Characterizing the long-term preparation phase of the 2014 North Chile Mw8.1 earthquake

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Abstract

The mechanisms leading to megathrust subduction earthquakes are poorly known. It has been proposed that the long-term precursory phase of interplate earthquakes is triggered by a slow slip on the fault interface. Recent studies also showed that a triggering link exists between intermediate depth seismicity and the occurrence of megathrust earthquakes. However, the link between the long-term foreshock activity and associated pre-seismic deformation transients has not been directly established.

The subduction zone in North Chile has been affected by several earthquakes during the two last decades and, as a consequence, has been the focus of an important international monitoring effort. Notably, the Mw8.1 2014 North Chile earthquake was preceded by a series of

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earthquakes swarms starting in July 2013, eventually leading to the megathrust nucleation 8 months later. It is therefore an excellent case to study the mechanisms of preparation of great seismic ruptures, and the link between interseismic coupling, slow slip and seismic response.

We attempt here to characterize the long-term precursory deformation and associated seismicity before 2014 Iquique earthquake. We show that a group of coastal GPS stations accelerated westward eight months before the mainshock, corresponding to a Mw6.5 slow slip event on the subduction interface, 80% aseismic in nature. Concurrent interface foreshocks underwent a diminution of their radiation at high frequency, suggesting that ruptures were progressively enlarging, with a reducing velocity. This suggests that, in response to the slow sliding of the subduction interface, the widening of foreshock ruptures gradually propagating beyond seismic asperities into surrounding metastable areas is the nucleation mechanism eventually leading to the mainshock.
At a longer time scale (1990–2015), we document interactions between intermediate depth and interplate seismicity. We show that the 2005 Mw 7.8 Tarapaca slab-pull earthquake was followed by 9 years of enhanced deep and shallow seismicity, together with the decrease of eastward average GPS velocities and associated interplate coupling, eventually leading to the 2014 Mw 8.1 Iquique megathrust earthquake. These long-term interactions between deep and shallow seismicity suggest that the plunge of a rigid slab into a viscous asthenospheric mantle could be the driving mechanism for the initiation of a slow slip at the subduction interface, that may eventually trigger a megathrust rupture.