented by deformed serpentinites with a variety of HP/LT metamorphic inclusions. This tectonic unit, yet to be properly characterized, may be an important element to understand the process of tectonic emplacement and metamorphism of the metamorphic terranes and the ophiolites. The Mayarí-Moa-Baracoa allochthon has been described in several papers. Its uniqueness with respect to other such bodies in Cuba, is its nearly horizontal position and the fact that it is intermingled with the Maastrichtian La Picota olistostrome and with the Maastrichtian-early Danian Mícara greywakes. Another exclusivity of the Mayarí-Moa-Baracoa allochthon is that it overlies Cretaceous volcano-sedimentary rocks (Santo Domingo Formation), while the allochthonous ophiolites west of the Cauto-Nipe Fault Zone usually rest above parts of the Bahamian continental margin units. The implication is that the mechanism of emplacement of this allochthon is probably different from those of the Northern ophiolites in central Cuba. Furthermore, as central Cuba was strongly deformed by the Paleocene-Eocene tectonic events, probably the Mayari-Moa-Baracoa allochthon is a clue to understanding the history of collision in central Cuba.

The fact is that in west-central Cuba there are olistostromic deposits in the latest Campanian-Maastrihctian rocks (Jibacoa olistostrome in Havana-Matanzas), suggesting the occurrence of some --and yet poorly understood-- early thrust event within the Cretaceous volcanic arc-northern ophiolites, at the end of the Cretaceous, as in eastern Cuba. All data from central and western Cuba suggest that just south of the Bahamian borderland there was an oceanic crustal basin that was the first element detached from the Caribbean crust (Northern ophiolites) and emplaced above the Bahamian borderland, and only later, segments of the Cretaceous volcanic arc suites. In Eastern Cuba the first element detached from the Caribbean crust and emplaced above the Bahamian borderland was also a slice of ocean crust (Güira de Jauco amphibolites). Above that one took place the emplacement of volcano-sedimentary rocks (Santo Domingo Formation and Purial massive), and just at the end of the accretionary process, a slice of ophiolites (Mayarí-Moa-Baracoa). Evidently the case for Eastern Cuba is different from that of central Cuba so the whole process needs to be more fully investigated.

SAGUA DE TÁNAMO BASIN.

The columnar section of figure 2 displays the most important Late Cretaceous - Middle Eocene lithostratigraphic units represented generally north of Sierra Maestra in Eastern Cuba, in the so called Sagua de Tánamo basin. These units yield a very low degree of regional deformation and there are no recorded unconformities or hiatus. Nevertheless, within the Maastrichtian sedimentary sections are found syn-sedimentary folding, olistostromes and olistoplates. Only very local volcanic activity is known in the section represented by small bodies of Paleocene-Lower Eocene basalts within the Sabaneta Formation.

Three main sources of clastic material are recognized for the Sagua de Tánamo basin. One source was probably the uplifted Cretaceous volcanic arc suites, which provided detritus composed of fragments of tuffs, tuffites, and basic to acid types of Cretaceous igneous rocks. This source may have been located South of the sedimentary pile. The second source were the ophiolites, probably located south of the sedimentary basin. These two sources are present, in different amounts, in the Latest Cretaceous to Lower Eocene formations (Mícara, La Picota, Gran Tierra, and Sabaneta). The third source were contemporaneous explosive subaereal volcanoes, generally located to the South, which is represented by volcanic ash and volcanogenic rocks and minerals. This source first occur as fine layers in the lower Danian (upper Mícara Fm.), later as some isolated beds in the middle-late Danian (Gran Tierra Formation), and became dominant since late Danian and until the end of the Lower Eocene (Sabaneta Formation). From South to North the pyroclastic material is of thinner grain and less abundant with respect to the sedimentary component of the rock sections. After the demise of the volcanic activity, carbonate rocks were deposited all over the basin in distinct shallow to deep marine environments. Above the carbonate level conglomerates and clastic rocks occur in general, derived from the exhumation of the Paleogene volcanic arc in the south (Camarones conglomerate and San Luis Formation).

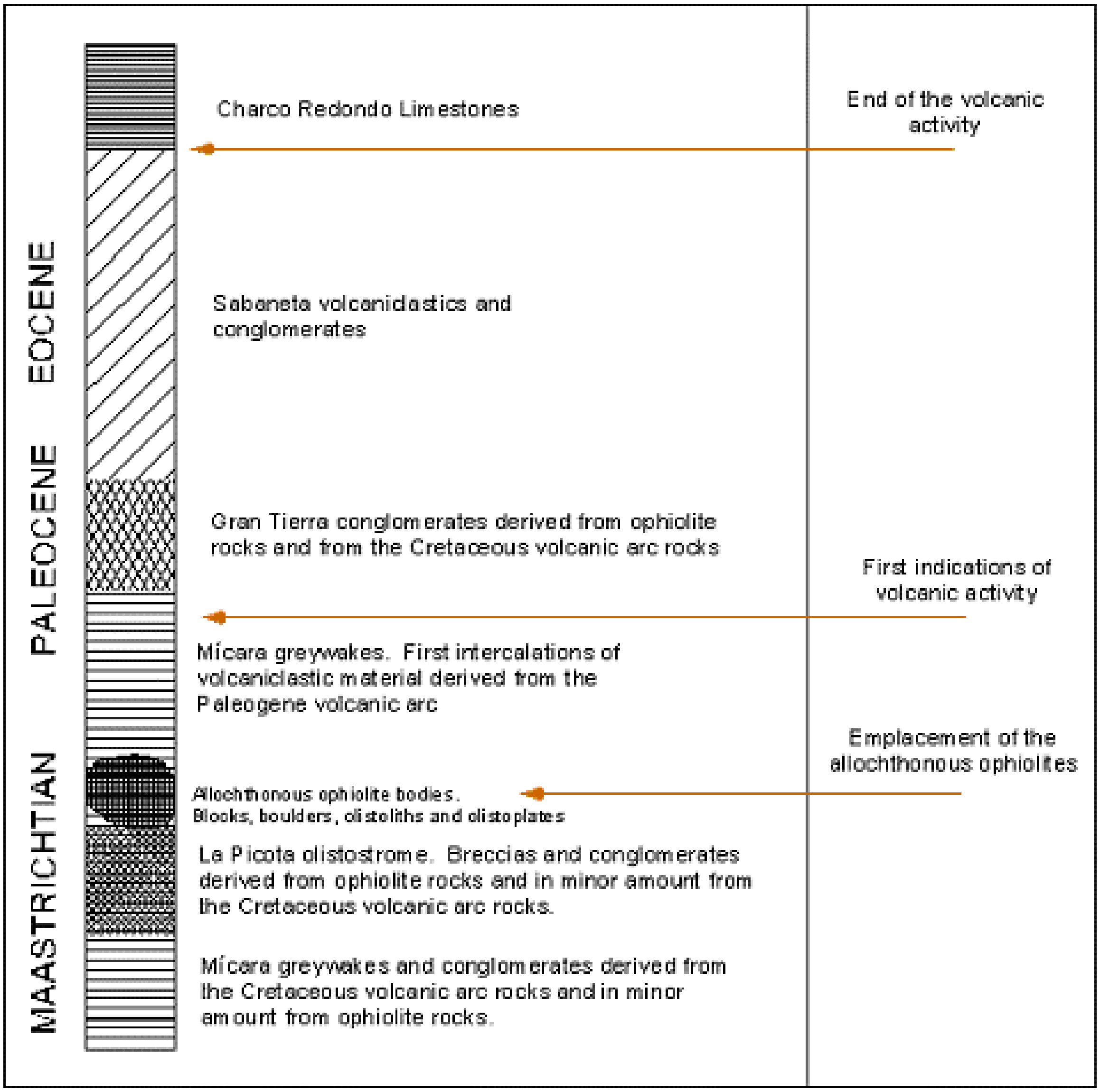

Figure 2. Simplified stratigraphic column of the Sagua de Tánamo basin

The present-day relationships of the latest Cretaceous-Middle Eocene litostratigraphic units are illustrated in the following drawing (Figure 3). It provides a mechanism of how the Mayarí-Moa-Baracoa allochton (ophiolites and Cretaceous volcanic arc rocks) was emplaced during the Maastrichtian as a gravitational body (Cobiella, 1976). This conclusion is based in the following observations: 1. Sedimentation in the Sagua de Tánamo basin was continuous since Latest Cretaceous till Latest Eocene-Oligocene, 2. During the Maastrichtian there was a large input of detritus (both in amount and size) of ophiolite composition, along with syn-sedimentary deformations, 3. The Paleocene and younger rocks in the basin are slightly deformed and deposited directly above allochthonous deformed bodies of ophiolites and Cretaceous arc rocks (both metamorphosed and non-metamorphosed), but also without interruption above some non-deformed Latest Cretaceous sedimentary sections. These facts strongly suggest that after

Maastrichtian there were not more strong tectonic deformations in Easternmost Cuba until the Oligocene.

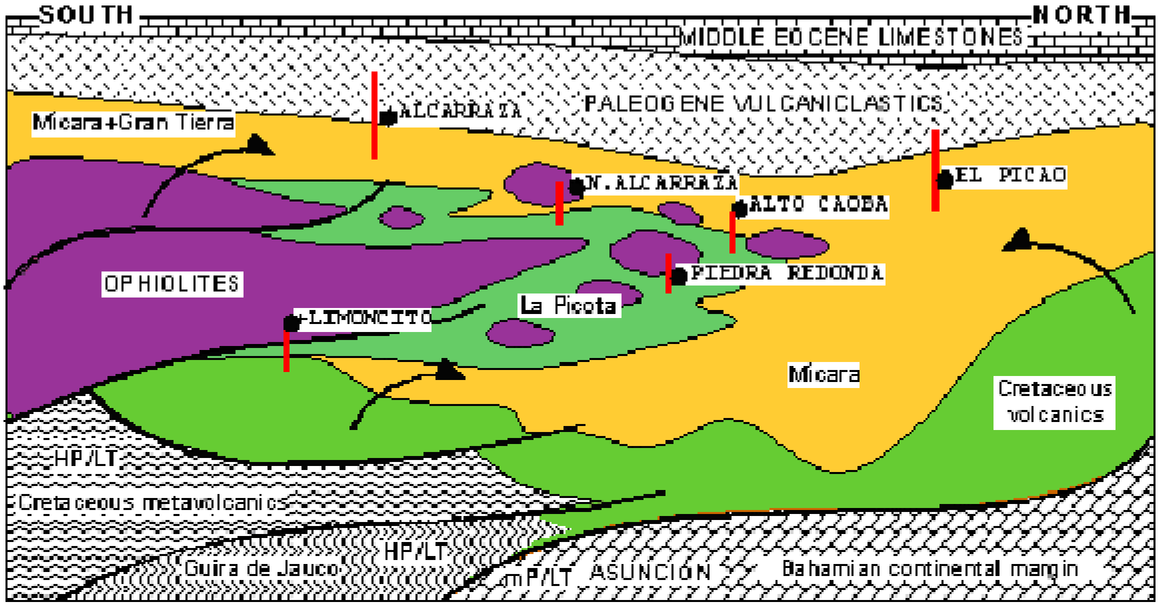

Figure 3. Sketch illustrating the mechanism of gravity emplacement of the ophiolites in Eastern Cuba. The black arrows illustrate the sources for the clastic materials in the sedimentary basin. The red lines are the sections that can be observed in the named stops. The position of the basement rocks below the Mícara Formation reflect the actual relationships of these rocks in outcrops (Iturralde-Vinent, 1998).

THE PALEOGENE ARC

Generally in Cuba, as well as in the Eastern Cuba Microplate, there is an unconformity within the late Campanian, coincidental with the extinction and deformation of the Cretaceous magmatic activity. Above these deformed latest Cretaceous volcanic and plutonic rocks, are found, along the Sierra Maestra near Turquino area, a latest Campanian-Maastrichtian clastic and carbonate unit (Manacal Fm), with its clastic material derived from the deep-seated erosion of the Cretaceous arc suite. Only since the Danian, a second volcanic arc rock suite occurs (El Cobre Group). The rocks of this second arc suite represent the axial part of the Paleocene-Lower Eocene volcanic arc along the Cayman ridge-Sierra Maestra belt (El Cobre group and plutonic rocks). The extrusive component of this second arc is Danian and Lower Eocene in age, while the plutonic rocks are slightly younger, Middle to Late Eocene in age. In the northern part of Eastern Cuba the latest Cretaceous rocks are conformably or locally unconformably underlying the slightly deformed Paleocene-Lower Eocene backarc deposits located along the Cayman rise-northeastern Cuba belt, North of Sierra Maestra. These deposits are mostly sedimentary and distal pyroclastics (Sabaneta and similar Formations). In the back arc area there are no plutonic rocks, and the only extrusive-like bodies are small sills of basalt. According to this tectono-magmatic scenario, as illustrated in figure 4, the subduction zone of the Paleocene-Eocene arc must be found South of the axis of the arc and southeast of the Cayman Ridge-Sierra Maestra belt. In such an event, the terranes located in Hispaniola, west of the Troi Riviere-Peralta-Ocoa belt, are representatives of the Cretaceous and Paleogene Caribbean crust. These are Lower and Upper Cretaceous oceanic basalts with intercalated sedimentary rocks in the Southern Peninsula of Hispaniola, and Paleocene-Eocene basaltic sills and flows intercalated within shales and limestones in the area North of the Southern Peninsula in Haiti. The Troi Riviere-Peralta-Ocoa belt and the Muertos trench probably represent the old Paleogene subduction zone, deformed and obliterated by strike slip and dip slip faulting after the Middle Eocene. The following reconstruction of the position of some Antillean terranes before the opening of the Cayman trench south of Cuba, valid for the Paleocene to Oligocene time interval (before the opening of the Bartlett trench south of Cuba), fully support this point of view (Figure 4).

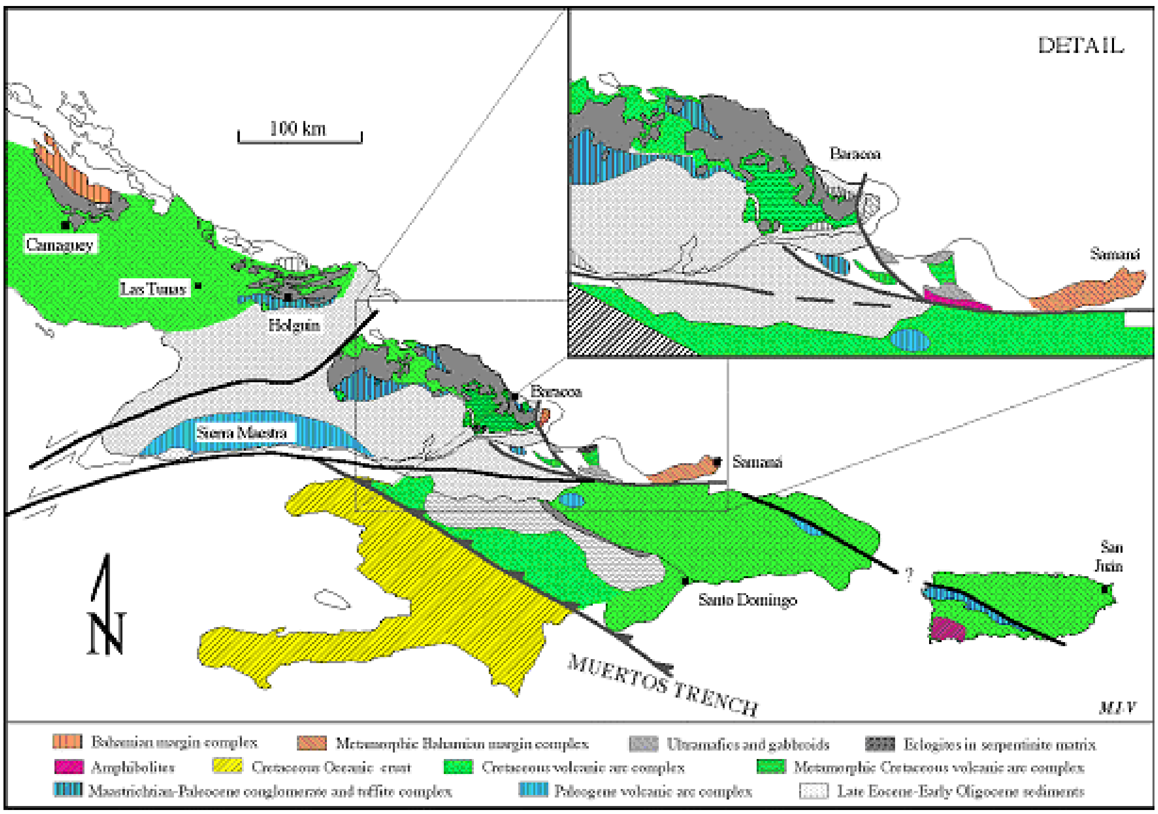

Fig. 4. Restored latest Eocene-Early Oligocene paleogeological map of eastern Cuba, Hispaniola and Puerto Rico.

Figure 4a. Restored latest Eocene-Early Oligocene paleogeological map of eastern Cuba, Hispanila and Puerto Rico.

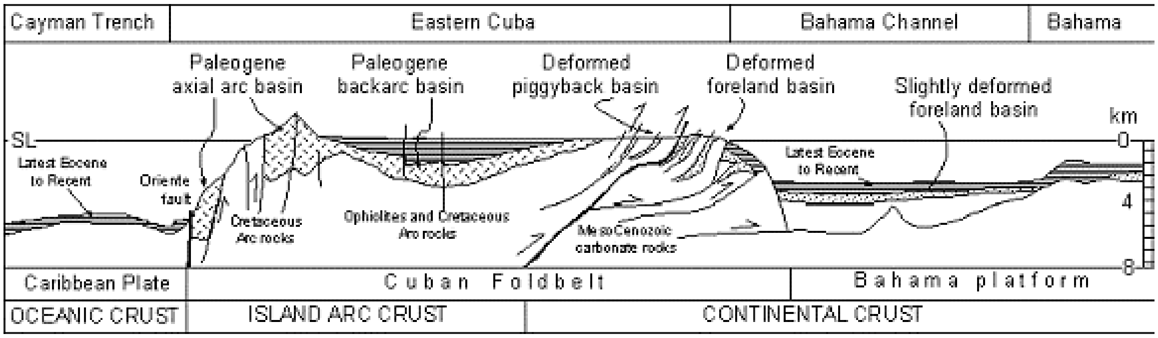

Figure 4b. Palinspastic map and cross section representing the main elements of Eastern Cuba from North of Gibara to the Cayman trench in the South. The deformations and thrust faults within the foreland basin are partially isochronous with the activity of the volcanic arc at the Cayman ridge-Sierra Maestra belt.

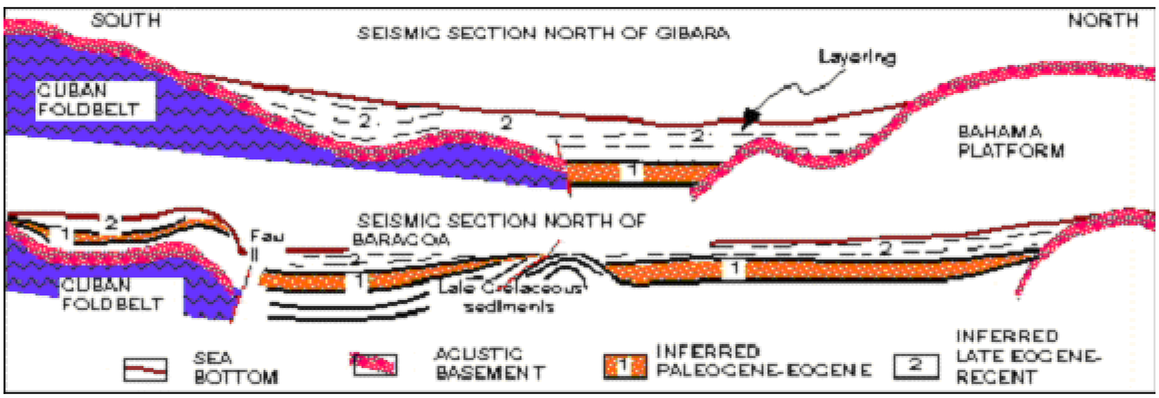

Figure 5. Seismic reflection profiles offshore of northeastern Cuba, show that there are not important deformations in the area of the shelf, so there is no place to locate a subduction suture for the Paleocene-Eocene arc.

SIERRA MAESTRA.

In the area of Sierra Maestra, southeastern Cuba, the section is different from the Sagua de Tánamo basin in many aspects. The oldest rocks are non-metamorphosed or slightly metamorphosed Late Cretaceous marine pyroclastics and sedimentary rocks including andesite-basaltic agglomerates and tuffs (Turquino Formation) of the Cretaceous volcanic arc. Above, unconformably, rest latest Campanian-Maastrichtian conglomerates, sandstones and limestones with detritus from the underlying Cretaceous arc suite (Manacal Formation). Up in the section the Paleocene - Lower Eocene section of El Cobre Group is represented by various types of sedimentary, pyroclastic and volcanic rocks, from basaltic to dacitic, intruded by large plutonic bodies. Within this area the environment of deposition and volcanic facies varies widely in short distances, from subaereal volcanism to marine pillow basalts, from fine grain pyroclastics to very coarse grain ones. Also are found nods of volcanic activity with sills, plugs and subaereal lava flows associated with sub-volcanic dikes, small plutonic bodies and hydrothermal alteration. The plutonic rocks of Middle-Late Eocene age are located usually along the deeply eroded southern slope of the Sierra Maestra Mountains. This scenario is typical for the axial part of an archipelago of volcanic islands. Geochemically the Paleogene arc suite has a strong tholeiitic character, with low K2O; very different from the older Cretaceous arc, which present a clear differentiation from tholeiitic to high alkaline composition (Cazañas et al., 1998). This fact strongly suggests that the Paleogene arc is not a continuation of the Cretaceous arc.

7.2. REPORT OF THE MEETING IN FREIBERG

Report of the IGCP Project 433 participation in the 18 Latinamerican Geological Colloquium,
Freiberg, April 3-5, 2003

By M. Iturralde-Vinent and E. Lidiak

The Latinamerican Geological Colloquium are held every three years in Germany, with extensive participation of South and Central American geologists. Members and the co-leader of IGCP Project 433 have attended the 17th meeting (see report forSttutgart) and now the 18th meeting. Attendance at the 18th meeting was less than the previous one, but the quality of the oral presentations and posters was equally high, as was the excellent organization. Four members of the IGCP Project 433 attended the meeting, two from Cuba (K. Nuñez and M. Iturralde-Vinent) and two from Germany (W. Maresch, P.- K. Stanek).

K. Nuñez presented a poster about the "Plate boundary between the North American and Caribbean plates, structural deformational phases" where four phases were described. Krebs, Maresch and coworkers reported on the "Geochronology and petrology of high pressure metamorphic rocks of the Rio San Juan complex, Northern Dominican Republic". Iturralde's Keynote presentation was about "IGCP Project 433 Caribbean Plate Tectonics, the origin and evolution of the Caribbean. Status of the debate: The multiple arc vs single arc hypothesis". This presentation focused on three issues: (1) The reconstruction of terranes in the Caribbean and the problems of restoring the original position and original dimensions of the terranes, as well as the problems of explanining the complex composition of some terranes. (2) The growing complexity of the origin and composition of circum Caribbean ophiolite belts. It is now well stablished that these belts encompass rocks of different ages, and distinct composition and origins, from oceanic plateau to suprasubduction environments. (3) The multiple arc vs single arc hypothesis. Utilizing the model of J. Pindell as a base, the possibility was discussed that the leading convergent edges of the Caribbean Plate may have developed as a series of distinct arcs and no as a single one.

Several presentations by non-members of the Project were extremely interesting, especially a series of reports about the study of the interactions between the Pacific plates and the SOAM-CARIB plates. New evidences were presented concerning infra-plate erosion taking place in several portions of the subduction zone in Central and South American trenches. These data additionally support the contention, by several authors, that the Nicoya complex of Costa Rica contains fragments of the Caribbean Plate.

The abstracts of the presentations are available from Terra Nostra 2: 2003: 1-93. They may be found at: http://www.geo.tu-freiberg.de/dynamo/LAK_18/Tagungsband-gesamt-24-3-03-final.pdf.

7.3. REPORT OF THE MEETING IN BARCELONA

AAPG International Meeting, September, 2003
Barcelona, Spain

By Keith James

The AAPG International Meeting, 2003, Barcelona, Spain, included a session on Caribbean tectonics. Proposed by K. H. James and chaired by F. Audemard, K. H. James and J. Pindell the session was intended to highlight differences between Pacific and in-situ models for the origin of the Caribbean Plate.

The session opened with a tribute to Bob Speed, who passed away September 18th, 2003. Bob made significant contributions to Caribbean geology, notably in Barbados and in the SE Caribbean.

The session comprised seven papers, abstracted below. They include regional papers on the Caribbean and Gulf of Mexico and progress to local focus on hydrocarbon aspects of Cuba and Trinidad.

The oral session was complemented by a poster session with nine contributions. Extended abstracts of papers and posters are available on the conference CD, issued by theAAPG.

In the opening address James noted that geologically the Caribbean remains one of the world's most highly debated areas. There are abundant models of plate migrations, hotspot and mantle plume activity, island arc development and disappearance, subduction reversals, opening of young oceanic basins, major block rotations and major plate migration.

Why so much discussion?
-The plate forms part of a region of great geographic diversity extending from southern N America to northern S America, including Central America, several thousand islands and the oceanic areas in between.
-Parts of the region are well known. Others, because of tectonic complexity, poor accessibility, poor exposure and tropical weathering are poorly known.
-The Caribbean Plate is largely oceanic, although it carries large continental fragments in the west. However, there are no spreading anomalies (except central Cayman Trough) to tell how and when the plate formed.
-The initial oceanic crust (unsampled in place) was thinned by extensional faulting to 3-5 km and then locally thickened to as much as15 km by basalt outpouring. Thickening

occurred on at least two occasions, at 120 and 90 Ma, both episodes lasting only a few million years. Hotspot and/or mantle plume activity is held responsible.
-Few people make comprehensive synthesis of all this geology. Most works simply quote "the generally accepted model" or state "It is well known that".

James emphasized that the two models have significantly different implications for the explanation of known and the prediction of remaining hydrocarbon reserves in the area.

Audience response expressed enthusiastic appreciation of this forum where the Pacific and in-situ models were presented side by side. There was strong encouragement for a formal public debate of these models.

7.4. REPORT OF THE MEETING IN GRANADA

IGCP Project 433 Caribbean Plate Tectonics: Workshop of the Working Group on Geochemistry and Geochronology (Carib-WGGP).
University of Granada (Spain). September 30-October 3, 2003

Conveners: A. García Casco and M. Iturralde-Vinent

The aim of the Carib-WGGP meeting was to present and debate new unpublished results of different ongoing projects that are studying the petrology and geochronology of igneous and metamorphic rocks in the Greater Antilles. These projects cover the Virgin Islands and Puerto Rico (E. Lidiak and W. Jolly), Hispaniola (J. Lewis and colleagues), Western Cuba (J. Proenza, J. Melgarejo, F. Gervilla, C. Garrido, C. Marchesi, and colleagues), and Cuban petrology and geochronology of metamorphic complexes (A. García Casco, R. Torres Roldan, C. Lázaro, K. Núñez, M. Iturralde-Vinent, and colleagues).
In the introductory session, M. Iturralde-Vinent presented an overview of the Greater Antillean so-called ophiolites, discussed the problem of the interpretation of the presumed allochthonous terranes in the Caribbean, and with the active participation of other Carib-WGGP members, examined in detail the main characteristics of the Caribbean Plate.

Tectonic model of Pindell and Kennan (2002)
The tectonic model of Pindell and Kennan was discussed in light of new data and new field observations that were presented by the various participants at the meeting. Particular emphasis was placed on trying to integrate this new information into a viable model of Caribbean Plate Tectonics. Discussions were open and very interesting, so we all enhanced our knowledge on the geology of the northern Caribbean. Our discussions also indicate that important data are missing from key areas of the northern Caribbean in order to produce a well-based Plate Tectonic Model.

Future research should be directed to address the problem of the age and petrology of the igneous and metamorphic complexes of the northern Caribbean, applying the latest development in the respective fields. Currently, research projects are studying these problems in Cuba, the Dominican Republic and Puerto Rico and the Virgin Islands. However, it is also extremely important to investigate the igneous and metamorphic complexes of Haiti, which have not been studied for a long time. As a great finale for the meeting, we participated in a field excursion to the Betic Cordillera and visited a number of outcrops of the Ronda subcontinental peridotites and related rocks.

We reached the following main conclusions as a result of debate and discussion at the Workshop:

1. Many features of Northern Caribbean geology are not properly addressed by the model of Pindell and Kennan (2002). This model must be elaborated in greater detail, and modified in several aspects, in order to account for these new data. Some of these modifications will be clear in the following paragraphs.

2. The mafic-ultramafic bodies that crops out along the northern Caribbean present much more complex settings and diversity in genesis than previously thought. The Cuban northern ophiolites (?), for example, are to be restricted, as a structural-genetic term, to those outcrops found between Cajalbana (NW Cuba) and HolguÌn (NE Cuba). These rocks encompass both suprasubduction and plateau (?) crustal sections. The Cuban northeastern ophiolites, formerly considered as part of the northern ophiolites, must be placed independently as the MayarÌ-Cristal and Moa-Baracoa massifs. Now they are identified as suprasubduction representing an arc/back arc crustal pair, and their present tectonic position is different from the ophiolites elsewhere in Cuba.

3. In Cuba (Margot and Guira de Jauco), as well as in the Jurassic Duarte complex of Hispaniola, within distinct geological contexts, occur mafic and metamorphic rocks that are interpreted as plateau basalts. But the age of the protolith of the Cuban occurrences need to be refined. Margot basalts have been recently dated as Cenomanian-Turonian (Pszczólkowski, 2002).

4. Metamorphic soles of Cuban ophiolites have been identified in Eastern Cuba. New structural and age data of these rocks indicate a complex emplacement history, with different steps during the Late Cretaceous starting, at least, in the Turonian.

5. The Sierra del Convento (Southeastern Cuba) has been considered as part of the northern ophiolites. However, new petrologic data suggest that it represent an accretionary subduction complex with HP/LT metamorphic rocks that should be placed as an independent tectonic element. On-going research in similar complexes, such as La Corea in Mayari-Cristal, show some compositional similarities with Sierra del Convento, adding complexities to previous interpretations.

6. The Median belt of Hispaniola, as originally defined by Carl Bowin, includes magmatic and metamorphic complexes of different types of suprasubduction environments as well as rocks of oceanic plateau setting. Such amalgamation of igneous and metamorphic rocks has no counterpart in any other place within the northern Caribbean. On the other hand, in central Hispaniola, the Early and Late Cretaceous arc complexes outcrop as independent, apparently non-related belts.

7. The available data from SW Puerto Rico's mafic-ultramafic complexes indicate that there are three belts that contain mafic rocks of either N-MORB or pre-arc, within-plate origin and Jurassic through Early Cretaceous radiolarian cherts. These rocks pre-date the subduction complex in western Puerto Rico, and probably have no counterpart in the northern Caribbean.

8. In all of the Greater Antilles occur isochronous arc-related volcano-plutonic bodies that crop out independently and generally juxtaposed against the mafic-ultramafic belts. The relationships between these two main geologic setting is as yet poorly understood. Are they paired arcs (?), or are they just different structural-compositional belts within an arc complex?
9. The extensive amount of new geochemical data from the Cretaceous volcano-plutonic (arc) complexes in the Virgin Islands suggest that the geological situation is more complex than previously understood. Virgin Islands yield an Early Cretaceous Primitive Island Arc complex, well known to occur also in eastern Puerto Rico, Hispaniola and Cuba. Nevertheless, the structural relationships between these Virgin Island rocks and those of eastern Puerto Rico are not yet clear.
10. The extensive amount of new and existing geochemical and geochronological data from the volcano-plutonic (arc) rocks in Puerto Rico allow the distinction of two main arc complexes (possible terranes), separated by a major NW-SE fault system. The Northeastern Puerto Rican suspect terrane (?) contains several stages of volcano-plutonic activity, from Albian to Middle Eocene, related to a subduction zone located toward the north and dipping southward. The Southwestern Puerto Rican suspect terrane (?) consists of an arc complex of Santonian to Middle Eocene age that is related to a north-dipping subduction zone located to the south.
11. The Paleocene-Eocene arc complex in Cuba generally is not genetically related to the Cretaceous arc complexes or mafic-ultramafic bodies, and probably was generated by an independent subduction zone. On the other hand, there are no obvious relationships between the Paleocene-Eocene arc rocks of eastern Cuba (Sierra Maestra) and Hispaniola, or between rocks of similar age in Hispaniola and Puerto Rico.
12. The Paleocene-Eocene pyroclastic-sedimentary rocks of northeastern Cuba (Sabaneta and related Formations), genetically related to the isochronous volcanic arc centers in the Sierra Maestra of southeastern Cuba, are also recorded from the Cayman Rise (ODP) and Imbert Formation of Hispaniola.
13. Late Eocene and younger arc rocks occur in the Virgin Islands, and have no counterpart elsewhere within the northern Caribbean. They probably belong to the Lesser Antilles arc.
14. It was realized that the occurrence of late Tertiary arc-related magmatic rocks in Hispaniola (Padre Las Casas, Valle Nuevo) has not found an explanation in any recent Caribbean Plate Tectonic Model.
15. We examined the significance of the Cuban SW terranes (Escambray, Pinos and Guaniguanico), and found them to represent fragments of Jurassic (?) -Cretaceous continental margin complexes mixed with oceanic crustal elements. Some of the metamorphism of these terranes involved and represent collision with the western segment of the volcanic arc in pre-Latest Cretaceous time ($< 70 \pm 2$ Ma). We found that each terrane represent a distinct collisional setting, and has no counterpart in other places of the northern Caribbean. The original location of these terranes, along the North American Continental Margin, has not found yet an agreement in terms of their precise position.
Reference:

Pszczólkowski, A. 2002. The Margot Formation of western Cuba: a volcanic and sedimentary sequence of (mainly) Cenomanian-Turonian age/ Bull. Polish Acad. Sc., Earth Sciences 50(2):193-205.
Project web page: http://www.ig.utexas.edu/CaribPlate/CaribPlate.html

7.5. REPORT ON VOLCANIC ACTIVITY IN THE CARIBBEAN

Caribbean Volcanic Activity And Forecast Report

by R.B. Trombley
Principal Research Volcanologist
Southwest Volcano Research Centre
Apache Junction, Arizona USA

6 October 2003

The Caribbean area primarily consists of the countries of Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Columbia and Venezuela and the island nations represented in the Lesser Antilles. Some countries such as Cuba, Dominican Republic, Peurto Rico, Jamaica and Venezuela, do not have any active volcanoes within.

The following table presents the current eruption status and forecast for all volcanoes within the Caribbean Plate boundaries. It will be upgraded from time to time as appropriate and as necessary.

All forecasts on the following table have been compiled, using presently loaded data, from the SWVRC software programme, ERUPTION Pro 10.4, the only known long-range and reasonably accurate forecasting programme of it kind in the world. Accuracy, relative to Caribbean area volcanoes only, is as follows: Of 12 Volcanoes originally forecasted, 8 have erupted for an accuracy of 72.73% to date for the year **2003**.

KEY:

Volcano = Name of volcano
Country = Country of volcano location
Next Forecasted Year = Year volcano is next forecasted to erupt
Yr. Of =>50% = Year volcano is forecasted to erupt with =>50% probability
Yr. Of =>95% = Year volcano is forecasted to erupt with =>95% probability
Current Status = Current status of the volcano at this time

ACTIVE VOLCANO STATUS OF THE CARIBBEAN
AS OF: 6 October 2003

Volcano	Country	Next Forecast Year	Yr. Of =>50%	=>Yr. Of 95%	Current Status
Ceboruco	Mexico	1874	2052	2658	In Repose
Colima	Mexico	2003	2004	2436	Erupted
El Chichon	Mexico	1998	2193	2858	In Repose
Jocotitlan	Mexico	1272	4646	15863	In Repose
Michoacan-Guanajuato	Mexico	1951	2752	5443	In Repose
Pico De Orizaba	Mexico	1712	1728	1865	Overdue
Pinacate	Mexico	1947	1959	2046	In Repose
Popocatepetl	Mexico	2003	2004	2620	Erupted
San Martin	Mexico	1944	2196	3074	In Repose
Socorro	Mexico	1997	2014	2085	In Repose
Tacana	Mexico	1990	2011	2096	In Repose
Tres Virgenes	Mexico	1861	1946	2241	In Repose
Acatenango	Guatemala	1977	2249	3172	In Repose
Almolonga	Guatemala	1821	2095	3019	In Repose
Atitlan	Guatemala	1873	1882	1970	Overdue
Fuego	Guatemala	2003	2006	2020	Erupted
Pacaya	Guatemala	2003	2028	2118	Erupted
Santa Maria	Guatemala	2003	2013	2052	Erupted
Tajumulco	Guatemala	1870	1925	2135	In Repose
Cerro Negro	Nicaragua	2014	2003	2018	Forecasted '03
Concepcion	Nicaragua	2003	2006	2009	Forecasted '03
Cosiguina	Nicaragua	1868	1908	2074	In Repose
Las Pilas	Nicaragua	1957	2063	2428	In Repose
Masaya	Nicaragua	2027	2003	2728	Erupted
Momotombo	Nicaragua	2013	2151	2675	In Repose
San Cristobal	Nicaragua	2017	2003	2085	Forecasted '03
Telica	Nicaragua	2027	2009	2041	In Repose
Arenal	Costa Rica	2003	2227	2975	Erupted
Barva	Costa Rica	1869	4657	13929	In Repose
Irazu	Costa Rica	2015	2001	2025	In Repose
Miravalles	Costa Rica	1948	4390	12510	In Repose

Poás	Costa Rica	2040	2112	2501	In Repose
Rincón de la Vieja	Costa Rica	2021	2085	2388	In Repose
Turrialba	Costa Rica	1875	2505	4629	In Repose
Baru	Panama	1552	2036	3651	In Repose
Azufral	Columbia	-916	-219	2139	In Repose
Cerro Bravo	Columbia	1728	2264	4072	In Repose
Cumbal	Columbia	1930	1969	2114	In Repose
Dona Juana	Columbia	1899	3474	8716	In Repose
Galeras	Columbia	2022	2098	2449	In Repose
Purace	Columbia	2001	2036	2236	In Repose
Nevado Del Ruiz	Columbia	2015	2266	3173	In Repose
Nevado Del Tolima	Columbia	1949	2890	6038	In Repose
Kick-'em-Jenny	West Indies	2008	2004	2016	In Repose
La Soufriere	West Indies	1997	2245	3140	In Repose
Liamuiga	West Indies	1849	2342	4001	In Repose
Mt. Pelée	West Indies	1981	2049	2450	In Repose
Soufriere	West Indies	2000	2117	2575	In Repose
Soufriere Hills	West Indies	2003	2004	2127	Erupted
The Quill	West Indies	403	2246	8381	In Repose

SWVRC's eruption forecasting programme, ***ERUPTION Pro 10.4***, the only known long-range reasonably accurate forecasting programme of it kind in the world, is currently forecasting 493 volcanoes throughout the world. You can learn more about all current eruptions (global) plus much, much more at the SWVRC website located at the URL of: http://www.swvrc.org.

The interpretation of the Year volcano is next forecasted to erupt, Year volcano is forecasted to erupt with =>50% probability and Year volcano is forecasted to erupt with =>95% probability is as follows: Let us use, for example, volcano **Nevado Del Ruiz** in Columbia. It currently forecasted (with current data loaded) to erupt again in 2015. If it does **not** erupt and if the year reaches 2266, then **Ruiz** would now go to an =>50% probability of an eruption. If **Ruiz** does **not** erupt when the year reaches 3173, then **Ruiz** would go to an =>95% probability of an eruption. Of course if **Ruiz** does erupt then new forecast year calculations would be rendered by ***ERUPTION Pro 10.4***.

In some cases, one will find that the year that a particular volcano is next forecasted to erupt is greater than say the year a volcano is forecasted to erupt with =>50%. For example, **San Cristobal** in Nicaragua is currently forecasted to erupt in 2017 but forecasted at =>50% probability in the year 2003. This seeming anomaly is due to the current data that is loaded into the computer. As the data changes, sometimes on a daily basis, the forecasted years will sometimes change on a daily basis as well. As new data is received and loaded into the ***ERUPTION Pro 10.4*** database, so are the forecast years calculations revised.

NOTE: This document report will be updated from time-to-time as necessary to reflect the latest outputs from the ***ERUPTION Pro 10.4*** database.

7.6 REPORT OF LOCAL REGIONAL GROUPS

Italian-Caribbean WG

Giuseppe Giunta (leader) Univ. Palermo
Members: Luigi Beccaluva (co-leader) Univ. Ferrara, Massimo Coltorti, Franca Siena, Carmela Vaccaro, Univ. Ferrara, Michele Marroni, Luca Pandolfi Univ. Pisa, Gianfranco Principi, Elisa Padoa, Ivan Aiello Univ. Firenze, Marco Menichetti Univ. Urbino, Emanuele Lodolo Univ. Trieste

The aims of the WG in the 2002-03 have been the researches related to the tectonic history of the Caribbean Plate margins, in particular through the study of the ophiolitic units involved in that orogenic belts.
In the 2002-03, the group has carried out field works in Hispaniola, Cuba and Guatemala, with a structural and petrological target, in particular studying the metamorphic belts connected with the collisional stages.
Some meetings and workshops have been attended, presenting talks and papers on the main results of the researches: Geomin 03, AAPG 2003, Fist GeoItalia 02, 03, etc.
The routine-researches have been carried out in the geological laboratories of the Italian universities of Palermo, Ferrara, Pisa and Firenze.
The present and next activities are the more detailed tectonic reconstruction (with at least 2 field trips in 2003-04) of some sectors of both the northern (Guatemala and Hispaniola) and southern Venezuela) plate?s margins, also in the aims of the final IGCP 433 symposium on the Caribbean Plate Tectonics (chairmans: M.Iturralde and G.Giunta) at the International Geological Congress of Florence 2004. In this symposium G.Giunta will present the results of the Italian-Caribbean WG researches in the last years.

8. PUBLICATIONS (RESEARCH PAPERS AND ABSTRACTS)

Publications this year are more than 100. Some are listed below and others titles and detailed abstracts section of this report; so they are not listed here.

Abbott R. N., and Draper, G. (2002) Retrograded eclogite in the Cuaba amphibolite of the Rio San Juan Complex, northern Hispaniola. in Jackson, T.A.,(ed.) Caribbean Geology into the Third Millenium: Transactions of the 15th Caribbean Geological Conference, Kingston , Jamaica, June 1998, (ISBN 976-640-100-4), p. 97-108

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Follow the chapters by members of the UNESCO/IUGS IGCP Project 433 Caribbean Plate Tectonics:

Chap. 3. The conflicting paleontologic vs. stratigraphic record of the origin of the Caribbean and the Gulf of Mexico. Manuel Iturralde-Vinent, Museo Nacional de Historia Natural, Cuba

Chap. 4. Early Paleogene isolation of the Gulf of Mexico from the world's oceans? Implications for hydrocarbon exploration and eustacy. Josh Rosenfeld and James Pindell, Yax Balam, Inc./Tectonic Analysis

Chap. 5. Geological constraints on the geodynamic evolution of the southern margin of the Caribbean Plate. Giuseppe Giunta, Michele Marroni, Elisa Padoa and Luca Pandolfi, Universita di Palermo/Universita di Pisa/Universita di Firenze, Italy

Chap. 6. No oceanic plateau, no Caribbean plate: The seminal importance of thick oceanic plateau(s) in the plate tectonic evolution of the Caribbean. Andrew C. Kerr, Rosalind V. White, John Tarney and Patricia M.E. Thompson, Leicester-Cardiff Caribbean Research Group, UK

Chap. 13. The Origin of the Macuspana basin of southeastern México with implications for petroleum systems in the surrounding area. Joshua Rosenfeld, Veritas Exploration Services, USA

Chap. 15. Economic potential of the Yucatan block of Mexico, Guatemala and Belize. Joshua Rosenfeld, Veritas Exploration Services, USA

Chap. 28. Sedimentological and tectonic evolution of central Jamaica: Implications for the plate tectonic evolution of the Caribbean. Simon F. Mitchell, University of the West Indies, Jamaica

Chap. 35. The formation of the Maturin Basin in Eastern Venezuela: Thrust sheet loading and continental subduction. M.I. Jacome, N. Kusznir, F. Audemard and S. Flint, PDVSA, Venezuela /University of Liverpool, UK

9. IGCP PROJECT 433. ABSTRACTS OF SOME PRESENTATIONS AND PAPERS
Year 2003

Aguilar, T., and P. Denyer, NICOYA COMPLEX SENSU STRICTU, CRETACEOUS STRATIGRAPHY AND TERRANES OF THE NICOYA PENINSULA, COSTA RICA, Report of the Field Workshop in Cuba, March 2003.

The Nicoya Complex s.st. was originally defined at the NW of Nicoya Peninsula. The Ar/Ar-dates and bio-stratigraphic data do not confirm either one of the current hypotheses, in which an oceanic basement and its Jurassic-Cretacecous sediment cover is overlaid by Upper Cretaceous plateau basalts. The Nicoya Complex s. str. is a fragment of the Late Cretaceous Caribbean Plateau created by uplift and southward tilting during an early Campanian collisional event. The deepest levels of the Plateau are exposed in NW-Nicoya, where over 50 % of the igneous rocks are intrusives (gabbros and plagiogranites). Ar/Ar-dates of igneous rocks (83-92 Ma) are consistently younger than most of the radiolarian cherts (Early Jurassic-Late Cretaceous). No Jurassic oceanic basement has been identified. Therefore, the Jurassic-Cretaceous rediolarites became disrupted and detached from its original basement by multiple intrusions during the formation of the Caribbean Plateau (Baumgartner and Denyer, in prep). The origin of the Cretaceous series of the Nicoya Peninsula has been described in different ways and by many authors. However, only Di Marco and others (1995), based on paleomagnetism and stratigraphy, proposed the existence of two teranes. The Nicoya terrane comprises the Santa Elena Peninsula and the outer Nicoya Peninsula, constituted by mafic and ultramafic oceanic basement and associated deep water sediments.

The Chorotega Terrane constitutes most of the southern Middle American land bridge and probablyformed the western edge of the Caribbean Plate during Late Cretaceous. Using the stratigraphic criteria, we have recognized two different terranes, subdividing the Chorotega terrane proposed by Di Marco and others (1984). The Chorotega terrane sensu stricto is constituted by oceanic basalts and bitouminous shales interbedded with siliceous and tuff sediments (Albian-Santonian). We propose a new terrane constituted by basalts and breccias overlaid by pre-Campanian (probably Santonian) green siliceous volcaniclastic shales, green very fine grain ignimbrites and occasionally bitouminous sediments. Microscopically these rocks show hornblende, piroxene, plagioclases, shards and collapsed pumice. The pelagic-hemipelagic Sabana Grande Formation (Late Santonian-Early Campanian) is overlapping both terranes.

Audemard, F., THE "OROGENIC FLOAT" OF NORTHERN SOUTH AMERICA, AAPG International Meeting, 2003, Barcelona, Spain.

A set of three parallel regional seismic transects allow to present the northern margin of Venezuela from Colombia to Trinidad as an "Orogenic

Float" developed by the interaction between oceanic crusts and the South-America's passive margin during late Cretaceous to Neogene times from west to east. These two distinct subduction zones play important roles in the geodynamic context: the "B" subduction of the Lesser Antilles (west polarity) and the coeval "B" Colombo-Venezuelan subduction (south polarity).
Additional examples of the structural styles formed in domains are also presented: - The Barbados Accretionary Prism evolves over oceanic crust to the west and progressively rides continental crust towards the south. The prism is currently being disrupted by gravitational tectonics associated with the Orinoco Delta edifice. - The south vergent Mid-Miocene Serrania del Interior shows differential uplift due to remobilization of Miocene shales along its leading edge. -Orogenic collapse of the igneous-metamorphic "Caribbean allochthonous belt" and transpression superimposed to the Neogene sequence are caused by a transfer system between two "B" subduction zones. -The Falcón anticlinorium resulted from partial inversion of a Neogene flexural basin, as opposed to the prevalent pull-apart model. It is actually overthrusted to the north, following the Present-day Colombo-Venezuelan Accretionary Prism. -Comments will be addressed on both the geodynamic setting of wrench tectonic models, e.g. the Boconó and Oca lineaments and "opposing" northwest vergence of the Mérida and Perijá folded belts. Implications for exploration will be discussed for all these structural styles.

Avé Lallemant, H.G. and Sisson, V.B., 2002, GEODYNAMIC EVOLUTION OF NORTHERN VENEZUELA: XI Venezuelan Congress on Geophysics, Caracas 2002, Abstract.
The boundary zone between the Caribbean and South American plates in Venezuela resembles a classical fold and thrust belt with a non-metamorphic foreland fold and thrust belt (Serranía del Interior [SdI]) and a metamorphic hinterland (Caribbean Mountain System [CMS]). However, the SdI formed in Tertiary time whereas the CMS formed in the Cretaceous. The CMS consists of several allochthonous belts. Two of these belts (Cordillera de la Costa belt [CdlC] and Villa de Cura [VdC] belt) contain high-pressure / low-temperature (HP/LT) metamorphic assemblages that typically are formed in subduction zones. The CdlC belt is a mélange containing eclogite and blueschist bodies, whereas the VdC belt consists of four internally coherent sheets of blueschist. Both HP/LT belts are of Cretaceous age and are related to west-directed subduction of the Proto-Caribbean lithosphere underneath the Leeward Antilles volcanic island arc. Deformation structures in the CdlC belt indicate that displacement partitioning occurred resulting in plate boundary parallel stretching of the arc and the subduction complex. This subduction zone / volcanic arc system migrated from the west (longitude of Panama) to the east (northeastern Venezuela) from mid-Cretaceous to Miocene times. Plate convergence was highly oblique causing diachronous collision of the system with South America. As a result of the collision the subduction polarity switched. New apatite fission-track data from the central and eastern SdI suggest that before the collision Early and mid Tertiary thrusting occurred along the Venezuelan continental margin related to north-south contraction possibly expressed by south-directed subduction. The interpretation of these preliminary results is controversial. Deep seismic studies ought to be carried out to test these preliminary conclusions.

Bartolini, C. MESOZOIC TERRESTRIAL VOLCANISM VS. COEVAL REDBED DEPOSITION IN THE RIM OF THE GULF OF MEXICO: WHERE IS THE BOUNDARY?, Report of the Field Workshop in Cuba, March 2003.

Volcanic, sedimentary and granitic plutonic rocks that are part of the early Mesozoic Cordilleran continental magmatic arc are exposed in a belt from the southwestern United States to Guatemala. In north-central Mexico, these volcanic arc suites are grouped into the Nazas Formation, which record volcanic activity, crustal extension, and erosion of volcanic edifices in a subaerial volcanic arc that developed from Late Triassic to Middle Jurassic time along the México western continental margin. The Nazas arc consists of more than 3 km of volcanic flows, pyroclastic rocks and clastic sedimentary strata that were formed in extensional intra-arc basins within the upper arc structure. These sequences are characterized by drastic facies changes over short distances, highly variable thicknesses of basin-fill, mixed sediment composition, heterogeneous lithologic associations, and poorly known fluvial and alluvial facies distribution, reflect the complexity of the arc environment. The size, original orientation and geometry of individual basins within the arc are unknown in detail due to younger tectonic events and erosion.

Early Mesozoic extension along the arc was contemporaneous with rifting along the western Gulf of México to the east. Rift basins along the Gulf were filled with Late Triassic and Early-Middle Jurassic redbeds, evaporite deposits and occasional intercalations of pyroclastic rocks that may have erupted from the arc and probably traveled east reaching the zone of rifting that created the Gulf of México. In this scenario, two distinct extensional provinces overlapped within the Nazas arc, one with volcanic and pyroclastic rocks dominant in the west (Nazas Formation) and redbeds (Huizachal Group) in the east and offshore in the western part of the Gulf of Mexico. The complex interaction of geologic processes related to two distinct but coeval tectonic settings (subduction beneath the arc and rifting along the Gulf of Mexico rim) rule out previously proposed simple rift system models. Whether extension along the Nazas magmatic arc is the result of westward propagation of Gulf-related rifting or extension along the Gulf of Mexico coastal region is related to back-arc extension is an issue to be resolved. The evolution of these two tectonic domains is critical in understanding the structural framework and the Late Jurassic source rock distribution of the prolific petroleum basins in Mexico.

Cazañas, X., Alfonso, P., Melgarejo, J.C., Proenza, J.A., Fallick, A.E. (2003): SOURCE OF ORE-FORMING FLUIDS IN EL COBRE VHMS DEPOSIT (CUBA): EVIDENCE FROM FLUID INCLUSIONS AND SULFUR ISOTOPES. Journal of Geochemical Exploration 78-79, 85-90.

The El Cobre deposit, east of Cuba, lies in the intermediate volcanosedimentary sequence of the Sierra Maestra intraoceanic island arc. The structure of the deposit corresponds to that of a VHMS model. It comprises: a) thick stratiform bodies (baryte and anhydrite), b) three stratabound bodies (formed by silicification and sulfidation of limestones or sulfate strata), c) stockwork zones: an older anhydrite stockwork and a younger quartz-pyrite stockwork gradind downwards to d) simple veins (quartz with sulfide ores). Pyrite, chalcopyrite and sphalerite are the most abundant sulfides. Fluid inclusions from This deposit have a salinity between 2.3 and 5,7 wt % NaCl eq., the homogenization temperatures range between 177 and 300°C. Sulfur exhibits a range of $\delta^{34}S$ values form –1.4 to +7.3‰, for sulfides, and +16 -+21‰, for sulfates. Fluid inclusions and sulfur isotope data at El Cobre deposit indicate that the hydrothermal fluid from which the sulfide precipitated was seawater, modified by reaction with volcanic host rocks during hydrothermal circulation.

Chambers, A. F., P. Lukito, C. Solla Hach, S. Torrescusa Villaverde, C. Riaza Molina and H. Bachmann, STRUCTURAL CONTROLS ON THE HYDROCARBON PROSPECTIVITY OF BLOCKS 25-29 AND 36, OFFSHORE NORTHERN CUBA, AAPG International Meeting, 2003, Barcelona, Spain.

Integration of new 3D seismic interpretations with a regional 2D seismic dataset has revealed the main structural controls upon hydrocarbon prospectivity in the deepwater north Cuban basin.

The plate tectonic evolution of the region can be simplified into three main phases. Firstly the carbonate-dominated Florida-Bahama passive margin developed during Jurassic-Cretaceous times. Secondly, during the late Cretaceous-Eocene, the Cuban volcanic arc converged and collided with the Florida-Bahama passive margin. Finally the infilling Cuban foredeep basin was subjected to late compression and erosion.
The evolution of the western and southern Florida-Bahama platform margin since mid-Cretaceous times has been defined using a regional 2D seismic dataset. This regional interpretation indicates that the platform margin to the west of Florida has remained static form Mid-Cretaceous Unconformity (MCU) to Neogene times forming a pronounced bathymetric escarpment. In the north Cuban offshore area, however, the platform margin has retreated northwards since Mid-Cretaceous times in response to loading by the Cuban thrust. It is observed that the well-defined MCU platform margin is consumed by the Cuban thrust belt in northern Cuba.
3D seismic data have been acquired over two zones in the study area. In one area the structural style is dominated by Mesozoic fault trends that have been extensionally reactivated during platform margin collapse. In the other, this pre-existing extensional framework has been strongly overprinted by oblique sinistral compression. Despite the large scale compressional regime, the majority of the small-scale, seismically-observed faults are extensional in nature and may potentially enhance reservoir performance

Cuevas Ojeda, José Luis, Lázaro A. Díaz Larrinaga y, Bárbara Polo González, MAPAS GENERALIZADOS DE LAS ANOMALÍAS GRAVIMÉTRICAS DEL CARIBE OCCIDENTAL Y AMÉRICA CENTRAL, Report of the Field Workshop in Cuba, March 2003.

The present paper has had as main goal the realization of free air gravity and Bouguer anomalies maps (with topographical correction up to 167 km) of the western Caribbean from the 9 degrees of north latitude up to the 27,22 degrees and between the -90 and -65 degrees of longitude west to scale 1:2 000 000. In 1994, culminates the making of the gravity Bouguer anomalies map for the first time (with topographical correction up to 167 km) of center easthern Cuba, being culminated in 1998 the making of the map of the same character of all Cuba, to scale 1:500 000, in both cases for Cuevas and others. In 1999, the gravitational effect of the terrain is calculated in the Caribbean western center (Cuba, The Hispaniola, Jamaica and adjacent seas). being elaborated in that same year the gravity Bouguer anomalies map (with topographical correction up to 167 km) in the Caribbean western center, to scale 1:2 000 000 for Cuevas and others (2000).
This result is the amplification of the methodological generalization of the calculation of the gravity Bouguer anomalies map in the area western Caribbean, where they are most of the islands belonging to the Greater Antilles, including central America, and the part northern Westerner of America of the South, what will allow in the frame the Project "Contribution to the Model of Geological Evolution of the Western Caribbean according to Geophysical Data", to carry out geological and geophysical interpretations with new information.

Fundora Granda, M. J., Sten--Ake Elming, C. Cruz Ferrán , J. Pérez Lazo, A. García Rivero, I. I. Pedroso Herrera y M. Campos Dueñas. PALEOMAGNETISMO DE FORMACIONES DEL CRETÁCICO SUPERIOR Y EL TERCIARIO INFERIOR EN LAS GRANDES ANTILLAS, Report of the Field Workshop in Cuba, March 2003.

Some results of the paleomagnetic investigations carried out by Technological University of Lulea, Sweden and the Cuban Institute of Geophysics and Astronomy, on Cretaceous and Lower Tertiary formations'rocks collected in Eastern Cuba, Dominican Republic and Jamaica during 1995-1998 in the frame of the Program of Scientific Cooperation of the Swedish Agency SAREC are presented.
The goals of this investigation were:
a) To test the possibility of using MesoCenozoic rocks outcropping in the three islands to be used in paleomagnetic studies and
b) To contribute to the deciphering of the tectonic relative positions between,Cuba, Jamaica and Hispaniola and the end of the Cretaceous and beginning of the Tertiary times.
There were also obtained the RCM and their for ten geological formations, being established their probable primary origin. The rotations and latitudinal displacements underground by the different blocks under study were calculated, which allowed to impose quantitative restrictions to the numerous models of tectonic evolution developed by different authors. Finally the relative positions of the three islands respect to the North American Craton for the Upper Jurassic-Lower Cretaceous? times to Eocene times are shown.

Gahagan, Lisa and Paul Mann, Institute for Geophysics, University of Texas at Austin, MONKEY WRENCH IN THE CENTRAL AMERICAN SUBDUCTION FACTORY: IMPROVED AGE ESTIMATES FOR THE SUBDUCTION HISTORY OF THE COCOS RIDGE, AGU Fall Meeting, San Francisco, California, 6-10 December 2002
Subduction of the Cocos and Carnegie ridges at the Middle America and Colombian trenches, respectively, have been shown by a variety of marine and land-based studies to have profound and disruptive effects on subaerial and submarine geomorphology, the spacing and composition of arc volcanism, cross-arc traverse faulting, forearc deformation and erosion, back-arc thrust faulting, and anomalously large forearc and backarc thrust-related earthquakes. To better understand past effects of these highly localized, collisional-driven processes, we use quantitative plate reconstructions to reconstruct the history of three originally, contiguous large igneous provinces (Cocos, Malpelo, Carnegie ridges) formed near the Galapagos hotspot in early Miocene time (~21 Ma). Plate reconstructions are based on a compilation of marine magnetic data from the Cocos, Nazca, Pacific, and Caribbean plates and make use of plate closure between those plates via circuits through Cocos-Nazca-Antarctica-Pacific and Antarctica-Africa-North America-Caribbean. Main events suggested by this reconstruction include: 1) formation of the Cocos-Malpelo-Carnegie ridges as a single large igneous province (LIP) in the vicinity of the Galapagos hotspot starting at ~21 Ma; 2) predicted formation of a now-subducted northeastward extension of the Cocos Ridge between 20-14 Ma; 3) rifting and divergence of the three LIPs occurred between 21 and 12 Ma following formation of the Nazca-Cocos plate boundary; 4) 750 km of right-lateral offset of the Cocos Ridge into an eastern (Malpelo) and western (Cocos) branch; 5) initial contact of the inferred extension of the Cocos Ridge with the Middle America trench at ~2 Ma; and 6) subduction of ~225 km of the inferred extension of the Cocos Ridge. We compare our predicted Cocos ridge subduction history with land-based geologic studies of deformation and uplift.

García-Casco, A., Carlos Pérez de Arce, Guillermo Millán, Manuel Iturralde-Vinent(, Eugenia Fonseca, Rafael Torres-Roldán, Kenya Núnez, Diego Morata, METABASITES FROM THE NORTHERN SERPENTINITE BELT (CUBA) AND A METAMORPHIC PERSPECTIVE OF THE PLATE TECTONIC MODELS FOR THE CARIBBEAN REGION, Memorias Geomin 2003, La Habana, 24-28 De Marzo. Isbn 959-7117.
The analysis of metamorphosed magmatic rocks along the northern serpentinite belt (Cuba) suggest a variety of tectonic settings of formation and metamorphism. Slightly deformed coherent bodies of metabasites from Cajálbana (western Cuba) and Iguará-Perea (central Cuba) underwent

ocean-floor type metamorphism at low-pressure (<3 kbar) amphibolite (locally granulite) facies conditions. 40Ar/39Ar plateau ages on amphiboles have yielded 88.0 +/- 3.2 (Iguará-Perea) and 129.8 +/- 1.9 Ma (Cajálbana). These rocks have tholeiitic (Cajálbana) and calc-alkaline (Iguará-Perea) signatures and evidence of formation in suprasubduction environments (Th, Nb and Sr anomalies). Based on geochemical similarities with the arcrelated metamorphic Mabujina complex (central Cuba), it is hypothesized that the Iguará-Perea complex may represent the roots of an embryonary or abandoned arc. Indeed, arc-related (instead of mid-ocean ridge) thermal focuses for metamorphism are favored because of the consistent relationships between the age of metamorphism and geochemistry of the protholiths and the age and geochemistry of the Lower and Upper Cretaceous volcanic arc suites of Cuba. The Güira de Jauco amphibolites (eastern Cuba) have NMORB and E-MORB basaltic to picritic composition that suggest an Upper Cretaceous plateau basalt origin of the protolith. These rocks were strongly deformed and metamorphosed to intermediate pressure(6-8 kbar) amphibolite facies conditions, indicating collision-related metamorphism. The documented Cretaceous formation of suprasubduction and intraplate oceanic complexes must be added to the inferred event of formation of oceanic lithosphere at Upper Jurassic to Lower Cretaceous times in ocean-ridge environments, and put important constraints to models of plate tectonic evolution of the Caribbean region.

Giunta G., Beccaluva L., Coltorti M., Cutrupia D., Dengo C, Harlow G., Mota B., Padoa E., Rosenfeld J., Siena F. ? 2002 ? THE MOTAGUA SUTURE-ZONE IN GUATEMALA. Field Trip Guide Book of the IGCP 433 Workshop and 2^ Italian-Latin American Geological Meeting in memory of Gabriel Dengo. Ofioliti.

The Caribbean Plate (Fig. 1) consists of a poorly deformed central portion (Colombia and Venezuela Basins) delimited by two pairs of active systems. It results from the Mesozoic to Present interactions with the adjacent Nazca, Cocos, and Americas Plates.

The margins of the Caribbean Plate are represented by extensive deformed belts resulting from several compressional episodes beginning in the Cretaceous, subsequently affected by tensional and/or strike-slip tectonics.

These deformations have affected large portions of the Caribbean and adjoining plates. The Caribbean lithosphere has been deformed and tectonically emplaced over the Pacific and Atlantic oceanic crusts producing the western and eastern arc systems of the Central American Isthmus and Lesser Antilles. It has also been squeezed against the North and South American continental crusts thereby originating suture zones in the Cordillera of Guatemala, the Greater Antilles and Venezuela. The more internal Caribbean marginal areas were subsequently deformed and are involved in several accretionary prisms in Venezuela, Colombia, Panama, Hispaniola, etc. (Stephan et al., 1986).

Various !flower structures! with opposing vergences are identified along the northern and southern Caribbean margins where preferential shortening directions were controlled by diachronous oblique, movements. The northern and southern Plate margins consist mainly of transpressive or strike-slip shear zones, whereas the western and eastern margins are represented by convergent systems and related magmatic arcs. The Caribbean Plate margins include Jurassic-Cretaceous ophiolitic complexes exposed along suture zones and as accreted terranes on the northern, southern and western sectors of the plate.

The present-day borders of the Caribbean Plate follow these deformed belts. Sinistral and dextral strike-slip shears occur respectively on the northern and southern margins. Therefore, certain portions of the deformed Caribbean lithosphere are now included in the crust of the adjacent plate margins, and should no longer be included in the Caribbean domain (s.s).

Systematic investigations carried out in recent years on the most important peri-Caribbean ophiolites allow reconstruction of the regional geometry, magmatic affinity and original tectonic setting of these oceanic units. The main results of investigations by the Italian-Caribbean Tectonics Group were presented at the International Geological Congress of Brazil 2000. The aim

of the present field-trip is to provide an overview of the Motagua Suture Zone architecture in Guatemala, and to contribute to the debate on the origin and evolution of the Caribbean Plate in the framework of the I.G.C.P.-Project 433.
The workshop and field-trip have been held !In memory of Gabriel Dengo!.
The field-trip was organized by the Italian Caribbean Working Group, under the aegis of IGCP-Project 433, the Sociedad Geologica de Guatemala, GLOM- the Italian Working Group on Mediterranean Ophiolites, CESEM-the Centro de Estudios Superiores de Energia y Minas - Facultad de Ingenieria, USAC Guatemala, CNR-the Italian National Council of Researches, the Direccion General de Mineria ? Ministerio de Energia y Minas de Guatemala, Cementos Progreso S.A. Guatemala, and the Italian Institute of Culture in Guatemala.

Giunta G., Beccaluva L., Coltorti M., Siena F., Mortellaro D., Cutrupia D. -2002- THE PERI-CARIBBEAN OPHIOLITES: STRUCTURE, TECTONO-MAGMATIC SIGNIFICANCE AND GEODYNAMIC IMPLICATIONS. Caribbean Journal of Earth Science.
New geological and petrological data on the ophiolitic complexes deformed and dismembered along the Caribbean Plate margins are presented in the framework of IGCP 433, in order to contribute to the debate on the origin and evolution of the Caribbean Plate. A ?near Mid-America? original location of the Jurassic-Cretaceous Caribbean oceanic realm (proto-Caribbean phase) is suggested. Its crustal accretion can be initially referred to multiple spreading centres (LREE-depleted MORB, in Venezuela, Costa Rica, Cuba, Guatemala, Hispaniola), evolving, in the western portion of the proto-Caribbean domain, to a thickened oceanic plateau (REE-flat MORB locally associated with picrites, in Costa Rica, Hispaniola, Venezuela, Dutch and Venezuelan Islands). At the same time both the South and North American continental margins were affected by rifting and within-plate tholeiitic magmatism (Venezuela and Cuba).
From the Early to Late Cretaceous (eo-Caribbean phases) one subcontinental subduction zone with melange formation (recorded only in Venezuela) and two main stages of intraoceanic subduction may be recognised: 1) a first NE- and SE-dipping sinking of unthickened proto-Caribbean lithosphere, recorded by deformed and HP/LT metamorphosed ophiolitic melanges and volcano-plutonic sequences with island-arc tholeiitic affinity (IAT) in Venezuela, calc-alkaline affinity (CA) in Cuba and both IAT and CA affinity in Guatemala and Puerto Rico; 2) a second intraoceanic subduction, with reverse polarity, responsible for the first tectonic settlement of the Caribbean margins, recorded by unmetamorphosed tonalitic intrusives, and related to the onset of the Aves-Lesser Antilles arc system and its eastward migration. In the Late Cretaceous, the inner and undeformed portions of the Caribbean Plate, i.e. the Colombian and Venezuelan Basins, were trapped by the intervening Pacific subduction, building the Central American Isthmus. The Tertiary to Present eastward displacement of the Caribbean Plate led to the progressive dismembering of the deformed ophiolitic belts and their involvement in its margins.

Giunta, G., L. Beccaluva, M. Coltorti and S. Franca, THE PERI-CARIBBEAN OPHIOLITES AND IMPLICATIONS FOR THE CARIBBEAN PLATE EVOLUTION, AAPG International Meeting, 2003, Barcelona, Spain.
Ophiolitic terranes deformed and dismembered along both the northern and southern peri-Caribbean margins represent fundamental markers for the origin and evolution of the Caribbean Plate.
The proto-Caribbean oceanic crust was generated in a "near Mid-America" location since Late Jurassic. Its accretion was initially related to multiple spreading centres (LREE-depleted MORB, in Venezuela, Costa Rica, Cuba, Guatemala, Hispaniola), evolving during the Cretaceous to a thickened oceanic plateau in its westernmost end (REE-flat MORG locally associated with picrites, in Costa Rica, Hispaniola, Venezuela, Dutch and Venezuelan Islands).

Sub-continental and intra-oceanic east-dipping subduction zones initiated within the proto-Caribbean domain since the early Cretaceous with generation of HP metamorphic subduction complexes and island arc tholeiitic to calcalkaline volcano-plutonic sequences (1° eo-Caribbean phase: in Guatemala, Cuba, Puerto Rico and Venezuela). Since the Late Cretaceous a second intra-oceanic subduction, with reverse polarity, took place, recorded by unmetamorphosed tonalitic intrusives, and related to the onset of the Aves-Lesser Antilles arc system (2° eo-Caribbean phase). During Late Cretaceous-Tertiary large-scale tear faulting along the northern and southern margins of the Caribbean Plate favoured eastward dispersion and uplifting of the subduction-accretion systems. The present Caribbean Plate is mainly represented by the Cretaceous plateau crust trapped in the Colombia and Venezuela basins by the intervening Pacific subduction, which built the Central American isthmus.
The recent data allow to better define some important constraints which lead the kinematic evolution of the Caribbean Plate's deformed margins.

Giunta G., Beccaluva L., Coltorti M., Siena F., C. Vaccaro - 2002- THE SOUTHERN MARGIN OF THE CARIBBEAN PLATE IN VENEZUELA: TECTONO-MAGMATIC SETTING OF THE OPHIOLITIC UNITS AND KINEMATIC EVOLUTION. Lithos .
The southern Caribbean Plate margin in Venezuela consists of a W-E elongated deformed belt, composed of several tectonic units piled up on a foredeep basin and dismembered along the northern part of the South America continental Plate since the Late Cretaceous. The present review, based on structure, petrology and tectono-magmatic significance of each unit, makes it possible to define the main geotectonic elements and to reconstruct the paleogeographic domains from Late Jurassic to Tertiary: a - Mid Ocean Ridge Basalt (MORB) proto-Caribbean oceanic basin (Loma de Hierro Unit and Venezuelan Islands Unit basement); b - rifted continental margin (Cordillera de La Costa and Caucagua-El Tinaco Units) with Within Plate Tholeiitic (WPTh) magmatism; c ? an intra-oceanic subduction zone represented by Island Arc Tholeiitic (IAT) magmatism (Villa de Cura and Dos Hermanas Units) of Early Cretaceous age; d - an ocean-continent subduction trench filled by melange (Franja Costera); e ? a new intra-oceanic subduction zone, represented by granitoid to gabbroid arc magmatism of Late Cretaceous age (Dutch and Venezuelan Islands).
Regional tectonic constraints and coherent kinematic reconstruction suggest an original (near-Mid America) location of the Jurassic-Cretaceous proto-Caribbean oceanic realm, progressively evolving through crustal thickening to the oceanic plateau structure of the Dutch and Venezuelan Islands.
From Early to Late Cretaceous one sub-continental subduction with melanges (Franja Costera Unit) and two main stages of intra-oceanic arc magmatism are recorded in the so-called eo-Caribbean phases. The first consists of generally metamorphosed and deformed volcano-plutonic sequences with IAT affinity (Villa de Cura and Dos Hermanas Units), probably in relation to a southeastward-dipping subduction. The second is mainly represented by generally unmetamorphosed granitoid to gabbroid intrusives cutting the oceanic plateau in the Dutch and Venezuelan Islands, and related to the new intra-oceanic subduction with reverse lithospheric sinking. The latter probably marked the onset of the Aves/Lesser Antilles arc system in the Late Cretaceous.
Since the Late Cretaceous, the oceanic plateau - corresponding to the Venezuelan and Colombian basins, coupled with the Aves/Lesser Antilles volcanic arc - migrated eastward relative to South America leading to a progressive dismembering of the Venezuelan Islands units, together with the

previous deformed belt, in the still active dextral mega-shear zone which constitutes the Southern Caribbean Plate margin (Caribbean phase).

Giunta G. And Y. Dilek - OPHIOLITES FROM THE PROTO-CARIBBEAN TO THE CARIBBEAN PLATE: DIFFERENT MODELS. IGCP 433, Barbados

The Caribbean Plate evolution records episodes of accretionary and collisional orogenic systems and orogen-parallel strike-slip faulting.

The proto-Caribbean oceanic crust was generated, since Late Jurassic, in a near-midAmerican position, representing the westward ending of the Tethys and the connection between the Atlantic and Pacific realms. The continental margins were affected, at that times, by rifting tectonics with subcontinental mantle intrusions.

The westernmost portions of the proto-Caribbean crust, during the Cretaceous, had been thickened by a continous magmatic event, giving rise to an irregular oceanic plateau, that is supposed to be located in a near-eastern Pacific position, very close to the middle America. The existence of this oceanic plateau constrains both the formation and the evolution of the Caribbean Plate, since the Cretaceous untill today.

In the middle-Late Cretaceous started the compressional accretionary tectonics in the Caribbean areas (eo-Caribbean), demonstrated by the occurrence of subcontinental and intraoceanic subduction zones, producing both HP/LT metamorphics (ophiolites and continental margins rocks) and volcano-plutonic sequences with IAT and CA affinities.

Various models can be proposed for the middle-Late Cretaceous, depending on, a) the paleogeography and morphology of the margins of the main continents and minor blocks; b) the sinking direction of the subducting slab; c) the location of and relationships between the intraoceanic and subcontinental subduction zones. All alternative models should provide one or more kinematic releases (i.e., paleo-strike-slip faults) related to oblique convergent zones, allowing the coexistence of different subduction systems.

In the Late Cretaceous, the progressive insertion of the Caribbean oceanic plateau between the two Americas, induced compressional regime at its eastern border, allowing the westward directed subduction of the proto-Caribbean unthickened oceanic crust below the plateau, after intruded by tonalitic CA magmatism. The eastward shifting of both the northern and southern triple-junctions gave rise either to the more and more bending of the Aves-Lesser Antilles arc, or the collisional orogenic systems along the continental borders.

The new intraoceanic subduction systems, related to transpressional regime, can be inferred to dip either eastward with a later flip westward below the oceanic plateau, or continuously westward, depending on the previous middle-Late Cretaceous accretionary tectonics. Behind the plateau, the different rotation rate of minor continental or arc-volcanic blocks, related to the subduction of the Pacific crust below the plateau, produced the western margin of the Caribbean Plate.

Since the latest Cretaceous, orogen-parallel strike-slip faulting facilitated lateral dispersion of accreted and continental margins units, juxtaposing the various derived terranes at the Plate?s borders; the Caribbean Plate is mainly represented by trapped plateau crust of Colombia and Venezuela basins.

Several lines of evidence may support either the mentioned models or even others, which may fit well one margin at once, rather than the whole plate?s margins.

Giunta G., M.Marroni, E.Padoa, L.Pandolfi ? 2002 ? GEOLOGICAL CONSTRAINTS FOR THE GEODYNAMIC EVOLUTION OF THE SOUTHERN MARGIN OF THE CARIBBEAN PLATE. AAPG-Sp.Vol. (in press).

The southern margin of the Caribbean plate, cropping out in the Venezuela belt, consists of an assemblage of four main terranes: the Dutch-Venezuelan Islands, Margarita Island, Cordillera de la Costa and Serrania del Interior. These terranes have been located, since the mid-Cretaceous, along the transform boundary between the Caribbean and South American plates. On the basis of both new data and the literature, a critical review of the complex and long-lived evolution recorded in different units of these terranes is herein provided in order to highlight the Mesozoic-Early Tertiary geodynamic evolution of the southern Caribbean.

The analysis of the lithostratigraphic, petrologic and tectono-metamorphic features of the terranes, as well as their regional correlations, allow us to define the main geotectonic elements (as oceanic basins, magmatic arcs, subduction zones, continental margins, continental microplates, etc.) involved in the evolution of the southern Caribbean margin. The magmatic, tectonic, and metamorphic histories of these elements are able to provide valuable constrains for the evolution of the southern Caribbean, as, for instance, the beginning of the convergence during the Early Cretaceous, the atypical evolution of the supra-subduction system during the mid-Cretaceous, the role of the mid-Cretaceous strike-slip tectonics, the exhumation histories of the HP-LT units. The collected data suggests a Middle Jurassic-Early Cretaceous location of these elements in a westernmost, ?near mid-America? position, almost at the north-western corner of the South American plate. Starting from the mid-Cretaceous, the elements have been affected by a right-oblique convergence along the transform boundary connecting the two oppositely-dipping subduction zones of the Andes and Aves-Lesser Antilles. According to the geological constraints, three possible geodynamic scenarios can be proposed for the beginning of the convergence during mid-Cretaceous, taking into account the different locations of the transform fault in the geodynamic setting of the southern Caribbean. The collisional belt, resulting from the mid-Cretaceous tectonics, have been dissected in different terranes, progressively rotated clockwise, juxtaposed to each other, and then eastward displaced. The geodynamic framework was closely related to the progressive eastward motion of the Caribbean plateau which, in turn, was associated with the development of a W/S-W dipping, intra-oceanic subduction of the proto-Caribbean oceanic crust below the plateau, and related island-arc calc-alkaline magmatism, today preserved in the Dutch-Venezuelan Islands and Aves-Lesser Antilles. At that time, the terranes were already emplaced onto the South America continental margin. Northward, the dextral strike-slip tectonics of the Caribbean southern margin increasingly involved the southern part of the magmatic arc, which gradually became inactive, and underwent a progressive rotation clockwise. In contrast, the Aves-Lesser Antilles were gradually bent eastward by the oblique convergence occurring at the southern end of the magmatic arc. Since the Late Paleocene, the whole marginal belt was already completely identifiable with the large shear zone occurring today at the transform boundary between the Caribbean and South American plates.

Giunta G., L. Beccaluva , M. Coltorti, F. Siena - SOME REMARKS ON THE CARIBBEAN SUPRA-SUBDUCTION OPHIOLITES AND RELATIONSHIPS WITH THE MODE OF SUBDUCTION. Geomin 2003

Supra-Subduction Zone (SSZ) ophiolites may be classified in two main types based on their structure, tectonics and magmatic features: 1) ?Tethyan complexes? (such as those of the Albanide-Hellenide belt) which mostly consist of complete and extensive volcanic, dyke, plutonic, and mantle sections with prevalent Island Arc Tholeiitic (IAT) magmatic affinity and the significant presence of Boninites, obducted as relatively intact lithospheric slabs onto collisional continental margins; 2) ?Cordilleran complexes? (including the circum-Caribbean ophiolites of Guatemala, Cuba and Venezuela), mostly represented by dismembered sections of arc volcanic, plutonic and subordinate mantle sequences with tholeiitic to calc-alkaline (IAC) magmatic affinity and acidic differentiates, commonly associated with metamorphic ?subduction complexes? and tectonically emplaced onto or juxtaposed against the continental margin within polygenetic terranes. These two types appear to be related to significantly different subduction modes and intra-oceanic plate dynamics whereby SSZ ophiolites were generated. The Tethyan complexes can be best accounted for by west Pacific-type subductions with accentuated steepening and retreat of the subducted slab, accompanied by progressive decoupling of the converging plates, intense mantle diapirism and tensional events in the upper plate; in fact, the presence of large sheeted dike complexes testify for continuous injection of basaltic magmas in ?open? oceanic spreading systems. Continuous slab sinking and roll back allow increasing asthenospheric diapirism from the arc axis to the forearc region, which may trigger: a) shallow partial melting of the sub-arc mantle with generation of boninites and/or very low-Ti tholeiites, and b) opening of a backarc basin with transitional MORB/IAT, up to pure MORB magmatism when mantle diapirs do not interfere anymore with the subduction zone. By contrast, the genesis of the Cordilleran complexes requires a subduction mode characterized by a steady-state regime, with moderate and constant dip of the subducted slab and limited extension in the backarc region. The magmatic evolution of these ophiolites from IAT to IAC and the significant presence of rhyodacite (and tonalite) differentiates coherently indicate a more mature stage of arc magmatism, as well as the occurrence of efficient differentiation processes developing under nearly ?closed-system? conditions in independent magma chambers. During convergence processes, Tethyan complexes are in a favourable condition to be obducted as large and relatively intact slabs onto the continental margins through the interposition of metamorphic soles, which represent relics of the MORB lithosphere underplating the SSZ ophiolites since the inception of the intra-oceanic subduction. On the other hand, the common emplacement of Cordilleran complexes within polygenetic terranes appears to be controlled by prolonged accretionary mechanisms which trap, against the continental margin, parts of the arc structure, subduction complexes, melanges, and volcanoclastic products. These features represent an important constraint for the kinematics of both the northern and southern Caribbean margins, even if with significant differences in the tectonic evolution of each margin.

Giunta G., L. Beccaluva, M. Coltorti, F. Siena - STRUCTURE AND TECTONO-MAGMATIC SIGNIFICANCE OF THE PERI-CARIBBEAN OPHIOLITES: IMPLICATIONS FOR THE EVOLUTION OF THE CARIBBEAN PLATE. AAPG Barcelona

Ophiolitic complexes deformed and dismembered along the peri-Caribbean margins represent fundamental markers for the origin and evolution of the Caribbean Plate.

The proto-Caribbean oceanic crust was generated in a ?near Mid-America? location since Late Jurassic. Its accretion was initially related to multiple spreading centres (LREE-depleted MORB, in Venezuela, Costa Rica, Cuba, Guatemala, Hispaniola), evolving during the Cretaceous to a thickened oceanic plateau in its westernmost end (REE-flat MORB locally associated with picrites, in Costa Rica, Hispaniola, Venezuela, Dutch and Venezuelan Islands). Sub-continental and intra-oceanic east-dipping subduction zones initiated within the proto-Caribbean domain since the Early Cretaceous with generation of HP metamorphic subduction complexes and island arc tholeiitic to calcalkaline volcano-plutonic sequences (1° eo-Caribbean phase: in Guatemala, Cuba, Puerto Rico and Venezuela). Since the Late Cretaceous a second intra-oceanic subduction, with reverse polarity, took place, recorded by unmetamorphosed tonalitic intrusives, and related to the onset of the Aves-Lesser Antilles arc system (2° eo-Caribbean phase). During Late Cretaceous-Tertiary large-scale tear faulting along the northern and southern margins of the Caribbean Plate favoured eastward dispersion and uplifting of the subduction-accretion systems. The present Caribbean Plate is mainly represented by the Cretaceous plateau crust trapped in the Colombia and Venezuela basins by the intervening Pacific subduction, which built the Central American isthmus.

The recent data allow to better define some important constraints which lead the kinematic evolution of the Caribbean Plate's deformed margins.

Harlow, George E., George R. Rossman, Satoshi Matsubara, and Hiroshi Miyajima, BLUE OMPHACITE IN JADEITITES FROM GUATEMALA AND JAPAN: CRYSTAL CHEMISTRY AND COLOR ORIGIN, Geological Society of America Abstracts, v. 35, no. 7, p. 620.

Blue titanian omphacite has been reported previously in jadeitite from Japan by Miyajima et al. (1997) and in an enclave from the Red Wine complex in Canada by Curtis and Gittins (1978). It is now found in jadeitite from Guatemala. Optical spectroscopy, imaging, and microprobe analyses have been carried out on samples from Quebrada Seca, near Carrizal Grande, Jalapa Dept., Guatemala, and Himekawa and Noguchi, near Itoigawa, Niigata Pref., Japan. In Quebrada Seca jadeitites, omphacite occurs as clots and veins with minor phengite and titanite, trace zircon, monazite, allanite and rutile. Itoigawa jadeitites contain omphacite clots, minor titanite, and intergranular albite and analcime. Although blue color may appear pervasive in these samples, it is always restricted to omphacite in clots and veins.
Blue omphacites have relatively high TiO2 content, but <1 wt% is sufficient to produce blue color; otherwise low-to-no-Ti omphacites are green. In a Himekawa sample TiO2 reaches >= 7.5 wt% (0.2 atoms per 6 O) with FeOT ? 4 wt% in 70% Na-cpx. For intense blue omphacite in a Quebrada Seca sample, TiO2 is 1.0 - 1.8 wt% (0.02-0.05 apfu), FeOT ? 3.5 wt% in 55-65% Na-cpx.
Optical absorption spectra show a dominant broad absorption band at ~720 nm overlapping a less intense one at ~600 nm, and a weak, sharp peak at ~435 nm on a sloping absorption edge. The first two absorptions are in the region where Fe2+ - Fe3+ intervalence charge transfer occurs in chain silicates, a well-known source of blue coloring. The association of blue color with elevated Ti content suggests it also plays a role in the coloring. In one sample, omphacite crystals were large enough to manifest pleochroism with blue intensity enhanced when the polarization vector is subparallel to the c axis, consistent with intervalence charge transfer between adjacent M1 sites, appropriate for Fe2+, Fe3+, and Ti4+.
In these jadeitites of HP/LT metasomatic origin, there is no tetrahedral Al in the pyroxene, and Ti content generally varies positively with Mg and negatively with Al, but FeT is uncorrelated. So, the exchange enhancing titanium is probably Ti+(Mg,Fe2+) = 2(Al,Fe3+) in the M1 site, and Ti is entering as a sodic pyroxene component, e.g., NaTi0.5Mg0.5Si2O6. It appears Ti was carried into these rocks by an omphacite-forming fluid and precipitated as both titanite and omphacite.

Iturralde Vinent, M. A., Museo Nacional de Historia Natural, Cuba and R.D.E. MacPhee, American Museum of Natural History, USA, CONTINENTAL TO ISLAND DISPERSION BY VIKING FUNERAL SHIP, NOHE'S ARK, ISLAND-ISLAND VICARIANCE, LAND BRIDGE AND LANDSPAN: A CASE STUDY IN THE CARIBBEAN,
Abstract volume of Insular Vertebrate Evolution, September 2003, Mallorca.
Since its formation, ~170 million years ago, the Caribbean developed as a seaway between the Pacific and the Tethys/Atlantic oceans. This seaway has suffer many modifications over the time, until about 2.5 million years (Ma) ago, when was closed by the emergence of the Panamanian ithmus. Since the beginning of the Cretaceous, about 140 Ma ago, shallows, banks, ridges, isolated islands, and archipelagos have been present between the North and South American continents, which have provided diverse scenarios for the flowerishing of land biotas in the area. Some of these scenarios are evaluated in this presentation, in order to underline the independence between the paleogeographical and biogeographical evidences. It is demonstrated that the paleogeographic scenarios are a consequence of the interactions between the internal and external forces acting over the Earth surfacel; while the present and past distribution of land animals is, on one hand, the consequence of the evolution of the paleogeographic scanerios, but also of biological factors. The fact that some group of animals dispersed overwater, or by any other means, is not a case against any particular paleogeographic scenario.

Iturralde Vinent, M. A., THE CONFLICTING PALEONTOLOGIC VS STRATIGRAPHIC RECORD OF THE FORMATION OF THE CARIBBEAN SEAWAY Manuel Iturrade Vinent, Bartolini, C., R. Buffler, K. Burke, J. Blickwede, B. Burkart (2003). The Gulf of

Mexico and Caribbean Region: Hydrocarbon Habitats, Basin Formation and Plate Tectonics. AAPG Memoir in 2 CDs. Chapter 3, 14 p.

This paper presents a set of paleogeographic maps that illustrate the formation and evolution of the Caribbean from latest Triassic to latest Jurassic. Stratigraphic data and plate-tectonic models indicate that the Caribbean first evolved as a system of latest Triassic-Middle Jurassic rift valleys in the west-central Pangea. Probably since the Bajocian, but certainly since the Oxfordian, it became a marine seaway connecting western tethuys with the eastern Pacific. In contrast, abundant paleontologic data strongly suggest that the seaway across west-central Pangea opened during the Early Jurassic (Hettanguian-Pliensbachian), which data conflict with the stratigraphic data. This contradiction between paleontology (biogeographgic interpretations) and stratigraphy (paleogeographic interpretation) reveals pur insufcicient knowledge about the Mesoozoic geology of west-central Pangea.

Iturralde-Vinent, M. A., THE MULTIARC HYPOTHESIS OF THE CARIBBEAN EVOLUTION, 18 Latin American Geological Colloquium, Freiberg, April 3-5, 2003.

There are several plate tectonic interpretations of the Caribbean origin and evolution, but in independence of this, is important to understand how, how many, and for how long were active the convergent margins of the Caribbean associated with volcanic arcs. In the present time there are two convergent margins: the Lesser Antilles and Central America, but in the past there may have been more.

The multiarc hypothesis substain that during the evolution of the Caribbean realm several independent volcanic arcs have been active. The multiarcs being identified taking into account several criteria, as: 1. Change in the trend of the axial part (vulcano-plutonic core) of one arc with respect to the other; 2. Major unconformities and tectonic events separating one arc from the other; 3. A particular geochemistry of each arc's igneous suite; and 4. Simultaneous evolution of two or more independent arcs.

In some convergent edges of the Caribbean plate two or more arcs are superimpossed for a particular time, giving the impression that there was only one arc evolving since the Early Cretaceous; but in other segments of the convergent edges each arc occupy a distinct belt during particular time lapses. The interpretation that some segments of the arc became inactive as they collided with the continental margins of NOAM and SOAM, do not correlate with the actual timing of the collisional events.

Iturralde-Vinent, M. A., ENSAYO SOBRE LA PALEOGEOGRAFÍA DEL CUATERNARIO DE CUBA, Report of the Field Workshop in Cuba, March 2003.

The Pliocene-Quaternary paleogeography of Cuba is strongly determined by the cyclic climatic changes which influenced the mean temperature and rain fall. These changes where associated with variations of the mean sea level, which 20-25 ka ago fall to -120 meters below the mean present-day position, and 120 ka ago rose slightly above present day level. Nevertheless, it has been found that the main factor in the formation and transformation of the relieve are the neotectonic movements and the erosion, which - despite local variations in rate and direction - have been identified that uplift dominated since the Late Miocene. These transformation of the relieve took place in such a way that 20-25 ka ago Cuba reached nearly 180 000 km2, the largest exposed area within the time frame into consideration; while in other times was reduced to small archipelagos and islands, separated by shallow seas and periodically inundated low plains. In the last 7 ka this paleogeographic evolution produced the present day configuration of the territory, a process that is stil active today. As a consequence, there were times whethe terrestrial biota was concentrated in the topographic highs (present day mountain areas), but there were also times when the biota had the opportunity for dispersion and colonization of low lands (mostly present day plains and shelf). Insuficient amount of adecuate dating of the Pliocene-Quaternary terrestrial fossil do not allow the accurate identification of these events in the fossil record.

James, K. H., A SIMPLE SYNTHESIS OF CARIBBEAN GEOLOGY, AAPG International Meeting, 2003, Barcelona, Spain.

Most modern syntheses of Caribbean geology derive the Caribbean Plate from the Pacific. They invoke changes of subduction direction, major rotation of island-arcs (90°) and continental blocks (up to 50°), plate thickening over a Pacific hotspot or mantle plume and major migration of the Caribbean Plate with a 45° change in direction. The models are complex and geometrically unlikely. This paper suggests a simple Pangean reconstruction and in-situ evolution that involves none of these complications and accounts for all Caribbean geology. Jurassic-Late Cretaceous, WNW oriented sinistral transtension produced N-S offset of around 950 km and sinistral offset of at least 1,000 km between N and S America. Cretaceous plate thickening resulted from extension over triple junctions heralding abandonment of spreading between the Americas and from N-S extension associated with 600-km growth of the Mid-Atlantic Ridge. A circum-Caribbean Palaeocene - Middle Eocene compressional event preceded Oligocene - Present, E - W strike-slip between the Caribbean and the American Plates. The contrast between the simple in-situ model and complex Pacific models argues for the former (Occam's razor).

Lewis, J. W.,, J.A. Proenza, J.C. Melgarejo, F. Gervilla, THE PUZZLE OF LOMA CARIBE CHROMITITES (HISPANIOLA), Report of the Field Workshop in Cuba, March 2003.

The Loma Caribe peridotite (mantle peridotites and associated chromitites) is exposed in the Cordillera Central, Dominican Republic. The peridotite body is about 4-5 km wide and extends for 95 km from La Vega to Cerro Prieta north of Santo Domingo, but the southeastern part of the peridotite is exposed as thin fault slices only. These mantle rocks are considered to have been exposed because of the collision of an oceanic plateau (Duarte plateau terrane) with the primitive Caribbean island-arc (Maimon-Amina terrane) at Aptian time. The Loma Caribe peridotite is composed of lherzolite, Cpx-rich harzburgite, harzburgite and dunite. In addition, pyroxenite and small bodies of podiform chromitites (Loma Caribe chromitites) also occur. The peridotites typically show porphyroclastic and coarse-grained granoblastic textures. Orthopyroxene phenocrysts are strongly deformed, showing kink bands deformation, suggesting that the peridotites could represent remnants of depleted upper mantle. The #Cr [(Cr/(Cr+Al)] in Cr-spinel (an indicator of melt depletion in the peridotites) from Loma Caribe peridotites vary from (0.30 to 0.88). These large compositional variations indicate the occurrence of peridotites with very different melting histories. Relatively fertile peridotites as found in Loma Caribe (e.g. #Cr ~ 0.3) have not reported in eastern Cuba ophiolites where they exhibit mostly #Cr > 0.5). The equilibration temperature estimates (according to three thermometric formulations using pyroxenes) give large ranges of equilibration temperatures, between 980 and 1260 oC. The upper mantle rocks present in Loma Caribe peridotite probably include rocks from suboceanic mantle, including mantle underneath oceanic ridge, oceanic plateau and island arc. The chromitite bodies associated with Loma Caribe peridotites have small size, and show massive textures. No primary silicate minerals are preserved in the matrix of the chromitite in any of the samples studied. The intergranular minerals mainly consist of chlorite, and minor serpentine. The Loma Caribe chromitite is Cr-rich chromite, the Cr# varies from 0.75 to 0.78 (corresponding to Cr_2O_3 contents between 49.42 and 51.66 wt%, and Al_2O_3 between 9.93 and 11.13 wt%), the Mg# from 0.47 to 0.50. These values are typical of ophiolitic chromitites elsewhere. However, Loma Caribe chromite exhibits systematically high TiO_2 (0.79-0.93 wt%) and Fe_2O_3 (7.23-8.46 wt%) contents. Chromite with the chemical composition of the Loma Caribe chromitite, to our knowledge, never has been reported in ophiolitic chromitites. In general, the chromite from Loma Caribe chromitite differs from Cr-spinel reported in bonitites, high-magnesian andesites, MORB, BABB and Alaskan-type plutonic complexes (arc magma chambers or arc-root complexes). Chromite in small podiform deposits, with relatively high #Cr (62-85) and ferric iron contents (up to 8.95 wt% of Fe_2O_3), have been described in ultrabasic rocks form the Bragança massif (Portugal), and are interpreted as having crystallized in the upper few kilometres of the magmatic arc mantle (Bridges et al., 1995). Nevertheless, the Bragança chromitites show low TiO_2 content (< 0.24 wt%). The high TiO_2 content in chromite from podiform deposits is associated with Al-rich chromite, never with Cr-rich chromite as in the Loma Caribe chromitite. The composition of chromite from Loma Caribe chromitite, is relatively close to that reported for Cr-spinel from oceoanic plateau.basalts. For example, Cr-spinels from Hole 462A (Nauru Basin Oceanic 44 Fe_2O_3 from 6 to 9 wt% (Tokuyama and Batiza, 1981). In general, Cr-spinels in the oceanic plateau basalts differ from MORB Cr-spinel in their higher #Cr and #Fe^{3+}, and are slightly higher in TiO_2 content than arc magma Cr-spinel (Arai, 1992). Also, the oceanic plateau Cr-spinels have sightly lower #Cr values than arc-magma Cr-spinel. The most recent interpretation on the genesis of ophiolitic chromitites suggests a suprasubduction zone setting for the precipitation of chromitite bodies. In contrast, no ophiolitic chromitite would be expected in mature spreading centers, such as midocean ridges. The genesis of Loma Caribe chromitite is still subject of debate. Here, tentatively, we suggest two possibilities to explain their "exotic" composition:

1) A product of crystallization during percolation of a deep portion of suboceanic mantle by magmas from the Duarte plume.

2) A result of interaction between a heterogeneous oceanic mantle (Loma Caribe peridotites) and Cretaceous island arc derived melts. Trace elements (including PGE) patterns and isotopic compositions (Sr, Nd, Os) in chromitites and associated peridotites could be help to characterize their genetic processes and tectonic setting (oceanic plateau or Island arc).

Mann, Paul and Lisa Gahagan, Institute for Geophysics, University of Texas, Austin, TX, 78759, paulm@ig.utexas.edu, 1-512-471-0452; Nancy Grindlay, Center for Marine Sciences, University of North Carolina, Wilmington, North Carolina 28403; Eric Calais, Dept. of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907, EARLY MIOCENE TO RECENT PLATE TECTONIC ANIMATION OF HIGHLY OBLIQUE COLLISION BETWEEN THE SOUTHEASTERN BAHAMA CARBONATE PLATFORM AND THE PUERTO RICO-VIRGIN ISLANDS AREA, Seismological Society of America Meeting, San Juan, Puerto Rico, April 30 - May 2, 2003

We present an Early Miocene to Recent plate tectonic animation of the diachronous oblique collision between the highstanding, southeastern Bahama carbonate platform on the obliquely-subducting North America (Noam) plate and the Puerto Rico-Virgin Islands area on the obliquely-overriding Caribbean (Carib) plate. Main tectonic features and events highlighted in the reconstruction include the following: 1) Earliest Miocene (23 Ma) oblique subduction of the southeastern tip of the Bahama Platform (Mona block) adjacent to the northern Virgin Islands; 2) Continued Late Miocene (11 Ma) oblique subduction of the Mona block to a position north of central Puerto Rico; initial rifting occurs between Puerto Rico and St. Croix (Anegada Passage) in the wake of the passing collisional front; 3) Late Pliocene (3.4 Ma) collapse of the northern shelf of Puerto Rico as a consequence of subduction erosion by the obliquely subducting Mona block; main phase of topographic uplift and SW-directed folding and thrusting within and to the south of Hispaniola (Muertos trench) as the Mona block and SE Bahama carbonate platform converges on Hispaniola; early phase of EW rifting in Mona Passage between collided area in Hispaniola and uncollided area in Puerto Rico and 4) Late Pliocene to Recent continued NE-SW shortening in Hispaniola and continued EW opening in the Mona Passage as the relatively faster-moving and uncollided Puerto Rico-Virgin Islands area moves with Caribbean plate away from the colliding

and impeded Hispaniola area. The reconstruction points out a fundamental difference between the geology of Hispaniola and Puerto Rico: Hispaniola has a post-Middle Miocene history of crustal convergence while the same period in Puerto Rico is dominated by diffuse extension probably related to a 25 degree CCW rotation that accompanied the collision and indentation in the adjacent Hispaniola area.

Maresch, W. V., Klaus-Peter Stanek, Friedemann Grafe, Bruce Idleman, Albrecht Baumann, Martin Krebs, Hans-Peter Schertl, Grenville Draper, AGE SYSTEMATICS OF HIGH-PRESSURE METAMORPHISM IN THE CARIBBEAN: CONFRONTING EXISTING MODELS WITH NEW DATA, Workshop in Cuba, March 2003.

The development of plate-tectonic models in the Caribbean has been traditionally based mainly on a two-dimensional perspective centred on terrane analyses and studies of relative movements between terranes and plates, augmented by geochemical and geochronological data on volcanic activity. However, the importance of the information recorded in the pressure(depth)-temperature-deformation-time development of crystalline rocks has recently become more widely acknowledged. Such data require a modern and diverse, yet highly correlated multidisciplinary methodology. As more, and more detailed P-T-d-t-paths become available around the Caribbean, a systematic picture is beginning to emerge.

The extent of this new level of perception is due to the increasing quantity and above all better quality of geochronological control on the pressure-temperature evolution of metamorphic rocks. Although early petrological studies were able to relate the high-pressure metamorphic rocks exposed along the northern and southern borders of the Caribbean to collisional geodynamic environments, it was detailed geochronological work that showed that the subduction environments responsible for the formation of these rocks were actually located far to the west of a nascent Caribbean gap. The available data set - both old and new - is consistent with the fact that peak high-pressure conditions of high-pressure suites around the Caribbean were uniformly reached between 120 to 100 Ma, i.e. before diachronous emplacement along the northern and southern margins commenced. By contrast, new data on the cooling, i.e. exhumation history of high-pressure suites as well as metamorphic rocks from the lower levels of associated volcanic arcs show that specific sections around the margins of the Caribbean exhibit characteristic and variable exhumation histories. Such data therefore faithfully record the particular timing and geodynamic setting of each area around the Caribbean perimeter and provide local stringent detailed constraints on plate tectonic models.

Although we are just beginning to "see through" the chronology of high-pressure metamorphic events and exhumation evolution to determine details on the timing of prior events, new data are providing enigmatic and intriguing prospects. Conventional multi-grain analysis as well as corroborating detailed SHRIMP investigations have revealed that zircons in certain eclogites from the Escambray massif in Cuba point to a 140-160 Ma event. Even if discussions on the significance of this age are in full progress (crystallization of the precursor gabbro? a second earlier, pre-Caribbean high-pressure event?), it is clear that studies of P-T-d-t histories are indispensable in our quest to better understand the plate-tectonic history of the Caribbean region.

Miranda, E., J. Pindell, J. Patino, I. Alor, A. Alvarado, H. Alzaga, A. Cerón, R. Dario, M. Espinosa, J. Granath, L. Hernandez, J. Hernandez, J. Jacobo, L. Kennan, M. Maldonado, A. Marin, A. Marino, J. Mendez, E. Pliego, A. Ramirez, G. Reyes, J. Rosenfeld and A. Vera, MESOZOIC TECTONIC EVOLUTION OF MEXICO AND SOUTHERN GULF OF MEXICO:FRAMEWORK FOR BASIN EVALUATION IN MEXICO, AAPG International Meeting, 2003, Barcelona, Spain.

Gravity, magnetics, seismic, wells, paleogeography, facies, structure, subsidence histories and plate kinematic data were appraised to test and refine existing models for the evolution of Mexico and southern Gulf of

Mexico (GoM). Closure of Atlantic oceans, restoration of Yucatán Block between Texas and Venezuela, and NW retraction of central and southern Mexican territories allows an entirely continental, internally consistent Pangean (Permian) reconstruction in which Yucatán was thrust onto USA. The Gulf then opened in two stages. Stage 1: Triassic-Oxfordian NW-SE asymmetric continental stretching (Yucatán was hanging wall), with minor CCW rotation of Yucatán, during which sinistral motion occurred along "Texas", "Burgos" and Trans-Mexican Volcanic Belt lineaments. Motion on an E-ward projection of Mojave-Sonora Megashear was unlikely. Stage 2: Oxfordian-Valanginian CCW rotation of Yucatán as seafloor crust formed in the central GoM. The Yucatán-NoAm pole of rotation migrated SE from the SE GoM to Isle of Youth during rotation. During Stage 2, the "East Mexican Shear Zone" at the base of the Tuxpan margin initially defined the trace of Yucatán/Mexico relative motion, but by Tithonian transform motion jumped into Veracruz Basin, which became a dextral pull-apart basin adjacent to the western GoM. Syn-rift subsidence (Stage 1) exceeded post-rift thermal subsidence (Stage 2) in the northern margin, whereas post-rift thermal subsidence was more significant into the Cretaceous for Yucatán. The model provides a kinematically robust paleogeographic and crustal- and basin-dynamic framework in which Pemex can assess existing exploration opportunities and also develop future strategic exploration programs and efforts.

Mitchell, S. F., TIMING AND TECTONIC EPISODES BASED ON A NEW LATE CRETACEOUS CARIBBEAN RUDIST BIOSTRATIGRAPHY

The integration of Late Cretaceous rudist biostratigraphic schemes with the international chronostratigraphy is essential in order to correlate shallow-water carbonate successions, radiometric dates from igneous rock units, and relate these to the tectonostratigraphic events that occurred on the northern margin of the Caribbean Plate. Jamaica is key to understanding the rudist successions because of the low degree of deformation of the late Cretaceous shallow-water sediments and the presence of inter-bedded shallow-water and deep-water successions.

Using a combination of macrofossils (rare ammonites and inoceramids), planktonic foraminifera and calcareous nannofossils, the different species of the rudist *Barrettia* can be correlated with late Cretaceous substages. *Barrettia coatesi* is of mid Santonian age, *B. ruseae* of late Santonian age, *B. multilirata* of late Middle Campanian age and *B. gigas* of late Middle to earliest Late Campanian age. *B. monilifera* is more difficult to date, but is probably of Middle Campanian age. Previous dating of the *Titanosarcolites* assemblages has been based on the last occurrence of certain calcareous nannofossils, which are now known to be reworked. New strontium isotope dating of well-preserved skeletal calcite suggests that the *Titanosarcolites* limestones range throughout the Upper Maastrichtian. Different species, previously incorporated within *T. giganteus*, can be distinguished and allow a zonal scheme to be developed for the Upper Maastrichtian.

Sections in the Central Inlier of Jamaica show a major unconformity between the *Titanosarcolites* limestones and the *Barrettia* beds, with preserved evidence of thrusting prior to the deposition of the *Titanosarcolites* limestones. This indicates a major tectonic event of late Late Campanian or Early Maastrichtian age. This event is linked to the collision of the Caribbean Plate with the Yucatan Peninsula. An extrapolation of this new scheme elsewhere in the northern Caribbean and Mexico will undoubtedly yield important results.

Mullin, P. and D. Truempy. EXPLORATION AT THE PLATE MARGIN: TRINIDAD BLOCK 25(A), AAPG International Meeting, 2003, Barcelona, Spain.

Deepwater hydrocarbon exploration dominantly focuses on passive margin settings. In Trinidad, however, ongoing and future exploration is taking place at a plate boundary: the southeastern suture between the Caribbean and Atlantic/South American plates. Drilling results by BHP in shallow water Block 2(c) have demonstrated that significant hydrocarbons can be discovered in such a setting.

Most workers believe that the Caribbean plate is stationary with respect to the mantle, while the Atlantic/American plate is moving westwards at two centimetres per year, being subducted underneath the Caribbean plate to the northwest of Trinidad, generating the Barbados accretionary prism, and is currently sliding past the Caribbean plate within and adjacent to Trinidad itself. The extent to which this motion has been purely strike-slip, or has included a significant transpressional element, is a matter of some dispute.

A Shell-led partnership (Shell 55%, Agip 40%, Petrotrin 5%) acquired deepwater acreage along this margin in 1998 (Block 25 (a)). Early evaluation had suggested that shale diapirism has generated most of the highs in the Block, which were therefore seen as non-prospective for hydrocarbons. Thus first exploration efforts were concentrated on the intervening Plio-Pleistocene depotroughs. Recent re-evaluation of the NW portion of the Block suggests that WSW-ENE trending strike-slip movements, rather than diapirism, have been the dominant structure forming mechanism from Miocene times to the present, and that the main highs are cored with older Pliocene and possibly Oligo-Miocene strata. This paper will review the structural development of the Block, in the light of recent drilling activity.

Núñez Cambra, K., E. Castellanos Abella, B. Echevarría, Angelica I. Llanes, ESTRUCTURA DEL ÁREA DE MERCEDITAS Y CONSIDERACIONES ACERCA DE LA PROCEDENCIA DE LAS OFIOLITAS DEL MACIZO MOA-BARACOA, Workshop in Cuba, March 2003.

Several hundred of structural measurement were taken and processed at the Merceditas mine area, within the Moa-Baracoa ophiollite massive, recognizing the principal faults systems, stresses directions, as well as the tectonics events sequence. The area is characterized by the fragmentation zones, faults and open joints in different directions, indicating different stresses. The principal faults systems are grouped with strike WNW (285°). Three deformation stages are present: postmineral deformations where gabroid dykes were formed, deformation during the ophiollite emplacement and deformation after the emplacement, probably as result of the recent sinistral strike slip movements of the Oriente fault.

At the first stage it is associated a distension, that faulting the rocks and dike systems appear. At the second stage it is associated generally brittle deformation, overthrust faults, inverse shear zones and dike deformation. To the third stage are associated generaly brittle deformations with predominance of horizontal movements and some distension faults filled with carbonates and reverse faults. The lineation structures on the overthrust faults planes, as well as reverse shear zone, which occurr in the second deformation stage, clearly indicate the sense of tectonic transport (vergence) towards the NNE, it can be interpreted as the Moa Baracoa ophiollite were emplaced over the cretaceous metavolcanic complex from the south.

Núñez Cambra, K., THE PLATE BOUNDARY BETWEEN THE NORTH AMERICAN AND CARIBBEAN PLATES, STRUCTURAL DEFORMATIONAL PHASES, 18 Latin American Geological Colloquium, Freiberg, April 3-5, 2003.

The work was aimed at determining structural characteristic and updating the geological map of San Antonio del Sur area, located in Oriente province, Cuba. As result, this study contains new structural data collected from the field observation. The tectono-stratigraphical column for the area was worked out and the geological map was updated. It has also allowed for a better synthesis on the tectonic evolution of the area.

The following evolutional stage and deformational phases were stablished:

First: Cretaceous period marked by the volcanic island arc. At that time the volcano-sedimentary rocks were formed and later deformed in the Campanian to early Maastrichtian with first deformation phase (D1). Consist of very close (F1) macro folds, which are almost isoclinal.

Second: Late Maastrichtian. The cretaceous volcanic rocks were thrusted by ophiolite complex. According to the observation, the sense of thrusting from SE to NW. The second deformation phase (D2) consist of folds from micro to meso fold (F2) with vergence towards NNW.

Third: Oligocene - Miocene . The deformation by transpressional movement and generation of the thrust movement from SW toward the NE gave rise to the third deformation phase (D3). This deformation almost perpendicular form superimposed folds above the D1 and D2. Open folds characterize the F3 folds, with fold axis oriented to the NNW (350º).

Fourth: Oligocene - Miocene to Recent. Transpressional-transtensional tectonic movement became active along the Oriente fault; the sinistral sense of the movement generated the fourth, predominately brittle, deformational phase (D4). It is characterized by gently dipping fold (F4) with fold axis oriented to the NW.

Núñez Cambra, K., Enrique Castellanos Abella, Bienvenido Echevarría, Angelica Isabel Llanes. Instituto de Geología y Paleontología, La Habana, ESTRUCTURA DEL ÁREA DE MERCEDITAS Y CONSIDERACIONES ACERCA DE LA PROCEDENCIA DE LAS OFIOLITAS DEL MACIZO MOA-BARACOA, , Memorias Geomin 2003, La Habana, 24-28 De Marzo. Isbn 959-7117

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At the first stage it is associated a distension, that faulting the rocks and dike systems appear. At the second stage it is associated generally brittle deformation, overthrust faults, inverse shear zones and dike deformation. To the third stage are associated generaly brittle deformations with predominance of horizontal movements and some distension faults filled with carbonates and reverse faults.The lineation structures on the overthrust faults plane, as well as reverse shear zone, which are occurred in the second deformation stage, clearly indicate the sense of tectonic transport (vergence) towards the NNE, it can be interpreted as the Moa Baracoa ophiollite were emplaced over the cretaceous metavolcanic complex from the south.

Pindell, James, HISTORY OF TECTONIC INTERACTIONS BETWEEN THE CUBAN FOREARC TERRANE AND MEXICO - CENTRAL AMERICA, Workshop in Cuba, March 2003.

North-vergent, Paleogene collision between the Cuban "arc" terrane with the passive Bahamas carbonate bank of the Proto-Caribbean Seaway is widely accepted among workers. In contrast to the "passiveness" of the Atlantic-type Proto-Caribbean margins, the Cuban arc terrane holds a wealth of information that tells of a complex tectonic, metamorphic and magmatic history that dates back to the Jurassic. Despite the fact that Cuba has been geographically isolated from the Caribbean Plate since the Eocene by the Yucatán Basin and Cayman Ridge, the geology of the Cuban arc terrane is so similar to that of numerous Caribbean terranes that it was clearly part of the Caribbean Plate prior to the Paleogene. And because the Caribbean Plate is of Pacific origin, then parts of the Cuban arc terrane may also be of Pacific origin, or perhaps the Neocomian inter-American arc that spanned the gap from Chortis to Ecuador.

Accepting that a Pacific/inter-American arc origin is viable, the geology of Cuba may be interpreted as part of the far-travelled Caribbean Plate, rather than in terms of more local modes of evolution. Thus, regional integrated models of Gulf of Mexico/Caribbean evolution potentially provide a geometric and kinematic framework in which to interpret that history. Further, considering Cuba's position at the northwesternmost part of the Caribbean Plate, then Caribbean-Mexico/Central American plate interactions are likely recorded in the geology of Cuba.

Using the Caribbean evolutionary model of Pindell and Kennan (2001) as a guide, cause-and-effect geological relationships between the Cuban arc terrane and Mexico-Central America are proposed. It is argued that the Cuban arc terrane derives from the inter-American Arc between Chortis (when Chortis lay adjacent to Guerrero, Mexico) and Ecuador, was involved in the Aptian Caribbean arc-polarity reversal during which west-dipping subduction beneath Caribbean Plate began, underwent arc-parallel extension during middle and Late Cretaceous time, converged obliquely with southern Yucatán in the Maastrichtian, and migrated ahead of the Yucatán intra-arc basin during the Paleogene on its way to collision with the Bahamas. Finally, it is proposed that the Cuban "arc" terrane represents a forearc piece of the Great Caribbean Arc only, and should not be considered as an arc in itself.

Pindell, J. L., PACIFIC ORIGIN OF CARIBBEAN OCEANIC LITHOSPHERE AND CIRCUM-CARIBBEAN HYDROCARBON SYSTEMS, AAPG International Meeting, 2003, Barcelona, Spain.

Circumstantial evidence overwhelmingly favours a Pacific origin for Caribbean oceanic lithosphere with respect to North and South America, as opposed to and "intra-American" origin whereby Caribbean lithosphere formed by spreading between North and South America. Direct implications of intra-American models are examined and found to violate dynamics of arc systems and significant aspects of Caribbean geology. Therefore, the kinematic, geometric, and geologic basis for Pacific origin models is presented, including a range of primary aspects requiring a Pacific origin model. For example, continent-verging arc-continent collisions between various portions of the Great Caribbean Arc with the Atlantic-type Proto-Caribbean margins are documented as younging east, from Chortis and Ecuador to Puerto Rico Trench and Trinidad, from Albian to Plio-Pleistocene, in accord with Caribbean-American relative displacements exceeding 1,500 km during that interval. This relative migration is outlined as a function of progressive westward drift of the Americas in a hotspot reference frames as the Atlantic opened, "engulfing" a piece of Pacific crust that is now Caribbean lithosphere. A "non-Caribbean" Paleogene tectonic event is proposed in NE South America that explains the only known relationships contrary to this model. An animation shows the relative migration and origin of larger circum-Caribbean tectonic features. Primary circum-Caribbean hydrocarbon systems are summarized in light of the model, making predictions for deposition of reservoir units, timing and magnitudes of source rock burial, and timing and direction of oil migration in the four circum-Caribbean foreland basins created by Caribbean loading as Caribbean Plate progressed relatively eastwards.

Proenza, J.A., Gervilla, F., Díaz-Martínez, R., Rodríguez-Vega, A., Lavaut, W., Ruiz-Sánchez, R., Batista, J.A., Blanco-Moreno, J., Melgarejo, J.C., Garrido, C.J., Marchesi, C., 2003. LA FAJA OFIOLÍTICA MAYARÍ-BARACOA (CUBA ORIENTAL): UN NUEVO RECONOCIMIENTO PETROLÓGICO Y ESTRUCTURAL. V Congreso Cubano de Geología y Minería, La Habana, Cuba. Libro de Resúmenes, p. 143-145.

La Faja Ofiolítica Mayarí-Baracoa (FOMB), de edad Jurásico-Cretácico, se puede dividir en 2 macizos: Mayarí-Cristal (parte occidental) y Moa-Baracoa (parte oriental). En este trabajo presentamos nuevos datos petrológicos y estructurales de la parte más occidental del Macizo de Mayarí-Cristal (zona de Mayarí) y de la zona de transición manto-corteza del macizo de Moa-Baracoa.

El Macizo de Mayarí-Cristal, en la zona de Mayarí, está constituido mayoritariamente por peridotitas mantélicas con un espesor no inferior a los 5 km, diferenciándose dos dominios principales: 1) Un dominio inferior que ocupa la parte S y central del macizo. Este dominio esta formado principalmente por harzburgitas porfiroclásticas, mostrando una foliación penetrativa de dirección NE-SW con buzamiento de 50-60º NW. También es frecuente la presencia de harzburgitas con parches centimétricos de dunita. Además, se reconocen capas (normalmente < 1m de espesor) subcordantentes e irregulares de dunitas (N75º 70ºNW), así como cuerpos concordantes de cromititas con una envolvente dunítica variable. Todas estas litologías están cortadas por, al menos, tres generaciones de diques de piroxenitas de espesores centimétricos. 2) Un dominio superior que aparece bien expuesto en la parte norte del macizo (cuya área tipo se encuentra en la Loma de la Bandera). Este dominio está constituido por harzburgitas porfiroclásticas (localmente muy ricas en piroxenos) que muestran una foliación de dirección NE-SW, con buzamiento de ~ 55ºNW. Las harzburgitas están cortadas por diques máficos que muestran una marcada zonación textural desde los bordes (diabasa) al centro (microgabro). Estos diques presentan un espesor variable, desde pocos centímetros hasta espesores superiores a los 10 m, y cortan a la foliación de las peridotitas con ángulos variables entre ~ 10º y ~ 60º.

El macizo de Moa-Baracoa se caracteriza por presentar: niveles mantélicos, niveles de gabros bandeados inferiores y niveles volcánicos discordantes. Sin embargo, los niveles de gabros isotrópicos superiores y de diques de diabasas de una secuencia ofiolítica clásica, no afloran. La secuencia mantélica tiene un espesor de "paleomanto" superior a 2.2 km y los niveles de gabros bandeados de ~ 300 m. La unidad mantélica expuesta del macizo Moa-Baracoa está compuesta por una zona de transición manto-corteza inusual, constituida predominantemente por harzburgitas, mostrando una foliación predominante de dirección NE-SW. En esta unidad existen varios niveles de impregnación magmática representados por peridotitas residuales impregnadas con plagioclasa y, en menor medida con clinopiroxeno, que llegan a formar zonas de lherzolitas con plagioclasa y de troctolitas, encajadas en harzburgitas. Además, es frecuente la presencia de cuerpos concordantes de dunitas, de gabros (*sills*) y de cromititas con una envolvente dunítica. Los cuerpos de dunitas, normalmente de pequeño espesor, se restringen principalmente a la cercanía de los cuerpos de cromititas. También están presente numerosos diques de gabros y de gabros pegmatitas, y en menor medida de diabasas. Asimismo hemos observado algunos diques de noritas olivínicas y de piroxenitas. Los niveles basales de gabros bandeados se componen de gabros olivínicos y gabronoritas, y presentan un bandeado modal bien desarrollado de orientación N30ºE, buzando ~30º al NW.

Proenza, J. A., J.C. Melgarejo1, F. Gervilla, A. Rodríguez-Vega, R. Díaz-Martínez, EVIDENCIAS MINERALÓGICAS DE MAGMATISMO ALCALINO EN LOS NIVELES MANTÉLICOS DE LA FAJA OFIOLÍTICA MAYARÍ-BARACOA (CUBA ORIENTAL), Workshop in Cuba, March 2003.

Los niveles mantélicos de la Faja Ofiolítica Mayarí-Baracoa (FOMB) encajan abundantes depósitos de cromita, los cuales han sido formados en un manto litosférico suboceánico en una zona de suprasubducción. Entre estos depósitos destaca el yacimiento Potosí, en el cual se pueden reconocer dos eventos de intrusiones magmáticas que cortan y/o "impregnan" los cuerpos de cromititas. El primer evento ha dado lugar a la cristalización de noritas olivínicas pegmatíticas, las cuales han reaccionado con las cromititas preexistentes. La zona de contacto entre las cromititas y las noritas olivínicas se caracteriza por presentar una atípica asociación mineral formada por cromita (#Cr = 0.51-0.64, #Fe3+ = 0.14-0.29), ilmenita (con alta proporción de componente geikielita, hasta 12.7 % en peso de MgO), rutilo, magnetita, sulfuros de Fe-Ni-Cu, ortopiroxeno (En83-86Wo1.4-4.9Fs12-15; TiO2 =0.42-0.58 % en peso), plagioclasa alterada, olivino (Fo = 86-87), kaersutita (#Mg = 82-87; TiO2 = 4.42-5.78 % en peso; Cr2O3 = 1.28-1.71 % en peso) apatito (Cl/F = 0.33-0.48), baddeleyita (HfO2 = 1.5-2.0 % en peso) y zirconolita (CaZrTi2O7). La zirconolita es un óxido raro de Ca-Zr-Ti, que ha sido descrito mayoritariamente en relación con magmatismo alcalino. La zirconolita de Potosí representa la primera descripción de zirconolita en niveles mantélicos ofiolíticos. En el diagrama triangular Zr-Ti-Ca, la zirconolita presente en las cromititas de Potosí se localiza en la parte correspondiente a bajos contenidos de Ca y altos de Zr. La zirconolita de Potosí presenta los contenidos más altos de Y descritos en zirconolitas terrestres (Y2O3 = 10.13-11.06 % en peso). Los contenidos de REE2O3 varían entre 9.25 y 10.7 % en peso, y los de HfO2 alcanzan valores de hasta de un 1 % en peso.

La "exótica" asociación mineralógica presente en las cromititas de Potosí es el resultado de la intrusión de un fundido silicatado alcalino (rico en volátiles, Ti, Zr, Y, REE) que reacciona con las cromititas provocando la disolución parcial y la recristalización de la cromita. Los altos contenidos en volátiles quedan reflejados en la cristalización de apatito rico en F y Cl, y la alta actividad de Ti en el fundido queda registrada en los altos contenidos de TiO2 presentes en la kaersutita (4.42-5.78 % en peso) y en los ortopiroxenos (0.42-0.58 % en peso). Los fundidos a partir del cual cristalizaron las noritas olvínicas y que reaccionaron con las cromititas de Potosí eran ricos en Na+K (ej: kaersutitas con valores de Na2O+K2O > 3.5 % en peso), favoreciendo el transporte de Zr. Trabajos experimentales sugieren que la solubilidad del Zr se incrementa hasta 4 % en peso en fundidos con alta relación álcali/alúmina. La presencia de fundidos alcalinos en los niveles mantélicos de la FOMB puede estar relacionada con la evolución de una cuenca trasera de arco. En un ambiente de este tipo la adición de sectores mantélicos "fértiles" a la cuña de suprasubducción, favorecida por subduction roll-back, provoca características geoquímicas muy heterogéneas (desde típicas signaturas tholeiíticas hasta alcalinas).

Rojas Consuegra, R., Museo Nacional de Historia Natural., MORPHOMETRIC EVALUATION OF THE AMERICAN HIPPURITIDS (RUDISTS, CRETACEOUS), Memorias Geomin 2003, La Habana, 24-28 De Marzo.

The rudist Family Hippuritidae is represented by elevators, with morphological and functional adaptations that allowed them to flourish in certain Cretaceous environments.

The relationship between height (H) and diameter (D) of the shell is defined here as the Coefficient of Elevation (R), on the basis of which shells can be classified in the following categories (submorphotypes): High Elevator, HE (R>2), Middle-High Elevator, MHE (1.9>R>1), Middle-Low Elevator, MLE (0.9>R>0.5) and Low Elevator LE (R<0.4). The graphic expression of the R-values, for a set of specimens of a known taxon, clearly reflects its general morphological trend. Therefore, this type of morphometric analysis should provide a new clue for the interpretation of palaeoenvironmental variations, comparison of sedimentation rates, estimation of the morphological evolution of the taxa through the time, and it may be useful for correlation between different area or regions.

Sisson, V. B., George E. Harlow, Sorena S. Sorensen, Hannes K. Brueckner, Eric Sahm, Sidney Hemming, Hans G. Ave Lallemant, LAWSONITE ECLOGITE AND OTHER HIGH-PRESSURE ASSEMBLAGES IN THE SOUTHERN MOTAGUA FAULT ZONE, GUATEMALA: IMPLICATIONS FOR CHORTIS COLLISION AND SUBDUCTION ZONES, Geological Society of America Abstracts, v. 35, no. 7, p. 6.

Left-lateral displacement along the Motagua fault juxtaposed Maya (North American plate) and Chortís block (Caribbean plate). Some tectonic slices of serpentinite contain blocks of eclogites, amphibolites, and jadeitites. The southern serpentinite bodies, adjacent to Chortís basement, contain abundant lawsonite eclogite, glaucophane eclogite, blueschist, jadeitite, and other high P/T rocks. In lawsonite eclogite, lawsonite occurs with omphacitic clinopyroxene as inclusions in garnet, indicating eclogite facies conditions during garnet growth. The inclusion assemblage of lawsonite eclogite includes phengite, biotite, zoisite, albite, rutile, zircon, allanite, and various sulfide minerals. A second generation of lawsonite and phengite (typically with sodic amphibole) occurs in irregular, undeformed patches. Experimentally derived P-T grids for lawsonite eclogite indicate minimum pressures of 20-25 kbar. Geothermometry on garnet rims and matrix clinopyroxene gives values from ~400 - 550 oC. Results from clinopyroxene inclusions with garnet cores yield slightly lower T = 350 to 450 oC. Variable major element, trace element and REE geochemistry indicates the metabasites encompass diverse protoliths, including MOR and primitive IA basalt. High initial 143Nd/144Nd (_Nd = +8.8) and low 87Sr/86Sr (0.70379) of clinopyroxene suggests a depleted source, as expected from MORB. Preliminary Sm-Nd geochronology indicates that the lawsonite eclogites formed at 161 +/- 20 Ma (2__. Ar-Ar geochronology on phengite indicates cooling of eclogite and jadeitite through ~350 oC at 113-125 Ma.

Jadeitite veins from the same serpentinite slices contain unusual assemblages, which include lawsonite, pumpellyite, quartz, and rutile; these are estimated to have formed at T = ~100-400 oC and P = 5 to 20 kb. Occurrence of these coexisting rock types points to a very high pressure and cold origin for the terrain, especially considering the amounts of lawsonite and pumpellyite. This terrain is an excellent field example of lawsonite carrying water into the mantle, as has been predicted by laboratory experiments and thermal models. The chemical and geochronological data indicate either a long-lived mature subduction zone, or possibly a Jurassic to Cretaceous collision zone existed between the Chortis block and Mexico.

Sisson, V. B., G.E. Harlow, H.G. Avé Lallemant, S. Hemming, S.S. Sorensen, TWO BELTS OF JADEITITE AND OTHER HIGH-PRESSURE ROCKS IN SERPENTINITES, MOTAGUA FAULT ZONE, GUATEMALA, Geological Society of America Abstracts, v. 35, no. 4, p. 75

The Motagua River of Guatemala follows the present plate boundary zone (PBZ) between the North American (Maya Block) and Caribbean plates (Chortís Block). The central portion of the Motagua River Valley is bordered by E-W striking tectonic slices of serpentinite, some of which contain blocks of high P/T rocks, including eclogites, amphibolites, and jadeitites. Previously, this has been interpreted as a single ophiolite complex - El Tambor Group. However, the sheeted dikes and gabbros of a complete ophiolite are rare, and the units are strongly dismembered. Metamorphosed basaltic rocks (prehnite-pumpellyite facies and, in cases, actinolite-bearing), radiolarian cherts, and greywackes occur sporadically within fault slices of the El Tambor Group. Recent exploration for commercial jadeitite - jade - has revealed large quantities in serpentinite bodies farther from the river; there is a far greater areal distribution of jadeitite than previously recognized. The southern bodies, adjacent to Chortís basement, also contain abundant eclogite, glaucophane eclogite, blueschist, and other high P/T rocks. The northern bodies, adjacent to Maya basement, include abundant jadeitite, albitite, and amphibolite but rare eclogite. Our initial studies find metasomatic signatures in most of the high-P/T rocks and mineralogical differences between the northern and southern jadeitites. Preliminary Ar/Ar dating of phengite consistently shows the northern rocks with 65-77 Ma ages and southern with 116-125 Ma ages; surprisingly, two high P/T events are evident. These dates would suggest the El Tambor Group is actually comprised of some combination of ophiolite and two sets of exhumed serpentinite, the older one emplaced into the Chortís block and the younger into the Maya block. The southern belt may record collision of the Chortís block with Mexico. This suite was exhumed during by transpression and left lateral strike-slip faulting along the ancestral MFZ. The younger ages in the Maya block probably reflect subduction of the Chortís block during closure of a back arc basin; the back arc basin is now represented as the Santa Cruz and other ophiolite belts. Thus, MFZ contains two high-pressure belts with different exhumation histories in the PBZ in Guatemala.

Sorensen, S.S., Dept. Min. Sci, Smithsonian Inst, PO Box 37012, NMNH MRC-119, Washington, DC 20013-7012, sorena@volcano.si.edu, Harlow, G.E., Dept. Earth & Planetary Sci, AMNH, New York, NY 10024-5192, and Rumble, D. III, Geophysical Laboratory, CIW, Washington, DC 20015, SIMS OXYGEN ISOTOPE ANALYSES OF JADEITITE: TRACE ELEMENT CORRELATIONS, FLUID COMPOSITIONS, AND TEMPERATURE ESTIMATES, Geological Society of America Abstracts, v. 35, no. 7, p. 225

Rare bodies of jadeitite (aggregates of near-end-member jadeite) represent variably deformed and recrystallized, fluid-deposited vein systems in HP/LT serpentinite-matrix mélanges. Because mineral d18O signatures can yield fluid source characteristics, we analyzed oxygen isotopes in cathodoluminescence (CL)-zoned jadeitite samples, previously analyzed for trace elements by SIMS.

Twenty d18O analyses were made for 6 jadeitites from Guatemala, California, Japan, Burma, and Kazakhstan. Separates from 2 samples and Eiler et al.'s (1997) jadeite standard were also analyzed by laser fluorination. Four samples yielded d18O from 8.18 to 9.89?; two ranged from 4.45 to 7.07 ?. Two samples are zoned in d18O: in CJ-01 (Burma) bright green-CL zones (4.9 ?; rich in Li, Rb, Ti, MREE, Zr) contrast with blue-CL zones (8.89 to 9.33 ?, rich in Be); in sample 112552-1, (Japan), a bright green (4.45 ?, rich in Li, Be, REE, Zr) zone again contrasts with red-blue zones (6.22 to 6.62 ?, rich in Rb). Separates from 112552-1 yield d18O of 6.63 to 7.07?. T-estimates based on d18O exchange between albite and jadeite range from 299o (CJ-01, Burma) to 414oC (112538, Guatemala), consistent with jadeitite-forming Ts predicted by phase equilibria and fluid inclusion data.

As has been shown for other minerals, SIMS detects large variations of d18O within (in this case, trace element- and CL-) zoned grains, which may go unnoticed in whole-rock samples or mineral separates. Globally, jadeitite-forming fluids apparently differ by as much as 5? in their d18O values. Jadeitite-forming fluids with such distinct d18O characteristics may have originated from different depths within subducting oceanic crust (e.g., pillow basalt versus gabbro) that underwent seafloor alteration at different temperatures, as is documented for high P/T meta-ophiolitic terrains.

Stanek, Klaus Peter, SUPRASUBDUCTION VERSUS POLARITY REVERSAL - A CASE STUDY FROM ORIENTE, EASTERN CUBA, Workshop in Cuba, March 2003.

In the light of new tectonic and geochronological data from Central Cuba the structure of easternmost Cuba will be discussed. The mostly accepted model for the origin of the Caribbean plate proceeds from a Protopacific oceanic plate indenting the rifted space between North and South America in the Late Jurassic / Early Cretaceous. At this time a primitive island arc has been developed along the evolving subduction zone. Subduction of the young hot Protocaribbean oceanic crust below the indenting Pacific plate led to a strong mechanical coupling between downgoing and overriding crustal slabs resulting in a tectonic offscraping (erosion) of large parts of the fore arc region. Beginning in the Upper Cretaceous the evolving Greater Antillean island arc collided with the southern margin of the Yucatan and Florida Straits blocks.

The suture zone between the Great Antillean arc and the Bahamas platform at the Cuban island can be subdivided into three structural domains, a pop up structure of continental margin sediments in western Cuba and the Cretaceous island arc thrusted onto the Bahamas margin in Central Cuba. Eastern Cuba consists of three main structural domains, in the south the Paleogene island arc (Sierra Maestra), the Paleogene Guatanamo basin and the Oriente complex. The Oriente complex represents an assemblage of metasedimentary, metavolcanic and serpentinic nappes. The metavolcanic rocks contain Hp-minerals like lawsonite and glaukophan. The uppermost nappe comprise the largest ophiolite massifs in the northern Caribbean. The strongly reduced ophiolitic section is restricted to ultramafic and rare diabasic to gabbroic rocks, the upper section of the ophiolite sequence is mostly absent. The age of trusting can be estimated by stratigrafic data between uppermost Cretaceous und Paleogene. The thrusting of the ophiolite massifs has been accompanied and followed by the development of the short lived Paleogene island arc of the Sierra Maestra, resting on a basement of Cretaceous volcano-sedimentary sequences.

Due to the association of metamorphic nappes, igneous rocks and synorogenic sediments Eastern Cuba looks like a key area for understanding of collision tectonics in the Northern Caribbean. Questions under discussion are the origin of the Oriente ophiolite (suprasubduction related basement of the Cretaceous arc or back arc-opening in the Paleogene); the polarity of the Paleogene arc (shifting of the Cretaceous magmatic front or polarity reversal of the subduction zone); age of HP-metamorphism in the Cretaceous island arc and what represents the Yucatan basin (new oceanic crust originated by fore-arc extension or trapped Pacific oceanic crust.

Stanek' K. P., W.V. Maresch, F. Grafe, Ch. Grevel, A. Baumann' CONTRASTING HIGH-PRESSURE AND LOW-PRESSURE P-T-T-D PATHS IN A NAPPE PILE – A CASE STUDY FROM THE CUBAN COLLISIONAL SUTURE, -- Ber. Dtsch. Min. Ges., Beih. z. Eur. J. Mineral., v. 15, p. 197 (2003).

Detailed study of the eastern part of the Escambray Massif in Central Cuba has shown that this metamorphic complex represents a pile of at least four nappes. Boudins of eclogite and blueschist-facies rocks in certain tectonostratigraphic horizons and deerite-bearing quartzites in the metasedimentary matrix provide proof of high-pressure metamorphism, which can be taken as evidence for a Cretaceous subduction zone. Peak metamorphic conditions of 500-600 °C and 25 kbar are indicated. The HP nappes are now tectonically overlain by LP metavolcanic units metamorphosed to 580 - 675 °C and 6 - 10 kbar, which represent the lower crust of the island arc associated with the above subduction zone. The HP and LP nappes were juxtaposed along a ductile shear zone along which converging metamorphic overprints can be observed in both. Available geochronological data suggest that the high-pressure metamorphism occurred between 105 to 90 Ma, but some zircons in eclogites preserve a pre-Caribbean history. Granitic pegmatites of the island arc dated at 88-82 Ma cut the foot-wall shear-zone between island-arc and high-pressure rocks, thus yielding a minimum age for juxtaposition and metamorphism of the two contrasting nappes. Paleogene uplift and erosion was followed by an unconformable covering of Eocene sediments. The geomorphological expression as a mountain range started only in the late Neogene.

Zulma, Gasparini, and Iturralde-Vinent, Manuel, OXFORDIAN REPTILES IN THE CARIBBEAN CORRIDOR, Workshop in Cuba, March 2003.

Phylogenetic affinities between the middle Jurassic marine reptiles of Europe and western South America suggest a connection through central-western Pangea. However, it is not until the Oxfordian when reptiles are first recorded in the Caribbean, and their taxonomic diversity is in agreement with a corridor related to a great oceanographicevent. So far, all the Caribbean Jurassic reptiles were found at western Cuba (Guaniguanico terrane). The bearing levels belong mostly to the Jagua Vieja Member of the Jagua Formation (middle reptiles are particularly important because of their geographic location and because of their age, since middleupper Oxfordian records are not frequent worldwide.Among the Cuban marine reptiles prevail the pelagic forms that frequently rambled in near shore environments. This was the case of long-necked plesiosaurs (Cryptoclididae: Vinialesaurus caroli), crocodiles (Metriorhynchidae: Geosausus sp.), and turtles (Pleurodira: Caribemys oxfordiensis). The relative vicinity of the shore, of the marine environments in which these reptiles are recorded, is supported also by the presence of pterosaurs (Rhamphorhynchidae: Nesodactylus and a new taxon), isolated post-cranial fragments of sauropod dinosaurs, and abundant plant remains, particularly logs. The Caribbean Corridor was also the way for other pelagic off-shore reptiles such as ophthamosarian ichthyosaurs and pliosaurs. The close taxonomic relationships between the Oxfordian reptiles -and fishes- of Cuba and western Tethys - eastern Pacific presupposes that the Caribbean Corridor played a main role in the association of the pelagic fauna from both regions.

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