Transition from Subduction to Strike-Slip in the Southeast Caribbean: Effects on Lithospheric Structures and Overlying Basin Evolution

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Abstract

Dynamic topography, basin structures and geomorphology of the southeast Caribbean-northeast South American margin are controlled by a 200-km-long transition from westward-directed subduction of South American lithosphere beneath the Caribbean plate, to east-west strike-slip motion of the Caribbean and South American plates. Our study of the transitional area integrates: (1) the tomographic imaging of lithospheric structures associated with the laterally variable subduction of the South American lithosphere and orientation of the slab beneath the Caribbean plate with; (2) the geometry and evolution of overlying sedimentary basins imaged with deep-penetration seismic data kindly provided by the petroleum industry and Trinidad and Tobago government agencies. We use an earthquake dataset containing >700 events recorded by the eastern Caribbean regional seismograph network to build travel-time and attenuation tomography models used to image the mantle to depths of 100 km beneath transition zone. Approximately 10,000 km of 2-D seismic reflection lines; which are recorded to depths >12 seconds TWT, are used to interpret basin scale structures including tectonostratigraphic sequences and structures that deform and displace sedimentary sequences. We use the observed satellite gravity to generate a gravity model for key sections traversing the tectonic transitional zone and to determine depth to basement in basins with sedimentary fill >12 km.

Within the study area, the dip of subducted South American oceanic lithosphere on tomographic images is variable from ~44 to ~24 degrees. There is a distinct low gravity, low velocity, high attenuation, northwest–southeast trending lineation located east of Trinidad that defines the location of a Mesozoic oceanic fracture zone which accommodated the opening of the Central Atlantic during the Jurassic to Middle Cretaceous. This feature is also coincident with the present-day continent-ocean-boundary and acts as a lithospheric weakness during subduction. We propose that this fracture zone is a key transition point between: the subduction of South American/Atlantic oceanic lithosphere; which descends into the mantle to the northeast of the fracture zone and; the under-thrusting of transitional to continental South American lithosphere which resists subduction to the southwest. Maps of South American basement and the overlying Cretaceous succession illustrate a northwesterly dip with a distinct change in angle of the northwest dip across the paleo-fracture zone consistent with our tomographic model. We propose that flexure of the subducting South American plate at this location exerts a critical control on the formation and evolution of the basins and the lateral distribution of Cretaceous through Pleistocene stratigraphic fill. To the east of the fracture zone, the overlying Tertiary strata is deformed by active subduction and accretionary prism processes with a wider zone of shortening with lower overall topography, while to the west of the fracture zone there is active oblique collision with a narrower zone of shortening and greater uplift. This has implications for the hydrocarbon habitat and petroleum systems across the subduction to collision transition.