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Caribbean Plate Origin: Discussion of Arguments Claiming to Support a Pacific Origin; Arguments for an In-Situ Origin

A) Discussion Of Arguments Proposed To Support A Pacific Origin:

A1-The Aves Ridge and the Lesser Antilles together present an upper Cretaceous - Recent (ca. 90 Ma) record of subduction of the Atlantic Plate beneath the eastern Caribbean. Minimum relative plate migration has been ca. 1000 km. There is no proof that the Aves Ridge is subduction-related. Bounded by normal faults, it may have the same origins as the Beata Ridge: extensionally faulted, thickened oceanic crust. The Grenada Basin to the east has the same velocity structure as the Venezuelan Basin to the west. Lesser Antilles subduction might be driven by Caribbean extension as well as by Atlantic spreading. Subduction does not necessarily reflect migration of the Caribbean Plate. It

A2-Cayman Trough oceanic crust and reassembly of Cuba, Hispaniola, Puerto Rico and the Aves Ridge indicate at least 1000 km of sinistral movement between the Caribbean and North and South America and the Atlantic Plate. "Cayman Trough" offset relates only to the Caribbean - North America boundary; it has no implications for Caribbean - South America offset or Caribbean Plate migration. Jurassic crust of the Central Atlantic, absent further south, and wider lower Cretaceous crust show that the offset developed mostly when North America drifted from Pangea (and S. America) in the Jurassic-Early Cretaceous. Extension along the Greater Antilles (Cuba, etc.) mirrors extension along northern South America and relates to only ~300 km of Oligocene-Recent, eastward movement of the Caribbean relative to the Americas.

A3-Seismicity and seismic tomography show a distinct west-dipping Atlantic Benioff zone extending at least 1200 km beneath the eastern Caribbean. Seismicity indicates penetration of American lithosphere to 200 km below the Lesser Antilles. Preliminary interpretation of tomographically imaged velocity anomalies to a depth of 600 km was presented as a tentative working hypothesis only.

A4-Caribbean Cretaceous stratigraphy is divisible into a Proto-Caribbean suite (pre-Mesozoic basement, Jurassic rift sediments, Cretaceous shelf sediments and foredeep clastics, no volcanics) and a volcanic Caribbean suite, juxtaposed across circum-Caribbean ophiolite belts. They must have formed in separate locations. Oceanic and continental margin rocks invariably form in different locations. Pacific origin of the volcanic suite is neither required nor implied.

A5-As the Caribbean Plate moved into place diachronous flysch basins formed (Guatemala, Campanian; northern Cuba, Latest Cretaceous-Eocene; Maracaibo area, Eocene; Eastern Venezuela, Miocene). Flysch and wildflysch formed regionally around the Caribbean during a coeval, Palaeogene event (see below). They show that the Caribbean Plate was in-place when it interacted with adjacent continental areas. Eastward-younging basins (Falc¢n and Gurico, Oligocene; Matur¡n, Miocene; Gulf of Paria-Caroni, late Miocene; Columbus, Plio-Pleistocene) formed during a separate and younger event: Oligocene-Recent eastward, strike-slip movement of the Caribbean relative to North and South America.

A6-The pre-Albian space between N. and S. America was too small to have housed a Jurassic Caribbean Plate. This argument is based on plate movements (poles of rotation of North and South America) derived from transform faults in the Central and South Altantic and on the current size of the Caribbean Plate. Faults in the Central and Equatorial

Atlantic show that the Caribbean area widened continuously (N-S) from Jurassic into Cenozoic time (see James, A Simple Model for the Caribbean, this conference). Lower Caribbean, Jurassic crust is extended and thinned; its original dimensions are unknown. It is covered by thick, Cretaceous upper crust basalts that probably resulted from extension-related decompression melting.

A7-Related to A6, above: Sea-floor spreading between North and South America had ceased by the Aptian. This argument relies upon the similarity of Atlantic sea-floor fabric west of Anomaly 34 (Cenomanian) to the fabric to the east, implying that it spreading had jumped from the Caribbean to the Equatorial Atlantic by the Albian. While the observation supports a pre-Cenomanian age for the sea floor west of Anomaly 34, it does not require that spreading had ceased in the Caribbean. Extension and basalt extrusion occurred in the Caribbean in the Turonian and extension continued into Cenozoic times (see James, A Simple Model for the Caribbean, this conference).

A8-Truncated structural trends and a truncated Pal'ogene arc of SW Mexico continue, across sinistral offset, in the Chortis Block of Central America. The latter rotated into a position south of, and sutured to the Maya Block along with the Caribbean Plate in the Cenozoic. It is impossible for Chortis to have rotated southeastward into its Central American location at the same time as the Caribbean Plate is supposed to have been moving NE between the Americas. NE trending Jurassic depocentres on the Chortis and Maya continental blocks parallel Jurassic rifts in North and South America: neither Maya nor Chortis has rotated. They formed through continental fragmentation and sinistral offset as North America moved NW from Pangea., Maya moved west relative to Chortis and both moved west with respect to South America.

A9-The Caribbean interacted with northwestern South America and southern Yucatan in the Campanian, when shelfal provinces in the Mexican-Caribbean region merged. This supports a Pacific location of the Caribbean. A regional Campanian unconformity in the Caribbean documents a plate-wide event; not just uplift of a land-bridge related to entry of the Great Arc into the western Caribbean space. It was Chortis, not the Caribbean leading edge arc, that interacted with Yucatan (Maya). Collision occurred in the Palaeogene and generated wildflysch (see B8, below) that includes ophiolites and serpentinites along with Cretaceous carbonates and Palaeozoic and Mesozoic conglomerate clasts derived from Chortis.

A10-Cold water Late Jurassic radiolaria associated with oceanic rocks on La D,sirade, Puerto Rico and Hispaniola must have come from the Pacific. The oldest, Pleinsbachian, predate inter-American spreading. Inception of inter-American spreading is nowhere directly calibrated; the statement that it is predated by Pleinsbachian radiolaria is not justified. These samples, from the north-northeast of the Caribbean, more logically were uplifted from adjacent Central Atlantic Jurassic Atlantic oceanic crust. Atlantic Pangean separation occurred in the Pliensbachian-Toarcian.

A11-The Pacific model predicts that the Greater Antilles formed earlier than the Central American arc; something not predicted by in-situ models. There is reported evidence that the Central American arc formed at the same time as the Greater Antilles. The in-situ model would suggest that Caribbean arc activity developed regionally when the plate became isolated sometime in the Aptian/Albian. The Pacific model would not .

B) Arguments Supporting An In-situ Origin:

It is physically impossible for the Caribbean Plate and its leading edge Great Arc to have entered the inter-American location from the Pacific.

B1-The total length of the Cretaceous Caribbean volcanic arc (Greater Antilles, Lesser Antilles, Netherlands-Venezuelan Antilles) is around 4,000 km in length (~300 km of Oligocene-Recent, pull-apart extension removed). Pacific models show the Caribbean Great Arc to have been a nearly straight, NNW trending feature in the Middle Cretaceous. Northern and southern Caribbean Plate boundaries are not shown; if they existed, they must have been 4000 km apart (c. f. the current N-S plate width of around 1000 km). The Arc is shown to have changed into an eastward convex curve as it entered between the Americas. In its current configuration the Greater and Netherlands-Venezuelan Antilles are parallel and east-west trending and only 700 km apart. Such severe bending of the arc front would have produced enormous compression (more than 80% shortening) in the Caribbean Plate behind it. In fact the Plate is highly extended (see B5, below).

B2-Chortis could not have rotated NW to SE into its current position at the same time as the Caribbean Plate was moving NE between North and South America, as Pacific models portray. The continental Chortis Block and its probably continuation, the Nicaragua Rise, form part of the present day Caribbean Plate. There is no evidence of overthrusting, subduction or suturing between these elements and oceanic Caribbean Plate. The margin is a simple, continent - extended continent - ocean boundary that formed during Jurassic-Early Cretaceous opening of the Caribbean.

B3-The Pacific model shows the Caribbean Plate migrating northeastwards and then eastwards as it entered between the Americas. The 3000 km long plate should show evidence of considerable (NW trending) extension followed by compensating compression as it turned the 45-degree corner and straightened up again. Neither is apparent.

B4-Parallelism of Jurassic depocentres on Chortis and Maya with regional NE extension (se B5, below) shows that neither block has rotated. These continental fragments have always been located at the western end of the Caribbean area. Passage of a migrating, 1000 km wide Caribbean Plate through a possible, < 800 km Costa Rica-Panama oceanic gap was not possible.

An in-situ origin of the Caribbean Plate is supported by geologic history shared with present day neighbouring elements.

B5-Regional NE extensional strain occurs in southern North and northern South America and in the intervening area, including the Caribbean. The strain results from sinistral offset of North America relative to South America. It developed largely during Jurassic-Early Cretaceous time.

B6-There is Mesozoic stratigraphic continuity from continental margin to deep marine rocks between the Florida-Bahamas Platform and Cuba and between northern South America and the Venezuelan Basin.

B7-A regional Aptian unconformity is followed by regional, Albian shallow-water limestones.

B8-Regional Palaeogene flysch/wildflysch deposits are followed by a regional unconformity, regional Middle Eocene shallow-water limestones and a regional Late Eocene hiatus.

B9-The associated Middle Eocene Scotland Group of Barbados (a B8 deposit) arrived by rapid submarine flow from northeastern South America. It contains rocks from that area. Flow terminated against the Tiburon Rise, on the Atlantic Plate, on top of which coeval clastics lie. Barbados Ridge sediments fill the Lesser Antilles subduction trench south of the Rise, showing that the Lesser Antilles were close to their present location at that time. The sediments have not been shunted from as far away as north of Maracaibo by the migrating Caribbean Plate, as depicted by Pacific models.

B10-Thick Eocene deposits in the Grenada Basin, the southern Venezuelan Basin and in the Curacao Ridge show that the Caribbean Plate lay north of the South American source at that time.

B11-Continental rocks in the Cayman Ridge, south of Cuba, show that the Cuban part of the so-called Great Arc never was in the Pacific area. They suggest that the 22 km thick Nicaragua Rise is underlain by extended continental crust and is the eastward continuation of the Chortis Block.

Note: a complete version of this paper and a related paper, with relevant data and extensive bibliographies, are in press:

James, K. H., Arguments for and against the Pacific origin of the Caribbean Plate: discussion, finding for an in situ origin: Transactions, 16th Caribbean Geological Conference, Barbados, 2002.

James, K. H., Palaeocene - Middle Eocene flysch-wildflysch deposits of the Caribbean area: a chronological compilation of literature reports, implications for tectonic history and recommendations for further investigation: Transactions,16th Caribbean Geological Conference, Barbados, 2002.