

SEISMIC DETECTION OF FAULT ZONE HYDROCARBON CONDUIT-SEAL POTENTIAL USING VELOCITY, FREQUENCY, AND Q ANALYSIS: LA CONCEPCIÓN FIELD, LAKE MARACAIBO VENEZUELA EXAMPLE

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University of Oklahoma. Ph.D. 2006
(**Texto completo 162 p. en DVD anexo, carpeta 046**)

The 3-D Post-Stack Time Migrated Seismic Data of La Concepción Field, Maracaibo Basin, Venezuela cover an existing field with known oil gas pay zones. The thesis problem is how to use this seismic data in an interpretation of leaky faults that occur in the exploration area of interest. A solution to the problem was obtained using an integrated geophysical approach that included published seismic attribute methods (Variance Cube, Geoframe IESX). Specific developments in this thesis to solve the interpretation problem of leaky faults in the region include (1) an image ray perturbation approach for updating the interval velocity in a faulted domain (2) a peak frequency approach to attenuation estimation within intervals and (3) a scaled interpretation of the velocity measurements at sonic, checkshot and surface seismic reflection data. The first development refines the interval velocities within fractures zones. The second development identifies anomalous attenuation most likely due to the presence of gas. The combined effects of low interval velocity and high attenuation are interpreted to be signs of leaking faults.

THE DEFORMATION OF THE VILLA DE CURA BLUESCHIST BELT, VENEZUELA: IMPLICATIONS FOR THE EVOLUTION OF THE CARIBBEAN-SOUTH AMERICAN PLATE BOUNDARY ZONE

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(**Texto completo 125 p. en DVD anexo, carpeta 047**)

This study presents a new conceptual tectonic model for the exhumation and emplacement of the Villa de Cura blueschist belt, which places specific constraints on the development of the Caribbean-South American plate boundary zone. New structural and fluid inclusion microthermometric analyses constrain the evolution of the western and central parts of the Villa de Cura blueschist belt, Venezuela. The structural evolution is represented by seven generations of deformation structures. Three ductile generations are associated with Late Cretaceous subduction zone deformation, and Paleocene-Eocene exhumation of the belt from the fore arc of the Great Arc of the Caribbean. Two brittle ductile generations record the Eocene-Miocene emplacement of the belt onto the South American continental margin; during this deformation early aqueous fluid inclusion assemblages are reequilibrated. Two brittle generations result from plate boundary deformation similar to that occurring at present; methane-rich fluid inclusion assemblages are associated with hydrocarbon entrapment during these deformations.

3-D SEISMIC STRUCTURE OF THE LEEWARD ANTILLES ARC FROM SEISMIC REFRACTION AND REFLECTION TOMOGRAPHY

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(**Texto completo 66 p. en DVD anexo, carpeta 048**)

We have developed new velocity and Moho interface models for the Dutch Antilles region of the Leeward Antilles arc from independent and simultaneous 3-D inversion of first arrival and PmP traveltimes. The first arrival and PmP traveltimes were picked from wide-angle offshore-onshore seismic data acquired in the Leeward Antilles arc region using 70 offshore and onshore instruments as part of the Broadband Onshore-Offshore Lithosphere Investigation of Venezuela and the Antilles arc region (BOLIVAR) experiment. The resulting velocity models show evidence for fault bounded basins and features associated with the under-thrusting of the Caribbean plate beneath South America. Velocities beneath the arc are higher than velocities elsewhere in the study region at all depths and they suggest that the arc may be made of intermediate granulites. Moho interface models vary in depth from 19 km to 37 km in the study area. Beneath the arc, shallow basement topography lies above deep Moho topography and vice versa. In other words, the Moho structure mirrors the basement topography. This observation indicates the possibility

of displacement partitioning during the formation of the arc. We compare an average 1-D velocity model from the Leeward Antilles arc to models from other island and continental arcs and find that the Leeward Antilles profile has velocities lower than mafic oceanic island arcs such as the Aleutians, Tonga and the Bonin arc, but has higher velocities than continental arcs such as the Sierra Nevada. Its velocities are however, similar to those of the Honshu island arc. The range of velocities in the Leeward Antilles arc profile is similar to that in the average continental crustal profile.

NÉOTECTONIQUE, SISMOTECTONIQUE ET ALÉA SISMIQUE DU NORD-OUEST DU VÉNÉZUÉLA (SYSTÈME DE FAILLES D'OCA-ANCÓN)

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(Texto completo 355 p. y 1 mapa. en DVD anexo, carpeta 049)

Seismic hazard of northwestern Venezuela is estimated by a neotectonic-seismotectonic approach because seismicity is rather scarce and diffuse. This study has identified several short (few tens of kilometers in length) and slow ($\leq 0,4$ mm/y) active faults that are capable of producing moderate earthquakes ($6 \leq M_s \leq 7$) with long recurrence (> 1500 y; much longer than the entire seismic history of this region). The E-W right lateral Oca-Ancón fault system stands out among these tectonic features and cuts across northwestern Venezuela and northern Colombia. Trenching has confirmed the recent activity of this 600 km long system and allowed to estimate its rate of displacement (2 mm/y). It also allowed to establish the occurrence of earthquakes of magnitude (M_s) 7.4 to 7.5 and the recurrence of such events is of 1752 ± 133 years on the Ancon fault and 4300 ± 1000 on the Oca fault.

Liquefaction features produced by two moderate earthquakes (m_b 5 and 5,7) located less than 30 km away have been trenched on the eastern coastlands of Falcón State. This study proved that events of magnitude 5 can induce sand liquefaction of unconsolidated deltaic deposits within their mesoseismal area.

The mesoseismal area of the November 24, 1990 Churuguara earthquake (central region of the study area) was mapped based on a survey. Other events of this same area have been re-evaluated and some focal mechanisms proposed. These are in perfect agreement with the present stress tensor of this region estimated from microtectonic data that is characterized by a NNW-SSE maximum horizontal stress.

The tectonic evolution of the Falcón basin since its opening in Eocene time was reconstructed, aiming to a better understanding of the previous tectonic setting of the youngest deformations. An experimental model was designed to simulate two main tectonic problems of this region: the existence of transfer zones along the Guadalupe thrust fault and the Miocene tectonic inversion of the Falcón basin.

Finally, a Cenozoic geodynamic model of the southern boundary of the Caribbean plate (oblique-collision between volcanic arc and passive margin) is proposed. This model takes into account the existence of a major tensile stress field during Oligocene, that is responsible of the Falcón basin formation. The graben formation is conceived in a back-arc setting.

TECTONIC AND SEDIMENTATION OF THE GULF OF PARIA AND NORTHERN BASIN, TRINIDAD

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University of Texas at Austin. Ph.D. 1997

(Texto completo 214 p. en DVD anexo, carpeta 050)

Trinidad lies within a complex, active plate boundary zone separating the South America continental plate from the Caribbean plate composed of arc and oceanic plateau rocks. Detailed analysis of seismic reflection profiles integrated with well data from the Gulf of Paria and Northern Basin of Trinidad has resulted in the definition of five stratigraphic sequences.

The oldest two stratigraphic sequences are Late Jurassic-Early Cretaceous in age and were deposited in a passive margin setting following the separation of North and South America. During this passive margin phase flat-lying thick carbonate-evaporite facies were deposited in a Late Jurassic-middle Valanginian carbonate megaplatform that covered most of the present day area of west-central Trinidad. During the Barremian-middle Aptian time this megaplatform disintegrated and more localized carbonate banks grew upward from the megaplatform. These banks

were progressively drowned during the middle-late Aptian, probably as a result of long term eustatic sea level rise, as well as tectonic and other environmental factors.

The other three sequences range in age from late Miocene to Pleistocene. They consist of clastic rocks deposited along an active strike-slip margin between the eastward moving Caribbean plate and South America. Analysis of isochron maps, seismic facies and well logs constrains the effects of Cenozoic strike-slip faulting in Trinidad. Migration of clastic depocenters suggests that the locus of right-lateral strike-slip faulting shifted southward from the El Pilar fault zone to the Warm Springs-Central Range fault zone between 12 and 8 million years ago. This shift in fault activity produced a zone of oblique extension and a northeast-oriented pull-apart basin in the Gulf of Paria (Goodrich subbasin). The eastward continuation of the Warm Springs strike-slip fault into the Central Range bends northeast and resulted in a restraining bend and late Neogene uplift of the Central Range. This uplift provided clastic sediments into the Northern Basin and Gulf of Paria.

OBLIQUE COLLISION AND ACCRETION OF THE NETHERLANDS LEEWARD ANTILLES ISLAND ARC: A STRUCTURAL ANALYSIS OF THE CARIBBEAN-SOUTH AMERICAN PLATE BOUNDARY ZONE

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(Texto completo 157 p. en DVD anexo, carpeta 051)

The Netherland Leeward Antilles volcanic island arc is an ideal natural laboratory to study the evolution of the Caribbean-South American plate boundary. The Leeward Antilles islands (Aruba, Curacao, and Bonaire) are located offshore western Venezuela, within the obliquely convergent diffuse plate boundary zone. Outcrop analysis, microthermometry, and 2D marine seismic reflection data provide evidence of three generations of regional deformation since the Late Cretaceous. Outcrop analysis of structural features, including faults, joints, and veins, characterizes the kinematic history of the islands. Fluid inclusion analysis of quartz and calcite veins coupled with apatite fission-track dating provides the island exhumation history. Finally, marine reflection seismic data processing and interpretation of newly acquired data elucidates offshore structures to integrate with our onshore results. The oldest regional deformation, resulting in both ductile (D_1) and brittle (F_1) structures, is attributed to displacement partitioning along the arcuate Caribbean plate boundary. Associated crustal thinning initiated island exhumation, at a rate of 0.18 km/my, from a maximum burial depth of 6 km in the late Cretaceous (~89Ma). Coeval with D_1 / F_1 deformation and exhumation, stretching of the island arc resulted in extensive basin rifting that separated the island blocks. At ~55 Ma, a change in the relative motion of the Caribbean plate altered plate boundary dynamics. Displacement along the right-lateral Caribbean transform fault and Oca-San Sebastián-El Pilar strike-slip fault system created a wrench tectonic regime within the diffuse plate boundary zone. A second generation of brittle structures (F_2) developed while the islands were at a maximum burial depth of 2 km during the Paleocene/Eocene. Since ~45 Ma, continued motion along the strike-slip fault systems and oblique plate convergence resulted in the youngest generation of structural features (F_3). Regional tectonics control the ongoing steady-state exhumation of the islands at a rate of 0.04km/my. Most recently, the northeast escape of the Maracaibo block also drives deformation within the diffuse plate boundary zone. Overall, the Caribbean-South American plate boundary geometry has evolved with diachronous deformation, from west to east, accompanied by 135° of clockwise block rotation during collision and accretion of the Leeward Antilles since the Late Cretaceous.

DECADAL-TO CENTURY-SCALE CLIMATE VARIABILITY IN THE TROPICAL NORTH ATLANTIC AS RECORDED IN SEDIMENTS FROM THE ANOXIC CARIACO BASIN, VENEZUELA

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(Texto completo 396 p. en DVD anexo, carpeta 052)

Laminated sediments of the anoxic Cariaco Basin record a detailed history of trade wind-induced coastal upwelling off northern South America, a seasonal phenomenon related to the meridional motion of the Intertropical Convergence Zone (ITCZ). The ability to construct paleoenvironmental time-series with near-annual resolution in the most recently deposited sediments allows for calibration to instrumental records, and extrapolation into the past.

Results of high-resolution analyses of box core and piston core sediments are reported that provide a record of upwelling variability spanning the last 825 yrs, and during the Bolling-Allerod/Younger Dryas (BA/YD) transition, respectively, and links are explored to tropical and extratropical phenomena as recorded in instrumental data.

Continuous sampling of well-dated box core sediments at 1-mm intervals yields a record with a temporal resolution of 1-3 yrs for the period of 1990-1165 AD. Over the interval of data overlap, a high correlation on decadal time scales between abundance of the upwelling-sensitive foraminifer *Globigerina bulloides* and local zonal wind velocities strongly suggests that *G. bulloides* accurately records upwelling and trade wind variability. Correlation of *G. bulloides* in the Cariaco Basin with global sea-surface temperature (SST) data show the strongest correlations with high latitude North Atlantic SST (50°-60°). Together, these relationships indicate that upwelling and trade wind intensities over the Cariaco Basin are stronger at times of colder SST in the northern North Atlantic region. This pattern of observation can perhaps be explained by decadal-scale fluctuations in the Atlantic's "conveyor belt" circulation. Over the pre-instrumental portion of the record, *G. bulloides* abundance continues to show evidence of large decadal-to century scale variability, with dominant periods close to well-known solar periodicities, suggesting a possible sun-ocean-atmosphere climate link.

In contrast to the record of the last 825 yrs, decadal variability is largely reduced over the BA/YD transition, indicating differences in the ITCZ/trade wind system during this time. This may be the result of a more southerly ITCZ and reduced sensitivity of the Cariaco Basin to changes in its position.

GEOCHRONOLOGY OF THE CENTRAL VENEZUELAN ANDES

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(Texto completo 159 p. en DVD anexo, carpeta 053)

Forty-three rock samples from the central Venezuelan Andes were analyzed principally by the U/Pb radiometric method utilizing chiefly the mineral zircon. Three and perhaps five distinct periods of igneous activity are documented. These includes: 1) a 620 m.y. – 580 m.y. period, 2) a 500 m.y. – 425 m.y. period or periods, 3) a 390 m.y. period, and 4) a 225 m.y. period. Division of the 500 m.y. – 390 m.y. interval into two or three distinct periods is regarded as tentative.

Several plutons contain inherited older radiogenic Pb. Presumably, older zircons were incorporated either through anatexis melting of crustal material, or by assimilation of country-rock during intrusion. These incorporated zircons maintained at least part of their original isotopic character and subsequently behaved as seed crystals for newly forming zircon material in the crystallizing magmas.

Two periods of Paleozoic uplift are proposed for the central Andes region. Rocks presently exposed in the west central axial region of the Andean basin were uplifted past biotite and whole-rock Rb/Sr closure temperatures for the last time about 290 m.y. ago. Likewise, presently exposed rocks in the Mérida Andes, north of the Boconó fault zone, were uplifted past Rb/Sr and K-Ar biotite radiometric closure temperature for the last time 240 m.y. ago. However, K-Ar hornblende and biotite radiometric ages have apparently not been altered in rocks from the southeastern Andes since at least 400 m.y. ago.

The Sierra Nevada and Bella Vista facies of the Iglesias Complex of the central Andes were deposited during latest Precambrian time in the interval of not more than 1400 m.y. to about 600 m.y. ago. Regional metamorphism of these rocks, at least the last regional metamorphism, probably occurred during earliest Paleozoic time. Additional unmetamorphosed latest Precambrian and earliest Paleozoic sedimentary rocks are indicated by the data to constitute part of the easternmost Caparo section.

Comparison of Andean and Appalachian radiometric results suggest similar widespread relatively continuous Mid-Paleozoic igneous activity.

EVOLUCIÓN ESTRUCTURAL DE FALCÓN CENTRAL

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(Texto completo 104 p. y 12 fig. en DVD anexo, carpeta 054)

El neoaútctono falconiano comprende 4 ciclos sedimentarios que descansan sobre rocas que conforman dos provincias geológicas bien diferenciadas: la provincia occidental de la Cuenca de Maracaibo y la provincia oriental constituida por las rocas del sistema de napas del Caribe; el límite entre ellas puede estar ubicado en la falla Lagarto.

Los ciclos sedimentarios reconocidos en el Terciario de Falcón son el Oligoceno medio a superior, Mioceno temprano, Mioceno medio y Mioceno tardío-Plioceno.

El ciclo Oligoceno está representado por los sedimentos de las formaciones Pecaya y Guacharaca, constituyendo así la sección más marina del ciclo; en el se incluyen episodios turbidíticos de carácter local; las facies más continentales de este ciclo se encuentran aflorando al oeste, y sur del Surco de Urumaco (Formación El Paraíso).

El ciclo Mioceno temprano incluye los sedimentos de las formaciones Agua Clara y San Lorenzo; la distribución actual de las facies del Mioceno temprano evidencian el predominio de condiciones próximo costero a continental hacia la plataforma de Dabajuro y marino somero a borde de talud al centro y este de Falcón; estas condiciones prevalecen hasta finales del Mioceno temprano; el cierre de este ciclo está marcado por un evento progradacional que posiblemente evoluciona bajo la influencia de los movimientos más tempranos del levantamiento andino; la discordancia La Puerta en Falcón occidental y la erosión de los sedimentos de Agua Clara en el Alto de Coro evidencian este proceso.

El ciclo Mioceno medio tiene sus máximos espesores preservados en el Surco de Urumaco, la distribución actual de facies muestra un patrón similar al ciclo subyacente con ambientes próximo costero a continental al oeste y marino somero al este.

Los sedimentos del Mioceno tardío-Plioceno conforman el ciclo más joven reconocido, el cual se encuentra profundamente afectado por la orogénesis andina; estos sedimentos son de ambiente marino somero a continental.

Se han reconocido dos etapas de deformación: una extensional que formó fallamiento normal y sinsedimentario de edad Oligoceno tardío-Mioceno temprano, evidente en la Ensenada de La Vela y Surco de Urumaco; la etapa compresional, muy reciente, contemporánea con la orogénesis andina, es la responsable de la configuración actual de Falcón. La deformación pliocena tiene como límite el corrimiento de Guadalupe en la costa falconiana.

Durante el Mioceno temprano la estructura de Falcón central y Ensenada de La Vela era un homoclinal de rumbo aproximado norte-sur y buzamiento al este; para esta época la provincia del Alto de Coro fue un área parcialmente cubierta por la transgresión de Agua Clara. Esta estructura homoclinal permanece sin mayores variaciones durante el Mioceno medio y hasta finales del Mioceno tardío. La inversión de la cuenca falconiana ocurre a fines del Plioceno, evento este relacionado con los afloramientos de la corteza que dieron lugar al levantamiento de los Andes de Mérida y Perijá.

La inversión de la cuenca de Falcón o formación del anticlinorio causó la erosión de grandes espesores de rocas oligocenas y miocenas que se estiman en el orden de los 5.000 m en la región meridional del área bajo estudio. Este mismo fenómeno ha expuesto en afloramientos las partes más subsidentes del área que en presencia de rocas madres efectivas fueron áreas generadoras de hidrocarburos o cocinas, actualmente extintas.

STRUCTURAL ANALYSIS OF CENOZOIC FAULT SYSTEMS USING 3D SEISMIC DATA IN THE SOUTHERN MARACAIBO BASIN, VENEZUELA

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(Texto completo 205 p. en DVD anexo, carpeta 055)

The Icotea and VLE¹ faults are two of the major faults in the Maracaibo Basin, Venezuela, and are known from seismic and well data to have been most active during Paleogene time. Both faults have linear traces over distances up to 100 km, are deeply buried under largely unfaulted Neogene sedimentary rocks, and are associated with localized continental growth strata of Paleogene age along their traces. The origin and displacement history of both faults has remained controversial partly because of along-strike complexities in fault structure, use of highly exaggerated 2D seismic lines, and the lack of synoptic views of both fault systems. Previous interpretations range from east dipping basement-involved thrust faults to sub-vertical left-lateral strike-slip faults controlling pull-apart

basins. I use regional 2D seismic data crossing both faults, and 3D seismic data covering a 1600 km² area of the southern Maracaibo Basin to describe structures along the traces of both faults and fault termination structures at their southern ends. These seismic reflection data show that both faults are inverted normal faults that first formed during the late Jurassic-early Cretaceous. The abrupt termination of both faults in the southern part of the basin probably corresponds to the southern ends of two parallel rifts structures. This study also uses 3D seismic reflection data to describe a karst horizon in the Aptian-Albian carbonate rocks that may have formed during a worldwide eustatic drop in Albian sea level that also produced the well-known mid-Cretaceous unconformity recognized in the Gulf of Mexico, France, and Middle East. The karst interpretation may allow a better understanding of reservoir characteristics at this level in the carbonate platform, which are generally attributed to fracturing rather than subaerial weathering. The presence of a regionally extensive karst surface at depth beneath other basins along the northern margin of South America may prove to be a useful oil exploration play concept.

¹VLE fault: named by MARAVEN to describe a NS striking fault in Block V located in the central area of the Lake Maracaibo.

CHARACTERIZING THE SOUTHEAST CARIBBEAN-SOUTH AMERICAN PLATE BOUNDARY AT 64°W

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(Texto completo 86 p. en DVD anexo, carpeta 056)

The crustal and lithospheric structure of the northern South America plate boundary with the southeast Caribbean has been the focus of many studies. In this region, westward subduction of (Atlantic) oceanic South America transitions to east-west transform between continental South America and the Caribbean plate. Previous models invoke a poorly-constrained component of north-south convergence between the Caribbean and continental South America, predicting that the westward subduction transitions to northwest-dipping subduction beneath the Serrania del Interior. These models predict that continental crust extends north of the Venezuela coast beneath the Leeward Antilles remnant arc islands, and that the Leeward Antilles are accreting onto South America.

The results presented in this dissertation determine instead that the dextral strike-slip system along the Venezuelan coast cuts near-vertically through the crust and offsets the Moho. The strike-slip system fundamentally defines the plate boundary, deriving from a shear tear through the entire lithosphere that is actively propagating north of the Paria peninsula. This shear tear detaches subducting oceanic crust from buoyant continental crust along the weakened, former passive margin. Thrust faults flanking the strike-slip system to the north and south dip systematically toward the plate boundary. These faults have been previously interpreted as delineating a 300 km-wide diffuse plate boundary zone, caused by oblique convergence partitioned into orthogonal thrust and strike-slip displacements. Instead, these faults are driven largely by vertical rather than horizontal tectonics, and are the result of the geodynamic response to the shear tear.

LOWER CRETACEOUS PALYNOSTRATIGRAPHY, ORGANIC SEDIMENTOLOGY AND EVOLUTION OF THE MARACAIBO BASIN, WESTERN VENEZUELA

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University of Toronto. Department of Geology. Ph.D. 1994
(Texto completo 459 p. en DVD anexo, carpeta 057)

Palynological analyses of four outcrops and four subsurface sections of the Aptian-Albian siliciclastic-carbonate platform facies of the Aguardiente Formation and the Cogollo Group of the Maracaibo Basin yielded a total of 97 species of microspores, 60 species of dinoflagellate cysts, freshwater protists and acritarchs, and numerous phytoclasts.

Corollina, *Araucariacites* and *Afropollis* are the most common elements, indicating close resemblance with coeval assemblages from Brazil and Africa. Quantitative comparison of the dinoflagellate cysts and the occurrence of *Xenascus plotei*, *Achomosphaera triangulata*, *Kiokansium unituberculatum* and some species of *Subtilisphaera* indicate similarities with low latitude areas. The occurrence of several species of *Subtilisphaera* in tropical and subtropical areas indicates initiation of provincialism of peridiniacean dinocysts during the Aptian-Albian.

Four biozones are defined using marine and terrestrial species of palynomorphs. Biozones I (early Aptian) and II (Early to Middle Aptian) have rich terrestrial assemblages and lesser or absent marine components. Biozone III (Late Aptian) is characterized by the diversification of tricolpate angiosperm pollen in northern South America and increasingly diverse dinocysts. Biozone IV is defined by the first occurrence of *Alarosporites klaszi* and *Xenascuz plotei*, determining the base to be Early Albian. The Aguardiente Formation is Aptian-Albian, the Apón Formation is restricted to the Aptian, the Lisure Formation is Late Aptian to Albian and the Maraca Formation is Albian. Regional palynostratigraphic correlation indicates major facies changes related to carbonate dominance northwards away from the siliciclastic influx from the south.

The palynofacies and palynological assemblages of the Aguardiente Formation are dominated by terrestrial organic matter. Size statistical variations of terrestrial phytoclasts and the compositional variation of the palynofacies are related to relative sea-level changes and to paleoenvironmental oxidation. Five sedimentary phases are defined indicating transgressive and regressive pulses, correlated to relative sea level changes.

The miospore assemblages of this study are inferred to represent mainly coastal plant communities. Dinoflagellate cysts are dominated by a few generalist species. Seven new species of miospores are described and new taxonomic combinations and emendations are also proposed. Many species of rare miospores and dinocysts are described in open nomenclature and may be new.

EXHUMATION, DEFORMATION, AND THERMOCHRONOLOGY OF EXPERIMENTAL OROGENIC WEDGES AND NATURAL TRANSPRESSIONAL OROGENS: VENEZUELAN PARIA PENINSULA

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University of Minnesota. Ph.D. 2005
(Texto completo 255 p. en DVD anexo, carpeta 058)

Surface processes play an important role in orogenic evolution. Mass can be transported and redistributed at the earth surface, which modifies the gravitational load and alter the stress field and kinematic within orogens. Using sandbox analog modeling, we explore the role of asymmetric erosion, indenter's dip angle, and flux steady state in determining the patterns of deformation and exhumation in doubly-sided orogenic wedges. We also investigate the implication of asymmetric erosion on the thermal structure of experimental doubly-sided orogenic wedges. Three end-member erosional scenarios were considered. In the first case, erosion was not applied, thus the doubly-sided orogenic wedge evolved with only minor surface readjustments. In the second case, erosion was concentrated solely on the indenter's side of the orogen (retrowedge), and in the third case, erosion was focused on the flank opposite to the indenter's side (prowedge). Strain and exhumation were calculated using displacement fields from 2D Particle Image Velocimetry (PIV) analysis. Asymmetric erosion and the condition of flux steady state have the most noticeable role on defining exhumation, deformation (strain), and topographic patterns on doubly-sided orogenic wedges. Geothermal gradient increases in the places where erosion is concentrated. Particles velocities seem to play a more significant role than altitude in the determination of FT ages. Our experimental FT ages are in agreement with the relative pattern of the FT age from the retrowedge erosional orogen in Southern Alps of New and in the Paria Península in NE Venezuela, and the prowedge erosional orogen in the Olympic Mountains.

The transpressional orogen of the Paria Península in eastern Venezuela exposes an E-W oriented mountain belt, in which the metamorphic grade, mostly greenschist facies, decreases from north to south in a direction perpendicular to the trend of the metamorphic belt. Foliation (S_1) dips steeply to the south along the southern coast and progressively gentler to the north. S_1 strikes approximately 60-75° subparallel to oblique to the general trend of the metamorphic belts. Stretching lineation (L_1) plunges variably to the SW. The pattern of CPO of quartz c -axes indicates a top-to-SW or oblique-normal sense of shear consistently throughout the region. Apatite fission-track ages range from 29 Ma in the south to 5 Ma in the north. Similarly, samples in the northern and central zone yielded the youngest zircon FT ages, ranging from 5 Ma to 9 Ma, and the southern zone yielded slightly older ages ~13 Ma. The topography of the Paria Península and its current precipitation pattern are both asymmetric. Exhumation, deformation, topography, erosion, and precipitation patterns from the transpressional orogen of the Paria Península are comparable to those described in the Southern Alps of New Zealand. A general model for these two-sided transpressional wedges is proposed based on geologic observations. Obliquity of the compression and erosion seems to play an important role in the evolution, exhumation, and deformation of these two naturally deformed orogens.

CLIMATIC VARIATION IN THE CIRCUM-CARIBBEAN DURING THE HOLOCENE

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(Texto completo 155 p. en DVD anexo, carpeta 059)

Climate variability has been reconstructed in the circum-Caribbean region on the basis of oxygen isotopic ratios in fossil shells of ostracods and gastropods from six lakes including Lakes Punta Laguna, Chichancanab, and Coba, Yucatan Peninsula, Mexico; Lake Peten-Itza, Peten, Guatemala; Lake **Valencia, Venezuela**; and Lake Miragoane, Haiti. By using these records, changes in evaporation to precipitation ratios for the region during the Holocene were reconstructed. Following arid conditions during the last Ice Age, climate in the Neotropics became wetter and lake basins filled between ~10,500 and ~7,600 ¹⁴C years BP. Holocene oxygen isotopic records for the six lakes, interpreted as a record of evaporation to precipitation changes, are broadly similar but regional differences do exist.

In the majority of the lakes, the overall climatic pattern indicates that conditions were dry but becoming wetter during the earliest Holocene (~10,500 to ~8,500 ¹⁴C years BP), followed by maximum moisture availability during the early to middle Holocene (~8,500 to ~3,000 ¹⁴C years BP), and a return to drier conditions during the latest Holocene (~3,000 ¹⁴C years BP to present). This pattern may be explained by precessionally driven changes in the seasonal distribution of solar energy that controls the intensity of the annual cycle and rainfall abundances. Differences between records include variability in the timing and rates of initial lake fillings and the occurrence of centennial to decadal climatic events (wet and dry periods). For example, the late Holocene history of the Yucatan Peninsula was marked by several periods of drought (centered on 585, 862, and 1391 AD) that coincided with major cultural discontinuities in the Classic Maya civilization. Some of the decadal-to centennial-scale differences in isotopic records are probably the result of local differences in a lake's response to climate forcing, such as lake volume, altitude, orography, basin morphology, and rates of filling. Abrupt climatic changes observed in the isotopic records can not be explained by orbitally driven forcing and must have roots in other mechanisms, such as solar variability, volcanism, ocean-atmosphere interactions, and natural unforced variability.

EOCENE TECTONIC CONTROLS ON RESERVOIR DISTRIBUTION IN VLE 196, BLOCK V, LAMAR FIELD, MARACAIBO BASIN, VENEZUELA

CHOI Byeonggoo

Texas A&M University. Ph.D. 2005

(Texto completo 175 p. en DVD anexo, carpeta 060)

Integrated interpretation of three-dimensional seismic and well-logging data reveals a prominent “pop-up” structure associated with the VLE 400 fault on the regional unconformity between the Eocene and Miocene in the VLE 196 field, Maracaibo basin, Venezuela. The VLE 400 fault family, an eastern splay of the left lateral Icoatea fault in the basin, played an important role in hydrocarbon migration and accumulation in the field. Hydrocarbons accumulated to the east of the fault but not to the west. The “pop-up” structure on the Eocene unconformity has a four-way dip closure, straddling the fault and extending to the west of the fault. Structures of the Misoa Formation, which is the main reservoir developed below the unconformity in the basin, differ from the structure of the unconformity. The structure of the Misoa Formation shows a tilted uplift of the eastern block of the fault dipping toward the east caused by thrust tectonic movements. Thrust movement and following strike-slip movements provided additional accommodation space to the west of the fault and generated expanded thickness of Eocene sediments compared to the area east of the fault. The thickness of the Misoa Formation east and west of the fault shows no significant changes. Expanded sediments overlie the Misoa Formation in the western block in lateral contact with Misoa sediments eastern block act as a lateral area.

Ductile movement of the Guasare Formation shale contributed to the lateral sealing of the fault against the reservoir rocks in the eastern block. Mobilization of the Guasare Formation modified the structure of overlying formations including the anticline of the Eocene unconformity.

The growth strata provide useful information of reactivation of existing faults, especially subtle movements which are not recognized by conventional seismic interpretation. Growth strata isochrons shows subtle reactivation of the VLE 400 fault family during Miocene time.

PALEOCEANOGRAPHIC INFLUENCES ON ACCUMULATION OF ORGANIC MATTER AND TRACE METALS IN CRETACEOUS BLACK SHALE AND CARBONATE, WESTERN MARACAIBO BASIN, VENEZUELA

DAVIS Cara Lynn
Indiana University. Ph.D. 1998
(Texto completo 363 p. en DVD anexo, carpeta 061)

Hundreds of meters of interbedded marine black shale and carbonate accumulated on the passive margin of northern South America during the middle Cretaceous. The Cenomanian-Santonian La Luna Formation and time-equivalent units represent a globally significant sink for reduced carbon and metals. These stratigraphic units are the source for vast petroleum reserves in the Maracaibo Basin, yet few studies have detailed the vertical distribution of sedimentary constituents through the more than 100 m of La Luna strata. In the present study, inorganic and organic geochemical, isotopic, and petrographic data for La Luna and underlying early Cretaceous black shales and carbonates in core ALP-6 from the western Maracaibo Basin are presented stratigraphically. Geochemical data are integrated with biostratigraphic and lithostratigraphic data to assess temporal changes in the accumulation and relative abundance of sedimentary components.

A five-part subdivision is proposed for the La Luna Formation in ALP-6 based on stratigraphic variation in the concentration of aluminum, titanium, iron, total sulfur, organic carbon and carbonate carbon. The relative abundance of biological marker compounds shows subtle variation between subunits due to the effects of mineral and elemental composition on pathways of molecular diagenesis. Chemostratigraphic subdivisions of La Luna in ALP-6 can be correlated with an outcrop section located more than 50 km to the west.

Globally reduced bulk sedimentation rates, widespread oxygen depletion in the evolving Atlantic basin, and episodic coastal upwelling off northern South America allowed unusually high concentrations of organic carbon and trace metals to accumulate in the La Luna Formation. Biological marker distributions and trace metal abundances in underlying Aptian-Albian black shale contrast sharply with trends in La Luna. Pronounced inorganic and organic geochemical variation through the ALP-6 core reflect the combined influence of sea level change, variations in the source and preservation of organic detritus, and fluctuations in the thickness and lateral extent of oxygen-depleted water.

SIMULATION NUMÉRIQUE DE LA PROPAGATION D'ONDES EN MILIEU GÉOLOGIQUE COMPLEXE: APPLICATION Á L'ÉVALUATION DE LA RÉPONSE SISMIQUE DU BASSIN DE CARACAS (VENEZUELA)

DELAVAUD Élise
Université Paris. Ph.D. 2007
(Texto completo 168 p. en DVD anexo, carpeta 062)

Este trabajo de tesis está consagrado al desarrollo de una herramienta numérica capaz de modelizar la propagación en 3D de ondas sísmicas en medios geológicos complejos caracterizados por efectos de sitio. El Método de Elementos Espectrales (SEM) es particularmente adecuado para tratar el problema de la respuesta sísmica en tales medios por diferentes razones: (1) la estimación precisa de ondas de superficie, (2) la capacidad de tener en cuenta geometrías complejas (topografía de la superficie del terreno y de las interfaces geológicas), y (3) la posibilidad de ajustar la resolución de longitudes de ondas sísmicas en medios heterogéneos por intermedio de mallas no estructuradas. Algunas extensiones numéricas del SEM ligadas a la respuesta de cuencas sedimentarias, son desarrolladas en este trabajo: *Perfectly Matched Layers* filtrantes y una introducción eficaz del campo de ondas incidentes. De todas maneras, a pesar del uso de mallas hexaedrales no estructuradas, la principal limitación del SEM reside en la falta de flexibilidad de dichas mallas, cuya generación requiere un esfuerzo considerable. Este trabajo pone énfasis en las dificultades asociadas a dicha generación y describe el proceso completo de modelado de la respuesta sísmica en medios complejos: desde la etapa de elaboración del modelo físico y numérico, hasta el análisis de resultados.

Presentamos aquí las simulaciones 3D de la respuesta sísmica de la región de Caracas (Venezuela), incluyendo la geometría tridimensional de la cuenca sedimentaria y de la cadena montañosa de Ávila que rodea la ciudad, cuyas características fueron otorgadas por la agencia de FUNVISIS, en el marco del proyecto ECOS-Nord. La importancia de los efectos ligados a esas dos estructuras es evaluada a través de diferentes escenarios de incidencia de ondas

planas. Los efectos geométricos 3D revelan fenómenos complejos de amplificación asociados a la reflexión y a la focalización de ondas que viajan en diferentes direcciones, así como la generación de ondas de superficie en los bordes y en las zonas poco profundas de la cuenca sedimentaria. Una comparación con resultados de simulaciones bidimensionales pone de manifiesto el interés del modelado tridimensional, a partir de diferencias claras entre el tiempo de residencia y el nivel de energía y de amplificación obtenidos en ambos casos.

THE IGNEOUS ROCKS AND TECTONICS OF THE LESSER ANTILLES AND NORTHERN SOUTH AMERICA. A RECONNAISSANCE OF THE IGNEOUS ROCKS OF THE PENINSULA OF PARAGUANA, VENEZUELA A RECONNAISSANCE OF THE IGNEOUS ROCKS OF THE ISLAND OF ARUBA, DUTCH WEST INDIES

DICKEY ATHERTON Parke
Johns Hopkins University. Ph.D. 1932
(Texto completo 93 p. en DVD anexo, carpeta 063)

The plain of Paraguana is composed of very gently folded sediments of Miocene, Pliocene, and Pleistocene age, Mesozoic and Eocene beds are found beneath the plain in wells, but nowhere outcrop.

Sticking out of the plain are two areas of igneous rocks. The northernmost of these, the cerro of Cocodite, consists largely of a mass of granodiorite of slightly varying composition and grain size, cut by aplites and pegmatites. Along its northern and western edges outcrop hard slates and quartzites, probably of Cretaceous age, and in places Tertiary or Pleistocene coral limestone fringe the igneous and metamorphic rocks.

The mountain of Santa Ana is formed of diabase, grading downward into gabbro of the same composition, but of a different texture and coarser grain size. This gabbro forms the lower spurs and ridges of the mountain. In the lower and easternmost parts of the two ridges running northeast and southeast from the mountain olivine gabbro appears to form segregations in the normal type. The ridge of hills called Cerro Tausabana which runs east from Santa Ana is formed of serpentinite.

All the rocks have been cut by various types of dykes, and have been much altered by hydrothermal solutions. The Santa Ana massif is believed to be a lacolithical mass showing gravitative differentiation.

EASTERN VENEZUELA BASIN: SEQUENCE STRATIGRAPHY AND STRUCTURAL EVOLUTION

DI CROCE Juan
Rice University. Ph.D. 1995
(Texto completo 362 p. en DVD anexo, carpeta 064)

A regional study has been carried out within the Eastern Venezuela Basin and its offshore continuation to the Orinoco Delta and the Barbados Accretionary Complex. The Eastern Venezuela Basin and its offshore continuation is a Neogene foredeep superimposed on a Mesozoic passive margin.

The Cretaceous to Paleocene of Eastern Venezuela is best subdivided into five second order transgressive-regressive cycles bounded by a 131 Ma (basal Cretaceous) sequence boundary, four maximum flooding surfaces with the inferred age of lower Aptian (111 Ma), upper Albian (98 Ma), middle Cenomanian (95 Ma), middle Turonian (91.5 Ma) and an upper Paleocene sequence boundary (58.8 Ma).

An upper Paleocene to Eocene second-order cycle (58.8 Ma-36 Ma) is followed by the Oligocene which is subdivided into two third-order cycles bounded respectively by 36, 30 and 25.5 Ma sequence boundaries.

An uppermost Oligocene to lower Miocene (25.5 Ma) basal foredeep unconformity is associated with the sudden deepening of the passive margin in response to the emplacement of the Serranía del Interior.

The Neogene of the Eastern Venezuela foredeep consists of three second-order sequences defined by 25.5, 16.5 and 10.5 Ma boundaries. In the offshore an upper Miocene (5.5 Ma) unconformity is associated with deeply incised submarine canyons. Sixteen third-order sequence boundaries are recognized and correlated over the region.

REGIONAL TECTONICS, SEQUENCE STRATIGRAPHY AND RESERVOIR PROPERTIES OF EOCENE CLASTIC SEDIMENTATION, MARACAIBO BASIN, VENEZUELA

ESCALONA Alejandro
University of Texas at Austin. Ph.D. 2003
(**Texto completo 238 p. en DVD anexo, carpeta 065**)

The Maracaibo basin of Venezuela is one of the most prolific hydrocarbon basins in the world. During the Paleogene, oblique collision between the Caribbean and South American plates produced a 4-km-thick wedge of clastic sediments, where over 40 billion barrels of hydrocarbons have been produced.

Previous studies in the Eocene interval are focused either at large regional scale or a field-size reservoir scale. Integration between both scales of observation has not been previously done, and, as a consequence, the effect of regional tectonics is not considered in the small-scale stratigraphic record. The aim of this dissertation is to study the interplay of tectonic and stratigraphic variables that controlled the Eocene sedimentation in the Maracaibo basin, and to establish a geologic model that incorporates data from a regional to reservoir scale.

Interpretation of 2-D and 3-D seismic data in the central and eastern Maracaibo basin reveals two major tectonic features formed during Paleogene collision between the Caribbean and the South American plates: 1) a late Paleocene-early Eocene foreland basin; and 2) a middle-late Eocene lateral ramp fault. The lateral ramp fault forms a paleogeographic facies boundary separating a less faulted and folded shelf area to the west from a fold-thrust belt to the east.

In the Eocene Maracaibo shelf area, intraplate deformation occurs by N-NE-striking left-lateral faulting with pull-apart basins localized at fault stepovers. Three-dimensional seismic time slice interpretation of more than 2000 km² of 3-D seismic data allows mapping of the Icoatea pull-apart basin. Extension of the Icoatea pull-apart basin is localized on pre-existing NW-SE-striking normal faults, formed by Paleocene-Eocene plate flexure during the foreland basin period.

Detailed sequence stratigraphic interpretation of the central Maracaibo basin was carried out using 330 wells and 3-D visualization methods that combined well and 3-D seismic data techniques providing greater vertical and lateral resolution (pseudo-seismic). These data reveal that Eocene clastic sedimentation is controlled by tectonic subsidence and to a lesser degree by changes in sediment supply and eustasy.

Hydrocarbon reservoirs of the central Maracaibo basin are concentrated in distributary channels and tidal sand bar facies on structural highs produced by strike-slip motion of N-NE-striking faults. Depositional environments and fluid content of Eocene reservoirs are inferred from cross sections based on closely spaced well logs.

QUATERNARY GEOLOGY OF NORTHWEST VENEZUELA: COASTAL PLAINS OF FALCÓN AND ZULIA

GRAF Claus H.
Rice University. Ph.D. 1968
(**Texto completo 281 p. en DVD anexo, carpeta 066**)

Geomorphic and petrologic studies of modern sedimentary features in northwestern Venezuela show that deposition now occurs in three main sedimentary environments. Continental deposition includes fluvial channel and flood-plain sedimentation. Textural properties of these sediments are dependent on climatic and tectonic conditions. Transitional deposition occurs in lagoons, deltas, beaches and aeolian dunes. Northwest Venezuelan lagoons are largely structurally controlled. Only one major delta is developing at the present time within the low energy environment of the Golfo de Coro. Terrigenous sand beaches are developed along the southern and western shores of the Gulf of Venezuela and carbonate beaches surround the Guajira and Paraguaná peninsulas. A large variety of aeolian deposits has developed near the coast. Their texture and mineralogy are directly upon the characteristics of the sediment source beaches. Marine deposition occurs in two major environments. The terrigenous deposits are encountered over most of the bottom of the Gulf of Venezuela shelf, except where calcareous deposits are forming. Areas of carbonate accumulation are located in the vicinity of the Guajira and Paraguaná peninsulas, along the shelf slope margin and on the Río Seco Anticline. These normal marine shelf environments of deposition are locally interrupted by structurally controlled areas of marine erosion. Anaerobic conditions prevail in the partially isolated Calabozo Bay.

Sediments deposited during high stands of Pleistocene sea level have similar distributions to the modern sediments. Low sea level sedimentation occurred in isolated river channels and in two major interior drainage basins (lacustrine). These two inland basins received continuous deposition throughout the Quaternary (Calabozo Bay and Maracaibo Basin).

The entire region has been subjected to different stages of tectonic activity, which have greatly influenced the sedimentary processes. The Falcón coastal plains, the Dabajuro Platform and the Maracaibo Arch were strongly affected by the late Pliocene-early Pleistocene Antillean Orogeny, as well as by late Pleistocene and Holocene tectonic rejuvenation. The Maracaibo Basin and Calabozo Bay are both areas of slow subsidence. The Guajira and Paraguaná peninsulas have presumably been uplifted slowly but continuously during Quaternary times.

Interrupted Pleistocene sequences have oxidized and leached relict soils, formed under humid climates of glacial stages. Laterites are common within older Pleistocene deposits. Climates presumably became dry some 10000 years ago. Present-day weathering favors calcification of the soils in environments where evaporation exceeds precipitation.

CRUSTAL STRUCTURE ACROSS THE CARIBBEAN-SOUTH AMERICAN PLATE BOUNDARY AT 70W-RESULTS FROM SEISMIC REFRACTION AND REFLECTION DATA

GUEDEZ María C.

Rice University. M.S. 2007

(Texto completo 55 p. en DVD anexo, carpeta 067)

The Caribbean-South America diffuse plate boundary is characterized by tectonic transpression with oblique convergence. In northwestern Venezuela, the underthrusting of the Caribbean Plate beneath northwestern South America, and the tectonic escape of the Maracaibo block complicate the boundary. The BOLIVAR project acquired onshore-offshore refraction and marine reflection data along the 450 Km profile 70W, which extends from the Venezuela Basin, on the Caribbean plate, to the Maracaibo block, in the diffuse boundary zone. A 2-D velocity model was generated from wide-angle data, and it shows good correlation with the reflection data analyzed. We present evidence consistent with the underthrusting of the 15 km Caribbean plateau; however, we propose that the landward extent and depth of the oceanic crust are substantially less than previously suggested. The model also indicates the presence of an 8 km crustal thinning located to the north of the Oca-Ancón Fault and the inverted Falcón Basin.

KINEMATIC ANALYSIS OF THE DEFORMATIONAL STRUCTURES ON EASTERN ISLA DE MARGARITA, VENEZUELA.

GUTH Lawrence R.

Rice University. Ph.D. 1991

(Texto completo 639 p. en DVD anexo, carpeta 068)

Because of its strategic location at the intersection of three regional trends, a kinematic study of the deformation on Isla de Margarita was undertaken to provide additional constraints for Caribbean plate tectonic models. Previous work revealed a metamorphic nucleus composed of amphibolites, schists, marble, serpentized ultramafics, and leucocratic intrusives. Studies on eclogite knockers provided quantitative estimates for the metamorphic pressure and temperatures.

In this study, five generations of deformational structures were identified on Isla de Margarita. The earliest structures (D_{1a}) are rarely preserved, occurring as the main foliation in the eclogite knockers and as a foliation within microlithons bounded by the S_{1b} foliation. The D_{1b} deformation is synchronous with epidote-amphibolite to greenschist facies metamorphism which overprints the eclogite assemblage. It forms the dominant metamorphic foliation on the island and is axial planar to associated isoclinal folds. Quartz c-axis and S-C fabrics developed under greenschist facies conditions and characterized the D_{1c} extensional deformation. In the Miocene; the non-metamorphic D_2 deformation folded the D_{1b} foliation into a southwest-plunging anticlinorium. The latest brittle deformation (D_3) shows northeast-southwest extension, aligned with the fold axes and extensions of all earlier deformations.

Analysis of the relative motions between North and South America shows there is insufficient Mesozoic convergence to form *in situ* the metamorphic belts of northern South America. These metamorphic belts must

therefore have formed far to the west along the Farallon/South American plate boundary. A proposed model relates the Cretaceous synmetamorphic D_{1a} , D_{1b} and D_{1c} progressive deformations to arc parallel extension in the Aves Ridge subduction complex. The remains of the Cretaceous arc have been disrupted by the strike-slip boundaries of the northern and southern Caribbean, as well as by the opening of the Grenada Basin. The associated metamorphic rocks have also been disrupted and progressively emplaced onto the continental margin of South America from west to east. The D_2 and D_3 deformations are associated with this dextral plate boundary deformation between the Caribbean and South America.

MIOCENE STRATIGRAPHY AND DEPOSITIONAL FRAMEWORK OF NORTHEASTERN MARACAIBO BASIN, VENEZUELA: IMPLICATIONS FOR RESERVOIR HETEROGENEITY PREDICTION IN TECTONICALLY ACTIVE SETTINGS

GUZMÁN ESPINAL José Ignacio
University of Texas at Austin. Ph.D. 1999
(Texto completo 198 p. en DVD anexo, carpeta 069)

Lateral and vertical changes in regime variables have a direct impact on the nature and distribution of macroscopic reservoir heterogeneity in tectonically-active basins. This relationship was tested in a clastic Miocene interval of the northeastern region of the Maracaibo Basin, Venezuela, by the integration and analysis of a comprehensive subsurface dataset.

Four unconformity-bounded sequences record changes in accommodation, sediment supply, and sediment dispersal directions. These shifts were controlled by the uplift of the Sierra de Perijá and by the marine connection between the Maracaibo and Falcón basins. The oldest sequence corresponds to the Early Miocene La Rosa Formation, which represents the episode of greatest increase in the regime ratio. After experiencing the maximum flooding event of the Neogene, accommodation space was filled by a mixed wave- and tide-influenced system of deltas and prograding shorelines that were fed from the west. Waterflooding in these reservoirs has been successful despite the compartmentalization and increased heterogeneity produced by rapid marine flooding of the deltaic pulses.

Increased uplift and erosion of the sediment source areas shifted the regime ratio to supply dominated, causing a major fall in relative sea level and the development of a network of southwest- to northeast-oriented fluvially incised valleys. This event separates the La Rosa Formation from a younger sequence of highly heterogeneous tide-dominated deltaic sediments, that characterize the Lagunillas Inferior member of the Lagunillas Formation. The stratigraphic relationships and sedimentary fill of these incised valleys explain the complex nature of the LL-03/LL-05 reservoir boundary to the southeast of the study area.

Continuing tectonic activity resulted in yet another significant drop in relative sea level, recorded by the abrupt onset of southeasterly flowing, mixed-load river, in the upper section of the Lagunillas Inferior Member. These deposits form the shelf- equivalent lowstand system tract of the next younger sequence, which also includes the Laguna Member.

A significant potential for targeting uncontacted and bypassed hydrocarbons exists in these reservoirs. Waterflooding has been relatively successful, but differences in directional permeability may be encountered across the fluvial entrenchment surfaces.

SEDIMENTOLOGY OF A MIXED CARBONATE-SILICICLASTIC SUCCESSION: THE GUASARE FORMATION, MARACAIBO BASIN, VENEZUELA

HERNÁNDEZ PÉREZ Elizabeth
University of Calgary. M.S. 1997
(Texto completo 443 p. en DVD anexo, carpeta 070)

The Paleocene Guasare Formation, Maracaibo Basin, Venezuela, represents a mixed carbonate-terrigenous clastic succession. Ten lithofacies were defined. Lithofacies can be grouped into three lithofacies successions representing coastal plain, off-shore and near-shore, tide and storm influenced settings. Recognition of encrusted shells, micrite envelopes, borings in skeletal fragments, flower spar, dissolution cavities, calcitization and equant spar in pelecypod beds indicate textural and compositional changes related to diagenetic processes in the marine, vadose and phreatic realms. Such limestones probably represent cheniers formed during periods of reduced sediment

influx and reworking by waves. Environmental reconstruction indicates that sedimentation of the Guasare Formation occurred in a dynamic delta setting with tidal influence where delta lobe progradation, abandonment, transgression and renewed progradation were the dominant controlling factors on sedimentation. The repeated development of similar lithofacies successions due to switching delta lobes indicates that deposition of the Guasare Formation was basically controlled by autocyclic processes.

FOREDEEP AND THRUST BELT INTERPRETATION OF THE MATURIN SUBBASIN, EASTERN VENEZUELA BASIN

HUNG Enrique J.

Rice University. M.A. 1997

(Texto completo 249 p. en DVD anexo, carpeta 071)

The nature of the basement underneath the Monagas foothills and the Serranía del Interior of the Eastern Venezuela Basin is unknown. It could consist of crystalline Precambrian, Paleozoic sedimentary rocks and/or Jurassic rocks deposited in half grabens. Alternative structural interpretations across the Monagas foothills range from basement-involved to non-basement-involved décollement tectonics. These hypotheses imply varying amounts of shortening along the Serranía to Foreland transect ranging from 15 to 115 km oblique component of the El Pilar fault.

The foreland-verging thrust system appears to be “in sequence”. In the Monagas foothills earlier décollements at the base of the Miocene are responsible for the formation of a complex accretionary wedge. The deeper structures of the Monagas foothills involve the Mesozoic which was thrust following the emplacement of the Carapita accretionary wedge. Apparent “out of sequence” are due to the interference of late deeper structures with the earlier structures of the accretionary wedge.

THERMAL EVOLUTION OF THE EASTERN SERRANÍA DEL INTERIOR FORELAND FOLD AND THRUST BELT, NORTHEASTERN VENEZUELA, BASED ON APATITE FISSION TRACK ANALYSES

LOCKE Brian David.

Rice University. M.A. 2001

(Texto completo 175 p. en DVD anexo, carpeta 072)

Apatite fission track data show a gradual decrease in age (~30 Ma to ~15 Ma) from north to the south in the eastern Serranía del Interior, northeastern Venezuela. Based on a previous study, a model for the tectonic evolution of the eastern Serranía is proposed in which two stages of deformation occurred. Stage 1 (45 Ma-20Ma) involves the internal deformation of fault blocks. Stage 2 (20 Ma-12 Ma) involves envelopment thrusting, doubling the thickness of the thrust sheet. Shortening within the Serranía del Interior ceased at 12 Ma. In stage 1, cooling and exhumation rates were 5.8 °C/km and 0.26 km/my, respectively, and in stage 2, cooling and exhumation rates were 4.25 °C/km and 0.26 km/my, respectively. The deformation of the Serranía prior to the collision of the Caribbean plate with South America is probably related to the convergence of the North and South America plates.

CRETACEOUS TO NEOGENE TECTONIC CONTROL ON SEDIMENTATION: MARACAIBO BASIN, VENEZUELA

LUGO LOBO Jairo Miguel

University of Texas at Austin. Ph.D. 1991

(Texto completo 248 p. en DVD anexo, carpeta 073)

The Maracaibo basin records a complex tectonic and depositional history. Compilation of seismic and well data allows me to distinguish six tectonostratigraphic episodes. The first episode is characterized by Jurassic rifting along north-northeast-trending half-grabens filled with continental red beds and volcanic rocks. The second episode is characterized by the deposition of shallow to deep marine carbonates and clastic rocks in which subsidence rates increase away from the northwest-trending Mérida arch, a mid late Paleozoic northwest-trending range anchored to

the Guayana Shield. The third episode is distinguished by oblique collision of south-southwest-verging Caribbean terranes toward the continental platform. As collision evolved, the tectonically carried crustal flexure and associated turbiditic basin migrated south-southeastward. Evidences from geohistory analysis shows the shift of the axis of subsidence in that direction. During this episode six unconformity-bounded deltaic wedges marked an equal number of regressive stages caused by thrust propagation above the flysch basin. Seismic clinoflexure orientations and sandstone composition document the regional northern provenance for such paralic wedges in the northeastern portion of the basin. The fourth episode developed from Late Eocene to Middle Miocene in which transpressive tectonism reactivated the structural weaknesses developed in the earlier rift. Left-lateral north-northeast-trending strike-slip faults and related en echelon secondary structures were built in two main active phases: one during Late Eocene and other in Middle Miocene time. The reactivation of the main Icoitea and Pueblo Viejo faults influenced the distribution of intrabasinal restraining beds, pull-apart basins, and associated sediment infill. The fifth episode is characterized by diachronous orogeny that began with Oligocene uplift along the Sierra de Perijá and continued southeastward toward the Mérida Andes. These uplifts created a closed depositional basin and converted the depositional environment from marine to continental. The sixth episode is characterized by compression evidenced by north-striking east-vergent reverse fault in the Sierra de Perijá.

A HIGH-RESOLUTION COMPARISON OF LATE QUATERNARY UPWELLING RECORDS FROM THE CARIACO BASIN AND ARABIAN SEA: COCCOLITH PALEOECOLOGY AND PALEOCLIMATIC INVESTIGATIONS

LYNN Matthew J.

University of Miami. Ph.D. 1998

(Texto completo 366 p. en DVD anexo, carpeta 074)

Coccoliths, the minute calcareous plates produced by photosynthetic algae, were studied in high-resolution, AMS ^{14}C -dated sediment cores from two sites of tropical upwelling located in climatically-sensitive regions, the Cariaco Basin (**Venezuela**) and the Arabian Sea. The Cariaco Basin is ideally situated to record changes in the strength of upwelling induced by migration of the Intertropical Convergence Zone (ITCZ) in the tropical Atlantic, while the Arabian Sea is strongly influenced by the broader dynamics of the Indian Ocean monsoon.

Scanning Electron Microscopy has revealed that two coccolith species, *Emiliana huxleyi* and *Gephyrocapsa oceanica*, dominate both assemblages for the last ~30000 years. Time series of relative abundance for these and other species show large variations that can be related to both local and regional climate changes, including the Younger Dryas cold interval, the onset of anoxia in the Cariaco Basin, and the reduced upwelling strength in the Arabian Sea during the Last Glacial Maximum.

Coccolith accumulation rate data, derived from modified direct settling techniques, complement and in some cases improve upon the relative abundance data, while also comparing favorably with modern flux estimates derived from sediment trap studies. Accumulation rates at both locations are on the order of 10^9 to 10^{11} coccolith/cm²/kyr, roughly equivalent to 10^8 - 10^9 coccolith/m²/day. Stable isotope time series from the <38 μm sediment fraction in the Cariaco Basin compare favorably with foraminiferal $\delta^{18}\text{O}$ records from the same core and provide further insights into the climatic and oceanographic history of the region. The fine-fraction $\delta^{18}\text{O}$ time series from the Oman margin records large influxes of eolian carbonate dust which overwhelms the glacial-interglacial signal of the coccoliths.

Interest in coccolithophore productivity has increased in recent years because of their potential impact on global climate as producers of DMS and CaCO_3 . Some species also produce alkenones, which are increasingly extracted from sediments and used as indicators of paleo-sea surface temperatures. The findings from this study have implications relevant to studies of past SST variations, global carbon cycling, and aerosol-induced climate change, in addition to the more direct insights into the climate history of the tropical Atlantic and Arabian Sea.

THE PALEOCENE OF LA CONCEPCIÓN FIELD (MARACAIBO BASIN, VENEZUELA): TRANSITION FROM ANDEAN TO CARIBBEAN ACTIVE MARGIN

MARCHA Lanette Mary
Rice Univeristy. M.A. 2003
(Texto completo 270 p. en DVD anexo, carpeta 075)

The Paleocene Guasare Formation of La Concepción Field (Maracaibo Basin, Venezuela) consists of thin carbonates that were deposited in a dynamic near-shore marine setting greatly influenced by terrestrial siliciclastics and muds. In seismic data, the Guasare Formation shows uniform thickness and subparallel reflectors. Facies trends were not evident from the 3D seismic data set. Amplitude map revealed one structurally-related anomaly. The regional setting of the Paleocene was clarified showing that Late Cretaceous foresets indicated a source from the Andean active margin to the west. These clinoforms were overlain by the Paleocene Guasare Formation and its western partial equivalent, the Marcelina Formation, a siliciclastic and coal sequence. Only the overlying Eocene Misoa Formation indicates a northeasterly clastic input and eastward thickening associated with the emplacement of the Lara nappes of the Caribbean active margin. This study is based on 3D seismic data, some well logs, and well cuttings. Cores were unavailable.

ANALYSIS OF FLEXURAL ISOSTASY OF THE NORTHERN ANDES

OJEDA Germán Yury
Florida International Univeristy. Ph.D. 2000
(Texto completo 105 p. en DVD anexo, carpeta 076)

The mode in which a lithosphere plate supports overlying topography is greatly driven by the strength of the plate. By analyzing the geophysical signature of lithosphere flexure, in the space and spectral domains, the strength of the plates that support the north Andean mountains and adjacent basins, and the topography of Kenya was investigated. In addition, the effect of windowing on elastic thickness estimates obtained via the coherence method was evaluated.

The coherence between the topography and Bouguer gravity spectra of northern South America suggests that the average elastic thickness of the lithosphere is 30 km. Although lateral variations were not resolved by the coherence implementation, these became apparent by modeling the foreland stratigraphy of the Llanos, Barinas and Maracaibo sub-Andean basins. Flexural models reveal a zone of lithosphere weakness beneath the eastern flank of the Eastern Cordillera and western flank of the Venezuelan Andes. The gravity anomaly calculated from these models is consistent with the observed Bouguer gravity anomaly. This zone of weakness appears to separate the strong, old Guyana shield lithosphere from the weaker and probably younger Andean lithosphere. The zone of weakness may correspond to a Paleozoic feature at the western margin of cratonic South America, or a Mesozoic rift arm that weakened the proto-Andean lithosphere.

Using synthetic data as well as the northern South America topography and gravity, this study demonstrates that lithosphere strength calculated from the coherence of mirrored data may over-estimate the true lithosphere strength. As a result, many lithosphere plates may be weaker than currently thought. In light of this observation, gravity and topography data from Kenya were reevaluated using multitaper spectral techniques. The elastic thickness of this plate, currently undergoing rifting, was estimated at 7 to 8km, a factor of 2 less than previously estimated. These estimates suggest that despite intense fracturing and sustained tensile stresses, continental lithosphere plates undergoing rifting are able to retain some strength.

TECTONIC AND THERMAL HISTORY OF THE WESTERN SERRANÍA DEL INTERIOR FORELAND FOLD AND THRUST BELT GUÁRICO BASIN, NORTH CENTRAL VENEZUELA: IMPLICATIONS OF NEW EVIDENCE FROM APATITE FISSION TRACK ANALYSIS AND SEISMIC INTERPRETATION

PÉREZ DE ARMAS Jaime Gonzalo
Rice University. Ph.D. 2005
(Texto completo 788 p. en DVD anexo, carpeta 077)

Structural analysis, interpretation of seismic reflection lines, and apatite fission-track analysis in the Western Serranía del Interior fold and thrust belt and in the Guárico basin of north-central Venezuela indicate that the area underwent Mesozoic and Tertiary-to-Recent deformation. Mesozoic deformation, related to the breakup of Pangea, resulted in the formation of the Espino graben in the southernmost portion of the Guárico basin and the formation of the Proto-Caribbean lithosphere between the diverging North and South American plates. The northern margin of Venezuela became a northward facing passive margin. Minor normal faults formed in the Guárico basin.

The most intense deformation took place in the Neogene when the Leeward Antilles volcanic island arc collided obliquely with South America. The inception of the basal foredeep unconformity in the Late Eocene-Early Oligocene marks the formation of a perisutural basin on top of a buried graben system. It is coeval with minor extension and possible reactivation of Cretaceous normal faults in the Guárico basin. It marks the deepening of the foredeep. Cooling ages derived from apatite fission-tracks suggest that the obduction of the fold and thrust belt in the study area occurred in the Late Oligocene through the Middle Miocene. Field data and seismic interpretations suggest also that contractional deformation began during the Neogene, and specifically during the Miocene.

The most surprising results of the detrital apatite fission-track study are the ages acquired in the sedimentary rocks of the easternmost part of the study area in the foreland fold and thrust belt. They indicate an Eocene thermal event. This event may be related to the Eocene NW-SE convergence of the North and South American plates that must have caused the Proto-Caribbean lithosphere to be shortened. This event is not related to the collision of the arc with South America, as the arc was far to the west during the Eocene.

NEW ASPECTS OF FLUID FLOW, MASS TRANSFER, AND PALEOTHERMOMETRY ASSOCIATED WITH FAULTS, FRACTURES, AND SEDIMENTARY BASINS

PÉREZ René J.
University of California Santa Barbara. Ph.D. 2003
(Texto completo 198 p. en DVD anexo, carpeta 078)

The most evident link between diagenesis and fluid flow is given by the interaction between deformed host rocks, such as zones and fractures, and aqueous and hydrocarbon phases. Aqueous fluids are usually, but not restrictively, drained from overpressured reservoirs. High pore fluid pressure may provide right conditions for the formation of hydraulic fractures and veining, as in the Eocene Misoa Maracaibo basin Venezuela, and fault reactivation and cementation, as in the Wheeler Ridge thrust fault in California.

Fluid drainage, caused by the decompression, results in vertical and lateral mass and heat transport, ultimately leading to mineral precipitation. Cements, in turn, may record thermal anomalies that reveal the scale of the process. For instance, fluid inclusion measurements in quartz veins from the Misoa Formation suggest kilometer scale upward transport of silica, whereas calcite veins suggest a local drop in P_{CO_2} present in the aqueous phase. Similarly, stable oxygen isotopes in five calcite veins from the Wheeler Ridge thrust fault in California record thermal anomalies that suggest vertical mass transfer between 0.75 and 1 km, whereas the oxygen isotopic ratios in other five veins suggest cementation by intraformational (lateral) flow focused into the thrust.

In siliciclastic basins, the transport of hot Na^{+2} rich fluids along faults or into fractures may lead to albitization of feldspars, an isovolumetric replacement reaction. Based on empirical fits of petrologic data in three basins, it is suggested that albitization of plagioclase is kinetically controlled, strongly dependent on temperature, and that could be appropriately used as a kinetic indicator of temperature higher than 90°C over geologic time scales in faulted and fractured arkosic sandstones. Finally, fault concentration and veining decreases the host rocks porosity and permeability restricting fluid pathways as evidenced, directly by petrography, and indirectly by the crude-oil correlation of hydrocarbons present in the hanging wall and in the foot wall of the Wheeler Ridge thrust.

It is suggested that there is an intimate interplay between deformation, decompression, fluid and heat flow, paleothermometry, diagenesis, and sealing properties that should be understood and studied as coupled processes.

LAKE RECORDS OF HOLOCENE CLIMATE CHANGE, CORDILLERA DE MÉRIDA, VENEZUELA

POLISSAR Pratigya J.

University of Massachusetts Amherst. Ph.D. 2005
(**Texto completo 220 p. en DVD anexo, carpeta 079**)

Multi-proxy sediment records from four lakes in the Venezuelan Andes document changes in tropical climate over timescales of decades to millenia. The results are grouped into three topics: the Little Ice Age, the Holocene climate history, and atmospheric moisture balance of South America from oxygen isotopes.

A 1500-year reconstruction of climate history and glaciation indicates four glacial advances occurred between 1250 and 1810 A.D. These advances are coincident with solar activity minima. Temperature declines of 2.3 to 3.4° C and precipitation increases of 25 to 70% are required to produce the observed glacial responses. These results highlight the sensitivity of high altitude tropical regions to relatively small changes in radiative forcing, implying even greater responses to future anthropogenic forcing.

On longer timescales, the Venezuelan Andes were generally wetter during the early Holocene. The middle Holocene was a time of low lake levels and reduced moisture balance whereas the late Holocene was wetter, with the wettest period occurring during the Little Ice Age. The patterns of millennial climate variability in Venezuela appears to be either a wet-dry-wet (Andes) or dry-wet-dry (lowlands) sequence. Comparison with climate records from North, Central and South America suggests this pattern is widespread near the northern and southern edges of the tropical monsoon climate regime and along the Andes near the equatorial Pacific.

The isotopic composition of Andean precipitation reflects evaporation conditions over the Atlantic Ocean, moisture recycling over the South American lowlands and uplift to the Andes. The isotopic composition of the precipitation in the Venezuelan Andes, reconstructed from lake sediment diatom oxygen isotope records, show a 2.4% decrease during the Holocene. This decrease reflects a reduction in the moisture entering South America which reaches the Andes. Ice cores from Perú and Bolivia exhibit similar isotopic trends.

Direct orbital changes in solar insolation can not explain the synchronous trends in both climatic and isotopic histories throughout the neotropics. However, sea surface temperature variation in the tropical Pacific may explain these trends because modern interannual variability in this region has similar effects in both hemispheres.

SEISMIC STRATIGRAPHY AND DEPOSITIONAL SYSTEMS OF THE ORINOCO PLATFORM AREA, NORTHEASTERN VENEZUELA

PRIETO CEDRARO Rodolfo

University of Texas at Austin. Ph.D. 1987
(**Texto completo 166 p. en DVD anexo, carpeta 080**)

Two distinct areas characterize the Orinoco Platform. First, a stable area to the south where a Cretaceous platform was established with continuous subsidence. Large amounts of post-Miocene sediments came into the basin through the progradation of the Orinoco deltaic system. During the Oligocene a downward shift of coastal onlap is inferred. Sands assumed to be shallow water in origin were deposited below the previous shelf edge. Progressive, retrogradational coastal deposits migrated toward the south and were capped later by a thin shale stringer rich in deep water fauna. The Oligocene wedge was covered by a carbonate platform during Early Miocene. The carbonate platform is interrupted by a regional unconformity that can be traced into the Guayana Basin. The Middle and Late Miocene represented a period of transgression. The first influx of sediments from the Orinoco Delta started during Late Miocene to Early Pliocene. Features interpreted as erosion, are observed on the available seismic records. Canyons were cut in the eastern flank of a deltaic system which, when later reactivated, prograded over the canyons. Shelf-margin deltas have caused continuous progradation of the continental slope since Pliocene time.

The second area is characterized by deformation of a thick sedimentary wedge by growth faulting (north-northwest) into a series of associated east-northeast anticlines and shale diapirs. Toward the east the initiation of growth faulting was controlled by the Lower Miocene shelf-edge. Toward the west growth faulting is judged to have been related to strike-slip lateral movement of Los Bajos fault and to the first major sediment influx of the Orinoco Delta. The growth faults are younger toward the northeast as indicated by the growth ratios. The faults in the southwest area have higher expansion indices in the pre-Pliocene sequence, whereas the northeastern-most faults have higher expansion indices post-Pliocene.

**HIGH-FREQUENCY SEQUENCE STRATIGRAPHY OF THE LA PASCUA FORMATION,
VENEZUELA: EFFECT OF RELATIVE SEA LEVEL ON THE SIZE, GEOMETRY AND SPACING OF
DEPOSITIONAL SYSTEMS**

REISTROFFER John I.

Univeristy of South Carolina. Ph.D. 2001

(Texto completo 313 p. en DVD anexo, carpeta 081)

The Rupelian aged La Pascua Formation is a basal transgressive sandstone unit that overlapped the Cretaceous Tigre Formation along the cratonic margin of the Eastern Venezuela basin. Ten fourth-order sequences were identified within the context of a 1.7 million-year third-order sequence composed of lowstand, transgressive and highstand sequence sets.

Fourth-order incised valley systems with the highest width: net-sand thickness ratios were deposited in the aggradational third-order lowstand sequence-set, the lowest ratios were found in sands of the third-order retrogradational transgressive sequence-set, while medium ratios were common to the third order progradational highstand sequence-set.

V-shaped and coalesced incised valleys dominated the third-order lowstand sequence-set. Narrow elongate-sinuuous to slightly sinuous valleys the third-order transgressive sequence-set, and wide elongate-sinuuous were most prevalent in the highstand sequence-set.

Much of the sediment deposited in transgressive system tract barrier shorefaces was reworked from the underlying highstand system tracts during wave ravinement and subsequent longshore current transport.

Elongate dip sands, unique to the transgressive system tract; were deposited directly above the underlying incised valleys during fourth-order transgression. They dominated fourth-order transgressive systems tracts in periods of strong incision followed by strong third-order transgressions. They were formed by sand eroded along the transgressive surfaces, that was transported by longshore currents and deposited into the erosional lows of the incised valleys of the underlying lowstands, later to be reworked by fluvial and tidal processes into elongate sandbodies.

Shoreface sands of late fourth-order highstands, were often semi-detached from the younger more landward shorefaces. These intervals present excellent targets for stratigraphic trap exploration for hydrocarbons.

It was possible to predict the net-sand tendencies, sand body measurements and geometry based on their location in the depositional systems along the fourth and third order eustatic curve. Another conclusion was the hazard of comparing modern depositional systems to the ancient without first comparing their respective locations along the third and fourth-order eustatic curves.

**TECTONIC ANALYSIS, STRATIGRAPHY AND DEPOSITIONAL HISTORY OF THE MIOCENE
SEDIMENTARY SECTION, CENTRAL EASTERN VENEZUELA BASIN**

RODRÍGUEZ Luis Oswaldo

University of Texas at Austin. Ph.D. 1999

(Texto completo 209 p. en DVD anexo, carpeta 082)

The post-Paleozoic tectonic origin of the Eastern Venezuela Basin (EVB) (a peripheral foreland basin) can be summarized in three major phases: 1) Late Paleozoic rifting, 2) Cretaceous-Paleogene passive margin, and 3) Paleogene-Quaternary strike-slip, compression-transpression and foreland development. Rifting occurred during the middle to late Paleozoic when North America separated from Gondwana and is represented by deltaic and shallow marine sediments of the Middle to Late Paleozoic Hato Viejo and Carrizal formations. The passive margin phase spans from the end of rifting in the Late Jurassic to the onset of tectonism in the Oligocene. During this passive margin phase the South America plate subsided to allow the accumulation of more than 4 km (approx. 12000 ft) of both clastic marine and carbonate units. The foreland basin phase in the northern part of South America is older in western Venezuela and northern Colombia, and becomes younger to the east. In the central part of the Eastern Venezuela Basin, tectonism started during late Oligocene (28-26 Ma) to early Miocene (22 Ma) and was episodic. It can be grouped in four distinct periods at 28, 22, 14, and 6-7 Ma ago. This tectonism controlled the stratigraphic pattern in the central part of the EVB, which is represented by more than 4 to 9 km of Miocene-Pliocene sandstone and shale.

The Tertiary section of the central part of EVB is composed of deposits of the Lower-Middle Miocene Oficina depositional episodes, the Upper Miocene Freites deepening depositional episode. All of these time units were

influenced by local tectonism that affected this region since Oligocene time (around 28-26 Ma). The Oficina depositional episodes (ODE) comprise two well defined genetic units (O.D.E. I and II). O.D.E. I can be subdivided into lower, middle and upper units that were deposited in deltaic depositional systems influenced by wave reworking, while O.D.E II was formed by a strongly fluvial-dominated delta depositional system.

Several contemporaneous sources contributed to infill the Eastern Venezuela Basin during Tertiary time. Initially, during the Oligocene sources were located to the north-west in the Guárico-Serranía del Interior thrust-fold belts, and to the south in Guyana craton. However, during Miocene time as the Caribbean plate continued its eastern migration, uplift of the Serranía del Interior created a new source of sediments which fed the deepest part of the Maturín sub-basin (Maturín foredeep) burying previously accumulated. Oligocene formations as is the case for the Oligocene Naricual Formation which was capped by the overlying deep marine Miocene Carapita Formation. In addition, in the southern shallower part of the EVB Miocene deltaic depositional systems associated to the accumulation of the Miocene Oficina and Freites Formations contributed to the infilling of this basin. The tectonic genesis of the EVB during Tertiary times produced a continuous creation of space into the craton creating a backstepping geometry of the Tertiary sedimentary section which overlapped the craton and increased the base level of cratonic rivers flowing into the basin. Under this scenario, sediment load transported by those were forced to be deposited upstream, making them unlikely as the origin for the high volume of sediment accumulated within the Oficina/Freites formations. Perhaps, the sediment source was located away from this area, as is today the case for the Orinoco delta where 99% of its sediments are produced by the Colombian/Venezuelan Andes and the Venezuelan cordilleras. A possible source for the Oficina/Freites Formation was associated with the Andean uplift active during Tertiary times.

EVALUACIÓN DE GEOAMENAZAS CON FINES DE MICROZONIFICACIÓN SÍSMICA EN LAS CIUDADES DE BARQUISIMETO Y CABUDARE, ESTADO LARA, VENEZUELA

RODRÍGUEZ Luz María

Universidad Simón Bolívar. Maestría en Ciencias de la Tierra. 2008

(Texto completo 185 p. en DVD anexo, carpeta 083)

La evaluación pluri-amenaza se desarrolló en el marco del proyecto de microzonificación sísmica de las ciudades de Barquisimeto y Cabudare, estado Lara; estudio del cual carece la mayoría de las ciudades del país, y viene a ser un insumo básico en la formulación de los planes de desarrollo urbano local (PDUL). Para la evaluación de las geoamenazas se revisaron fotografías aéreas de distintas escalas y años, mapas geológicos estructurales de la zona, documentos históricos y contemporáneos, incluyendo las crónicas locales y entrevistas a cronistas, así como también se realizaron misiones de campo.

El estudio se concentró en tres aspectos temáticos: *Amenaza Hídrica*, representada por las manifestaciones peligrosas de torrencialidad urbana y por las difluencias históricas ocasionadas por los ríos Claro y Turbio, en terrenos urbanizados correspondientes al área de expansión de Cabudare. *Amenaza Geotécnica*, manifestada por las evidencias de inestabilidad sub-superficial (proceso de tubificación) que afecta la terraza de Barquisimeto y planicie de inundación de los ríos Claro y Turbio, así como por las inestabilidades gravitacionales (movimientos de remoción en masa), particularmente en el talud sur de Barquisimeto. *Amenaza Sísmica*: por encontrarse ambas ciudades, sobre una de las estructuras tectónicas de mayor importancia sismogénica, como es el sistema de fallas de Boconó.

Como resultado de este trabajo se obtuvo un catálogo que incluye mediante tablas un inventario catastral de antiguas lagunas encima de la terraza de Barquisimeto, un inventario de siniestros históricos y un inventario de inestabilidades geomorfológicas. Así como también siete mapas desglosados de la siguiente forma: (1) mapa de unidades geomorfológicas; (2) mapa que muestra las difluencias de los ríos Claro y Turbio, en el área de expansión de Cabudare; (3) mapa de evidencias de tubificación en el tope de la terraza de Barquisimeto; (4) mapa de geoamenaza sísmica, (5) mapa de siniestros ocurridos en el tope de la terraza de Barquisimeto, (6) mapa de siniestros e inestabilidades observadas en Cabudare y sus áreas de expansión y (7) un mapa general que engloba las geoamenazas estudiadas.

Se estima que la zona que representa mayor vulnerabilidad frente a las geoamenazas planteadas, con base en las características geológico-geotécnicas corresponde a la parte oeste y central del talud sur de la terraza de Barquisimeto. Así mismo es importante señalar que las manifestaciones de torrencialidad urbana, observadas en los periodos de lluvias abril-julio y septiembre-noviembre, pueden causar mayores daños de los reportados a lo largo de la historia, si no se mejoran los sistemas de desagüe.

SEDIMENTOLOGY OF THE MIOCENE OFICINA FORMATION IN THE CERRO NEGRO AREA, ORINOCO OIL SANDS, VENEZUELA

RODRÍGUEZ GONZÁLEZ Argenis
University of Toronto. Ph.D. 1985
(**Texto completo 455 p. en DVD anexo, carpeta 084**)

The Cerro Negro oil-sands area is located in the eastern part of the Orinoco Petroliferous Belt in eastern Venezuela. Although the Oficina Formation is the only oil producing formation in this region, till now no attempt has been made to analyse and produce a sedimentological model for these sediments using modern sedimentological techniques.

Seven continuously cored wells penetrating the Oficina Formation provide the 1955.9 m (6417 feet) of cored section employed in this study. Paleontological data obtained from these cored wells were utilized and geophysical well logs were available for over 100 additional wells within the study area.

The sedimentological information gathered during analysis of the cored sedimentary sections comes from study of lithology, trace fossils and bioturbations structures, abundant shell fragments, clay mineralogical assemblages and microfaunal data. This information provides a basis for recognizing thirteen facies as representative of the cored sedimentary intervals, and leads one to divide the sedimentary section into four genetically related Facies Assemblages or Stratigraphic units. Stratigraphic Unit I is characterized by the absence of any marine influence, by thick sand deposits separated by thick shale breaks, and by a clay mineral assemblage consisting of kaolinite and illite. Stratigraphic Unit II is characterized by the first appearance of burrows and or bioturbation structures, a lithology composed of multilayered sand deposits with thin burrowed shale or siltstone interbeds, the first appearance of microfaunal assemblage consisting of brackish, hypersaline and shallow-marine specimens, and by a clay mineral assemblage consisting of kaolinite, illite, and illite/smectite. Stratigraphic Unit III is characterized by a fine-grained-lithology, an abundance of shell fragments, the occurrence of burrows, bioturbation structures, sideritic bands and concretions, coal beds, a microfaunal assemblage composed of brackish, hypersaline and shallow-marine specimens, and by a clay mineral assemblage consisting of kaolinite, illite, and illite/smectite. Stratigraphic Unit IV is characterized by a lithology composed of multilayered sand with thin bioturbated shale or siltstone interbeds, limestone beds, a strongly bioturbated texture, the presence of a microfaunal assemblage consisting of a brackish, hypersaline and shallow-marine specimens, and a clay mineral assemblage consisting of kaolinite, illite, and illite/smectite. These facies assemblages, sedimentary structures and textures, faunal assemblages, and clay mineral assemblages are interpreted as being deposited in a deltaic to shallow-marine environment. Stratigraphic Unit I represents a deltaic progradational phase. Stratigraphic Unit II represents reworked delta-front sand deposits redeposited as proximal bars. Stratigraphic Unit III represents an interdeltic bay environment. Stratigraphic Unit IV is a deltaic reoccupational phase. This interpretation is supported by computer-drawn isopach maps of selected sands within each Stratigraphic Unit, by sand percentage and sand isolith maps of individual Stratigraphic Units and is consistent with isopach maps of each Stratigraphic Unit, and of the total Oficina Formation.

This deltaic to shallow-marine facies model proposed for Cerro Negro predicts that sand bodies should have different trends, thicknesses and distribution depending upon the Stratigraphic unit in which they were formed. The model also predicts that several deltaic systems formed the sediments of the Oficina Formation in the Orinoco Petroliferous Belt. Therefore the model can be used as a guide in future studies of this Petroliferous Belt, in other areas of the Eastern Venezuela Basin, and in areas having similar geological characteristics to those of Cerro Negro.

The division of the Oficina Formation into four stratigraphic units suggests a new stratigraphic division for this formation in the Cerro Negro area and one which can undoubtedly be extended to other areas of the Orinoco Petroliferous Belt and to the Anaco area of the Eastern Venezuela Basin. This division allows one to make objective well correlations which bear upon sand-counting and sand-geometry delineation and in consequence bear upon reserve estimates, exploration and exploitation strategies, and the acquisition of oil and gas leases.

STALAGMITE BASED PALEOCLIMATE RECONSTRUCTION, NORTHERN VENEZUELA: A RECORD OF CARIBBEAN HOLOCENE CLIMATE CHANGE

ROSNER Stacy M.
University of Kansas. M.S. 2006
(**Texto completo 83 p. en DVD anexo, carpeta 085**)

Northern Venezuela stalagmites from Cueva Zarraga (Sierra de San Luis, Falcón) were analyzed for their $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values and dated using U/Th disequilibrium. Goals included producing terrestrial record of Caribbean/South American climate change; determine the expressions of Northern Hemisphere climate change in the tropics; and tracking the migration of Inter-Tropical Convergence Zone (ICTZ) throughout the Holocene. The record extends from 11,000 yBP to present and captures the early Holocene transition from the cooler climate of the Last Glacial Maximum to the warmer wetter Holocene, correlating well with regional and high-latitude records. Insolation driven migration of the ICTZ controls climate change for the majority of the Holocene, up until ~3000 yBP when climatic change and insolation are decoupled. The decoupling has been attributed to less migration of the ITCZ or higher variability in El Niño activity. Timing is suggestive of an anthropogenic cause from increased population and/or changes in agricultural practices.

MODELO ESTRUCTURAL 2D BALANCEADO DE LA REGIÓN CENTRAL DE LA SUBCUENCA DE MATURÍN, CUENCA ORIENTAL DE VENEZUELA

SÁNCHEZ YTANARE José Gilberto
Universidad Central de Venezuela. Ph.D. 2008
(**Texto completo 157 p. en DVD anexo, carpeta 086**)

Se generó un modelo estructural 2D balanceado de la región central de la subcuenca de Maturín, cuenca Oriental de Venezuela. Partiendo de datos sísmicos de reflexión en tiempo y de pozos, para el balanceo y restauración de secciones se aplicó la conservación de longitud de línea y el mecanismo de deformación de deslizamiento entre capas (flexural slip), se simuló diferentes modelados cinemáticos con las respectivas calibraciones termales y se generó la visualización en 3D. Diferentes autores han construido diversos modelos. Sin embargo a la fecha, no se han desarrollado suficientes secciones estructurales balanceadas, que permitan visualizar las variaciones laterales y la evolución estructural, generando así la apertura de nuevos retos exploratorios en Venezuela.

Se desarrollaron 9 secciones estructurales balanceadas con sus respectivas interpretaciones sísmicas, una visualización 3D del área de interés exploratorio, se restauraron dichas secciones y se calcularon los acortamientos. Se generó un mapa palinspástico al tope del Oligoceno y un esquema del bloque piso con los diferentes niveles de despegue y rampas existentes. Se simuló y analizaron varios modelos cinemáticos, y finalmente se escogió el más cónsono con los datos existentes.

El nuevo modelo estructural sugiere:

- Tres dominios estructurales.
- La existencia de un bloque no perforado ubicado por debajo del campo Orocual tradicional, el cual genera un alto relieve estructural que controla el desplazamiento del bloque Pirital.
- Ausencia de basamento cristalino en el área de estudio, hasta profundidades de 30.000 pies al Sur y hasta 40.000 pies al Norte aproximadamente.
- El acortamiento promedio de las secciones y transectos es de 51,6%.
- Cambios del estilo estructural en el área de Jusepín.
- La evolución estructural definitiva es aquella donde los tres niveles de despegue comparten la misma superficie de falla en la parte más profunda del bloque de Pirital.
- Se establecieron los tiempos de la formación de las trampas en función de la evolución estructural.
- Por último, se propone que el borde Sur del graben de Espino está involucrado en el bloque de Pirital.

GEOCHEMISTRY AND GEOCHRONOLOGY OF THE IGNEOUS ROCKS OF THE VENEZUELAN COAST RANGES AND SOUTHERN CARIBBEAN ISLANDS AND THEIR RELATION TO TECTONIC EVOLUTION

SANTAMARÍA Francisco J.
Rice University. Ph.D. 1972
(**Texto completo 127 p. en DVD anexo, carpeta 087**)

One approach to testing plate tectonic models is through a study of the igneous rocks produced at plate boundaries. Dewey and Bird (1970) have recognized the geologic history of the Appalachian Orogen of the eastern United States through the use of plate theory, and Hamilton (1969, 1970) has undertaken a similar task for the western United States and the Ural Mountains. The three basic types of plate boundary interactions produce three different types of igneous products (our present stage of knowledge is still imperfect, e.g. see Gilluly, 1971), which are being studied in modern oceans. Remnants of these igneous products can be recognized orogenic belts and thus offer a means to unravel past plate interactions. Rifting produces igneous rocks characterized by rock types of the midocean ridges. Subduction produces igneous rock suites of island arc or andean arc types. Moreover, subduction also produces a characteristic geochemical variation in rock types across an arc so that the dip direction or polarity of the subduction zone can be determined (Dickinson, 1970). Transform plate boundaries as yet are not characterized by any particular igneous rock suites; in fact this study may be able to contribute some valuable information on this problem.

Thus, by studying the geochemistry and geochronology of the igneous rocks of Venezuelan Andes, Coastal ranges and offshore islands we will be able to test the present plate tectonic models for the evolution of Venezuela and related islands. In particular, the Late Mesozoic to Early Tertiary period of subduction should be particularly characteristic and new data can be provided on the problem of igneous rock suites generated during the Middle Tertiary to Recent period of transcurrent (transform) plate interaction.

Intrusive granitic rocks of the Venezuelan Andes and north of the Andes (Paraguaná, El Baúl, El Baño, El Palmar) have been dated and they appear to be of Late Paleozoic age probably related to the Hercynian Orogeny. Comparable ages from similar rocks of the Appalachian Mountains have been published. These ages together with the distribution of the post-tectonic red beds of Triassic-Jurassic La Quinta Formation (in the Venezuelan Andes) and the red sandstones of the post-orogenic Newark Group of Late Triassic (in the Appalachians) appear to support the contention that the Paleozoic tectonic belt of eastern North America (Appalachian) may be continuous with similar belt in western South America (Andes).

Potassium-argon ages of approximately 120 m.y. from mafic intrusives of Paraguaná Peninsula, Curacao and Los Roques Islands, suggest that underthrusting of the Caribbean plate beneath South America first began in Early Cretaceous time. Ages of 63 ± 4 to 76 ± 7 m.y. on andesites from Paraguaná Peninsula and Curacao island respectively, suggest further underthrusting and volcanism during Upper Cretaceous.

Uplift, syntectonic magmatic activity and metamorphism, occurred during the Upper Cretaceous-Lower Paleocene times. An upper limit for the age of metamorphism of the Venezuelan Coast Ranges is provided by the ages determined on the post-metamorphic granites of Guaremal (79 ± 5 m.y.), and Matasiete (72 ± 6 m.y.). Ages of 65 ± 5 to 67 ± 6 m.y. on gabbros of the Tiara Formation (Villa de Cura Group) probably represent cooling ages due to uplifting during or prior to thrusting.

Potassium-argon ages ranging between 44 ± 5 to 47 ± 6 m. y. amphiboles separated from pegmatitic diabases of the Los Testigos islands indicate that the volcanic arc of Lesser Antilles moved eastward to its modern position during the Eocene. The Caribbean region attained essentially its modern aspect by the end of the Middle-Eocene (45 m.y.)

Potassium-argon determination on biotites from granites of the Cordillera de la Costa, (Guaremal and Choroní), in northern Venezuela yielded ages between 30 ± 2 to 33 ± 2 m.y. which suggest that the late (uplift) event occurred at the Middle Oligocene as a consequence of the Andean Orogenesis during the Upper Eocene to Oligocene times. These cooling ages probably represent Tertiary uplift which produced an episode of gravity sliding of the Upper Cretaceous Lower Eocene sequence of the Coast ranges and the allochthonous units contained within it (Villa de Cura block).

Throughout the remainder of the Cenozoic to the Present there was and is continued differential motion, interaction and closure between the two American plates. Potassium-argon age of 5 ± 0.5 m. y. for the dacite collected in Peninsula Araya-Paria indicates the southernmost extent of Lesser Antilles volcanism.

COUPLED REACTION-TRANSPORT MODELING OF BAUXITE FORMATION: APPLICATION TO THE LOS PIJIGUAOS BAUXITE DEPOSIT (VENEZUELA)

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Yale University. Ph.D. 1997
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The Los Pijiguaos bauxite deposit, located in the northwestern edge of the Guayana Shield, Venezuela, is a lateritic bauxite developed on a Precambrian Rapakivi Granite Batholith, the Parguaza Granite. This deposit is located in a planation surface at elevations between 600 and 700m, which is believed to have originated during an erosional event that took place in late Cretaceous-early Tertiary times.

The weathering profile is composed of an upper bauxitic zone, followed by a saprolite, and merging gradually to the fresh granite. The upper bauxitic zone contains gibbsite, quartz, hematite, goethite, and locally traces of kaolinite. The saprolite contains kaolinite, quartz, and goethite. The major element geochemistry of the deposit shows enrichment of the Al_2O_3 , Fe_2O_3 , and TiO_2 oxide components, and depletion of SiO_2 , relative to the parent rock. The chemical composition of the bauxite shows patterns that can be traced back to the composition of the parent granite.

The weathering of a granitic protolith leading to the formation of bauxite, at constant temperature, has been simulated by means of numerical models that couple solute transport and chemical reaction in porous media. The chemical reactions considered include mineral dissolution and precipitation, and the speciation of solutes in the aqueous phase. Mineral reaction rates are calculated according to rate laws which have been obtained from experimental work published in the literature. The rate laws include the effects of mineral surface area, pH, and solution saturation state. Speciation in solution is considered to be at local equilibrium at all times. The results of long term (>1Ma) one- and two-dimensional simulations indicate that the dissolution of the primary minerals leads to the formation of an upper gibbsite-rich and lower kaolinite-rich zone, separated by a kinetically controlled transition zone where both mineral coexist. The effect of mechanical denudation has been added to a one-dimensional reaction path model. Results using published estimates of mechanical denudation rates are consistent with an overall steady evolution of the weathering profiles at Los Pijiguaos (approximately constant profile thicknesses). The results of two-dimensional simulations show that the intensity of weathering is maximum close to steep slopes. However, the field data show that the profiles are thinner under those slopes, reflecting the importance of mechanical denudation in the evolution of the weathering sequences.

IDENTIFICACIÓN DE SISTEMAS ENCADENADOS EN SEDIMENTOS PELÁGICOS MEDIANTE MÉTODOS GEOQUÍMICOS, FORMACIÓN LA LUNA, OCCIDENTE DE VENEZUELA

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Universidad Central de Venezuela. MSc. 2007
(Texto completo 234 p. en DVD anexo, carpeta 089)

Este estudio se realizó con el objetivo de determinar las características geoquímicas que permitan detectar la influencia de los cambios del nivel del mar que pudieron afectar la depositación cretácica venezolana.

La evaluación geoquímica se realizó en cuatro secciones de afloramiento en el flanco norandino venezolano: Flor de Patria (Edo. Trujillo), Las Hernández (Estado Mérida), San Miguel y San Pedro del Río (Estado Táchira). Consistió en la aplicación de geoquímica inorgánica ($CaCO_3$, elementos mayoritarios, minoritarios y trazas, isótopos estables) y geoquímica orgánica (COT, IH) sobre un muestreo de cada 0,5 a 1 m en las secuencias carbonáticas estudiadas.

La descripción a través de parámetros geoquímicos de las litologías presentes en la Formación La Luna indica: a) calizas y lutitas carbonáticas poseen elementos mayoritarios Si, Ca y Al, y elementos minoritarios Fe, Mg, P y K; b) lutitas basales de la Formación Colón poseen elementos mayoritarios Si, Ca, Al, Fe, Mg y K, y elementos minoritarios Ti, P, Zn; c) las lutitas calcáreas en comparación con las calizas poseen mayores elementos asociados con arcillas (Al, Fe, Ti, Rb, Na), materia orgánica (V, Zn, Cu, Ni), valores más pesados de $\delta_{13}C$ y más livianos de $\delta_{18}O$.

Entre las mineralizaciones más importantes que pueden verse reflejados y resaltados en parámetros geoquímicos son las fosilizaciones (mayores valores de Ca, P, Fe, Mg, K, Na, Ba, Sr, galuconitizaciones (mayores valores de Si, Al, Fe, Mg, K, Ti, Ba, Zn, y Cr) y silicificaciones (mayores valores de Si y valores muy livianos de $\delta_{13}C$ org).

La determinación de patrones litológicos, sedimentológicos, estratigráficos y geoquímicos de la Formación La Luna permitió su comparación con la curva de largo plazo de HAQ *et al.* 1987. El aumento del nivel del mar a largo plazo durante el Turoniense se manifiesta como una sección condensada en Trujillo, menores tasas de sedimentación en el Coniaciense, micro facies tipo wack-packstone, con abundancia y diversidad de foraminíferos plánticos que disminuyen hacia el tope, altos valores de CaCO₃ y niveles anóxicos. El descenso relativo del nivel del mar a largo plazo durante el Santoniense parece manifestarse en un cambio litológico, paso de lutitas a calizas, aumento de la tasa de sedimentación, presencia de matriz más arcillosa y/o silícea, microfacies wack-mudstone, disminución de los foraminíferos plánticos y comienzo del aumento de los béticos y niveles anóxicos-disóxicos. El siguiente ascenso del nivel del mar parece manifestarse en otra sección condensada, la de Tres Esquinas (finales Campaniense-inicios Maastrichtiense), previa a ella predominan los foraminíferos béticos, litologías de calizas, disminuye la tasa de sedimentación y mayores niveles disóxicos. Estas dos secciones condensadas definen un ciclo regresivo-transgresivo de segundo orden.

La definición geoquímica de estas dos secciones condensadas (Turoniense en Trujillo y Tres Esquinas en Mérida y Táchira) permitió la ubicación de niveles similares de menor intensidad (a corto plazo o MFS) durante la depositación de la Formación La Luna, que pueden permitir la identificación de por lo menos 5 secuencias y marcar la división entre sistemas encadenados transgresivos (TST) y sistemas encadenados de alto nivel (HST). Estos MFS de tercer orden ocurrieron a inicios del Coniaciense y desde finales del Coniaciense hasta inicios del Campaniense, que son correlacionables temporalmente con la curva de tercer orden de HAQ *et al.*, 1987.

GEOCHEMICAL EVIDENCE FOR ISLAND-ARC ORIGIN OF THE VILLA DE CURA BLUESCHIST BELT, VENEZUELA

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Rice University. M.A. 2000

(Texto completo 105 p. en DVD anexo, carpeta 090)

New geochemical data from the Villa de Cura indicate that it is a subducted (and exhumed) island-arc terrane. The majority of the basalts are primitive island-arc tholeiites (44.8-51.1 wt% SiO₂, 6.7-22.8 wt% MgO). REE and immobile trace element data from the Villa de Cura exhibit island-arc signatures, including 1) flat to LREE enriched REE patterns with La/Yb ratios of 1.23-6.03, and 2) enrichment of LILE relative to HFSE with a strongly negative Nb anomaly (La/Nb = 1.56 - 7.90). Thus, the Villa de Cura is similar to other Albian-Aptian age island arc tholeiites documented throughout the Caribbean. A model for formation and initial subduction of the Villa de Cura is presented. Correlation of the Villa de Cura with other allochthonous basalts in the Caribbean will help to constrain developing paleotectonic models of Caribbean.

DEVELOPMENT OF PALEOENVIRONMENTAL PROXIES AND THEIR APPLICATIONS TO THE HOLOCENE CLIMATE RECORD OF THE CARIACO BASIN, VENEZUELA

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University of South Carolina. Ph.D. 2002
(Texto completo 213 p. en DVD anexo, carpeta 091)

The Cariaco Basin is located on the northern continental shelf of Venezuela in a region characterized by intense upwelling due to the seasonal migration of the Inter-Tropical Convergence Zone (ITCZ) and associated variations in trade wind intensity. Hydrographic observations indicate that coastal upwelling occurs during the late winter-early spring at which time sea surface temperatures are lowest (~22° C) and primary productivity and planktonic foraminiferal fluxes are high (4000-8000 shells m⁻² day⁻¹). A three-year sediment trap experiment was conducted in the Cariaco Basin (January 1997- December 1999) to study variations in flux, assemblage composition and shell chemistry for comparison with the climatology and hydrography of the region on seasonal and interannual time scales. Nine species of planktonic foraminifera constitute > 85% of the assemblage: *Orbulina universa*, *Globigerinoides ruber* (pink and white varieties), *Globigerina bulloides*, *Globigerina quinqueloba*, *Neoglobocadrina dutertrei*, *Globorotalia crassaformis*, *Globorotalia menardii*, and *Globigerinita glutinata*. *Globigerina bulloides* is dominant during spring upwelling, however, the peak annual flux of all nine species occurs during this period. The stable isotopic composition was used to evaluate the application of each species in

paleoceanographic reconstructions. Temperature estimates based on species-specific paleotemperature equations and the analysis of the annual flux-weighted $\delta^{18}\text{O}$ signal indicate the $\delta^{18}\text{O}$ record of *G. ruber* (pink) is most suitable for estimating mean annual SSTs while *G. bulloides* provides information regarding conditions during spring upwelling.

Oxygen isotope records of *G. ruber* (pink), *G. bulloides* and *N. dutertrei* from gravity core CAR7-1 were used to construct a high-resolution climate for the Caribbean region for the last 6000 years. Our results indicate major decreases in sea surface temperature and/or increases in salinity in the basin at least four times in the last 4000 years (~3800-3200, 2800, 2200-2000, and after 650 cal yrs. B.P). These events are coincident with high stands of Lake Titicaca, Bolivia/Peru suggesting a similar forcing mechanism. The onset of arid conditions in the circum-Caribbean region between ~3600-3200 cal yrs. B.P. corresponds to a 1% increase in the $\delta^{18}\text{O}$ of *G. ruber* (pink), decreases in $\Delta\delta^{18}\text{O}$, and the migration of the subthermocline dwelling planktonic foraminifer *Globorotalia crassaformis* into the basin. Taken together these data indicate colder SSTs and a shallow thermocline, possibly due to increased upwelling. Dry conditions in the circum-Caribbean tropics and wetter conditions in the Altiplano of Bolivia/Perú and the Amazon basin during the mid to late Holocene are consistent with a southward displacement of the ITCZ which would have resulted in decreased precipitation and increased trade wind intensity in the Cariaco Basin.

TERTIARY EVOLUTION OF THE NORTHEASTERN VENEZUELA OFFSHORE

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On the northeastern offshore Venezuela, the pre-Tertiary basement consists of deeply subducted accretionary complex of a Cretaceous island arc system that formed far to west of its present location. The internal structure of this basement consists of metamorphic nappes that involves passive margin sequences, as well as oceanic (ophiolitic) elements.

The Tertiary evolution of the northeastern Venezuela offshore is dominated by Paleogene (Middle Eocene-Oligocene) extension and Neogene transtension, interrupted by Oligocene to Middle Miocene inversions. The Paleogene extension is mainly an arc-normal extension associated with a retreating subduction boundary. It is limited to the La Tortuga and the La Blanquilla basins and the southern Margarita and Caracolito subbasins. All of these basins are farther north and not directly tied to the El Pilar fault system. On a reconstruction, these Paleogene extensional systems were located to the north of the present day Maracaibo Basin.

By early Miocene the leading edge of the now overall transpressional system had migrated to a position to the north of the Ensenada de Barcelona. This relative to South America eastward migration is responsible for the Margarita strike-slip fault and the major inversions that began during the Oligocene and lasted into the Middle Miocene.

The Boconó-El Pilar-Casanay-Warm Springs and the La Tortuga-Coche-North Coast fault systems are exclusively Neogene with major transtension occurring during the Late Miocene to Recent and act independently from the earlier Paleogene extensional system. They are responsible for the large Neogene transtensional basin of the area: the Cariaco trough, the Northern Tuy-Cariaco and the Paria sub-basins, and the Gulf of Paria Basin.

This latest phase is characterized by strain-partitioning into strike slip faults, a transtensional northern domain and transpressional southern domain that is responsible for the décollement tectonics and/or inversions of the Serranía del Interior and its associated Monagas foreland structures. Part of the latest (Middle Miocene to Recent) phase is the formation of a large arch that corresponds to the Margarita-Testigos- Grenada zone which perhaps was subject to mild lithospheric compression during the Plio-Pleistocene.

DINOFLAGELLATES FROM THE UPPER CAMPANIAN-MAASTRICHTIAN OF COLOMBIA AND WESTERN VENEZUELA: BIOSTRATIGRAPHIC AND SEQUENCE STRATIGRAPHIC IMPLICATIONS

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Dinoflagellate biostratigraphy of the Upper Campanian-Danian was studied in five surface sections from Colombia and one from western Venezuela (Rio Loro section, Estado Mérida). The Rio Molino section is in northern Colombia, the Chiguata Creek and Tausa sections are in the central part of the Eastern Cordillera, La Buitrera Creek section is in the western flank of the Eastern Cordillera, and the Aico Creek Section is in the Upper Magdalena Valley. At least twenty-two biostratigraphically significant events were identified in the upper Campanian and Maastrichtian of the studied sections. In absence of calcareous macro- and microfossils the Campanian/Maastrichtian boundary was identified based on the highest occurrence of *Trichodinium castanea* and near the lowest occurrence of *Phelodinium tricuspe*, *Yolkinigymnium lanceolatum* and *Hafniasphaera fluens*. Several third-order coarsening upward cycles were recognized within the overall shallowing upward pattern displayed in the six sections. Dinoflagellates tend to be more abundant at the base of these cycles and peridinooid cysts dominate the dinoflagellate assemblage in most samples. During the upper Campanian carbonate sediments accumulated in northern Colombia (Socuy Limestones), while high paleo-productivity conditions generated biosiliceous sediments and condensed phosphorites in the Eastern Cordillera and the Upper Magdalena Valley (Plaeners Formation and Lidita Superior). These become younger to the east. Continuous, cyclic progradation from the east and south during the upper Campanian accumulated coarse-grained siliciclastics in proximal settings where sandstones are interbedded with porcelanites and cherts (Chiguata and Tausa sections). In more distal environments, micritic limestone and dark mudstones from the Buscavida Formation represent coeval sediments (La Buitrera Creek and Aico Creek sections). An expanded section of mudstones and sandstones from Los Pinos and Tierna Formations was recognized in the Chiguata Creek section relative to the Aico, La Buitrera, Río Molino and Tausa sections. The K/T boundary is present in the Venezuelan section but coincides with an 11.5m unexposed interval separating uppermost Maastrichtian dinoflagellate events below from Danian dinoflagellates above.