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**"Caribbean Exploration – Planning for the Future"**

## ABSTRACT

# VENEZUELA – TRINIDAD "CARIBBEAN OBLIQUE COLLISION MODEL" REVISED

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The popular tectonic model for Venezuela and Trinidad, whereby a Jurassic rift evolved into a Cretaceous-Tertiary passive margin, destroyed by E-younging (Paleocene-Miocene) collision with the relatively SE-migrating Caribbean Arc, has been tested rigorously by the author during 17 years of geological consulting studies in the region and an exhaustive literature review. The Caribbean Model requires three revisions, crucial for petroleum exploration:

1. Rifting continued much later, as indicated by an unseen "Carib Halite Formation" (c. 4 km; above Couva anhydrite), neither exposed (largely dissolved) nor drilled, of inferred Berriasian-Valanginian age (see companion abstract). In fact, rifting continued into Albian time, about 50 m.y. later than the generally accepted late Jurassic termination, as indicated by the syntectonic character of Lower Cretaceous strata (confined; sand rich; isolated carbonate highs; evaporites), e.g. Rio Negro; Barranquin; Laventille-Domoil

carbonate banks flanked by Toco-Lopinot-Cuche deep-water shale/turbidite/olistostrome basins (Fig. 1);

2. Orogenic onset was neither diachronous (Paleocene to Miocene), nor Caribbean, but began in latest Cretaceous (Campanian) time, synchronously along the entire Venezuela-Trinidad margin. The cause was slow (amagmatic) Proto-Caribbean subduction, driving southward the former outermost-margin (former) rift block and its passive-margin cover as a "Slope Nappe" (Fig. 1). This nappe overrode and metamorphosed rift and passive margin deposits (e.g. Caracas and Caribbean Groups), which in turn moved south (Miocene in Trinidad) in a "Shelf Nappe", whose frontal thrust lies just south of the Guaico and Couva wells, subcropping under the Gulf of Paria-Caroni supraorogen basin (Upper Miocene-Quaternary), except in eastern Caroni where the (Fishing Pond) thrust propagated to surface in the Quaternary (see below). The nappes produced a S-migrating thrust belt and Proto-Caribbean Foreland Basin (Figs 1, 2), comprising a flysch trough with an olistostromal-turbiditic northern slope and a muddy southern slope and outer shelf, resulting in a succession of paired formations (Campanian-Miocene in Trinidad, see fig. 1 of companion abstract): Galera wildflysch-Guayaguayare shales; Chaudiere-lower Lizard Springs; Pierre-upper Lizard Springs; San Fernando (part)-Navet; northern Cipero-lower Cipero; Nariva and Retrench-middle Cipero; lower Cunapo-upper Cipero; Brasso-upper Cipero; Herrera, Karamat, Lengua and Lower Cruse-unnamed in Columbus Basin. The advancing flysch trough arrived in Columbus Basin in Late Miocene time, becoming "overfillled" with Orinoco sediments; the thrust belt thus embraced all of Trinidad, Gulf of Paria and the eastern offshore, behind the South Coast Thrust. Starting in the Late

Miocene, despite continued Proto-Caribbean convergence, the thrust belt collapsed by buried-halite dissolution, forming a supraorogen basin throughout Trinidad and the Gulf of Paria (Manzanilla-Cruse through Talparo-Erin Fms, fringed by upper Cunapo; see companion abstract); and

3. The Caribbean Arc passed Guajira in Oligocene time (not Paleocene), arriving in Trinidad in the Pliocene (not Miocene). A forearc nappe was obducted diachronously onto the rear of the Slope Nappe, which was foundering by halite dissolution, producing a diachronous dissolution basin (Carupano-North Coast; Mio-Quaternary in the W, Plio-Quaternary in the E) atop the Caribbean basement and its forearc-basin cover (?Paleocene-Miocene). Caribbean collision took over as driver of subsidence in Columbus Basin, which thus evolved from a Proto- to a Caribbean Foreland Basin. Thrust-belt dissolution subsidence ended upon halite exhaustion, whereupon tectonic shortening reasserted itself, causing folding, thrusting and uplift of the dissolution-basin fill in early Quaternary time (southern 2/3 of Trinidad; post-Talparo/Erin).

Around 1.5 Ma, Caribbean relative motion switched from SE to nearly E (085; GPS), due to the Panama Arc at the rear of the Caribbean Plate suturing against Colombia. In Trinidad the plate boundary jumped from the South Coast Thrust to the North Coast-El Pilar Fault Zone, whose 080 trend results in acute transpression, but uplift is outweighed by dissolution subsidence in the western N Range (companion abstract). South of the fault zone, the rest of Trinidad is isostatically rebounding, causing mud diapirism and dip-slip earthquakes (compressive-stress release). Rebound is outweighed by dissolution subsidence in the Gulf of Paria, and by compaction- and shale-withdrawal subsidence in the Columbus Basin.

These new concepts will affect exploration strategy, changing interpretations of subsidence and heat-flow (maturation) history, paleogeographic evolution, etc.. Many new plays will arise. For example, the Proto-Caribbean Foreland Basin model predicts dual sand fairways: northern turbiditic and southern shelf. Both fairways host large or giant oilfields in Trinidad and eastern Venezuela (e.g. Angostura, Brighton in the N; El Furrial in the S), serving as analogues for future exploration. The El Furrial play is predicted low in the S Trinidad thrust pile.

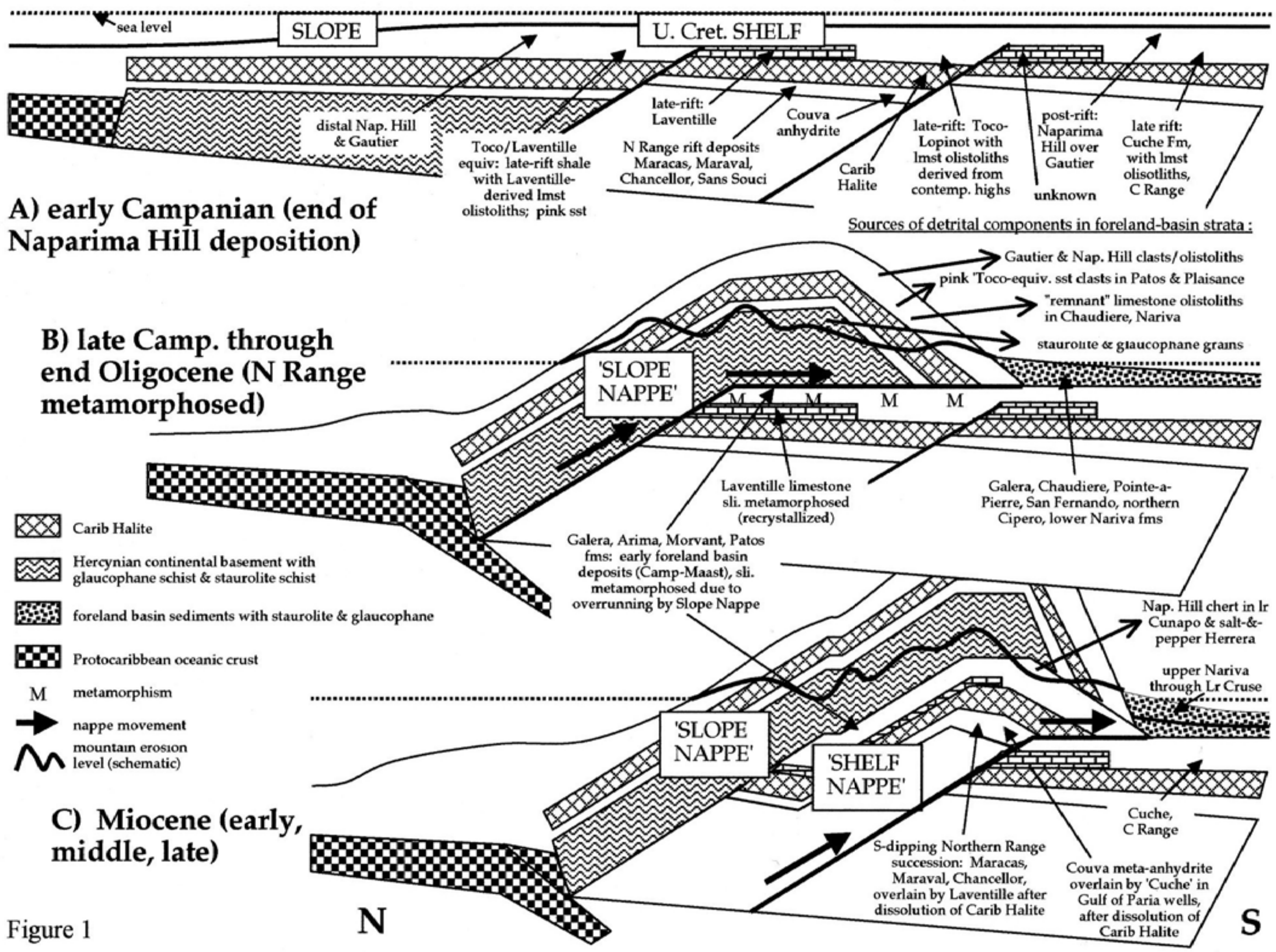
sea level
SLOPE
U. Cret. SHELF
distal Nap. Hill & Gautier
Toco/Laventille equiv: late-rift shale with Laventille-derived lmst olistoliths; pink sst
late-rift: Laventille
N Range rift deposits Maracas, Maraval, Chancellor, Sans Souci
Couva anhydrite
Carib Halite
late-rift: Toco-Lopinot with lmst olistoliths derived from contemp. highs
post-rift: Naparima Hill over Gautier
unknown
late rift: Cuche Fm, with lmst olisotliths, C Range
A) early Campanian (end of Naparima Hill deposition)
Sources of detrital components in foreland-basin strata:
Gautier & Nap. Hill clasts/olistoliths
pink 'Toco-equiv. sst clasts in Patos & Plaisance
"remnant" limestone olistoliths in Chaudiere, Nariva
staurolite & glaucophane grains
B) late Camp. through end Oligocene (N Range metamorphosed)
'SLOPE NAPPE'
M
M
M
M
Laventille limestone sli. metamorphosed (recrystallized)
Galera, Chaudiere, Pointe-a-Pierre, San Fernando, northern Cipero, lower Nariva fms
Galera, Arima, Morvant, Patos fms: early foreland basin deposits (Camp-Maast), sli. metamorphosed due to overrunning by Slope Nappe
Carib Halite
Hercynian continental basement with glaucophane schist & staurolite schist
foreland basin sediments with staurolite & glaucophane
Protocaribbean oceanic crust
M metamorphism
nappe movement
mountain erosion level (schematic)
Nap. Hill chert in lr Cunapo & salt-&-pepper Herrera
upper Nariva through Lr Cruse
'SLOPE NAPPE'
'SHELF NAPPE'
Cuche, C Range
C) Miocene (early, middle, late)
S-dipping Northern Range succession: Maracas, Maraval, Chancellor, overlain by Laventille after dissolution of Carib Halite
Couva meta-anhydrite overlain by 'Cuche' in Gulf of Paria wells, after dissolution of Carib Halite
N
S

Figure 1

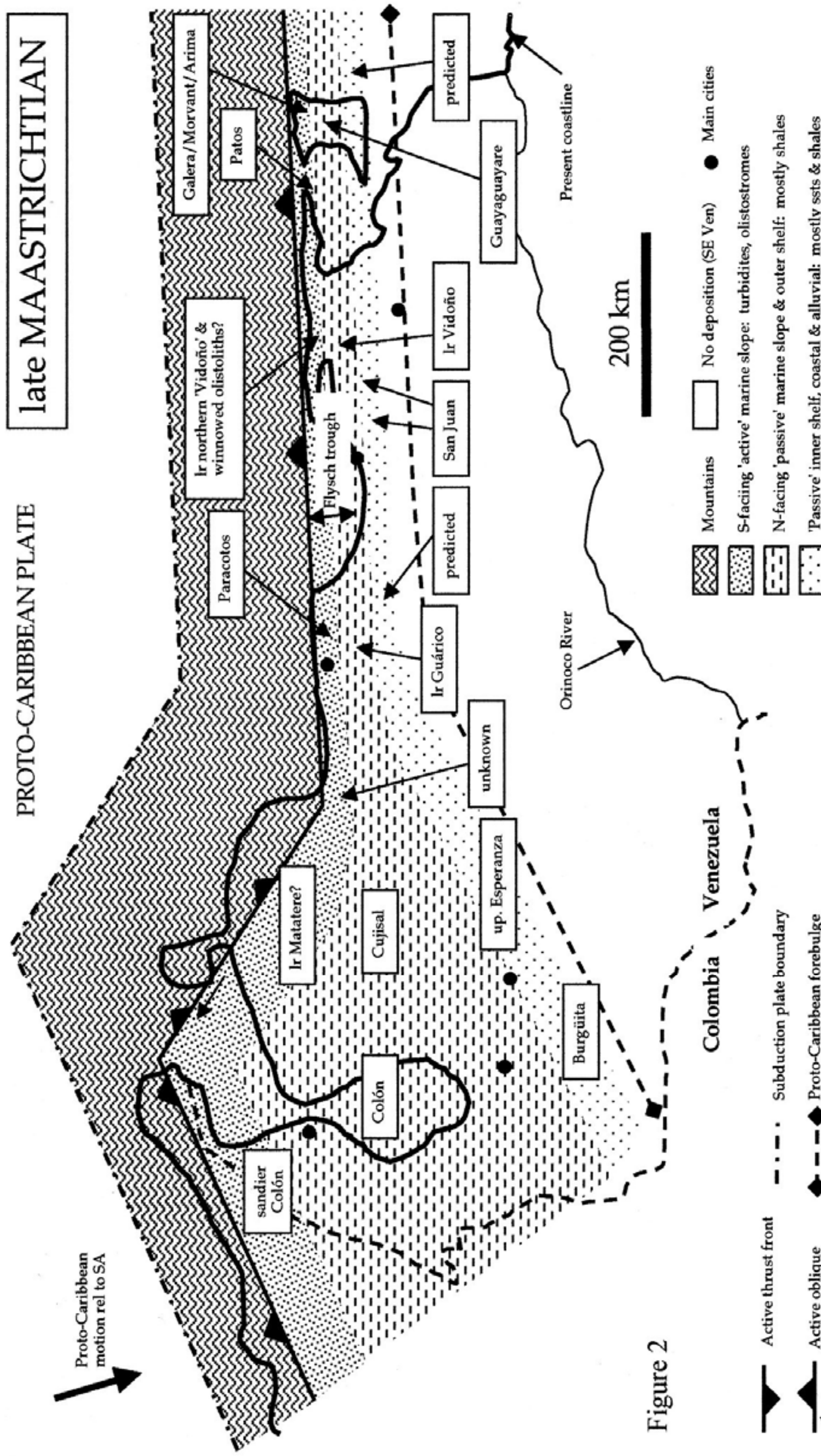
late MAASTRICHTIAN
PROTO-CARIBBEAN PLATE
Proto-Caribbean motion rel to SA
Galera/Morvant/Arima
Patos
lr northern 'Vidoño' & winnowed olistoliths?
Paracotos
Flysch trough
predicted
Guayaguayare
Ir Vidoño
San Juan
predicted
Ir Guárico
unknown
up. Esperanza
Cujisal
Ir Matatere?
Colón
sandier Colón
Burgüita
Colombia
Venezuela
Orinoco River
Present coastline
200 km
Mountains
No deposition (SE Ven)
Main cities
S-facing 'active' marine slope: turbidites, olistostromes
N-facing 'passive' marine slope & outer shelf: mostly shales
'Passive' inner shelf, coastal & alluvial: mostly ssts & shales
Active thrust front
Active oblique thrust front
Subduction plate boundary
Proto-Caribbean forebulge

Figure 2

**Figure 1.** Schematic N-S paleo-section across northern South America continental margin at longitude of western Trinidad, at three different times, showing development of Slope Nappe and Shelf Nappe. Equally applicable to W, C and E Venezuela, except Shelf Nappe was uplifted earlier (Paleocene) in W and C Venezuela, as shown by foreland-basin clast compositions (Higgs, in review). For simplicity, this figure assumes faults cut entire crust, and neglects (a) halokinesis, (b) cannibalisation and nappe-overriding of early foreland-basin deposits, and (c) advance of thrust belt beyond nappe front.

**Figure 2.** Late Maastrichtian tectonogeographic map of Venezuela and Trinidad, showing the proposed Proto-Caribbean Foreland Basin, comprising a northern flysch trough flanked, in the south, by a N-facing slope and shelf. Formation names shown in boxes. "Unknown" signifies that strata of this age, if deposited, are undiscovered or eroded or buried under younger deposits. "Predicted" means non-exposed, either buried in thrust sheets, or deeply buried under (or immediately ahead of) the present-day frontal thrust. Northern "Vidoño" is locally olistolithic (Higgs, in review).