Welcome - Croeso

Welcome to Cardiff (or 'Croeso i Gaerdydd' as they say in Welsh) and to the workshop on Circum-Caribbean and North Andean tectonomagmatic evolution: impacts on palaeoclimate and resource formation.

This is an exciting time for Caribbean geological research with a significant amount of new geochemical, geochronological, stratigraphic and tectonic data becoming available. However, if we are to gain a clearer understanding of the tectonic evolution of the Caribbean it is important that these data sets are not considered in isolation and it is hoped that this workshop will help facilitate interaction, understanding and co-operation between different disciplines.

Originally a fort built by the River Taff, Cardiff remained a small town until the coal boom in the 19th century. It was once the largest coal exporting port in the world – and the place where the world's first million pound cheque was signed. Cardiff was granted city status in 1905 and became Wales' Capital city in 1955. Thanks to an extensive and ongoing regeneration scheme, Cardiff Bay is now Europe's largest waterfront development. The University, founded in 1883, is host to some 33,000 students and staff.

We hope you will find some time to explore the compact city centre with its innovative architecture sitting alongside fine historic buildings. At the Workshop banquet on Wednesday evening you will have a chance to see Cardiff Castle, site of the original Roman fort, parts of which are nearly 2000 years old.

We trust that you will find the meeting enjoyable and profitable and that it will lead to increased collaboration in Caribbean geological research. Thanks are due to our sponsors Shell, BP; Tectonic Analysis Ltd. and the IMA Commission on Solid Earth Composition and Evolution. We are also grateful for the travel support provided to delegates by IGCP 546 "Subduction zones of the Caribbean".

Andrew C. Kerr
Jim Pindell
Iain Neill
Alan Hastie

September 2009

SCHEDULE OF ORAL PRESENTATIONS

WEDNESDAY SEPTEMBER 2
08:30-08:40
Welcome. Andrew Kerr, Jim Pindell, Alan Hastie, Iain Neill

Chair: Jim Pindell

Keynote 1
08:40-09:20
Bob Duncan - The Caribbean LIP and Oceanic Anoxic Event (OAE) 2: Further resolution of timing and trace metal release

09:20-09:45
Esteban Gazel Dondi - Life cycle of mantle plumes: A perspective from the Galapagos plume

09:45-10:10
Andrew C Kerr - Despatches from the plateau front: possible and impossible sources of the CCOP

10:10-10:35
Luca Ferrari - New geochronologic, geochemical and isotopic data on the Gorgona island, Colombia: revisiting the Caribbean plume model

10:35-11:00 **Coffee**

11:00-11:25
Iain Neill - Petrogenesis of the latest Jurassic basement complex of La Désirade Island, French West Indies

11:25-11:50
John Lewis - The Monte del Estado peridotite, SW Puerto Rico. New interpretations based on new high resolution trace element analyses

11:50-12:15
Alan Hastie - Geochemistry and petrogenesis of rhyodacite lavas in eastern Jamaica: a new adakite subgroup analogous to early Archaean continental crust?

12:15-13:00 **Discussion**

13:00-13:45 **Lunch**

Chair: Andrew Kerr

13:45-14:25
Keynote 2
Jim Wright - Late Cretaceous subduction initiation on the southern margin of the Caribbean plateau: One Great arc of the Caribbean or two?

14:25-14:50
Roelant van der Lelij - Thermal and Tectonic History of the Dutch Antilles: Aruba and Bonaire

14:50-15:15
Jose Duque Trujillo - The Santa Marta batholith: a combined record of Palaeogene collision and onset of the Caribbean plate subduction beneath the northern margin of the South American plate

15:15-15:45 **Tea**

15:45-16:10
Diego Villagómez Diaz - Late Cretaceous-Tertiary tectonic evolution of Western Colombia

16:10-16:35
Hildebrando Leal-Mejía - Pb-Pb systematics on sulfides from Andean Colombian gold deposits

16:35-5:15 **Discussion**

THURSDAY SEPTEMBER 3

Chair: Alan Hastie

09:00-9:40
Keynote 3
Jim Pindell - Migration of the Great Caribbean Arc relative to the Americas, Part 1: Plate kinematics derived from arc-continent interaction

09:40-10:05
Peter Baumgartner - The Caribbean Seaway: Plate tectonics and palaeoceanography of the Mesozoic Tethys – Proto-Caribbean Connection

10:05-10:30
Kennet Flores - Mesozoic to Eocene plate tectonic evolution of the circum Pacific area: New constraints of far travelled exotic terranes, subduction zone mélanges and arc-arc collisions in Central America

10:30-11:00 **Coffee**

11:00-11:25
Grenville Draper - Paleomagnetic study of Cretaceous arc terranes in Central Hispaniola: paleogeographic implications

11:25-11:50
Roberto Molina-Garza - Constraints from palaeomagnetism to the Late Jurassic-Early Cretaceous tectonic evolution of Mexico.

11:50-12:15
Simon Mitchell - Towards a tectonic evolution of Jamaica in a plate tectonic framework

12:15-12:45 **Discussion**

12:45-13:45 **Lunch**

Chair: Iain Neill

13:45-14:25

Keynote 4

Walter Maresch - Migration of the Great Caribbean Arc relative to the Americas, Part 2: History of subduction and collision along the arc

14:25-14:50

Klaus Stanek - The development of the northern Caribbean Arc: geochronological constraints from island-arc related rock suites in Central Cuba

14:50-15:15

Uwe Martens - Late Cretaceous continental subduction at the Caribbean-North American plate boundary

15:15-15:45 **Tea**

15:45-16:10

John Lewis - A new look at the Nicaraguan Rise, western Cayman Rise and Cayman Trough: Implications for stratigraphic/structural relations and tectonic/magmatic evolution

16:10-16:35

Alan Smith - The geological and petrological evolution of Dominica, Lesser Antilles

16:35-17:15 **Discussion**

FRIDAY SEPTEMBER 4

Chairs: Andrew Kerr& Jim Pindell

08:30-9:10

Keynote 5

Paul Mann - Overview of results from the BOLIVAR-GEODINOS geologic-geophysical study of the Caribbean-South America arc-continent collision

09:10-09:35

Esteban Alfaro Sabogal - Subsidence and tectonic inversion in the north and west of the Colombian basin

09:35-10:00

Victor Ramirez C. - Hydrocarbon generation of northern Colombia basins – a petroleum systems modeling approach

10:00-10:25

Claude Rangin - Neotectonics of the Gulf of Mexico Margins

10:25-10:45 **Coffee**

10:45-12:00 **Concluding discussion**

12:00 Continuing informal discussions over Lunch

Note: for those planning their journey home it is 20 minute walk to Cardiff Central Station from the Main building. You should allow at least two hours to get to Cardiff airport from the Main Building via public transport (45-60 minutes by taxi).

The Caribbean LIP and OAE2: Further resolution of timing and trace metal release

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Oceanic plateaus are elevated and anomalously thick oceanic crust, believed to form rapidly by enhanced partial melting of the mantle. They are regarded as the oceanic equivalent of continental flood-basalt provinces. A natural consequence of such massive submarine volcanism is the release of extraordinary amounts of heat and metal-rich fluids to the ocean over geologically brief intervals. The environmental impact of oceanic plateau volcanism may be ocean anoxic events (OAEs) and mass extinctions. One of the most intriguing features of the Cretaceous ocean is the sporadic interruption of normal marine pelagic sediment deposition by organic-rich sediments deposited during oxygen-deficient conditions (OAEs).

A current model for the abrupt onset and conclusion of these events relates delivery of trace metals to the surface ocean during massive volcanic activity associated with ocean plateau construction, that increased phytoplankton production, and led to the eventual depletion of oxygen in the deep ocean, deposition of organic-rich sediments, and extinction of selected marine organisms. It is proposed that the trace metals were released in eruption-related "event plumes", i.e., degassed magmatic fluids mixed with seawater, as well as hydrothermal effluents dominated by water/rock exchange.

We have evaluated the proposed link between "event plumes" associated with the construction of the Caribbean plateau and OAE2 at the Cenomanian-Turonian (C/T) boundary (ca. 93.5 Ma), by (1) establishing a firmer time scale for the initial, volumetrically dominant phase of Caribbean plateau magmatic activity through ^{40}Ar-^{39}Ar dating of basaltic rocks from thick crustal sections exposed on the northern margin of the intact central plateau (in Haiti), and by (2) determining the inventory of trace metals in parental magmas for submarine lavas and sills through analysis of melt inclusions in olivines (from picrites), for comparison with seawater-altered glassy pillow margins. Eruption ages, determined from feldspar and groundmass separates for oldest exposed lava flows are 93.4-90.9 Ma (Cenomanian-Turonian), while sills and overlying lavas are 87.1 to 85.5 Ma (Coniacian-Santonian). Initial melt inclusion analyses show that volatile/refractory ratios such as Mo/Ce and Sn/Ce are within the normal range of terrestrial basalts, suggesting that these trapped melts are robust recorders of pre-degassed trace metal abundances. A complementary study has already identified trace metal abundance anomalies in near-field and far-field marine sedimentary sections that record OAE2.

Life cycle of mantle plumes: A perspective from the Galapagos plume

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Hotspots are localized sources of heat and magmatism considered as modern-day evidence of mantle plumes. Some hotspots are related to massive magmatic production that generated large igneous provinces (LIPs), an initial-peak phase of plume activity with a mantle source hotter and more magmatically productive than present-day hotspots. Geological mapping and geochronological studies have shown much lower eruption rates for oceanic island basalts (OIB) compared to lavas from Large Igneous Provinces (LIPS) such as oceanic plateaus and continental flood provinces. Our study is the first quantitative petrological comparison mantle source temperature and extent of melting for OIB and LIP sources. The wide range of primary magma compositions and inferred mantle potential temperatures for each LIP and OIB occurrence suggest that this rocks originated form a spatially localized source of heat and magmatism restricted in time, a hotspot. Extensive outcrops of basalt, picrite, and sometimes komatiite with ~65-95 Ma ages occupy portions of the pacific shore of Central and South America included in the Caribbean Large Igneous Province (CLIP). There is general consensus of a Pacific-origin of CLIP and most studies suggest that it was produced by melting in the Galápagos mantle plume. The Galápagos connection is consistent with isotopic and geochemical similarities with lavas from the present-day Galápagos hotspot. A Galápagos link for rocks in South American oceanic complexes (eg. the island of Gorgona) is more controversial and requires future work. The MgO and FeO contents of lavas from the Galápagos related lavas and their primary magmas have decreased since the Cretaceous. From petrological modeling we infer that these changes reflect a cooling of the Galápagos mantle plume from a potential temperature of 1560 - 1620°C in the Cretaceous to 1500°C at the present time. These temperatures are higher than 1350±50°C for ambient mantle associated with oceanic ridges, and provide support for the mantle plume model of the CLIP. The exact form of the secular cooling curve depends on whether the Gorgona komatiites were produced by the Galápagos or another plume. Iceland also exhibits secular cooling, in agreement with previous studies. In general, mantle plumes for LIPS with Paleocene-Permian ages were hotter and melted more extensively than plumes of more modern oceanic islands. This is interpreted to reflect episodic flow from lower mantle domains that are lithologically and geochemically heterogeneous. The majority of lavas from the present-day Galápagos plume formed in a column where melting ended at > 2 GPa, and this pressure is highly variable. Melting ended at much lower pressures for lavas from the Cocos and Carnegie Ridges, consistent with the channeling of the Galápagos plume to locations of thinner lithosphere. Low pressures of final melting are also inferred for older CLIP lavas, which suggest that the plume head impacted a mid-ocean ridge system.

Dispatches from the plateau front: Possible and impossible sources of the CCOP

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The Caribbean oceanic plateau formed in the Pacific realm when it erupted onto the Farallon plate from the Galapagos hotspot at ~90 Ma. The plateau was subsequently transported to the northeast to collide with the Great Arc of the Caribbean thus initiating subduction polarity reversal and subduction backstep such that the plateau and the segmented Great Arc of the Caribbean were tectonically emplaced between the westward moving North and South American continents to form the Caribbean plate. The plateau ($\sim 4\times 10^6$ km^3) represents a large outpouring of predominantly mafic volcanism, which has been interpreted, by many as having formed by melting of a hot mantle plume. Conversely, some have suggested that a slab window could be involved in forming the Caribbean oceanic plateau. However, differing volcanic rock types in oceanic plateau and slab window environments combined with geochemical modelling shows that the source regions of oceanic plateaus are distinct from N-MORB (the likely source composition for slab window mafic rocks). Furthermore, melt modelling using primitive (high-MgO) Caribbean oceanic plateau lavas from Curaçao, shows that their primary magmas contained 19.6-22.2 wt.% MgO and were derived from 30-32 % batch partial melting of a fertile peridotite source region which had a T_p of 1564-1614^{o}C. Thus, the Caribbean oceanic plateau lavas are derived from decompression melting of an upwelling mantle plume with excess heat compared to ambient upper mantle. It is clear that extensional decompression partial melting of sub-slab asthenosphere in a slab window with an ambient mantle T_p cannot produce enough melt to form a plateau. The formation of the Caribbean oceanic plateau by melting of ambient upper mantle in a slab window setting, is therefore highly improbable.

New geochronologic, geochemical and isotopic data on the Gorgona island, Colombia: revisiting the Caribbean plume model

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Gorgona Island, offshore the Pacific coast of Colombia, is an accreted fragment of the Caribbean oceanic plateau, postulated to be the result of the initial melting of the Galapagos plume head at ~92-89 Ma. Gorgona ultramafic suite was previously considered to be ~89 Ma based on a few, poorly constrained ^{40}Ar-^{39}Ar ages. Accordingly, both enriched basalts and highly depleted komatiites and picrites in the island were assumed to have formed roughly at the same time from the head and tail of the plume, respectively. A new set of ^{40}Ar-^{39}Ar ages for Gorgona igneous rocks and a paleontological age of the overlying sediments document a longer period of magmatic activity (from ~92 to >56 Ma). Variation in trace element ratios points to a progressive increase in the degree of melting and melt extraction as well as a decreasing depth of melting with time. In addition, Nd isotope data are consistent with a progressive increase in recycled material. This long lasting magmatic activity in a small area (~12 km^2) is inconsistent with the formation of the island above a stationary hotspot. High volatile contents (H_2O, B, Cl) in olivine melt inclusions (Kamentsky et al., 2003) are uncommon in plumes and suggest interaction with subduction fluids. Plate tectonic reconstructions preclude the Galapagos hotspot from being the source of Gorgona. Even allowing a 2,200 km westward drift with respect to the Indo-Atlantic hostspot reference frame since 92 Ma (e.g. Pindell & Kennan, 2009) leave Gorgona outside the Galapagos hotspot. However, the island formed to the south of a slab window formed by the intersection of the proto-Caribbean spreading ridge and the Great Caribbean Arc, and in proximity of the incipient Central America arc. The persistent magmatic activity and the secular compositional variation at Gorgona need a more complex explanation than the impact of a plume head coming from the lower mantle. Decompression melting and lateral flow of sub-slab mantle within the opening Late Cretaceous slab window need to be considered to explain the Gorgona petrologic enigma.

Kamenetsky, V., Sobolev, A.V., McDonough,W., 2003. Melt inclusion evidence for a volatile-enriched (H_2O, Cl, B) component in parental magmas of Gorgona Island komatiites. Geophysical Research Abstracts, **5**, 14,774.

Pindell, J., and Kennan, L., 2009. Tectonic evolution of the Gulf of Mexico, Caribbean and northern South America in the mantle reference frame: an update. In: James, K., Lorente, M. A. & Pindell, J. (eds) The geology and evolution of the region between North and South America, Geological Society of London, Special Publication.

Petrogenesis of the latest Jurassic basement of La Désirade Island, French West Indies

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The basement complex of La Désirade Island consists of pillowed basalts, basaltic and rhyolitic lava flows, andesitic dykes and a trondhjemite pluton. Biostratigraphic dating of radiolarian assemblages in the basalts as well as U-Pb CA-TIMS dating of the trondhjemite have both revealed Tithonian ages[1]. This indicates that the suite was formed in rapid eruptive phases with the trondhjemite appearing to be the plutonic equivalent of the rhyolites[1]. Few comprehensive geochemical surveys have been undertaken and the tectonic affinity of the island is unknown. Authors have been generally split between island arc[e.g. 2], back-arc[3] and MORB-like origins[e.g. 4].

We collected samples from all suites and analysed for major and trace elements by ICP-OES and MS. The island has been affected by strong weathering and hydrothermal metamorphism rendering only immobile element data effective in tectonic discrimination. We also discuss unpublished Pb, Sr and Nd radiometric isotope determinations[5].

Trace element diagrams show that the basalts trend between true basalts and basaltic andesites. REE patterns for the basalts are both enriched and depleted with respect to N-MORB. Some basalts show LREE-enrichment and middle-heavy REE depletion, which along with petrological evidence may suggest a boninitic affinity. All suites on the island show flat to slightly LREE-enriched patterns indicating that they are mostly tholeiitic. On PM-normalised spider plots, all suites are depleted in Nb-Ta and Th. Intermediate-felsic units commonly show Zr-Hf enrichment and Ti depletion. The basalts are not Ti-depleted. Nd/Sr_i isotopic ratios show all Désirade rocks plotting close, or to the left of the mantle array with a linear Sr trend at constant Nd indicating weathering and hydrothermal contamination. Pb-Pb_i and Nd/Pb_i ratios fall largely in the MORB field with a slight trend towards Pacific sediment compositions. There is no evidence that the trondhjemitic unit is TTG or adakite-like. These results collectively suggest that Désirade is arc related and either represents the subduction zone magmatism in a forearc or indeed a back-arc setting. The primitive isotope signatures suggest it has not been contaminated with any continental material.

Palaeogeographic reconstructions of the Caribbean indicate that the Americas split apart during the late Jurassic to form a proto-Caribbean Sea extending southwards to the Colombia-Equador seaway[e.g. 6]. The seas formed the back-arc to an east-dipping subduction zone extending down the Americas, which expanded as the Americas split and eventually reversed polarity. It is likely that fragments both of the arc and back arc region have been preserved as ophiolites following reversal, furthermore implying that remnants of the Jurassic arc could be found to the west of the Lesser Antilles, perhaps underlying parts of the Aves Ridge, Greater and Dutch Antilles.

[1]Mattinson, J.M. et al., 2008. GSA Special Paper, **483**, 175-190.
[2]Bouysee, P. et al. 1983. Geology, **11**(4), 244-247.
[3]Montgomery, H. & Kerr, A.C. 2009. Geological Society of London Special Publication, in press.
[4]Mattinson, J.M. et al. 1980. Contributions to Mineralogy and Petrology, **71**(3), 237-245.
[5]Gauchat, K.C. 2004. Unpublished MS Thesis, University of Lausanne.
[6]Pindell, J.L. & Kennan, L. 2009. Geological Society of London Special Publication, in press.

Cenozoic analogues support a plate tectonic origin for the Earth's earliest continental crust.

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Eocene rhyodacite lavas from the Wagwater Basin in eastern Jamaica have adakitic-like major element compositions, low Y and heavy rare Earth element (REE) concentrations and negative Nb and Ta anomalies on a normal mid-ocean ridge basalt normalised multi-element diagram. They also have lower Sr (<400 ppm), MgO (≤2.0 wt.%), Ni (mostly ≤30 ppm) and Cr (mostly ≤40 ppm) concentrations compared to other modern adakites and middle-late Archaean (3.5-2.5 Ga) trondhjemite, tonalite and granodiorite/dacites (TTGs). ε_{Nd}(i) and ε_{Hf}(i) values indicate that the adakites can not been formed by assimilation and fractional crystallisation processes involving any other igneous rock in the area and so the composition of the adakites is the result of the residual mineralogy in the source region. Low Sr and Al_2O_3 contents indicate a fluid/vapour-absent source region with residual plagioclase and REE systematics point to residual amphibole and garnet in the source region. The plagioclase and garnet residue implies that the Newcastle magmas were derived from partially melting a metabasic protolith at 1.0-1.6 GPa, which would intersect the amphibole dehydration partial melt solidus at ~ 850-900^{o}C.

Radiogenic isotopes along with the low MgO, Ni and Cr concentrations in the adakites demonstrate that the garnet amphibolite source region cannot be part of (1) the lower Jamaican arc crust, (2) delaminated lower crust or (3) subducted Proto-Caribbean "normal" oceanic crust that may, or may not, have detached. This data, in addition to partial melting models involving a theoretical garnet-amphibolite source region for the Newcastle lavas, shows that the adakites are derived from metamorphosed Caribbean oceanic plateau crust that underthrust Jamaica in the early Tertiary. The underplated oceanic plateau crust partially melted by either (1) influx of basaltic magma during lithospheric extension in the early Tertiary or (2) direct partial melting of the underthrusting (subducting) plateau crust. The Newcastle magmas ascended and erupted without coming into contact with a mantle wedge thus forming the low MgO, Ni and Cr contents.

Most Cenozoic adakites have compositions similar to the middle-late Archaean TTG suite of igneous rocks. In contrast, early (>3.5 Ga) Archaean TTG crustal rocks have lower Sr, MgO, Ni and Cr concentrations and prior to this study had no modern adakite analogue. However, the Newcastle adakites have similar compositions to the, early Archaean TTG. The discovery of these rocks has important implications for our understanding of the formation of the Earth's earliest continental crust and so it is proposed that the Newcastle lavas be classified as a unique sub-group of adakites: *Jamaican-type adakite*.

Late Cretaceous subduction initiation on the southern margin of the Caribbean plateau: One Great Arc of the Caribbean or two?

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The Leeward Antilles are isolated subaerial exposures of a prominent submarine ridge that extends from west of Aruba to La Blanquilla on the east. They have played a pivotal role in models for tectonic evolution of the Caribbean plate because they contain on land exposures of CLIP rocks, in addition to Cretaceous magmatic arc assemblages and continentally-derived sedimentary strata. Many studies have concluded that Cretaceous arc rocks in the Leeward and Greater Antilles were originally contiguous, forming a single great arc of the Caribbean. If correct, the geology of the Leeward Antilles should record collision of an Aptian-Albian volcanic arc with the CLIP, followed by construction of a Late Cretaceous arc on the amalgamated basement.

We present results of a comprehensive study of the geology of the islands of the Leeward Antilles, Aruba, Curacao, and Bonaire, Gran Roque and La Blanquilla. Our analysis is based on new detailed mapping, stratigraphic and structural analysis, and geochronology on all three islands, and is integrated with previously published data. In addition we have carried out detrital zircon geochronology on Paleocene/Eocene turbidites located on the Leeward Antilles as well as mainland Venezuela and Margarita Island. Overall our results indicate subduction initiation beneath the southern CLIP no earlier than ca 90 Ma, inconsistent with the single great arc model. We further show that the islands have marked differences in geologic evolution that strongly limit possible tectonic scenarios. Paleocene/Eocene turbidites have a mixed provenance that implies a Colombian continental margin and island arc source. Detrital zircon ages record the initiation of the arc at ca 90 Ma, cessation of arc magmatism at ca 64 Ma due to collision with the Colombian/Ecuadorian margin and renewed magmatic activity following collision at ca 60 Ma.

Thermal and tectonic history of the Leeward Antilles: Aruba and Bonaire

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The Leeward Antilles, including the islands of Aruba and Bonaire, represent the emergent portions of the Bonaire Block which have undergone tectonic interactions with the Caribbean and South American plates since the time of their formation. We present $^{40}Ar/^{39}Ar$, U/Pb, apatite fission track and apatite (U-Th)/He data which record the tectonic history of Aruba and Bonaire since ~90 Ma. Our new data show that tonalitic plutonism on Aruba lasted from ~89 to ~82 Ma. Vertical structural displacements resulted in >80°C of rapid cooling on Aruba between 70 and 60 Ma, at rates of >5 °C/Ma. On Bonaire, major exhumation phases occur at 85 – 80 Ma and at 60 – 40 Ma. Santonian exhumation on Bonaire follows low temperature metamorphism and may be related to early interaction with the Caribbean Plate. We attribute Maastrichtian – Danian exhumation on Aruba and late Palaeocene – early Eocene exhumation on Bonaire to sequential diachronous accretion of the basement blocks of these islands to the South American Margin, followed by the onset of oblique underthrusting of the Caribbean Plate beneath the South American Plate. Widespread unconformities indicate surface exposure between ~40 and ~30 Ma. Subsequently, late Oligocene – early Miocene dextral transtensional rifting within the Bonaire block (Gorney et al., 2007) resulted in subsidence and burial of the Aruba and Bonaire basement to a maximum depth of ~2 km. Late Miocene – recent transpressional tectonics drove rift inversion, resulting in a maximum of ~2 km of exhumation. Combining our data with data obtained from other studies shows that K/Ar and Rb/Sr systems on Aruba and Bonaire have been disturbed to varying degrees by thermal resetting and chemical alteration. Caution must be exercised when interpreting radiometric data obtained from these islands using these techniques.

Gorney, D. et al. (2007), Chronology of Cenozoic tectonic events in western Venezuela and the Leeward Antilles based on integration of offshore seismic reflection data and on-land geology, AAPG Bulletin, **91**(5), 653

New geochemical and geochronological data from the Santa Marta batholith, Colombia, and its relationship to Caribbean tectonics

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The Santa Marta batholith and its related rocks are composed of an extensive and very complete series of intrusive rocks, traditionally considered of Paleogene age (Tshanz et al., 1974), but whose link with Caribbean tectonics have not been yet considered.

New field data allowed us to identify complex magmatic activity, represented by five magmatic facies, mafic enclaves, mafic cumulates and two mica garnet bearing granites. This diversity indicates a complex magmatic history with assimilation, mixing and recirculation of materials from the deepest parts of the magmatic chamber.

Geochemical analyses show a mainly metaluminous, I-type magmatic suite. In a broader sense the whole suite from cumulates to granites have the same trace element trends where the magmatic arc signature is clear. Nevertheless there are clear differences between components remarking the complex magmatic history.

The crystallization age of the main magmatic pulse ranges from 58 to 50 Ma (LA-ICP-MS, U/Pb on zircon). Nevertheless, a more felsic, peraluminous magmatic pulse at 65 to 63 Ma is also identified. Hornblende and biotite Ar/Ar cooling ages range between 47-46 Ma and 47-42 Ma, respectively. Those different ages define cooling paths with a relatively fast cooling rate of 56-60 ^{o}C/My. In general terms, the generation mechanism for this magmatism can be related to the interaction between the South American and Caribbean plates in the onset of a new subduction zone context during Paleocene-Eocene.

Tshanz et al., 1974. GSA Bulletin, **85**, 273-284.

Late Cretaceous-Tertiary tectonic evolution of Western Colombia

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Any attempt to decipher the time of accretion of the oceanic terranes (which crop out in the Western Cordillera and the Interandean depression of Colombia) onto the palaeocontinental margin (exposed in the Central Cordillera) must take into account 1) thermochronological data in the indenting oceanic rocks and buttressing continental rocks, 2) characterization of syn- and post-accretionary sedimentary rocks within the accreted terranes and the continental margin in the peripheral and retro-foreland basins, and 3) geochronological information from arc-related batholiths, which intrude both the allochtonous and autochtonous terranes, thus pre- and post-dating terrane accretion.

We have addressed all of these points by using several geochronological (U/Pb LA-ICPMS) and thermochronological (multiphase $^{40}Ar/^{39}Ar$, zircon and apatite fission track, zircon and apatite U-Th/He) methods in order to constrain the timing of the accretion of the large Caribbean Colombian Oceanic Plateau (CCOP) in Western Colombia. Our data suggest that allochtonous terranes were accreted to the palaeocontinental margin at some point between 80 and 75 Ma. The accretion of equivalent, oceanic plateau rocks in Ecuador (south of Colombia) has been tightly constrained at 75 Ma (Spikings et al., 2009), suggesting that accretion may have been diachronous along the Northern Andes. An older accretion age towards the north may simply reflect the palaeogeographic shape of the CCOP.

Spikings R., Crowhurst P., Winkler W., & Villagomez D. 2009. Syn- and post accretionary cooling history of the Ecuadorian Andes constrained by their in-situ and detrital thermochronometric record. Tectonophysics (submitted).

Pb-Pb systematics on sulfides from Andean Colombian gold deposits

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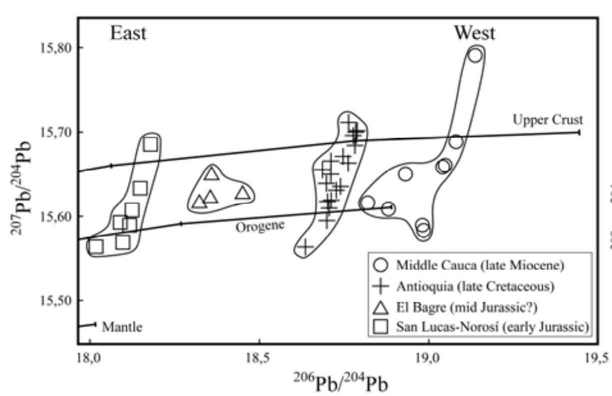
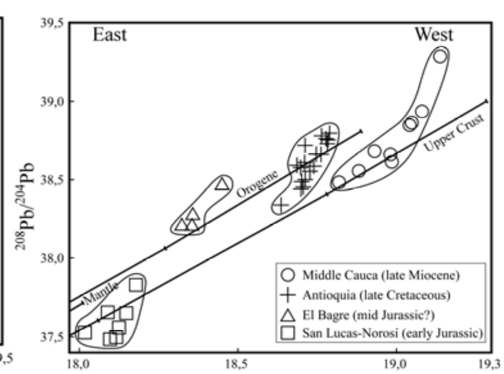
Pb-Pb analyses were performed on sulfides from temporally/metallogenetically distinct gold districts across the Colombian Andes, including the San Lucas-Norosi (early Jurassic), El Bagre (mid Jurassic), Antioquia (late Cretaceous), and Middle Cauca (late Miocene) metallotects. Each metallotect is broadly spatially/temporally associated with calc-alkaline magmatic arc development and separated by crustal-scale fault/sutures resulting from prolonged and punctuated accretion along the northern Andean margin. Data reveal clustered arrangements with narrow ranges for $^{206}Pb/^{204}Pb$ on both uranogenic and thorogenic diagrams. The overall Pb isotopic composition of the sulfides is radiogenic ($^{207}Pb/^{204}Pb>15.55$). Results indicate strong spatial-temporal data clustering, from less radiogenic values in older deposits in the east to more radiogenic values in younger deposits to the west, with no overlap between the data sets. Given the distinct lithological, magmatic and metallogenetic evolution of each metallotect, the generally steep data clusters indicate variable but internally consistent mixing of distinct Pb sources including less radiogenic (depleted upper?) mantle+/-mantle-derived magmas (lower $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ values) with variable proportions of more radiogenic Pb sources (higher $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ values), potentially including continental crust and pelagic sediments (and their metamorphic equivalents?). The diminishing influence of continental crust, and increasing influence of pelagic sediments is apparent in the E-to-W trend, with the eastern-most San Lucas-Norosi metallotect being constructed within Precambrian meta-granitoid crust (high Th/Pb ratio indicative of lower crustal influence) whilst the western-most Middle Cauca metallotect was emplaced into an accreted mélange of Paleozoic and Mesozoic rocks of oceanic affinity with no underlying continental basement. The E-to-W temporal-spatial migration of data clusters suggests gold deposit Pb isotopic evolution is intimately related to the lithologic and tectono-magmatic evolution of the hosting metallotect.





Migration of the Great Caribbean Arc relative to the Americas, Part 1: Plate kinematics derived from arc-continent interaction

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The oceanic interior of the Caribbean Plate is a piece of pre-mid Cretaceous Pacific lithosphere that was engulfed between the Americas since the Early Cretaceous as they drifted west from Africa. Northerly and southerly continuations of this lithosphere that did not fit between the American continents were subducted beneath Mexico and the northern Andes; thus the geometric insertion between the Americas was perfect. Mainly intra-oceanic island arcs were built upon the edges of this lithosphere during Caribbean-American motion history. Portions of the arc system were accreted to various segments of the American margins as dictated by the evolving plate boundary geometry, thus terminating subduction and progressively forming the circum-Caribbean suture belt. An eastward-younging diachroneity of Caribbean-American interaction is recorded by (1) the conversion of passive margins to arc-continent collision zones, (2) the periods of subduction-related arc magmatism at the Caribbean arcs, and (3) the cessation of subduction at the various segments of the circum-Caribbean suture zone, among other things. Part 1 of this paper examines the history of Caribbean-American interactions from Ecuador and Mexico to Tiburón Rise, showing the timing and sequence of events in the autochthons of the northern Andes, southern Maya Block, the Bahamas, Venezuela/Trinidad, and the Atlantic plain. The onset of interaction clearly youngs eastward from the mid-Cretaceous through to the Present. Contractile Caribbean-American interaction was already underway prior to the formation of most of the Caribbean basalt plateau (LIP), suggesting that the onset of west-dipping subduction of Proto-Caribbean (inter-American) lithosphere beneath the Caribbean Plate pre-dated most plateau extrusion. Further, analyses of rocks from the circum-Caribbean arcs and suture zones (Part 2 of this paper) show that W-dipping subduction was underway by the Aptian (125-112 Ma). This first-order supposition places significant constraints on the mode of emplacement of Caribbean plateau basalts, most samples of which do not show a supra-subduction signature. Possible mechanisms for explaining this conundrum are entertained, and other important tectonic aspects for the Early Cretaceous are identified, but we acknowledge that, in the absence of a quantitative Pacific-American kinematic framework for that time, a comprehensive model for the Early Cretaceous remains elusive.

The Caribbean Seaway: Plate tectonics and palaeoceanography of the Mesozoic Tethys – Proto-Caribbean connection.

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The breakup of Pangea has been a major concern since the early days of plate tectonics. The opening history of the Central Atlantic is now very well constrained, and serves as a “ruler” to resolve the complex puzzle of microplates preserved in Circum-Caribbean terranes into a model of opening and closing of successive ocean basins, separated by micro-continents and/or intra-oceanic arc systems. Remnants of Mesozoic Proto-Caribbean ocean crust, today preserved in subduction complexes, are scarce and their interpretation is controversial. The Proto-Caribbean geodynamic history is at least as complicated as Mesozoic Tethyan one, but there is far less field data available.

The evidence of very similar fossils on the Tethyan and the W-American side of Pangea suggests an at least intermittent normal marine pathway at low latitudes through Pangea at least since the Pliensbachian. However, this evidence does not imply the existence of a trans-pangean oceanic current system in the early-middle Jurassic.

At present, the hypothesis of a Late Juarssic – Early Cretaceous circum-global, equatorial current system flowing through the Tethayn –Atlantic – Caribbean Seaway seems to be largely accepted and used to explain global climate changes during this time. Several groups have done modelling using a General Ocean Model. However, the plate tectonic reconstructions used in these models are very generalized, as for instance, the oceans are assumed to be of infinite depth from shoreline to shoreline. This is clearly a false assumption, since it ignores the existence of vast epicontinental shallow seas, especially in Europe and North America. These shallow seas allow for the dispersal of most fossil groups, but are obstacles to major oceanic, unidirectional current systems.

The sedimentary record of Tethys, the Central Atlantic and the few localities considered to represent the Proto-Caribbean speak against such a current system: Middle to Late Jurassic basinal sediments are predominantly radiolarian cherts in Tethys and the W-Pacific, while sections recovered from the Central Atlantic, the Gulf of Mexico and the Proto-Caribbean lack radiolarian cherts but contain pelagic carbonates or claystones (beneath the CCD). The occurrences of Middle to Late Jurassic ribbon radiolarian cherts on the leading edge of the Caribbean Plate are interpreted by us to have formed along the E-Pacific margin, before the existence of the Caribbean Plate, and for some even before the formation of Proto-Caribbean ocean crust.
An E-W directed global current system would account for the higher fertility radiolarian cherts on both extremes, but is in contradiction with the low fertility (nannofossil limestone) facies in the Central Atlantic.

By latest Jurassic times, the Western Tethys changed from radiolarite sedimentation to calcareous low-fertility facies sedimentation like the Atlantic, while in the Circum-Pacific realm radiolarite sedimentation continued. It is only by Campanian times that we can observe a global homogenisation of facies. In conclusion, realistic modelling of a hypothetical circum-global equatorial current system during the Jurassic-Early Cretaceous needs to be based on refined plate tectonic models, especially in terms of bathymetry.

Mesozoic to Eocene plate tectonics of the Circum Pacific area: New constraints of far travel exotic terranes, subduction zone mélanges and arc-arc collisions in Central America.

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A new tectonic synthesis of the plate tectonic evolution of the Circum Pacific area since the Pangea breakup (230 Ma, Late Triassic) has been elaborated based on data derived from different geological and geodynamic constraints. Besides our own geological researches in Central America, the distribution, composition and age of the Circum Pacific HP/LT mélanges and belts, magmatic activity, sedimentary patterns, metamorphism, structural geology, paleomagnetic data and geophysics have been systematically compiled.

Reconstructions were performed using ArcGis 9.2, which enabled us to apply and quantify rotational motions and spreading/subduction rates to the numerous plates and tectonic blocks involved in the evolution of the Circum Pacific area. Boundary conditions are provided by the relative motions of the different plates with respect to fix Europe. Plate tectonic concepts are applied all along the process and plate boundaries are built and transformed in space and time. Plate velocities can be calculated at any time and are never in excess of 20cm/y.

This new model allows a more comprehensive analysis of the development of the Circum Pacific realm in space and time. In particular, the relationship between diachronous island arc-active margin and island arc-passive margin collisions, subduction zones evolution, and back-arc spreading and closure.

Paleomagnetic Study of Cretaceous arc terranes in Central Hispaniola: Paleogeographic implications

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A paleomagnetic study was conducted on Lower and Upper Cretaceous arc volcanic and volcaniclastic rocks of Hispaniola to test Caribbean plate evolution models and provide paleogeographic constraints for the Greater Antillean region. For the lower part (Albian age) Upper Cretaceous Tireo Group, four sites yield a positive fold test and give a mean direction of Dec = 320.7°, Inc = 19.1°, k = 98.3, α_{95} = 9.3°, a paleolatitude of 9.8° +5.3°/ -4.9°. Comparison of the observed Tireo Group paleomagnetic pole with the North American reference pole indicates anticlockwise vertical axis rotation of ~23°, and northward transport of ~11° (± ~9°), with respect to the North American plate. Two sites from the Lower Cretaceous Los Ranchos Formation significantly differ from the Tireo Group results, although the lack of sufficient sites for the Los Ranchos precludes the calculation of a mean direction. However, shallow inclinations and westerly declinations suggest near equatorial placement and additional anticlockwise vertical-axis rotation. The results are in agreement with the position of Hispaniola indicated by recent reconstructions. Comparison with results of a study by Tait et al. (2009) from central Cuba, indicate a more southerly position for Hispaniola, which is also suggested by the reconstructions. Clockwise rotation is also less than for Cuba, but it is not clear when this rotation occurred.

Tait, J., Rojas-Agramonte, Y., García-Delgado, D., Kröner, A. and Pérez-Aragón, R. 2009. Tectonophysics, in press.

Constraints from paleomagnetism to the Late Jurassic-Early Cretaceous tectonic evolution of Mexico

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We present a summary of paleomagnetic data from Mexican terranes, with an emphasis on results relevant to Caribbean and Gulf of Mexico tectonic models. Previously published paleomagnetic data for the Chiapas massif support counterclockwise rotation of the Maya Block during opening of the Gulf of Mexico. But the amount of rotation reported (~70º) is far greater than that inferred on plate kinematic models. New results for the Lower Jurassic Todos Santos Formation, which overlies the massif are consistent with ~35º of counterclockwise rotation of the Maya Block, and the stratigraphy of Todos Santos supports reconstruction of the massif in the present region of the Burgos basin. Previously published paleomagnetic data suggest that by latest Jurassic time the Maya Block had arrived to its present position. Rotation of the Maya block is linked to dextral slip along the Tamaulipas-Chiapas transform, and opening of the Late Jurassic Cuicateco basin between Paleozoic terranes in southern Mexico and the Maya block. Opening of the Gulf of Mexico is also linked to southwestward migration of arc magmatism, forearc extension, deposition of massive volcanogenic sulfide deposits in central Mexico, and eventual opening of the Arperos backarc basin between the oceanic Guerrero arc terrane and North America. Lower Cretaceous primitive island arc volcanic rocks and associated pelagic sediments of the Las Pilas Volcanic complex in Zacatecas, central Mexico, were deposited at near equatorial paleolatitude (4º+/-5º N), requiring a width of ~2,000 km for the Arperos basin. The opening gap between South and North America was partly occupied by the Arperos basin. Recently published paleomagnetic data suggest that rocks of the central Cuban volcanic arc were deposited at similarly low latitudes as the Guerrero arc, suggesting a genetic link between the Greater Antilles and Guerrero, but not the Alisitos arc of Baja California.

Towards a tectonic evolution of Jamaica in a plate tectonic framework

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Jamaica currently lies on the northern margin of the Caribbean Plate and has a continuous geological record that extends back at least to the earliest Cretaceous. Any model for the evolution of the Caribbean must be able to explain the geological and tectonic history of Jamaica, yet Jamaica has never been fully integrated into existing models. Extensive new data on the geology of Jamaica has been collected over the last 13 years. This has included: (1) regional mapping of Cretaceous and early Paleogene sequences across Jamaica to determine geological successions, identify major unconformities and distinguish different terranes; (2) biostratigraphic, chemostratigraphic and radiometric studies to correlate stratigraphic successions with the chronostratigraphy; and (3) major element, minor element and isotopic geochemistry to understand the evolution and tectonic setting of the various volcanic suites found in Jamaica. Three terranes (western Jamaica, SE Blue Mountains and NE Blue Mountains) are now recognized and can be integrated with current models for the evolution of the Caribbean Plate. Two regional unconformities are developed in the Western Jamaican Terrane: one near the Campanian/Maastrichtian boundary where a shallow water mixed clastic-volcaniclastic-carbonate succession was deposited on an uplifted and deformed early-late Cretaceous arc succession; and one in the Paleocene-Early Eocene, where a late Early to early Middle Eocene shallow- to deep-water succession of limestones and clastics was deposited on a deeply folded and eroded Early Cretaceous to Paleocene succession.

The first unconformity records: (i) the collision of the leading edge of the Caribbean Plate with North America; (ii) the accretion of the Western Jamaica Terrane to the North American Plate; (iii) the initiation of NE-SW arc-transform faults allowing the northwards escape of the eastern part of the Great Arc and the progressive assembly of Jamaican Terranes; and (iv) the initiation of northwards facing subduction of Jurassic oceanic crust (that existed between the Jamaican arc and the Caribbean Large Igneous Province or CLIP) beneath Jamaica.

The second unconformity records: (i) the collision of the CLIP with the new Jamaican arc; (ii) the underplating of the arc by the CLIP; (iii) the initiation of relative eastwards motion of the Caribbean Plate; and (iv) strike-slip capture of North American terranes (including Western Jamaica and Chortis) by the Caribbean Plate. The arc-transform faults and a relative eastward creep of the accreted Western Jamaica Terranes, coupled with slab roll-back, allowed episodic extension in eastern Jamaica forming a series of grabens. Extension led to decompressional partial melting of the asthenosphere (basalts) that caused partial melting of the underplated CLIP (dacites) leading to the eruption of adakite-like lavas in the early Eocene.

Subsequent to the full onset of eastwards motion of the Caribbean Plate, and the capture of the Jamaica terranes by the Caribbean Plate, Jamaica's geological history is straightforward and has been adequately dealt with elsewhere. The new datasets, therefore, demonstrate that Jamaica arose as a series of terranes with different Cretaceous geological histories that were amalgamated in the latest Cretaceous to early Paleogene.

Migration of the Great Caribbean Arc relative to the Americas, Part 2: History of subduction and collision along the arc

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Modern techniques of petrology, geochronology and structural geology allow subduction and collision histories to be reconstructed from the rocks exhumed in fossil zones of plate interaction. Our knowledge of such histories along the bow of the Great Caribbean Arc (GCA) is becoming increasingly more precise, allowing important constraints for GCA migration relative to the Americas to be formulated. Collision of the GCA with North America has conserved and exhumed profiles throughout exposed GCA in the Greater Antilles. The most straightforward case histories can be reconstructed for segments of the GCA with extended intra-oceanic histories before interaction with North America. In the serpentinite mélanges of Hispaniola and Eastern Cuba (Krebs *et al*., 2008; Lázaro *et al*., 2009) detailed study of the P-T-t paths of rocks entrained in the fossil subduction-zone channels and numerical forward modeling indicate a continuous, uninterrupted history of intra-oceanic subduction beginning prior to 120 Ma with subduction of hot, young lithosphere and lasting to at least 55 Ma. This history is in complete accord with the volcanic sections exposed in Hispaniola and also Puerto Rico further to the east, for which persistent island-arc volcanism and southwest-dipping subduction has been documented between 120 to 45 Ma (*e.g.*, Jolly *et al*., 2008). In Central Cuba to the west, the volcanic products of the GCA are dated at ~ 130 - 73 Ma, and exhumation of eclogites began shortly after 70 Ma (Stanek & Maresch, this conference). However, between 85 and 70 Ma the GCA interacted with a spur of thinned continental crust or a thick sedimentary prism extending SE from southern Yucatán (*Caribeana* of García-Casco *et al*., 2008; Stanek & Maresch, this conference). In addition, it is conceivable that some of the material older than 120 Ma may in fact have been inherited from east-dipping subduction in the Pacific realm (*e.g.*, Pindell & Kennan, 2009).

In the southern Caribbean, transpressive dextral Caribbean/South American interaction has transported fragments of the GCA passively to the east since the Late Cretaceous and complicated relationships between the GCA and South America via a strong and penetrative shear overprint. Nevertheless, well-defined P-T-t paths for the rock sequences of northern Venezuela show that collision of an actively subducting GCA with South America was in progress by 105-95 Ma (*e.g.*, Maresch *et al*., 2009). These and other constraints from GCA-related rocks around the Caribbean (Pindell *et al*., 2005) strongly argue for the existence of a west-dipping GCA subduction zone overriding proto-Caribbean/Atlantic lithosphere by 120 Ma and continuing to the present day without interruption.

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The development of the northern Caribbean Arc: geochronological constraints from island-arc related rock suites in Central Cuba

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After separation of the North and South American continental plates in the Late Jurassic, an oceanic island arc was formed by subduction along the paleo-Pacific/Atlantic plate margin. During the Late Cretaceous and Early Tertiary (75-40 Ma), this Caribbean Arc (CA) first interacted with southeastern Yucatán by oblique subduction, and subsequently was thrust onto the southern edge of the Bahamas platform. In this latter event, the subduction-related rocks of the CA were deformed and exhumed. They now form the present backbone of Cuba.

We present for the first time an integrated set of geological, geochemical and geochronological data on the island-arc-related rocks of Central Cuba. U/Pb data on zircon and titanite of the igneous rocks indicate a continuous magmatic history of the CA from the Early Cretaceous (about 130 Ma) up to the Late Cretaceous at about 75 Ma. As in Puerto Rico and Hispaniola, the igneous rocks of the CA in Central Cuba can be divided into a bimodal suite consisting of a tholeiitic and calc-alkaline to alkaline series. Geochemical data verify an increasing maturity with time from the tholeiitic to the alkaline and calc-alkaline series of the main magmatic axis of the CA. The tholeiitic rocks yield ages from 130 to about 110 Ma, whereas the alkaline intrusions followed at 107 Ma, and calk-alkaline magmatism continued until about 80 Ma. In the eastern part of Central Cuba, a tholeiitic igneous series interpreted to be of fore-arc origin is coeval with the calc-alkaline series. In the Late Campanian the island arc was eroded and covered by platform-type sediments. At this time (74-73 Ma), small stocks of biotite granite intruded the uplifted arc. We suggest that the origin of these granites is related to collisional crustal thickening. Geochemical data showing the influence of continent derived material on the melting process and the occurrence of Proterozoic to Archean detrital zircons in the granites support this interpretation. At the same time, continental margin sequences southeast of the Yucatán platform were involved in the subduction zone, as indicated by the HP-metamorphic event overprinting the metabasic and metasedimentary rocks of the Escambray Complex of western Central Cuba). The 70 Ma Lu-Hf age data on eclogites mark the beginning of exhumation and cooling of these metamorphic rocks, as also constrained by low-temperature dating methods.

Two main conclusions can be deduced from the data set: there is no indication for a polarity switch of subduction in the Cretaceous Caribbean Arc after its birth in the Early Cretaceous. The end of subduction-related magmatism in the Campanian took place during the collision of this segment of the CA with southern Yucátan. Based on the data from Central Cuba, the oblique interaction of the oceanic Caribbean Arc with the southwestern North American continental plate lasted from about 85 to 70 Ma. In the Maastrichtian and Paleogene, the dismembered arc units were displaced towards the southern Bahamas margin, and the related magmatic axis shifted -- after a time interval of about 15 Ma -- to the southern margin of the Yucatán Basin.

Late Cretaceous continental subduction at the Caribbean-North American plate boundary

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Late Cretaceous collision of the southernmost portion of the North American plate with an undetermined block is well recorded in supracrustal rocks. This record can be straightforwardly linked with the metamorphic evolution of high-pressure belts of the Guatemala Suture Complex. Campanian deepening of the continental platform at southernmost North America was contemporaneous with subduction and eclogite-facies metamorphism of the plate's Mesoproterozoic–Jurassic sialic basement (Chuacús Complex). Cpx-Grt-Phg thermobarometry of gneiss-hosted eclogites indicates near ultra-high-pressure conditions at ~700–800 °C and ~2.1–2.4 GPa, implying continental subduction to >60 km depth. SHRIMP-RG dating of eclogite metamorphic zircon yielded a 75.5 ± 2 Ma age. Chondrite-normalized rare earth element patterns of zircon lack Eu anomalies and show depletions in heavy rare earths, consistent with a plagioclase-free, garnet-rich, eclogite-facies assemblage during zircon formation. Therefore, the Campanian age represents the timing of continental subduction, as confirmed by a 76 ± 16 Ma Sm/Nd mineral isochron of an eclogite band contained in orthogneiss. Which Caribbean block collided with the Maya Block is disputed, but clues regarding the colliding terrane are given by the Maya Block's ubiquitous Upper Cretaceous flysch, which contains 75 ± 1 Ma volcanic cobbles ($^{40}Ar/^{39}Ar$ on plagioclase). Whole-rock trace element concentrations show that the cobbles were derived from a mature arc, suggesting that the hanging wall block was not the continental Chortís, in which no Late Cretaceous magmatism has been established, but the Greater Antilles Arc, which is known to have been active then. Coeval arc volcanism in the Greater Antilles and continental subduction of southernmost North America can be explained in terms of an oblique collision that asynchronously closed the intervening ocean from west to east (zipper tectonics) as the Greater Antilles migrated eastward toward the Bahamas platform.

A new look at the Nicaraguan Rise, Cayman Ridge and Cayman Trough: Implications for stratigraphic/structural relations and tectonic/magmatic evolution

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We have integrated seismic reflection and refraction, marine and aero-magnetic, gravity and satellite remote sensing data with stratigraphic studies of wells and cores and geochemical/geochronological studies of igneous rocks from wells and dredge hauls to constrain the offshore boundaries of tectonic terranes over the Nicaraguan Rise (NR) and their projections onto adjacent land areas in Central America, Mexico and Belize. We recognize a Jurassic-Cretaceous rift fabric that trends ENE from onshore E. Honduras along the NR as defined by the 200 m isobath in Honduran waters. These rifts were partially-inverted in late Cretaceous and then reactivated in the Paleocene and E. Eocene as non-marine extensional basins that were inverted again in the M. Eocene. Continental crust may underlie the NR where an earlier Mesozoic rift fabric can be inferred by the presence of U. Jurassic (?) to L. Cretaceous syn-rift clastics overlain by a L. Cretaceous carbonate platform. Igneous intrusions and extrusive flows are intercalated with Cretaceous and Eocene strata penetrated by numerous wells along the NR eastward to Jamaica and southward into Nicaraguan waters. The location and nature of the transition from continental to arc crust along the NR is not known. Nd-Sr and Pb isotope ratios of arc-related calc-alkaline granitoids and volcanic rocks from the W. part of the Cayman Ridge indicate that these rocks were intruded into continental crust. This confirms that crustal rocks of the W. Cayman Ridge are the rifted eastern extension of the continental Maya block of Belize, Mexico and Guatemala, as has been suggested previously. The compositions of the W. Cayman granitoids differ significantly from those of the Sierra Maestra, forming the easternmost part of the Cayman Ridge, and from other granitoids in the Greater Antilles and the NR, including Jamaica. The W. Cayman granitoid magmatism (66-62 Ma) is slightly older than that of the Sierra Maestra (60-47 Ma) but overlaps in age the Above Rocks in Jamaica, the Terre Neuve in Haiti, and plutons of the NR and N. Honduras. These data indicate the probability of three different, partly coeval, subduction-related magma systems in the NW Caribbean over the area of the NR during the interval 66 to 47 Ma. Northward (oblique?) subduction of the Siuna terrane along the Honduras-Nicaragua border and northern NR is suggested for the granitoid magmatism onshore N. Honduras and offshore along the NR. Our studies place new constraints on models for the tectonic/magmatic evolution of the area.

Geological and Petrological Evolution of Dominica, Lesser Antilles

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The Cenozoic geology of Dominica can be divided into 4 time-stratigraphic units. Miocene rocks, which are all subaerial, are only exposed along the east coast. After a possible period of quiescence two stratovolcanoes, Morne Diablotins and Cochrane-Mahaut, were formed during the Pliocene. The stratigraphy of both can be divided into an older submarine sequence and an overlying sequence of subaerial lava flows interbedded with pyroclastic deposits. Cutting through the deposits from the Cochrane-Mahaut center is a large area of subsidence termed the Central Graben. During the latest Pliocene and earliest Pleistocene three centers were active, Morne aux Diables and Morne Diablotins in the north and Foundland in the south. Around 1 Ma the major focus of volcanic activity switched from the north to the south, with the development of six major volcanoes, Morne Trois Pitons, Wotten Waven, Watt Mountain, Grande Soufriere Hills, Morne Anglais, and Morne Plat Pays. Activity also continued in a reduced manner at the two northern centers. Within the last 100 ka, 3 periods of Plinian-style activity, from Morne Diablotins and the calderas of Morne trios Pitons and Wotten Waven, produced extensive pumiceous deposits, each of which is estimated to have produced tens of km^3 of pyroclastic material. In the southwestern part of the island, Morne Plat Pays volcano is characterized by alternations between periods of growth and periods of destruction produced by flank collapse. Recent eruptive activity appears to be confined to the centers within the sector collapse scar of Morne Plat Pays and with the Wotten Waven caldera.

Dominica contains a number of unique geological features not found on the other islands of the Lesser Antilles: (1) Geothermal activity occurs throughout the island; (2) There are possibly 8 potentially active volcanoes, while one is the norm on the other islands; (3) It is the only island with a large central graben structure; (4) At least two calderas that have been active within the last 100 ka; (5) Pumiceous eruptions have occurred from essentially every center on the island and many of these have been of relatively large volume; (6) For the past 2 million years the compositions of erupted products on Dominica show considerable overlap, in contrast to centers on other islands, which can be readily distinguished on the basis of their chemistry.

Cenozoic volcanic rocks on Dominica range from basalts to dacites and are usually porphyritic (phenocrysts of plagioclase, augite and hypersthene). The Pliocene and older deposits tend to show the complete range from basalts to dacites. In contrast, the younger sequences are dominantly andesites and dacites often of much more restricted composition making it difficult to distinguish geochemically between the different centers. Sr, Nd, and Pb isotopic values from all rock types and all time-stratigraphic units show very restricted ranges, which makes the volcanic products from Dominica more similar to those from the Northern Antilles rather than those from the nearby islands of Martinique and St. Lucia. Spatial and temporal variations within and among individual centers will be presented and discussed in terms of a model for the evolution of Dominica where the island is underlain by a large lower crustal magma chamber, which has periodically fed the upper crustal magma chambers under the individual volcanic centers.

Overview of results from the BOLIVAR-GEODINOS geologic-geophysical study of the Caribbean-South America arc-continent collision

Paul Mann and BOLIVAR-GEODINOS working group
University of Texas at Austin, and collaborating institutions

The BOLIVAR-GEODINOS study of northern South America investigated tectonic and continental growth processes using a wide array of methods including earthquake seismicity, geochemistry, active and passive seismic experiments, structural geology, and studies of on- and offshore basins. The study involved about 60 academic and petroleum geoscientists at institutions in the USA and Venezuela, surveyed a partially submerged plate boundary zone that extends from western Venezuela to Trinidad and as far north as the Venezuelan basin, and lasted over a period of 7 years. Funding for the project was jointly provided by the USA and Venezuela. This talk will focus on project-related results completed by researchers and graduate students at the University of Texas but will also attempt to integrate our UT results with the project results of other members of the working group. Topics to be illustrated with the acquired data sets will include: 1) distribution of continental, arc, and oceanic crust; 2) GPS-based plate and microplate motions; 3) tectonic origin of arc-related basins along the Caribbean arc; 4) diachronous deformation of Caribbean arc-related features within the Caribbean arc-South America collision zone; 5) diachronous formation of foreland type basins on continental crust; 6) diachronous, subduction polarity reversal as a consequence of Caribbean-South America collision; 7) formation of strike-slip zones and basins above previously formed collisional features; and 8) plate evolution and tectonic controls through time.

Subsidence and tectonic inversion in the north and west of the Colombian basin

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The tectonic evolution of the Colombian Basin is related with the interaction of the Caribbean, Cocos, Nazca and South American Plates[1] and specially the microplate of Panama, the North American Plate and the Andean Orogeny[1,2,3,4,5,6,7,8,9]. It has been proposed that the Colombian Basin has been controlled by the active margin of the Caribbean plate, located to the east, west and south[1,3,4,5,9,10,11,12,13]. We have performed a tectonic subsidence analysis using seismic and well data, together with the seismic interpretation, and we have reconstructed the history of tectonic subsidence, the tectonic environment and two tectonic inversions in the northwest of the Colombian Basin, since the Upper Cretaceous to Present.

The west zone of the Colombian Basin, presented cortical thinning with normal faulting, during the late stages of a rift in Upper Cretaceous. In this period, the subsidence was controlled by a passive in margin environment and isostatic processes. During the Eocene, the tectonic subsidence increased, due to a post rift cooling of the lithosphere and was generated a tectonic inversion of the late extensional structures, in the north of the basin. During the late Oligocene-Miocene, the tectonic subsidence decreased abruptly with a possible period of erosion, generating a "forearc" basin. The mechanism of subsidence was of flexural type. From the Pliocene to present, the basin presented a period of uplift and erosion, and a second tectonic inversion that affected Oligocene-Miocene extension structures. The events of tectonic inversion are possibly related with the interaction of the Caribbean Plate, the microplate of Panama, South American Plate and the Andean Orogeny.

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Hydrocarbon generation of northern Colombia basins – a petroleum systems modelling approach

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The Guajira Basin is located in the northern part of Colombia, partially onshore and offshore into the Caribbean Sea. Results of more than 50 years of exploration in the Guajira Basin show it as a typical biogenic gas province. The integration of recent geochemical and geological data from the deep offshore area supports the interpretation for several petroleum systems, involving thermogenic generation of hydrocarbons.

The stratigraphic record includes Jurassic and Cretaceous units with both petroleum source and reservoir rock potential. The Tertiary interval, Eocene to Upper Miocene, accounts for the majority of the stratigraphic section in the basin, and the main reservoir intervals recognized are Oligocene carbonates and siliciclastics, Lower Miocene calcareous sandstones and Upper Miocene turbiditic sandstones.

Hydrocarbon occurrences in wells and gas production from fields, along with the interpretation of geophysical, geological and geochemical information, have resulted in the recognition of four petroleum systems in this basin:

1. Macarao – Siamana P.S. (.) Eocene-Oligocene in the northeastern part of the basin.
2. Tertiary – Jimol/Uitpa P.S. (.) Lower Miocene reservoirs producing in the gas fields.
3. Castilletes-Castilletes P.S. (?) reservoir potential in Upper Miocene deep water clastic environments.
4. Mesozoic-Cretaceous P.S. (?) reservoirs as fractured Cretaceous limestones, with analogy from Venezuelan Mara-La Paz fields.

Sequence stratigraphy interpretation from the onshore and platform areas towards the deep offshore areas provides the input for modelling the petroleum systems in the Guajira Offshore frontier Basin. The modeling and simulation presented explain the concurrence of thermogenic and biogenic processes, and constitute a framework for several exploration opportunities identified in this Colombian area.

Neotectonics of the Gulf of Mexico Margins

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The Gulf of Mexico North, Western and Southern margins are characterized by spectacular gravity sliding processes favoured by Triassic salt and mud diapirism. A regional study of deep penetration seismic and borehole data provided by TOTAL and PEMEX provide an unique opportunity to investigate recent to active tectonic process down to top of the crust that could have induced general collapse around this basin.

The early Mesozoic attenuated crust of the Jurassic rifting offshore Texas was significantly reactivated during the Cainozoic, up to present time. This neotectonic extension is marked by anomalously high heat flow associated extremely thinned crust and with listric faults flattening down to the Moho such as the Corsair Fault.

Along the "Texas Lineament", the Cainozoic Rio Bravo Fault connected to this reactivated rift have absorbed close to 40 km of motion.

Southwards along the West Gulf of Mexico margin trantensile and transpressive dextral motion is clearly recorded from the US Mexico border into the north to the Veracruz basin into the south. This dextral motion affects the sediments above and below the main décollement related to active gravity sliding of the Mexican Ridges, but also the upper crust. It could be interpreted as the Neocene tectonic reactivation of the Early Mesozoic East Mexican Shear Zone that have absorbed the CCW rotation of Yucatan during the early Mesozoic. 2D MCS and 3D seismic mega bloc of PEMEX constrain the geometry of this recent wrenching. Gravity modelling indicates this shear zone is located along a narrow band of attenuated crust.

The active NW SE trending Veracruz sinistral fault zone, parallel to the Rio Bravo Fault, has an offset of 40 km since the late Middle Miocene. Both faults are interpreted as reactivated Mesozoic trans-Mexican shear zones.

Offshore Yucatan, the southern conjugated passive margin of the Gulf of Mexico is exposed in Tabasco and along the northern flank of the Chiapas orogenic belt active since 12 Ma. PEMEX onshore seismic reveal general collapse of this former passive margin towards the northwest, probably related to active dextral transpressive motion of the Chiapas Belt. The Jurassic tilted blocks are presently tectonically remobilized long time after their primitive 45° CCW rotation of Yucatan during opening of the Gulf of Mexico.

This large set of data indicates the attenuated crust of the passive or transform margins of the Early Mesozoic Gulf of Mexico can be viewed as relatively weak trough time and is significantly reactivated tectonically since the mid Cainozoic.

We question this recent tectonics affects also the eastern margin of the Gulf along the Florida escarpment and the western Bahamas margin offshore Cuba? How this mechanism of tectonic reactivation could be integrated to the complex neo-tectonics of the Caribbean?

Most of this work developed by our College de France Scientific group during the last 6 years was recently published in a suite of articles in a thematic issue of the Bulletin de la Société Géologique de France 2008, t. 179, n°2.

POSTER PRESENTATIONS

Igneous petrology and petrogenesis of the island of La Désirade, Guadeloupe, F.W.I.

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The island of La Désirade hosts the only rocks of Jurassic age in the Lesser Antilles Island Arc. Palaeofaunal studies on radiolarian cherts are corroborated by U-Pb CA-TIMS work from a sub-adjacent trondhjemite intrusion giving an age of ~144 Ma (Tithonian) (Mattinson et al., 2008).

This study focuses on the field and petrological aspects of the island. Five distinct geological units were identified from fieldwork, including a 'Basalt Complex' with basaltic pillows and flows, radiolarian chert, hyaloclastite and dykes of intermediate composition; a 'Rhyolite Complex', with rhyolite flows and breccia; a 'Trondhjemite Intrusive Complex' with mafic dykes and rhyolite flows; and an 'Andesite/Dacite Dyke Complex' with associated breccia. XRD and thin section analyses allow us to propose a west-east progression of decreasing metamorphic grade (prehnite-pumpellyite to zeolite facies) which is suggested to be a manifestation of a contact-metamorphic aureole around the trondhjemite intrusion, emplaced shortly after the basalt.

The presence of boninitic rocks and the arc-like primitive chemistry (presented by Neill, Kerr & Gibbs *this volume*) does suggest that Désirade could have resulted from the initiation of an island arc during the late Jurassic or perhaps, a back-arc setting. Palaeogeographic reconstructions of the Caribbean region suggest that east-dipping subduction was active at this time along the western margin of the proto-Caribbean and Colombia-Equador seaways. Our data are among the first to confirm the presence of such an arc.

Mattinson, J.M. et al., 2008. GSA Special Paper, **483**, 175-190.

Structure of the accretionary prism, and the evolution of the Paleogene northern Caribbean subduction zone in the region of Camagüey, Cuba

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The deformation history of sedimentary units incorporated in the North Cuban fold- and thrust-belt in the Paleocene to middle-late Eocene was associated with major shortening between the Caribbean and North American plates. This led to the formation of an intensely deformed tectonic pile comprising from top to bottom of a volcanic arc nappe, a deformed mafic-ultramafic complex with Mesozoic ophiolite components and a serpentinitic melange with blocks of sedimentary (the Placetas Belt) and metamorphic rocks; and the structurally lower unit composed by folded and thrusted sediments of the southern promontory of the Bahamas platform. In this paper we study the deformation history of sedimentary units incorporated in the North Cuban fold- and thrust-belt associated with this shortening history. We find that the occurrences of the Placetas sedimentary rocks within the foliated serpentinite mélange show varying styles and intensity of deformation, and varying number of deformation phases. They form isolated blocks within the serpentinite mélange and do not represent a coherent nappe underlying the allochtonous mafic-ultramafic complex. The deformation of the Remedios belt, part of the Bahamas platform, underwent a single phase of folding and thrusting, with shortening perpendicular to the plate contact. This folding occurred in the middle to late Eocene and marks the arrest of subduction and arc-continent collision. We find no evidence for a component of strike-slip during collision. The volcanic arc is thrusted upon the mafic-ultramafic complex, and the original forearc ophiolite appears to be shortened. This shortening may attest to a period of subduction erosion. Thrusting of the volcanic arc led to deposition of the Paleocene-lower Eocene Taguasco olistostrome which may date this event. We show that careful analysis of the complexely deformed Cuban fold and thrust belt may allow identification of subduction erosion and subduction accretion episodes. Expanding the analysis carried out in this paper to the scale of the northern Caribbean fold and thrust belt may provide a new and independent geological tool to constrain the geodynamic processes associated with subduction and arc-continent collision along the northern Caribbean margin.

Age and petrogenesis of the Aves Ridge: interaction of island arc and oceanic plateau components in the Caribbean Sea

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The Aves Ridge is a linear topographic anomaly on the Caribbean Sea floor between the Venezuelan basin which is floored by ~92-88 Ma oceanic plateau rocks[1] and the Grenada Basin which is a mid-Tertiary back-arc to the currently active Lesser Antilles[2]. Dredging in 1969 on the far south of the ridge retrieved two sets of granitic rocks and one with some basaltic material, but only limited geochemical analysis was carried out. Several samples were dated by K-Ar methods, producing a range of late Cretaceous to early Tertiary ages[3]. The current consensus from numerous other studies is that Aves represents a sunken remnant island arc but there are no indications as to the age of the entire ridge, its geochemistry and the nature of the basement.

We have been able to re-sample the remaining rocks from Lamont Doherty Earth Observatory. Analysis was by major and trace element geochemistry by ICP-OES and MS methods at Cardiff. All samples were weathered on the seafloor, although protected from severe alteration by the formation of manganese rinds. Furthermore, pervasive hydrothermal alteration has taken place, so samples are only considered for their immobile element characteristics. Zircons were extracted from a single large granitic sample and were sent to St. Petersburg for SHRIMP analysis with results due.

The “basalts” have LREE-enriched patterns with La/Yb_{CN} clustering at 2.2 and 4.9 and Th-Co plots show that both tholeiitic and calc-alkaline rocks are present. Relative to N-MORB they tend to be slightly enriched, but are strongly depleted in Nb-Ta, Zr-Hf and Ti with a strong positive Eu anomaly. They plot within the tramlines on a Fitton diagram indicating that they have more in common with a mantle plume source than N-MORB. The granitic samples are homogeneous with an average La/Yb_{CN} ~4.4 (calc-alkaline). The REE patterns are slightly concave-up with depletion in the middle REE. N-MORB trace element diagrams show a strong depletion in Nb-Ta, Sm and Ti, with enrichment in Zr-Hf and no Eu anomaly. There are dissimilarities in shape between the REE and trace element diagrams for the basalts and the granites, which suggest that they may have slightly different source regions, but all appear to be concurrent with a subduction-related plume-like mantle source.

Funding has been obtained for radiogenic isotope analysis which will allow us to further explore the nature of the source region of this part of the Aves Ridge. However the current data indicate that these rocks most likely formed by west-dipping subduction underneath the oceanic plateau. Correlative units are present or appear to be present on Aruba[4], the US Virgin Islands and Jamaica[A.R. Hastie, this volume, unpublished data]. The Ridge was thus likely a part of a wider Caribbean arc system which became extinct following the opening of the Grenada Basin and the initiation of the Lesser Antilles arc.

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A metallogenic map of the Caribbean Basin

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The metallic mineral endowment of the Caribbean Basin (Central America and the Greater Antilles) totals 98 million ounces (Moz) gold, 1089 Moz silver, 27.7 million tonnes (Mt) copper, and 8.4 Mt lead plus zinc (past production plus known resources). Precious metal production comes from epithermal quartz vein and stockwork deposits (e.g. the Talavera, Bonanza, and Orosi deposits in Nicaragua and the Marlin deposit in Guatemala) and from shallow submarine, volcanogenic massive sulphide deposits (e.g. the Pueblo Viejo district in the Dominican Republic). Base metal production comes from skarn and replacement deposits (e.g. Mochito, Honduras) and from traditional volcanogenic massive sulphide deposits (e.g. Cerro de Maimon, Dominican Republic). Most of the region's copper endowment is hosted by two large undeveloped porphyry districts (Cerro Colorado and Petaquilla, Panama). In addition, weathering and erosion have led to the formation of alluvial gold, lateritic nickel, and bauxite (aluminium) deposits. A metallogenic map of the region has been prepared that locates over 2200 mineral occurrences on a mosaic of country-scale geologic maps. The deposits are colored according to deposit type and sized according to total contained metal. The map provides a useful tool for capturing at a glance the metallic mineral endowment of the region and may be helpful to explorationists who are looking for emerging districts and/or the relationship between mineral deposits and particular rock types. The distribution and genesis of these deposits, some of which are dated quite accurately, also reflects on the tectono-magmatic evolution of the Caribbean Basin.

Tectonic evolution of the Gulf of Mexico, Caribbean and northern South America in the mantle reference frame: an update

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We present an updated synthesis of the "single-arc Pacific-origin" and "Yucatán-rotation" models for Caribbean and Gulf of Mexico evolution, respectively, in 14 palaeogeographic maps. Caribbean lithosphere has moved little relative to the hot spots in the Cenozoic, but moved north at c. 50 km/Ma during the Cretaceous, while the American plates have drifted west farther and faster and are responsible for most Caribbean–American migration history. New/revised features of this model include: (1) refined reconstruction of western Pangaea; (2) refined rotation of Yucatán Block during Gulf of Mexico evolution; (3) an origin for the Caribbean Arc that invokes Aptian conversion to a SW-subduction zone of a trans-American plate boundary from Chortís to Ecuador that was part sinistral transform (northern Caribbean) and part pre-existing arc (eastern, southern Caribbean); (4) acknowledgement that the Caribbean basalt plateau may pertain to the palaeo-Galapagos hot spot, the occurrence of which was partly controlled by a Proto-Caribbean slab gap beneath the Caribbean Plate; (5) Campanian initiation of subduction at Panama–Costa Rica Arc, although a sinistral transform boundary probably pre-dated subduction here; (6) inception of a north vergent crustal inversion zone along northern South America to account for Cenozoic convergence between the Americas ahead of the Caribbean Plate; (7) a fan-like, asymmetric rift model for Grenada Basin, where Margarita and Tobago footwall crustal slivers were exhumed from beneath the SE Aves Ridge hanging wall; (8) an origin for the Early Cretaceous HP/LT metamorphism in the El Tambor units along the Motagua Fault Zone that relates to subduction of Farallon crust along western Mexico rather than to collision of Chortis with S Mexico; (9) Mid-Miocene tectonic escape of Panamanian crustal slivers, followed by Late Miocene-Recent eastward movement of the "Panama Block" that is faster than that of the Caribbean Plate, allowed by inception of E–W trans-Costa Rica shears. The updated model can be used to test and guide more local research across the Gulf of Mexico, the Caribbean, and northern South America. Using examples from the regional evolution, the processes of slab break off and flat slab subduction are assessed in relation to plate interactions in the hot spot reference frame.

Thermochronology and tectonics of the Ecuadorian Andes: When did the Caribbean Plateau collide with NW South America?

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The determination of accurate and precise ages for the timing of collision between oceanic plateaus and continental crust requires an understanding of how the indenting and buttressing plates respond to the collision. We present geochronological (zircon U/Pb SHRIMP), thermochronological ($^{40}Ar/^{39}Ar$, apatite fission-track and (U-Th)/He), palaeomagnetic, geochemical and isotopic analyses of magmatic rocks from the Ecuadorian Andes and external forearc, which constrain the timing of collision of the late Cretaceous Caribbean plateau and Great Arc sequence with NW South America to within ±1 Ma.

The in-situ and detrital thermochronological records show that rapid exhumation (>1km/my) of the Campanian buttressing margin (Eastern Cordillera and Amotape Complex) south of S1°30', at 73-55 Ma occurred as an immediate response to the collision and accretion of the CCOP at 75-73 Ma. Structural fragmentation of the indenting plate and rapid clockwise rotations of ≤70° at 73-70 Ma strongly support an initial collision event during the late Campanian. Elevated exhumation rates did not commence north of S1°30' until 65 Ma within the temperature sensitivity realm of the analytical methods, indicating that collision may have been diachronous, and young to the north. Subduction related magmatism beneath the approaching edge of the Caribbean Plateau in northern Ecuador terminated at 65-64 Ma, corroborating a younger accretion age towards the north. The proximal indenting margin (now exposed in the Western Cordillera) did not exhume in response to the collision event, corroborating its burial beneath the Palaeocene Silante Arc, which developed within ~5 Ma of accretion. This contrasts with late Campanian exhumation recorded in the Western Cordillera of Colombia and within the Bonaire Block of the present-day southern Caribbean Plate.

Zircon U/Pb and $^{40}Ar/^{39}Ar$ geochronology, combined with palaeomagnetic data suggest that all late Cretaceous indenting mafic basement blocks within western Ecuador have a common tectonic and palaeogeographic origin, and formed part of a single plate, which fragmented during collision with the NW South American Plate, contrasting with previous models that suggest varied palaeogeographic origins for the mafic, crystalline basement.

Geochemistry and petrogenesis of Campanian-Maastrichtian Caribbean oceanic plateau lavas in central Hispaniola

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Basalts of the Pelona-Pico Duarte Fm (PPDF) offer an opportunity to study an on-land section of the Late Cretaceous Caribbean Oceanic Plateau (COP) in Central Hispaniola. Geochemical, Sr-Nd isotope, and ^{40}Ar-^{39}Ar radiometric age data combined with detailed mapping have shown that the PPDF is composed of a massive and homogeneous >2.5 km thick pile of basaltic submarine flows, mostly aphyric and vesicular, frequently banded and rarely porphyritic. Lava flows are locally interlayered by mafic tuffs and intruded by synvolcanic dykes and sills of basalts and dolerite. Whole rock and hornblende ^{40}Ar-^{39}Ar plateau ages of 68.40±0.75 Ma and 79.4±1.0 Ma obtained in a basaltic flow and a mafic dyke, respectively, indicates both extrusive and intrusive magmatic activity at least during the middle Campanian to lower Maastrichtian.

For a restricted range of SiO_2 (46.2-50.2 wt.%), basalts of the PPDF have relatively low CaO (10.0-13.1 wt.%) and Al_2O_3 (12.8-14.3 wt.%) contents, and high contents in alkalis (2.0-2.6 wt.%), TiO_2 (1.5-3.6 wt.%), and Fe_2O_{3T} (10.7-13.1 wt.%). These basalts are transitional and alkalic (Nb/Y>0.5) and show a typical tholeiitic trend of increasing TiO_2, Fe_2O_{3T}, CaO, Al_2O_3, Zr and Nb, for decreasing MgO (Cr or Ni). These trends can be attributed to the fractionation of olivine plus Cr-spinel, clinopyroxene (Ti-augite) and plagioclase, observed as microphenocrysts in the lavas. The basalts have LREE enriched ($[La/Nd]_N$=1.5-2.2) and depleted HREE ($[Sm/Yb]_N$=2.0-3.7) patterns, with very high Nb contents (9-30 ppm). These patterns are characteristic of alkalic oceanic-island basalts. In terms of Sr-Nd isotopic composition, the PPDF samples are homogeneous and enriched relative to other COP units in Hispaniola, with $(^{87}Sr/^{86}Sr)_i$ ratios between 0.70330 and 0.70348 at restricted range of $(\varepsilon_{Nd})_i$ values between +5.0 and +5.9 (i=68 Ma). The PPDB are interpreted as partial melts of a plume-related, deep enriched source, which have not been contaminated by active subduction. The elevated TiO_2 and Zr_{15} contents, combined with high $[La/Nd]_N$ and $[Sm/Yb]_N$ ratios, are consistent with a primitive mantle source consisting of spinel lherzolite with 25-35% amounts of garnet lherzolite. Mantle melt modelling indicates that this source underwent about 6-15% melting to form PPDF magmas. Alternatively, these magmas can also be explained by mixing processes in the melt column, and result by mixing of very small degree melts (<2%) of a deeper garnet lherzolite region and 15-25% melting of a shallower source region.

Together, the data indicate that the basalts of the PPDF have geochemical affinities with the mantle domain influenced by the Late Cretaceous Caribbean plume. However, this magmatism is younger than the main phase of the COP (91-88 Ma), but coeval with basalts of the Siete Cabezas, Sabana Grande/ Maricao (SW Puerto Rico) and upper Dumisseau (SW Haiti) Fms, and several dolerites recovered at the Beata Ridge, all attributed to the COP and located in its northern edge.