INTERNATIONAL GEOSCIENCE PROGRAMME (IGCP)

Final Report of IGCP Project No. 433
2000-2004

Caribbean Plate Tectonics

Duration and status: termination (2000-2004)

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1. Website address related to the project

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

This website contain all the information concerning the project, including project logo, project description, past events and reports of the meetings, Caribbean bibliography, Caribbean models comparison, interesting information, and forum. The FORUM section contain important papers and presentations about the Caribbean Plate Tectonics as ppt* and pdf* files. It is regularly updated in order to keep the scientific community informed about the progress of the project. This web site will be active after the end of the project, in order to serve as a link among Caribbean geologists.

The project also established an email group carib@yahooegroups.com which is a highway for exchanging useful information concerning new publications, scientific events, news about our area of interest, and a question/answer system which is widely used to search for information among the carib group members. Fortunately the group have been kept at a low profile, in order to avoid loading the people with unneeded mails. This group will be kept active after the end of the project.

2. Summary of major past achievements of the project

The past and present achievements of the project are discussed singularly below, as this is the final report. For reference to past achievements, please visit the project's web site.

3. Achievements of the project this year 2002

3.1 List of countries involved in the project

During the time span of the project, an increasing number of scientists have joined the egroup and there are now over 200 members involved in activities related to the project. This is not the case for meetings and field trips, where a much smaller group of members attended. In general the amount of participants in field trips, worshops and scientific meetings have varied from over 80 to a minimum of 20. However, reports of these activities are widely circulated among egroup members and web site visitors, so the impacts of the project are spread far beyond our membership.

Active participants in the past 4 years have been from the following countries: Argentina, Barbados, Canada, Colombia, Costa Rica, Cuba, Dominican Republic, France, Germany, Guatemala, Hungary, Italy, Jamaica, Japan, Mexico, New Zealand, Nicaragua, Panama, Peru, Poland, Puerto Rico, Spain, Trinidad & Tobago, United Kingdom, USA, and Venezuela.

3.2. General scientific achievements

During our first meeting in Río 2000, the project leaders raised the following points:

- At the present time, there are many interpretations of the Caribbean, most of them hard to reconcile.
- This situation is the consequence of poor coordination of efforts, and due to working as isolated individuals --or small groups of individuals.

• If we want to understand the origin and evolution of the Caribbean, we urgently need actual interaction and exchange of data, and sharing the expertise that each one has developed working in different arenas.

• Consequently, the aim of this project is to improve communication within the Caribbean geoscience community, and jointly explore common grounds for the interpretation of the origin and evolution of the Caribbean region.

Today, after five years of activities, we are proud to say that our goals were fulfilled, although the results may not be as good as we dreamed. Let us, therefore, critically evaluate our goals versus our achievements.

The dream of achieving a general agreement concerning the plate tectonic origin and evolution of the Caribbean was not completed. Right now the two main types of models, allochthonous and *in situ*, with different versions and conceptions, are strongly championed by experienced scientists that have spent many years of research in the area.
Debate has been hot and enthusiastic in different arenas, and the results, in our opinion, are very important. We have been able to witness how local evidence and data are now utilized to test and elaborate general models. Today's models are trying to offer explanation to local facts and phenomena that previously were just ignored. Also, some geologists are requesting each day more information from others, in order to improve their interpretations of particular elements of the Caribbean geology. Nevertheless, at the same time, we have realized that some scientists keep just ignoring other people results to the detriment of their own performance.
Consequently, we have to conclude that exchange and debate have been very useful and active during these years, but the way this process has impressed individual scientists is very different. We strongly believe that the project has opened a major highway to focus present and future research in the Caribbean. The issue is to improve the appropriate exploitation of this highway.
Our project had also the goal of providing new insights into the geologic hazards related to plate tectonic movements. To fulfil this problem we have posted on our web site a section on forecasting volcanic activity in the area. Some members have also been active investigating the present activity and seismic response of major fault systems around the Caribbean. We understand, as our colleagues did long ago, that only continuous research will shed light into the scientific and practical problems of a rational use and exploitation of the natural resources and environment. Particularly in connection with the Plate Tectonic understanding of the Caribbean, this fact is more than important, if we want to protect society from geologic hazards.

Quick overview of the present status of the debate

There are many general and singular points of debate concerning the origin and evolution of the Caribbean. In the following paragraphs we briefly review some of them, but we encourage those interested in these matters to read conference and annual reports in our web site. Several papers in preparation for the final volume of this IGCP project 433 will be discussing these and other matters.

1. *From simplicity to complexity*. A major trend in the scientific scenario of the Caribbean region is the fact that, as more research and subsequent knowledge is accumulated, the more complex the geological picture becomes. Investigations of the igneous and metamorphic complexes with modern techniques are demonstrating that our concepts need to be modified, sometimes drastically, as is happening over the last two decades. Also detailed paleontologic and stratigraphic studies are providing unexpected new information. These trends demonstrates that our present understanding of

Caribbean Geology has to be improved, and properly focused investigations are utterly needed, even in these times when academic research is under-financed.

2. *The Galapagos hotspot and Caribbean plateau.* 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).

3. *Tectonic terranes*. Ever since the first meeting of the project we have been debating the concept and use of tectonic terranes. Terrane tectonics is an integral part of the Caribbean, as many tectonic crustal fragments have been transported along the plates margins. In order to produce a sound model for the evolution of the area, terranes have to be investigated and incorporated into appropriate palinspastic reconstructions. Important examples are Andean, Peñón-Dagua, Siquisiqui, Chortis, CSWT (Guaniguanico, Escambray, and Pinos), just to mention a few of them.

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.

4. *In situ vs allochthonous origin of the Caribbean*. Beginning with this project we had the hope of finding good clues as to the allochthonous vs the *in situ* controversy regarding the origin of the Caribbean. But the controversy goes on, and new advocates of both views are raising their voices. The

authors of this review favour the allochthonous type of models, but respect the opposite opinions because scientists following such a trend, are providing good arguments that have to be taken into account if an agreement is to be reached. In fact we also agree that the present allochthonous models have a long way to go before someone can feel that this approach is providing the right tool to understand past and present tectonic developments of the Caribbean area. A great debate about this issue was the meeting in Granada, where we reach a series of conclusion. 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 allochthonous models availables. This means that models 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 that 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. The role of the Galapagos hotspot in the geology of the Caribbean, was 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 (see Leicester's meeting report).

5. *Arc Polarity and Great Arc vs Multiple Arc*. These have been matters of much debate in our meetings and field trips, but the authors believe that only after some current research projects are completed, will we be in the right position to provide answer about the age and origin of metamorphic inclusions in the serpentinite melanges, about the geochemistry and age of igneous rocks, and about the origin of some allochthonous terranes such as Escambray. These projects, initiated as a result of our debates and meetings, are currently in progress and will require several more years before they are completed. It is only necessary to review several of the most recent papers published about these matters, and visit our web site, to understand that many question are waiting for the right answers. These questions include the age span of the volcanic arcs in south Central America, Northern Central America, the comparison between volcanic arc rocks of the Guerrero Terrane and volcanic arc terranes in South Central Cuba, the age span and polarity of the volcanic arc rocks in the Greater Antilles and in the Lesser Antilles, and the age and cause of alleged polarity reversals during the evolution of these arcs.

One of the controversial subject, the existence of an active Albian-Campanian island arc in Central America, was solved, specially during the field trip to Costa Rica. 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.

Also the point regarding the geometry of the arcs was discussed during the meetings in Rio de Janeiro, Stuttgart, Granada and Cuba. 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.

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 occurs, the easier it would be from a tectonic standpoint. 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, 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 presently preferred.

3.3. List of meetings with approximate attendance and number of countries just ignored and not properly debated by those with a different interpretation. 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.

During this project we have organized scientific meetings and field workshops in several countries as United States of America (Boston and Austin), Guatemala, Costa Rica, Cuba (central, western and eastern), Barbados, Brazil, Spain (Granada and Barcelona), Germany (Freiberg and Stuttgart), Italy, and United Kingdom. Reports of these meetings are available at the web site.

3.4. Educational, training or capacity building activities

The project itself did not plan any activities in this concern, but in fact several people from Puerto Rico, Cuba, Mexico, Colombia, Venezuela, Spain, Italy and the United States of America have been developing their Master and PhD dissertation in thematic topics related to the project, and have participated in meetings and field workshop with partial project support.

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, and one of the leaders is from a developing country. We believe that there has been important participation, especially because we have been able to celebrate the meetings in developing countries, utilizing the assistance of local geologists as in Guatemala, Costa Rica, Barbados and Cuba.

3.6. List of most important publications

During the past 5 years, project members have been producing a great deal of publications, unfortunately some of them without recognition that they belong to the project, but many others did, and are on the order of 100. The list of recent publications is included in this report, and a complete list is available on the web site in every yearly report. This year was also marked by the publication of AAPG Memoir 79 (Bartolini, C., R. Buffler and J.B. Blickwede, 2004. *The Circum-Gulf of Mexico and the Caribbean: Hydrocarbon habitats, basin formation and plate tectonics.* AAPG Mem. 79, Oklahoma, USA), in CR-ROM format, which includes many papers about the geology and plate tectonics of the Caribbean and Gulf of Mexico area. Seven papers are from IGCP project members as is recognized in the Introduction.

Currently we are preparing a Final Memoir of the project, to be published next year as a special issue of *Geologica Acta*. Eight important contributions are under review process, including some concerning plate models (Pindell, James, Giunta) and some with new data about local areas and their implications for present-day tectonic models (Jolly, Lidiak, Iturralde-Vinent, García Casco, Proenza, Audemard). More are expected to be received toward the end of this year, from Y. Rojas, A. Garcia Casco, P. Denyer, W. Jolly, and some others.

LIST OF PAPERS IN REVIEW

Audemard M., F. A., 2005, Key issues on the post-Mesozoic southern Caribbean plate boundary.

Giunta, G., and Beccaluva, L., 2005, Caribbean plate margin evolution: constraints and current problems.

Iturralde-Vinent, M. A., Díaz Otero, C., Rodríguez Vega, A., and Díaz Martínez, R., 2005, Tectonic implications of paleontologic dating of Cretaceous-Danian sections of northeast Cuba.

James, K., 2005, Arguments for and against the pacific origin of the Caribbean plate: discussion, finding for an in situ origin.

James, K., 2005, Caribbean plate tectonics: an *in-situ* model.
Jolly, W. T., Lidiak, E. G., and Dickin, A. P., 2005, Cretaceous to mid-Eocene pelagic sediment budget in Puerto Rico and the Virgin Islands, northeast Antilles Island Arc.
Pindell, J. 2005,Origin of the Caribbean plate.
Proenza, J. A., Díaz-Martínez, R., Marchesi, C., Melgarejo, J. C., Gervilla, F., Garrido, C. J., Rodríguez-Vega, A., Lazano-Santacruz, R., and blanco-Moreno, J. A., 2005, Primitive island-arc Cretaceous volcanic rocks in eastern Cuba: the Téneme Formation.

OTHER CONTRIBUTIONS THIS YEAR:

Beccaçluva, L., M. Coltorti, G. Giunta, F. Siena – 2004 – Tethyan vs Cordilleran Ophiolites: a reappraisal of distintctive tectono-magmatic features of supra-subduction complexes in relation to the subduction mode. Tecthonophysics (in press).
Beccaluva L., Coltorti M., Giunta G., Siena F. – 2004 – Distintive tectono-magmatic features of supra-subduction complexes in Tethyan Vs Cordilleran ophiolites. 32^ Intern. Geological Congr., Florence (Sess. G20.11).
Corona-Chávez, P., P. Schaaf, B.Bigioggero, A.Tunesi, A.Cavallo, A.Colombo, 2005, Laramidic Plutonism In The Guerrero Terrane, Southern Mexico: New Geochemical And Geobarometric Data And Tectonic And Ore Deposits Implications, First Cuban Earth Science Convention, Convention Palace, Havana, April 5-8, 2005.
Gervilla, F., González Jiménez, J.M., Proenza, J.A., Melgarejo, J.C., Garrido, C.J., Díaz-Martínez, R., Lavaut, W., Ruiz, R. - 2004 - Geoquímica y mineralogía de los elementos del grupo del platino en los depósitos de cromita del cinturón ofiolítico Mayarí-Baracoa (Cuba Oriental). Macla, 2, 17-18.
Giunta, G. M.Marroni, E.Padoa, L.Pandolfi – 2004 – Geological constraints for the Geodynamic evolution of the southern margin of the Caribbean Plate. “The Circum-Gulf of Mexico and the Caribbean…” C. Bartolini, R. Buffler, J. Blickwede Eds, AAPG Memoir 79, Ch. 5, 104-125.
Giunta G., Beccaluva L., Marroni M. – 2004 – Constraints and current problems for the Caribbean Plate margins evolution: the main results of the Italian-Caribbean research group (IGCP 433). 32^ Intern. Geological Congr., Florence (Sess. G20.11).
Iturralde-Vinent, M., - 2004 - The conflicting paleontologic vs stratigraphic record of the formation of the Caribbean seaway. AAPG Memoire 79, CD-ROM and book, Chapter 3, p. 75-88.
Jolly, W. T., and Lidiak, E. G., 2003, Geochemical characteristics and tectonic setting of volcanic rocks, southwest Puerto Rico: Caribbean Plate Tectonics Symposium, Grenada, Spain, October 2003.
Jolly, W. T., Lidiak, E. G., and Dickin, A., P. 2004, Geochemical links between pelagic sediments and Mesozoic island arc volcanism, northeast Antilles: Canadian Mineralogical Society Annual Meeting.
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4. Activities planned

Although the project is done, we will continue the preparation and publication of the final memoir which is scheduled to be completed in the Year 2005. Will also keep updating the web site and using the egroup. No other activities are planned.

5. Project funding requested

No funding is needed.

6. Request for extension, on-extended-term-status, or intention to propose successor project

We are preparing another project to continue our debate and exchange of data and ideas concerning the origin and evolution of the Caribbean region, and will be presented separately. This new proposal will be more focused on implications of plate dynamics for geologic hazard forecast and mitigation.

7. Attach any information you may consider relevant

1. Scientific Report on the Symposium G20.11 "Caribbean Plate Tectonics" in Florence, August 20-28, 2004

M. Iturralde-Vinent
Project co-Leader

The final scientific meeting of the IGCP Project 433 was held in Florence (Italy), August 25th, 2004, as the General Symposium G20.11 "Caribbean Plate Tectonics", Convened by G. Giunta (Italy) and M. Iturralde-Vinent (Cuba). Eighteen presentations were planned, but there were two absents and one added. Both the poster session and the scientific meeting were attended by nearly 150 persons. There were presentations by authors from Venezuela, Cuba, Puerto Rico, Mexico, United States of America, Italy and Spain. There were also Project members and attendees from Costa Rica, Colombia, United Kingdom, Germany, Canada, Japan, and many other countries.

The meeting started with the keynote presentation by the author, where today's status of the debate about the plate tectonic origin and evolution of the Caribbean was presented, after five years of the project. The main point is that, been the Caribbean a single place in the planet, surely with a single history, still there is not a consensus concerning the basic issue of the -allochthonous vs. *in situ*- origin of the Caribbean Plate. The causes are probably two fold: 1. Insufficient geological knowledge of important segments of the region, and 2) Lack of interaction with all the available data, specially some authors that simply choose to ignore important contributions to the geology and geophysics of the region.

The main problem with the *in situ* version, among other things, is the absent of volcanic materials mixed with the Cretaceous-Eocene sections of the Florida, Bahamas and Yucatan carbonate platforms; which evolved surrounding the arcs. In the four oral presentations of G. Giunta and his colleagues, and by J. Rueda-Gaxiola, this type of model was supported.

The allochthonous models were also discussed by M. Iturralde-Vinent, to indicate that existing versions generally do not explain some local geological phenomena. There seems to be that this type of model, usually the more popular today, needs further development before it can be fully accepted.

The general evolution of the Caribbean was discussed in the framework of the world plate tectonic evolution by the keynote speaker (LINK TO PLATES 2004). It was shown that the area evolved between Late Jurassic and mid Cretaceous as an *in situ* ocean crust being created by an extension of the North Atlantic ocean-ridge system. But since Latest Cretaceous, probably a new crust overrode and “bulldozer” the previous one, forming orogenic belts along the Caribbean margins, and emplacing a fragment of the former Pacific crust between North and South America. This type of model was originally proposed by Malfait and Dinkelmann in their 1973 paper, and later has been elaborated in greater details by several authors, but following distinct pathways (Pindell, Burke, Kennan, Ross, Scotese, Mann, Bouysse, Kerr, Iturralde-Vinent, and many others). The more common version of these models follow the Malfait and Dinkelmann's idea of a Great Caribbean Arc (named like this by Pindell and Burke in 1984), evolving in the leading edge of the Caribbean Plate since latest Jurassic times.

This idea is not followed by the author, which presented a new version of his multiarc model. It was suggested that since latest Jurassic, the convergent margins of the Caribbean Plate had evolved, with a minimum of nine distinct arcs displaying different geochemistry, time range and orientation, usually separated by a major unconformity. It was also proposed that the Caribbean plate was first delineated in the Albian, when a volcanic arc evolved in the west-ward convergent edge of the plate (present Central America).
The others presentations and posters were more focused on regional geology and geophysics, and their implications for the understanding of the Caribbean Plate. These papers showed a pattern, realized in previous reports, it is, that the more detailed any area is investigated, more complex is the resulting scenario. This naturally leads to the conclusion that our present knowledge of the Caribbean is as yet insufficient to be able to produce a detailed plate tectonic model of its origin and evolution.

An interesting presentation by G. Mattioli and coworkers proposed the organization of a Caribbean Plate Boundary Observatory. The idea is to fill the gaps in the GPS station network around the Caribbean, and create a centralized database to be used to improve our understanding of the present geodynamics of the plate. This information can also be combined with investigations of the former plate boundaries, in order to advance in the understanding of the origin and evolution of the Caribbean, and the implications of this knowledge for the well being of the communities that populate the region.

In this concern, it was announced the preparation of a follow-up IGCP project, concerned with the "Geodynamics of the Present and Past Plate Boundaries of the Caribbean: and its implications for the local communities". This proposal will be elaborated late in this year, to be presented to UNESCO/IUGS.

Another issue that was taken care of, concerns the preparation of the final memoir of the IGCP Project 433. It was informed that nine papers are now under review, and a call for more contributions was announced, extending the dead line until December 2004.

Abstracts of the Presentations

M. Iturralde-Vinent, Caribbean plate tectonics: state of the debate and future developments

G. Giunta et al., Constraints and current problems for the Caribbean margins evolution.

L. Beccaluva et al., Distinctive tectono-magmatic features of supra-subduction complexes in tethys and the Caribbean.

M. Marroni et al., Geological constraints to the geodynamic evolution of the southern margin of the Caribbean.

M. Manichetti et al., Geometry and structure of the Eastern Polochic and Motagua transform fault systems in eastern Guatemala.

J. Rueda-Gaxiola, Caribbean implications of the triple junction model for the Gulf of Mexico origin.

C. Marchesi et al., Genetic relationships between cummulate gabbros and volcanic rocks in the Mayarí-Baracoa opliolitic belt (eastern Cuba).

G. Mattioli et al., A proposal for a Caribbean Plate Boundary Observatory.

F. Urbani. New geological map of the Cordillera de la Costa, northern Venezuela.

L. Chacín and M. Jacome, A kinematic model of the Barinas-Apure basin and the southern Venezuela basin.

J. Urrutia and R. Ornellas, New aeromagnetic anomaly map of Mexico- study of crustal structure, magmatism and tectonics.

M. Chiari et al., Paleontologic evidences for a Late Jurassic age of the Guatemalan ophiolites.

R. Rojas. The Cuban rudts mollusks, and important tool for bioestratigraphic correlation of the Caribbean Cretaceous.

I.W. Aiello et al., Stratigraphy of Cretaceous radiolarian cherts of Cuba.

K. Núnez et al., Emplacement of the Ophiolite complex in Eastern Cuba.

C. Marchesi et al., New geochemical data on peridotites from Mayarí-Cristal and Moa-Baracoa ophiolite massifs (Eastern Cuba).

D. Laó-Dávila et al., Olistostromes and allochthonous serpentinite: major tectonoestratigraphic elements in southwest Puerto Rico.

F. Oleani et al., Crustal upper mantle structure in the Caribbean region by group velocity tomography and regionalization.

2. Report about the status of volcanic activity in the Caribbean.

Holocene Volcanic Activity in all Caribbean Plate Margins: Forecast and Risk Assessment

by R.B. Trombley
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Apache Junction, Arizona USA

CARIBBEAN VOLCANIC ACTIVITY AND FORECAST REPORT
05 August 2004
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 10.5, the only known long-range and reasonably accurate forecasting programme of its kind in the world. Accuracy, relative to Caribbean area volcanoes only, is as follows: Of **10** volcanoes originally forecasted, **7** have erupted for an accuracy of **70.00%** to date for the year **2004**. One volcano has erupted that was not forecasted for year 2004.

KEY:

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

ACTIVE VOLCANO STATUS OF THE CARIBBEAN
AS OF: 05 August 2004

Volcano	Country	Next Forecast			
Year	Yr. Of =>50%		=>Yr. Of 95%		Current Status
Ceboruco	Mexico	1874	2052	2659	In Repose
Colima	Mexico	2004	2068	2436	Erupted
El Chichon	Mexico	1998	2193	2858	In Repose
Jocotitlan	Mexico	1272	4647	15865	In Repose
Michoacan-Guanaj	Mexico	1951	2753	5443	In Repose
Pico De Orizaba	Mexico	1712	1728	1865	Overdue
Pinacate	Mexico	1947	1960	2047	In Repose
Popocatepetl	Mexico	2049	2004	2620	Erupted
San Martin	Mexico	1944	2196	3075	In Repose
Socorro	Mexico	1997	2014	2086	In Repose
Tacana	Mexico	1990	2011	2097	In Repose
Tres Virgenes	Mexico	1861	1946	2243	In Repose
Acatenango	Guatemala	1977	2249	3172	In Repose
Almolonga	Guatemala	1821	2096	3020	In Repose
Atitlan	Guatemala	1873	1882	1970	Overdue
Fuego	Guatemala	2051	2004	2021	Erupted
Pacaya	Guatemala	2004	2029	2116	Erupted
Santa Maria	Guatemala	2008	2004	2046	Erupted
Tajumulco	Guatemala	1870	1926	2137	In Repose
Cerro Negro	Nicaragua	2014	2003	2018	In Repose
Concepcion	Nicaragua	2003	1990	2009	In Repose
Cosiguina	Nicaragua	1868	1908	2074	In Repose
Las Pilas	Nicaragua	1957	2063	2429	In Repose
Masaya	Nicaragua	2030	2004	2704	Forecast ‘04
Momotombo	Nicaragua	2013	2151	2676	In Repose
San Cristobal	Nicaragua	2017	2004	2085	Forecast ‘04
Telica	Nicaragua	2027	2009	2042	In Repose
Arenal	Costa Rica	2004	2228	2975	Erupted
Barva	Costa Rica	1869	4658	13930	In Repose
Irazu	Costa Rica	2015	2001	2025	In Repose
Miravalles	Costa Rica	1948	4390	12511	In Repose
Poás	Costa Rica	2040	2112	2501	In Repose
Rincón de Vieja	Costa Rica	2021	2085	2388	In Repose
Turrialba	Costa Rica	1875	2505	4630	In Repose
Baru	Panama	1552	2036	3653	In Repose
Azufral	Columbia	-916	-219	2139	In Repose
Cerro Bravo	Columbia	1728	2264	4073	In Repose
Cumbal	Columbia	1930	1970	2116	In Repose
Dona Juana	Columbia	1899	3475	8718	In Repose
Galeras	Columbia	2022	2098	2449	Erupted
Purace	Columbia	2001	2036	2236	In Repose
Nevado Del Ruiz	Columbia	2015	2266	3173	In Repose
Nevado Del Tolima	Columbia	1949	2890	6039	In Repose
Kick-‘em-Jenny	West Indies	2008	2004	2017	Forecast'04
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 2011**	**2004**	**2127**	**Erupted**
The Quill	**West Indies 403**	**2247**	**8382**	**In Repose**

SWVRC's eruption forecasting programme, ***ERUPTION Pro 10.5***, 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 10.5***.

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, Masaya in Nicaragua is currently forecasted to erupt in 2030 but forecasted at =>50% probability in the year 2004. 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 10.5*** 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 10.5*** database.

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