A SIMPLE SYNTHESIS OF CARIBBEAN GEOLOGY

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This model reconstructs the Pangean palaeogeography (Fig. 1) of the area between North and South America by:

1 Removal of oceanic and island arc material (Fig. 2).
2 Removal of sinistral offset between continental areas of North and South America and between the Maya and Chortis Blocks.
3 Removal of continental/transitional crust extension (Gulf of Mexico margins, Florida-Bahamas platform, Nicaragua Rise).
4 Restoration of northwestern South America (Bolivar Block) to the southwest.

The area evolved from this configuration as follows (Figs. 3A and B summarize drift history/relative motions of N and S America): ?Triassic-Jurassic migration of North America to the west (1000 Km) and north (850 km), relative to Pangea, resulted in intracontinental rifting (Fig. 4), extension of marginal continental crust, sinistral offset of remnant continental blocks (Maya, Chortis) and development of oceanic crust (Gulf of Mexico, the Yucatán Basin, the Cayman Trough and Caribbean) (Fig. 5). In the Early Cretaceous parts of the Yucatán, Venezuelan and Colombian basins thickened into oceanic plateaus (Fig. 6). Decompression melting triggered by extension over triple junctions heralding spreading jumps was a likely cause. Spreading abandoned the area between North and South America in the Aptian (Fig. 7) and moved to the Atlantic and Pacific. Convergence between these areas and the Caribbean resulted in a newly isolated plate, bounded by island-arcs. South America left Africa and commenced westward movement, gradually catching up, longitudinally, with North America. Through the Cretaceous the Mid Atlantic Ridge lengthened, N-S, by some 650 Km and stepped westward by some 1,000 km in the latitudes of 7-15° N (the Vema Wedge, Fig. 8). Associated NW-SE sinistral shear In the Caribbean, to the west, caused NE-SW oriented intraplate extension and plate thickening (further decompression melting?) in the western Venezuelan Basin/Beata Ridge/Haitian Basin area (the Aves Ridge may have formed at the same time). In Latest Cretaceous ? Middle Eocene time island arc activity ceased along the northern and southern Caribbean Plate boundaries (Fig. 9) where outward-migrating thrust belts involving continental margin and oceanic/island arc material developed. . Associated flysch/wildflysch basins accommodated detritus from the rising nappes in the Palaeocene-Middle Eocene (Fig. 10). Since the Oligocene, the Caribbean plate has moved eastward relative to South America. Northwestern South America (Bolivar Block, Fig. 2) moved northwards at the same time, driven by sea-floor spreading in the Pacific. Its northernmost part (the Bonaire Block) delaminated and transgressed the Caribbean-South America dextral plate boundary, suffering major internal pull-apart strain (Figs. 11, 12). Extension of the

Aruba-Blanquilla island chain (formerly obducted island-arc) indicates up to 300 Km of eastward movement of the Caribbean relative to S America. Diachronous migration of thrust fronts and molasse basins occurred along northern Venezuela/Trinidad.

Important features of this model are:
- It's simplicity contrasts sharply with the unlikely complexity and geometric improbability of models that derive the Caribbean Plate from a Pacific location.
- No major block rotations are involved.
- Oceanic crust of Middle America (Gulf of Mexico, Yucatán Basin, most of the Cayman Trough and the Caribbean, including the Grenada Basin) formed in the Jurassic. Only the central Cayman Trough, Miocene-Recent, is young oceanic crust.
- Sinistral strike-slip displacement between the Caribbean area and North America (ca. 1000 km) developed mainly in the Jurassic.
- Cretaceous plateau thickening probably occurred as a result of decompression melting prompted by severe extension. No mantle plume/hotspot was involved.
- Oligocene ? Recent dextral strike-slip between the Caribbean and S America amounts to no more than 300 Km.

Figures

1 Pangean reconstruction of North and South America and intervening continental fragments. Reconstruction involves removal of Mesozoic-Cenozoic island arcs, closure of oceanic areas in the Atlantic, the Gulf of Mexico, the Yucatán Basin, the Cayman Trough and the Caribbean, removal of sinistral offset of N ? S America and continental fragments of the Maya and Chortis blocks (no rotations), and restoration of extended continental crust in the Bahamas, around the Florida Peninsula and the Gulf of Mexico, and possibly the Lower Nicaragua Rise. The Bolivar and Bonaire blocks of NW S America are restored SW along the Boconó Fault.

2 Middle America, crustal types.

3 (A, B) Drift reconstructions as N America and S America move west from the Pangean reconstruction of Figure 3. Vertical lines show N ? S offset between the continents that occurred in the Jurassic, while S America remained attached to Africa, and again in the Cretaceous, when the Vema Wedge (Fig. 8) developed and when S America moved westward, catching up, longitudinally, with N America. Dashed vertical line (Middle Eocene) indicates N-S separation of Late Cretaceous time for comparison with Middle Eocene separation: Late Cretaceous- Middle Eocene convergence has occurred.

4 Triassic ? early Jurassic reconstruction. Rifting in Middle America trends NE, sinistral offset begins along WNW faults. Note the orientation of rifts and the Catoche Tongue of the Maya Block remains unchanged (no rotation occurred) today.

5 Callovian ? Berriasian reconstruction. Ocean crust forms in the Gulf of Mexico, Yucatán Basin, Cayman Trough and the area of the future Caribbean Plate. Extended

continental crust forms along the northern coast of S America, and in the Gulf Coast, Florida-Bahamas and eastern seaboard of N America.

6 Aptian reconstruction 1. Spreading has ceased in the Gulf of Mexico. Triple junction spreading in the Yucatán and "Caribbean" areas heralds abandonment of those areas. Related extension allows basalt extrusion (decompression melting) and thickening of extended original ocean crust.

7 Aptian reconstruction 2. Spreading has jumped to the Equatorial Atlantic and Pacific. The Caribbean area is isolated between spreading westwards from the Atlantic and eastwards from the Pacific. Resultant convergence causes subduction and island-arc volcanism. The Caribbean Plate is born.

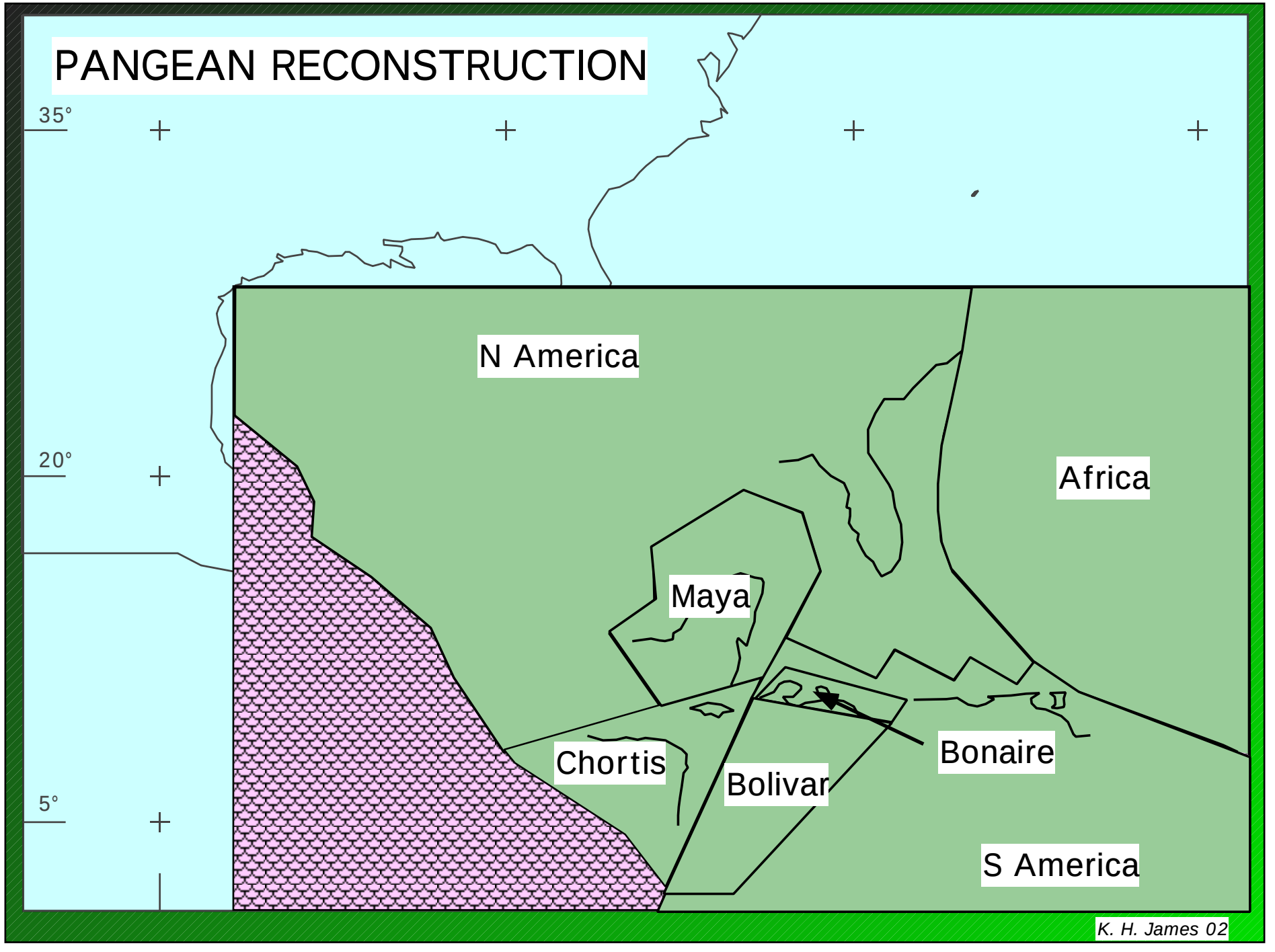
8 Detail of the Vema Wedge and typical transform faults of the Central and Equatorial Atlantic. The former shows that approximately 650 km of N ? S extension occurred between the North and South American plates. The latter show that North America moved NW away from Pangea in the Jurassic ? Early Cretaceous. Divergence between transforms in the Equatorial Atlantic, offshore from the Amazon Basins, shows that northern South America has moved differentially with respect to southern South America (see text for significance to drift reconstructions). Dashed lines 1 and 2 indicate the mid-Atlantic Ridge to continental edge distances of South and North America. The greater length of 2 relates to Jurassic crust in the Central Atlantic that is absent from the South Atlantic, together with a broader lower Cretaceous crust. This distance (2 minus 1) corresponds to offset along the Cayman Trough area (3).

9 Middle Eocene reconstruction. Latest Cretaceous ? Middle Ecoene convergence between the Caribbean Plate and N and S America results in cessation of island-arc volcanicity along the northern and southern Plate boundaries and violent uplift of marginal areas with flysch and wildflysch accumulating in foreland basins (Fig. 10). The future Aruba ? Blanquilla island chain is emplaced onto northern S America along with the Villa de Cura nappe (see Fig. 12). Quartz sands of the Scotland Group (Barbados), derived from S America, are abruptly deposited as far as the Tiburón Rise, on the Atlantic Plate, more than 300 km offshore northern S America (shunting of the sands from a site north of Maracaibo [allochthonous Caribbean models] did not occur).

10 Regional distribution of Palaeocene- Middle Eocene flysch/wildflysch deposits referred to in Fig. 9. They record regional, coeval interaction of the Caribbean Plate with neighbouring elements and contradict models of diachronous entry of the Plate between the Americas.

11 Detail of the Middle Eocene distribution of flysch/wildflysch deposits and the Aruba ? Blanquilla ? Villa de Cura ? Margarita ? Lesser Antilles island-arc complex along northern S America. The Chaudiere/Pointe-a-Pierre/ Lizard Springs flysch/wildflysch and the oceanic Sans Souci basalts of Trinidad, and the island-arc rocks of Tobago indicate that the arc migrated westwards to the location indicated in this figure.

12 NE translation of the Bolivar ? Bonaire blocks (Fig. 2), driven by convergence with the Pacific Nazca Plate, has occurred. The Bonaire Block transgressed the dextral Caribbean ? S America plate boundary and suffered pull-apart extension since the Oligocene. The extension indicates that no more than 300 km of dextral plate relative movement occurred between the Caribbean and S America. Oligocene ? Miocene ? Pliocene migration of the associated deformation front/molasse basin is indicated.


PANGEAN RECONSTRUCTION
35°
20°
5°
N America
Africa
Maya
Chortis
Bolivar
Bonaire
S America
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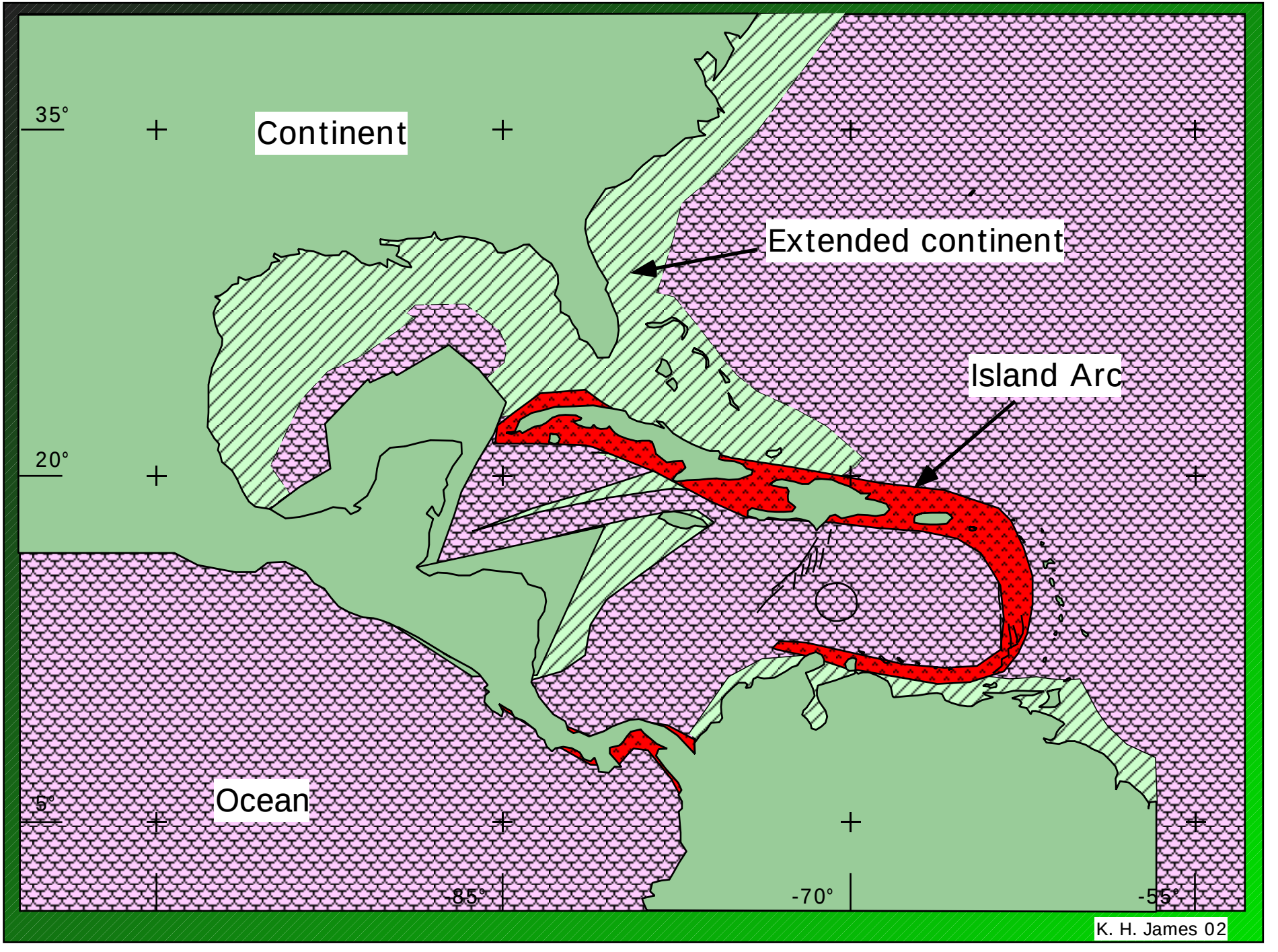
Continent
Extended continent
Island Arc
Ocean
35°
20°
5°
85°
-70°
-55°
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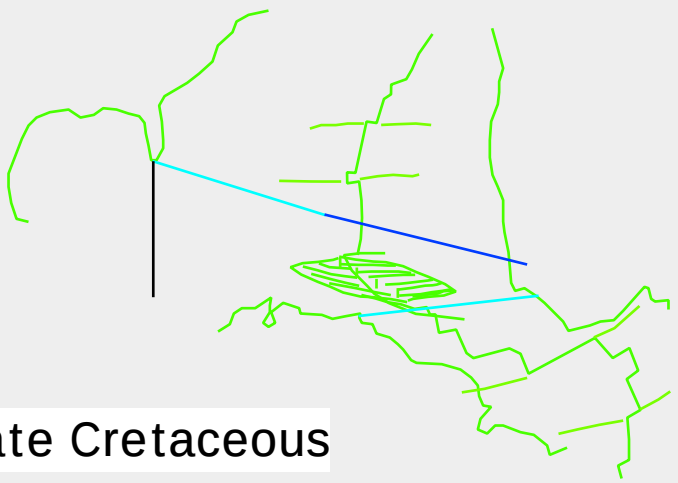
DRIFT HISTORY, A

Late Jurassic

M. J. - L. J. (~170 - 150 Ma)



Late Cretaceous

L. J. - L. K. (150 - 83Ma)

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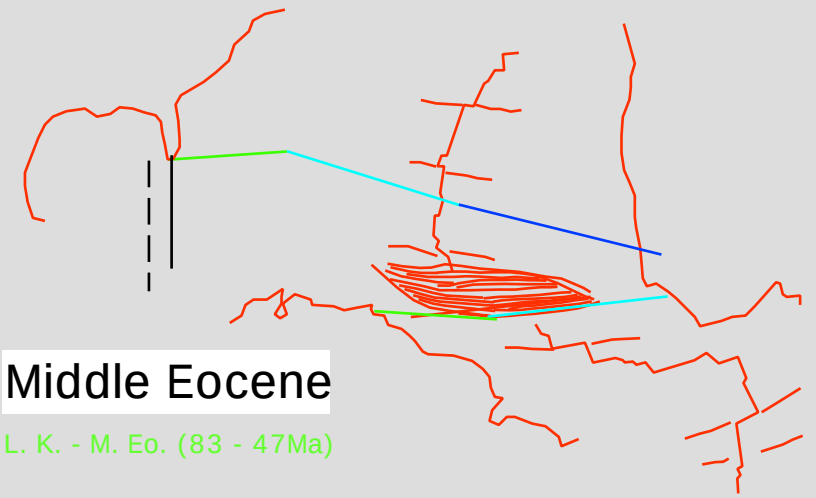
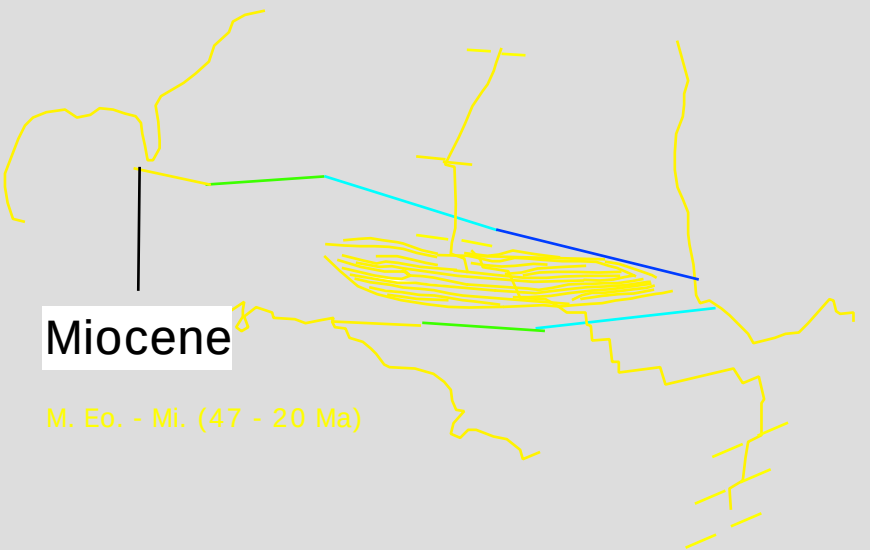
DRIFT HISTORY, B



Middle Eocene

L. K. - M. Eo. (83 - 47Ma)



Miocene

M. Eo. - Mi. (47 - 20 Ma)

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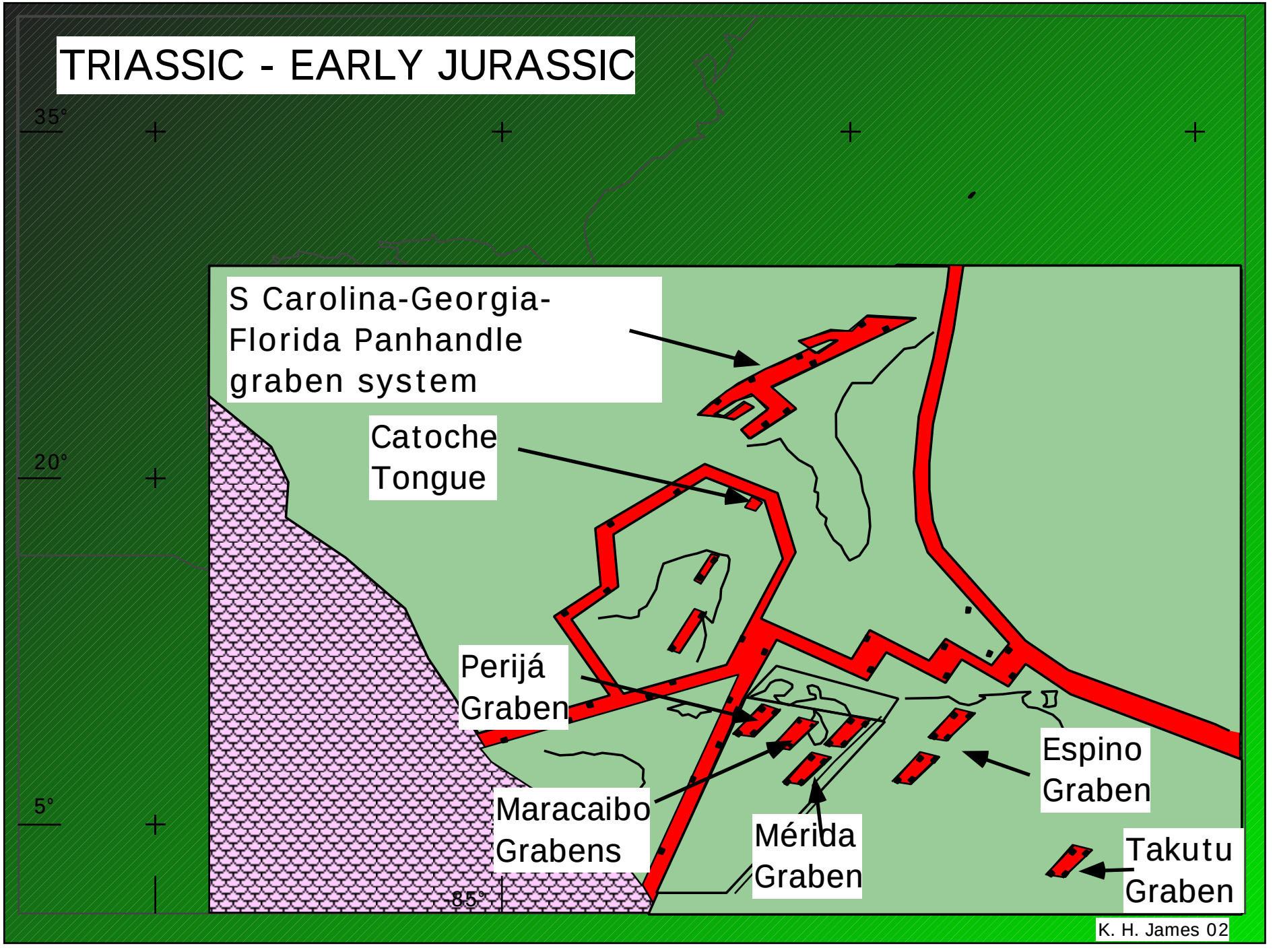
TRIASSIC - EARLY JURASSIC
35°
20°
5°
85°
S Carolina-Georgia-
Florida Panhandle
graben system
Catoche
Tongue
Perijá
Graben
Maracaibo
Grabens
Mérida
Graben
Espino
Graben
Takutu
Graben
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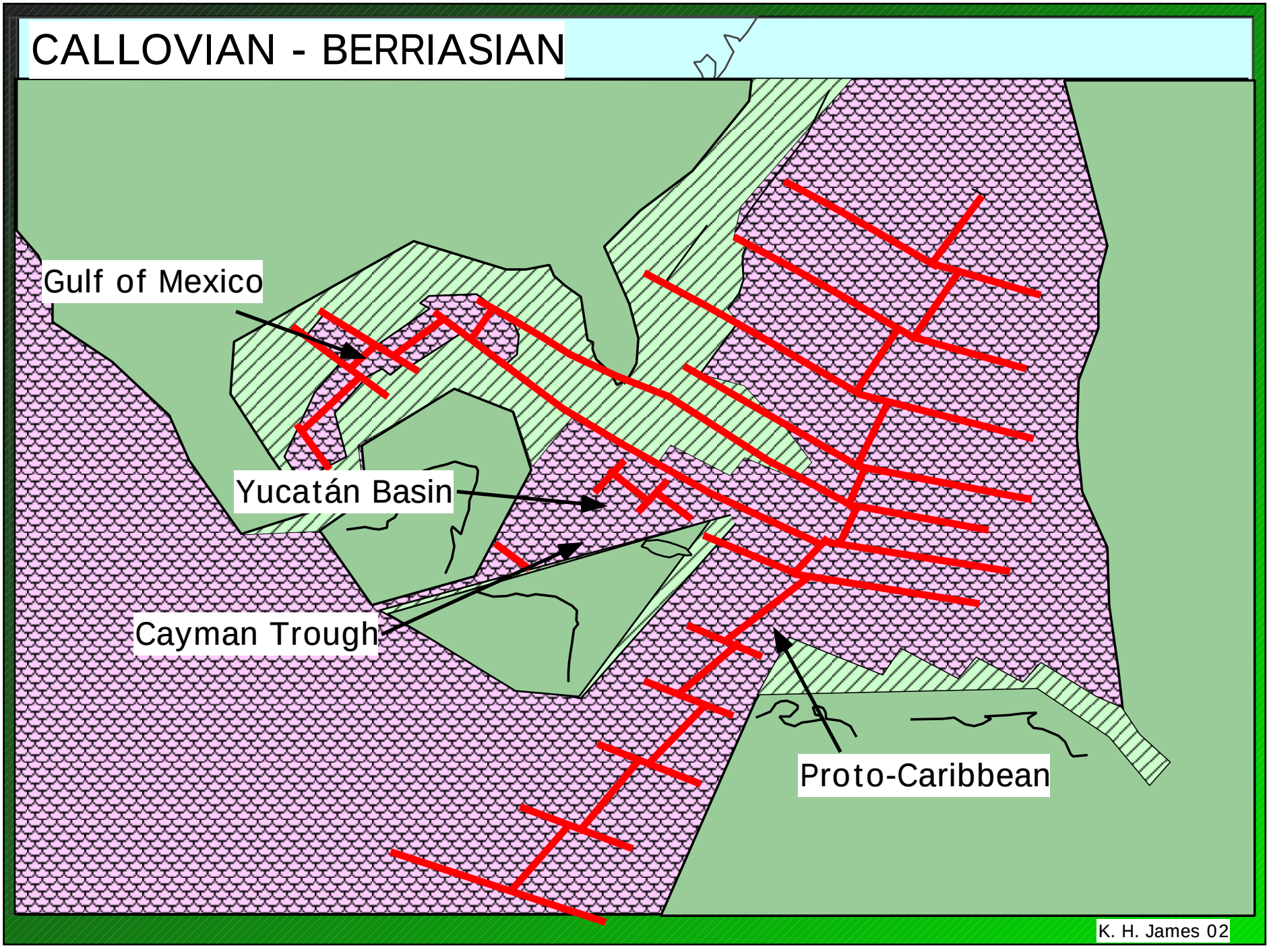
CALLOVIAN - BERRIASIAN
Gulf of Mexico
Yucatán Basin
Cayman Trough
Proto-Caribbean
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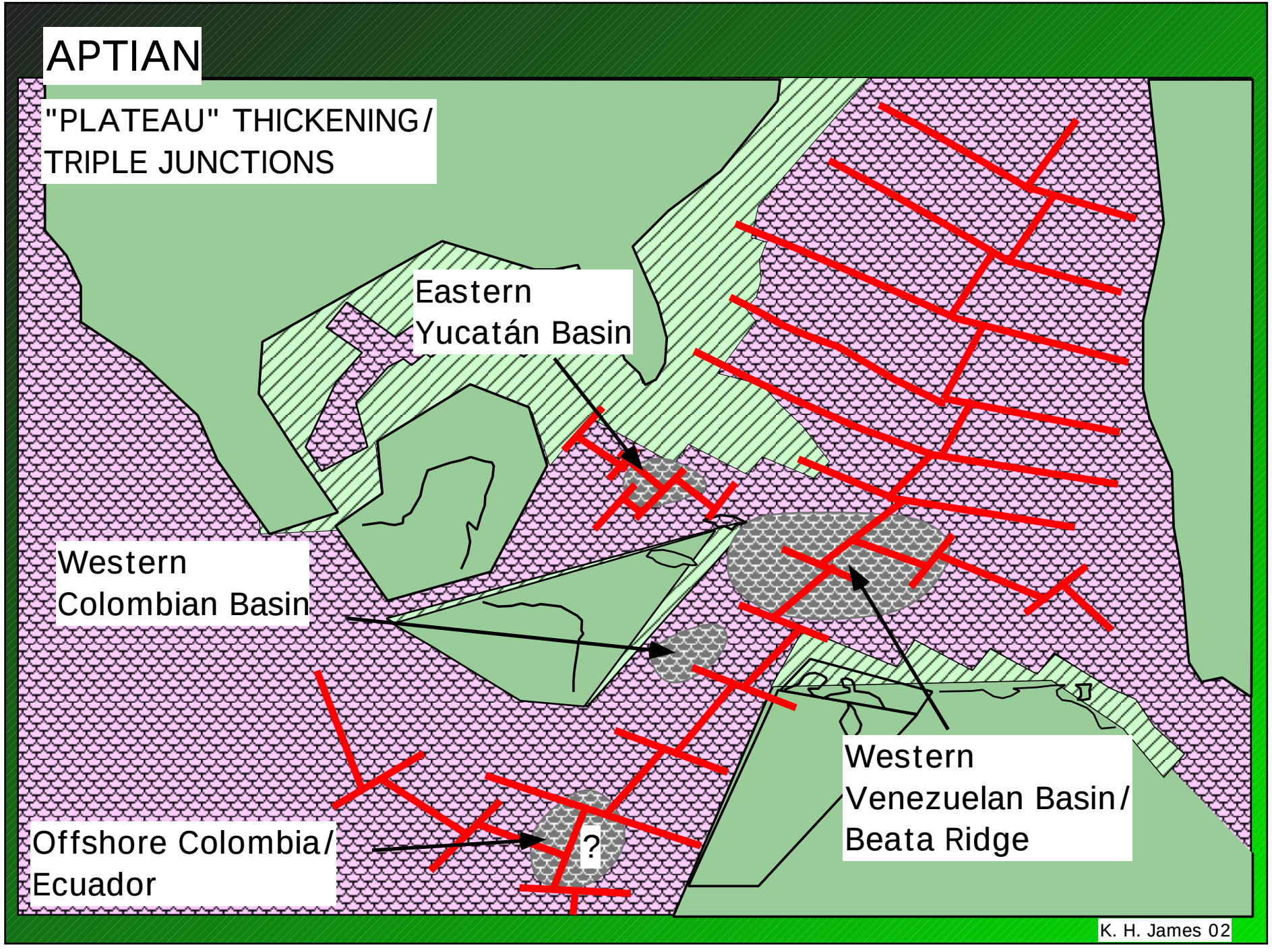
APTIAN
"PLATEAU" THICKENING/
TRIPLE JUNCTIONS
Eastern
Yucatán Basin
Western
Colombian Basin
Western
Venezuelan Basin/
Beata Ridge
Offshore Colombia/
Ecuador
?
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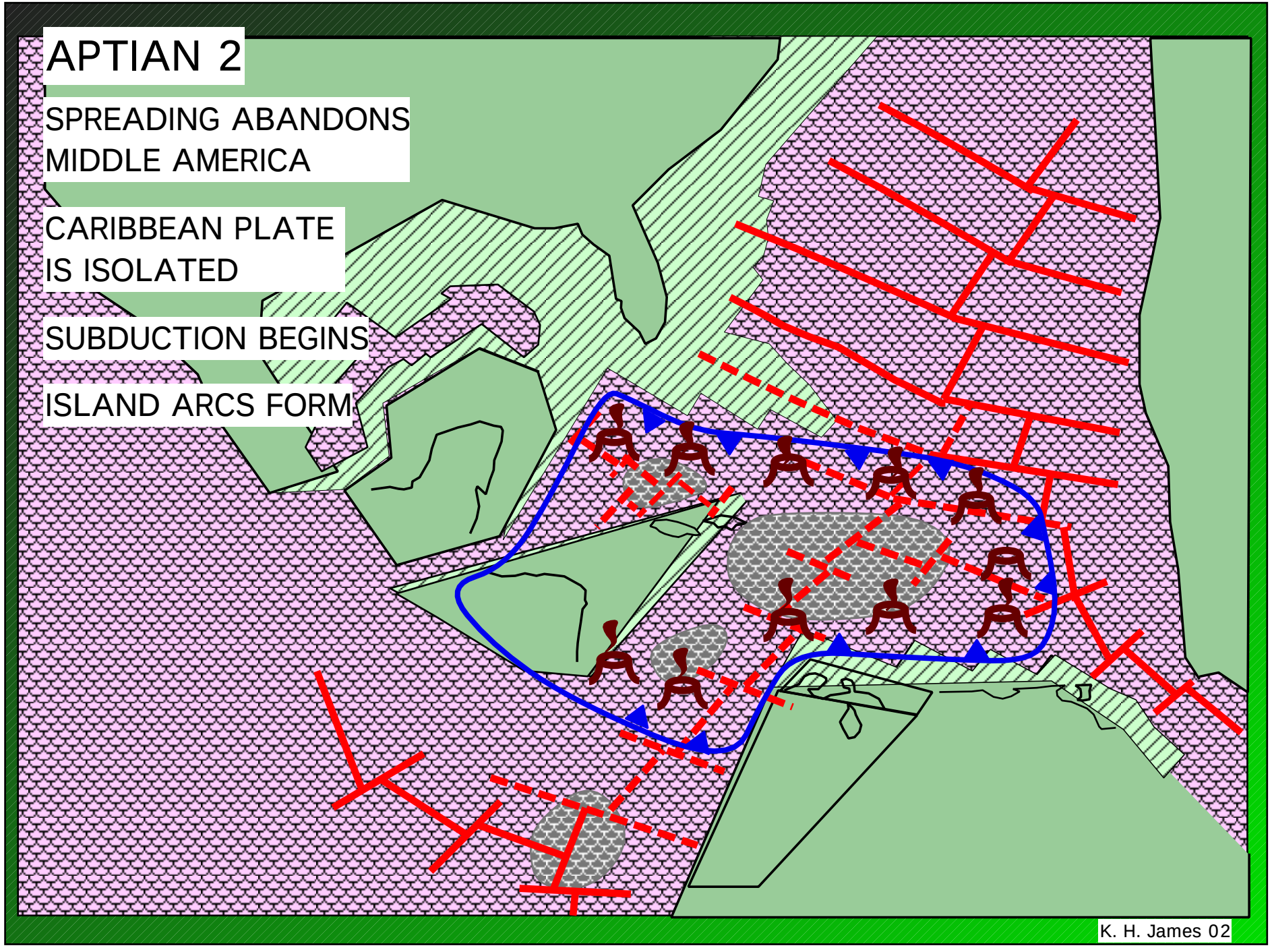
APTIAN 2
SPREADING ABANDONS MIDDLE AMERICA
CARIBBEAN PLATE IS ISOLATED
SUBDUCTION BEGINS
ISLAND ARCS FORM
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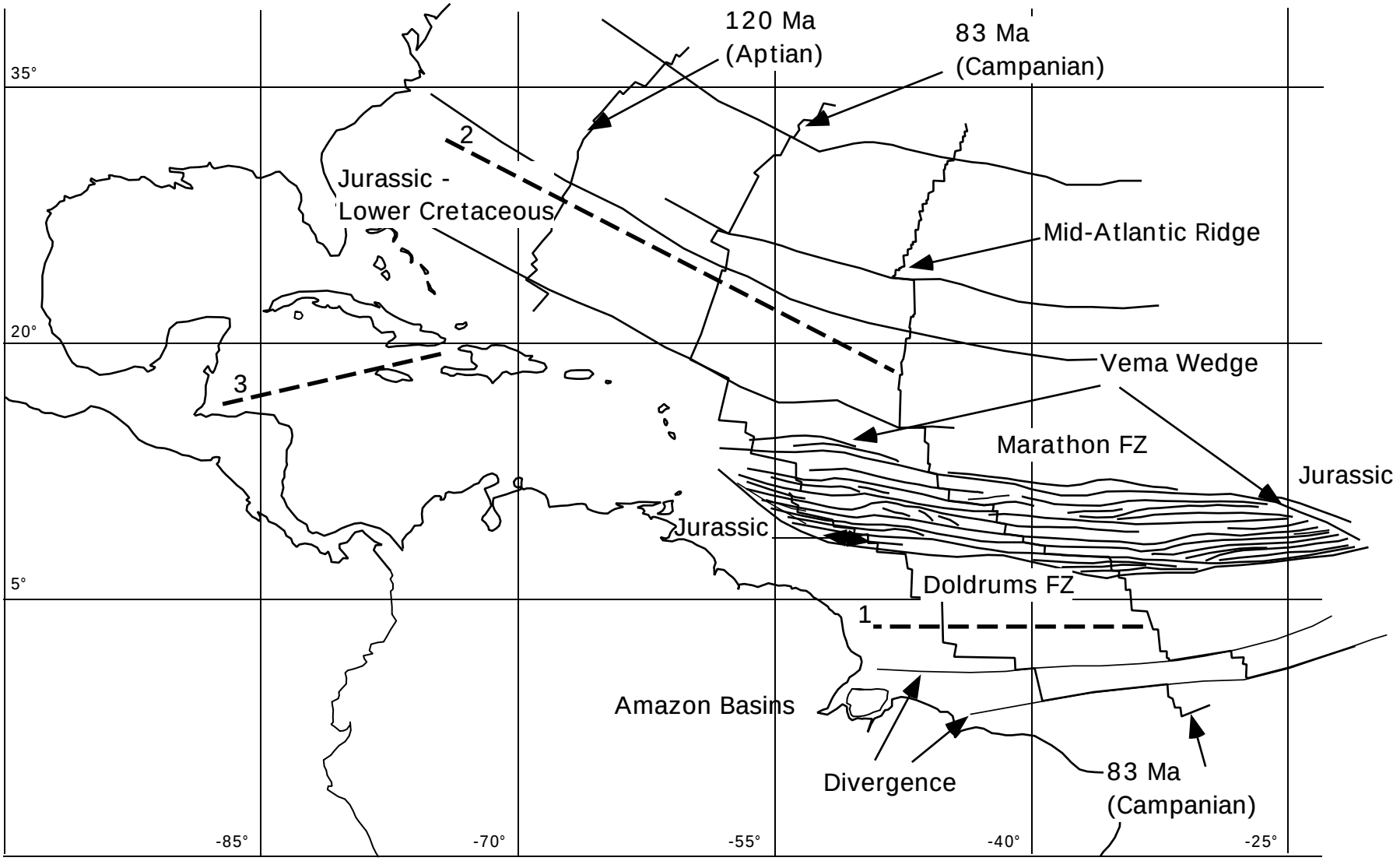
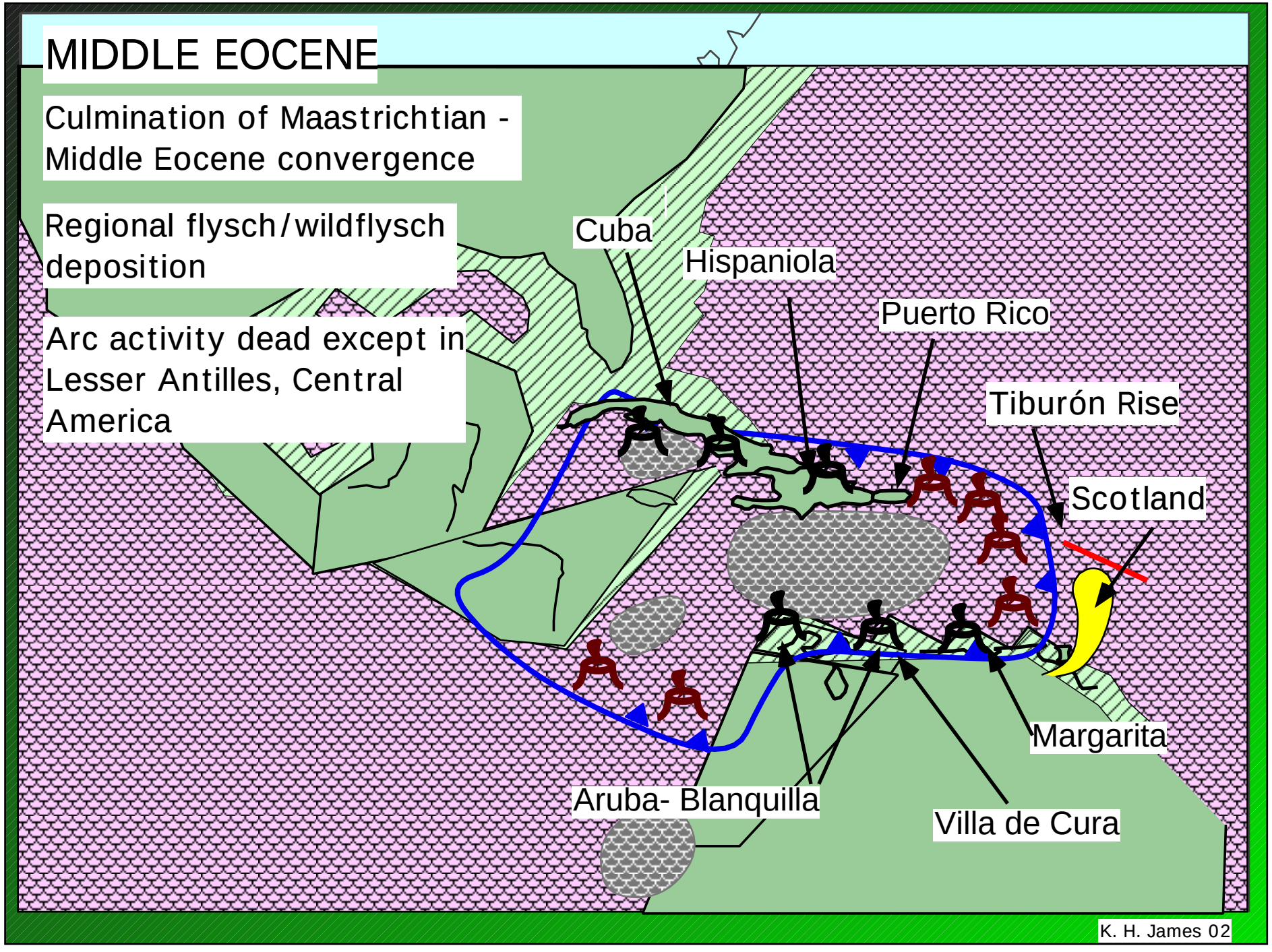

120 Ma
(Aptian)
83 Ma
(Campanian)
35°
2
Jurassic -
Lower Cretaceous
Mid-Atlantic Ridge
20°
Vema Wedge
3
Marathon FZ
Jurassic
Jurassic
5°
Doldrums FZ
1
Amazon Basins
Divergence
83 Ma
(Campanian)
-85°
-70°
-55°
-40°
-25°


MIDDLE EOCENE
Culmination of Maastrichtian - Middle Eocene convergence
Regional flysch/wildflysch deposition
Arc activity dead except in Lesser Antilles, Central America
Cuba
Hispaniola
Puerto Rico
Tiburón Rise
Scotland
Margarita
Aruba- Blanquilla
Villa de Cura
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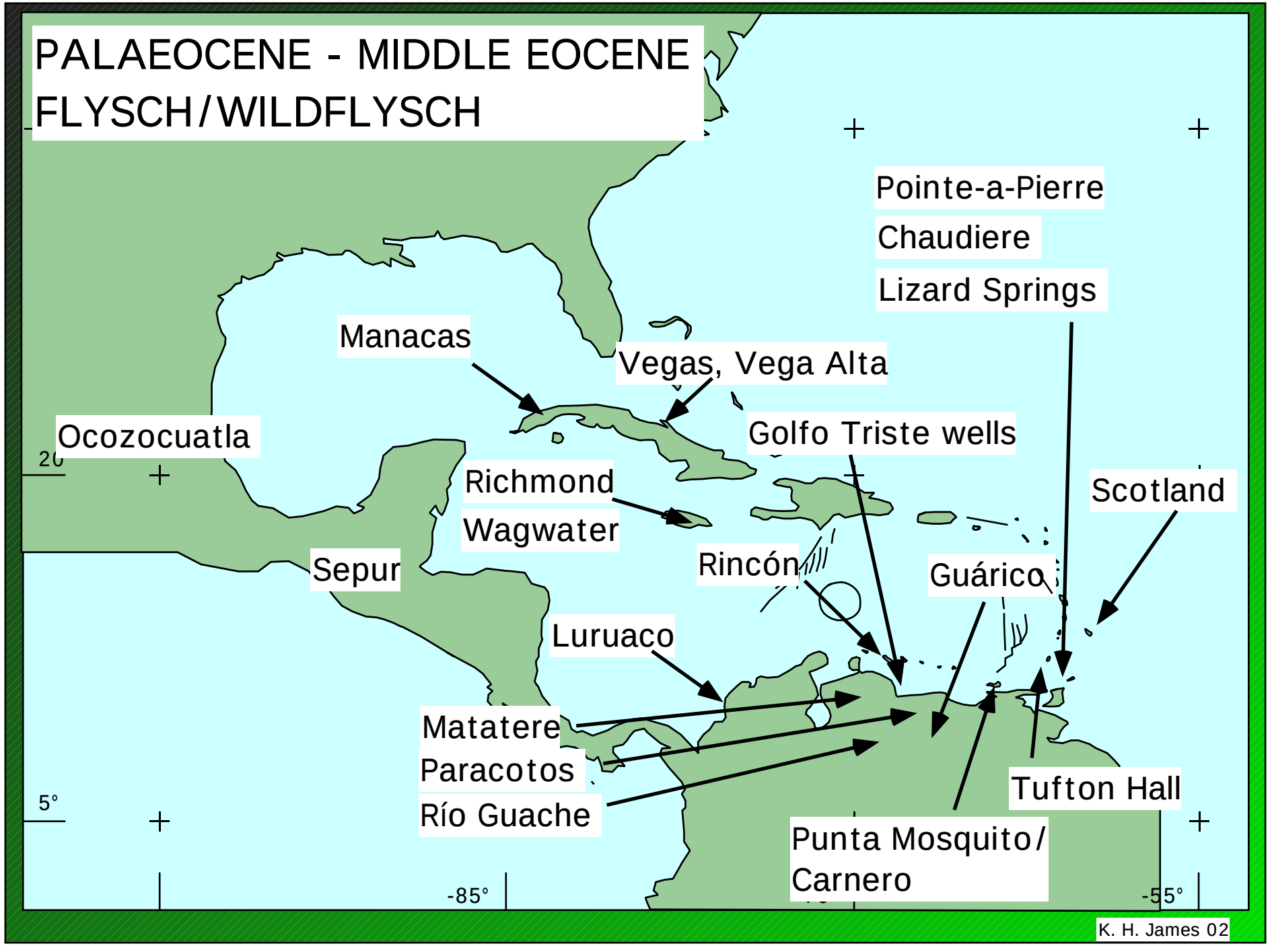
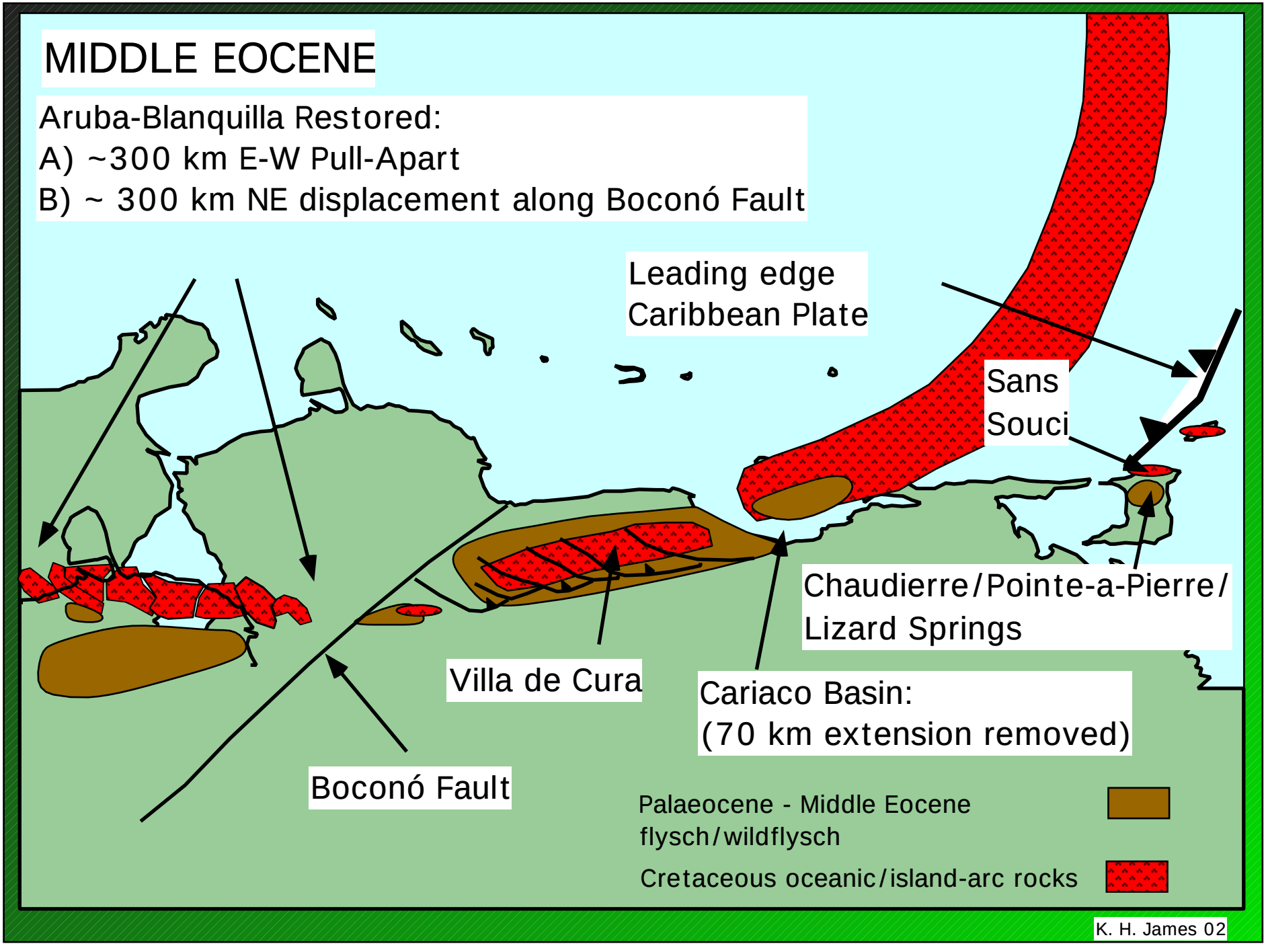
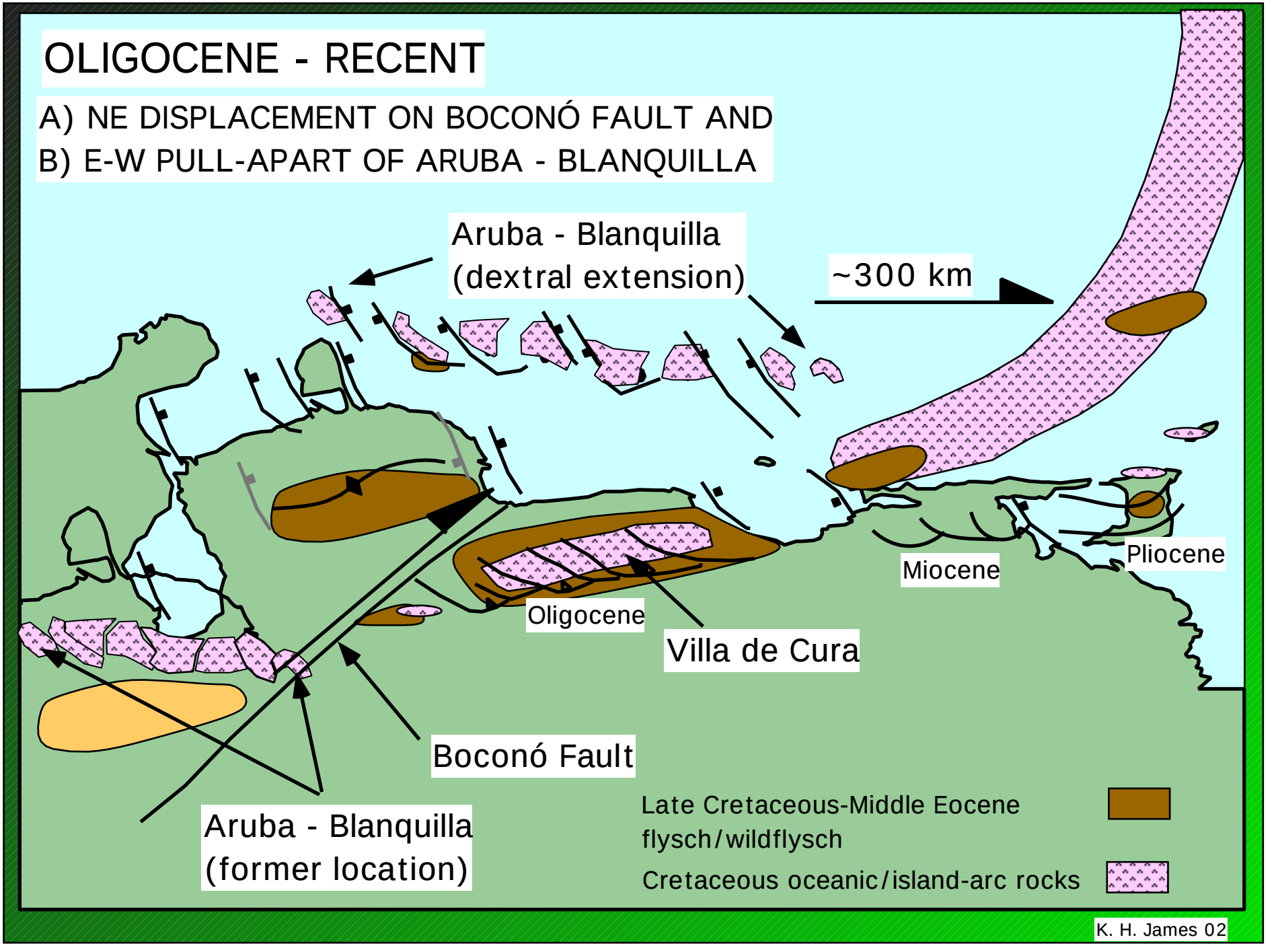

PALAEOCENE - MIDDLE EOCENE
FLYSCH/WILDFLYSCH
Pointe-a-Pierre
Chaudiere
Lizard Springs
Manacas
Vegas, Vega Alta
Ocozocuatla
Golfo Triste wells
20
Richmond
Wagwater
Scotland
Rincón
Guárico
Sepur
Luruaco
Matatere
Paracotos
Río Guache
Tufton Hall
Punta Mosquito/
Carnero
5°
-85°
-55°
K. H. James 02

MIDDLE EOCENE

Aruba-Blanquilla Restored:
A) ~300 km E-W Pull-Apart
B) ~ 300 km NE displacement along Boconó Fault




OLIGOCENE - RECENT
A) NE DISPLACEMENT ON BOCONÓ FAULT AND
B) E-W PULL-APART OF ARUBA - BLANQUILLA
Aruba - Blanquilla
(dextral extension)
~300 km
Pliocene
Miocene
Oligocene
Villa de Cura
Boconó Fault
Aruba - Blanquilla
(former location)
Late Cretaceous-Middle Eocene
flysch/wildflysch
Cretaceous oceanic/island-arc rocks
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