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Crustal Structure and Deformation of the Incoming and Overriding Plates of the North Chilean Subduction Zone, 21-23.5ºS

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We present multichannel seismic (MCS) reflection images of the structure of the subduction zone of northern Chile. We focus on 3 MCS lines from the cruise Sonne 104, collected with a 3-km-long, 120 channel streamer and a 3124 c.i. well-tuned airgun array. Two lines are ∼450 km long each, and image the structure of the overriding plate and some ∼350 km of the oceanic incoming plate across the outer rise bulge and into the undeformed segment of the incoming plate. The third line images the structure of the overriding plate and under the oceanic trench slope.

The seismic images show a well-defined top of the igneous crust and fairly continuous reflections from the base of the crust (Moho), typically 2 seconds (TWT) below the top of the igneous crust, indicating a ∼6 km thick crust. Only across the Iquique Ridge segment Moho reflections occur at about 3 seconds (TWT) under the top of the igneous crust indicating a thicker crust (about 9 km thick).

The images also show the bending-related deformation of the incoming oceanic crust as it approaches first the outer rise bulge and subsequently bends into the trench. The plate bulges at the outer rise, and abruptly dips into the trench. The top of the igneous crust shows the formation of offsets indicating new faulting: Offsets formed by bend-faulting in the outer rise are difficult to distinguish from offsets formed at the spreading center, but abruptly increase into the trench slope. Dipping reflections –possibly indicating faulting-across the crust apparently related to top basement offsets occur along the entire line. Dipping reflections also occur in the mantle under the outer rise (clearly below the Moho reflection), in spite of the limited evidence for large scale faulting during outer-rise deformation. The the large horst-and-graben structures in the trench possibly prevent proper imaging of dipping reflection, but faults offsets continue growing into the trench axis and possibly as the plate under-thrusts beneath the margin.

The overriding plate of the continental margin is structured in an upper, middle and lower slope containing a frontal prism. The upper slope shows a well-stratified sediment sequence cut by discrete landward dipping normal faults that display tens of km of lateral continuity in multibeam bathymetry maps. Across an abrupt variation in slope dip the middle slope is defined by changes of: normal fault dip changing from landward to seaward, and a poorly defined sediment stratification obscured by pervasive faulting and mass wasting processes.

The trench axis is largely devoid of stratified turbidites. But the 3 seismic lines show abundant debris from the continental slope accumulating at the slope toe, forming a 5-10 km wide sediment prism. The prism is also observable in multibeam bathymetry maps as a fairly continuos feature for hundres of km. The landward segment of the frontal prism appears to be under-thrusting the overriding margin basement, thus providing abundant clastic material to the subduction channel. Thus the amount of fluid-rich sediment in this apparently starved trench seems to be considerable. A bright plate boundary reflection, probably fluid-rich, is imaged for ∼50 km under the continental slope.