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Comment to "Nature and tectonic significance of co-seismic structures associated with the Mw 8,8 Maule earthquake, central-southern Chile forearc" from Arriagada et al. (2011)

J. Quezada [a,*], K. Diaz [a], R. Moreira [a], E. Jaque [b], A. Belmonte [c], A. Fernández [b], C. Martínez [b]

[a] Departamento de Ciencias de la Tierra, Universidad de Concepción, Casilla 160-C, Concepción, Chile
[b] Departamento de Geografía, Universidad de Concepción, Casilla 160-C, Concepción, Chile
[c] Departamento de Geofísica, Universidad de Concepción, Casilla 160-C, Concepción, Chile

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The paper of Arriagada et al. (2011) "Nature and tectonic significance of co-seismic structures associated with the Mw 8,8 Maule earthquake, central-southern Chile forearc" demonstrates that normal and reverse faults along the northern edge of the rupture were generated during the Maule earthquake event. They separated the faults of tectonic origin from others related to co-seismic processes such as liquefaction. Then, they concluded that most of these structures are due to the elastic rebound or reactivation of former structures. We also undertook fieldwork along most of the rupture area (Quezada et al., 2010) and similarly observed structures as illustrated in the paper of Arriagada et al. (2011): normal faults, reverse faults and also strike slip faults, as indicated by the displacement of roadways. Although the conclusions presented in the paper may be correct, some of the observed structures could be also due to seismic waves. This important co-seismic phenomenon is not mentioned in the paper and we believe that most of the structures illustrated in Arriagada et al. (2011) are the consequence of seismic waves. Seismic waves produced compression, tension (*P* and Rayleigh waves) and shear (*S* and Love waves) deformation and the surface could be deformed by these waves. If the strength of the soil or rock is low, some structures may develop. Most of the illustrations in Arriagada et al. (2011) show structures in soil rather than hard rock and our interpretation is that most of these structures are due to seismic waves. Fig. 1 shows a reverse fault with a N–S strike, a scarp of 20 cm in height and a fault trace of 30 m. This fault was generated by compression deformation due to shear of Love waves with E–W movement; variable strength of the soft soil and the concrete of the main road generated the reverse fault in the soil. This case is similar to that shown in Figure 4 from Arriagada et al. (2011). Figures 5a, 5c, 5d and 5e (from Arriagada et al., 2011) show features that indicate shortening, but no fault traces were developed. These features are generated by compression deformation due to seismic waves. Figures 3b and 3c from Arriagada et al. (2011) show extensional cracks. Their origin is the existence of a slope that generated a free surface of extension. The photos in our Fig. 2 clearly shows the effect of Love waves on a road with a N–S strike. The upper portion of the road is made of soft soil compared to the surrounding ground and the normal faults and open cracks due to extension indicate E–W movements.

On March11 2010 a seismic sequence began with a Mw = 6,9 earthquake close to the town of Pichilemu (34,4°S). The aftershocks of this event continued until August 2011 and are clearly separated

* Corresponding author. Tel.: +56 41 2204907; fax: +56 41 2246075.
E-mail address: jquezad@udec.cl (J. Quezada).

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Fig. 1. Reverse fault scarp (∼N–S) generated during E–W movements due to Love waves and the different strength between the soft soil and the concrete of the roadway.

Fig. 2. Deformed ground due to Love waves in the city of Coronel (37°S). The soil is soft and the orientation of the road is N10°E. a), b) Normal faults and open cracks. c), d) Undulated road, open cracks and normal faults.

from the Maule earthquake aftershocks. The distribution of the epicentres indicates a fault length of ∼50 km. The National Earthquake Information Center (NEIC) indicates normal focal mechanism and hypocenter depths between 5 and 50 km indicating that a normal crustal fault was reactivated. Arriagada et al. (2011) mentioned the event, and like them, we did not find any surface evidence of the fault. The tip of the fault may be located some kilometres underground and the surface deformation may be due to flexure. Our fieldwork (Quezada et al., 2010) indicates that the normal fault dips south with the hanging wall located south of the fault trace. From NEIC focal measurements, this fault has an orientation of N54°W/57°SW. Considering the co-seismic extension models of Allmendinger et al. (2007) for the 1995 Mw = 8,1 northern Chile, Antofagasta subduction earthquake with a ∼N–S fault strike, the maximum extension axis (T) has an NNE-SSW orientation in the northern part of the rupture, ENE–WSW or E–W in the central part of the rupture and NW-SE in the southern part of the rupture. Considering this analogy for the Maule earthquake, the orientation of the fault that generated the Pichilemu earthquake is consistent with an NNE–SSW extension, also considering that Pichilemu is located close to the northern border of the Maule earthquake rupture (Farías et al., 2010). The normal fault located close to Pichilemu appears to be similar to the Caleta Coloso fault of the Atacama Fault System of northern Chile that is also located in the northern zone of the rupture of the 1995 Antofagasta earthquake. If this argument is true, it could represent a case were former structures with an orientation perpendicular to the maximum extension axis being reactivated during the co-seismic extension. Arriagada et al. (2011) in their paper concluded the same but using other arguments.

In summary the paper of Arriagada et al. (2011) is a good example of structures developed or reactivated during an earthquake, but they did not mention the effects of seismic waves. It is difficult to separate structures generated directly by co-seismic extension and seismic waves. Co-seismic extension is complex as showed in the models of Allmendinger et al. (2007).

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