19th Caribbean Geological Conference - Guadeloupe 2011 - Abstracts booklet 19ème Conférence Géologique de la Caraïbe - Guadeloupe 2011

Auran Randrianasolo, Yves Mazabraud

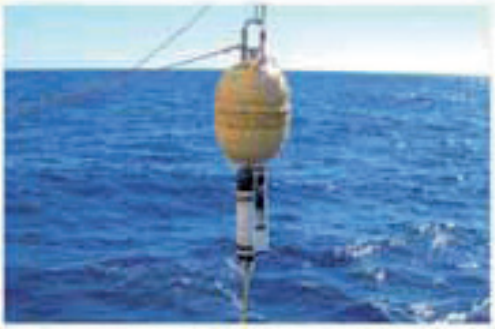
Université des Antilles et de la Guyane

IUFM Guadeloupe

19TH CARIBBEAN GEOLOGICAL CONFERENCE 2011

Le Gosier - Guadeloupe - French West Indies





MARCH - 21st - 24th - 2011

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TABLE DES MATIERES

BIENVENUE - WELCOME - BIENVENIDOS - WELKOM

LE MOT DE BIENVENUE DU PRÉSIDENT D'HONNEUR

Tout le monde le reconnaît, la géologie est une science majeure dans la compréhension non seulement de l'histoire de notre planète, mais aussi des enjeux actuels et futurs de notre région: la Caraïbe. De la sismologie, à la pétrographie, en passant par la volcanologie, la géologie irrigue de nombreuses autres disciplines. Ensemble, elles nous permettent de comprendre, les phénomènes complexes qui régissent la vie de la Terre et l'environnement dans lequel nous évoluons.

L'UAG, consciente des enjeux contemporains a fait de cette thématique un élément clé de sa recherche : la modélisation, la gestion et la réduction des impacts des risques naturels, sont au centre de ses problématiques de recherche. Les manifestations géologiques récentes de la Caraïbe ont démontré la puissance de leurs impacts et leurs conséquences économiques, politiques et sociétales. Les Etats doivent donc être en mesure d'anticiper ces évolutions à venir. C'est la raison pour laquelle nous considérons avec un grand intérêt la tenue à l'UAG de cette 19ème conférence géologique de la Caraïbe. C'est pour nous un honneur et un privilège de recevoir l'ensemble de celles et ceux qui au sein de leurs laboratoires travaillent et contribuent à une meilleure connaissance de la géologie de notre planète et de notre région. Lors de la dernière conférence qui s'est tenue dans les Antilles françaises, notre université n'existait pas. C'est donc avec un immense bonheur,en tant que Président de l'Université des Antilles et de la Guyane, mais aussi en tant que géographe que je lance les travaux de cette 19ème conférence.

Bon travail à tous!

Pascal SAFFACHE
Président de l'Université des Antilles et de la Guyane
Président d'honneur de la 19ème Conférence Géologique de la Caraïbe

LE MOT DE BIENVENUE DU COORDINATEUR GÉNÉRAL

C'est avec un grand honneur que nous accueillons les participants de la 19ème édition de la Conférence Géologique de la Caraïbe. Evènement important pour notre équipe de recherche, si récente par rapport à l'historique de la conférence, la plus ancienne de toutes les conférences de géologie actives à ce jour !

Nous tenons à remercier le comité permanent, ainsi que les organisateurs de la précédente conférence, en 2008 à Santo Dominguo, de nous avoir accordé l'organisation de cette édition. Afin de donner une continuité et une identité visuelle à la conférence, nous avons utilisé une base commune pour le logo avec la 18ème CGC. Nous remercions les précédents organisateurs pour nous avoir autorisé à le faire. Nous remercions aussi tous les sponsors et partenaires qui ont souhaité soutenir la venue en Guadeloupe de la conférence. C'est la deuxième fois qu'elle se tient aux Antilles françaises, la précédente étant en 1974.

Dans le contexte qui est le notre, soumis aux aléas naturels (sismique, tsunamique, volcanique, cyclonique…), avec des ressources naturelles si précieuses mais si fragiles, nous avons voulu cet évènement ouvert à la société civile, à travers deux cycles de conférences grand public. L'une, en partenariat avec l'exercice d'alerte tsunami Caribe Wave 2011, l'autre sur la Géologie de la plaque caraïbe et la médiatisation des Sciences de la Terre aux Antilles.

Au cours des quelques jours que dure la conférence, nous espérons que chacun aura l'opportunité de confronter ses idées originales et le résultat de ses recherches avec d'éminents collègues. Puissent les discussions être riches et profitables à tous, pour le plus grand bénéfice de la Science, au service des hommes. Nous espérons que la conférence sera aussi l'occasion de créer ou de renforcer les liens entre les différents acteurs des Géosciences du Domaine Caraïbe.

Yves MAZABRAUD
Maître de Conférence à l'Université des Antilles et de la Guyane
Coordonnateur Général de la 19ème Conférence Géologique de la Caraïbe

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REMERCIEMENTS

Ce programme a été co-financé par le FCR, le FSE, le MOM et nos partenaires qui sont le DEAL, le BRGM, l'IPGP/OVSG, L'ACADÉMIE DE LA GUADELOUPE, l'IUFM, l'Université Pinar del Rio (Cuba) et le Seismic Research Centre (UWI)

En plus des entreprises, organismes et Collectivités territoriales dont les logos sont sur les pages de couverture, nous tenons à remercier:

Tous les Collègues qui ont participé à l'organisation des excursions post conférence;

Mmes Vanessa Weck, Michelle Léticée-Compper et Sylvie Bercion qui nous ont aidé dans notre recherche de financement;

Mme Patricia Galbas, Valerie D'Agruma, Mlles Fabienne Zami, Lyvane De Min, MM. Didier Marchisio, Frédéric Dondin, Bernard Dudon, Adoum-Ammy Mahamat qui sont venus étoffer le comité d'organisation;

Messieurs le Doyen Meril, le Président Arconte, le Vice-Président Eustase Janky ainsi que le Lycée des métiers de l'hôtellerie et du tourisme «Archipel Guadeloupe» qui ont apporté leur soutien à l'organisation.

PROGRAMME DES SESSIONS

MONDAY - MARCH 21ST

Amphi Merault - Univ. Antilles Guyane - Fouillole	
15:00	**Opening ceremony**

TUESDAY - MARCH 22ND

MARACUJA ROOM			GOYAVE ROOM		
		Session : Cenozoic Carbonate Systems			**Session : Hydrogeology, Water Ressources Monitoring**
8:00	C. Sherman	. 1 Geomorphology and sediment dynamics in mesophotic coral ecosystems of the upper insular slope of southwest Puerto Rico	8:00	A. Dumon	. 14 Identification of infiltration and run-off areas with the River's network Persistence and Development Index (IDPR): applications in Basse-Terre Island and in Martinique.
8:20	E. Lasseur	. 2 Stratigraphy, sedimentology and Pliocene-Pleistocene evolution of the South-eastern part of the Dominican Republic. Tectonics, eustasy and climate controls.	8:20	B. Vittecoq	. 15 New elements toward hydrogeological schemes of Martinique aquifers
8:40	S.F. Mitchell	. 3 Stratigraphy of the White Limestone of Jamaica.	8:40	L. Arnaud	. 16 Prospections hydrogéologiques en milieu volcanique. Etude de cas : Cœur Bouliki, commune de Saint-Joseph, Martinique.
9:00	T.A. Stemann	. 4 Ecology and zonation of coral build-ups in the Late Miocene August Town Formation, Jamaica.	9:00	A. Dumon	. 17 Diphasic hydrodynamic modeling of the Grande-Terre groundwater flows (Guadeloupe)
					Session : Geothermy
9:20	S. A. James-Williamson	. 5 TECTONO-STRATIGRAPHIC DEVELOPMENT OF SOUTHEASTERN JAMAICA	9:20	V. Bouchot	. 18 The High-Temperature Geothermal System of Bouillante (Guadeloupe, French West Indies)

9:40	A. Lenoble	. 6 Pleistocene Infilling of Guadeloupean Caves	9:40	S. Lopez	. 19 Modeling of Bouillante geothermal field (Guadeloupe, French Lesser Antilles)
		Coffee break			**Coffee break**
10:30	J.J. Cornée	. 7 Sedimentology and paleoenvironments of the Pliocene-Pleistocene carbonate platform of Grande - Terre (Guadeloupe, Lesser Antilles forearc).	10:30	L. Gailler	. 20 Contribution of multi-methods geophysics to improve the regional knowledge of Bouillante geothermal Province (Guadeloupe)
10:50	P. Munch	. 8 Tectonostratigraphy of the Pliocene-Pleistocene carbonate platforms of the Guadeloupe Archipelago, Lesser Antilles fore-arc.	10:50	G.A. Ryan	. 21 The use of Magnetotelluric and Time domain electromagnetic methods in the geothermal survey of Montserrat, W.I.
11:10	P.J.N. Weber	. 9 $^{87}Sr/^{86}Sr$-ratios, foraminifera and sedimentology of the Late Miocene – Pliocene cyclic carbonates of La Désirade (Guadeloupe, France)	11:10	B. Sanjuan	. 22 Comparison of the fluid geochemical signatures between the hydrothermal systems of Bouillante and Soufrière (Guadeloupe, French West Indies)
11:30	L. de Min	. 10 Pliocene-Pleistocene fore-arc vertical motion recorded at Karukera Spur, (Lesser Antilles)	11:30	P. Calcagno	. 23 A 3D Structural Model to Merge Onshore and Offshore Geological Knowledge in the Bouillante Geothermal Province (French West Indies)
11:50	J.F. Lebrun	. 11 Architecture of Offshore Carbonate Plateform (Guadeloupe Archipelago - Lesser Antilles Forearc)	11:50	C. Dixit	. 24 On site experiments about silica deposition and kinetics data during the cooling of the Bouillante geothermal fluids (Guadeloupe, French West Indies)
		Lunch			**Lunch**
		Session : Geosciences education and Geodiversity			**Session : Applied Geology**
13:30	P-M Sarant	. 28 Séismes vécus : 2 films court-métrages relatent des expériences croisées sur les Saintes (2005) et L'Aquila (2009)	13:30	N. Harvey	. 39 Sequence Stratigraphic and Geodynamic Interactions in the North Cuba Basin: a Multidisciplinary Approach
13:50	J.C Audru	. 29 Actions towards seismic risk mitigation in Martinique, French Antilles.	13:50	C.J. Schenk	. 40 Estimates of Undiscovered Conventional Oil and Gas Resources of the Barbados Accretionary Prism
14:10	J.L. Berenguer	. 30 Tuned in to the Earth from the classroom with 'Sismos à l'Ecole' the french educational seismological network	14:10	J-F Thimus	. 41 Projet pilote de cartographie géotechnique de la zone de Frères à Port-au-Prince
14:30	Y. Mazabraud	. 31 Teaching Geology in the French West Indies. From scientific results to pupil's conceptions.	14:30	E. Vanoudheusden	. 42 Seismic microzonations of municipalities in French West Indies

14:50	T. Forissier	. 32 Les représentations d'élèves de Guadeloupe sur la géothermie. Relation entre connaissances scientifique et opinions.	14:50	K. Guerrier	. 43 Comportement mécanique et rhéologie du sol de la formation géologique « Morne Delmas » en Haïti.
15:10	S. A. James-Williamson	. 33 The changing role of the uwi geology museum: from repository to an interactive learning environment.	15:10	P. Nehlig	. 44 3D resistivity mapping of volcanic islands
15:30	P. Lecomte	. 34 Patrimoine Géologique de la Guyane : une démarche d'inventaire et de valorisation en cours de réalisation	15:30	L. Ducreux	. 45 Evolution et dynamique du trait de côte de l'archipel de la Guadeloupe de 1956 à 2004
15:50	L. Legendre	. 35 Géodiversité, inventaire et protection en Caraïbe : le cas de la Guadeloupe, département français d'Amérique.	15:50	H. Martinez	. 46 Public Policy in Groundwater: Far from the Rhetoric, Closer to the Reality
16:30 to 18:30		**Coffee break and Poster session**	16:30 to 18:30		**Coffee break and Poster session**
	A. V. Barras	. 36 Inventory of the geological heritage of France's Overseas Departments: the Guadeloupe and Martinique example		C. Copol	. 25 Études mathématiques et numériques pour la modélisation des systèmes hydrothermaux. Applications à la géothermie
	R . Tarkowski	. 38 The accumulation of Quaternary anthozoa (*Scleractinia*) in St-Félix (Guadeloupe, Grande-Terre) – proposal of protection		P. Patrier	. 26 Occurrence of epithermal breccias in the Bouillante geothermal field (Basse Terre – Guadeloupe) - Part 1
	G. Louisy-Louis	. 37 Le risque sismique en Guadeloupe : conceptions d'élèves.		C. Vérati	. 27 First Ar-Ar dating of the high temperature epithermal breccias in the Bouillante geothermal field (Guadeloupe, French West Indies) – Part 2
	A. Queffelec	. 13 Thermic system of Guadeloupe caves : consequences on sedimentation and wall preservation		E. Lopera	. 47 Map of Mineral Resources in the Dominican Republic
	C. Baumgartner-Mora	. 12 Late Miocene-Early Pliocene Larger Foraminifera of La Désirade (Guadeloupe, France)		R . Tarkowski	. 49 Carbon Capture and Storage – example from Poland
		Session : General Geology (Poster Only)		H. Martinez	. 48 Mitigación de Potencial Conflicto entre Departamentos Colombianos por los Planes Departamentales de Aguas: Lejos de la Retórica, Más Cerca de la Realidad.
	L. J. Chizmadia	. 54 Reproducing phyllosilicate textures found in the fine-grained matrices of the CM2 carbonaceous chondrites.		S. J. Muñoz Tapia	. 50 Dessarrollo de los estudios geotematicos y el Servicio Geologico Nacional en Republica Dominicana

S. A. Lebrón-Rivera	. 56 Understanding temperature and pH conditions during aqueous alteration of the CM2 carbonaceous chondrites	J. Rodriguez-Reyes	. 51 Atlas por provincias del potencial geologico-minero de la Republica Dominicana
A. Ould Hamou	. 57 Minéralisations uranifères liées aux dépôts greseux du Dévonien Inférieur du Bassin de Tin Seririne OUA N'AHAGGAR, HOGGAR, ALGERIE.	Marie Gisèle P.A. Pierre	. 52 Etat des connaissances sur le Lac Azuei ou Etang Saumâtre (Haïti). Importance écologique de cette ressource hydrique.
F. Dabbaghisadr	. 55 Biostratigraphy and Lithostratigraphy of the Middle and Late Jurassic Rocks West of Binalud Range Northwest of Neyshabour, Northeast of Iran	(Wolfield Tingué)	. 53 Mineralogical and geotechnical characterization of dredged sediments from the canal Bois-de-Chêne (Port-au-Prince, Haiti).

WENESDAY MARCH 23RD

MARACUJA ROOM			GOYAVE ROOM		
Time		**Petro-geochemistry and History of the Caribbean**	Time		**Volcanology and Volcanic Risks**
8:00	M. Villeneuve	. 58 The Caribbean domain by the late Palaeozoic time.	8:00	G. Boudon	. 80 On the explosivity of lava domes
8:20	S. Brouwer	. 59 Is the Beata Ridge the cause of the bending of the structures in Central Hispaniola? (The Hispaniola Swing)	8:20	J-C Komorowski	. 81 Scenario definition, hazards assessment and risk mitigation for the next eruption of La Soufrière of Guadeloupe: contributions from the CASAVA Projectt
8:40	G. Chicangana	. 60 La Sierra Nevada de Santa Marta y la Serranía de Perijá, Colombia y Venezuela: ¿Son resultado de la convergencia entre la placa Caribe y el margen suramericano durante el Neógeno Superior?	8:40	H. Balcone-Boissard	. 82 Halogen behaviours during andesitic magma degassing: from magma chamber to volcanic plume
9:00	S. Radford	. 61 The Ocean Drilling Program around the Caribbean Sea	9:00	G. Boudon	. 83 Effects of large flank collapse events on the magma production and evolution of volcanoes: Examples from the Lesser Antilles Arc
9:20	G. Andjic	. 62 Late Cretaceous pelagic and arc-derived sedimentation in the S-Nicoya Peninsula, Costa Rica	9:20	M-L Bernard	. 84 Remote and in situ plume measurements of acid gas release from La Soufrière Volcano, Guadeloupe
9:40	P.O. Baumgartner	. 63 Early Jurassic alkaline basalts in the Santa Rosa Accretionary Complex (Santa Elena, Costa Rica): Petit spot volcanism within an old pacific plate	9:40	P. Allard	. 85 Géochimie isotopique de l'hélium dans les eaux et gaz de la Guadeloupe : interations entre fluides magmatiques et eaux souterraines
		Coffee break			**Coffee break**
					Seismic risks and Tsunamis
10:30	P.O. Baumgartner	. 64 Mesozoic Ribbon Radiolarites of the Caribbean Plate: Remnants of Pacific Ocean Floor.	10:30	J-R Altidor	. 92 Efforts pour établir une surveillance sismique et géodésique en Haïti.

10:50	J.M. Lardeaux	. 65 Discovery of Lower Cretaceous syn-metamorphic thrust tectonics in French Lesser Antilles (La Désirade Island, Guadeloupe): Implications for Caribbean geodynamics	10:50	J-B de Chabalier	. 93 ECAR Observatories : a collaborative program for monitoring and science
11:10	C. Vérati	. 66 New radiometric ages for the basement of La Desirade Island (Guadeloupe, Lesser Antilles)	11:10	M-P Bouin	. 94 Source parameters of the Mw 7.4 Martinique earthquake (windward islands) of November 29, 2007 deduced from near-field strong motion data inversion
11:30	I. Corral	. 67 New constraints on the tectonostratigraphy, geochemistry and radiometric ages of the Panamanian Cretaceous – Paleogene volcanic arc.	11:30	S. Drouet	. 95 Evidence of stress drop magnitude scaling and stochastic ground-motion model from accelerometric data recorded in the French West Indies
11:50	K. Glaccum	. 68 Paleomagnetic Study of Cretaceous Arc Terranes in Central Hispaniola: Paleogeographic Implications	11:50	M. Belvaux	. 96 Regional and local seismic hazard mapping for seismic risk mitigation of Santiago de los Caballeros (Dominican Republic)
12:10	R. N. Abbott	. 69 Thermotectonic history of metamorphic rocks in the Blue Mountain inlier, Jamaica.	12:10	F. de Martin	. 97 Blind inversions of shear-wave velocity and damping factors at a borehole station in Belle-Plaine, Gosier, Guadeloupe
		Lunch			**Lunch**
		Petro-geochemistry and History of the Caribbean			**Seismic risks and Tsunamis**
14:00	J. F. Lewis	. 70 Cr-spinel composition and platinum-group minerals from placer deposits associated with ultramafic-mafic intrusives in the Loma de Cabrera batholith, Dominican Republic: Comparison with ophiolites and Alaskan-type complexes: a preliminary report	14:00	M. Bengoubou-Valerius	. 98 Bootstrap Determination of b-values: An assessment of Statistical Estimators with Synthetic ETAS Sequences of Magnitudes
14:20	Rojas-Agramonte	. 71 Early Cretaceous arc formation and crustal inheritance in central Cuba: geochemistry and age of the Los Pasos Formation	14:20	L. Valmy	. 99 Etude comparative de modèles stochastiques pour l'activité sismique
14:40	R. N. Abbott	. 72 Fragments of a mantle plume in northern Dominican Republic : Garnet-ultramafic rocks in the Rio San Juan complex.	14:40	F. de Martin	. 100 From Geology to Realistic Large-Scale Spectral-Element Earthquake Simulations in the Pointe-à-Pitre Region
15:00	T. N. Ufret	. 73 Petrologic and Geochemical study of Culebra's Eastern Cays: Cayo Norte and Culebrita, Puerto Rico	15:00	J-L Léticée	. 101 Tsunami deposits and liquefaction structures in the plio-pleistocene sedimentary deposits of Guadeloupe Grande-Terre, FWI

15:20	F. Longo	. 74 Co mineralization in the Falcondo's laterite deposits, Dominican Rep. (preliminary results)		15:20	N. Zahibo	. 102 Tsunami Hazard for the French West Indies, Lesser Antilles
15:40	Laó-Dávila D. A.	. 75 Paleogene thrust emplacement of serpentinite in southwestern Puerto Rico		15:40	F. Dondin	. 103 Tsunami source generated by a sector collapse episode at Kick'em Jenny volcano: waves propagation and risk assessment
16:00	J.L. Cobiella-Reguera	. 76 Cretaceous/Paleogene boundary deposits and paleogeography of western and central Cuba at the time of the Chicxulub asteroid impact event.		16:00	E. Pelinovsky	. 104 Rogue Waves in the Ocean as a Part of Marine Natural Hazards
From 16:20 to 18:30		**Coffee break and Poster session**		From 16:20 to 18:30		**Coffee break and Poster session**
	J. Escuder-Viruete	. 78 Tectonothermal evolution of the high-P Samaná metamorphic complex: record of intraoceanic subduction and continental collision in the northern Caribbean convergen margin			G. Lalubie	. 86 Volcanic hydro-geomorphology and the rediscovery of an ancestral (Carib, Kalinago) problematic in the Lesser Antilles : the case of the Montagne Pelée
	(J. Escuder-Viruete	. 77 Intraoceanic subduction and arc-continent collision in northern Caribbean: insights from the large-scale structure of the Río San Juan metamorphic complex.			A.Finizola	. 87 Etude des circulations hydrothermales associées aux principaux axes de faiblesse recoupant le dôme de la Soufrière de Guadeloupe, par couplage de méthodes de tomographie de résistivité électrique, polarisation spontanée, thermique et gaz du sol.
	IGME-BRGM-INYPSA	. 79 Geothematic mapping in the Dominican Republic			Y. Legendre	. 88 A high-resolution reconstruction of the recent eruptive past of La Soufrière de Guadeloupe over the last 12 000 years.
					O. Coutant	. 89 Geophysical Imaging of La Soufriere Volcano
					A. Samper	. 90 Timing of flank collapse events in the Lesser Antilles arc
					A. Samper	. 91 K/Ar dating and DEM-based reconstruction of southern Basse-Terre volcanoes (Guadeloupe, FWI): contribution to the Lesser Antilles arc construction rates

ROOM MARACUJA	
From	**CARIBE WAVE 2011, Public conference**

18:00		
	Narcisse Zahibo (UAG)	Qu'est-ce qu'un tsunami ? Historique des tsunamis dans les Petites Antilles.
	Jean-Marc Mompelat (BRGM)	Modélisation des impacts, des risques : état des lieux et perspectives.
	Marie Paule Bouin (OVSG-IPGP)	Le système d'alerte aux tsunamis dans la Caraïbe : où en est-on ?
	Eric Jouret (SIDPC, Préfecture de Guadeloupe)	Etat des lieux et perspectives de la réponse de sécurité civile.

THURSDAY MARCH 24TH

MARACUJA ROOM		
Time		**Active Geodynamics**
8:00	Pulliam, J.	. 105 Seismic Sequences Associated with Complex Subduction in the Northeast Caribbean
8:20	Mercier de Lepinay, B.	. 106 The Jan.12, 2010 Haiti earthquake : looking for the fault, from aftershock distribution. Results of the Haiti-OBS experiment
8:40	Llanes-Estrada P.	. 107 Is the Caribbean plate subducting underneath Hispaniola?
9:00	Carbò-Gorosabel A.	. 108 Marine geophysical research helps to asses the seismic hazard at the Hispaniola Island.
9:20	Granja-Bruña J.-L.	. 109 Offshore shallower structure of the collision zone between the Muertos thrust belt and the Beata Ridge (NE Caribbean)
9:40	Lopez-Venegas A.	. 110 Continuous GPS Observations Give Insight into Puerto Rico -Virgin Islands Forearc Deformation
		Coffee break
10:30	Monfret T.	. 111 Seismic Activity offshore Martinica and Dominica islands (Central Lesser Antilles Subduction Zone) from temporary onshore and offshore seismic networks
10:50	Laigle M.	. 112 Approach to the submerged fore-arc of the Lesser Antilles subduction : integrated marine MCS, refraction, OBS seismic activity and noise recording.

GOYAVE ROOM		
Time:		**Pedology, Subsurface, biogeology**
8:20	A. Rousteau	. 123 The West-Indian Sloanea and the age of the recent arc
8:40	Rad, S.	. 124 Chemical weathering and erosion rates in Lesser Antilles: an overview in Guadeloupe, Martinique and Dominique
9:00	Cabidoche, Y.M.	. 125 Sols dérivés de roches volcaniques : un patron de leurs constituants et propriétés
		Landslides and Gravity instabilities
9:20	L. Brown	. 126 Earthquakes induced landslides: using Carbon -14 technique to date earthquake events.
9:40	V. Clouard	. 127 2009-2010 landslide crisis in Martinique related to the 2007 North Martinique earthquake
		Coffee break
10:30	A. Mandal	. 128 Rainfall induced river flood modelling in Jamaica with special emphasis on Port Maria, St Mary
10:50	J-M Mompelat	. 129 Séisme du 12 janvier en Haïti : Premiers enseignements sur l'importance des effets de site et des mouvements de terrain induits dans l'explication des dégâts observés

11:10	Pichot T.	. 113 Tectonic evolution of Barracuda Ridge and Tiburon Rise at the front of Barbados accretionary prism as recorded by Cenozoic stratigraphy. 113 Tectonic evolution of Barracuda Ridge and Tiburon Rise at the front of Barbados accretionary prism as recorded by Cenozoic stratigraphy	11:10	H. G. Rameau	. 130 Pluviométrie et calculs de stabilité de talus routiers en Haïti :
11:30	Weil-Accardo J.	. 114 Relative sea level variations on the last two centuries in Martinique: Insights from corals microatolls	11:30	A.V. Barras	. 131 Mouvements de terrain associés aux intempéries du 5 mai 2009 en Martinique (Antilles françaises) – retour d'expérience
11:50	Mazabraud Y.	. 115 Les Saintes volcanic system: a field survey for structural reappraisal.	11:50	J. Berthoumieux	. 132 Etude des caractéristiques géophysiques, géotechniques et de rétention d'eau des sols du Massif de la Selle (Kenscoff-Haïti)
12:10	Thinon I.	. 116 Structural context of the Bouillante area: Contribution of high resolution marine geophysical surveys (western shelf of Basse-Terre Island, Guadeloupe, French West Indies)	12:10	E. Vanoudheusden	. 133 Evaluation and prevention of soil liquefaction at Fort-de-France (Martinique)
		Lunch			**Lunch**
From 14:00 to 16:00		**Workshops**	From 14:00 to 16:00		**Workshops**
		Coffee break			**Coffee break**
From 16:30 to 18:30		**Coffee Break and Poster session**	From 16:30 to 18:30		**Coffee Break and Poster session**
	Galvé A.	. 119 3D Fore-arc structure offshore Martinique and Dominique island		V. Clouard	. 134 Analysis of 2009-2010 lahars in Prêcheur River, Martinique, with acoustic, seismic, Lidar topographic, and meteorological radar data
	Leclerc, F.	. 120 Active faulting induced by slip partitioning in Montserrat and link with volcanic activity: New insights from the 2009 GWADASEIS marine cruise data		C. Aubaud	. 135 Historical record of landslides, floods, and lahars in the Prêcheur river catchment, Montagne Pelée Volcano (Martinique Island, Lesser Antilles arc) from 1865 to 2010
	J.F. Lebrun	. 121 The Kashallow Program - A study of the tectono-sedimentary architecture of the Marie-Galante basin, Lesser Antilles fore-arc		B. Vittecoq	. 136 Interpretation of the piezometric fluctuations associated to the november 29, 2007 7.4 earthquake in Martinique

	J. Weil-Accardo	. 122 Vertical deformations related to the January 12 2010 Haïti earthquake		E. Foerster	. 137 Liquefaction risk assessment for natural soils: the Belle-Plaine borehole test site (Gosier, Guadeloupe)
	T. Alvarez	. 117 Subduction-to-Strike-Slip Transition in the Southeast Caribbean Using Deeply Penetrating Seismic Reflection Lines and Tomography			
	G. Chicangana	. 118 Sobre el origen de la sismicidad en la Sierra Nevada de Santa Marta y la Península de La Guajira, Colombia.			

Amphi Merault - Univ. Antilles Guyane - Fouillole		
From 14h00		**All audience conferences at the Université Antilles Guyane**
	J-M Lardeaux	L'évolution géologique de la plaque Caraïbes: un cas d'étude exemplaire de la convergence des plaques
	Y. Mazabraud	Enseigner la Géologie aux Antilles: quels savoirs pour quel public?

RESUMES

SESSION : CENOZOIC CARBONATE SYSTEMS

. 1 Geomorphology and sediment dynamics in mesophotic coral ecosystems of the upper insular slope of southwest Puerto Rico

C. Sherman, M. Nemeth, H. Ruiz, I. Bejarano, R. Appeldoorn, E. Weil, Y. Hutchinson and M. Rojas

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Multibeam bathymetry, ROV and diver observations, photo transects and sediment trap collections provide data to characterize the interrelationships among geomorphology, sediment dynamics and mesophotic coral ecosystems (MCEs) of the insular slope of southwest Puerto Rico from ~20 to 90 m water depth. Southeast-facing slopes, more exposed to prevailing seas, consistently have a gentler gradient and smoother, lower rugosity topography than more sheltered southwest-facing slopes, which are steep and irregular. MCEs are preferentially concentrated on topographic highs. Accordingly, MCEs are more abundant, extensive and diverse on southwest-facing slopes where the steep, irregular topography provides extensive suitable substrates and downslope sediment transport is quickly funneled into narrow grooves. MCEs are more sporadic on southeast-facing slopes where topographic highs are more widely spaced and downslope sediment transport is spread over open, low-rugosity slopes. Though concentrated on topographic highs, in slope settings, all MCEs must still adapt to some level of downslope sediment transport. MCEs on lower rugosity slopes are exposed to a more uniform and constant flux of downslope bed load transport than MCEs on steep, irregular slopes where downslope transport is slightly lower and more variable. These differing levels of disturbance affect the character and composition of these communites.

***

. 2 Stratigraphy, sedimentology and Pliocene-Pleistocene evolution of the South-eastern part of the Dominican Republic. Tectonics, eustasy and climate controls.

Lasseur E.[1], Braga J.C.[2], Diaz de Neira, J.A.[3], Mediato Arribas J.[4], Monthel J.[5]

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2) Granada University – Granada, Spain
3) IGME – Madrid, Spain
4) INYPSA – Madrid, Spain
5) BRGM – Department of Mineral Resources – Orléans, France

The Plio-Pleistocene geological history of the South-eastern Dominican Republic coastal plain (*Llanura Costera del Caribe*) is tentatively restored using geological mapping, sedimentological analysis and data from airborne geophysics. This work was carried out by the IGME-BRGM-INYPSA Consortium, which is currently finalising the 1:50,000-scale geological mapping coverage of the Dominican Republic under the Sysmin project, financed by the European Union from 1996 to 2010.

The Plio-Pleistocene deposits of this area consist of carbonate platforms and associated sediments, overlying the Cretaceous substratum of the Eastern Cordillera.

Two successive platform types, with different depositional profiles, faunal content and sedimentary architectures, can be identified in the area.

- The older Pliocene-Lower Pleistocene deposits accumulated in a relatively flat carbonate platform, several tens of kilometres across. Sediments vary from continental and lagoonal deposits to large coral build ups.
- Later Pleistocene deposits formed after a period of emersion. These deposits correspond to reef rimmed platforms and occur as a flight of successive terraces (from 2 to 4), several kilometres in width. Dating is scarce, but deposition could range from MIS (Marine Isotopic Stage) 11 to MIS 5.

Geological mapping and geomorphological studies also allow the reconstruction of the fluvial network evolution during the last cycles of sea level variations. The influence of deep tectonic structures on the present

day relief and on the Pleistocene evolution of the Dominican coastal plain will be questioned using data from airborne geophysics.

The evolution of this area, particularly the differences between the two types of carbonate platforms, will be addressed and compared with the known evolution of the Caribbean area. Within this evolution, we will try to decipher the roles of tectonics, eustasy and climate on the observed patterns.

***

. 3 Stratigraphy of the White Limestone of Jamaica.

S. F. Mitchell

Department of Geography and Geology, The University of the West Indies, Mona, Kingston 7, Jamaica.

The White Limestone (Eocene-Miocene) of Jamaica covers some 60% of the island, represents the main aquifer, a potential hydrocarbon reservoir offshore, and is increasingly being seen as a unit suitable for quarrying activities. During the 1950s-1970s, members, based largely on microfacies or palaeontological criteria were erected for the shallow-water limestones on the Clarendon Block, and used to construct idealized models for these platform deposits with high-energy reefs and carbonate sands on the platform margin and low-energy micritic limestones in the platform interior. During the last year, I have mapped across the northern part of the Clarendon Block in the parishes of St. Ann, St. Catherine and Manchester and this has resulted in the recognition of a revised lithostratigraphic succession. Lithostratigraphic units are largely based on their texture (that is largely micritic units, or largely grainy units), their colour, and their bioclast content. Although bioclasts are important components of the limestones, particularly the foraminifers, it is broad groups (for instance, small miliolids, large complex miliolids, large lepidocyclinids, corals, etc.) that are used for identification purposes rather than actual species. For instance, the Somerset Formation can be described as a pale grey to pale pink limestone largely composed of packstones and grainstones, but with subordinate wackestones, that contains a variety of bioclasts (corals, molluscs and larger foraminifers) but particularly large white complex miliolids that give the limestone a white blotchy appearance. The new lithostratigraphic scheme indicates the existence of angular unconformities in the late Eocene and late Oligocene, related either to eustatic sea level falls or two Caribbean tectonics.

***

. 4 Ecology and zonation of coral build-ups in the Late Miocene August Town Formation, Jamaica.

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Late Miocene coral communities in the Caribbean are rare compared to those of the later Neogene and Quaternary. Thus, patterns of coral abundance and richness on these older reefs are poorly understood. In Jamaica, the late Miocene August Town Formation contains common coral accumulations in growth position. These have provided an opportunity to examine the paleoecology of these build-ups and their transition into more modern reef communities.

We used comprehensive coral sampling and transect methods to document coral species richness and relative abundance across different sites bearing in-place coral from the August Town Formation in St. Andrew and St. Thomas Parishes in southern Jamaica. Coral build-ups here vary from metre scale patches of coral growth fabric to a fringing reef system ~10m across, up to 3-4m thick and extending across some 30m of outcrop. This fringing system develops on coarse shallow marine clastics and shows a distinct succession with species of *Diploria* and *Favia* colonizing clasts followed rapidly up-section by larger massive, columnar and ramose colonies of *Porites, Montastraea* and *Stylophora*. Though richness is low, coral growth is dense and colonies commonly reach sizes of 1m or more.

Data from *in situ* corals throughout the formation suggest a distinctive zonation pattern. In the wave exposed reef core, *Stylophora monticulosa, Porites chipolanum* and *Montastraea limbata* dominate. In smaller less wave exposed build-ups, species of *Siderastrea*, *Solenastrea* and *Montastraea* spp. are dominant. Some common August Town Fm. species, such as *S. monticulosa* and *M. limbata,* persist into the Early Pleistocene

where they co-occur in much more diverse reef communities with dominant modern reef formers such as *Acropora palmata* and *A. cervicornis*. Their position on these diverse Quaternary reefs is essentially the same as in those of the Late Miocene though their abundance is greatly reduced.

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. 5 TECTONO-STRATIGRAPHIC DEVELOPMENT OF SOUTHEASTERN JAMAICA

S. A. James-Williamson and S. F. Mitchell

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The sedimentary succession of southeastern Jamaica preserves a depositional record of accommodation changes and tectonic events for the last 14 Ma. The depositional systems which occur in the area have been classified according to distinct tectono-stratigraphic packages based on the depositional environments, rapid facies changes, and or significant erosion surfaces. This paper places the sedimentology and geochemistry within a tectonic evolutionary framework for the northern margin of the Caribbean Plate over the last 14 Ma. This involves considering issues of changing accommodation; deformation episodes including folding and faulting and the subsequent cutting of unconformities. A model for the tectono-stratigraphic development of southeastern Jamaica is also proposed. The model incorporates critical surfaces, major faults, subsidence and uplift which later influence the depositional environments.

***

. 6 Pleistocene Infilling of Guadeloupean Caves

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Calcareous islands of Guadeloupean Archipelago represents a well-developed karst. More than two hundred caves have been recorded. Depending on their genesis mode, theses caves are grouped into seven main types. Cavities of the same type share morphological features and have a common location in the landscape. This classification also helps determine the age of cave formation and the likelihood of ancient deposit to be preserved.

Testing has been carried out in caves with the highest potential of containing preserved deposits. Old deposits have been found in four caves. The different lithofacies are presented, and their petrographic, mineralogical and paleontological content described. This characterization allows for the recognition of several kinds of deposits: storm deposits in littoral settings, organic stacks resulting form guano fossilization, and haloclastie-derived autochthonous sediments.

Three caves located in Marie-Galante provided fossil vertebrate assemblages of Pleistocene age. A Taphonomic study conducted on bones indicates accumulation by birds of prey. The specific determination helps to establish a faunal list of Marie-Galante Pleistocene vertebrate biocenoses in the second part of Upper Pleistocene and at the beginning of the Holocene.

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. 7 Sedimentology and paleoenvironments of the Pliocene-Pleistocene carbonate platform of Grande - Terre (Guadeloupe, Lesser Antilles forearc).

Jean Len Léticée[1], Jean-Jacques Cornée[2], Philippe Münch[3-2,] Jean-Frédéric Lebrun[1], Auran Randrianasolo[1], Juan-Carlos Braga[4], Frédéric Quillévéré[5], Pierre Moissette[5], François Fournier[3], Lyvane de Min[1,2]

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New sedimentological and paleoenvironmental studies of the Pliocene-Pleistocene carbonate platform of Grande Terre, and comparison with previous investigations in the Lesser Antilles, allow us to:

- identify seventeen facies types arranged into four main depositional environments, from fluvial to outer ramp;
- evidence four erosional surfaces (SB0 to SB3), one transgression surface and three maximum flooding surfaces, which were identified over the whole island, allowing regional correlations;
- reconstruct the sedimentary organization of the deposits and propose a sequence stratigraphic interpretation.

The Grande Terre platform comprises four main depositional sequences.

Sequence 1 and 2 (early Pliocene): aggrading deposits, with rhodolith-rich, inner to mid ramp deposits in the West changing into muddy, outer ramp deposits to the East. Sedimentation was emplaced on a distally steepened ramp under low subsidence. The ramp suffered subaerial exposures during the early Pliocene (SB0) and the late Pliocene (Pl5 biozone), both related to 20-30 metres amplitude tectonic uplift events. ***Sequence 3*** (latest Pliocene to early Pleistocene): sea-level controlled sedimentary cycle deposited on an east-dipping ramp, between emersion surfaces SB1 and SB2. Latest Pliocene red algal deposits changing into muddy outer ramp deposits, which constitute a transgressive systems tract emplaced on a distally steepened ramp. Upward, early Pleistocene coral-reefs and associated sediments developed during a highstand on a homoclinal, very low angle ramp. At the end of sequence 3, Grande Terre emerged at ~1.6-1.7 Ma. ***Sequence 4*** (probably late early Pleistocene): extensive development of shallow-water *Acropora* boundstones and bioclastic/oolitic deposits. It corresponds to a sea-level controlled sedimentary cycle deposited on a flat-topped platform also covering the submerged Guadeloupe plateau.

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. 8 Tectonostratigraphy of the Pliocene-Pleistocene carbonate platforms of the Guadeloupe Archipelago, Lesser Antilles fore-arc.

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In the Guadeloupe Archipelago, the Plio-Pleistocene carbonate platforms were emplaced in a fore-arc setting on top of an ancient (Oligocene?-Miocene) abandoned arc (Bouysse et al., 1990). The main chronostratigraphic frame for these platform was established from the planktonic foraminifers study of the *La Simonière* drilling (Andreieff et al., 1987). We conducted an integrated stratigraphic study from new onshore and offshore localities by using planktonic foraminifers, calcareous nannofossils, magnetostratigraphy and $^{40}Ar/^{39}Ar$ dating of volcanic tuffs. This allows to precise the timing of Pliocene to Pleistocene tectonosedimentary events over the whole Guadeloupe archipelago.

Our results show that the islands of the archipelago, together with the submerged *Karukéra* spur (De Min et al., this volume), were emergent during the Miocene-Pliocene transition. The carbonate platforms started to develop during the Zanclean first infilling relieves of the inherited aerial topography (*Marie-Galante, La Désirade, Karukéra*). During the Late Piacenzian, these platforms suffered synsedimentary extensional faulting (*Grande-Terre, La Désirade, Karukéra*). During the Pliocene, the *La Désirade* platform was uplifted whilst *Grande-Terre*, *Marie-Galante* remained under sea-level. The final uplift of *Grande-Terre* and *Marie-Galante* can not be precisely dated because of the lack of available chronostratigraphic data in the youngest reefal platform (Reef Unit 2 *in* Léticée et al., 2005). However, Feuillet et al. (2004) proposed an age of 330 kyr for the last emersion surface of *Marie-Galante*. From the Calabrian age (C2n subchron, Olduvai) of the underlying Reef Unit 1 this would imply a 1.4 Ma time gap for the erosional surface SB2 (Léticée et al., this volume). Indeed, karstic features are almost absent on SB2 rather suggesting a short period of emersion. Consequently, we favour a Calabrian age (C1r subchron) for the youngest reefal platform (Reef Unit 2) of *Grande-Terre* and *Marie-Galante*. Then, the westward tilting of the islands is polyphased and started much earlier than previously proposed.

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. 9 $^{87}Sr/^{86}Sr$-ratios, foraminifera and sedimentology of the Late Miocene – Pliocene cyclic carbonates of La Désirade (Guadeloupe, France)

Philippe, J.,N. Weber, Claudia Baumgartner-Mora, Peter O. Baumgartner.

Institut de Géologie et Paléontologie, Anthropole-Dorigny, Université de Lausanne, 1015 Lausanne, Switzerland

The "Limestone Table" (LT) of La Désirade has been considered as a Plio-Quaternary reefal deposit. However, the prominent feature of this <140 m thick formation is its rhythmic bedding of alternating marly/tuffaceous/dolomitic, and winnowed bioclastic carbonate layers. To the west of the island the "detrital offshore limestones" represent alternating offshore marls, tuffs and channelled mass flow deposits, that accumulated below wave base beneath a steep fore-reef slope. They document the mobilisation of carbonate material on an adjacent platform by storms and their gravitational emplacement. The provenance of both the reefal carbonate debris and the tuffaceous components must be to the west, i. e. Marie Galante and Grande Terre.

Planktonic foraminifera of the "detrital offshore limestones" give a latest Miocene/early Pliocene age (lower zone N19), while $^{87}Sr/^{86}Sr$-ratios cluster in the latest Miocene. For the LT $^{87}Sr/^{86}Sr$-ratios from the base of the section cluster in the earliest Pliocene, while the top gives a late middle to late Pliocene age. These ages constrain the Neogene vertical tectonic movements of the island. We have also dated Pleistocene terraces that are in an unconformable contact along paleocliffs with the Mio-Pliocene sediments.

The history of the carbonates begins with initial tectonic uplift and erosion of the Jurassic igneous basement. It occurred before late Miocene times, when sea-level oscillated around a long term stable mean. The rhythmic deposition of the LT can be explained by synsedimentary subsidence during rapidly oscillating, precession-driven (19-21 kyr) glacio-eustatic sea-level in the latest Miocene/earliest Pliocene-middle Pliocene. Except for a thin reef cap at the eastern edge of the LT, no in-place reefal constructions occur in the LT. Pre-late Miocene uplift, Pliocene subsidence and late Pliocene-Pleistocene emergence (up to 200 m above modern sea-level), and westward tilting must be the result of repeated subduction of buoyant ridges along the Caribbean trench located offshore La Désirade.

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. 10 Pliocene-Pleistocene fore-arc vertical motion recorded at Karukera Spur, (Lesser Antilles)

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In the Lesser Antilles fore-arc at the latitude of Guadeloupe archipelago and about 150km West of the deformation front, the Karukera spur corresponds to the accretionary prism crustal backstop that rises about 4000m above the fore-arc basin. At this latitude the Tiburon Ridge is subducted beneath the Karukera spur. Since the late Miocene the sedimentary cover of the spur recorded vertical motion in response to surface tectonics and to subduction-related geodynamical processes. During the KaShallow cruises, high-resolution multichannel seismic reflection and multibeam bathymetric data were acquired and rock samples were cored all over the spur.

The spur surface morphology is a NNW/SSE elongated ridge deepening from 40m bsl to the North to more than 2000m bsl to the South. We distinguished four normal fault systems: 1/ N160°-N130° trending faults that represent the main system observable all over the spur; 2/ N090° trending faults mainly developed in the central part of the spur; 3/ N180° trending faults that separate the spur from the Marie-Galante basin; 4/ N040° discrete trending faults.

The seismic profiles show that the sedimentary cover rests unconformably upon the fore-arc acoustic basement. The sedimentary cover thickens from ca. 0.1s (twtt) to the North to ca. 1,5s (twtt) to the South. We identified six seismic units (U0-U5) and five (S1-S5) bounding surfaces. 16 seismic facies have been distinguished, among three are clearly reefal facies. The surfaces bounding seismic units are erosive, mainly in the northern part of the spur. This reveals that the northern part emerged at least 5 times whereas the southern

part was continuously subsiding. Rock sampling allowed the calibration of the seismic units and confirmed the occurence of reefal units alternating with pelagic marls. Planktonic foramifers and calcareous nannofossils indicate Pliocene to Pleistocene ages. In the southernmost part of the spur, we sampled a 3.54 – 1.93 Ma old coral boundstone at a depth of ca. 2000m bsl, thus indicating a mean vertical motion rate ranging from 0.56 to 1.03 mm/an. All is indicative of a general southward tilt of the spur during the Pliocene.

The Kashallow project is funded by the European Union FEDER project FED1/1.4/30700 and Intereg IIIb Espace Caraibes - Project 1.2. as weel as French Government INSU support. L. De Min received grants from "Région Guadeloupe" during her PhD.

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. 11 Architecture of Offshore Carbonate Plateform (Guadeloupe Archipelago - Lesser Antilles Forearc)

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Fore-arc and arc islands of Guadeloupe archipelago are surrounded by Plio-Pleistocene to Holocene carbonate platforms resting at shallow depth (between 30 and 50m bsl). Single channel HR seismic reflexion acquired over these platforms during the Kashallow 1 cruise together with very detail multi-beam bathymetric data (Kashallow 3 cruise - Mnt with a 2m grid spacing and sub-metric vertical precision) and dredge and core sampling (Kashallow 2 and 3 cruise) allow to reconstruct the offshore platform architecture. We correlate it with the onshore Plio-Pleistocene platfrom that cover the Grande Terre forearc island and we identify its relations with the Basse-Terre volcanic island to the west.

Moreover, detail bathymetry along the platform hinge shows terraces and holocene refal construction that recorded paleo-sea levels probably since the early Pleistocène. Because the platform hinge extends over more than 80km from the fore-arc (to the east) to the volcanic island (to the west) we are able to test the kinematics of differential vertical motion that affect the fore-arc transversally to the subduction front.

The Kashallow project is funded by the European Union FEDER project FED1/1.4/30700 and Intereg IIIb Espace Caraibes - Project 1.2. as weel as French Government INSU support. L. De Min received grants from "Région Guadeloupe" during her PhD.

The Kashallow Team include: J. Begot, K. Biscarrat, R. Cancouët, C. Claud, J.-J. Cornée, A. Deschamp, C. Delacourt, N. Feuillet, F. Fournier, M. Franzetti, D. Graindorge, P. Guennoc, J. Hamman, F. Leclerc, JL Léticée, B. Marcaillou, Y. Mazabraud, M. Melinte-Dobrinescu, P. Munch, F. Quillévéré, A. Randrianasolo, I. Thinon, C. Verati.

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POSTERS : CENOZOIC CARBONATE SYSTEMS

. 12 Late Miocene-Early Pliocene Larger Foraminifera of La Désirade (Guadeloupe, France)

C. Baumgartner-Mora

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The rhythmically bedded sequence of the Limestone Table of La Désirade and the “detrital off-shore limestones” contain locally abundant coquinas of Larger Foraminifera examined here. The provenance of reefal carbonate debris redeposited in the carbonates of La Désirade must be to the west, i. e. the platforms of Marie Galante and Grande Terre.

Larger Foraminifera occurring in the Caribbean carbonate banks have been used to resolve their biostratigraphy, despite of the lack of continuous shallow carbonate successions.

During the Caribbean geological history, punctuated by tectonic events, Larger Foraminifera colonized small areas forming short-lived carbonate banks each time when the substrate was in the photic zone. Carbonate banks were commonly swept by currents and supplied material into deeper zones of the platforms. Sediments became mixed with planktonic foraminifera that allow for the application of planktonic foraminiferal zonations.

In the evolution of Larger Foraminifera very similar morphological characters were reached in populations of widely separated localities. This was the case in the Caribbean genus *Nummulites*. Minor morphological differences led to splitting of the Eocene species based on very few morphological characters.

Near the end of the Tertiary, only few *Nummulites* spp. Survived, reducing the described taxa to 2 well distinct species: *Operculina cojimarensis* and *O. chawneri* which is only known until now in the eastern Caribbean. On Désirade Island the reefal carbonate debris and the tuffaceous marls redeposited in an offshore carbonate bank contain these 2 taxa and one recently described new species: *O. desiradensis*, together with other opportunist taxa such as *Archaias* spp., *Peneroplis*, and *Amphistegina* spp. Planktonic foraminifera of the "detrital offshore limestones" constrain its age to the late Miocene/early Pliocene (lower zone N19), while $^{87}Sr/^{86}Sr$-ratios clearly cluster in the latest Miocene. $^{87}Sr/^{86}Sr$-ratios from the base of the the rhythmic carbonates cluster at the base of the Pliocene, while the top reveals values corresponding to a late middle to late Pliocene age.

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. 13 Thermic system of Guadeloupe caves : consequences on sedimentation and wall preservation

A. Queffelec[1] - A. Lenoble[1] – P. Malaurent[2]

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2) *UMR 5295 I2M-GCE – Université Bordeaux 1 - Bât B18 Avenue des Facultés 33405 TALENCE Cedex*

Hygrometric and thermic measurements have been recorded to assess the microclimatology of some Guadeloupean caves. The results from Blanchard Cave and Morne Rita Cave, two Pre-columbian archeological sites, are presented here. Recordings have been conducted according to two modes: a short-step one which defines the daily cycle, and a long-term one which documents the annual cycle.

Measurements show two distinct patterns:

1. The first cave records temperatures globally warmer than the exterior conditions. But the regime is very unstable due to air currents bringing cold air deep into the cave. The result is a limited hygrometry and a very high sensitivity to daily hygro-thermic variations. Annual data collection reveals fluctuations in the hot air trap system, that we link to the influence of seasonal cloud covering.
2. The second cave can be considered as a cold air trap. Lack of air currents helps to establish a more stable system, and a more humid air to be maintained in the cavity. Daily fluctuations are strongly weakened. However, seasonnal variations are still recorded.

These data open up prospects for further understanding of physical processes occurring in these sites. Thus, air flows that have been highlighted in the first site can explain the presence of evaporitic minerals in the ancient deposits by seaspray transported into the cave with cold air flows. Highlighting this supply also support the assumption that salt fretting contributes heavily to wall desegregation. A 0.6 cm/century weathering rate is thus estimated from sedimentation age model. Such a rate would explain the total lack of engravings in this kind of cave. Conversely, the stable system in Morne Rita cave would have favored the preservation of the Pre-columbian art.

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SESSION: HYDROGEOLOGY, WATER RESSOURCES MONITORING

. 14 Identification of infiltration and run-off areas with the River's network Persistence and Development Index (IDPR): applications in Basse-Terre Island and in Martinique.

D. Allier[1] – B.Vittecoq[1] – A. Dumon[2]

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The River's network Persistence and Development Index (IDPR) is today an essential tool for regional groundwater vulnerability mapping. This qualitative index is based on a comparative analysis between the drainage system (calculated from a Digital Elevation Model) and the natural hydrological flow. By replacing many of the criteria usually employed for producing vulnerability maps, the IDPR describes indirectly the influence of geological formations.

A project carried out in the island of Basse-Terre in Guadeloupe and in Martinique delivers new conclusions about the use of the IDPR. Maps have been constructed showing the areas of preferential infiltration and facilitating the assessment of main groundwater resources. IDPR has been a useful tool to guide future exploration drilling campaigns. The results were confirmed by field observations.

The IDPR's resulting maps provide a basis for groundwater protection zoning and land-use planning, especially useful for countries for which no detailed geological or soil map is available. Nevertheless, this tool should not replace more detailed methods performed at smaller scales because the results are limited by the accuracy of the input data's. The resultant map must be interpreted not as reflecting an absolute vulnerability, but as showing a hierarchy of the systems in terms of their vulnerability, and enables the targeting of priority areas.

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. 15 New elements toward hydrogeological schemes of Martinique aquifers

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The majority of the Lesser Antilles islands are characterized by andesitic volcanism. However, their hydrogeological functioning and associated structures are little known and little studied, while water needs are obvious. Indeed, at the end of dry seasons, water cuts mark the daily routine of the population, although, significant volumes of water could be collected through water boreholes.

Volcanic aquifers are complex in terms of geological structure (geometry) and spatial distribution of hydrodynamic parameters. Indeed, only basaltic islands have hydrogeological schemes: the Hawaiian model (low-lying basal aquifer and perched aquifer) and the Canary Island model (continuous basal aquifer).

The objective of this presentation is to summarize the results of geological, hydrogeological and geophysical prospecting conducted in Martinique since 2006. Dozens of electrical profilings were conducted to characterize the geological structure. Boreholes were then carried out firstly to calibrate the electrical profiles and also to identify the aquifers. Finally, pumping tests were conducted to determine the hydrodynamic parameters of the encountered aquifers. These researchs have provided new evidence showing that the hydrogeological scheme of the Martinique aquifers is different from the two previously mentioned: Martinique is not marked by lava flows of large extension with high permeability and has not any basal aquifer.

The Martinique aquifers are on the contrary very heterogeneous. Their structure and groundwater flow are mainly controlled by embricated and tight paleo-valleys and, for lavas, fissures resulting from cooling stress. Thus, the aquifers are often characterized by a high spatial variation in hydraulic properties, a low storage coefficient and bounded by several no-flow boundaries. Some low permeable layers, resulting from weathering processes (which transforms primary minerals into clay-rich materials) also play an important role as capacitive layers. In some conditions, they can be drained by underlying lavas groundwaters, thus increasing the sustained yield of water boreholes.

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. 16 Prospections hydrogéologiques en milieu volcanique. Etude de cas : Cœur Bouliki, commune de Saint-Joseph, Martinique.

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En Martinique, la production en eau potable provient à plus de 90 % des rivières et pose des problèmes en cas d'étiage sévère avec le non-respect des débits réservés. Aussi, conformément aux orientations fondamentales du SDAGE de la Martinique, la CACEM (Communauté d'Agglomération de Centre de la Martinique) mène depuis 2006 un programme de recherche en eaux souterraines dont la direction technique et scientifique a été confiée au BRGM.

Des méthodes de prospection adaptées aux aquifères volcaniques ont ainsi été mises en œuvre par le BRGM : identification des sites favorables selon une analyse cartographique multi-critères, reconnaissances géologique et hydrogéologique de terrain, investigations géophysiques par la méthode des panneaux électriques, réalisation de forages de reconnaissance.

La dernière étude aboutie, sur la commune de Saint-Joseph, a mis en évidence une ressource en eau souterraine de premier plan pour la Martinique. L'interprétation des pompages d'essai (janvier à avril 2010) a révélé un système aquifère de type bicouche (alluvions et laves fissurées) dont la transmissivité semble varier en fonction de l'épaisseur saturée des alluvions (entre 1.10^{-3} et 4.10^{-3} m²/s sur la période testée).

Tout laisse à croire que les alluvions seront rapidement rechargées après un épisode de crue du cours d'eau et donc qu'elles devraient à leur tour recharger rapidement l'aquifère sous-jacent. Un tel comportement hydrodynamique doit pouvoir permettre d'appliquer un concept de gestion active de l'aquifère en optimisant les prélèvements en fonction des épisodes de crue du cours d'eau. Ceci pourrait permettre d'envisager la réalisation d'un champ captant basé sur plusieurs forages d'exploitation.

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. 17 Diphasic hydrodynamic modeling of the Grande-Terre groundwater flows (Guadeloupe)

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The island of Grande-Terre (in Guadeloupe archipelago) is characterized by an extensive reef platform made up of Pliocene and Pleistocene sedimentary deposits which overlies Eocene to Oligocene volcano-sedimentary deposits of the older Lesser Antilles arc. The carbonate platform of Grande-Terre forms a continuous porous limy aquifer which contains freshwater in hydrostatic balance with salt water. The groundwater is recharged exclusively by rainwater and is exploited by drillings and wells for potable water, agricultural and industrial uses.

The groundwater levels in Grande-Terre are monitored by a piezometric network since the 70's. The limy aquifer of Grande-Terre has been studied for the last 40 years by BRGM. Therefore the hydrogeological functioning is well known, and the numerous data available, especially on the geological structure and spatial distribution of hydrodynamic parameters, allowed a modeling of the groundwater flows.

The modeling is performed with a diphasic multilayer model with square cells (20355 cells of 200 meters side). The model was built with the finite volume code MARTHE developed by BRGM. The model is calibrated over a period of 20 years (1985-2005). The climatic and water balance are calculated at daily step and the hydrodynamic calculations are performed at a monthly time step. The freshwater and salt water interface is taken into account through a diphasic approach with a sharp interface.

The model is used for exploitation and climate change simulations, in order to assess available resource and saltwater intrusion. This model is a decision support tool for the water resource administration in Guadeloupe, and is used in many scientific projects.

However, some improvements should be done to this model especially on the freshwater and salt water interface localization, the volcanic substratum localization and the study of the karstification role on the groundwater flows.

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SESSION : GEOTHERMY

. 18 The High-Temperature Geothermal System of Bouillante (Guadeloupe, French West Indies)

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The Bouillante geothermal field, located on the west coast of Guadeloupe (Lesser Antilles), was explored in the 1970s, developed in the 1980s, brought into production in 1986, and expanded in 2005 to currently produce up to 15 MWe. In addition to its electricity-producing role, the Bouillante field is an outstanding research laboratory for improving our knowledge of a reference high temperature (260°C) geothermal system in island-arc environment.

A great deal of scientific research and exploration investigation have been carried out on the Bouillante geothermal field for 10 years, including geological investigation (volcanism), structural analysis of the fluid conduits, geophysical investigations both offshore (magnetics and high-resolution shallow seismics, see Calcagno *et al.*) and onshore (gravimetry, electrical resistivity tomography profile and passive seismic, see Gailler *et al.*), characterization of the surface and deep hydrothermal manifestations, numeric geological modelling of the developed field, fluid geochemistry and tracer tests (Sanjuan *et al.*) and hydrogeological modelling. This large range of multidisciplinary data has made it possible to develop an innovative conceptual model of this type of high-temperature geothermal system.

The model highlights the major influence of structural control on the development of the geothermal activity at different scales and especially on the geometry of the reservoir. It also explores new ideas concerning the geothermal system in terms of heat source, fluid circulation and spatio-temporal scenario. This scenario takes into account all events from the early magmatic activity of the Bouillante volcanic Chain (~500,000 y) up to the beginning of the geothermal field some 250,000 years later, having probably started with a phreatic explosion in the bay of Bouillante (see Patrier-Mas *et al.,* Verati *et al.*).

This 2D geothermal resource conceptual model will be used as an exploration tool to reduce geological risks for the next exploration drilling campaign.

This work is supported by the French Agency for Energy and Environment (ADEME).

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. 19 Modeling of Bouillante geothermal field (Guadeloupe, French Lesser Antilles)

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With a 15MWe capacity the Bouillante geothermal plant can supply the Guadeloupe Island (French Lesser Antilles) with 6 to 8% of its annual consumption of electric energy. New exploration projects are currently considered to expand this production capacity.

Several simple models have been developed to support optimal development of the geothermal field and its management especially as reinjection of the cooled brine started recently. Lumped parameters models were used as first exploration tools to test conceptual schemes of the geothermal field. They were successfully used to forecast pressure evolutions and link production flow rates with reservoir pressure as inferred from wellhead pressure.

As a first step towards a more general understanding, all available data is being gathered to build a conceptual geological and hydrogeological model integrating both regional and reservoir scale data. Current efforts are focusing on the development of regional scale hydrothermal modeling to help exploration activities. Numerical developments are still necessary to model the whole hydrothermal system over a large range of thermodynamical conditions (Copol *et al.*, this conference).

At reservoir scale, we are using the Tough2 geothermal reservoir simulator to test different hypothesis. Despite the relative scarcity of data concerning the reservoir state, the impact of fracturation on the reservoir behavior has been considered and well pressure interferences data have been successfully reproduced using the

MINC concept. Yet, the need to use excessively high fluid compressibility to fit available data could be explained by a possible two phase zone somewhere in or around the reservoir. This hypothesis still remains to be tested. Our goal is to use complex meshes derived from the geological model built from observation and seismic data. Thus we'll try to identify which are the main phenomena that control reservoir behavior.

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. 20 Contribution of multi-methods geophysics to improve the regional knowledge of Bouillante geothermal Province (Guadeloupe)

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The need to understand the geological context of the Bouillante geothermal Province (Basse-Terre, Guadeloupe, French West Indies) has led to numerous onshore and offshore geophysical investigations. This work presents a compilation of all available, subaerial and marine, gravity and magnetic, electric and magnetotelluric data acquired during the last 30 years.

Oldest electric and magnetotelluric data were digitalized from manuscripts (area of interest from Mahaut to Basse-Terre). Although we faced different problems related to missing acquisition parameters, we partially reconstruct MT tensors to provide a qualitative interpretation of resistivity distribution at depth. The previous interpretations have been improved and evidenced well developed conductive anomalies overlying more resistive ones at the location of, but also beyond, the geothermal field area.

The large-scale gravity signal (from Montserrat to La Dominique) is used to explore existence and geometry of deep dense intrusive complexes beneath La Soufrière and the Bouillante Chain (if existing) volcanoes which could be interpreted as heat sources for the geothermal systems. Modelling has been initiated to constrain the geometry of such structures together with the distribution of more or less dense products both onshore and offshore.

Because Guadeloupe volcanism spars the Brunhes-Matuyama geomagnetic reversal (0.78 Ma), analysis of magnetic anomalies highlight areas predominantly composed of formations either younger or older than the reversal. Modeling is used to reconstruct a generalized topography of the island at 0.78 Ma. The detailed analysis of the offshore magnetic lineaments will be tentatively used to understand the inheritance of the lithosphere structure in the island evolution.

An updated large-scale model of the geothermal system will be proposed based on geological constraints and previous geophysical interpretations. This synthesis could act as a guide in the implantation of upcoming surveys in order to better constrain the Bouillante geothermal Province, and to improve the knowledge the island evolution as a whole.

This post-doctoral study is carried out in the framework of a "Carnot institute" labeled project.

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. 21 The use of Magnetotelluric and Time domain electromagnetic methods in the geothermal survey of Montserrat, W.I.

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Montserrat is a small island in the Lesser Antilles at the eastern end of the Caribbean Sea. Since 1995 there has been an actively erupting volcano on the island. The majority of the Lesser Antilles islands are volcanic due to the subduction of the Atlantic plate beneath the Caribbean plate. This region of the Caribbean is thought to have high geothermal potential. There have been geothermal surveys and studies in this region since the 1950s but there is currently only one operational geothermal power station in the Caribbean. This power station is located on the French island of Guadeloupe. In recent years there has been a renewed interest in exploiting the geothermal potential of this region. In this presentation, we discuss the results obtained from Magnetotelluric (MT) and Time domain electromagnetic (TDEM) techniques. Both techniques were used to help identify structures which may host geothermal resources on the island. The MT technique utilises naturally occurring magnetic and electric fields to measure the earth's impedance tensor at frequencies from 320 to 0.001 Hz. This data can then be inverted to produce variation in resistivity with depth among other things. TDEM is an

active technique in which the inductive response of the earth to an artificially generated magnetic field is measured. In this survey the TDEM data were used to correct the static shift inherent in the MT data. Data from 28 MT soundings and 22 TDEM soundings were analysed and the results indicate the possible existence of a geothermal system controlled by NW and NE trending fault/fracture systems in the southwest of the island. Interpretation of the collected data indicates that a reservoir may exist at a depth of 800-1200m and could host fluids with temperatures in excess of 180 -220 °C.

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. 22 Comparison of the fluid geochemical signatures between the hydrothermal systems of Bouillante and Soufrière (Guadeloupe, French West Indies)

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This study presents a comparison of the fluid geochemical signatures between the hydrothermal systems of Bouillante and Soufrière, carried out from numerous works existing on these two systems. If the thermal springs located around the Soufrière volcano discharge low salinity (< 2 g/l) waters with different chemical compositions and for which the chemical geothermometers indicate no deep temperature higher than 80°C, those emerging from the Bouillante area can be divided into two groups following their chemistry and salinity:

- the first group is constituted of Na-HCO_3 waters, with low salinities (< 1 g/l) and low emergence temperatures (< 40°C), which are warmed by thermal conduction at surface as those located around the Soufrière volcano;
- the second group is represented by Na-Cl waters, with salinities higher than 1 g/l and partially constituted of deep Na-Cl fluid of the Bouillante geothermal reservoir. This fluid which can be collected from the geothermal production wells has salinity close to 20 g/l and results from a mixing of 58% of seawater and 42% of freshwater reacting with volcanic rocks at temperatures close to 260°C.

The fumaroles located in the Bouillante area are associated with this geothermal fluid. According to the δD and $\delta^{18}O$ values, their water steam would result from vaporization at 100°C of a mixing of this fluid with surface cold freshwater. The chemical composition of their non-condensable gases (predominance of CO_2 with different air contributions) is in agreement with this assumption. The fumaroles located around the Soufrière volcano are constituted of 93 to 99% of acidic water steam and corresponding non-condensable gases. These gases have a magmatic chemical and isotopic signature much more marked than that of the gases associated with the Bouillante geothermal fluid, less abundant and acid, of mixed origin and which could rather result from a tectonic source.

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. 23 A 3D Structural Model to Merge Onshore and Offshore Geological Knowledge in the Bouillante Geothermal Province (French West Indies)

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The Bouillante area is well known for geothermal resources on the West side of the Guadeloupe Island (French West Indies). This sector is located at the junction of two regional fault systems. The first one is the major submarine NNW-SSE strike-slip fault belonging to the normal-sinistral Montserrat-Bouillante-Les Saintes system. The other one is the interpretative ESE-WNW Bouillante-Capesterre normal fault which is probably a major fault of the E-W Marie-Galante graben system. At the junction, faults observed on the field mainly elongate along the E-W to ESE-WNW direction whereas offshore structures interpreted from marine seismic lines shows a larger range of directions.

Building a 3D structural model gives the opportunity to combine onshore and offshore geological knowledge that were previously interpreted separately. Onshore data consist in faults observations and measurements acquired mainly on the seaside during field work. Offshore locations and dips of the faults are interpreted from about 180km marine seismic lines. Data and observations are combined - using the 3D GeoModeller* software - into a 3D structural block, modeling a 15 km x 16 km zone over land and sea.

The model exhibits a coherent 3D interpretation crossing the island coast. It reveals 3 main families of faults: (i) E-W direction onshore and offshore set in 3 clusters, (ii) NE-SW direction only offshore, and (iii) NW-SE direction almost not observed onshore. Such a 3D structural model is a tool for geothermal exploration because it shows potential favorable areas as a permeable site. It is also a guide for onshore fieldwork by indicating targets where faults observed only at sea could cut the coast. The 3D structural model will be filled with geological formations and constrain by geophysical inputs such as gravimetry, magnetics or electric parameters. Finally it will be meshed to model temperature distribution and flow.

This work is supported by ADEME (French Agency for Energy and Environment), contract: 0805C0044.

* 3D GeoModeller is a commercial software developed by BRGM and Intrepid Geophysics. For further information visit: http://www.geomodeller.com.

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. 24 On site experiments about silica deposition and kinetics data during the cooling of the Bouillante geothermal fluids (Guadeloupe, French West Indies)

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The main aim of this study was to examine the silica deposition mechanisms and estimate their deposition kinetics at acidic and basic pH conditions, during the cooling from 260 to 25°C of separated waters, discharged from production wells, located in the Bouillante geothermal field. These information are very useful not only for the geothermal exploitation but especially, if production fluids are re-injected in the ground, as this is envisaged in the Bouillante geothermal field.

The different on site experiments showed that, in these conditions, the silica deposition was always initiated by a silica polymerization mechanism and the formation of a white colloidal gel, which slowed down the silica precipitation. The silica precipitation under amorphous silica form was observed much later, after the polymerization stage, and only in particular conditions (long time of atmospheric exposure, water stagnation…).

In agreement with the literature data, the polymerization mechanism is characterized by an order 2 kinetic law, strongly dependant on pH. The determination of the specific surface area by specific mercury porosimetry for this gel (250 m^2/g) in this study allowed to better estimate the corresponding kinetic constant at 25°C. Other experiments in progress at different final temperatures (50, 75 and 100°C) will allow defining this constant as a function of the temperature.

Moreover, the pH of the Bouillante geothermal fluid is estimated to be close to 5.3 ±0.3, at 260°C, in the reservoir conditions. If this parameter, very influent on the kinetics of silica deposition, can be preserved at values less than 7 during the re-injection of the production fluids in the ground at relatively high temperatures (150 - 160°C), it is strongly probable that no chemical treatment is necessary to avoid silica precipitation.

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POSTERS : GEOTHERMY

. 25 Études mathématiques et numériques pour la modélisation des systèmes hydrothermaux. Applications à la géothermie

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Avec la centrale de Bouillante, la Guadeloupe possède le seul site français de géothermie haute énergie conventionnelle. Le principe de fonctionnement est simple : des forages de production artésiens permettent la remontée naturelle d'une saumure à haute température. En surface la baisse de pression entraîne la vaporisation du fluide produit. Vapeur et eau sont ensuite séparées. La vapeur qui emmagasine une partie du contenu

énergétique du fluide est turbinée pour la production d'électricité. L'eau chaude n'est pas exploitée. Une partie est rejetée à la mer après refroidissement, l'autre est réinjectée dans le réservoir.

Le réservoir est un milieu perméable (roches fracturées) rempli d'une saumure dont les conditions de température et pression sont très variables. La présence de fumerolles en surface atteste que certaines zones sont diphasiques sur le pourtour du champ, aux conditions atmosphériques. Lorsque l'on considère la source de chaleur du système hydrothermal, on doit prendre en compte des gammes de température et pressions pouvant aller jusqu'à 1000°C et une centaine de MPa avec un fluide potentiellement supercritique.

Le problème est défini par les équations de conservation de la masse et de l'énergie, par la loi de Darcy et par les lois d'état obtenues à partir d'une implémentation libre des tables d'état IAPWS-IF97 (Freesteam). On rajoutera ultérieurement une loi de conservation du sel et les tables thermodynamiques associées pour modéliser le comportement de la saumure exploitée à Bouillante. On a choisi comme variables principales la pression et l'enthalpie pour des raisons de stabilité par rapport aux lois d'états. Les équations étant essentiellement hyperboliques on a retenu des schémas volumes finis pour la discrétisation.

À ce jour nous testons différentes méthodes dans le but de comprendre le comportement des équations dans le cadre de la mise en place du champ géothermal à l'échelle géologique (« état naturel » du champ).

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. 26 Occurrence of epithermal breccias in the Bouillante geothermal field (Basse Terre – Guadeloupe) - Part 1

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Surficial mineralogical markers of recent geothermal activity were carried out around Bouillante (Guadeloupe, French West Indies). Until lately, most mineralogical parageneses identified in this area were typical of low temperature alterations (< 100°C) with the occurrence of dioctahedral aluminous smectites accompanied by zeolites ± calcite ± silica ± kaolinite, as an evidence of the caprock of the geothermal system. Recently, numerous samples of highly silicified breccias containing high temperature minerals have been identified in the Bouillante Bay (Anse Marsolle). Their petrographic study reveals several hydrothermal parageneses typical of distinctive alteration facies:

Stage 1) An early potassic alteration facies typical of high temperature epithermal systems (mesothermal-epithermal transition zone, > 320°C) is characterized by adularia + quartz + pyrite. Adularia is evidenced both in the clasts (replacement) and cement of these breccias. It is associated with quartz whose textural properties evidenced fracturing associated with boiling. This alteration is related to highly saline fluids.

Stage 2) An advanced argillic alteration facies with the occurrence of jarosite, gypsum ± silica associated with an intense acidic alteration (H_2S oxidation) as usually observed in the upper part of epithermal systems worldwide as marker of previous ebullition.

Stage 3) An argillic alteration facies (illite/smectite mixed layers ± smectite ± calcite). Typical of temperature lower than 200°C, this alteration facies is associated with near neutral fluids of mainly meteoric origin as known in the present geothermal reservoir. This alteration is the later one as evidenced by petrographic observations.

These results highlight assemblages and mineral textures characteristic of high temperature hydrothermal alterations in epithermal context. Such breccias are the first surficial evidences of high temperature hydrothermal activity in this area. They can be considered as indicators of a deeper hindered hydrothermal system, the origin of which needs to be elucidated, particularly regarding its relationships with the present geothermal system.

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. 27 First Ar-Ar dating of the high temperature epithermal breccias in the Bouillante geothermal field (Guadeloupe, French West Indies) – Part 2

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Samples of highly siliceous breccias containing high temperature minerals have been identified recently in the Bouillante Bay (Anse Marsolle; see Patrier-Mas *et al.,* and Bouchot *et al.,* this conference), *ie* in the present day Bouillante geothermal field. Single minerals of adularia (160 – 315 μm) from this high temperature epithermal system were extracted from three samples of breccias (BO19-K4, BO19-K6 and BO19-K11) and investigated in ^{40}Ar-^{39}Ar geochronology.

The irradiation was performed with a duration of 1h with Cd shielding in 5C position at McMaster University Reactor (Hamilton, Canada) along with the calibrated standard ACs (Alder Creek sanidine; age = 1.194 Ma). The adularia grains were loaded in a copper plate by sets of about 50-60 grains per hole for multigrain aliquots analyses. Gas was extracted with an infrared continuous laser and analysed with a mass spectrometer VG 3600 working with a Daly detector system.

8 samples from the BO19-K4 were analysed with total-fusion method on multigrain aliquots, 2 samples from BO19-K6 and 2 samples from BO19-K11.

All the argon isotopic results indicate an important atmospheric contamination for the adularia crystals (up to 80 %). This atmospheric contamination is probably due to the hydrothermal conditions, and makes the Ar-Ar dating more difficult given that pure radiogenic ^{40}Ar is less defined. Furthermore, the $^{36}Ar/^{40}Ar$ vs $^{39}Ar/^{40}Ar$ inverse isochron diagram indicates for adularia from the BO19-K4 breccia (n=8) a well-defined age of 248.0 ka ± 50.0 ka (2□, MSWD = 0.3), with initial $^{40}Ar/^{36}Ar$ ratios of atmospheric composition (309.0 ± 12 (2□)) attesting that this age is valid. Adularia from BO19-K6 yields concordant ages. In the other hand, fragments of BO19-K11 breccias give younger ages that must be redefined.

The age of 248.0 ka ± 50.0 ka is thus considered to date an epithermal event in Basse-Terre, related to the magmatic activity of the Bouillante volcanic Chain (~500,000 years ago) or to the magmatic activity of the La Soufrière volcano (300,000 to 200,000 years ago). This data constitutes the first radiometric dating of hydrothermal system in the Lesser Antilles arc.

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SESSION: GEOSCIENCES EDUCATION AND GEODIVERSITY

. 28 Séismes vécus : 2 films court-métrages relatent des expériences croisées sur les Saintes (2005) et L'Aquila (2009)

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Les témoins racontent le moment du séisme du 6 avril 2009 à L'Aquila - Italie
Année : 2009. Durée : 10'58. Langue : italien sous-titré soit en français soit en anglais

Film réalisé à la suite de la mission scientifique française de l'Association Française du Génie parasismique.

Cinq témoins livrent deux mois plus tard, leur témoignage sur la catastrophe qu'ils ont vécue en direct, frôlant la mort pour certains.

Comment décrire le tremblement de terre qui n'a duré que quelques secondes interminables ? Comment affronter un séisme majeur lorsqu'on est unijambiste ? Comment appliquer les consignes de sécurité connues lorsqu'on n'a pas la force de bouger ? Une fois sorti des décombres comment s'y prendre sans lumière pour dégager les survivants qui crient dans la nuit ? Comment la construction parasismique ou le renforcement d'un bâtiment protège ses occupants ? Quel héritage laisser à son enfant quand on a sa maison récente lézardée ?

Le lundi 6 avril 2009 à 3h32, dans un pays développé, l'Italie, la région de L'Aquila a été frappée par un puissant tremblement de terre : magnitude 6.3, profondeur 10 kms environ, plus de 300 morts et plus de 1500 blessés.

Un an après le séisme de novembre 2004, les Maires des Saintes témoignent
Année : 2005. Durée : 5'36. Langue :français

Le film a été réalisé et présenté pour l'anniversaire du séisme au sein du Ministère, en ouverture de l'Allocution de Madame Nelly Ollin, Ministre, et de son annonce du lancement du Plan Séisme Antilles.

Le film propose les regards croisés des chefs d'édilités des deux communes voisines de l'épicentre, Terre-de-Bas et Terre-de-Haut, aux Saintes, un an après le séisme de novembre 2004 qui a affecté particulièrement ces deux communes. Ce sont deux visions différentes d'un même événement.

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. 29 Actions towards seismic risk mitigation in Martinique, French Antilles.

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The French Antilles (French West Indies) are located within a high seismic hazard zone. In 2007, the French Government has launched the French Antilles National Earthquake Plan to reduce the vulnerability of people and buildings in these islands.

In Martinique, actions regarding public information are implemented by the Réplik group (‘Réplik’ means ‘aftershock’ in French) since 2006. Actions include events and innovations which intend to raise awareness among the public: theatre skits, prevention caravan and earthquake simulator, conferences, posters and plastic arts exhibitions related to earthquakes, specific goodies, information stands in fairs, TV and radio spots, information in companies during working hours, training courses for construction professionals and recently a specific internet site dedicated to the local actions.

The seismic hazard mitigation policy also consists in actions regarding the vulnerability of previous buildings and lifelines or infrastructures. The seismic diagnosis (and their potential capacity to be reinforced) of public primary and high schools has begun; based on this inventory, several retrofit or strengthening projects to the seismic standards are now launched, with techniques adapted to the local context. On a scientific point of view, a regional evaluation of coastal exposure to tsunami has been completed and seismic microzonations are currently being implemented in several districts.

Surveys and observations outline a growing knowledge demand and preparedness concern from the community and from the local representatives. However, despite these initiatives, surveys about preparedness

appropriation and the low number of retrofit projects suggest that there is still much to do towards seismic risk mitigation in Martinique.

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. 30 Tuned in to the Earth from the classroom with 'Sismos à l'Ecole' the french educational seismological network

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In lines with diverse initiatives regarding scientific culture and education, the 'Sismos à l'Ecole' experience (http://www.edusismo.org) has set up a permanent educational network of schools in the french caribeans islands, building an exchange of knowledge on natural risks prevention.

The "Sismos à l'Ecole" innovative project, managed by 'Sciences à l'Ecole', is established after 12 years (1996-2008) of regional and national original programs for education. The programme is born to promote a responsible behavior of citizens in front of the evolution of a society where scientific information is promptly available.

Since 2006, a school network in central America has been equipped with seismometers sensors of an educational vocation. The data on the ground motion recorded in the schools and processed by the students are collected on dedicated servers and then made available through internet to the entire community.

This network, once installed, is the starting point of activities for students. Indeed, various general objectives are pursued:

- To promote the applied sciences and new technologies.
- To put in network the actors of Education and formative teaching.
- To develop the sense of the autonomy and the responsibility in the young people.
- To reinforce and develop relationships with regional partners of the educational and university fields.
- To support a rational awakening for the prevention of the natural risks

Teachers from this network can share experiences and produce new didactic tools for the classroom. This collaborative work could illustrate the conjugated efforts of researchers and teachers for a better education and awareness of the risk culture especially in young populations. Some student's and teacher's productions will be shown to appreciate this essential effort.

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. 31 Teaching Geology in the French West Indies. From scientific results to pupil's conceptions.

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In Guadeloupe, the school and high-school teachers are lecturing within a specific environment. Volcanic activity, earthquakes, coral reefs, hurricanes, even tsunamis are relevant subjects, here. Of course, these are not all daily issues in Mainland France, 6500 km away. Obviously, these educators must receive an initial and/or permanent formation that makes them able to deal with these items. To solve these epistemological problems, one needs to contextualize the teachers's formation. Here, we present some examples of pupil's conception in Earth Science, as well as teacher's practice, to enlighten the necessity for the teachers to adapt their professional activity to the local environment, within the general frame of national requirements. Some theoretical and applied solutions have been experimented in Guadeloupe. Efficiency in the contextualization of the teaching is shown to be strongly dependant to research, both in Earth Science and in Education. Diffusion of scientific results must then be supported by specialized media, accessible to local educators. These media may come in the various forms (books, periodicals, conferences, e-learning…). Then, permanent formation of the teachers should involve field based tutoring, in order to help them appropriate their environment.

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. 32 Les représentations d'élèves de Guadeloupe sur la géothermie. Relation entre connaissances scientifique et opinions.

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Si la production d'énergie renouvelable solaire, éolienne et géothermique est bien développée en Guadeloupe, il n'en est pas de même de l'éducation au développement durable dont la mise en place est récente. Issu de travaux portant sur les mécanismes de contextualisation des savoirs scientifiques, l'enquête exposée ici vise à caractériser les conceptions d'élèves de CM2 sur la géothermie en fonction de deux contextes : le contexte géologique dans lequel ils vivent et celui de la classe. L'objectif est d'estimer les relations entre les connaissances scientifiques des élèves et leurs opinions sur la géothermie. L'impact de l'opinion de l'enseignant sur celles de ses élèves est également mis en question. Cette recherche qualitative s'appuie sur un questionnaire s'adressant à 62 élèves de CM2 (10 ans) de Guadeloupe et sur deux entretiens semi directifs d'acteur locaux de Bouillante ayant des avis contradictoires sur les nuisances et les atouts de la géothermie. Trois conclusions limitées à cet exemple peuvent être tirées des résultats obtenus : premièrement les connaissances des élèves sur la géothermie sont étroitement liées aux lieux de vie des élèves. Deuxièmement, l'avis sur l'intérêt de la centrale géothermique est lié à la fois aux lieux de vie et aux connaissances scientifiques qu'ont les élèves sur la géothermie. Troisièmement, l'avis des élèves sur la géothermie ne reproduit pas l'avis des enseignants mais les avis des élèves sont plus tranchés dans les classes où l'enseignant est engagé. La détermination de l'opinion des élèves sur cet exemple semble donc soit être plus influencée par le contexte familial que par le contexte scolaire, soit se construire plus nettement, par accord ou par opposition, face à l'implication de l'enseignant.

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. 33 The changing role of the uwi geology museum: from repository to an interactive learning environment.

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The University of the West Indies Geology Museum (UWIGM) established in 1961 was, and still is, the only museum of its kind in the English-speaking Caribbean. It is currently situated on the ground floor of the De la Beche Building of the Department of Geography and Geology at the University of the West Indies, Mona Campus.

The role of the UWIGM has changed over the years largely due to the promotion of the earth science and curriculum changes within Jamaican school system and the need for teaching and learning resources. In the 1960's when the museum was established it served as a research repository for the then Department of Geology, but now through its collections and museum education programmes has been able to provide a learning environment not only for students of geology, but for students of other disciplines as well.

The museum promotes science and geoscience education by providing opportunities for students to be active participants in their learning through the manipulation of real objects in an enabling environment with a multimedia technology-based interface. The museum provides curriculum support by hosting organized visits and tours for primary, secondary and tertiary level students and teachers from schools and colleges in Jamaica; seminars and workshops for teachers and children as well as summer science camp activities.

This paper seeks to share information on object-based learning at the UWIGM and how it is used to promote the sciences; teach complex topics; and provide a learning environment for non-science disciplines.

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. 34 Patrimoine Géologique de la Guyane : une démarche d'inventaire et de valorisation en cours de réalisation

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BRGM Orléans (1), BRGM Guyane (2)

La Guyane française appartient au bouclier des Guyanes, vaste ensemble géologique limité au Nord par l'Océan atlantique et au Sud par le Bassin de l'Amazone. Il s'étend sur 900 km de large du Nord au Sud et sur 1800 km d'Est en Ouest.

Régionalement, plus de 90% des roches sont datées du Paléoprotérozoïque, les plus anciennes formées vers 2,2 milliards d'années et liées à l'ouverture d'un océan ayant séparé les boucliers archéens d'Amazonie et d'Afrique de l'Ouest. Ce sont les plus vieilles roches de France…Après une longue période sans évènement jusque vers 200 millions d'années, la Pangée se fracture et des filons et coulées volcaniques se mettent en place sur les bordures de ce qui deviendra l'Océan Atlantique. En Guyane, des filons, très nombreux, sont observés, recoupant toutes les formations paléoprotérozoïques.

A partir du Crétacé supérieur mais surtout de l'Eocène, les phénomènes d'altération tropicale façonnent les paysages en pénéplaines successives séparées de grandes phases d'érosion. Les cuirasses latéritiques constituent les produits principaux de ces altérations chimiques intenses. Enfin, au Quaternaire, sous l'effet conjugué des variations du niveau marin, des apports des produits d'érosion des fleuves régionaux et de l'Amazone, le littoral de Guyane a enregistré une série de phénomènes sédimentaires successifs sablo-argileux.

Si la notion de patrimoine naturel a fait son apparition dans la loi de 1976 relative à la protection de la nature, elle a toutefois pendant quelques décennies davantage concerné la biodiversité que la géologie. Ce n'est qu'en 1991, qu'a été actée la prise de conscience officielle pour la protection d'un patrimoine géologique, à travers une « *Déclaration internationale des droits de la mémoire de la Terre »,*mais l'inventaire national n'a officiellement été lancé qu'en avril 2007.En Guyane, il a démarré en 2010, avec une première phase consacrée à la frange littorale et 39 sites remarquables répertoriés ;une seconde phase prévue en 2011 se focalisera sur le sud de la région, notamment sur le territoire du Parc amazonien de Guyane. Au total, plus de 130 sites ont été recensés qui mériteraient potentiellement d'en faire partie.

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. 35 Géodiversité, inventaire et protection en Caraïbe : le cas de la Guadeloupe, département français d'Amérique.

L. Legendre[1]

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Essentiellement consacrée, lors de sa mise en place (1976), au monde vivant ou aux paysages, la protection du patrimoine naturel français englobe également depuis septembre 2000 tout ce qui concerne les matériaux de l'écorce terrestre : roches, minéraux, fossiles, sites importants pour la compréhension de l'histoire de la terre. Pour mettre en œuvre ce nouveau type de protection, il convient de réaliser, dans un premier temps, l'inventaire de ce patrimoine, cette géodiversité. En Guadeloupe, Direction régionale de l'environnement et BRGM en ont commencé la réalisation en concertation avec les scientifiques de l'UAG et de l'OVSG. 33 géosites remarquables ont été sélectionnés.

Parmi ces sites, certains font déjà l'objet d'une protection au titre du Code de l'environnement français : le volcan de la Soufrière, les Mamelles et les chutes du Carbet se situent dans le périmètre du Parc national de la Guadeloupe, le Pain de Sucre des Saintes et la Pointe des Châteaux se trouvent dans des site déjà classés. D'autres en revanche présentent un caractère patrimonial d'intérêt régional avéré et ne sont ni mis en valeur ni protégés. Tel est le cas de la pointe est de l'île de la Désirade : pillow-lava et radiolarites forment les anciens témoins d'un probable arc volcanique datant du Jurassique terminal, cas unique dans les Petites Antilles. C'est pourquoi la Direction de l'environnement de Guadeloupe a proposé à la commune de Désirade la procédure de mise en réserve naturelle nationale de cette partie du littoral (affleurements sur falaises basses). Il s'agit de la première expérience de ce type pour l'Outre-mer français.

Il est proposé aux géologues ici présents, intéressés par ce type de patrimoine naturel, de pouvoir comparer les différents outils d'inventaire et de protection existant, dans la Caraïbe afin de dégager des pistes de coopération et de mise en valeur de la géodiversité caribéenne.

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POSTERS : GEOSCIENCES EDUCATION AND GEODIVERSITY

. 36 Inventory of the geological heritage of France's Overseas Departments: the Guadeloupe and Martinique example

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The BRGM, within the framework of one of its basic assignments which is the acquisition and dissemination of geological information, has been engaged for several years in drawing up inventories of the rich geological heritage of France's Overseas Departments.

The inventories are compiled according to a methodology defined at the national level by the Standing Conference of Geological Heritage (CPPG). They are carried out under the supervision of this body and the regional authorities, and are based on a local network of professional and amateur information collectors.

The inventories aim to register, describe, illustrate and georeference outstanding geological sites and objects (deposits, structures, rocks, minerals, fossils, etc.), as well as landscapes that illustrate particular morphologies or events, plus museographic locations and collections.

The instruction of these sites and objects is in the national GEOTOPE database.

The actions in Guadeloupe and Martinique are the continuation of what has already been done in French Guiana, Réunion and Mahore. In order to respond as efficiently as possible to local demand, the BRGM's Regional Geological Surveys work in close collaboration with the Department of the Environment, Planning and Housing (DEAL) and the Regional Geological Heritage Commission (CRPG) on the two islands.

The inventories also meet complementary aims. They fall under a policy of environmental conservation and also constitute the base for multi-support valorisation. In Guadeloupe, a map of outstanding sites has been drawn up, whilst in Martinique, as in Guadeloupe, a guide of geological curiosities is being considered in the short term.

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. 37 Le risque sismique en Guadeloupe : conceptions d'élèves.

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Comme toutes les îles des Petites Antilles, la Guadeloupe est située au cœur d'une zone de convergence entre la lithosphère océanique de l'Atlantique et le plateau océanique Caraïbe. L'aléa sismologique y est par conséquent élevé. Plusieurs séismes ont frappé les Antilles récemment, occasionnant des pertes matérielles et parfois humaines (Les Saintes, 21 octobre 2004, Mw=6,4 –BCSF- ou la Martinique, 29 novembre 2007, Mw=7,3 –OVSM-). Par ailleurs, la vulnérabilité est importante en Guadeloupe (ancienneté du bâti, constructions en zones inadéquates ou liquéfiables, non respect des normes, sous-dimensionnement de structures portantes…). De nombreuses campagnes de prévention et d'information (« SISMIK ») sous forme de spots télévisés, de tracts, de conférences, d'affiches… viennent compléter les actions éducatives menées auprès des élèves de primaire et de secondaire. En janvier 2010, le tremblement de Terre de Haïti et ses conséquences ont-il eu un effet sur le ressenti de jeunes guadeloupéens vis à vis du risque sismique ? Où en sont les connaissances dans ce domaine au sein de la population ? Dans cette étude, nous tenterons d'apporter des éléments de réponse à partir de l'analyse des différents programmes de médiation scientifique et d'enseignement, ainsi que de résultats d'analyses de questionnaires remplis par des élèves du secondaire. En particulier, nous analyserons la dichotomie entre la crainte liée aux tremblements de Terre ressentis en Guadeloupe, qui viennent rappeler à la population que le risque est réel, et l'effet de ressenti « rassurant » faisant penser que les séismes en Guadeloupe sont moins dangereux qu'en Haïti.

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. 38 The accumulation of Quaternary anthozoa (*Scleractinia*) in St-Félix (Guadeloupe, Grande-Terre) – proposal of protection

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Between St-Félix beach (Guadeloupe, Grande-Terre) and Gossier, in a seeshore area with mangrove growths the subfossil accumulation of redeposited anthozoa skeletons has been studied. The redeposited, detrital material is an evidence of copious live on the see bottom and – on the other hand – extraordinary energy of sea waves, which threw up the broken reef fragments onto the shore.

The fauna assemblage represents interesting and unique accumulation of *Scleractinia (Acropora, Diploria, Manicina, Montastrea, Solenastrea, Stephanocoenia, Dichocoenia, Meandrina, Agaricia, Siderastrea, Porites)*. Slightly more than ten species have been already identified and most probably detailed study will increase this number to several tens. The assemblage is composed of taxa common in the area of Antilles which represent forms living at various depth and three groups of corals participating in reef building (reef constructors of 1st, 2nd and 3rd order). The accumulation of anthozoa is the effect of one of cyclones which visited this area in 20th century.

It should be emphasized that the surroundings of the St-Félix beach deserve particular protection, owing to their extraordinary natural-landscape values. The landscape and numerous biotic and abiotic elements occurring at the relative small area, represent characteristic seashore features of the Grande-Terre island. The regional authority in cooperation with the Office National des Forêts established educational trail here, and the above described geosite can be the next stop on this trail. This geosite is an illustration of important process forming seashore deposits in the geological history of the Earth (whose results are recorded in sediments) as well as enables to acquaint with anthozoa specific for Antilles seashores (of Carribbean anthozoa province). Such scientific and educational values motivate protection of described geosite in the frame of legal power of local authority determined by French Nature Protection Act and subsequent legislations.

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SESSION : APPLIED GEOLOGY

. 39 Sequence Stratigraphic and Geodynamic Interactions in the North Cuba Basin: a Multidisciplinary Approach

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Hydrocarbon generation in the North Cuba Basin is primarily the result of thrust loading of proto-Caribbean Jurassic and Cretaceous source rocks during formation of the North Cuba fold and thrust belt in the Late Cretaceous to Palaeogene. Hydrocarbons migrated into complex structures in the mature fold and thrust belt, the foreland basin and potentially into the adjacent in situ and talus carbonate rocks of the Yucatan and Bahamas platforms (Schenk, 2010).

Recent work (Stanek, 2007; Pardo, 2009) has demonstrated that the various stratigraphic provinces of Cuba are the result of complex tectonic interaction between the sediments of the Late Jurassic to Early Cretaceous passive margins of the eastern Maya block and the North American Craton, and the pelagic sediments of the proto-Caribbean with the increasingly alkali volcanic arc rocks at the leading edge of the Great Arc of the Caribbean. Needless to say, the petroleum systems of the North Cuba Basin are complex and the need for a regional stratigraphic framework integrated with an explicit geodynamic reconstruction of the area is manifest.

An independent, global sequence stratigraphic model has been developed using the expansive datasets in the public domain (Simmons et al., 2007) that allows plate to plate and basin to basin chronostratigraphic correlation based on biostratigraphically constrained maximum flooding surfaces (MFS) and sequence boundaries (SB), facilitating a regional stratigraphic framework for the northern (proto)Caribbean. This stratigraphic framework has been integrated with a Geodynamic Reconstruction devised by University of Lausanne to produce palinspastically restored Gross Depositional Environment reconstructions. This multidisciplinary approach provides crucial insight into the lithostratigraphic relationships of complex structures in the fold and thrust belt, the foreland basin and the adjacent carbonate reservoirs, thus refining the exisiting and defining new play concepts in the region and crucially reducing risk.

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. 40 Estimates of Undiscovered Conventional Oil and Gas Resources of the Barbados Accretionary Prism

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The U.S. Geological Survey recently assessed the potential for undiscovered conventional oil and gas fields within the Barbados accretionary prism as part of a program of re-assessing the oil and gas potential of the Caribbean. Two assessment units (AU) were geologically defined in this study – the Inner Forearc Deformation Belt AU and the Main Accretionary Prism AU. The geologic model for the assessment is for oil and gas generated from Cretaceous and Tertiary source rocks within the prism to have migrated up faults and into the compressional structures of the prism, and possibly laterally into the margin of the prism adjacent to the undisturbed forearc sediments of the Tobago Trough. Source rocks include Upper Cretaceous marine shales and Paleogene marine and terrestrial mudstones and organics. Traps within the prism are varied, and include anticlines, faulted anticlines, folds, growth structures, and closures formed by mobile mud diapirs. Effective seals are the main source of geologic risk in the two assessments units. Reservoirs in traps are interpreted to be mainly deepwater, sediment gravity flow sandstones of the paleo-Orinoco system that were scraped and piled during subduction to form the accretionary prism. Several wells have been drilled onshore in Barbados to test similar reservoirs to the offshore and oil is produced from sandstone reservoirs at Woodbourne Field. One significant test well has been drilled in the offshore part of the prism. The Inner Forearc Deformation Belt AU was defined to encompass those structures of the accretionary prism that terminate in Tobago forearc sediments. The Barbados Accretionary Prism AU was defined to encompass all structures within the prism, including structures within the Barbados Ridge and Barbados Trough.

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. 41 Projet pilote de cartographie géotechnique de la zone de Frères à Port-au-Prince

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Dans le cadre d'un projet de coopération interuniversitaire entre d'une part l'Université d'Etat d'Haïti et d'autre part l'Université catholique de Louvain et l'Université de Liège financé par la Communauté française de Belgique, un projet pilote de cartographie géotechnique a été mené à bien entre 2005 et fin 2010. Les principaux objectifs de ce projet étaient de fournir un outil géologique et géotechnique contribuant à ordonner un développement urbanistique relativement anarchique et dans ce cadre à identifier des zones à risques naturels comme les instabilités de pente ou éboulis rocheux et à caractériser les sols présents dans la zone d'étude.

La zone cartographiée d'une superficie de 60 km² au Sud-Est de l'agglomération de Port-au-Prince a été choisie de façon à couvrir des zones différentes tant du point de vue géologique et topographique qu'urbanistique.

L'inventaire des informations disponibles est apparu fortement limité dès le départ : peu d'essais géotechniques ont pu être recensés. De nombreux essais complémentaires ont par la suite été réalisés par l'Unité de Recherche en Géotechnique (URGéo) mise sur pied dans le cadre du projet : outre des levés sur terrain et essais classiques de laboratoire, il s'agit de sondages ou tomographies électriques, de sondages sismiques réfraction et d'essais de pénétration dynamique PANDA pour lesquels le matériel a également été financé par le projet.

274 stations ont été implantées sur le terrain pour près de 450 essais. Cette campagne a permis l'établissement d'un atlas géotechnique composé de quatre cartes (carte géologique, carte d'occupation des sols, carte de localisation des essais et carte interprétative), d'une notice explicative et d'annexes reprenant les résultats des différents essais.

Seront aussi abordés certaines démarches plus particulières comme la représentation des résultats sur un outil comme Google Earth, comme la cartographie du risque géotechnique ainsi que l'apport d'URGéo dans la problématique de l'après séisme en Haïti.

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. 42 Seismic microzonations of municipalities in French West Indies

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3) BRGM Guadeloupe – Gourbeyre – Guadeloupe

Spatial variability of ground motion may be explained by local soil conditions; it is the so-called "site effects". Site effects are responsible for increasing duration and important amplification of strong ground motion during earthquakes and must be considered as a key parameter in local seismic hazard assessment. French West Indies are prone to strong site effects because of a particular geology, characterized by soft soil deposits and strong alteration of volcanic deposits.

In this framework, and considering that French West Indies are considered as a high seismicity level zone in the French building code, part of seismic hazard mitigation policy consists in technical studies to perform identification and mapping of zones characterized by homogeneous seismic response and quantification of associated ground motion. It is the aim of seismic microzonations.

In this presentation, we will expose the methodology used on the scale of municipalities for mapping homogeneous seismic areas, based on studies of geological and geotechnical conditions and some geophysical testings.

Then, the study of vulnerability of buildings allows to estimate the probability of damage on various sectors for a scenario of risk corresponding to the seismic microzonation.

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. 43 Comportement mécanique et rhéologie du sol de la formation géologique « Morne Delmas » en Haïti.

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Le développement urbain haïtien se fait de manière très spontanée. Les villes s'étendent sur les terrains sans planification préalable et dans des conditions sanitaires précaires. L'absence de réseau d'assainissement adéquat dans ces zones d'habitation, oblige les eaux usées à emprunter un réseau de canalisations naturelles (ravines, rigoles en terre, …). Ces eaux emportent les résidus huileux à la surface du sol et lessivent les déchets composés de détritus organiques, de plastique, de bout de métaux,…, rencontrés sur leur passage avant de pénétrer dans le sol.

L'objectif de cette étude est double. Dans un premier temps, il convient de déterminer les propriétés physiques et mécaniques d'échantillons de ce sol et dans quels sens celles-ci sont modifiées au contact de ces eaux. Le sol étudié a été prélevé dans l'agglomération de Port-au-Prince dans la formation géologique « Morne Delmas », une formation argileuse du Pliocène. C'est un sol à potentiel de gonflement moyen mais ce gonflement peut être amplifié au contact des eaux usées.

Un autre point traité dans cette étude est le comportement rhéologique du sol de « Morne Delmas ». L'argile étant un matériau viscoélastique, la rhéologie permet d'étudier l'évolution de son comportement sous des vibrations de basses fréquences. Le paramètre principalement ciblé est la viscosité ; elle diminue en fonction de la teneur en eau et de la nature des effluents en contact avec le sol.

Il est aussi possible, avec le rhéomètre, de déterminer le module de cisaillement du matériau à étudier. Cette valeur sera déterminée pour le sol de « Morne Delmas » et des corrélations seront établies avec le module de cisaillement déterminé (pour le même matériau) à l'aide des essais de cisaillement direct à la boîte de Casagrande. La possibilité de travailler avec le module de cisaillement déterminé par sismique réfraction (Vs) sera aussi abordée, cette technique étant à ces débuts en Haïti.

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. 44 3D resistivity mapping of volcanic islands

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The demographic explosion of many volcanic islands requires an urgent investigation of their subsurface in order to provide sustainable solutions to the increasing demand for fresh water and the management of natural hazards. Traditional geological studies and ground-based geophysical measurements are often of limited value due to the generally poorly outcropping, difficult access in the terrain and complex geological geometry.

In 2010, BRGM (the French geological survey) and the Prefecture of Mayotte decided to fund a geological mapping project involving a preliminary helicopter borne 3D resistivity survey of the island. A research agreement was signed with Aarhus University (http://www.hgg.au.dk) and SkyTEM (http://www.skytem.com) in order to use their dual-moment Time Domain Electromagnetic system (TEM) specifically designed for hydrogeological surveys with a resolution of the near surface geological layers previously accessible only by means of ground based geophysical techniques. SkyTEM can discriminate between weak conductivity contrasts in the top layers concurrently with those at depth and provides a detailed insight to understand the internal geological structure of the upper 200 m of the volcanic islands.

Mayotte is a french territory located in the northern Mozambique Channel in the Indian Ocean. Mayotte has an area of 374 km^2, and it is - like many other volcanic islands - very densely populated (> 500 inh/km^2). The terrain of the island is undulating, with deep ravines and ancient volcanic peaks culminating at 660m. Underground rocks and structures are hidden beneath thick soils densely forested and cultivated.

The contract between BRGM and the Prefecture of Mayotte was signed early august 2010 and the survey started October 9th with the arrival of a helicopter form the Reunion Island and of the geophysical equipment shipped by boat and air freight from Denmark. 72 flight hours allowed to survey 2915km flight lines, with 200 or 100m spacing and 40m ground clearance.

Good conductivity contrasts between the different rock types, allow to define the geometry of the principal geological units in 3D, up to 200m depth. Preliminary results are very promising and will be presented during the congress.

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. 45 Evolution et dynamique du trait de côte de l'archipel de la Guadeloupe de 1956 à 2004

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Les pouvoirs publics (Etat et Région) ont souhaité évaluer la dynamique du trait de côte de l'archipel Guadeloupéen au cours des 50 dernières années afin de comprendre les phénomènes en jeu à l'échelle régionale et établir un état de référence.

La méthodologie employée repose sur une approche qualitative des dynamiques littorales. Elle permet d'avoir une vision globale de la nature du littoral et des tendances associées, ceci afin d'identifier les sites considérés comme sensibles et devant faire l'objet d'études plus détaillées.

La caractérisation de la nature du littoral a été réalisée sur la base des documents cartographiques existants et d'observations de terrains, ce qui a permis d'obtenir 8 grandes unités littorales homogènes (ULH).

La dynamique et l'évolution historique du trait de côte ont été appréhendées par l'analyse des cartes et orthophotos disponibles. Cette analyse a permis de mettre en évidence un régime érosif général sur l'ensemble de l'archipel dont les facteurs principaux sont la lithologie des côtes, l'hydrodynamisme marin et les évènements météorologiques marquants.

Il apparaît que 62 % des 630 km de côtes sont stables ou en équilibre (évolution notable mais retour à l'état de référence), 25 % sont en érosion et 13 % en régime d'accrétion (d'origine anthropique pour moitié). L'ensemble des données et des résultats est rassemblé dans un SIG.

Des évolutions futures sont étudiées en tenant compte de la description du littoral, des évolutions récentes et des informations disponibles sur l'élévation du niveau marin en lien avec le changement climatique. Ainsi plusieurs secteurs de vulnérabilité aux risques côtiers sont identifiées (Sud Grande-Terre, Folle Anse, Petit et Grand Cul-De-Sac Marin,…). Plus précisément, une liste de 43 sites considérés comme sensibles a été dressée. 7 d'entre eux présentent de forts enjeux humains, environnementaux ou socio-économiques.

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. 46 Public Policy in Groundwater: Far from the Rhetoric, Closer to the Reality

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The absence of a Water Act and the lack of underground water policy in Colombia lead the authorities to creating stagnation in the development of the country, increasing uncertainty in the scientific communities, discouraging national private industry initiatives. It also tends to generate potential conflicts between neighboring municipalities and departments. Logically, this situation creates benefits only for investors who do not know the importance of water, specifically groundwater.

For several years some Colombian government agencies have sought to establish clear criteria for the extraction of water from aquifers for industrial, agricultural, public service and other uses. This article is based on hydrogeological studies and construction of groundwater wells in several areas of Colombia. In addition, a review of the results from several *National Development Plans* which showed and the failure of government agencies related to natural resources. Finally, I analyzed public policies of water that the local, departmental, and central governments have tried to be implemented; I did it through personal political analysis studies numerous years ago.

The environmental agencies of control, created from the Political Constitution of Colombia of 1991, called Regional Autonomous Corporations for each administrative division of the country, have not been able to establish clearly the mandates of the Constitution. The executive and legislative powers are limited to write documents called CONPES. However, during the political campaigns of the last ten years the people have heard promises for Water legislation. Today, a Water Act does not appear. The problem exists and the Water Act does not exist. As a result, it is necessary to establish a design, promotion, and implementation of water's public policies, which will be clear, specific, concrete, and easy to measure in order to protect groundwater resources, communities, and authorities as well. Those resources at are at risk to be privatized in the Water Departmental Plans as a local model plan of the uncertain development system because the local plans are not connected to each other. The privatization of groundwater in large tracts of land habited by people of many municipalities is a high risk for Colombian communities, especially after a very long armed conflict. Moreover, privatization of

groundwater can lead to the extension of illicit crops negative causing social effects. Social effects are known as serious level of concern for consumer countries.

As recommendations, public education policies of water through the creation of the University of Water will educate people. The distribution, use and protection of water through the creation of a specialized agency of the government should improve the living conditions of Colombians.

Key words: Groundwater, public policy, risk

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POSTERS : APPLIED GEOLOGY

. 47 Map of Mineral Resources in the Dominican Republic

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To encourage research and mining, the European Union, through its SYSMIN I and II, developed in the Dominica Republic thematic mapping projects between the years 1996-2010.

One of the thematic mapping carried out, were the Mineral Resources Map at 1: 100,000

These maps aim to provide and equip the country with an orderly and systematic knowledge of their mineral resources.

The work is done on the basis of geological mapping at 1: 50,000 with a defined methodology. Their results are and have been referred for exploration of mining companies and a management tool to design and develop programs in the field of mining and other sectors such as Environment, Territorial Planning and Infrastructure.

Different Mineral Resources shown on maps, is presented in terms of morphology, genetic and host rock.

The different groups are: metal ores, nonmetallic minerals, energy and Ornamental Rocks Minerals and Industrial.

The maps are accompanied by a corresponding report explaining in whose surrender is collected: Synthesis geological description of the mineralization, list of signs and metallogenic analysis.

It has covered almost the entire country with this type Topic.

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. 48 Mitigación de Potencial Conflicto entre Departamentos Colombianos por los Planes Departamentales de Aguas: Lejos de la Retórica, Más Cerca de la Realidad.

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El Plan Departamental de Aguas en Colombia parece ser un moderno generador de conflicto más que una oportunidad de cooperación entre algunos departamentos en la división político-Administrativa Colombiana. El modelo simplista de separar recursos naturales de acuerdo a la división administrativa, además de ser contraproducente, ignora la existencia de una geomorfología, hidrología, geología, e hidrogeología común entre dos o más Departamentos de Colombia. Un Plan Departamental de aguas debería ser desarrollado basado en un Plan de Ordenamiento Territorial (POT) de superficie y de subsuelo, más que en un concepto económico de servicio basado en la comercialización y privatización del agua. La privatización de los recursos naturales está negando en toda América Latina, la eficiencia administrativa de las agencias de los gobiernos y sus funcionarios. Algunos políticos, empleados administrativos, algunos científicos, y personas del común, se preguntan: ¿por que razón el POT debe contemplar el contenido subterráneo con los recursos naturales? Con esta pregunta están demostrando su desconocimiento y cuasi ignorancia administrativa, financiera, política, científica y técnica, a la vez.

La investigación se basa en experiencia personal como geólogo laborando en hidrogeología por más de veinte años a lo largo del territorio nacional colombiano y algunas de sus fronteras. Además, en una revisión de las publicaciones tanto legales, geológicas y técnicas, existentes en Colombia y otros países latinoamericanos. El artículo se basa en tres aspectos fundamentales, las cuales son: a) Es el Plan Departamental de Aguas en Colombia una oportunidad de progreso?, b) Es el Plan Departamental de Aguas en Colombia un generador de conflicto? y c) Debemos permitir la privatización de las aguas subterráneas que aparentemente son "invisibles" para las autoridades nacionales, departamentales y locales, pero bien "visibles " para las multinacionales?

Adicionalmente, se observa en los Planes Departamentales de Aguas en Colombia, que el individuo es un sujeto económico más que un sujeto social. De igual manera, el agua pasa de ser un recurso natural indispensable como fuente de vida, a convertirse en un producto puramente comercial. Lo peor, es que el agua pasa de manos de sus propietarios a manos de empresas transnacionales del negocio del agua. Se convierte el tesoro nacional en beneficio económico para extraños y deja de ser una rentabilidad social del gobierno.

Al no existir una voluntad social en Colombia de proteger el agua subterránea, se permite que los sectores privados se apropien de los yacimientos yo depósitos de agua subterránea, distrayendo la atención de la sociedad a través de mencionar el agua superficial como recurso principal de los Planes Departamentales de Agua. Las comunidades no tienen voluntad social porque no tienen un tejido social fuerte. El agua superficial, en algunas ocasiones, se encuentra contaminada y se cree que con entregarla al sector privado la recibirán descontaminada.

Palabras claves: Acuíferos, Plan de Aguas, Riesgo, Conflicto, Brío institucional, arrojo social.

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. 49 Carbon Capture and Storage – example from Poland

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Poland is one of the largest CO_2 emitters in Europe (about 310 millions tones of CO_2/year). Emissions of this gas come from burning coal. Country reduces CO_2 emissions mainly by improving energy efficiency, diversify energy sources, and increase the use of renewable energy sources. It is considered to capture CO_2 from the combustion gas and storage it in geological structures (Carbon Capture and Storage - CCS). Launched National Program: *Assessment of formations and structures for safe CO_2 geological storage, including monitoring plans* is to provide to the Ministry of Environment information necessary for decisions on the granting of concessions for exploration and development of potential storage sites in accordance with the requirements of EU directives.

Poland represents on the European scale exceptionally favorable conditions for underground carbon dioxide storage, it is connected with existence in Poland the thick (several kilometers of thickness) Permo-Mesozoic sedimentary rock complexes. It is considered to storage CO_2 in deep saline aquifers (the largest capacity), in deposits of oil and natural gas (depleted and EOR) and deep unexploited coal beds (ECBM). Potential 36 structures (anticline structures) for CO_2 geological storage in Poland in saline aquifers are located in Mesozoic aquifers in Polish Lowland.

The largest CO_2 emitter in Europe (from coal burning) - Bełchatów Power Station in Poland builds a demonstration CCS plant (start 2015). It is to be integrated with a newly built block with a capacity of 858 MW (annual CO_2 emissions - 1.8 Mt). Geologists have pointed out three possible structures for underground CO_2 storage, each with a capacity allowing to storage this gas for 30-40 year. CCS project pursued by the Power Station was granted 180 million euros under EEPR grant.

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. 50 Dessarrollo de los estudios geotematicos y el Servicio Geologico Nacional en Republica Dominicana

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Hablar de estudios Geotemáticos en Republica Dominicana anterior al año 1996, era un tema muy poco tratado, porque todo se enfocaba únicamente a la cartografía geológica, sin tocar los temas de los Recursos Minerales, la Geomorfología, Geoquímica y los Procesos Activos Geológicos, hay que recordar que el proyecto con el Servicio Geológico Alemán (BGR) y la Dirección General de Minería (DGM) iniciado en los años 80s se centralizó en la realización de los mapas geológicos a escala 1:100,000 de las zonas de San Juan y Comendador, además del cuadrante de San Cristóbal a escala 1: 50,000. Otro producto en formato de papel fue el Mapa Geológico de la Republica Dominicana, a escala 1:250,000, publicado en el año 1991.

El Programa SYSMIN en Republica Dominicana financiado por la Unión Europea para países ACP (África, Caribe y Pacifico) fue iniciado con el objetivo de dotar a estos países de una base infraestructural de información, que posibilite el desarrollo del sector Geológico-minero. El primer programa SYSMIN I se inició en el año 1996 concluyendo en el año 2000 con los resultados del Proyecto de "Cartografía Geotemática en Republica Dominicana" con unas 12 hojas geológicas a escala 1:50,000 de los cuadrantes Bonao, Constaza y Azua, además de otros proyectos de base de información geocientifica. Una segunda fase de SYSMIN I continúo en el año 2002 hasta el año 2004 del cual resultaron otras 35 hojas geológicas a escala 1: 50,000, incluyendo además, los Mapas Geomorfológicos, Geoquímica, Recursos Minerales y Procesos Activos Geológicos a escala 1:100,000.

El SYSMIN II se inicia en el año 2006 y termina en el 2010, uno de los objetivos principales de este programa es la creación del Servicio Geológico Nacional mediante una Ley, y que este fortalecido con presupuesto y personal técnico calificado, otro objetivo es completar la cartografía geológica a escala 1:50,000 de todo el país, convirtiéndolo en uno de los pocos en tener esta cartografía completa. Toda esa información estará disponible en el Servicio Geológico Nacional (SGN), creado mediante la ley 50-2010 como un organismo autónomo, descentralizado adscrito al Ministerio de Economía, Planificación y Desarrollo.

Palabras Claves: Cartografía Geotemàtica, Cartografía Geológica, Geoquímica, Recursos Minerales, Geomorfología, Procesos Activos Geológicos, Servicio Geológico Nacional.

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. 51 Atlas por provincias del potencial geologico-minero de la Republica Dominicana

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El Servicio Geológico Nacional de la República Dominicana, está desarrollando el Proyecto denominado "ATLAS DEL POTENCIAL GEOLOGICO-MINERO DE LA REPÚBLICA DOMINICANA", que tiene como principal objetivo promocionar, orientar y poner en conocimiento de la administración del Estado, de la sociedad dominicana y de los inversionistas promotores en los recursos geológicos-mineros, los indicios minerales y las rocas ornamentales, localizados en todo el territorio dominicano. Estos puntos y zonas con potencial económico, se referenciarán en los mapas regionales, provinciales y municipales, con el interés en potenciar económicamente cada renglón.

Objetivos del Proyecto:

1. Dar a conocer y promover los recursos geológicos-mineros, en cada una de las Provincias.
2. Mejorar la situación ambiental de la minería en la República Dominicana y contribuir al desarrollo sostenible y sustentable.
3. Pretender que la actividad minera en la República Dominicana sea solidaria, esté ordenada territorialmente, regulada y formalizada, rentable y genere valor agregado.

ESTE PROYECTO VA DIRIGIDO A: Instituciones de la administración del Estado Dominicano, específicamente a los implicados en la planificación del ordenamiento territorial, a entidades y organizaciones locales, provinciales y profesionales del sector geológico-minero e inversionistas nacionales e internacionales.

ALCANCE DEL TRABAJO: El alcance del trabajo se estima que será de un total de 427 indicios, tanto para los yacimientos metálicos y los no metálicos, de todas las provincias de la República Dominicana.

METODOLOGÍA DEL TRABAJO.

Para poder representar de forma homogénea, toda la información de los indicios y/o yacimientos de minerales metálicos y no metálicos (Rocas Industriales y Ornamentales), obtenidas dicha información del Catastro Minero de la República Dominicana y de los Mapas de Recursos Minerales, a Escala 1:100.000, realizados dentro de los Programas de Desarrollo Geológico Minero "Proyecto de Cartografía Geotemática", realizados por los Programas (SYSMINs), Convención Lomé IV, se han desarrollados varias fases de trabajo:

- Diseño de Fichas Técnicas

- Diseño de Base de Datos
- Diseño del Formato de Edición
- Alimentación de la Base de Datos

De esta forma se elaboró una base de datos georeferenciada, en un Sistema de Información Geográfica (GIS).

Por operatividad y mejor aprovechamiento de los datos, se diseñaron bases de datos específicas e independientes para las rocas industriales y ornamentales y otra para el resto de los yacimientos e indicios de interés económico.

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. 52 Etat des connaissances sur le Lac Azuei ou Etang Saumâtre (Haïti). Importance écologique de cette ressource hydrique.

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Les écosystèmes lacustres subissent régulièrement les contrecoups des catastrophes naturelles. Pourtant, il aurait simplement fallu prendre des mesures pour leur suivi régulier**.** Il s'agit, pour le moment, de définir les responsabilités conjointes pour préserver les riches écosystèmes aquatiques situés notamment dans les bassins Azuei et Enriquillo de l'île d'Haïti. Il est aussi question de réhabiliter les régions placées dans l'environnement de ces écosystèmes, suite aux déséquilibres de ces sites naturels occasionnés par les inondations de septembre 2007 à février 2008, de la remontée du Lac Azuei lors du séisme du 12 janvier 2010 et, à la fin de décembre 2010, de la mort de nombreux poissons attestant d'une situation d'asphyxie et de pollution de l'eau de ce lac. Les rapports jusqu'ici élaborés en font largement état. Ils montrent clairement que le Lac Azuei doit être protégé. Le défi devient de préserver ce site plein d'avenir et les espèces animales et végétales, pour la plupart endémiques, qui s'y réfugient. Cette synthèse réunit l'essentiel des informations sur le Lac Azuei en vue d'une meilleure approche de sa problématique. Les idées des auteurs semblent s'accorder pour lier l'augmentation du niveau de l'eau du Lac Azuei, origine des inondations des années 2007, 2008 et de janvier 2010, à diverses causes, notamment aux très fortes pluies des cyclones, à l'érosion des sols et la déforestation et, dans l'ensemble, à la géodynamique interne, la modification des paramètres physico-chimiques de l'eau du lac, et vraisemblablement au phénomène d'infiltration à partir des fosses communes, non-protégées par des tissus géotextiles, situés du côté de Titanyen, au N-O de Port-au-Prince, autrement dit de la dégradation quasi-totale de l'environnement physique de la région etc. Des idées-forces capables d'orienter les décideurs en ce qui concerne l'évaluation des besoins et la gestion globale de cette ressource ont été finalement émises.

Mots clés : lac Azuei, pollution, écosystème, inondation, hydrogéologie, environnement.

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. 53 Mineralogical and geotechnical characterization of dredged sediments from the canal Bois-de-Chêne (Port-au-Prince, Haiti).

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The management of sediments raises more and more important technological, economic and environmental challenges. These sediments are especially constituted by fragment of calcareous and detrital rocks accumulated in the canal. They also contain waste resulting from industries, from the draining of engines etc., susceptible to have fatal consequences on the environment and the health of the local residents. The realized mineralogical, geotechnical tests and chemical analyses report their essentially carbonated nature and they are poor in physical and mechanical quality. However, this work can make a considerable contribution to the reduction of the environmental impacts due to the existence of sediments polluted in the urban community of

Port-au-Prince, strengthens the idea to envisage the use of sediments of the canal Bois-de-Chêne as building materials for common usages.

Keywords: sediments, mineralogy and chemistry, geotechnical, construction, environment.

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SESSION: GENERAL GEOLOGY

POSTERS : GENERAL GEOLOGY

. 54 Reproducing phyllosilicate textures found in the fine-grained matrices of the CM2 carbonaceous chondrites.

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Fine-grained materials in the CM2 carbonaceous chondrites can make up over 30vol% of the meteorite. In the most primitive CM chondrites, the fine-grained silicates are dominantly composed of amorphous non-stoichiometric materials. With increasing levels of aqueous alteration, the amorphous materials are progressively replaced with phyllosilicates. In order to better understand the relationship between amorphous silicates and the formation of phyllosilicates, a series of hydration experiments were conducted, using amorphous silicates produced at Goddard SFC. These "smokes" are vapor-deposited in an apparatus especially designed to approximate conditions in our early solar nebula.

Mg-smokes show an immediate reaction to H_2O, forming a viscous gel. The hydrated smokes were characterized by TEM. After 24 hours' exposure to H_2O, Mg-smoke is an amorphous gel, its initial particulate nature having been obliterated. As early as 2 days in contact with water ~50nm crystallites appear. In the subsequent time steps the crystallites grow more resistant to the e- beam. At 10 days, the crystallites are stable enough to image the lattice spacing,0.7 nm, consistent with the mineral serpentine. By 4 months, intergrown mats of phyllosilicates were observed, similar in texture to those reported in moderately to highly altered CM2 chondrites.

The immediate reaction of Mg-smoke with H_2O implies that there is no pristine unhydrated amorphous material remaining in chondrite matrices. Amorphous gel remains the dominant phase throughout the Mg-smoke experiments and the resistance of Fe-smokes to hydration could explain how amorphous material survived aqueous alteration of the parent-body asteroid.

After exposure to distilled H_2O for 6 months, Fe-smokes show no textural changes. However, Fe-smokes can be hydrated when mixed with Mg-smokes; the rate of hydration is directly related to the Mg:Fe ratio. This dependence on the Mg:Fe ratio suggests that a thermodynamic barrier exists and that with heat, the activation energy of hydration can be overcome.

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. 55 Biostratigraphy and Lithostratigraphy of the Middle and Late Jurassic Rocks West of Binalud Range Northwest of Neyshabour, Northeast of Iran

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Upper Jurassic rocks are well developed at the western part of the Binalud Range (northeast Iran). These consist mainly of limestone, marlstone and marl with few intercalations of sandstone and conglomerate. The thickness of this succession in the study section (Bormahan, at northwest of Neyshabour) is 1084 meters and it can be subdivided into 6 members. The lower boundary with the dark siliciclasts of ?Kashafrud Formation (Upper Bajocian / Lower 4 Bathonian) is sharp. The upper boundary with buff and cliff-forming carbonates of the ?Mozduran Formation (Upper Jurassic) is transitional. Ammonites are the most important and abundant macrofossils.Totally more than 300 specimens have been collected, comprising 21 genera and 36 species.The relative abundances at the family level are: Phylloceratidae (48%), Perisphinctidae (42%), Oppeliidae (6%), Haploceratidae (2%), Aspidoceratidae (1%) Based on the ammonite fauna 15 biozones are recognized which can be fairly good compared with the ammonite biozonation of Sub-Mediterranean Province. According to the ammonite fauna an Early Bathonian to Kimmeridjian age is proposed.The ammonite fauna is closely related to those of the Sub-Mediterranean Province, indicading a permanent faunal exchange.

Key words: Binalud, Bormahan, biostratigraphy, lithostratigraphy, Jurassic, Ammonite

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. 56 Understanding temperature and pH conditions during aqueous alteration of the CM2 carbonaceous chondrites

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The CM2 carbonaceous chondrites are known and characterized by the phyllosilicates in their fine-grained matrices. Numerous researchers have observed various quantities of amorphous non-stoichiometric silicate materials. In fact, at this time, the amount of amorphous materials is being used to ascertain the level of alteration sustained by the individual CM chondrite and compare the relative amount of alteration between meteorites. The best available analogs of amorphous non-stoichiometric silicates are being produced by Dr. Joseph Nuth at Goddard Space Flight Center). Previous workers have reacted these smokes to distilled water in time steps from 1 day to 6 months and were able to reproduce similar phyllosilicate textures as those observed in the CM chondrite ALH81002. Therefore, these smokes could have been incorporated into primitive meteorites and that the current secondary minerals grew as a result of contact with an aqueous fluid.

We measured temperature-time series and pH-time series data as a result of experimental hydration of different Fe-smoke ratios and of mechanical mixtures of Mg-Si-O and Fe-Si-O smokes, with an OakTron pHTestr30 meter every 10 seconds for 30 minutes. Similar to previous theoretical calculations performed on compositions similar to the CM carbonaceous chondrites, hydration of the Mg-smokes results in the fluid becoming alkaline immediately and converging on a pH of ~10.4 in less than 30 seconds, forming sub-millimeter bubbles immediately following the addition of water. The lower the water:smoke ratio has the more alkaline the solution becomes. Alternatively, hydration of Fe-smokes at different ratios results in the fluid becoming increasingly more acidic down to ~4.0 in less than 30 seconds depending on the smoke ratio. The lower the Fe:Si ratio in the smoke the less acidic the solution becomes. The water:smoke ratio in the Fe-Si smokes does not markedly affect the pH and temperature of the reaction.

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. 57 Minéralisations uranifères liées aux dépôts greseux du Dévonien Inférieur du Bassin de Tin Seririne OUA N'AHAGGAR, HOGGAR, ALGERIE.

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Le bassin de Tin-Seririne, prolongement septentrional du bassin de Tin-mersoi (Tassili Oua' N Ahaggar), faisant partie intégrante de la plateforme saharienne, est le siège d'une importante concentration des minéralisations radioactives. Les travaux de recherche antérieurs y ont mis en évidence les indices de Tamart-N-Iblis et Timouzeline Les travaux de recherche menés pendant une décennie par les équipes du CREM dans cette région ont mis en évidence un certain nombre d'indices et d'anomalies uranifères liées essentiellement à des formations détritiques de la série sédimentaire du dévonien inférieur**.** L'uranium encaissé dans les grés « uranium des grés » est le gîte qui fournit prés de 20°/o de l'uranium dans le monde (Jebrak et Marcoux 2008).L'histoire de ces gisements remonte à la première moitié du vingtième siècle, où les minéralisations uranifères ont été découvertes en Colorado et étaient reconnu aussi pour ses grandes ressources en radium et en Vanadium.

Mots clés : Bassin de Tin Seririne, Timouzeline, Dévonien inférieur, Arkoses, Minéralisations Uranifères

La région étudiée appartient au domaine des grés externes du Paléozoïque inférieur du Bassin de Tin Séririne. prolongement septentrional du bassin de Tin-mersoi (Tassili Oua' N Ahaggar). Ce bassin est constitué de deux flancs : un flanc Est avec une sédimentation tabulaire relativement stable, un flanc Ouest très structuré témoignant du rejet de l'accident régional In Abégui en différentes phases de la mise en place de la couverture sédimentaire et une partie Nord (périclinal Nord) sur élevée témoignant de la remobilisation des accidents Tahifet et Issalène syn. et post mise en place des formations du Dévonien inférieur.

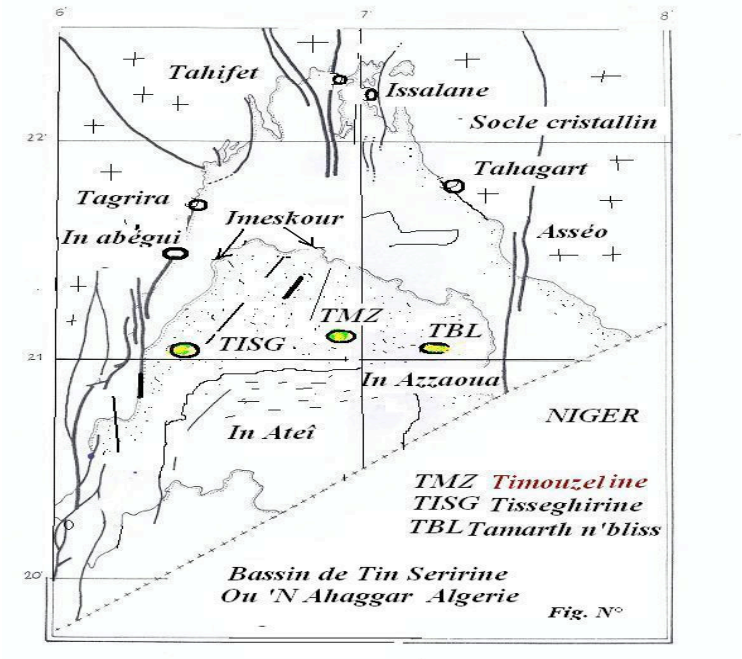

Fig. 1 Esquisse structurale du bassin de Tin Seririne

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SESSION: PETRO-GEOCHEMISTRY AND HISTORY OF THE CARIBBEAN

. 58 The Caribbean domain by the late Palaeozoic time.

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Previously to the opening of the Atlantic Ocean, the Caribbean domain was occupied by several blocks, most of them coming from the Gondwana margin. Some originated from the South America western margin and others from the West African margin.

The main "criterion" to differentiate them is the age of their basement. A "grenvillian" age (circa 1000 Ma) is though to be of South American origin and a "Birrimian" (circa 2000 Ma) or "Panafrican" (circa 600-to 500 Ma) is supposed of African origin.

However, due to a very complicated geological history for both Laurentia and Gondwana continents this is not enough consistent. Really, some "grenvillian" ages have been reported on the present West African margin (Villeneuve et al, 2005).

So, the location of the "Rheic" Ocean separating the West African Craton from the North American Craton, before the Variscan orogen, is badly constrained. Many authors set this ocean within the Appalachian belt, but others (Villeneuve et al, 2010) locate it within the Senegalese basin basement and within the Western Saharan belt (Moroccan Sahara).

In another hand, the occurrence of a large "Neoproterozoic" ocean (West African Neoproterozoic Ocean) closed by the Middle Cambrian time could disturbed the previous models devoted to the Variscan accretionnary process in the Caribbean domain.

New data allows us to propose a new scenario for the accretion of Paleozoic "terranes" by the Early Permian period in this area.

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. 59 Is the Beata Ridge the cause of the bending of the structures in Central Hispaniola? (The Hispaniola Swing)

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A striking morphotectonic feature of central Hispaniola is the marked bending of major structures such as the Bonao Fault from N70^{0}W to N45^{0}W in its southern-most end. Two geomorphic features that follow this trend in the south central part are the Sierra Martín García and Sierra de Ocoa and two important geological units, namely the Tireo and Peralta Formations also follow the same curvature. Slightly to the north of the Bonao Fault, the Hispaniola Fault Zone, which includes the Caribe serpentinized peridotite, bends slightly from the same N70°W trend to about N40°W. The foliation and other structures in the Maimon belt follow this trend. Thrusting to the north along the Hatillo thrust and parallel faults has brought the Maimon and other units, such as the Los Ranchos, containing ore deposits formed in different environments, into close juxtaposition. We invite discussion as to how these structures formed, by suggesting that most, if not all, of the features can be explained by interaction of the Beata Ridge with the oblique convergence between the North American and Caribbean Plates. The Beata Ridge is a narrow, elongated and rigid thick oceanic crustal structure situated quasi perpendicular to the current North American – Caribbean plate boundary at Hispaniola, in such a way, that it has

acted as a "pivot" point for the portion of Hispaniola north and northeast of the Enriquillo-Cul de Sac basin. The Beata Ridge seems to be also responsible for the bending toward the north, along the southwest boundary of the Muertos Accretionary Prism (Muertos thrust belt), as it joins, and is apparently continuous with, the San Juan – Los Pozos Fault Zone. The authors do not present these ideas as a solution to the tectonics of this area, but as a point of discussion.

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. 60 La Sierra Nevada de Santa Marta y la Serranía de Perijá, Colombia y Venezuela: ¿Son resultado de la convergencia entre la placa Caribe y el margen suramericano durante el Neógeno Superior?

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La Sierra Nevada de Santa Marta (SNSM) limita hacía el sureste con la cuenca Cesar – Ranchería, una cuenca del tipo retroarco, que a su vez limita al sureste con la Serranía de Perijá, la cual se ubica en la frontera entre Colombia y Venezuela. La SNSM, la cuenca Cesar – Ranchería y la Serranía de Perijá están limitadas por la Falla Santa Marta - Bucaramanga (FSMB) al suroeste, la Falla de Oca al norte y la Falla de Perijá – el Tigre al sureste, definiendo un complejo orogénico piramidal.

Con información geológica y geofísica regional junto con datos de sensores remotos, se propone que el complejo orogénico se originó como resultado del acrecentamiento durante el Neógeno Superior del Bloque Costa Rica – Panama – Chocó (BCRPC) con la esquina noroccidental de Suramérica. El ajuste final durante el Neógeno Superior de la placa Caribe entre Norteamérica y Suramérica, produjo la activación de grandes sistemas de fallas corticales como la Falla de Oca – Morón – El Pilar en Colombia y Venezuela al sur, y las Fallas Motagua – Walton - Enriquillo - Plantain Garden para el sector que corresponde a Guatemala, la fosa de Caimán , Jamaica y la Isla de La Española, al norte, originando un nuevo desarrollo en la subducción de la placa del Pacífico al sur y el oeste del BCRPC, que dio lugar al desarrollo de la actual configuración de las placas de Nazca y la Dorsal de baja expansión de Galápagos. Desde el Plioceno Inferior se reactivaron la FSMB y la Falla de Oca. La primera con un movimiento relativo lateral izquierdo y la segunda con un movimiento relativo lateral derecho. Al ocurrir esto último comenzó a crecer el macizo montañoso produciendo el estilo orogénico actual de éste sector de los Andes del norte.

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. 61 The Ocean Drilling Program around the Caribbean Sea

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Results of scientific exploration around the Caribbean Sea have been published for 5 Legs of the Ocean Drilling Program, 78, 110, 156, 166 and 171.

Forthcoming expeditions in 2011 will continue exploration in the region.

From 15 March to 13 April 2011, during this conference, Leg 334, the Costa Rica Seismogenesis Project, will core and log two slope sites to examine processes that control large earthquakes in this erosive margin.

Leg 336 will begin in Barbados on 16 September 2011 and end on 19 November in the Azores. It will investigate the Central Atlantic subseafloor biosphere in observatories at three sites through biological, geochemical and hydrological experiments, coring and logging.

Proposal 656 will investigate reefs of Belize.

Proposal 681 will explore volcanism in Martiniqe, Dominica and Montserrat.

Key words: IODP, Caribbean Sea, Central America, Central Atlantic, seismicity, volcanism, coring, logging, biosphere.

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. 62 Late Cretaceous pelagic and arc-derived sedimentation in the S-Nicoya Peninsula, Costa Rica

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Outcrops of the Nicoya area represent a collage of Mesozoic oceanic terranes that became assembled during the latest Cretaceous-Paleogene. Three units have been recognised: (1) the Nicoya Complex s. str., a highly deformed mélange of pre-Campanian plateau-like igneous rocks that extruded and intruded into Middle Jurassic to Santonian Ribbon Radiolarites; (2) the Matambu Terrane, a pre-Albian oceanic basement covered by hemipelagic/turbiditic Late Cretaceous sediments, and (3), the Manzanillo Terrane, a pre-Turonian oceanic basement covered by Coniacian-early Campanian arc-derived deep-water sequences, cropping out in the eastern Nicoya Peninsula and on the eastern side of the Nicoya Gulf.

This study focuses on pre-Campanian pelagic/hemipelagic and arc-derived siliceous deposits cropping out in the southern Nicoya Peninsula. New paleontological and geochemical data suggest that these sequences are no older than Coniacian. The Late Cretaceous radiolarian-bearing siliceous mudstones discussed here imply that these outcrops belong to the late Turonian- early Campanian Berrugate Formation and not to the Albian Loma Chumico Formation as thought by previous authors.

Green decimetric, fine-grained tuffaceous turbidites of dacitic to rhyolitic composition may represent a distal equivalent of the plurimetric mass flows of the type area of the Berrugate Formation in the Nicoya Gulf. Incompatible element patterns normalized to primitive mantle yield characteristic island arc signatures with relative Nb-,Ti-, and P- depletions and Pb-enrichments, identical to those from the Berrugate mass flows.

The occurence of the Berrugate Formation in the southern part of the Nicoya Peninsula indicates that this area is in paleogeographic continuity with the Gulf area and belongs to the Manzanillo Terrane.

The Manzanillo Terrane represents a paleo-fore-arc setting that receives sediments from a Late Cretaceous (Late Turonian- early Campanian) island arc, that predates the late Campanian-Maastrichtian Golfito island arc, and was located east of the modern Nicoya Gulf. This arc is probably buried beneath the Neogene-Recent volcanic arc.

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. 63 Early Jurassic alkaline basalts in the Santa Rosa Accretionary Complex (Santa Elena, Costa Rica): Petit spot volcanism within an old pacific plate

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The Santa Rosa Accretionary Complex (SRAC) crops out beneath the Santa Elena Ultramafic Nappe, part of the Mesquito Oceanic Terranes forming a mafic/ultramafic oceanic basement of N-Costa Rica and S-central Nicaragua. The SRAC contains mostly ribbon radiolarites associated with trench fill sediments. Radiolaria recovered from bedded radiolarites or blocks in breccias/megabreccias range in age from Early Jurassic to early Late Cretaceous (early Pliensbachian to earliest Turonian). A major volume of the SRAC is made of alcaline basalts that occur both as km-thick units of massive and pillowed flows and thinner units in which early-middle Pliensbachian - early Toarcian ribbon radiolarites are intruded by numerous alcaline basalt sills. Green amphiboles of both sills and massive flows have recently yielded well-defined $^{40}Ar/^{39}Ar$ plateau ages of 176.9±0.9 to 173.9±0.5 Ma (late Toarcian/Aalenian). These ages confirm the field evidence that basalts intruded into not much older, soft sediment. Whole rock, poorly defined $^{40}Ar/^{39}Ar$ ages of the same basalts indicate a thermal event around 120-130 my, possibly corresponding to initial accretion and the influence of the Nancite primitive island arc complex which has the same the structural position as the SRAC. Layered gabbros of Nancite yielded a 124.0 ± 4.0 Ma (Barremian/Aptian) $^{40}Ar/^{39}Ar$-date.

The steep primitive mantle–normalized REE-element plots of the SRAC alcaline basalts are identical to those of « petit spot » lavas recovered from young intraplate volcanoes of the Pacific Plate off NE-Japan. Geochemistry of these petit spot volcanoes supports a depleted (nonplume) mantle source. Vesicular lavas are interpreted as incipient partial melts, that formed in the asthenosphere in the presence of volatiles (probably

CO_2). The emplacement of these lavas to the surface was controlled by brittle, tectonic fracturing of an old (cold) lithosphere in areas of plate flexure, either due to loading by seamounts or subduction-related bending. The occurrence of such lavas in the SRAC represents the first example of accreted petit spot volcanism. Late Early Jurassic ages of these petit spot volcanics would imply their formation on a considerably older paleo-Pacific ocean floor – still older than the Rhaetian (200 Ma) radiolarites recovered at El Castillo (S-Nicagragua) and the DSDP 84 OIB-like rocks dated < 220 Ma.

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. 64 Mesozoic Ribbon Radiolarites of the Caribbean Plate: Remnants of Pacific Ocean Floor.

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Mesozoic Ribbon-bedded radiolarites occur in the Antilles in oceanic mélanges and as original cover of ancient ocean floor of variable petrogenetic origin, such as MORB (Duarte Complex, Dominican Republic) or in back-arc settings (La Désirade, Guadeloupe). Radiolaria, now studied from many localities, date these rocks as Middle Jurassic (late Aalenian) to early Late Cretaceous (middle Cenomanian). Along the Pacific façade of Central America ribbon radiolarites commonly occur in accreted terranes and range in age from Late Triassic (Rhaetian) to Late Cretaceous (Coniacian-Santonian).

Early Jurassic to Early Cretaceous ribbon-bedded radiolarites are widespread in Tethyan and circumpacific orogenic belts, but they are unknown from the Atlantic, the Gulf of Mexico and the Venezuelan Mesozoic passive margin. Mesozoic radiolarites formed in detritally starved, oceanic areas beneath moderate to high surface productivity, such as many areas of Tethys and the Paleo-Pacific. The Jurassic-Early Cretaceous Central Atlantic – Proto-Caribbean seaway was a "mediterranean" sea rich in detrital sediments along its margins, but of low surface productivity, resulting in clay-rich (below the CCD) and/or calcareous pelagic facies throughout. The Early Cretaceous rock forming productivity of nannoconids, thought to be oligotrophic, is restricted to this seaway. It contrasts markedly with ongoing radiolarite production in the circumpacific realm.

We consequently interpret the Mesozoic radiolarite occurrences associated with the Caribbean Plate as remnants of Pacific ocean floor, some of which may have been formed in arc-related settings off the Western American Margin. Radiolarian assemblages display either broadly defined low-latitutde (= "Tethyan") affinity, or show more specific marginal "upwelling" (= "boreal") characteristics. These differences do not allow for a palaeo-latitudinal interpretation, but rather suggest a palaeo-longitudinal displacement from the Eastern Pacific and/or the western American Margin into their present position in Central America and the Eastern Caribbean. This interpretation supports an allochthonous, Pacific origin of the Modern Caribbean Plate.

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. 65 Discovery of Lower Cretaceous syn-metamorphic thrust tectonics in French Lesser Antilles (La Désirade Island, Guadeloupe): Implications for Caribbean geodynamics

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We present and discuss the discovery of syn-metamorphic thrust tectonics in the La Désirade island. Based on detailed structural analysis we evidenced two main compressive events. The first event (D1) is characterized by pervasive folding associated with thrust development. In the northeastern part of the island, a major thrust fault, the Grand Abaque Thrust, has been discovered which displaces for several kilometers the acid igneous complex onto the ophiolitic unit. The second deformation event (D2) is featured by a main pervasive cleavage S2 observed at the regional scale associated with upright folding (F2) and by the development of two sets of conjugated steeply dipping strike-slip shear zones, respectively dextral N130° and sinistral N20° striking. Micro structural observations indicate that Greenschist facies metamorphism is clearly contemporaneous with the development of D1 and D2 superimposed tectonic structures. Ar/Ar geochronology was performed on two bulk of adularia minerals sampled in the northeast volcanic complex within a deformed zone related to D2 event. These analyses yield well defined and concordant plateau ages at 106.2 ± 1.7 My and 107.2 ± 1.8 My. Thus, shortening and thickening tectonics occurred during Lower Cretaceous (Albian). In the available framework of

Caribbean geodynamics, the syn-metamorphic thrust tectonics we discovered in the French Lesser Antilles is related to the collision between an Aptian-Albian oceanic plateau and the Andean/Cordilleran east-dipping subduction zone. Our results support subduction polarity reversal during Lower Cretaceous.

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. 66 New radiometric ages for the basement of La Desirade Island (Guadeloupe, Lesser Antilles)

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Located east of Guadeloupe archipelago, the island of La Desirade exhibits the oldest rocks of the Lesser Antilles arc and the eastern Caribbean plate. An old magmatic basement is composed of (1) late Jurassic ophiolitic complex with pillow-lavas and interbedded radiolarites, (2) plutonic complex with quartz-rich diorites, (3) acid volcanic complex comprising rhyolitic lava flows and (4) diabasic/microdioritic dyke swarm complex.

Our petrological data show that a greenschist facies metamorphism is widespread in the entire basement rocks, as previously underlined by Westercamp (1980). This metamorphism has been previously interpreted as ocean-floor hydrothermalism and /or as back-arc related metamorphism in relation with the dyke swarm complex emplacement during Oligocene (Westercamp, 1980; Maury et al., 1990). Unfortunately, greenschist facies metamorphism is difficult to date because related metamorphic minerals are not available in classical geochronology. In order to approach the ages of the metamorphism, sericites (plagioclase destabilization) or whole rocks (for dykes) were investigated for ^{40}Ar-^{39}Ar geochronology.

Our geochronological ^{40}Ar-^{39}Ar results, as well as our structural investigations (see Lardeaux *et al.,* this conference), support a radical revision for the origin of the greenschist metamorphism.

Preliminary ^{40}Ar-^{39}Ar results on microdioritic dyke samples (except dykes from the ophiolitic complex) yield ages ranging from 82 to 91 Ma: they are no longer related to an oligocene magmatic event. Sericites separated from plutonic complexes (metagabbro in the ophiolitic complex and meta-diorite complex) give Ar-Ar ages ranging from 109.5 ± 2.0 Ma to 124.2 ± 1.8 Ma, defining the time interval for greenschist facies conditions. The rhyolitic lava flows (anorthoclase) from the Grand Abaque unit give for the first time an age of 149.3 ± 5.5 Ma.

This geochronological data were discussed along with geochemical data in order to propose a geodynamical model for this unique carribean jurassic basement.

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. 67 New constraints on the tectonostratigraphy, geochemistry and radiometric ages of the Panamanian Cretaceous – Paleogene volcanic arc.

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The geological evolution of Panama is directly related to the Farallon Plate subduction beneath the Caribbean Plate during Cretaceous-Paleogene times. This subduction generated a volcanic arc on the westernmost margin of the Caribbean Plate. Although recent studies provided new insight into the origin of the Caribbean plate, the onset of the volcanic arc and its time-space evolution is still unresolved.

The present work focuses on the Panamanian Cretaceous – Paleogene volcanic arc and its forearc basin, cropping out in the Azuero Peninsula, (SW Panama). A tectonostratigraphic study based on field and geochemical data, and complemented by biostratigraphic and radiometric (Ar-Ar) dating is presented.

The Azuero Peninsula is constituted by four major units summarized in the Río Quema stratigraphic section (Central Azuero Peninsula): (1) the Azuero Igneous Basement (AIB), a volcanic series characterized by a tholeiitic differentiation trend and by a flat or slightly enriched pattern in terms of trace elements, typical of plateau-like affinities. (2) the Azuero Primitive Volcanic Arc (APVA), a volcanic and volcanosedimentary series of tholeiitic character, showing a flat trace element pattern with enrichment in fluid mobile elements (e.g. Ba and Sr) and depletion in Nb and Ti, representing an intermediate trend between plateau-like and volcanic arc affinities. (3) The Arc group, composed of the Río Quema Formation, (69.7±1.2 Ma; RQF sensu Corral et al., in press) and the quartz-diorite batholiths of “el Montuoso” (68.8±0.9 Ma) and “Vallerico”, (54.8±1.2 Ma) and their related volcanic rocks, characterized by calc-alkaline character with trace element content, typical of

volcanic arc. (4) The Tonosí Formation, an Eocene - Oligocene sedimentary sequence unconformably overlapping all previous units.

Biostratigraphic and radiometric dating together with geochemical data indicate that a primitive tholeiitic volcanic arc (APVA) was developed on an oceanic plateau (AIB) and evolved over time to a calc-alkaline volcanic arc (Arc group) during Cretaceous - Paleogene times.

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. 68 Paleomagnetic Study of Cretaceous Arc Terranes in Central Hispaniola: Paleogeographic Implications

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We present results of a paleomagnetic study conducted on Lower and Middle Cretaceous arc volcanic and volcaniclastic rocks of Hispaniola that was undertaken to test Caribbean plate kinematic predictions and provide paleogeographic constraints for this region of the Greater Antilles. Unweathered outcrops that are suitable for paleomagnetic samples are notoriously difficult to find in the tropics, however we succeeded in obtaining quality results from six sites. Four sites from the Upper Cretaceous Tireo Group yield a positive fold test and give a mean direction of Dec = 320.7°, Inc = 19.1°, k = 98.3, a_{95} = 9.3°, and a corresponding paleolatitude of 9.8° +5.3°/ -4.9°. Comparison of the observed Tireo Group paleomagnetic pole with the 100 Ma North American reference pole indicates anticlockwise vertical axis rotation of 31.9° ± 9.1°, and northward transport of 10.9° ± 8.8°, with respect to the North American plate. Two sites from the Lower Cretaceous Los Ranchos Formation differ significantly from the Tireo Group results, although the lack of sufficient sites for the Los Ranchos precludes the calculation of a mean direction. Although these results are few in number, when placed in the context of the existing paleomagnetic results from the Caribbean/North American plate boundary region, they support a consistent pattern of northward translation and anticlockwise rotation that occurred prior to the Eocene.

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. 69 Thermotectonic history of metamorphic rocks in the Blue Mountain inlier, Jamaica.

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Two fault-bounded sequences of metamorphic rocks are exposed in the Blue Mountain inlier in eastern Jamaica. Westphalia schist is dominated by hornblende schist (locally garnetiferous) and mica schist, with volcanic and sedimentary protoliths. Mt. Hibernia schist consists of blueschist and greenschist, with predominately basaltic protoliths. We present new $^{40}Ar/^{39}Ar$ whole rock ages and trace element data that clarify the origin of the protoliths and the timing of metamorphism. Westphalia schist is geochemically variable with basaltic to andesitic compositions, enriched in LREEs, with pronounced negative Nb, Ta, and Ti anomalies. Mt. Hibernia schist shows little chemical variability, with subalkaline basaltic compositions, essentially flat REE patterns, and no Nb, Ta, or Ti anomalies. Tectonic discrimination diagrams indicate a calc-alkaline subduction-related, island arc environment for Westphalia protoliths, and indicate a MORB environment for Mt. Hibernia protoliths. Details of the Mt. Hibernia schist trace element geochemistry are consistent with eruption (MORB) in an ocean-plateau province (i.e., CLIP). Clearly, Westphalia schist and Mt. Hibernia schist have very different protoliths. However, in terms of 36 of 39 analyzed elements, Mt. Hibernia metabasalts are geochemically indistinguishable from nearby ~90 Ma basaltic rocks of the Bath-Dunrobin Formation. The exceptions (3 of 39 elements) are Ba, Sr, and Mn. We suggest that Mt. Hibernia schist is the metamorphosed equivalent of Bath-Dunrobin basalt.

New whole rock $^{40}Ar/^{39}Ar$ ages for Westphalia schist (71-72 Ma) and Mt. Hibernia schist (58-60 Ma) are generally consistent with previously determined K-Ar ages for hornblende (77 Ma) and biotite (49-53 Ma) from Westphalia schist. Stratigraphic constraints require two distinct episodes of metamorphism: (M1) late Cretaceous subduction-related, and (M2) Late Paleocene/Early Eocene transtensional-related burial

metamorphism. We hypothesize a clockwise P-T path (cool subduction, hot exhumation) for M1, and a counter-clockwise P-T path (hot burial, cool uplift) for M2.

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. 70 Cr-spinel composition and platinum-group minerals from placer deposits associated with ultramafic-mafic intrusives in the Loma de Cabrera batholith, Dominican Republic: Comparison with ophiolites and Alaskan-type complexes: a preliminary report

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An ultramafic-mafic intrusive complex forms a significant part of the Loma de Cabrera (LDC) tonalite batholith in the western Cordillera Central, Dominican Republic. The ultramafic rocks (dunites, harzburgites, lherzolites, and pyroxenites) form centers enclosed by gabbros, gabbro-norites, pyroxene-rich gabbros, hornblende gabbros, and amphibolitized gabbros. The ultramafic rocks are massive bodies in outcrop but show typical cumulate magmatic textures. Gabbros show rare layering as well as cumulate textures. Samples of heavy mineral concentrates were taken by panning from close to the ultramafic bodies. Cr-spinel from samples of the placer deposits display a large range in composition. Cr# [Cr/(Cr+Al)] varies from 0.51 to 0.83 corresponding to a Cr_2O_3 content of 31-56 wt.% and an Al_2O_3 content between 8-22wt%. Fe_2O_3 (up to 25 wt.%) and TiO_2 (up to 1.8wt.%) are high. Compositions of Cr-spinel from dunites fall within the range found in the placers. $Fe^{2+}/(Fe^{2+}+Mg)$ in Cr-spinel from dunites varies from 0.25 to 0.74 (with MgO up to 7.96 wt%). Small grains (<10 microns) of idiomorphic to subidiomorphic PGM are included within the Cr-spinel grains from the placer deposit samples. Their qualitative compositions indicate that they include native platinum. These features of the Cr-spinel mineralogy and PGM association correspond closely with that found in the Alaskan-type of ultramafic-mafic rock suites in the Urals. However, the LDC rocks contain orthopyroxene and their major and trace element compositions differ significantly from the corresponding rock types of the Uralian Alaskan type which characteristically lack orthopyroxene. Compositions of the minerals in the mafic and ultramafic rocks in the LDC suite differ significantly from those in ophiolites and in particular from those in the El Caribe ultramafic belt in the central Dominican Republic. The Loma de Cabrera ultramafic-mafic rocks can be regarded as a primitive suite formed deep in the root of the arc in its early stages of formation.

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. 71 Early Cretaceous arc formation and crustal inheritance in central Cuba: geochemistry and age of the Los Pasos Formation

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Recent studies on the early Cretaceous (~136-125 Ma) Los Pasos Fm., provide important clues on the early development of the Caribbean island-arc system. Eleven unfoliated samples of volcanic rocks and five

intrusive rocks genetically related to the arc sequence were collected throughout the unit. For the volcanic rocks the εNd(t) values (+7.8 to+8.7) are consistent with a juvenile origin. Zircons from a dacite and a basaltic andesite collected from the lower part of the sequence did not reveal the age of volcanism but only contained inherited zircons suggesting a crustal source. The dacite yielded concordant zircons ages at ~237, ~257, ~999, and ~1930 Ma, whereas zircons from the basaltic andesite produced concordant ages at ~530, ~754 Ma, and ~1097 Ma. High Th/Nb and low Ce/Pb ratios are also compatible with a recycled crustal component, in contrast, the remarkably positive εNd(t) values suggest an entirely juvenile source. The εNd(t)-values (+5 to +6) of our intrusive samples are again consistent with a juvenile source. A relatively high Th/Nb ratio again hints at crustal material. Magmatic zircons from a granite intruding an unfoliated granodiorite within the Los Pasos unit yielded a mean age of ~88 Ma with zircon inheritance at 120, 490, 778 1000, 1800, and 2160 Ma, while zircons from the granodiorite yield an intrusive age of 125 Ma with one inherited grain at 769 Ma. The age of 125 Ma places a younger age limit to the Los Pasos Fm. and corroborates its old nature. It also confirms that the Mabujina complex and Los Pasos Fm constitute different crustal entities. Furthermore, it indicates a lack of correlation between Los Pasos Fm. with other early Cretaceous but younger arc rocks in the Caribbean. At 130 Ma the arc occupied a position close to continental areas in North, Central and South America that would potentially provide old zircons into an intra-oceanic trench.

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. 72 Fragments of a mantle plume in northern Dominican Republic : Garnet-ultramafic rocks in the Rio San Juan complex.

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Ultra high pressure (UHP) garnet-ultramafic rocks from the Rio San Juan complex in northern Dominican Republic may represent the only known example where such rocks were exhumed at an ocean-ocean convergent plate boundary, and where the protolith crystallized from a UHP magma (>3.2 GPa, >1500°C). Here, we consider the petrology and trace element geochemistry of the most unusual of these ultramafic rocks, pegmatitic corundum-spinel-bearing garnet-clinopyroxenite (Grt+Cpx+Spl+Crn+hornblende). Three texturally and chemically distinct types of garnet are recognized: **Type-1 garnet** (low Ca, high Mg; ave. $prp_{23}grs_{31}sps_{01}alm_{45}$) is interpreted as near magmatic (P>3.2 GPa, >1500°C). **Type-1' garnet** (high Ca, low Mg; ave. $prp_{12}grs_{42}sps_{01}alm_{45}$) is interpreted as having formed approximately isochemically from high-Al magmatic clinopyroxene. **Type-2 garnet** (intermediate Ca, high Mg, low Fe+Mn; ave. $prp_{23}grs_{36}sps_{01}alm_{40}$) and hornblende formed late as a result of low-pressure retrograde hydration. The observed clinopyroxene is close to diopside-hedenbergite (Mg# ~88; ave. $wo_{48}en_{44}fs_{06}jd_{02}$), and reflects reequilibration with hornblende at T<900°C. Spinel ($spl_{42}hc_{53}mt_{04}$; Cr below detection) and corundum occur as microinclusions in both type-1 and type-1' garnets. Coexisting Grt+Spl+Crn is indicative of very high pressure. Chondrite-normalized REEs (rare earth elements) of the garnets show humped or weakly sinusoidal patterns, typically associated with garnet inclusions in diamond and garnet in kimberlite. The humped and weakly sinusoidal REE patterns developed as the result of interaction with a light REE-enriched metasomatic fluid. Partitioning of REEs between type-1' and type-1 garnets is consistent with the former having inherited its REEs from a high-Al clinopyroxene predecessor. As such, the partitioning is consistent with near-solidus temperatures (~1475°C). Phase relationships and Grt-Spl thermometry independently indicate near-solidus conditions (~1500°C). These very high temperatures suggest an origin in a mantle plume. The Dominican garnet ultramafic rocks may represent exhumed fragments of the ancestral Galapagos mantle plume, widely accepted to be responsible for the Caribbean Large Igneous Province.

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. 73 Petrologic and Geochemical study of Culebra's Eastern Cays: Cayo Norte and Culebrita, Puerto Rico

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This investigation conducted quantitative studies of aphanitic and porphyritic lavas from Cayo Norte and Culebrita, both of which are eastern cay's of Culebra Island, Puerto Rico. Until the present day sub-quantitative studies have been the only measures for geological analysis of lavas of Culebra's cays. In order to build on previous works, petrographic studies of rocks in thin section and geochemical analyses by X- Ray Fluorescence (XRF) and Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) were made. Cayo Norte and Culebrita display similar morphologies, disequilibrium textures and matching mineral assemblages. Cayo Norte's aphanitic lava flows and pillows are in general silica-rich, ranging from 58 to 66 weight percent (wt. %) SiO_2 and are classified as trachy andesite in addition to trachyte/dacite. Mineral assemblages include abundant plagioclase (plag), clinopyroxene (cpx) and secondary minerals such as quartz, calcite, chlorite and opaque oxides. Culebrita's aphanitic lava flow and porphyritic pillow lavas are 54 to 55 wt. % SiO_2 and are classified as basaltic trachy andesite in addition to basaltic andesite. Magmatic disequilibrium textures seen largely in plagioclase crystals are pervasive. The resulting compositions from this study are almost identical to those collected previously on Culebra, the main island. Lava compositions are very similar to previous analysis by Adorno (2008) and Pérez (2009), possibility it would be the same event of lava extrusion. Geochemical analysis also prove the true rock type of the Culebra Andesites Formation , named by Banks in 1962, to be basaltic andesites.

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. 74 Co mineralization in the Falcondo's laterite deposits, Dominican Rep. (preliminary results)

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Nickeliferous laterites are an important source of Co and contain some of the world's largest reserves of this metal. In this work we present the preliminary results of a mineralogical study of the main Co mineralization present in the Falcondo laterite deposit, in the Dominican Republic.

In the profiles studied the Co mineralization is found associated with Mn phases, located in the upper part of saprolite horizon and in the limonite horizon. Mn phases are closely intergrown with Fe oxides, and have a low crystallinity.

In the saprolite horizon at Falcondo, Mn-Co phases replace pyroxenes, olivines and serpentines, following grain rims and/or fractures. The most abundant Co mineralization is present as asbolane $[(Co,Ni)_{1-y}(MnO_2)_{2-x}(OH)_{2-2y+2x}\cdot n(H_2O]$ and especially Ni-rich asbolane (up 4.3% Co weight and 12% Ni weight). Other Co-bearing mineral phases are heterogenite, intermediate products between lithiophorite and asbolane (up to 4.25% Co) and criptomelane. However, lithiophorite $[(Al,Li)MnO_2(OH)]$ a common phase in the oxide-type laterite deposits of eastern Cuba (Moa Bay), has not been identified yet.

The Mn-Co mineral distribution through the lateritized profile is a product of the variation in Eh and pH along the profile. In the laterite profiles at Falcondo, with a large development of the saprolite horizon (pH~8), there is a predominance of Ni-rich asbolane. On the other hand, in the profiles in eastern Cuba, with a well-developed limonite horizon (pH~6 in the lower limonite zone), predominant phases comprise intermediate products between lithiophorite and asbolane-lithiophorite. Therefore, the mineralogy of the Mn-Co phases shows the following sequence, from the saprolite to the limonite horizon: Ni-rich asbolane ⇨ asbolane-lithiophorite ⇨ lithiophorite.

In conclusion, the preliminary results indicate that the Co mineralogy in the laterite deposits depends on: (i) The depth to which they form within the weathered profile, associated with variations in pH (saprolite or limonite horizon) and (ii) original rock composition (Al content low or high), from which the deposits developed.

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. 75 Paleogene thrust emplacement of serpentinite in southwestern Puerto Rico

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In southwestern Puerto Rico, shallow-dipping fault contacts along the southern margins of the Monte del Estado and Río Guanajibo serpentinite bodies indicate southwestward thrust displacement of serpentinite. The serpentinite is thrust over deformed rocks of Yauco, El Rayo, and Sabana Grande formations, constraining the age of thrust emplacement to post Late Cretaceous. Structural analysis of faults, folds, and foliation within the serpentinite bodies reveals that most thrust faults occurred concurrently with left-lateral strike-slip faults and oblique slip faults, describing a strain regime of transpression. Transpression caused folding and tilting in Cretaceous and early Tertiary rocks as well as imbrication of the sequence. The contractional structures show orientations similar to fold hinges, thrust faults, and strike-slip faults recorded by strata of the Eocene Cerrillos belt. However, greater variability in the orientation of faults within the serpentinite, suggests a more complex deformational history related to structures formed prior to and during serpentinization. Thus, the episode of thrust faulting and southwestward emplacement of serpentinite ended in the late Eocene. Transpression was imposed upon serpentinite formed from Early Jurassic-Early Cretaceous peridotite obducted onto southwest Puerto Rico. Paleogene thrust emplacement of serpentinite is in contrast to earlier hypotheses that serpentinite was finally emplaced in response to diapirism or Late Cretaceous obduction during plate collision. Emplacement of the Monte del Estado and Río Guanajibo bodies is temporally different to serpentinite emplacement in nearby Sierra Bermeja (Puerto Rico), Duarte Complex (Hispaniola), Guatemala, and parts of Cuba, and mechanically different to serpentinite emplacement in northern Hispaniola. These differences may be related to a longer history of plate interactions, as well as spatial variations of pre-existing zones of weakness within the crust, fracture architecture, and rheology of serpentinized peridotites along the Caribbean-North American plate boundary.

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. 76 Cretaceous/Paleogene boundary deposits and paleogeography of western and central Cuba at the time of the Chicxulub asteroid impact event.

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The Cretaceous/Paleogene boundary sediments (K/PBS) are widely distributed in central and western Cuba. These deposits rest on several basements, pointing to a complex geologic and geographic scenario at the moment they settled upon the earth's surface. The K/PBS accumulated instantaneously and give an excellent horizon to restore the geography of a segment of the earth's surface about 65.5 Ma before present.

At the Maastichtian decline, in western and central Cuba and its surroundings, two tectono-paleogeographic domains were present. To the north was located the sediment starved flooded North American Mesozoic margin. Southward, the western Cuban basin develops upon the Late Cretaceous volcanic arc rocks. A source of volcaniclastic sediments filled it with turbidites (Vía Blanca Formation) whereas in central Cuba carbonate sediments and reworked tefra accumulated (lower Vaquería Formation and Santa Clara, Cocos and Fomento formations). A narrow tectonic collision zone probably was represented by a submarine high and marked the boundary between both domains.

The K/PBS sediments in western and central Cuba record the event chronology related to the asteroid impact in an original area of approximately 90000 km^2. In such wide area, several types of K/PBS sediments accumulated (Cacarajícara, Moncada and Amaro formations in the paleomargin; Peñalver and Loma Capiro formations in the western basin). However, the original distribution of the deposits is distorted by the early Paleogene orogenic events in Cuba and the erosion of the underlying uppermost Maastrichtian sediments in some places complicates the paleogeographic restoration. According to different sources, the northward horizontal displacements for different tectonic units range between 12 and 200 km. A combination of palinspastic reconstruction and detailed sedimentological research of such deposits and the underlying Maastrichtian beds shows the original K/PBS distribution and paleogeography in the northwestern Caribbean corner at the time of the asteroid impact.

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POSTERS : PETRO-GEOCHEMISTRY AND HISTORY OF THE CARIBBEAN

. 77 Intraoceanic subduction and arc-continent collision in northern Caribbean: insights from the large-scale structure of the Río San Juan metamorphic complex.

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In northern Hispaniola, the Septentrional Cordillera-Samaná Peninsula geological domain is composed of arc and oceanic derived units formed during arc-continent convergence. In this tectonic context, the Río San Juan complex is a subduction-related metamorphic complex whose internal structure consists of an imbricate stack of high-P rocks. In ascending order, the major tectonic units/nappes are: Gaspar Hernández, Jagua Clara, Morrito and La Cuaba.

The Gaspar Hernández serpentinized peridotite-tectonite is composed by massive, serpentinized harzburgite and dunite forming "native" mélange blocks (protolith) that grade into surrounding sheared serpentinite or gouge. Gabbroic rocks and dolerite sills are sparse and altered to greenschists facies sea-floor metamorphism. They are Mg- and Fe-rich tholeiites with N-MORB to BABB geochemical signatures. U-Pb data indicate a Lower Cretaceous magmatic age (136.4±0.32 Ma). These rocks are interpreted as fragments of the proto-Caribbean oceanic lithosphere.

In the Jagua Clara serpentinite-matrix mélange, the massive serpentinite with relict peridotite textures was overprinted by schistose and sheared serpentinite, and serpentinite gouge, recording various degrees and conditions of internal deformation. Serpentinite schistosity surfaces warp around mélange hard blocks (<1m to 2.5km). Blocks are massive serpentinized peridotite, and "non-native" eclogites, blueschists, greenstones and orthogneisses. High-P metabasites originated from N-MORB and IAT type protoliths. Other "non-native" high-P rocks are the Hicotea schists, whose protoliths are basic-intermediate volcanic rocks with a low-Ti IAT signature. In the mélange, kinematic indicators are asymmetric strain shadows around garnets in blueschists and rotated tonalite-trondhjemite pods in antigorite-bearing serpentinitic schists, which indicate a general top-to-the-ENE shear sense. U-Pb and Ar-Ar data in foliated tonalites indicate that these structures are Campanian to Maastrichtian in age.

The high-P Puerca Gorda and the Guineal schists compose the Morrito unit. Protoliths are basic-intermediate volcanic rocks with boninitic, low-Ti IAT and IAT geochemical signatures. The Morrito basal fault-zone brings the Guineal schist onto the Jagua Clara mélange. The Cuaba unit is composed by several structural subunits of serpentinized peridotites, garnet-bearing mafic and ultramafic gneisses, metacumulates, metagabbros, metadiorites and amphibolites. Mafic rocks originated from low-Ti and low-LREE IAT, IAT, N-MORB and calc-alkaline type protoliths. The Morrito unit was intruded by the Río Boba batholith. Parental mafic melts are refractory and subduction-related, with low-Ti IAT and boninitic signatures.

The geochemical characteristics of many mafic units and volcanic rocks found within the Jagua Clara mélange and particularly in the Morrito unit indicates that they occupied a supra-subduction zone position at some time in their history and, therefore, reflect the position of the intra-oceanic subduction zone. The Morrito basal fault-zone now forms the suture zone between the Caribbean arc terranes and the paleo-continental margin of North America.

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. 78 Tectonothermal evolution of the high-P Samaná metamorphic complex: record of intraoceanic subduction and continental collision in the northern Caribbean convergen margin

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The Samaná metamorphic complex exposes a segment of a high-pressure accretionary wedge, built during Caribbean island arc-North America continental margin oblique convergence. Combined detailed

mapping, structural and metamorphic analysis, and $^{40}Ar/^{39}Ar$ geochrono-logy show that the tectonothermal evolution can be divided into three main events.

Sediment-accretion and subduction (60-35 Ma; D1). The nappe pile of the Samaná complex is interpreted to have formed a metasedimentary accretionary wedge during Cenozoic subduction of the proto-Caribbean ocean, followed by the subduction of the more distal North America margin beneath the Caribbean upper plate. The age of the youngest meta-sediments within this accretionary wedge is Campanian-Maastrichtian. The high-P M1 metamorphic mineral assemblages and relics in syn-metamorphic quartz-calcite veins formed during the first deformation event D1 under lawsonite blueschist (325-425 ºC/12-18 kbar; Rincon Marbles and Santa Bárbara Schists lower structural nappes) and eclogite facies conditions (425-450 ºC/18-20 kbar; Punta Balandra upper structural nappe). $^{40}Ar/^{39}Ar$ plateau ages on phengite, T-t/P-t estimations and regional isotopic age data revealed Eocene to Late Oligocene high-P metamorphism in the different nappes, conform they are sequentially incorporated to the accretionary wedge.

Nappe-stacking and exhumation (35-25 Ma; D2). Nappe-stacking in the Samaná complex was associated with substantial exhumation of the high-P rocks. The retrograde mineral assemblages and thermobarometric calculations indicate decompression under nearly isothermal or cooling conditions in the blueschist facies conditions. All $^{40}Ar/^{39}Ar$ plateau ages in this 35-25 Ma time interval were obtained on phengite and interpreted to record cooling or growth at their closure temperature during decompression that is contemporaneous with D2 folding, thrusting and nappe-stacking. T-t and P-t estimations revealed Late Eocene to earliest Miocene retrograde M2 metamorphism in the different nappes, top-to-the-ENE tectonic transport towards the foreland and a general northeastward progradation of deformation in the northern Caribbean.

Late deformations (D3, D4 and D5). The D3 nappe re-folding event substantially modified the nappe-stack in the Samaná complex and produced open to tight folds with amplitudes up to kilometric-scale. The D4 ductile to brittle normal shear zones and faults record a late extensional deformation, which also affects the whole nappe pile of the metamorphic complex. Non-penetrative D3 and D4 fabrics indicate M3 cooling in the greenschist-facies conditions. These late deformations are probably associated with ongoing accretion of thicker continental basement and unroofing. Subsequently, from the Lower Miocene to the Present, the nappe pile was cut and laterally displaced by a D5 regional system of sinistral strike-slip and reverse faults associated with the Septentrional fault zone.

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. 79 Geothematic mapping in the Dominican Republic

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The IGME-BRGM-INYPSA Consortium is finalising the 1:50,000-scale geological mapping coverage of the Dominican Republic under the Sysmin project financed by the European Union from 1996 to 2010.

The field mapping relied heavily on the airborne geophysical survey results, satellite imagery and Digital Elevation Models. All the data were homogenised and gathered into a GIS under ArcGIS format.

A total of about 100 geological maps will be produced to a standard inspired by that used by the IGME for Spain.

In addition to characterising the country's subsurface, the project has helped developed our scientific knowledge of the area: Hispaniola, located at the junction of the Caribbean Plate and the American Plates, is of a great geological interest as much for the diversity of its volcanic, sedimentary and intrusive rocks as for its structural evolution since the Late Jurassic. The geological surveys have provided many descriptions, age determinations and interpretations that are developed through scientific publications.

A better knowledge of the geology also goes towards helping a reasoned development of the country as well as towards offsetting certain natural hazards. In addition to geological maps, the project has provided geomorphological maps and "active process" maps at a scale of 1:100,000. A particular effort was made to locate and map faults and unstable geological formations (ground motion).

Finally, an exhaustive mining inventory of the country is being drawn up through a grass root exploration programme (stream sediment sampling and alluvial panning). The Dominican Republic is a major actor in the mining world: it contains one of the world's largest gold deposits in the Pueblo Viejo mine with reserves assessed at 700 tonnes, as well as extensive resources of nickel and semi-precious stones (amber and larimar).

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un numbered abstract -

A tectono-stratigraphic map of the Greater Antilles

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Geologic maps of the Caribbean Basin generally display rock units according to their age and lithology (e.g. Late Cretaceous limestone). Few geologic maps display rock units according to their tectono-stratigraphic setting (e.g. North American platform carbonates). A preliminary 1:1,000,000 scale tectono-stratigraphic map for the Greater Antilles provides an easier-to-interpret map of the northern margin of the Caribbean Plate. Conference participants are invited to offer suggestions for improvement to both the map and the legend. Contributions will be incorporated and, at the next conference, an updated map will be presented for further review and revision. Plans are to extend this effort to the entire Caribbean Basin.

SESSION: VOLCANOLOGY AND VOLCANIC RISK

. 80 On the explosivity of lava domes

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Dome-forming eruptions are one of the most frequent eruptive styles that occur on volcanoes. Though generally considered as features of effusive style, they can generate more or less violent pyroclastic activity. The main pyroclastic activity occurs when parts of the growing lava dome become unstable and collapse, involving block-and-ash flows channelled in one or two valleys. In rare cases, a violent explosive activity may be generated directly at the base of the growing lava dome as on Montagne Pelée during the first months of the 1902-1905 eruption. In this case, violent laterally directed explosions produced highly destructive turbulent and dilute pyroclastic density currents. Volcanic hazards related to lateral directed explosions are higher than for collapses of unstable parts of a lava dome. On Montagne Pelée, in 1902, they destroyed the two towns of St. Pierre and Morne Rouge and killed ~30 000 inhabitants. Determining the factors at the origin of the explosivity and the eruptive style changes during dome-forming eruptions is essential to manage future eruptions on volcanoes. Pre-eruptive conditions in magma chamber play an important role. But the evolution of the magma during its ascent in the feeding conduits, particularly in the superficial part (last kilometer), is fundamental and determines the eruptive styles. Degassing induces bubble growth during magma ascent but also extensive groundmass crystallization if ascent rates are sufficiently low. Observations of volcanic eruptions and their products indicate that these processes can influence eruption dynamics, principally by changing magma rheology. We correlate the textural characteristics (vesicularity and groundmass microcrystallization) and the evolution of the volatile content in the melt of a series of clasts sampled in pyroclastic products covering the field of low and high explosivities of lava domes. On this basis, we will propose a model on the explosivity of the lava domes.

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. 81 Scenario definition, hazards assessment and risk mitigation for the next eruption of La Soufrière of Guadeloupe: contributions from the CASAVA Project

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Authorities and civil society are confronted with Hamlet's dilemma when they need to reconcile efficient, pragmatic crisis reduction strategies that can foster the rise of a society of prevention and a state of well-living with active volcanoes instead of a short-sighted society of repair. Effective risk assessment and management require that scientists, governments, civil protection agencies, communities develop synergistic activities. The ANR funded CASAVA proposes a multidisciplinary integrated research strategy for quantitative volcanic risk assessments that takes into account the socio-cultural dimension and is focused on active volcanoes

of the French Lesser Antilles, Soufrière (Guadeloupe) and Montagne Pelée (Martinique). CASAVA aims at: 1) reconstructing the eruptive past and understanding volcanic processes; 2) defining calibrated volcanic scenarios and modelling hazards in a probabilistic GIS framework; 3) assessing social, cultural, and economic vulnerability; 4) quantifying territorial, human, and institutional vulnerability including legal and insurance risk policies; 5) developing tools for probabilistic risk assessment and crisis management that consider impact analysis and mathematical modelling of evacuation strategies; 6) elaborating an eruption display and simulation software that will use artificial intelligence to model eruption scenarios, impact, and the behaviour of population and crisis managers; and 7) integrating scientific knowledge, community-based initiatives and government policies into effective and sustainable disaster risk reduction. As a starting point we discuss the implications of our detailed geological reconstruction of the eruptive past of La Soufrière of Guadeloupe on eruptive scenario definition. Based on the reconstruction of the 1530 AD last magmatic eruption of La Soufrière and lessons learnt from recent eruptions in 2010 at Eyjafjallajökul (Iceland), Soufrière Hills (Montserrat), and Merapi (Indonesia), we discuss credible scenarios for La Soufrière and the challenges they pose in terms of monitoring, hazard assessment, and crisis decision-making to reduce risk to life and societal infrastructures on the short and longer term.

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. 82 Halogen behaviours during andesitic magma degassing: from magma chamber to volcanic plume

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Halogen (F, Cl, Br and I) behaviours during degassing of H_2O-rich silicic magmas are investigated using volatile content of glass (matrix glass and melt inclusions) of volcanic clasts (pumice and lava-dome fragments) in a series of plinian, vulcanian and lava dome-forming eruptions. Examples are taken from andesitic systems in subduction zones: Montagne Pelée and Soufrière Hills of Montserrat (Lesser Antilles) and Santa Maria-Santiaguito (Guatemala). Halogens behaviour during shallow magma degassing primarily depends on their incompatible character in melts and on H_2O solubility. But variations in pre-eruptive conditions, degassing kinetics and syn-eruptive melt crystallisation, induce large variations in halogen extraction efficiency during H_2O degassing, up to prevent halogen loss. In all studied systems, Cl, Br and I are not fractionated relative each other neither by differentiation nor by degassing processes: thus Cl/Br/I ratios remain well preserved in melts from reservoirs to eruption. These ratios measured in erupted clasts are characteristic of pre-eruptive magma compositions and may be used to trace deep magmatic processes. Moreover, during plinian eruptions, Cl, Br and I are extracted by H_2O degassing but less efficiently than predicted by available experimental fluid-melt partition coefficients, by a factor as high as 5. F behaves as an incompatible element and, contrary to other halogens, is never significantly extracted by degassing. Degassing during lava dome-forming eruptions of andesitic magmas occurs mainly at equilibrium and is more efficient at extracting halogens and H_2O than explosive degassing.

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. 83 Effects of large flank collapse events on the magma production and evolution of volcanoes: Examples from the Lesser Antilles Arc

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Flank collapse events are increasingly recognized as a common process in the construction and destruction of volcanic edifices. In the Lesser Antilles Arc, more than 50 flank-collapse events were now recognized. Voluminous flank-collapse events may have significant effects on the magma chamber stability and the magma evolution. The volcanic edifice induces a threshold effect on the magma plumbing system. The decreasing of the edifice load after a large flank collapse can reduce significantly the lithostatic pressure on the magma chamber and may trigger an eruption. Denser and more basic magma or more viscous magma may ascent and reach the surface whereas they were at lithostatic equilibrium at depth when the volcanic cone was present. An increase of the magma production rate may also be induced by large flank collapse until the

construction of a new and voluminous cone that induces progressively a new threshold effect and can stop the magmas ascent and favour their differentiation at depth. Evidences for such effects are rare. Three of the flank-collapse events studied in the Lesser Antilles Arc have generated a change in the magma composition and magma production after their occurring: at Montagne Pelée, the 25 ka flank-collapse event (13 km^3) involved the eruption of more basic magmas and an increase of the magma production rate; at Pitons du Carbet, Martinique (30-40 km^3, ~350 ka) and Soufrière Volcanic Centre, St. Lucia (~ 100 ka) eruption of more viscous and highly crystallized magmas, generating voluminous lava domes followed immediately the sector-collapse events. On the basis of theorical studies recently published in the literature we can propose different models explaining the effect of the flank-collapse on the magma plumbing and petrology of erupted magmas in these different examples.

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. 84 Remote and in situ plume measurements of acid gas release from La Soufrière Volcano, Guadeloupe

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La Soufrière volcano (Guadeloupe, FWI) is presently undergoing a mild continuous phase of seismic and enhanced fumarolic unrest since 1992, and particularly 1998. Three volcanic plumes rise above the summit. The strongest one is emitted from the South Crater. The fumarolic activity has progressively extended toward the North-North-West, with a reactivation of the Tarissan vent in 2000 and the Napoléon vent in 2002. Gas emissions became suddenly acid in 1998 (pH<1) due to the apparition of hydrogen chloride and hydrogen sulfide gases.

The strong reactivation of the fumarolic activity at the summit and the remarkable change in chemical parameters are not associated with significant variations of the other monitoring parameters such as seismic activity at depth, large scale ground deformation, and higher gas temperatures. However, many catastrophic volcanic events are related to explosive activity on apparently dormant volcanoes. As a consequence, any attempt to understand an increase in volcanic activity in quiescent systems deserves attention.

To gain new insights on La Soufrière undergoing degassing, we begin in 2003 to study in situ the chemical composition of La Soufrière gas releases. We present the first remote measurements of La Soufrière gas emissions since the fumarolic and seismic reactivation in 1992. The chemical composition of the plumes has been measured using an Open Path Fourier Transform InfraRed (OP-FTIR) spectrometer, up to 15 m downwind the South Crater. HCl is clearly detected whereas SO_2 and H_2S generally remain below the detection limit of the OP-FTIR. Direct measurements of SO_2 and H_2S near the South Crater with a Lancom III analyzer show a fast decrease of their concentrations with the distance. Calculated Cl/S mass ratios are high: from 9.4 ±1.7 at 15 m from the vent to 2.8 ± 0.6 at 140 m.

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. 85 Géochimie isotopique de l'hélium dans les eaux et gaz de la Guadeloupe : interations entre fluides magmatiques et eaux souterraines

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We report on geochemical studies of thermal waters, cold waters and gas emissions in the Basse Terre island of Guadeloupe, including the active volcanic complex of La Soufrière and the Bouillante geothermal area. Waters and gases collected during several field campaigns were analysed for their chemistry (major, minor and trace elements, dissolved gases) and the isotopic ratio of helium in order to characterize the geographical distribution and intensity of interactions between deeply derived mantle-magmatic fluids and local aquifers. The

$^3He/^4He$ ratio of helium is indeed a univoque tracer of mantle-derived fluids, owing to its distinct values in mantle crustal and atmospheric reservoirs.

We shall present the results and their implications in terms of areal distribution of magmatic supplies, gas-draining faults and applications to volcano monitoring at La Soufrière.

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. 86 Volcanic hydro-geomorphology and the rediscovery of an ancestral (Carib, Kalinago) problematic in the Lesser Antilles : the case of the Montagne Pelée

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The hydrographic network of volcanoes has an impact as much on the constructive as on the destructive processes. This study is potentially rich in information. Volcanic hydro-geomorphology studies volcanic hydrographical system from a naturalist and multiscale approach.

On volcanoes, the analysis of processes that are produced in volcanic streams, during eruptions or rest periods, shows that the hydro-volcano-geomorphologic (HVG) hazards are numerous and cannot be reduced to simply flooding. All the different HVG destructive phenomena act to evacuate the excess of volcanic material. The morphological impact is more definite than the "standard" water floods. As a result, the threat of volcanic streams is significant because it is frequent, spontaneous and cannot always be predicted. Which bring us to the following question: are volcanic streams more dangerous than eruptions?

If the HVG risks have been neglected by the society in favor of the crater phenomena, it has not always been so in Lessers Antilles. The vocabulary, that we have reached the native Caribbean (Kalinago), through the dictionary Carib-French of Father Breton (1665), is rich in information. It allows to indentifying several gradients in the hydro-geomorphologic factors: the meteorological crisis, the stability of land and the torrential phenomena intensity. The Kalinagos vocabulary contains another words about different geosciences domains, but no one concerning the volcanic eruption. This Amerindian society had probably a perception about volcanoes with another time scale than our: a temporal scale adapted to the impacts hazard, their dangers.

Keywords: Volcanic hydro-geomorphology volcanic, Hydrologic network, volcano, spatiotemporal scales, Hydro-volcano-geomorphologic hazards, Amerindian, Lesser Antilles

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. 87 Etude des circulations hydrothermales associées aux principaux axes de faiblesse recoupant le dôme de la Soufrière de Guadeloupe, par couplage de méthodes de tomographie de résistivité électrique, polarisation spontanée, thermique et gaz du sol.

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Le passé historique de la Soufrière de Guadeloupe montre qu'au cours des diverses éruptions phréatiques qui se sont succédées (1690, 1797-98, 1809-12, 1836-37, 1956 et 1976-77), des axes principaux de faiblesse ont recoupé l'édifice. Le dernier événement éruptif de 1976-77 a eu pour conséquence la réactivation et l'ouverture de nouvelles fractures éruptives ainsi que l'apparition de zones fumeroliennes. Depuis 1992, une lente et progressive reprise de l'activité hydrothermale se manifeste dans la zone sommitale.

En Janvier 2008, un réseau de 634 points de mesures a été installé sur l'édifice le long de 3 axes de faiblesse majeurs afin de suivre l'évolution de la polarisation spontanée (PS), de la température et des gaz du sol lors de campagnes de ré-itération (Janvier 2008, 2009, 2010 et 2011). Ces réseaux de ré-itérations ont été complétés en Janvier 2011 par une campagne de mesures sur l'ensemble de l'édifice en polarisation spontanée ainsi que par l'acquisition de 3 profils de tomographie de résistivité électrique (945m, 2430m, et 2925m de longueur).

Les premiers résultats de couplage tomographie, PS, température, CO_2 ont permis de contraindre des zones fortement conductrices associées à des remontées préférentielles du système hydrothermal le long d'un axe majeur de fracturation. Depuis Janvier 2010, ce système est suivi par une station permanente multi-paramètres

(PS/T°C). Des fluctuations de l'ordre de 30°C, associées à des anomalies négatives de polarisation spontanée, ont pu ainsi être mises en évidence. Le suivi à long-terme de la dynamique du système hydrothermal présente un intérêt majeur pour la surveillance du volcan.

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. 88 A high-resolution reconstruction of the recent eruptive past of La Soufrière de Guadeloupe over the last 12 000 years.

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Sedimentary eruptive archives were obtained using a novel approach based on using a manual sediment corer in sheltered areas where a longer eruption record is likely to be preserved. We describe two cores (6.32 m and 6.64 m long), located on the soutwestern flanc of the volcano, that extend over the last 9500 years. We combined these data with data from stratigraphic sections to identify hidden eruptions, re-interpret mis-identified eruptions, and thus provide a more precise eruptive chronology over the last 12000 years. This chronology is robustly constrained by 155 new ^{14}C age dates that complete the existing ^{14}C database of 260 age dates.

We dated at least the deposits of 10 flank-collapse events over the last 12000 years, 9 of them associated with magmatic activity that includes the emplacement of laterally-directed pyroclastic density currents. We identified 10-12 distinct pumice and scoria fallout and flow deposits resulting from explosive eruptions, and 9-10 distinct pyroclastic block-and-ash flow deposits and dilute pyroclastic density currents deposits resulting from dome-forming eruptions. We also identified numerous exceptionally preserved thin tephra layers. We interpret these deposits as ephemeral markers of vulcanian explosions associated with a period of protracted dome growth during the reconstruction of the edifice which followed the numerous destructive edifice-collapse events. Although these low-magnitude eruptions cannot be taken into account reliably, the number of Holocene magmatic eruptions has significantly increased compared to previous knowledge. The magmatic eruptive rate could be thrice as important with 17-20 eruptions in 12000 years providing a revised rate of 1.42–1.67 magmatic eruption per 1000 years. These new data provide a refined determination of the recurrence, magnitude, intensity, and spatio-temporal evolution of deposit types for different credible eruptive scenarios. Hence we will significantly improve probabilistic hazard and risk assessment for La Soufrière de Guadeloupe.

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. 89 Geophysical Imaging of La Soufriere Volcano

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We present the results of several geophysical imaging experiments that were conducted on La Soufriere de Guadeloupe volcano since 2006. Several projects have been devoted to the geophysical characterization of this geothermal system, in order to better constrain the zone of mechanical weakness, and zones of water and gaz circulation. These methods include seismic and EM imaging, gravimetry. In this presentation we show the results obtained from active seimic experiments, noise correlation passive imaging, resistivity profiles and gravity measurements that are analysed together to give more details on the upper volcanic system, above sea level.

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. 90 Timing of flank collapse events in the Lesser Antilles arc

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We provide constraints to estimate the recurrence of flank collapse events, which are now considered as one of the major hazards associated with volcanoes, and in particular within the Lesser Antilles arc. Large-scale debris avalanches deposits have been identified off the coasts of Dominica, Martinique and St. Lucia with volumes up to 20 km^3. The collapses are always directed to the west as a result of the high overall slopes of the islands toward the deep back-arc Grenada Basin. Radiometric dating using the unspiked Cassignol-Gillot K–Ar technique have been carried out on rocks taken onland, out of the horseshoe shaped scars of five Pleistocene major events. The oldest large-scale flank collapse having affected southern Basse-Terre (Guadeloupe) is constrained at 630 ka by the dating of an older and a younger bound. In the Qualibou depression of St. Lucia, a collapse has been constrained by dome emplacement prior to 95±2ka. In Dominica, where repetitive flank collapse events have occurred, the Plat Pays event probably happened after 96±2ka. Inside the depression caused by this event, Scotts Head, interpreted as a proximal megabloc from the subsequent Soufriere avalanche event has been dated at 14±1ka, providing an older bound for this event. On Martinique three different domes within the Carbets structure dated at 337±5ka constrain the age of this high magnitude event and one of the Montagne Pelée repetitive collapses has been dated at 126±2 ka with an older bound at 127±5 ka and the younger limit at 126±2 ka from the lava dome of Piton Marcel that was emplaced inside the resulting depression.

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. 91 K/Ar dating and DEM-based reconstruction of southern Basse-Terre volcanoes (Guadeloupe, FWI): contribution to the Lesser Antilles arc construction rates

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Timing of effusive volcanism of the active volcanic island of Basse-Terre, Guadeloupe, is investigated through 52 new and 30 previous unspiked K–Ar ages. Four volcanic massifs shape the island. Oldest activity is dated at 2.79 ± 0.04 Ma on the far northern coast and migrated southwards until present time at a rate of 18 km/Myr, similar to the Atlantic plate subduction rate. Most of Basse-Terre volcanics are basaltic andesites and andesites, showing typical non-primitive magma signatures. While the Basal Complex's lifetime only spans 110 kyr (2.79 ± 0.04 – 2.68 ± 0.04 Ma), the Septentrional and Axial Chains spread each over 600 kyr (1.81 ± 0.03 - 1.15 ± 0.02 Ma and 1.02 ± 0.03 - 0.435 ± 0.008 Ma respectively). Further south, the Grande-Decouverte-Soufriere volcanic complex (GDVC) initiated at least 0.2 Ma. Using the ArcGIS software and Basse-Terre Island DEM, we also modelled 3D reconstructions of ten successive main morphological and volcanic stages of the last 650 kyr, covering the most recent story of the Axial Chain and of GDVC. Average construction rates reach 2.4 ± 0.2 x10-4 km^3/yr for the last million years, 0.9 ± 0.3 x10-4 km^3/yr for the last 100 kyrs, and 0.9 ± 0.2 x10-4 km^3/yr for the last 15 kyrs. Although Basse-Terre volcanism is characterized by a marked dominance of effusive products, our estimates should be considered as minimum values as material sent to the sea during explosive events was not taken into account.

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SESSION: SEISMIC RISKS AND TSUNAMIS

. 92 Efforts pour établir une surveillance sismique et géodésique en Haïti.

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Suite au tremblement de terre dévastateur survenu en Haïti le 12 Janvier 2010, le BME, l'ONEV et la FDS ont conjointement travaillé avec plusieurs institutions scientifiques qui ont mené des enquêtes sur terre et en mer en vue d'une meilleure compréhension du séisme et aussi d'évaluer les dangers des futurs séismes en Haïti. Citons, entre autres, Columbia University, l'Institut Géophysique du Globe, l'Université d'Austin, l'US.Geological Survey, les Ressources Naturelles du Canada, l'Université Antilles Caraïbes et Purdue University. Les investigations comprennent, par exemple, l'échantillonnage de coraux soulevés dans l'environnement de la faille Enriquillo-Plantain Garden, les tests sur les propriétés géotechniques de la région métropolitaine de Port-au-Prince, les enquêtes de dommage aux bâtiments publics, le déploiement de sismomètres et la poursuite des mesures GPS en ce qui concerne les déplacements co-sismiques.

Les résultats préliminaires indiquent que les effets de site jouent un rôle non négligeable dans la destruction de certains quartiers de Port-au-Prince, les épicentres des répliques sont en majeure partie localisées dans la zone de Petit-Goâve / Léogâne, les mauvaises pratiques de construction et la forte densité de la population sont les premières causes de l'ampleur des dégâts et du nombre élevé de victimes.

En vue de développer le réseau permanent de surveillance sismique et géodésique en Haïti, les institutions ci-mentionnées, à savoir le BME, l'ONEV et la FDS, en partenariat avec l'USGS, Purdue University et les Ressources Naturelles du Canada, vont bientôt déployer des instruments sur tout le territoire d'Haïti. Il s'agit de 5 accéléromètres de type NetQuakes, 4 stations sismologiques / nanométriques systèmes et 9 stations GPS supplémentaires à raison d'un (1) GPS / par site.

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. 93 ECAR Observatories : a collaborative program for monitoring and science

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The Seismic Research Centre (SRC), the Montserrat Volcano Observatory (MVO), the Guadeloupe Observatory (OVSG) and the Martinique Observatory (OVSM) operate seismic and geodetic networks that span the entire Eastern Caribbean. They are the agencies responsible for providing scientific advice and information on seismic and volcanic hazards in this region to civilian authorities and the public. Most of these institutions have been in operations for over 50 years.

Due to a combination of cost saving from pooled orders and collaborative projects there has been a significant increase in the number of broad-band seismic stations and cGPS stations operated by the ECAR Observatories over the past decade. We present here the different collaborative projects aiming at improve the earthquakes and faults activity monitoring and the scientific collaboration to better address the seismic regional risk assessment.

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. 94 Source parameters of the Mw 7.4 Martinique earthquake (windward islands) of November 29, 2007 deduced from near-field strong motion data inversion

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A large (Mw=7.4) intermediate-depth earthquake occurred on 29 November 2007 north of Martinique island, in the Lesser Antilles. Intermediate depth earhquakes are often more destructive than the interplate subduction events because hypocenters are usually below the islands, thus below large population centers.

In this study, the robust source parameters of the Martinique earthquake are inferred from the inversion of near-field and intermediate-field of the strong motion data recorded by the French Accelerometric Network (RAP). The results are compared with the main aftershocks distribution obtained after precise relocation procedure. Our results show a slab-pull down dip extension mechanism on a nearly horizontal plane. These two characters are common with those of the few well studied large intermediate-depth earthquakes in Japan and in Chile. This suggests that those characters may be representative features for large intermediate-depth subduction events. Seismic moment is 1.6x10^{20} N.m, with an averaged slip of 3.9 m and a stress drop estimate of ± 4-13 MPa.

Our study demonstrates the suitability of inverting near-field and intermediate-field terms to retrieve the main source parameters of earthquakes.

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. 95 Evidence of stress drop magnitude scaling and stochastic ground-motion model from accelerometric data recorded in the French West Indies

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We analyse data from the « Les Saintes » seismic sequence, following a M_w=6.3 event which occurred in Guadeloupe on November 21, 2004. The data set contains 485 events with magnitudes from 2 to 6.3, and recorded at distances from 5 to 150 km on the two French Antilles islands: Guadeloupe and Martinique.

S-waves Fourier spectra are computed and source, path and site parameters are determined using a global inversion scheme. A moment magnitude scale is established calibrated on the M_w from USGS for the 6 largest events in the dataset. Our results show a stress drop magnitude scaling which flattens toward high magnitudes. Our analysis also shows that the local duration magnitude scale underestimate moment magnitude by 0.5 units.

Obtained source, path and site parameters are used to compute ground-motions through stochastic simulations. We show that ground-motions are well reproduced using this simple simulation tool. The results indicate that stress drop variations and directivity effects control the inter-event variability.

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. 96 Regional and local seismic hazard mapping for seismic risk mitigation of Santiago de los Caballeros (Dominican Republic)

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In order to propose methodological solutions for reducing seismic risk in Caribbean urban zones, efforts concentrate on applying research activities. For example, elaborating seismic risk scenarios allows a better

assessment of the consequences of an earthquake affecting the organization of social structures, in order to highlight sensitive sectors where considering seismic risk must be given priority. Because of its primary objectives, the SYSMIN II program in Dominican Republic takes place in this context.

In this paper, we show how methodologies developed during seismic microzonation studies in the French West Indies, were suitable to be applied to the case of Hispaniola, the second island in the Greater Antilles. The north of Hispaniola is threatened by the eventual rupture of a major seismogenic fault zone, named Septentrional. The town of Santiago de los Caballeros in the Dominican Republic is particularly exposed because of its close location to this fault (<10 km). The paper gathers results obtained from the seismic hazard and microzonation studies developed in the city of Santiago: i) quantification of regional seismic hazard dominated by the Septentrional fault, ii) a new geological mapping of superficial formations at the scale 1:10.000, and iii) mapping of zones of homogeneous seismic response and liquefaction susceptibility. These interpretations are based on field geotechnical and geophysical measures, but also on the geological expertise achieved over several years in the Cibao region by the consortium IGME-BRGM-INYPSA.

On the French West Indies, the volcanic origin of the geological formations punctuated by sedimentary episodes, gives a particular signature to the amplification phenomena of seismic vibrations due to site effects. The investigations carried out in Santiago revealed a new issue: surprisingly minor site effects (based on the H/V method of ambient noise) in the plastic continental argillaceous unit that represents the main layer for foundations in the whole city area.

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. 97 Blind inversions of shear-wave velocity and damping factors at a borehole station in Belle-Plaine, Gosier, Guadeloupe

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Soil structure properties between free surface and bedrock in the linear domain (e.g., S-wave velocity, P-wave velocity, damping factor, etc.) are essential to perform direct ground motion simulations and to evaluate nonlinear site effects.

In this article, we present the inversion of shear-wave (S-wave) velocity and damping factors of a one-dimensional soil column by genetic algorithm at the Gosier borehole station in Guadeloupe, French West Indies. The drilling providing only soil classification and thickness of layers, we perform the inversion from free surface to bedrock. We first compute surface-to-downhole spectral ratios on the S-wave portion of several weak ground motions recorded between July 2008 and December 2008 in order to determine a possible averaged transfer function of the soil column and then, we select a specific aftershock whose transfer function is close to the averaged one and invert it by genetic algorithm coupled with the Thomson-Haskell propagator matrix method.

The optimal S-wave velocity of fourteen soft sediment layers is searched in the space [30 - 700] m/s and the S-wave velocity of the bedrock in the space [100 - 2100] m/s. Constant damping factors over frequency are searched in the space [0 - 6] % for all layers. S-wave velocity and damping factor are inverted together so that the total number of solutions is about $5x10^{58}$. In order to guarantee the convergence to a possible global optimum, 16 independent inversions are performed. For each independent inversion, we compute about 200,000 soil columns that evolve toward a best solution via the genetic algorithm method. The results show that both S-wave velocity and damping factor have a reasonable standard deviation and guarantee an acceptable inversion. The simulation of the time history of the selected weak motion is consistent with the observations.

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. 98 Bootstrap Determination of b-values: An assessment of Statistical Estimators with Synthetic ETAS Sequences of Magnitudes

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We proposed the statistical determinations of b-values by the bootstrap method for short sequences of quantified earthquake magnitudes in order to examine their temporal variation behavior. The bootstrap approach is applied by analyzing synthetic Epidemic-Type Aftershock Sequences (ETAS) with known properties.

The statistical distribution of the b-values with respect to the length, L, of the sequences of magnitude is experimentally studied by analyzing a set of ETAS sequences with L = 50, 100, 200 and 400 events, and applying two statistical estimators: the Maximum Likelihood Estimator (bMLE) which maximizes the posterior Bayesian probability of a power-law model with an adjustable exponent gives the b-value, and the estimator bKS which minimizes the Kolmogorov-Smirnov distance between the cumulative distribution of magnitudes and a power-law model whose adjustable exponent gives the b-value. The bMLE and bKS estimators produce almost similar results with no bias and a small variance. We experimentally establish that bootstrapping a single sequence of length L correctly reproduces the space of the statistical realizations for both the bMLE and the bKS estimators. Two versions of the Maximum Likelihood estimator, bB and bU, are derived to account for rounded magnitude values, and are tested for three quantization levels = 0.1, 0.2 and 0.3. When applied to ETAS series, these estimators allow a clear distribution between b = 0.9, 1.0 and 1.1 even for short series with L = 50 events and m = 0.2.

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. 99 Etude comparative de modèles stochastiques pour l'activité sismique

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Le calcul de risques sismiques dans une zone s'appuie sur des modèles stochastiques décrivant au mieux l'activité sismique. Il s'agit de calculer les probabilités d'occurrences de tremblements de terre, et d'analyser l'évolution spatio-temporelle de ces probabilités. L'objectif est de construire des cartes prévisionnelles de risque à différentes dates, en tenant compte des localisations d'éventuelles failles. L'outil principal de modélisation est la théorie des processus ponctuels qui permet, pour une date donnée, d'intégrer l'information jusqu'à cette date (exclue) dans l'expression du risque conditionnel. Deux approches se distinguent dans la littérature : l'approche tectonique pour laquelle la localisation de failles est primordiale, et l'approche sismique qui intègre l'activité sismique antérieure dans la zone. Dans cette dernière approche, on retrouve les modèles (Epidemic Type Aftershock Sequence) dont plusieurs aspects théoriques ont été étudiés. Ainsi, des outils probabilistes et statistiques ont été développés par des équipes de recherche localisées en des lieux de haute sismicité, principalement en Californie, Japon et Nouvelle-Zélande. Le but est d'exploiter au mieux l'information disponible afin d'élaborer une stratégie prévisionnelle. Récemment, une classe de modèles BASS (Branching AfterShock Sequence) a été proposée pour pallier certaines propriétés qualitatives du modèle ETAS. Cependant, le modèle ETAS reste très prisé par les praticiens sismologues et des extensions de ce modèle sont en cours, dans le but d'améliorer sa capacité prédictive. Une étude comparative est effectuée et les données de sismicité de l'arc antillais de 1999 à 2004 sont utilisées à titre illustratif.

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. 100 From Geology to Realistic Large-Scale Spectral-Element Earthquake Simulations in the Pointe-à-Pitre Region

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The goal of this study is to perform realistic large-scale spectral-element simulations in the vicinity of Pointe-à-Pitre, valid up to rather high frequencies (around 5 Hz) with a minimal shear-wave velocity around 200 m/s and considering magnitude 5 to 6 earthquakes. For this purpose, a detailed modeling of both the seismic source and geology of the medium for wave propagation and of the local urban underground is necessary.

The local geology (size: 7 x 7 x 0.1 km) has been constructed using brgm Geomodeler© software, by compiling the available underground data (e.g. boring data) in the vicinity of the city of Pointe-à-Pitre. Four main geological formations are considered for the regional model: a weathered limestone (which form the substratum) and clay, silt and ballast (which form soft sedimentary basins). The shear-wave velocities within each formation have been derived from the existing geophysical campaigns (e.g. SASW, cross-hole, H/V, etc.). The S-wave velocity value of the limestone is supposed to be 1000 m/s. For the clay, silt and ballast formations,

S-wave velocity values are respectively equal to 350 m/s, 250 m/s and 200 m/s. In order to mimic energy dissipation, the constitutive law of these formations is supposed to be viscoelastic. The local geology of the urban zone is included into a larger geological model (Dorel, 1978) of size 40 x 30 x 30 km. Moreover, topography is included in the model by using a 40 meters DTM.

In the present simulations, the Gosier fault, located to the Southeast of Pointe-à-Pitre, has been considered. The slip distributions of the finite-fault are generated according to the spatial random field model developed by Mai and Beroza, 2002. For magnitude 5 or 6 earthquakes, the kinematic fault is composed respectively by 899 or 7881 sub-faults with a heterogeneous slip distribution.

The results of these simulations are shown as PGV map on the entire domain or time history recorded at high stake facilities of Pointe-à-Pitre (e.g. city council, hospital, schools, etc.).

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. 101 Tsunami deposits and liquefaction structures in the plio-pleistocene sedimentary deposits of Guadeloupe Grande-Terre, FWI

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Guadeloupe archipelago belongs to the Lesser Antilles volcanic arc. It is subject to many seismic events but also to volcanic eruptions. Both volcanic eruption aspecially when it is explosive and avalanche debris are likely to generate tsunami and tsunamiites deposits. So do powerfull earthquakes related to subduction of North American and South American plates under the Caribbean one, strike slip in its northern and southern transform fault boundaries as well as intraplate earthquakes. It is therefore quite natural that tsunami deposits were identified and studied in the Caribbean arc. We just note that all described tsunamiites are relatively recent. It seems to us quite curious that such sediments are absent in the plio-pleistocene sedimentary deposits of Guadeloupe Grande-Terre.

Our study shows that part of the so-called PVS formation has tsunamigenic origin and have also registered effects of violent earthquakes. All deposits are polygenic with a mixture of sandy matrix and many exotic boulders. Liquefaction structures affected previous tsunami deposits and are correlated with the volcanic process of the Basal Complex of Basse-Terre.

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. 102 Tsunami Hazard for the French West Indies, Lesser Antilles

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Detailed analysis of historical data of tsunamis in the French West Indies collected in different books, papers and sites is given. Totally, 18 events are selected as true and almost true. Nine tsunami events have been generated by underwater earthquakes; seven events – by the volcano eruptions, two have been classified as teletsunami. The maximal value of tsunami runup height in the Caribbean Sea (Virgin tsunami 1867 when 18 m runup was recorded in Guadeloupe) is revised. The geographical and temporal distributions of tsunami events are studied. The results of numerical modeling of historical and potential tsunamis are discussed.

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. 103 Tsunami source generated by a sector collapse episode at Kick'em Jenny volcano: waves propagation and risk assessment

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Kick'em Jenny (KeJ) volcano, the only active submarine volcano of the Lesser Antilles volcanic Arc, is seated within a horseshoe-shaped structure. Dondin et al. (submitted) identified at least 3 distinct debris avalanche deposits including a main debris avalanche deposit (MDAD). The MDAD volume estimate is 4.4 km^3 and the collapsed volume estimated is 5 km^3. At the time of the collapse, which is unknown to date, the proto-KeJ edifice was potentially emerging above the sea level; an hypothesis that makes numerical modeling trickier.

We focus firstly on the modeling the source of tsunami generation triggered by the sudden collapse into the sea-water of 5 km^3 of a solid volcanic material mass coming from the unstable proto-KeJ edifice. Collapsed material density considered is 2000 kg/m^3. The best simulation of the source carried out with *VolcFlow*, a finite difference hydraulic model, displays a semi-circular source typical of sub-critical flow (Fr ~ 0.47) generated by the avalanche front displacement. At *to* = 27s, *i.e.* approximately the time of avalanche maximum momentum, the source amplitude is *ca.* 440 m high; the maximum length wave is 9 km; source maximum elevation propagate towards N-NW. Next, source parameters retrieved at *to* were used to simulate tsunami waves propagation into the Caribbean Sea via FUNWAVE, a Boussinesq equations-based model. Recordings of offshore numerical gauges are used to assess first wave time arrival off the Lesser Antilles islands western coast. Recordings reveal that Grenada north coast is rapidly hit (*ca.* 2 min) by a high amplitude first waves train (Amp_{max} ~ 60 m) which can be double due to shaoling effect. Tsunami risk decreases towards North while tsunami waves keep propagating.

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. 104 Rogue Waves in the Ocean as a Part of Marine Natural Hazards

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Rogue wave*s* in the ocean are now a part of marine natural hazards. Physical mechanisms of freak wave appearance are discussed. They are among waves naturally observed by people on the sea surface that represent inseparable feature of the Ocean. Rogue waves appear from nowhere, cause danger and disappear at once. They may occur at the surface of a relatively calm sea, reach not very high amplitudes, but be fatal for ships and crew due to their unexpectedness and abnormal features. The serious studies of the phenomenon started about 20–30 years ago and have been intensified during the recent decade. The research is being conducted in different fields: in physics (search of physical mechanisms and adequate models of wave enhancement and statistics), in geoscience (determining the regions and weather conditions when rogue waves are most probable), and in ocean and coastal engineering (estimations of the wave loads on fixed and drifting floating structures). Thus, scientists and engineers specializing in different subject areas are involved in the solution of the problem. The state-of-art of the rogue wave study is summarized in book (Kharif Ch., Pelinovsky E., Slunyaev A. Rogue waves in the ocean. Springer, 2009) and presented in given review. Two approaches to the rogue wave description (deterministic and statistical) are presented. Briefly, the physical mechanisms that have been already suggested as possible explanations of the freak wave phenomenon are: i) wave-current interaction; ii) geometrical (spatial) focusing; iii) focusing due to dispersion (spatio-temporal focusing); iv) focusing due to modulational instability; v) soliton collision; vi) atmospheric action.

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SESSION: ACTIVE GEODYNAMICS

. 105 Seismic Sequences Associated with Complex Subduction in the Northeast Caribbean

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The northeastern Caribbean, in the vicinity of Puerto Rico and the Virgin Islands, has a long history of devastating earthquakes and tsunamis, including major events in 1670, 1787, 1867, 1916, 1918, and 1943. Recently, seismicity has been concentrated to the north and west of the British Virgin Islands, in the region sometimes referred to as the Sombrero Seismic Zone. In the combined seismicity catalog maintained by the Puerto Rico Seismic Network (PRSN), several hundred small to moderate magnitude events can be found in this region prior to 2006. However, beginning in 2006 and continuing to the present, the rate of seismicity in the Sombrero abruptly increased, and a new locus of activity developed to the east of the previous location.

Accurate estimates of seismic hazard, and the tsunamigenic potential of seismic events, depend on an accurate and comprehensive understanding of how strain is being accommodated in this corner region. Are faults locked and accumulating strain for release in a major event? Or is strain being released via slip over a diffuse system of faults? A careful analysis of seismicity and focal mechanism patterns in the Sombrero region has the potential to identify faults and modes of failure, provided the geometrical constraints of recording seismic stations can be improved.

We were able to capture several such seismic sequences, or swarms, during two deployments of ocean bottom seismographs in 2005 and 2007. Relocations and focal mechanism determinations of these sequences reveal a complicated morphology of the subducting North American lithosphere and local stress patterns that are inconsistent with broad regional trends. Results from the OBS deployments, as well as from other studies, will be discussed in the context of their implications for the fate of the subducting slab.

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. 106 The Jan.12, 2010 Haiti earthquake : looking for the fault, from aftershock distribution. Results of the Haiti-OBS experiment

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After the Mw=7.0 January 12, 2010 Haiti earthquake, it was critical to record the aftershock sequence, and due to the geography of the area, a mainly offshore temporary network of seismologic stations appeared to be a convenient option. During the Haiti-OBS cruise, we deployed 21 OBS and 4 onland stations around the damaged area. Post-seismic studies showed that the event was not caused by a rupture along Enriquillo fault (EF), at least in surface. Almost all the aftershocks have N-S compressive mechanism, and not the expected left-lateral strike-slip mechanism. A first-order slip model of the mainshock show a N264°E north-dipping plane, with a major left-lateral component and a strong reverse component. Because the aftershock distribution is parallel to EF, we assume that, although the cause of the catastrophe was not a rupture of EF, this fault play an important role as a mechanical boundary for the elastic stress. In the eastern part of the damaged area, azimuth of focal planes of the aftershocks are parallel to the north-dipping folds of the Transhaitian Belt, suggesting a triggering of these discontinuities. In the western part the aftershock distribution reflect the triggering of similar planes, and/or, alternatively, of steep south-dipping faults such the Trois-Baies active submarine fault. All these observations, as well as the surface geometry on the Gonâve Bay area, are in agreement with the model of an oblique collision of the oceanic crust of Southern Peninsula and the sedimentary wedge of the Transhaitian Belt : the rupture occurred on a wrench fault at the rheologic boundary on top of the underthrusting rigid oceanic block

(Léogâne Fault), and possibly along a south-dipping fault (Trois-Baies Fault), whereas the aftershocks are the result of the relaxation on the hanging wall of these faults, along pre-existing discontinuities in the frontal part of the Transhaitian Belt.

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. 107 Is the Caribbean plate subducting underneath Hispaniola?

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A 200 km long, wide-angle seismic refraction transect was collected in the spring of 2009 across the widest part of the Muertos compressive margin (longitude 69°W). The transect was designed to test the hypothesized subduction of the Caribbean plate's interior beneath the eastern Greater Antilles island arc. Shots were fired every 90 seconds from the R/V Hesperides' 3850 cubic inches water-gun array, which, towed at 5 knots, resulted in a shot spacing of ~ 230 m. The seismic signal was recorded by five ocean-bottom seismometers deployed at distances varying from 30 to 50 km. Published and nearby reprocessed reflection seismic lines provided an initial model of the sediment column and on the pattern of upper crustal reflectors.

Results of a 2-D forward ray-tracing model have enabled us to outline the broad-scale crustal structure across the Muertos margin. The Caribbean oceanic slab is imaged underneath the Muertos margin to about 50 km north of the deformation front and up to 19 km depth. A change in crustal *p*-wave velocity at ~60 km from the deformation front is interpreted to be the boundary between the arc crust and the compressive deformed belt. The Caribbean oceanic crust does not appear to extend farther north. Results of gravity modeling using ship data on this same profile also reject the existence of a subducting Caribbean slab.

The analysis of vertical cross-sections of *p*-wave global tomography imaged the lack of a subduction of the Caribbean plate across the Muertos margin. The analysis also imaged the subduction of the North American slab dipping to the south with a high P-wave velocity anomaly. Our results indicate limited thrusting of the island arc over the Caribbean plate's interior rather than subduction of the Caribbean slab beneath the island arc at the Muertos margin.

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. 108 Marine geophysical research helps to asses the seismic hazard at the Hispaniola Island.

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Detailed seafloor mapping of complete geological provinces together with seismic profiles provide critical perspective for the detection and study of active faults, which helps to assess their seismic and tsunami hazard. Since 2003 the Universidad Complutense de Madrid has been leading an international research group to study the north-eastern Caribbean, from the Lesser Antilles to Jamaica. This area comprises the boundary zone between the North American and the Caribbean plates, where the relative movement of the later relative to the former is ~18-20 ± 3 mm/year towards 070º-075º. The highly-oblique convergence between the plates in Hispaniola is accommodated by strain partitioning on seismic fault systems parallel to the plate boundary: strike-slip (the Enriquillo-Plantain Garden and the Septentrional Fault zones) and the compressive deformed belts (the Muertos thrust belt and the North Hispaniola thrust belt).

Results from several research cruises offshore Hispaniola have permitted to identify and characterize zones of active deformation that were not observable on land, such as the Beata Ridge summit fault zone or the Muertos out-of-sequence thrust. In other fault zones, such as the Enriquillo-Plantain Garden and the

Septentrional Fault Zones, it is necessary to integrate offshore and onshore work. Future upcoming research cruises (e.g., NORCARIBE) have as a target the study of the offshore continuity of seismic fault zones.

After two centuries without significant earthquakes in southern Hispaniola, the Enriquillo-Plantain Garden fault system was responsible for the seismic crisis of January 2010 in Haiti. A review of the original historical records located in the *Archivo General de Indias* and the *Archivo General de la Marina* (Spain), and the archives of the Dominican Republic will provide new constrictions for the epicenters and intensities of the main events from the 16th century, and will help to assess seismic and tsunami hazard in the region.

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. 109 Offshore shallower structure of the collision zone between the Muertos thrust belt and the Beata Ridge (NE Caribbean)

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The Beata Ridge is an aseismic bathymetric high located in the interior of the Caribbean plate which is acting as an obstacle and colliding with the island arc at the Hispaniola. The collision seems to be driven by a small N-S compression into a broad zone of E-W left-lateral motion between the North American and Caribbean plates. The basin-and-range physiography of southern Hispaniola and the sharp termination of the Muertos thrust belt and the Enriquillo-Plantain Garden Fault Zone seem to be related with this collision process.

Swath bathymetry data and reflection seismic profiles acquired during the 2009 CARIBENORTE cruise aboard the Spanish R/V Hespérides, together with re-processed multichannel seismic profiles were used to analyze the morphology and deformation of the western end of the Muertos thrust belt and the northern aseismic Beata Ridge.

The 650 km-long retroarc Muertos thrust belt oroclinally turns from E-W to N and then becomes narrower and disappears in the collision zone with the NNE-SSW trending Beata Ridge. The collision is evidenced because the active Muertos thrust belt has a southward transport direction and the NNE-SSW trending Beata Ridge acts as a basement high in the foreland area.

The northern Beata Ridge shows a strongly asymmetrical cross-shape, with a main west-facing steep fault-scarp (4300 m-high) and a gentler eastern flank formed by an alternation of terraces, interior basins and subsidiary ridges. Except for some minor faulting in the flanks, we have only observed evidence of active tectonics at the summit of the Beata Ridge. This fault zone is parallel to the NNE-SSW-oriented western scarp and is composed of several straight scarp faults, which do not offset laterally the canyon network, arguing against a recent strike-slip motion.

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. 110 Continuous GPS Observations Give Insight into Puerto Rico -Virgin Islands Forearc Deformation

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The northeastern Caribbean, an area which includes Puerto Rico, the Virgin Islands and the northern Lesser Antilles, is home to 13 million people plus numerous tourists, and has been subjected in historic times to several devastating earthquakes and tsunamis. Northeastern Caribbean tectonics is mostly dominated by oblique convergence between the North America and Caribbean plates. As a result of such interactions, strain partitioning, forearc slivers and block rotations have been suggested to occur at the forearc area. Continuous GPS (cGPS) data

are used for the first time to monitor crustal deformation along the forearc, whose combination with a tight arc curvature and obliquity convergence have resulted in intriguing effects on the forearc. In addition, the subduction of the North America plate slab underneath the northeastern Caribbean may be responsible for an

unusually high, but low intensity seismic activity north of the Virgin Islands. This study provides new results from continuously operated GPS stations in the northeastern Caribbean. The velocity field obtained from all of the available data for this sutdy suggest active deformation currently undergoing at the forearc. This deformation is a result of the active current tectonic regime in the region.

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. 111 Seismic Activity offshore Martinica and Dominica islands (Central Lesser Antilles Subduction Zone) from temporary onshore and offshore seismic networks

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An onshore-offshore deployment of a regular grid of 80 OBS and 30 temporary land stations was conducted in the Central Lesser Antilles, where the Atlantic plate dips into the mantle underneath the Caribbean plate. The stations were installed from January to August 2007, from Antigua to the north till Martinica to the south. Each station recorded on a continuous mode seismic data from active sources and the local seismicity. This work focuses on the analysis of the seismological data recorded offshore Martinica and Dominica islands. During the recording period, more than 1300 local seismic events were detected in the area. Site correction beneath each OBS takes into account mud and sedimentary covers from the multichannel seismic profiles analysis and improves the hypocentral locations. Finally, only 638 local earthquakes were located with high precision and 22 focal mechanisms of the best azimuthally constrained earthquakes were determined using P-wave polarities. Between Dominica and Martinica, deep subduction events delineate the Wadati-Benioff Zone till 150 km depth. At shallower depths, a few outer-rise events, related to the bending of the Atlantic plate before it subducts, have been detected. There is also a seismic activity associated with crustal deformation into the Caribbean plate. Offshore Dominica, the seismicity is shallower than offshore Martinica and is characterised by normal and reverse fault mechanisms with an important strike-slip component. The earthquakes which occurred in this region are probably due to the interaction between the Tiburon Ridge and the Caribbean basement. To the south, the focal mechanisms show some purely reverse fault solutions, with one of their nodal planes dipping to the south-west, which agrees with the geometry of the seismogenic zone. Some normal fault solutions with an important strike slip component or purely strike-slip focal mechanisms also have been obtained and are related to intraplate deformation.

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. 112 Approach to the submerged fore-arc of the Lesser Antilles subduction : integrated marine MCS, refraction, OBS seismic activity and noise recording.

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In order to increase the understanding of plate boundaries that show currently low seismic activity, as was the Sumatra-Andaman subduction before the major earthquake in 2004, a cluster of integrated surveys and cruises has been carried out in 2007 and coordinated under the European Union THALES WAS RIGHT project

on the submerged forearc domain of the Lesser Antilles subduction zone, located at the eastern Carribean-America plates boundary.

We collected in a Reflection-Leg (SISMANTILLES 2 - N/O Atalante) a grid of multi-channel reflection profiles which provided structural and velocity constraints through the ~5 km thick accretionary prism down to the decollement and top of the subducting oceanic crust, and also down to the forearc basement. Significant along-strike variation of its shallow upper-crustal structure is revealed and attributed to the ongoing obliquely subduction of two aseismic topographic ridges. In coincidence with two of these dip-profiles, a Refraction-Leg (TRAIL - F/S Merian) operated two 280 km long profiles crossing the whole subduction, with 50 Ocean Bottom Hydrophones or Seismometers (OBH/S) tightly deployed along each profiles, and obtained a depth penetration and resolution that could not be reached by previous regular surveys. The Moho depth revealed under the arc and forearc, as large as 28 km, lends strong support to a new view considering an oceanic plateau crust. Consequently, a larger downdip seismogenic width than previously considered is suggested in the common assumption of the depth of the upper plate Moho being a proxy of this downdip limit.

A dense network with OBSs from several pools (Geoazur, INSU-IPGP, IFM-GEOMAR, AWI) has been deployed far-offshore in an Earthquake-Leg (OBSANTILLES - N/O Antea), with support from ANR Catastrophes Telluriques et Tsunamis (SUBSISMANTI), by the EU SALVADOR Programme of IFM-GEOMAR, as well as by the EU project THALES WAS RIGHT. Reliably and accurately relocated within the 3D structural velocity model and megathrust fault, this network provides new fundamental constraints, particularly on focal depths, to the previously mislocated seismicity studied with the usual observation from only land seismometers. The continuous recordings by this OBS array comprising a variety of water depths and diverse types of seismometers (3-components short-periods, intermediate- and broad-band), allows to sort out among responses depending on instrument configuration or sites, and thus validate conditions of observation of real signals. This broad-spectrum analysis of offshore continuous recordings prevented us for misinterpreting detected Non Volcanic Tremors-like bursts of amplitude. We could instead attribute it to other origins, as diverse as being instrumental or signal forcing by the external envelopes of the solid earth or its tides. Some of these causes which are not related to the earthquake phenomena may also induce apparent transient signals in the case of recording on emerged forearc or with band-limited instruments, that may not be identifiable as such.

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. 113 Tectonic evolution of Barracuda Ridge and Tiburon Rise at the front of Barbados accretionary prism as recorded by Cenozoic stratigraphy

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The Barracuda Ridge and the Tiburon Rise, two major basement ridges, lie at the front of the Barbados accretionary prism, which forms the eastern margin of the Caribbean plate. The region of these two ridges is where the western end of the diffuse North America-South America plate-boundary zone is located. Analysis of a geophysical data set including new multibeam and seismic reflection profiles acquired in 2007 has enabled us to propose an evolutionary model for the geological history of this area, including the timing of the uplift of the Barracuda and Tiburon Ridges.

Terrigenous turbidites derived from South America have been present since the Paleogene over the entire area extending up to the north of the Barracuda Ridge. While the Neogene turbidite sequence is thinner north of the Tiburon Rise, the Quaternary pelagic-distal turbidites form a depocentre in the middle of the basin situated between the two ridges and in the deep trough north of Barracuda Ridge. Two lens-like bodies (interpreted as mass transport deposits), up to 800-m thick, dated as late Early-Pleistocene and occupying an area of the order of 20×103 km2 are described here. Although their source remains poorly located, their deposition coincides chronologically with the onset of the last major tectonic phase affecting this region. From our stratigraphic study, we propose that the seafloor topography inherited from the crustal accretion at the mid-oceanic ridge, was buried by sediments at the end of the Paleogene. It is only later, during the Middle-Late Miocene and the Pleistocene respectively, that the Tiburon Rise and Barracuda Ridge were uplifted further, and

attained their present elevation. We were able to identify a general northward migration of deformation during the Tertiary. This complex geodynamic situation is produced by transpression between North American and South American plates and their deformation as they enter the Lesser Antilles subduction zone.

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. 114 Relative sea level variations on the last two centuries in Martinique: Insights from corals microatolls

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The Lesser Antilles arc is a region of high seismic hazard, which results from the convergence of American and Caribbean plates at 2cm/yr. Several earthquakes of magnitude ≥ 7 have struck the islands in the past. The largest, latest ones occurred only 4 years apart in the mid-19th century, on January 11, 1839 and February 8, 1843, destroying the towns of Fort-de-France and Pointe-à-Pitre, respectively, and killing several thousand people. Today, an earthquake comparable to that of 1843 might cause tens of thousands of casualties in Guadeloupe. In addition to devastating seismic shaking, such earthquakes may trigger large tsunamis. In the Lesser Antilles, the behavior and seismic history of the plate interface remain unknown. Important questions that must be answered are: what is the exact geometry and segmentation of the subduction zone? How large might mega-thrust earthquakes be? What are typical recurrence times for such earthquakes on each segment? Could a large earthquake recur in the next few decades?

To better understand and constrain the seismic hazard related to megathrust in the Lesser Antilles, we tend to retrieve the history of strain accumulation and relief at the plate interface from alive or dead corals. Certain coral species form micro-atolls that grow just below the intertidal zone and thus "fossilize" with their upper surfaces a history of local relative sea level. The annual coral band (or ring) growth is limited upwards by the so-called Highest Level of Survival (HLS, connected to the elevation of the yearly lowest tide level). When the sea level rises or drops due to tectonic or climatic events, the micro-atoll growth is perturbed. By analyzing in detail the coral aragonite skeleton, and U/Th dating specific events, it is possible to retrieve the history of sea level change through at least parts of several centuries.

We identified several sites with living micro-atolls in the islands we visited (Martinique, Guadeloupe, Antigua, Barbuda). In January 2008, we performed our first chain-saw test-sampling of six micro-atolls in Martinique. The coral of interest (Siderastrea Siderea) is a rather slow-growing species. Its annual growth rate (≈ 3-5 mm/yr) was determined by counting annual bands, chemical analysis calibration and U/Th dating. Preliminary results indicate that during the last two centuries, the micro-atolls have record a sea-level rise of ≈ 3 mm/yr, regularly interrupted by sudden emergence events of few centimeters, 15 to 50 years apart. This signal is due both to interseimic deformation and climatic events. The oldest micro-atoll, which is ≈ 250 year-old, may have recorded the 1839 earthquake.

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. 115 Les Saintes volcanic system: a field survey for structural reappraisal.

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Located in the Guadeloupe Archipelago, the islands of Les Saintes are in the middle of the Lesser Antilles volcanic arc. It is constituted of calco-alcaline volcanites ranging from 1 to 5 My old (Jacques et al., 1984). Although the volcanic system is not active any more, the area is consistently struck by earthquakes. This seismicity is well recorded since the 21st of October 2004 Mw=6.4 damaging event. This event has a normal

focal solution with NW-SE nodal planes (USGS, GEOSCOPE-IPGP, Courboulex et al., 2010). The overall distribution of the seismicity is characterized by a NW-SE seismic swarm (Bengoubou, 2008) that follows the trend of a N140° offshore fault system extending from the northern tip of the Arc to Dominica (Feuillet 2000). In Les Saintes, this fault system merges with the western end of the E-W Marie Galante graben (N90°). The conflicted relations between these two systems have been the subject of very few studies. In the geological map established in 1984, Jacques and Maury evidence two phases of fracturation. The first one, from 5 to 3.6 My being NNE-SSW and E-W, the second one, from 1.3 to 0.6 My being NNE-SSW and WNW-ESE. To study the relations between the two fault systems (NW-SE along the Arc and E-W Marie Galante graben), and explore their possible link with the volcanic activity, we conducted a field survey from February to April 2010. Samples for Ar-Ar dating have also been collected and are currently under process. Preliminary results show that the two offshore fault system (N140° and N90°) have been synchronously active in Les Saintes, posterior of 0.85 My. Two other fault families, known in Guadeloupe (Chabelard et al., 1986), have been evidenced as well (N60° and N20°). Inversion of structural data tend to show a compatibility with a transtensive regime since 5 My.

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. 116 Structural context of the Bouillante area: Contribution of high resolution marine geophysical surveys (western shelf of Basse-Terre Island, Guadeloupe, French West Indies)

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In order to understand the structural context of the *Bouillante* geothermal field, ADEME and BRGM has carried out offshore studies on the western shelf of Basse-Terre Island. Detailed analysis of high-resolution seismic, bathymetric and magnetic data allowed determination of the origin of the submarine topography, distribution of the sedimentary units, morphology of the basement and offshore continuation of the tectonic structures identified onshore.

The present-day morphological features of the shelf are mainly related to the latest post-glacial deposits. Off the *Bouillante* bay, a thick sedimentary deposition has induced an important widening of the shelf, thus hiding the real morphology of the basement. The sedimentary cover has recorded two major erosions – low sea-level phases, the last one being correlated with the last 20 ky glacial maximum.

The main faults, offshore the geothermal field anomaly, have been mapped. The N160°W escarpment, which bounds the shelf, may be a major sinistral strike-slip system, playing the role of transfer zone between the N140 *Montserrat* and *Les Saintes* systems. The N140-trending faults and NE-SW faults were also observed on the shelf. The EW-trending *Bouillante—Capesterre* fault system, which belongs to the *Marie-Galante* graben system (e.g. Feuillet et al., 2002), extends into the *Bouillante* bay. This structure cuts the whole western shelf as well as the N160 and N140-trending faults, and controls the morphology of the basement. South of *Bouillante* Bay, a volcanic edifice of the *Bouillante* chain extends over the shelf in the axis of the andesitic submarine volcanoes. The 3D structural model (Calcagno et al., in this congress) allows to confirm the land-sea prolongation of the structures, and to specify the relationships between the fault sets.

This study confirms that the Bouillante area is a key sector of regional geodynamic interest in the Lesser Antilles Arc.

Feuillet N., Manighetti I., Tapponier P. and Jacques E. (2002), Arc parallel extension and localization of volcanic complexes in Guadeloupe, Lesser Antilles, J. Geophys. Res., 107(B12), 2331.

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POSTERS : ACTIVE GEODYNAMICS

. 117 Subduction-to-Strike-Slip Transition in the Southeast Caribbean Using Deeply Penetrating Seismic Reflection Lines and Tomography

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The subduction-to-strike-slip transition (SSST) zone of the southeastern Caribbean is one of thirty identified locations where active subduction and strike-slip tectonic styles transition along strongly curved and seismogenic plate boundaries. This SSST zone provides a field laboratory for understanding how sedimentary basins, faults, basement areas and subducted slabs change from an area of dominantly westward-directed subduction beneath the Lesser Antilles arc to an area of dominantly east-west strike-slip faulting along northern South America. We use two geophysical data types to study the relationships between lithospheric scale deformation and basin scale response to the transitional tectonic configuration. Interpretation of deeply-penetrating seismic reflection lines recorded down to 16 seconds TWT, or depths of ~18 km, is combined with tomographic slices of the upper mantle and lower crust which were constructed using the coda method on ~ 700 earthquakes in the 0-250 km depth range.

Results from the tomographic study are compared with nine seismogenic zones in the southeast Caribbean SSST zone defined based on the depth, and focal mechanism of earthquake events. These zones include: (1) the Paria slab tear region; (2) Caribbean/South American strike-slip zone; (3) Hinge area separating continental margin in Trinidad from Tobago forearc basin; (4) Central Range – strike-slip fault zone, onshore Trinidad; (5) Underthrust zone of South American beneath southern onshore and offshore eastern Trinidad, including the hydrocarbon-bearing Columbus Basin; (6) Venezuela foreland and fold-thrust belt; (7) Flexural bulge area of oceanic crust located east of Barbados accretionary prism (BAP); (8) Subducted slab beneath the stabilized and supracomplex zones of the BAP; (9) Inner accretionary prism of the BAP. Primary controls on the seismogenic character of each curving tectonic belt include the strike of the plate boundary faults relative to the plate vector for crustal earthquakes and the location and morphology of the subducted slab for sub-crustal earthquakes.

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. 118 Sobre el origen de la sismicidad en la Sierra Nevada de Santa Marta y la Península de La Guajira, Colombia.

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Con el análisis de imágenes Landsat y trabajo de campo en varios lugares del norte de la Sierra Nevada de Santa Marta y la península de La Guajira, se han encontrado evidencias de tectónica activa. Igualmente la Red Sismológica Nacional de Colombia (RSNC), registra sismicidad para esta región, la cual es periódica con $3.0 \leq M_L \leq 5.0$ al igual que la red sismológica mundial (NEIC) que ha registrado para esta región sismos con una magnitud de momento (M) $\geq 4{,}5$. Lamentablemente estas redes sismológicas poseen un número muy pequeño de estaciones en la región y su diseño ha sido establecido para determinar la sismicidad regional y no la sismicidad local. La profundidad focal de los sismos detectados por estas redes varía de entre 0 y 45 km, definiéndose que son de naturaleza intraplaca y no sublitosférica. Aquí planteamos que la sismicidad se debe al empuje que la placa Caribe ejerce sobre la península de La Guajira generando un campo de esfuerzos regional en dirección ESE, por lo que la península se está moviendo hacia el E a lo largo de su contacto con el norte de Suramérica que está definido por la Falla Oca. A esta falla se atribuye el sismo que afectó a la ciudad de Santa Marta en 1834. El gran tamaño de la Falla Oca, cuyo rumbo es E -W y la similaridad de su contexto geodinámico con el de las fallas del norte de la placa Caribe como la Enriquillo – Plantain Garden de Haití, hace pensar que la falla Oca ofrece las mismas probabilidades que esta última para producir un sismo con una magnitud semejante al presentado el 12 de enero de 2010 en la República de Haití.

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. 119 3D Fore-arc structure offshore Martinique and Dominique island

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In the framework of the European project "Thales was Right", three seismic surveys (Trail, Sismantilles II and Obsantilles) were carried out to better constrain the lithospheric structure of the Lesser Antilles subduction

zone and its seismic activity. The 3D crustal structure of this convergent margin is presented here from first arrival tomographic inversion from 3D wide-angle seismic dataset acquired offshore Martinique and Dominique islands.

We differentiate an inner fore-arc crust characterized by a strong velocity gradient from an outer fore-arc made of a weaker velocity gradient crust. To the north the limit between both fore-arc corresponds to the Karukera spur. The backstop defines the eastern limit of the outer fore-arc. It was imaged combining our 3D tomography to multi-channel seismic profiles. To the north of our study area, it is in continuation of the backstop imaged by Christenson et al. (2003). To the south, the outer fore-arc does not exist and the backstop coincides to the eastern limit of the inner fore-arc. So the outer fore-arc has a triangular shape that ends offshore Martinique. It appears deform offshore Dominique by the subduction of the Tiburon ridge. Whereas the inner fore-arc is a high-velocity crustal block that can be interpreted as the extension at depth of the Mesozoic Caribbean crust outcropping at La Désirade island, the outer fore-arc is deformable and different hypothesis can explain its origin.

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. 120 Active faulting induced by slip partitioning in Montserrat and link with volcanic activity: New insights from the 2009 GWADASEIS marine cruise data

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New high-resolution marine data acquired aboard R/VLe Suroît was used to map active normal faults offshore Montserrat in greater detail. The main faults of the Montserrat-Havers fault zone have cumulative scarps up to 200 m high, and offset sedimentary layers by hundreds of meters. They are arranged in a right-stepping, en echelon, trans-tensional array, which confirms that they accommodate the left-lateral component of motion resulting from slip partitioning of oblique convergence along the volcanic arc. They cut across Montserrat's recent volcanic complex. Faulting and fissuring exerted control on the position of andesitic domes, which are aligned along the N110°E average fault trend. The ≈10 km-long fault segments that cross the island could produce damaging, M ≈ 6 events comparable to the shallow, 16 March 1985, Mw~6.3 earthquake that ruptured a submarine, N140°E striking, leftlateral fault near Redonda.

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. 121 The Kashallow Program - A study of the tectono-sedimentary architecture of the Marie-Galante basin, Lesser Antilles fore-arc

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The Marie-Galante basin has experienced high amplitude (up to several thousands meters) vertical movements in response to both local tectonic in the fore-arc (trench perpendicular extensional tectonic) and geodynamical events at the plate interface such as long-term interplate coupling changes or ridges subduction or alternating period of under-plating/basal erosion...

During the KaShallow cruises 1 and 2, ca. 3500km of high-resolution multichannel seismic reflection data (sparker and miniGI airgun sources), together with HR multibeam bathymetric (50m gridspacing DTM with ~2m depth precision) were acquired in the basin and the shallow-water plateaus of the islands. A systematic rock sampling using piston and rock corers, and 2 ROV dives, allowed sedimentological and stratigraphical (radiometric dating and micropalaeontology) studies of the main seismic units.

The Marie-Galante basin comprises 3 main morphological and geological domains:

1/ the deep basin, gently deepens southeastward from the volcanic arc islands of Basse-Terre and Dominica to the accretionnary prism down to 5000m bsl. Seismic profiles revealed channels-levee systems

intrepreted as turbiditic deposits. ROV dives permitted to sample volcanosedimentary turbidites early Miocene in age. Cores provided late Miocene to Pliocene slope to pelagic sediments. The new bathymetric data lead to identify four striking fault systems (N160°, N40°, N90° and N130°).

2/ the shallow-water plateaus exhibit the offshore extent of the emerged Pliocene-Pleistocene carbonate platforms (refer to associate presentation by *Lebrun et al*, this conference) and isolated Pleistocene-Quaternary carbonate platforms (Banc Colombie, Banc Flandres, Les Saintes Plateau).

3/ the Karukera spur limits the Marie-Galante basin to the east. It extends North/South and deepens southward. It corresponds to a southward tilted block during Pliocene times. Tectonic structures and sedimentary organisation of the Karukera spur are detailed in De Min et al associated presentation (this conference).

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. 122 Vertical deformations related to the January 12 2010 Haïti earthquake

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The January 12, 2010 Haiti earthquake was first supposed to have ruptured a segment of the left-lateral Enriquillo fault. This fault, with the septentrional, is the most important one in Haiti. It accommodates a significant part (7mm/yr) of the oblique convergence between the Caribbean and North-American plates. It crosscuts the southern part of the Hispaniola island and was already identified as a potential source for the destructive 1751 and 1770 M>7 earthquakes. The lack of surface breaks and the pattern of coseismic deformations suggest that a north-dipping unmapped fault named « Leogane fault » could have been responsible for the earthquake. (*Calais et al., Prentice et al., 2010*)

Westward of Port-au-Prince, near Leogâne, the coast rose by several tens of centimeters during the earthquake. Several pieces of fringing reefs from at least Ca-Ira to Petit-Goâve were uplifted and massive coral microatolls were exposed and died. Such corals record the relative sea level variations due to tectonic or climatic events with a precision of few centimeters (Sieh et al., 2008). Most of them are *Siderastrea siderea* that grow at rate of about 4-5 mm/yr (Weil Accardo et al., 2010). Given their size, some microatolls are older than 200 years. A detailed mapping of coral heads with a theodolite revealed that they have been uplifted by 55 ± 8 cm at the site of Belloc. To retrieve the history of the interseismic deformation over the last two centuries, we sampled four slices of microatolls on the emerged Belloc reef, few weeks after the earthquake. Moreover, clear indications of past tectonic deformations exist in this area. A flight of marine reef terraces is uplited by few meters along the coast. We sampled these reefs for U/Th dating to date past historical earthquakes.

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SESSION : PEDOLOGY, SUBSURFACE, BIOGEOLOGY

. 123 The West-Indian Sloanea and the age of the recent arc

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The Lesser Antilles archipelago has a long and complex history. The first volcanic activities associated with it are 145 millions years (BIB) old but the present islands are more recent. These lands result from two or may be three distinct tectonic episodes. The first one sets up before 50 millions years, some volcanic edifices that afterwards, were eroded. When submerged under shallow water, these lands were recovered by marine limestone. More recently, they emerged as flat islands and constituted the so-called "ancient arc". Elevation in these islands is always less than130m high, inducing relatively dry climates and allowing only a seasonal forest to develop (semi-deciduous and evergreen seasonal forest).

The second tectonic episode, which is always currently in progress, build up high volcanoes along with the present subduction line. In the middle of the archipelago, this recent arc collapses with the ancient one. The islands that are built around the volcanoes exhibits rainy climates, up to 2500 mm/yr, and harbours rain forest (submontane and montane rain forest). Datation of superficial volcanic materials are very recent (less than 5 Myr) even if we can suppose that these news rocks hide some older ones.

The rain forests of the Lesser Antilles harbours 22% of endemic tree species that significantly contribute to regional biodiversity. Such insular endemics result form local speciation. Genetic analysis of West-Indian *Sloanea* suggests that the more ancient speciation (*S. dentata*) is 20 millions year old. Since the Old-World Sloanea live in rain forests, this vegetation type seems to exist continuously from this long-dated time. Such a hypothesis in turn, implies that volcanic islands with high ridges could exist as far as 20 Myr.

The biogeography may support some hypothesis relative to the tectonic history of the West Indies. The premises of the recent arc could be localised in the South and dated 20 Myr. These first events could then coincide with the breaking-up of Aves Ridge.

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. 124 Chemical weathering and erosion rates in Lesser Antilles: an overview in Guadeloupe, Martinique and Dominique

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Lesser Antilles are located in a tropical climate with high temperatures, high precipitations, very dense vegetation, sharp relief and very thick soils. It is characterized by a uniform andesitic lithology and presents an East-West variation in precipitations and hence in runoff. Moreover, the implantation of agriculture induces important land use changes which replace existing native forest cover with banana and sugar cane plantations.

Guadeloupe, Martinique and Dominique Islands alike numerous tropical environment present therefore extreme weathering regimes.

Physical denudation is mainly controlled by landside, especially where pyroclastic formations are thick. It is discontinuous and proceeds by pulses during tropical storms. This reflects the torrential dynamics of the rivers. For Guadeloupe, the mechanical weathering rates are 800-4000 t/km^2/yr.

As for many volcanic islands erodible lithology such as pyroclastic flows with ashes or even massif lava flows involve important material transported during the erosion processes. The lithology is also very porous with high infiltration rates, which induces that most of the elements fluxes are produced on subsurface as the chemical erosion rates are 2 to 5 time higher than the rates from surface water (Rad et al., 2007). We show how kinetic of chemical weathering rates depends on the age of the lava and subsurface circulation with local hydrothermal springs produce by the acidity of volcanoes, which highly increases chemical weathering rates. These islands present some of the highest surface chemical denudation rates that can reach 1290 t/km^2/yr.

We show that among the combined impact of all parameters (climate, runoff, slopes, vegetation…), the basins age seems to be the control parameter on chemical weathering and land use: the younger the basin, the higher the weathering rate.

We could observe a combined effect between the higher erodibility and a higher climate erosivity of the younger reliefs.

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. 125 Sols dérivés de roches volcaniques : un patron de leurs constituants et propriétés

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Les roches volcaniques comportent des silicates tous altérables, dont l'hydrolyse fournit des sols riches en minéraux secondaires fins. Leur nature est déterminée par l'importance du lessivage des constituants solubles, silice et cations alcalins et alcalino-terreux.

Ainsi, dans les zones pluvieuses, se forment des argiles 1/1 à faible activité, principalement l'halloysite, désaturée par le lessivage des cations alcalins et alcalino-terreux. La fertilité minérale des sols est faible dès l'épuisement des minéraux primaires. La micro-agrégation des argiles par les oxy-hydroxydes de fer, et le pH acide leur confère une infiltrabilité et une stabilité élevées, et donc une résistance à l'érosion superficielle.

Sous forte pluviométrie, les sols jeunes sont constitués d'allophanes, gels organo-minéraux amorphes très hydratés et hydroxylés, dont l'organisation porale est fractale. L'abondance des minéraux primaires, une capacité d'échange anionique et cationique, une infiltrabilité et une stabilité structurale élevées confèrent à ces sols une fertilité et une résistance à l'érosion exceptionnelles. Consommation du CO_2 par l'altération et séquestration du carbone organique en font un exceptionnel puits de carbone.

Les sols des zones sèches comportent essentiellement des smectites 2/1, dont la capacité d'échange cationique élevée reste saturée par Ca, Mg, Na, maintenant un pH neutre. Sur des supports calcaires, le calcium les maintient floculées. Au contraire, elles sont dispersables dans les horizons sous-superficiels sur roches volcaniques et leur gonflement entraîne une faible infiltrabilité à saturation, exposant les sols à l'érosion hydrique superficielle (Haïti, Sud Martinique).

L'histoire des volcans peut placer des smectites dans des conditions où leur hydrolyse les transforme transitoirement en intergrade à aluminium échangeable, toxique pour les végétaux. Mangroves soulevées et hauts versants recevant des pyroclastites phréatiques partagent le même mécanisme d'acidification par oxydation des pyrites. L'augmentation de pluviométrie, après érosion ou subsidence des volcans, serait l'autre cause de déstabilisation des smectites.

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SESSION: LANDSLIDES AND GRAVITY INSTABILITIES

. 126 Earthquakes induced landslides: using Carbon -14 technique to date earthquake events.

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The most devastating effect of the 1692 earthquake in Jamaica has been associated with the liquefaction incidents in Port Royal with two-thirds of the city of Port Royal sinking into the harbour and over three-thousand (3000) lives lost. Other incidents associated with the event is the Judgement cliff landslides in the parish of St. Thomas and other less intense landslides and ground shaking across the island. Other large landslides in St. Thomas and Portland are believed to be associated with the 1692 earthquake. Lesser known landslides are believed to be associated with other earthquakes, e.g. Ness Castle- Arntully Slides with the 1907 earthquake; however, although believed to be more recent the event is less precise with regards to the 1907 earthquake. As a means to improve the history of earthquakes in Jamaica landslides believed to be associated with prehistoric and historic earthquakes these landslides are analysed in order to date, and examine their failure mechanism with regards to the earthquake intensity. Carbon -14 dates from the Judgement Cliff landslide is used as a means to calibrate the date of failure and also to date these other major slides that has less precise documentation of their time of occurrence.

Keywords: landslides, earthquake induced, failure mechanism,

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. 127 2009-2010 landslide crisis in Martinique related to the 2007 North Martinique earthquake

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In November 2007, the North Martinique earthquake, M=7.4 occurred at 140 km depth. During the following year, after years of silence, the Volcano and Seismic Observatory of Martinique (OVSM) recorded tens of shallow volcanic earthquakes (0 to 3 km depth) in Montagne Pelée volcano. Spectral analysis of these events enables us to relate them with fluid circulation within the upper volcano. In August 2009, a first large landslide occurred at Piton Marcel, on the western flank of Montagne Pelée volcano. In May 2010, a new sequence of landslides began, volcano seismicity ended and water resurgences appeared in the middle of the scar. It can be noted that this kind of resurgences already existed on the 1980 scar produced by the previous large landslide crisis. By the end of the year 2010, the OVSM seismometers have recorded 3 main landslide sequences representing 241 events of various intensities. Two topographic Lidar missions, one before and the other one after the most important landslide of May, were piloted by the Direction de l'Environnement, de l'Aménagement et du Logement (DEAL) within the framework of its missions of knowledge improvement of natural hazard assessment and of environmental data distribution. We process these high-resolution data (1 point/m2) to obtain a volume estimation of ca. 2.25 millions of m3 removed from Piton Marcel. Finally, using our large landslide database, we evidence that each sequence not only follows a Gutenberg-Richter distribution (logarithmic distribution of intensities), but also that the temporal activity decreases in agreement with the Omori law. This result evidences that each landslide sequence following a large landslide, by similitude with earthquake crisis, corresponds to a physically closed system that does not receive further energy once initiated, and then will decrease and go back to balance rapidly.

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. 128 Rainfall induced river flood modelling in Jamaica with special emphasis on Port Maria, St Mary

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Climate change associated with increased rainfall has led to an increase in flood frequencies globally as well as regionally. The effects are widely felt in the Caribbean and in Jamaica where the hurricane frequencies have increased along with flooding in the recent past. Jamaica has been devastated by many hurricanes in recent years due to its geographical situation in the path of Atlantic hurricane belt, eg Gilbert in 1988, Ivan in 2004, Dean in 2007, Gustav ad Paloma in 2008 and Nicole (tropical storm) in 2010. All of these have led to devastated flooding and widespread landslides and debris flooding in different sections of the island causing loss of life and property. Port Maria owing to its location in the high rainfall zones of Jamaica is exposed to sever flooding from intense rainfall, causing collapse of bridge and loss to life and property. The present study aims in modelling the flooding events of November 2006 and December 2009 where a single 24 hr rainfall of 240mm caused extensive flooding of the entire town with flood waters rising as high as 1.8m. Modelling the 2006 and 2009 flooding events of Port Maria are being carried out using hydraulic and hydrologic modes eg HEC-RAS and HEC-GEORAS using both steady and unsteady state flow and creating flood plain maps covering the entire town, located near the mouth of the river. Cross-sectional studies conducted over the past one year has shown significant change in the water levels of the river with values as low as 1.6 feet in October 2009 and May 2010 to 10.5 feet in Sept 2010 ie after the heavy rainfall caused by Nicole. It must be noted here that low water levels could be attributed to less rainfall in 2009 due to the presence of El-Nino in the Atlantic.

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. 129 Séisme du 12 janvier en Haïti : Premiers enseignements sur l'importance des effets de site et des mouvements de terrain induits dans l'explication des dégâts observés

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L'hétérogénéité de la distribution des dommages dans les zones les plus affectées par le séisme du 12 janvier 2010 en Haïti s'explique largement par la vulnérabilité du milieu construit. Mais elle est en partie liée à des variations du niveau d'agression sismique causées par des effets de site et des phénomènes induits (glissements, éboulements, liquéfaction).

A partir de deux missions d'expertise auxquelles le BRGM a participé en février puis en mai, des premiers éléments de réponse sont apportés. Ils reposent sur une synthèse documentaire, des échanges avec des scientifiques et ingénieurs locaux (notamment ceux du BME et du LNBTP), des reconnaissances de terrain et des mesures de bruit de fond sismique (méthode H/V).

Les résultats obtenus soulignent dans la région de Port-au-Prince, le rôle particulier des formations de piémont du Miocène et du cône détritique du Pliocène (« formation de Delmas »), pour les effets de site liés au sous-sol. Toutefois, ceux-ci sont a priori complexes en raison de la grande hétérogénéité lithologique et structurale au sein de ces formations (effets 2D et 3D probables). Les mesures H/V ne permettent pas (ou mal) de mettre en évidence de tels effets. Dans d'autres cas (comme à Carrefour), les effets de site sont plus classiques et peuvent être mis en évidence. De manière générale, l'absence de données accélérométriques et des données géotechniques insuffisantes (en qualité et en quantité), sont préjudiciables à une bonne compréhension des effets de site.

Des mouvements de terrain induits se sont manifestés de manière spectaculaire : liquéfaction au Port de Port-au-Prince, glissements côtiers vers Petit-Goave, éboulements à La Boule (au sein des calcaires éocènes), éboulements multiples en zone d'habitat dense au sein de la formation de Delmas à Port-au-Prince, … Mais de manière globale, ils contribuent relativement peu aux dégâts du séisme.

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. 130 Pluviométrie et calculs de stabilité de talus routiers en Haïti :

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Roads are normally equipped with drainage systems sized and implemented in accordance with the rules of art to evacuate as quickly as possible to the right of way, water precipitation to be considered on the basis of return periods taken into account. However, there are often water flows at the slope side and sometimes in the shoulders and / or running surfaces that are not waterproof. A succession of rain causes a certain amount of water infiltration, which varies according to climatic conditions and depending on the soil texture and structure. Such infiltrations have resulted in reduced safety factor of slopes.

Although there are several scientific publications on rainfall leading to landslides (Lim et al. 1996; Cho et al. 2001, Kim et al. 2004; Xue et al. 2007; Gavin and al. 2008), impacts resulting from infiltration of successive rains on the behavior of surface layers of unsaturated soils are usually not taken into account. Models for calculating the slope stability of unsaturated soils require many parameters that can be, in certain circumstances, difficult to assess and refer generally to cases of instability caused by a rise in groundwater level.

Based on laboratory tests, a suitable methodology for assessing the spatial and temporal variation of soil water content induced by a set of rains has been developed. This methodology facilitates the inclusion of the cumulative effects of the infiltration rates associated with rain events and infers from them the profile of suction and that of the apparent cohesion to be used to calculate, for a slope angle β, the range of variation of the safety factor. This methodology is particularly relevant in the case of limited budgets and infrastructures.

Keywords: Safety factor – Apparent Cohesion – Infiltration – Rainfall – Unsaturated soil – Stability of Slopes – Suction

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. 131 Mouvements de terrain associés aux intempéries du 5 mai 2009 en Martinique (Antilles françaises) – retour d'expérience

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De très fortes pluies sont tombées sur la Martinique le 5 mai 2009 (temps de retour de 30 à 50 ans). Ces intempéries ont provoqué de nombreux glissements de terrain et coulées boueuses (plus de 170) sur une grande partie du territoire. L'état de catastrophe naturelle a été décrété.

Le BRGM, établissement public de l'État et la DEAL (administration en charge localement de la prévention des risques naturels) ont été fortement impliqués : interventions en situation de crise pour la définition de mesures d'urgence vis-à-vis des instabilités, puis réalisation d'expertises sur des maisons évacuées et des canalisations d'eau potable endommagées pour définir des mesures de mise en sécurité et enfin, un travail d'inventaire et de retour d'expérience, vis-à-vis notamment des zonages d'aléa existants, de la géologie, de l'impact sur les réseaux, etc.

Les cumuls extraordinaires de ces pluies en quelques jours et en pleine saison sèche ont favorisé une mobilisation plutôt superficielle des terrains. Les grands glissements profonds et actifs de la Martinique n'ont eux que très peu réagi. Les nappes d'eau profondes qui influent sur ces glissements n'ont pas été sollicitées.

De nombreuses instabilités sont survenues dans des zones d'aléa moyen où les constructions sont autorisées par les Plans de Préventions des Risques (outil permettant en France, la prise en compte réglementaire des risques dans la construction et l'aménagement). Cela souligne la grande vulnérabilité de la Martinique et des iles antillaises en général. Dans ces territoires exigus, densément peuplés, seules les zones exposées à un aléa élevé à très élevé sont interdites à la construction.

Cet épisode a confirmé la vulnérabilité du bâti martiniquais face aux mouvements de terrain (fondations peu profondes, murs exposés mal adaptés, mauvaise gestion des eaux). Il a aussi révélé la grande vulnérabilité du réseau d'eau potable. Un glissement de terrain a provoqué la rupture d'une canalisation majeure qui desservait

100 000 personnes, entrainant des coupures d'eau pendant deux semaines. Le réseau routier a également été fortement perturbé.

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. 132 Etude des caractéristiques géophysiques, géotechniques et de rétention d'eau des sols du Massif de la Selle (Kenscoff-Haïti)

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Suite au glissement de terrain survenu à Kenscoff en 2006 (Haïti), une campagne d'acquisition de données géophysiques (sondages et tomographies électriques et sondages sismiques réfraction), et de caractéristiques géotechniques (essais d'identification physiques, minéralogiques, et chimiques) a été réalisée sur ce site avec l'objectif d'apporter une explication sur les causes du glissement.

La prospection géophysique nous a permis de déterminer à partir de plusieurs propriétés physiques, la structure et la composition du milieu souterrain. La reconnaissance géotechnique, quant à elle, a identifié physiquement, minéralogiquement et chimiquement les échantillons prélevés. Une étude comparative a été faite entre ces deux approches de caractérisation de sols en croisant les résultats issus de chacune d'elles.

Une fois les sols caractérisés et identifiés, ils ont été étudiés dans un premier temps en conditions hydromécaniques saturées afin d'avoir un état de référence. Ensuite, des essais de mesure de succion et des essais triaxiaux à succion non contrôlée (essais non consolidés et non drainés UU) ont permis de mettre en évidence certains comportements hydromécaniques en conditions non saturées. La prise en compte de la succion dans ces sols favorise le drainage des sols et s'accompagne d'une augmentation des résistances en cisaillement via la « cohésion capillaire ».

D'une façon générale, cette étude expérimentale a montré que cette prise en compte de la succion conduit à une augmentation de la résistance des sols, donc à une augmentation du coefficient de sécurité de la pente. Cette observation nous permet de déduire dans cette zone d'influence saisonnière qu'en période sèche où la succion augmente, les talus sont stables ; alors qu'en période pluvieuse où la succion diminue et s'annule en surface, les talus sont instables. On en conclut que la diminution de la succion sur la stabilité de ce talus est le principal facteur qui a dû conduire au déclenchement de ce glissement.

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. 133 Evaluation and prevention of soil liquefaction at Fort-de-France (Martinique)

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Soil liquefaction describes a phenomenon whereby a loose soil loses strength and stiffness, due to an increase of pore water pressure, in response to an earthquake shaking. At Fort-de-France some studies have revealed several area where soil liquefaction risk is important. These areas are already urbanized or will be by future program of urbanization.

The Prevention Plan of Natural Risks (Territorial Plan of prevention) of the city does not contain prescriptions or recommendations for constructions in liquefaction area, while this phenomenon must be integrated into any program of development of Territory.

Then a R&D agreement has been establish between the city of Fort-de-France and BRGM (the French Geological Survey) in order to:

- increase knowledge of soil liquefaction susceptibility,
- refine liquefaction hazard cartography,
- establish adequate geotechnical in situ tests for soil liquefaction potential assessment in Martinique's context,
- establish recommendations for prevention and construction in liquefiable areas.

The study leans on a database with 1678 boreholes. This database stores all information described in the borehole log sheets such as lithological description and geotechnical information relative to liquefaction

characterization. This information essentially come from various archives and from a specific survey includes to this study.

In order to evaluate thickness of liquefiable soil in each point of the study area, a multi-layer 3D geological model has been developed using geostatistical methods.

For the susceptibility analysis, the method used was based on geological information and results of identification laboratory tests (in accordance with European rules Eurocode8). For the intensity analysis, procedures developed by Robertson & Wride (1998) and Iwasaki (1984) were adopted.

Knowledge of liquefiable thickness and of liquefaction susceptibility and intensity allows the cartography of liquefaction hazard area.

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POSTERS : LANDSLIDES AND GRAVITY INSTABILITIES

. 134 Analysis of 2009-2010 lahars in Prêcheur River, Martinique, with acoustic, seismic, Lidar topographic, and meteorological radar data

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Following the 2009-2010 landslide crisis at Piton Marcel, Montagne Pelée, over 45 lahars of various intensities occurred in the Prêcheur River. These lahars were fully recorded by the Martinique Observatory (OVSM) through its geophone (Acoustic Flow Monitoring system, developed by the Cascade Observatory) and seismic networks. Lahar events are fed by landslide deposits in the upper part of the river, and are subsequently remobilized by rainfalls. In this study, we try to estimate the most relevant lahar-triggering factor, i.e. rainfall intensity vs. water accumulation, with rainfall data coming from the weather radar operated in Martinique by MeteoFrance, and constrained by the Martinique rain gauge network.

We present a temporal analysis between landslide, lahars and rainfalls. Interpretation of time arrival along our geophone network evidences large variations in flood velocity from 2 to 12 m/s, well correlated with the rainfall intensity. However, lahar initiation is likely related to rainfall accumulation. In addition, we use high-resolution topographic LIDAR data, acquired before and after the 2010, June 19-20 main lahars, to quantify the effect of both lahars and landslides on the river topography. We find 1) a continuous distribution of changes in the river profile from -7m in the upper part to + 5m in the lower part, 2) the volume eroded by the June lahars in the river to be ca. 0,25 millions of m3, 3) the slided material at Piton Marcel during the major 2010 May 12 landslide to be 2,25 millions of m3. In total, it is 2,5 millions of m3 that have been transported to the Caribbean Sea. As historical information shows a few decades recurrence for this kind of events, it confirms their major influence to shape the landscape, by comparison with cataclysmic landslides that occur at tens of thousand year intervals.

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. 135 Historical record of landslides, floods, and lahars in the Prêcheur river catchment, Montagne Pelée Volcano (Martinique Island, Lesser Antilles arc) from 1865 to 2010

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Lahars and floods are major hazards in tropical volcanic islands. They may have several origins : (1) lahar due to a volcanic eruption, (2) lahars triggered by rainfall after large-volume landslides, and (3) floods triggered by cyclonic events.

Le Prêcheur is a small town located in the Northwest of Martinique Island. In 2010, a major landslide occurred in May 11th which was followed by more than 40 rainfall-triggered lahars. The lahars with the greatest intensity occurred in June 19-20th, 2010 causing partial destruction of the bridge and inundations of ~20 homes.

In this study, we compiled lahar and flood events in Le Prêcheur river during the period 1865-2010. The material used in the compilation are local archives, newspapers and books, all in French language, which had no or a limited diffusion.

The preliminary results of this compilation is as follows :

(1) One lahar is of eruptive origin. It occurred during the night of May 7-8th, 1902 at 2 a.m. local time and caused 400 deaths.

(2) Lahars caused by rainfall after large-volume landslides occurred with certainty in Dec. 1980 (bridge destruction), January 1997, January 1998, Aug.-Sept. 2009, and May-Nov. 2010 (bridge destruction).

(3) Floods triggered by tropical storms or cyclones occurred in Apr. 1865, Aug. 1891, Oct. 1909, Apr. 1927, 1950 or 1951 (1 death), Sept 1963 (Edith), Sept 1967 (Beulah), Aug. 1970 (3 deaths), Nov.-Dec. 1976, Aug. 1977, Aug. 1979, Nov. 1984, Oct. 1990, Aug-Sept 1993 (Cindy), and Aug. 1995.

The largest difficulty of this analysis resides in deciphering between lahars caused by landslides and floods caused by cyclonic events.

The major conclusion of our study is that syn-eruptive lahars are by far the largest contributor to deaths and casualties that occurred in Le Prêcheur during the 20th century.

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. 136 Interpretation of the piezometric fluctuations associated to the november 29, 2007 7.4 earthquake in Martinique

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On November 29, 2007, at 3:00 pm local time (7:00 TU), a 7.4 earthquake occurred at about 30 km north from the island of Martinique, and was widely felt in all the Caribbean, from Jamaica to French Guyana. Piezometric levels changes (some abrupt rises or decreases), apparently correlated with the earthquake, were recorded by 12 of the 24 piezometers from the groundwater monitoring network of Martinique.

Such reactions have already been observed notably in Japan, in the US or in Armenia. Variation of spring discharge or piezometric level changes induced by earthquake have been widely described, and synthesized. Most of them occur after the quake, nevertheless, some precursors have also been described.

The present earthquake and its effects on piezometric levels are very interesting as the piezometric network is dense and the levels are not affected by external noise. The earthquake occurred after two dry weeks, and the local seismic activity was very low prior to the quake. Moreover, to our knowledge, it is the first time that hydrologic responses to an earthquake are reported and described in the Caribbean. The main objectives of this poster are to analyze the piezometric level changes observed in Martinique and attributed to this earthquake, to deeper characterize the earthquake mechanism and if possible to better understand the structure and functioning of the aquifers from Martinique.

This poster will also spot piezometers that show probable precursors. These precursors consist in a decrease of the recession slope and/or of no more discernable barometric and/or tidal effects. These precursors begin approximately 30 to 75 h before the earthquake each at a different date. They all reveal a compression (a probable increase of the stresses) before the quake; the piezometers with such a precursor showing then systematically a co-seismic distension.

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. 137 Liquefaction risk assessment for natural soils: the Belle-Plaine borehole test site (Gosier, Guadeloupe)

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Soil liquefaction is one of the impressive effects induced by earthquakes, which may cause important loss to buildings, infrastructures, lifelines, etc. Remediation techniques can be considered for liquefiable soils for new constructions, but they are generally too expensive to be used for existing structures. Moreover, critical behaviours are generally observed when intermediary soils (between "sand-like" and "clay-like") are present, for which current methods for liquefaction assessment still lack accuracy. It is hence essential to predict the seismic response of exposed soils and structures, and to improve the reliability of the evaluation methods for liquefaction risk assessment, in order to propose possible mitigation measures.

We present here a synthesis of the main technical and scientific works performed by the consortium of the BELLE-PLAINE project (ANR-06-CATT-003, 2007-2010), which have consisted in:

- Installing a borehole site inside the enclosure of the waste water treatment plant of Gosier district (Guadeloupe), which couples the monitoring of 3 acceleration (one surface / two at depth) and 5 water pore-pressure sensors;
- Performing natural liquefiable soil characterization, through various geophysical (SASW, ambient noise - H/V- recordings, down-holes) and geotechnical (CPTU, cyclic pressiometer) in-situ investigation techniques, together with lab testing on core samples (intact and remoulded) from the site, hence aiming at improving practical methods for liquefaction risk assessment.
- Testing/validating numerical modelling techniques by checking against lab experiments and field observations and by performing sensitivity analyses, in order to predict the nonlinear seismic response of natural soils, including pre-/post-liquefaction behaviour.

The soil configuration of the Belle-Plaine test site (buried mangrove covered with moderately dense sands highly prone to liquefaction), is widely found at the border-coast of the Caribbean regions, exposed to high seismic hazard. The direct observation of the seismic response of such a site is hence crucial for risk mitigation strategies conducted by local authorities.

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PROGRAMME DES EXCURSIONS SUR LE TERRAIN

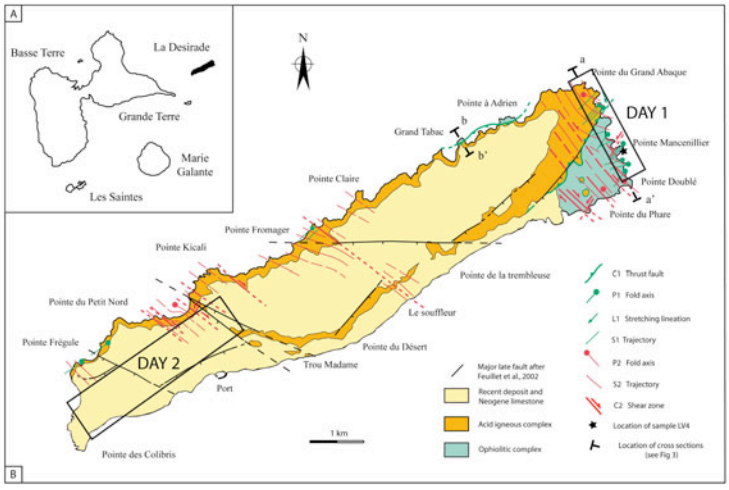
TWO DAYS FIELD TRIPS

La Désirade

Jurassic basement and Pliocene sedimentary cover at La Désirade

25 and 26, march 2011
Cornée J.-J. et Lardeaux J.-M., with participation of M. Corsini and P. Münch

La Désirade is the outer most fore-arc island along the Lesser Antilles subduction zone. It is the lone outcrop of the caribbean plate metamorphic substratum in the Lesser Antilles and it is cap by Pliocene carbonate formations



The first day will focus on the island basement to the NE :
- Late Jurassic ophiolitic units with pillow-lava basalts, radiolarites and dikes;
- Late Jurassic volcanique ancien with rhyolitic flows and volcanic breccias;
- Mezozoic tectonic et metamorphism structures.

The second day will be dedicated to the calcareous cover in the Southwestern part of the island:
- Lower Pliocene to lower Pleistocene Red Algal facies and reefal facies;
- Intra upper Pliocene tectonic;
- Recent tectonic

Volcanism in Basse-Terre

La Grande Découverte - Soufrière and the Monts Caraïbes volcanoes

25 and 26, march 2011

G. Boudon, J.C. Komorowski, Y. Legendre, J.B. de Chabalier

La Grande Découverte - Soufrière volcano is the only active volcanic center of Guadeloupe. It experienced a series of flank collapse events, the last one occurring during the 1530 AD magmatic eruption. Since this date, numerous phreatic events occurred up to the 1976-77 crisis. South of the Soufrière volcano, the Monts Caraïbes volcanic complex (~500 ky old) was built by dominantly explosive hydromagmatic activity.

The first day will focus on the summit area of La Grande Découverte - Soufrière volcano:
The Soufrière lava dome and its surrounding
Deposits from the recent magmatic and phreatic activity
Visit of the Volcanological and Seismological Observatory of Guadeloupe

The second day will be dedicated to the pyroclastic deposits in the basal part of La Grande Découverte - Soufrière volcano and the Monts Caraïbes complex:
Pintade pumiceous deposits and debris avalanche deposits from Soufrière volcano
Hydromagmatic deposits from Monts Caraïbes volcanic complex

ONE DAY FIELD TRIPS

Geothermy in Basse-Terre

Geology and geothermal activity of the Bouillante Volcanic Chain.

25 march 2011

Scientific coordinator (s):
E. Bourdon, V. Bouchot, A. Gadalia, H. Traineau, B.Sanjuan.

1st Stop. Anse Thomas. Hot spring / hydromagmatic and plinian deposits / lava flow. Overview of the geology of Basse-Terre and Bouillante Volcanic Chain.

2nd Stop. Anse Marsolle. Faulting and lava flows / Hydrothermal eruption breccia. Importance of faults in the creation of Bouillante geothermal system.

3rd Stop. Visit of the geothermal plant (Géothermie Bouillante S.A.) and/or the exploitation wells. Overview of the field capacity for geothermal electricity production. Brief history of the development of the geothermal field of Bouillante since the 70's. (*Optional: nearby hot springs in the city*).

4th Stop. Pointe à Lézards /Anse Machette. Machette fault / scoria cone and plinian deposits. Lava flow of Pointe à Lézards. Extension of Bouillante geothermal reservoir on-shore and off-shore.

5th Stop. Bain du Curé. Hot springs / normal faulting / hydromagmatic and plinian deposits.

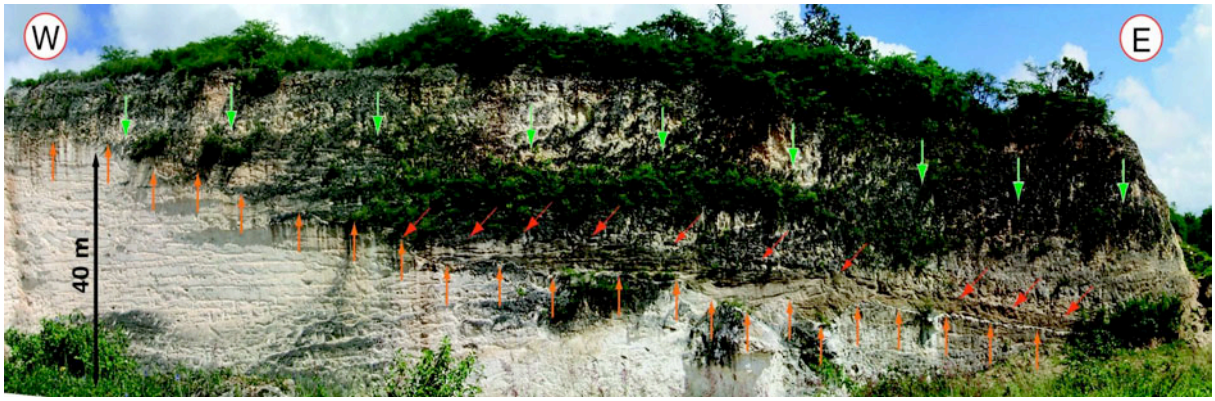
Grande-Terre Carbonate Plateform

The Pliocene-Pleistocene carbonate platform of Grande –Terre

25 march 2011

Scientific coordinator (s): Dr Jean-Lèn LETICEE
With collaboration of Pr. Auran Randrianasolo and Dr. Jean-Frédéric Lebrun

The Pliocene-Pleistocene Grande-Terre (GT) carbonate platform provides an excellent example of active margin platform with well-preserved outcrops. We will explore the sedimentary organization of this carbonate platform submitted to eustasy and fore-arc tectonics vertical motion. The visit will lead us to present the architecture of the depositional sequences through four stops.



Papin Quarry : The Calcaires à rhodolithes inférieurs Formation.

The Papin quarry represent the lowermost part of the section. It is composed of rhodolith-rich packstones to grainstones facies organized into agradational elementary sequences.

Poucet or Cocoyer outcrops : Upper Pliocene Emersion of the carbonate plateform

Poucet and Cocoyer sections shw an erosional surface at the roof of the limestones "rhodolithes inférieurs" formation overlain by the upper Pliocene “volcano-sédimentaire” formation.

Delair Quary - Record of a transgressive track system.

At the Quary, the “Calcaires à Agaricia” Formation shows a major erosional surface overlain by retrograding beach to inner ramp deposits ending with high energy, inner ramp coral boudstones deposition a record of a complete transgressive track system.

Anse-à l’Eau or Moule Porte d’Enfer cliffs - Outer ramp facies.

Anse à l’Eau and Porte d'Enfer Cliffs, exhibit outer ramp facies of Grande-Terre formations with whitish wackestones displaying planktonic foraminifers, hardened parallel-bedded surface, volcanoclastic and carbonate deposits, coarse grained wackestone to packstone with large benthic foraminifers, bioclastic limestones and red alga with cross-stratification sets. The top of the cliff is the “Calcaire à Agaricia” Formation.

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