8th International Symposium
on Andean Geodynamics
(ISAG)

New data and updated interpretation of the Billecocha Fault System, using geomorphological and geophysical evidence, Imbabura Province, Ecuador

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While several destructive earthquakes have occurred in the seismic history of Ecuador, few of them have been assigned to a specific fault. This is the case of the M~7 Ibarra earthquake in 1868, which devastated nearby towns in this part of the Inter-Andean Valley (IAV) and resulted ~20 thousand fatalities. In this study, we explore the hypothesis that this event could have been generated by the Billecocha Fault System (BFS), a series of NNE-SSW basement faults at ~4000 meters a.s.l. in the Western Cordillera, at the margin of the IAV (NW Cotacachi Canton). Actually, reassessment of the 1868 Ibarra event intensity distribution (Beauval et al., 2010) suggests an epicenter near the BFS.

By means of geophysical, remote sensing and geological techniques, we provide a preliminary estimation of the geometry, kinematics and slip history of the fault system. The BFS is distributed over a 5-km wide and 20-km long area. Detailed geomorphological analyses indicate a primary strike direction of N30ºE. Field observations document evidence of transcurrent motions. These include laterally offset moraines, apparently contraction structures in Pleistocene and Holocene deposits and soils, and drainages either offset horizontally or cut and abandoned. Seismic refraction lines and ground-penetrating radar (GPR) were collected perpendicular to the trend of the fault with the most dramatic surface signature, revealing that soft-sediment layers between 2 - 6 m thick are cut by a southeast dipping plane. Additionally, three fault-perpendicular trenches were dug where the fault shuts the drainage, exhibiting a volcano-sedimentary pack displaced by fault planes. Those are mostly volcanic deposits, fluvio-glacial to pond sediments and organic soils. Colluvial wedges and geometrical relationships between faults and deposits suggest at least 3 offset episodes. Stratigraphic correlation of affected pumices and ash falls indicates that those events are historical and, interestingly, with the last one actually reaching the surface. All these new data and the analyses carried out in this and previous studies suggest a tectonic and even seismic origin of the deformation associated with the BFS. This new model questions the previous interpretation according to which the structures would be extensional and generated by post-glacial isostatic adjustment (Ego et. al., 1995). Finally, our field observations are consistent with an historical surface rupture along the main trace, suggesting that this could be the source of the 1868 Ibarra earthquake. When available, the complete dataset (geophysical profiles, lithological analyses, datings) will provide a comprehensive picture which will be critical for defining fault displacements, kinematics, age and timing of the faulting and then constrain the seismic hazard related to the BFS.

Beauval, C., H. Yepes, W. H. Bakun, J. Egred, A. Alvarado, and J.-C. Singaucho (2010). Locations and magnitudes of historical earthquakes in the Sierra of Ecuador (1587-1996), Geophys. J.

Ego, F., Sebrier, M., Carey-Gailhardis, E., Beate, B., 1995, Are the Billecocha normal faults revealing of extension due to lithospheric body forces in northern Andes (Ecuador)?:Orsay, France, Université de Paris