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Heterogeneous density-structure of the northern Chile marine fore-arc and its relation to the rupture of the 2014 Mw8.2 Iquique earthquake

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The rupture process of the megathrust earthquakes shows strong complexities that can be explained by a combination of factors such as the inhomogeneous distribution of the accumulated stresses and the inhomogeneous rheological conditions at the seismogenic contact. Numerous authors have highlighted a spatial correlation between nucleation zones, barriers and high slip patches of the megathrust earthquakes with physical heterogeneities both in the oceanic plate and in the continental wedge. The genesis of these heterogeneities has a broad nature and their mechanical impact on the interseismic deformation, coseismic rupture, and aftershocks distribution, is not fully understood. Here we present a quantitative interpretation of the gravity signal in the zone of the Chilean margin where the Mw8.2 Iquique earthquake was ruptured on April 1, 2014. The density structure of the forearc was generated by using a 2-D forward modelling schema specially developed for subduction margins, with a database composed by marine gravity, onshore gravity stations and satellite data. The modelling was constrained by seismological and seismic reflection information.

Our analysis shows that the rupture of 2014 Mw8.2 Iquique earthquake and the associated foreshocks present a remarkable spatial correlation with the offshore gravity anomalies. The approximated southern limit of the Iquique 2014 earthquake (∼20º30'S) corresponds to a big change in the offshore gravity, from an almost uniform high signal southward to the more low and complex signal to the north. This big gravity change seems to correlate with the southern limit of the segment where the Perdida Ridge collides with the continent. The density models reveal that this limit corresponds to an important northward decrease of the vertical normal stresses over the seismogenic contact and a general northward decrease of continental wedge densities. To the north, the slip patch of the Iquique earthquake is located below a zone of low gravity and the northern limit of the earthquake correlates with the location of a relatively high local gravity anomaly. This local gravity high corresponds to the southern border of the well developed Arica marine forearc basin. The models show that the frontal portion of the continental wedge in the studied area is formed by low density material that is interpreted as fractured rock. The location of the foreshocks suggests that the presence of this highly fractured material is related to the location of the rupture updip and the stress accommodation process after the earthquake. The results show that detailed studies of the forearc gravity signal provide information of the structures that can play a key role in the earthquakes along the current seismic gaps to the north and to the south of Iquique earthquake.