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Dynamics of the extension in the Fonualei Rift in the northern Lau Basin at 16 °S

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The Lau Basin is a young back-arc basin steadily forming at the Indo-Australian-Pacific plate boundary, where the Pacific plate is subducting underneath the Australian plate along the Tonga-Kermadec island arc. Roughly 25 Ma ago, roll-back of the Kermadec-Tonga subduction zone commenced, which lead to break up of the overriding plate and thus the formation of the western Lau Ridge and the eastern Tonga Ridge separated by the emerging Lau Basin.

As an analogue to the asymmetric roll back of the Pacific plate, the divergence rates decline southwards hence dictating an asymmetric, V-shaped basin opening. Further, the decentralisation of the extensional motion over 11 distinct spreading centres and zones of active rifting has led to the formation of a composite crust formed of a microplate mosaic. A simplified three plate model of the Lau Basin comprises the Tonga plate, the Australian plate and the Niuafo'ou microplate. The northeastern boundary of the Niuafo'ou microplate is given by two overlapping spreading centres (OLSC), the southern tip of the eastern axis of the Mangatolu Triple Junction (MTJ-S) and the northern tip of the Fonualei Rift spreading centre (FRSC) on the eastern side. Slow to ultraslow divergence rates were identified along the FRSC (8-32 mm/a) and slow divergence at the MTJ (27-32 mm/a), both decreasing southwards. However, the manner of divergence has not yet been identified. Additional regional geophysical data are necessary to overcome this gap of knowledge.

Research vessel RV Sonne (cruise SO267) set out to conduct seismic refraction and wide-angle reflection data along a 185 km long transect crossing the Lau Basin at ~16 °S from the Tonga arc in the east, the overlapping spreading centres, FRSC1 and MTJ-S2, and extending as far as a volcanic ridge in the west. The refraction seismic profile consisted of 30 ocean bottom seismometers. Additionally, 2D MCS reflection seismic data as well as magnetic and gravimetric data were acquired.

The results of our P-wave traveltime tomography show a crust that varies between 4.5-6 km in thickness. Underneath the OLSC the upper crust is 2-2.5 km thick and the lower crust 2-2.5 km thick. The velocity gradients of the upper and lower crust differ significantly from tomographic models of magmatically dominated oceanic ridges. Compared to such magmatically dominated ridges, our final P-wave velocity model displays a decreased velocity gradient in the upper crust

and an increased velocity gradient in the lower crust more comparable to tectonically dominated rifts with a sparse magmatic budget.

The dominance of crustal stretching in the regional rifting process leads to a tectonical stretching, thus thinning of the crust under the OLSC and therefore increasing the lower crust's velocity gradient. Due to the limited magmatic budget of the area, neither the magnetic anomaly nor the gravity data indicate a magmatically dominated spreading centre. We conclude that extension in the Lau Basin at the OLSC at 16 °S is dominated by extensional processes with little magmatism, which is supported by the distribution of seismic events concentrated at the northern tip of the FRSC.