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New insights on the Tonga subduction zone from a seismotectonic study.

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Despite some of the main features of the plate tectonics theory were figured out with data from the Tonga subduction zone, this convergent plate boundary is still poorly understood in details. The present day pattern of the isodepth contours of the Benioff zone is unresolved especially at depth where the large seismic gap beneath the Lau basin questions whether or not the slab is continuous. The role of the main tectonic units since the opening of the Lau basin is also not fully understood as precise reconstructions haven't been done yet.

We carried out a seismotectonic study of the Tonga Lau subduction zone using catalogues of global seismicity (Engdahl et al.,1998) and of focal mechanisms (CMTS, Dziewonski et al., 1981). Both catalogues were processed in order to get new images of the shape of the Benioff zone and of the variation of the stress tensor in both Pacific and upper plates. The stress tensor was computed using Gephart's program (Gephart et al., 1984).

In the upper plate, the computation of the tectonic regime confirms an island arc undergoing a compressional regime and a back-arc in a state of extensive stresses. However a complex pattern of the stresses variation implies an upper plate subdivided into small areas that has been recognized based on tectonics structures and bathymetric data.The wide Lau back-arc basin is segmented by major strike-slip fracture zones like the Peggy ridge. The east-west extension regime determined at the southern end of the Valu Fa Ridge and of the Fonualei Spreading Center is in good agreement with the Lau basin propagation southward. Within the volcanic arc, some variations in direction of the main stresses are resolved, especially to the north of 17˚S, that shows the influence of the curved subduction termination. The increase of the seismic data base allows now to identify new tectonics features revealed by remarkable alignement of shallow hypocenters, such as the Futuna-Niua Fo'ou segment in the back-arc and the large active intra-arc zone from 15.5˚S to 17˚S. Together with bathymetric data, the analysis of the stress tensor in the upper plate shows the evidences for a complex tectonics organization involving the existence of many individualized microplates.

In the slab, based on the distribution of the seismicity and on the identification of the main tectonic features, we carefully divided the slab in 100 km thick layers in depth and four sectors in latitude (14˚-18˚S, 18˚-21˚S, 21˚-24˚S and 24˚-27˚S) to perform the stress tensor analysis. From 21˚ to 27˚S, the slab has a quite homogeneous downdip compressional regime, whereas the two other areas show strong variations of the stress orientation in the depth range 300 to 700 km. Within the slab in the depth range 60 to 300 km, there are evidences that downdip compressional mechanisms cluster close to the upper surface of the slab. These internal variations suggest the existence of a double seismic zone.

We focused on the northernmost part of the plate boundary where we attempted to link the newly evidenced linear clusters of shallow seismicity with the east-west trending deep seismicity zone into a scheme of a multistage roll back of the subduction. We think that the initiation of the phenomenon was induced by the arrival of the Louisville ridge in the trench and then maintained by the opening of the Lau basin.

These results provide a new geodynamical model for the evolution of the Tonga-Lau system, but they also have to be integrated in the global evolution of the Tonga-New Hebrides region to re-examine some of the main tectonics structures (i.e.the North Fiji Fracture Zone) and their initial role in the early stages leading to the current system.