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Timing, opening style, heterogeneous extension and subsidence of the Progreso Pull-Apart Basin in Southwestern Ecuador

A. Palencia[1], A. Aleman[1], E. Lezama[1]

[1]GPG SERVICES S.A. - Quito, Ecuador.

The atypical pull-apart isosceles triangle shape Progreso Basin was formed and opened episodically during the Oligocene to Late Miocene oblique convergence between the Nazca and South America plates. As an aftermath, the strain was partitioned along the La Cruz Fault with both dip slip and left lateral motion as documented in seismic data and fault kinematic analysis. The dip slip component of the La Cruz Fault caused the uplift of the Estancia hills, which enacted as a sediment source while its strike slip motion was accompanied by development of a series of synthetic Riedels such as the Carrizal and Chongón/Colonche faults that set off the diachronous and heterogeneous extension as well as the anti-clockwise rotation of the Chongón-Colonche High. This block rotation entailed significant lithosphere decoupling of this high, thus creating the Jama-Colonche Orocline. Indeed, this rotation as an after-effect of the crustal extension, also gave rise to important northward contraction deformation documented by means of seismic data and by kinematic analysis faults and folds, which balanced the Progreso Basin extension.

The complex stratigraphy and subsidence is an outcome of the episodic and diachronous basin aperture where the active faults played a very important role in sediment shedding and facies distribution and were also the sites of maximum subsidence. The syn-extension facies (Zapotal Formation) was characterized by high rates of subsidence and dominated by alluvial fan and braided stream facies, while intermittent sea incursion gave rise to localized delta fan facies. Abundant medium to thick bedded ash-fall tuff units interbedded with these facies document the volcanic activity associated with the maximum paroxysm of arc activity (Saraguro Formation). The crustal extension, although episodic and sporadic in space, was concomitant with widespread marine flooding, which continued throughout the Middle Miocene as documented by the occurrence of thick conglomerates in the active hangingwalls as well as by the presence of coralline algae carbonate facies in the footwall of the La Cruz Fault (San Antonio Formation). Equally important are the facies changes in the Subibaja Group caused by the basin axial transport and the widespread marine incursions characterized by restricted circulation from the open ocean. Indeed, the continuous deposition of ash fall tuffs triggered high rates of productivity and upwelling as documented by the stratigraphic recurrence of diatomaceous tuffs known as the Villingota Facies. Extension termination was recorded by the incision of the right lateral Rodeo and Playas faults, which were synthetic Riedels to the Pallatanga Fault system, which in turn caused the opening of the Gulf of Guayaquil pull-apart Basin. Finally, the basin sagging phase was documented by the fluvio-deltaic to paludal facies of the Progreso Basin.