Mud Diapirism Associated to Neotectonic Transcurrent Leaky Faults in the Colombian Caribe — A Pass Way to Hydrocarbon Migration*

Camilo I. O. Aristizábal¹, André L. Ferrari², and Cleerson G. Silva²

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¹LAGEMAR, Federal Fluminense University, Niterói, Brazil (cioageoeu@gmail.com)
²LAGEMAR, Federal Fluminense University, Niterói, Brazil

Abstract

The north Colombian continental edge tectonic framework is related to the Nazca/South American/Caribbean Plates triple junction. The seismological records and the geology of the Cartagena city and neighborhoods have been interpreted as a result of the deformation and sedimentary processes caused by NW direction regional compressive tectonics. The stratigraphical scenario of this area is characterized by a typical Pliocene-Pleistocene carbonate inner-shelf overlaying continental clastic sediments that cover a thick Miocene deep sea mud sequence. Major structures of the Sinu and San Jacinto Deformation Belts (SSJDB) characterize the area and are represented by anticline and synclinal folds, NE-SW high angle thrust-faults, NW-SE left-lateral strike-slip faults, and E-W right-lateral strike-slip faults. Locally, there are diapiric features like mud volcanoes, sometimes associated to gas/oil seeps, previously attributed to fold structures orthogonal to regional compression based on geophysical data.

In this case study, we identified a close relationship between diapiric features and morphostructural lineaments on the land area as well as on the continental shelf, mainly denoted by E-W and WNW-ESE direction structures. Seismic information allowed the identification of a relationship between the lower mud level underlying the Tertiary sedimentary sequence and Pliocene-Pleistocene diapiric features. The inversion stress analysis indicates that the E-W / NW-SE structures are related to a WNW-ESE regional compressional stress, so implying that the E-W structures are right-lateral strike-slip faults and the NW-SE structures are reactivated left-lateral strike-slip faults. In both cases, a normal component was detected and that suggests a transtractive character to these structures. The presence of mud volcanoes indicates that the lower mud levels submitted to overpressurization help to generate and/or reactivate secondary fractures and faults associated to the NW compression related to the E-W dextral transcurrent binary.
The E-W and WNW-ESE dextral transcurrent faults and the NW-SE sinistral transcurrent faults, which control the mud diapirism, act as fluid-conducting surfaces - or leaky faults - that must be taken into account on the studies aiming the characterization of hydrocarbon migration processes in the SSJDB.

References


Website

Jackson School of Geoscience, University of Texas at Austin, Texas: Web accessed 19 July 2011, www.jsg.utexas.edu/images/big/111507/f2.jpg
MUD DIAPIRISM ASSOCIATED TO NEOTECTONIC TRANSCURRENT LEAKY FAULTS IN THE COLOMBIAN CARIBE - A PASS WAY TO HYDROCARBON MIGRATION

CAMILO I. O. ARISTIZÁBAL; André L. Ferrari; Cleverson G. Silva

FEDERAL FLUMINENSE UNIVERSITY
GEOSCIENCES INSTITUTE
MARINE GEOLOGY AND GEOPHYSICS LAB
Lithotectonic and morphostructural map of northwestern South America. **SP**= Santander Massif - Serranía de Perijá; **SM**: Sierra Nevada de Santa Marta; **CA-VA** = Cajamarca-Valdívia terrane; **sl** = São Lucas block; **BAU** = Baudó terrane; **PA** = Panamá terrane; **SJ** = São Jacinto terrane; **SN** = Sinú terrane; **GU-FA** = Guajira-Falcon terrane; **1** = Atrato (Chocó) basin; **6** = Middle Magdalena basin; **7** = Lower Magdalena basin; **8** = Cesar-Ranchería basin; **9** = Maracaibo basin; **10** = Guajira basin; Additional Symbols: **RZF** = Romeral Zone Faults, **URABA** = suture/fault (system); red points = Plio-Pleistocene volcanoes; **Valledupar** = town or city.

**TECTONIC REALMS**

CCSP: Central Continental Sub-Plate = (CA-VA, sl)

MSP: Maracaibo Sub-Plate = (SP, SM)

WTR: Western Tectonic Realm = (CAT-CHO)

GU-FA: Guajira-Falcon Terrane Composite

Modified from (Cediel et al. 2003).
Example modeling Sinu Accretionary prism

- Slumps
- Décollement
- Oceanic crust
- Megasplay fault
- Accretionary prism thrusts
RESULTS

TOPOGRAPHY AND BATHYMETRY IMAGES
MOSAIC OF CARTAGENA CITY AND NEIGHBORS ADJACENT SHELF
A Clay chaotic edge

Accretionary wedge frontal imbricate

CARTAGENA

Sampling

Vertical Exaggeration X9

MBES Bathymetry

GEOMORPHOLOGY

Sampling

MBES Bathymetry

Clay chaotic edge

Accretionary wedge frontal imbricate

Sinu

CARTAGENA

PROTO-MAGDALENA
SEABED CORE LOCATION BY OIL & GAS COMPANIES REVEALS METHANE COMPOSITION
MUD DIAPIRISM

Loma Arena Village

Stereographic Pair
MORPHOSTRUCTURAL CHARACTERIZATION

TOPOGRAPHY AND BATHYMETRY IMAGES MOSAIC OF CARTAGENA CITY AND VICINITIES ADJACENT SHELF

Legend (not shown in the image)

1. Punta Canoas
2. Cartagena Bay
3. Barú Peninsula
Sector 2: Cartagena Bay

El Rodeo V.

E-W fractures
SEISMIC LINES DRAWING OF THE OFFSHORE NORTHWEST COLOMBIA ACCRETIONARY WEDGE

MAJOR STRUCTURAL UNITS AND THE RELATIVE TIMING OF THE UNITS HAS BEEN OUTLINED

PRESENT DAY

OFFSHORE SINÚ ACCRETIONARY WEDGE

Legend

- Accretionary wedge
- Overpressurized Oligocene Mud
- Cretacic Ocanic Crust
- Normal faults
- Overthrust faults
- Subducted oceanic Crust
- Miocene-Pleistocene Overwedge Units
- Coast Line
Extension fractures, hybrid and shear (faults)

Superimposing of all structures

Fluid Pressure
Turbaco

Bedding

Faults & fractures

Stress

Compressional Strike-slip

SW

NE

20/20

160/83 // 073 // 24 // dextral

162/80

120/82

356/88 // 85/19 // dextral
Punta Canoas

Faults: 250/33 // 179/12 // dextral
Fractures: 223/70
Fold axis: 157/60
Bedding: 185/30
Fractures: 223/70

Compressional strike-slip
Diapir
New diapir
Anticline
Syncline
Thrust fault
Slip Slide F.
Deduced F.
Interpreted F.
Normal F.
Holocene
Pliocene
Miocene
Oligocene
Eocene
Pleistocene
Lineament

0 Km
1:300.000

CARTAGENA

Los Morros
Ponta Canoas
Banco Nokomis
Bancos Salmedina
Bancos do Tesouro
Ponta Gigante
La Popa
I. Tierra Bomba
Ilhas do Rosário
Dique Channel

Tesouro Island
Rosário Island
Apistica
Point Barú
Grande Island

1:300.000

σ1

σ1
Limit between the abyssal plain and the deformation front. This limit displays folded turbidites at the continental foot slope (Vernette et al., 1992).
NEOTECTONIC CONTROL OF MUD DIAPIRISM MAP IN THE CARTAGENA VICINITIES

**Legend**
- **Holocene**
- **Pleistocene**
- **Pliocene**
- **Miocene**
- **Oligocene**
- **Eocene**
- **Old Diapir**
- **New diapir**
- **H. earthquake**
- **Anticline**
- **Syncline**
- **Thrust Fault**
- **Slip Slide F.**
- **Inferred F.**
- **Interpreted F.**
- **Deformation front**
- **Line coast**
NEOTECTONIC CONTROL OF MUD DIAPIRISM MAP IN THE CARTAGENA VICINITIES

Projection system UTM-WGS84
Esc.: 1:500,000

σ1

FIRB FITS
FPSR
FBNB
FMSC
FNCS
FBSM
FBCM
FBCL
FTPNI
FITS
FIRB
FBPB
FDCD
FMLB

σ1

Holocene
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
H. earthquake
Old Diapir
New diapir
H. deformation front

Anticline
Syncline
Thrust Fault
Slip Slide F.
Inferred F.
Interpreted F.
Normal F. (measured)
Lineament
Normal F. (interpreted)
Deformation front

Line coast
CONCLUSIONS

• The control of the injection of the mud volcanoes is determined by the E-W right-lateral and the NW-SE left-lateral faults, although the regional compressive structures strikes to NE direction.

• The NW-SE left-lateral faults are clearly reactivated strike-slip faults, like the Dique Fault, and the E-W right-lateral are an incipient array of faults identified by the secondary structures. The inversion of the fault slip data indicates that both are related to the WNW-ESE compressive stress.

• $\sigma_1$ Strike changes related to variations in the E-W oriented structures responsible for the local releasing/restraining bends or reactivation processes because faults evolution are favored by overpressurization.

• These structures are hybrid fractures. That is, fluid-conducting surfaces or leaky faults that must be taken into account on the studies aiming the characterization of hydrocarbon migration processes in the SSJDB.
CONCLUSIONS

- Enlarged economic importance of mud volcanoes
- New knowledge about hybrid structures
- Model optimization to gas prospecting
THANKS

E-mail: camilo@igeo.uff.br