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Monitoring the northern Chile megathrust with the Integrated Plate boundary Observatory Chile (IPOC)

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The oceanic Nazca plate subducts beneath the continental South American plate by recurrent rupture of large segments of its interface. The resulting earthquakes are among the largest and most frequent on Earth. Along the Chilean and southern Peruvian margin, all sizeable segments have ruptured at least once in the past 150 years for which there exist historic and/or instrumental records. The one segment that is most mature for re-rupture stretches for more than 500 km along the northernmost Chilean coast between roughly -23° and -18° latitude. It last broke in 1877 in a magnitude ∼8.5 earthquake, triggering a major Tsunami. From the historical record, it has been known to have a recurrence cycle of approximately 110 years. The adjoining segments to the south and north broke rather recently in 1995 and 2001 in M>8 earthquakes and an M 7.7 earthquake intruded into the southern part of the seismic gap in 2007 between Antofagasto and Tocopilla. This makes northern Chile a unique natural laboratory to observe a subduction megathrust at various stages of its seismic cycle.

For that purpose, installation of long-term observatories started in 2006 in a close cooperation of the Universidad de Chile (Santiago, Chile), the Universidad Catolica del Norte (Antofagasta, Chile), the Institut de Physique du Globe de Paris (France), and the GFZ German research Centre for Geosciences (Germany). Currently we are operating 17 modern seismological stations equipped with STS-2 broadband seismometers and accelerometers (EPI sensor). At least two more stations will be installed in the near future. Continuous GPS, tilt, creep, climate and magnetotellurics measurements are complementing the seismological part. A majority of the sites provide data near real-time.

We will present results of seismic monitoring including analysis of the 2007 M7.7 Tocopilla earthquake sequence that was recorded during the installation stage of the observatory. We relocated the mainshock and about a one thousand aftershocks during the following week using waveform cross-correlation and the double-difference algorithm. Aftershocks reveal that rupture during this earthquake was confined to the deeper part (35 - 55 km depth) of the seismogenic coupling zone, except near the Mejillones peninsula that marks rupture termination in the south. Here earthquake activity reaches to depths of 20 km and even shallower, possibly indicating upper plate activation. The sequence also features an M 6.8 earthquake that broke the oceanic slab on an almost vertical plane at the down-dip end of the megathrust rupture. Confrontation with the aftershock distribution of the 1995 M 8.0 Antofagasta earthquake on the adjoining southern segment reveals an intriguing mirror symmetry with an axis crossing the Mejillones peninsula, emphasizing the penisula's significance as a segment boundary. Since then activity inside the remaining seismic gap to the north picked up with three earthquakes exceeding magnitude 6, maybe heralding the next great rupture.