Western central Andean neotectonics: What we know and where we go from here

J. Bruce H. Shyu, Mark Simons, and Jean-Philippe Avouac, Tectonics Observatory, California Institute of Technology

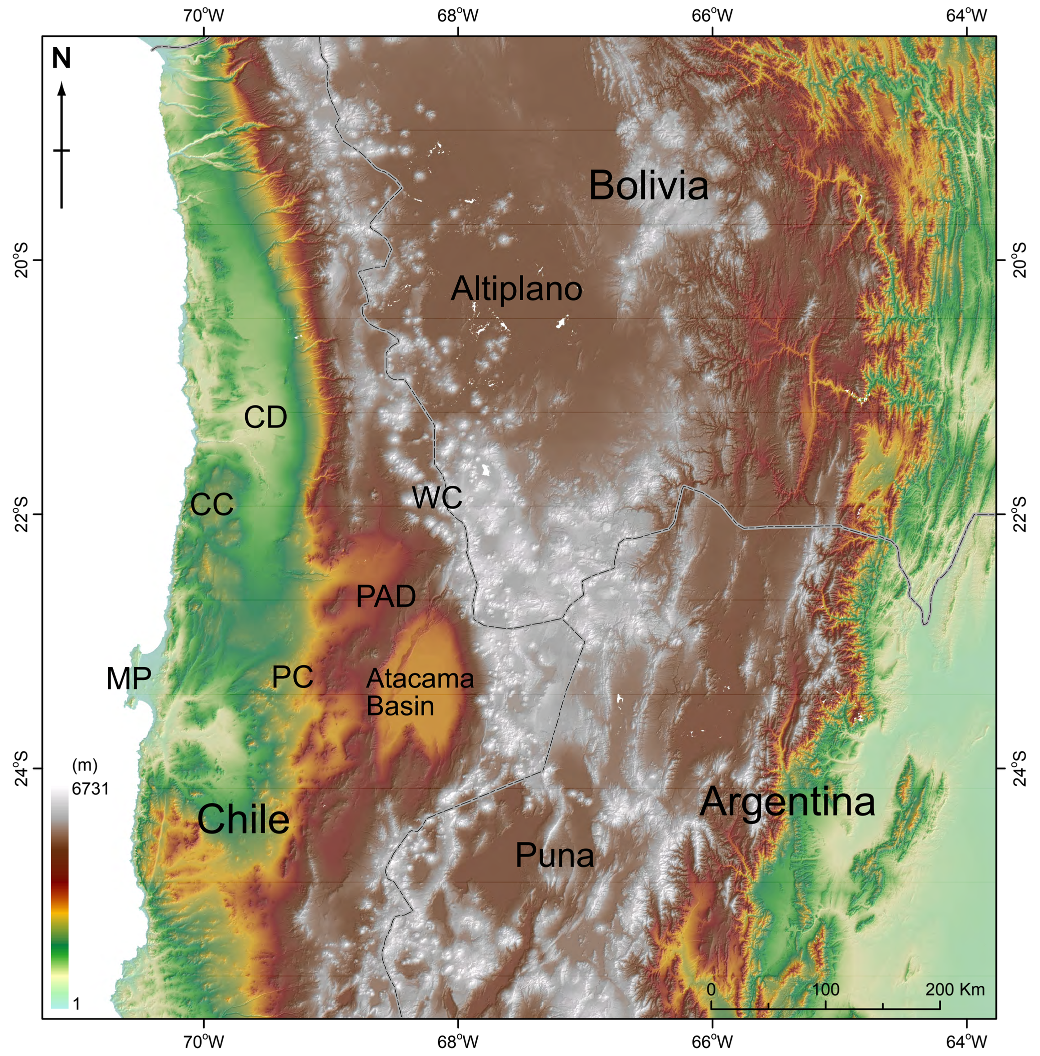


Figure 1. The western South American margin is one of the most active plate boundaries in the world. The central segment of the belt, between about 15°S and 28°S, also includes the Altiplano-Puna, one of the largest and highest plateaus in the world, where average elevation is above 4 km. Along this segment, the subducting Nazca plate has a 30° ("normal") angle of subduction. The western central Andes are characterized by several N-S trending topographic units. From west to east, these units are the Coastal Cordillera (CC), the Central Depression (CD), the Precordillera (PC), and the Western Cordillera (WC) which forms the crest of the range. Between about 22°S and 26°S, a Preandean Depression (PAD), including the Atacama Basin, appears between the Precordillera and the Western Cordillera. Also at this latitude, several normal faulted blocks form the Mejillones Peninsula (MP) that extends westward into the Pacific Ocean.

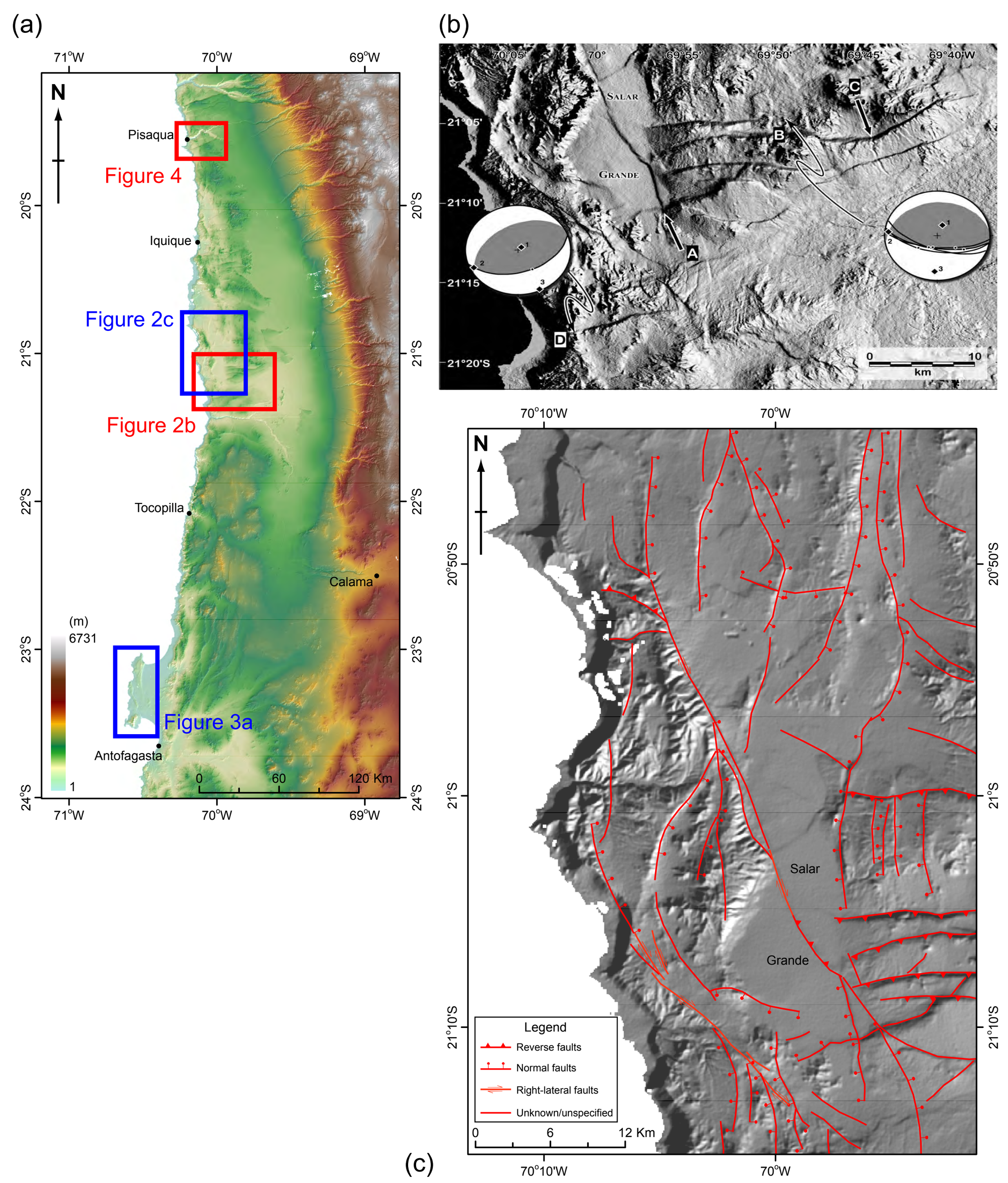
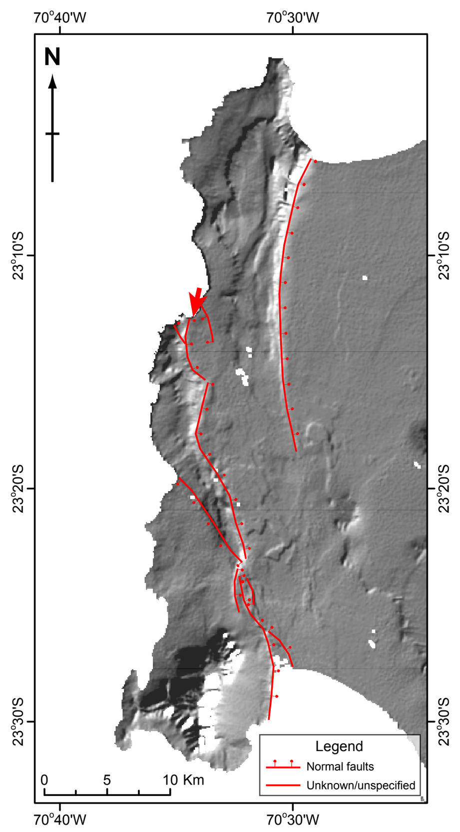


Figure 2. Selected previous mappings of possible active structures in Coastal Cordillera. (a) Shaded relief map of Coastal Cordillera. (b) Between 19°S and 21°30'S, Allmendinger et al. (2005) identified a series of E-W striking scarps, and suggested that they are reverse fault scarps, primarily on the basis of structural observations and measurements in limited outcrops. However, since these scarps are very linear and sometimes even convex toward the upthrown block, they seem more likely to be strike-slip or normal fault scarps. (c) Gonzalez et al. (2003) have produced a map of possible active structures in the Salar Grande area, on the basis of topographic features shown in the DEM. Many of the mapped structures, however, may have been active at very different times, since these structures sometimes form structurally unreasonable cross-cutting relationships.



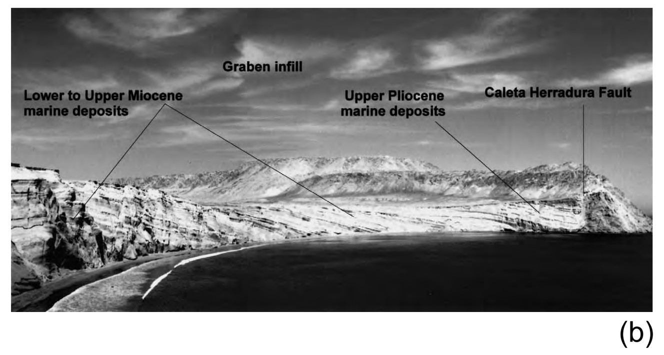


Figure 3. (a) Several normal faults have produced distinct scarps and half-graben basins around the Mejillones Peninsula (Gonzalez et al., 2003). (b) The half-graben basins in the Mejillones Peninsula area have been filled up since early Miocene. These graben fill deposits thus have very long depositional history. It is difficult, however, to determine the age of the youngest graben fill deposits, since the youngest sediments are mostly non-marine and datable materials are hard to find. Therefore, we are unsure if these faults are currently active. The view of this photo is shown as a red arrow in (a).

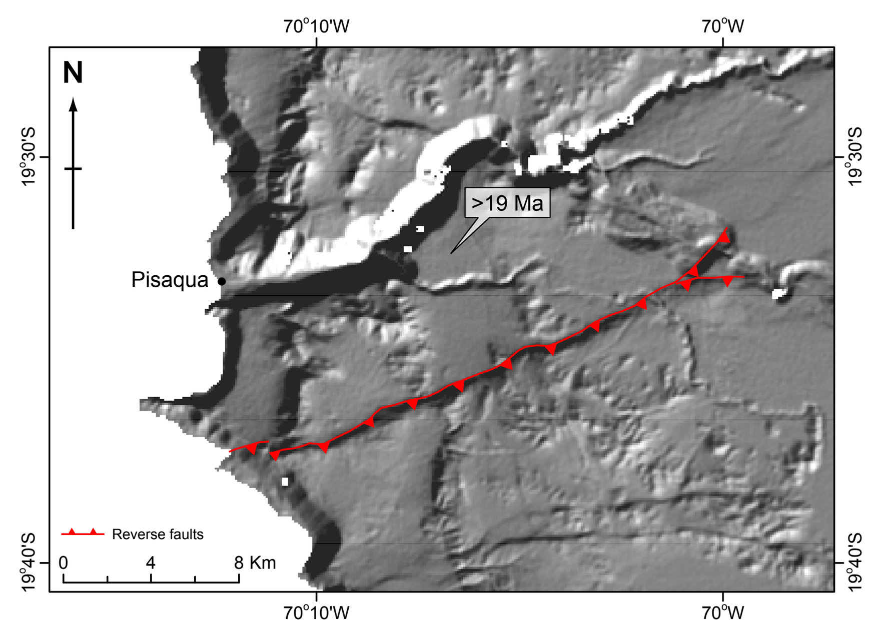


Figure 4. Although many of the previously mapped active structures were identified since they have formed scarps at the surface, the "surface" in Coastal Cordillera may in fact be very old. For example, a recent exposure dating study indicates that some of the sediments at the surface are older than 19 Myr old near Pisaqua (Dunai et al., 2005). Therefore, the fault considered to be active because they offset these surficial sediments, as mapped by Allmendinger et al. (2005) here, may have been inactive for tens of millions of years.

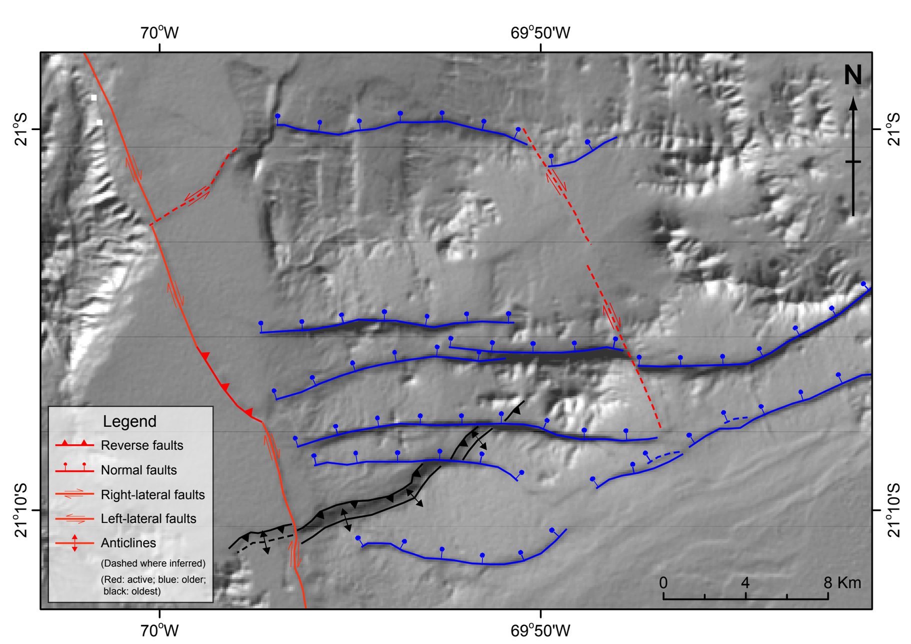


Figure 5. Occasionally, cross-cutting relationships between structures can help us distinguish systems of different ages. In this preliminary map, which has roughly the same area as shown in Figure 2b, we have identified three different structure systems that appear to be active at different times. The oldest system is a NE-SW striking reverse fault, with an anticline in its hanging-wall block. The second system is a series of E-W striking dip-slip faults with possible dextral component. The youngest system is a NW-SE striking dextral fault system, which is the only system that appears to be active currently. There are, however, many other scarps in the area that are difficult to characterize.

This experience led us to realize that, for Coastal Cordillera, due to the lack of active drainages to serve as offset markers and the fact that offset surface may be very old, we need to find structures with cross-cutting relationship in order to figure out which structure system is likely to be currently active. Such relationship is, however, not easy to find. A systematic knowledge of surface ages may therefore be needed before further neotectonic investigations of Coastal Cordillera.

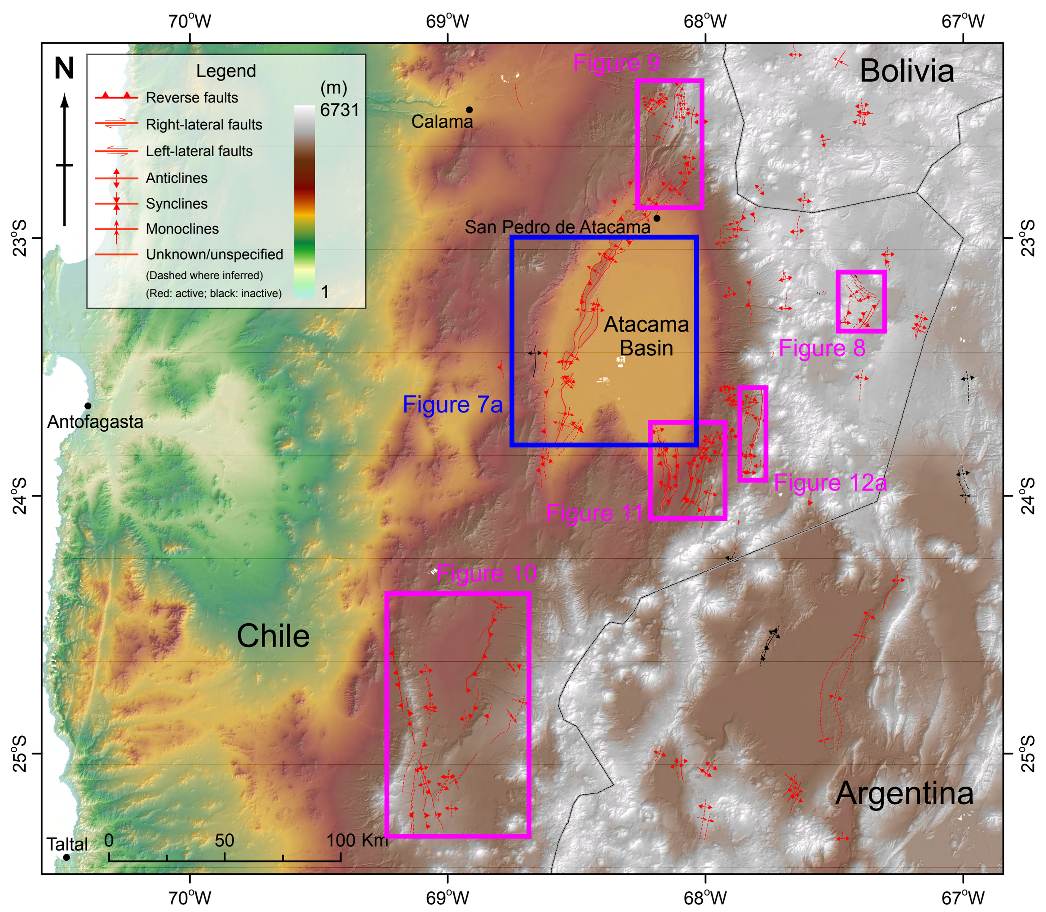


Figure 6. Unlike Coastal Cordillera, identification of possible active structures in Western Cordillera and Preandean Depression appears to have better constraint. Here we show an area with previously mapped active structures (the Atacama Basin, blue box) and five potential target areas for further investigations (pink boxes).

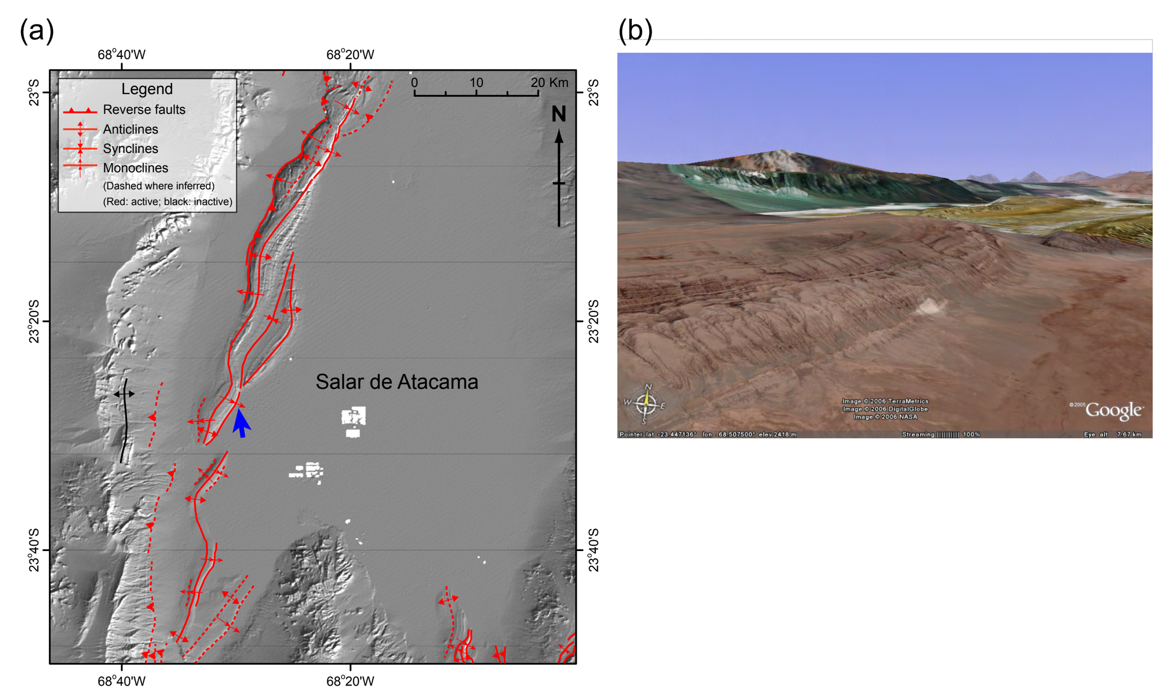


Figure 7. (a) Map of active structures in the Atacama Basin. A series of fault-propagation folds produced the approximately N-S trending ridge west of the Salar de Atacama in the basin. (b) A 3-D view of the western Atacama ridge from Google Earth. The view of this figure is shown as a blue arrow in (a). The age of the folded sediments, however, may be difficult to constrain, and may require other information such as seismic analysis of subsurface strata.

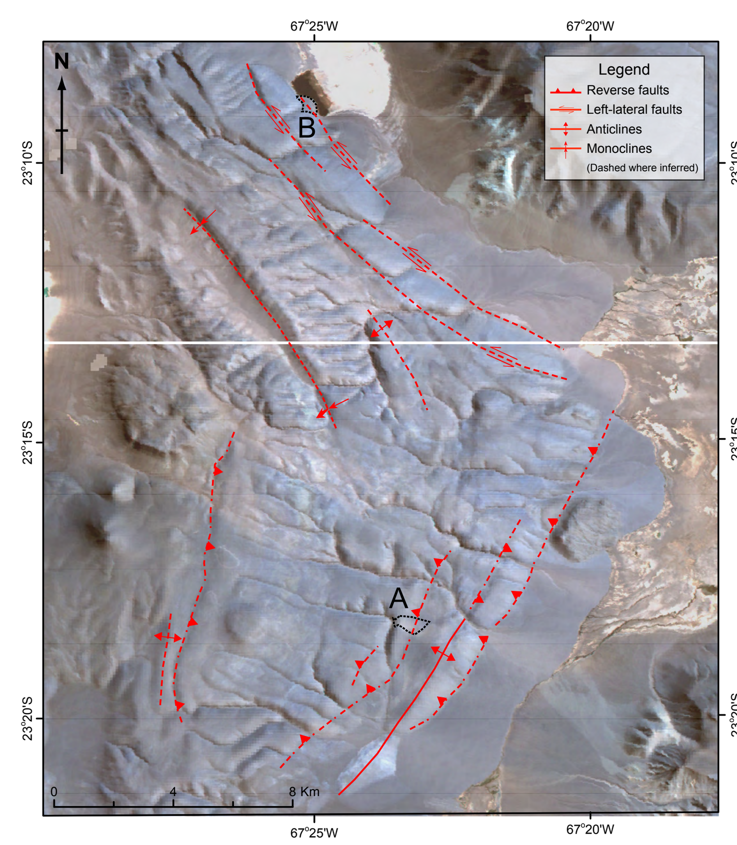


Figure 8. A detailed map of active structures of potential target area A. This area is located to the east of the Atacama Basin in Western Cordillera, and has a series of reverse faults, folds, and a left-lateral fault system in its northern part. Abandoned alluvial channel deposits (A) and alluvial fan deposits (B) may be potential dating targets to determine the ages and slip rates of the structures.

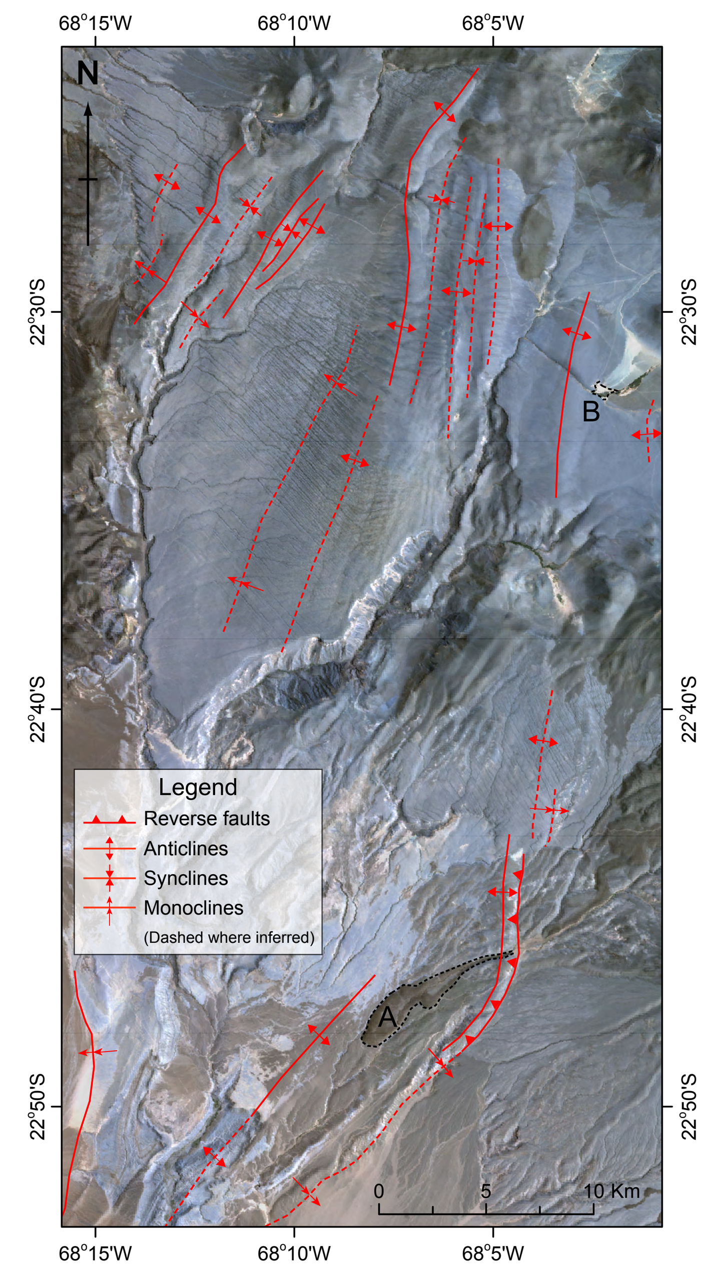


Figure 9. A detailed map of active structures of potential target area B. This area is located just north of the Atacama Basin, and has a series of folds that deformed the surface and drainage systems. A tongue-shaped lava flow (A) and lake deposits of a dammed river (B) may be potential dating targets to determine the ages and slip rates of the structures.

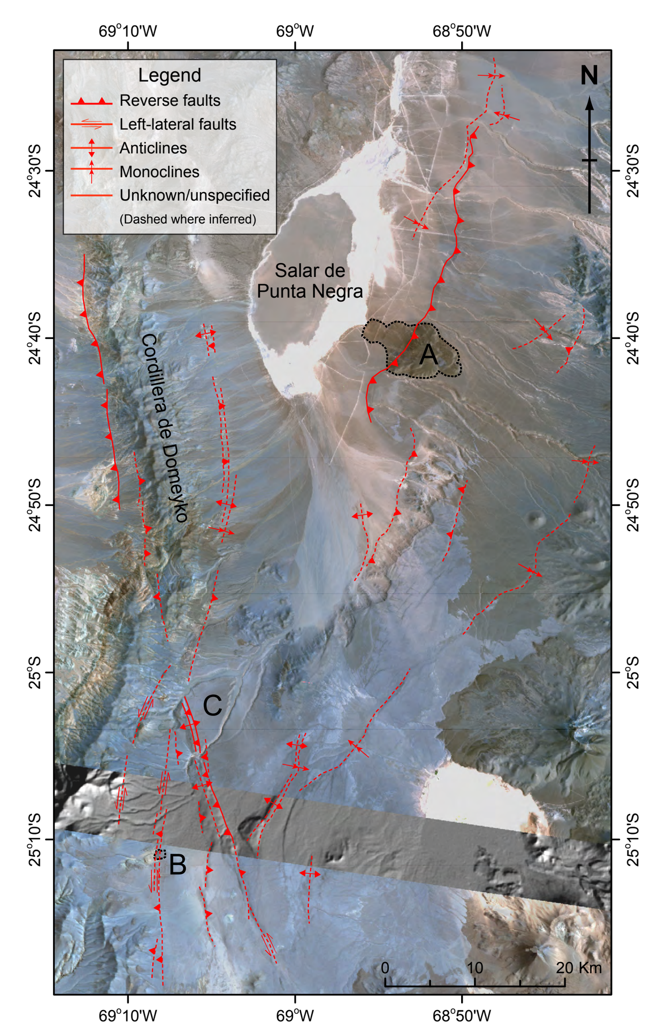


Figure 10. A detailed map of active structures of potential target area C. This area is located near the Salar de Punta Negra, south of the Atacama Basin at the southern end of Preandean Depression. The area has a west-vergent reverse fault system that borders the eastern side of the basin, and has systems of reverse and strike-slip faults that run on both sides of the Cordillera de Domeyko. A lava dome (A) and a small cinder cone (B) may be potential dating targets to determine the ages and slip rates of the structures. The actively incising river system (C) may provide information of the growth of the folds.

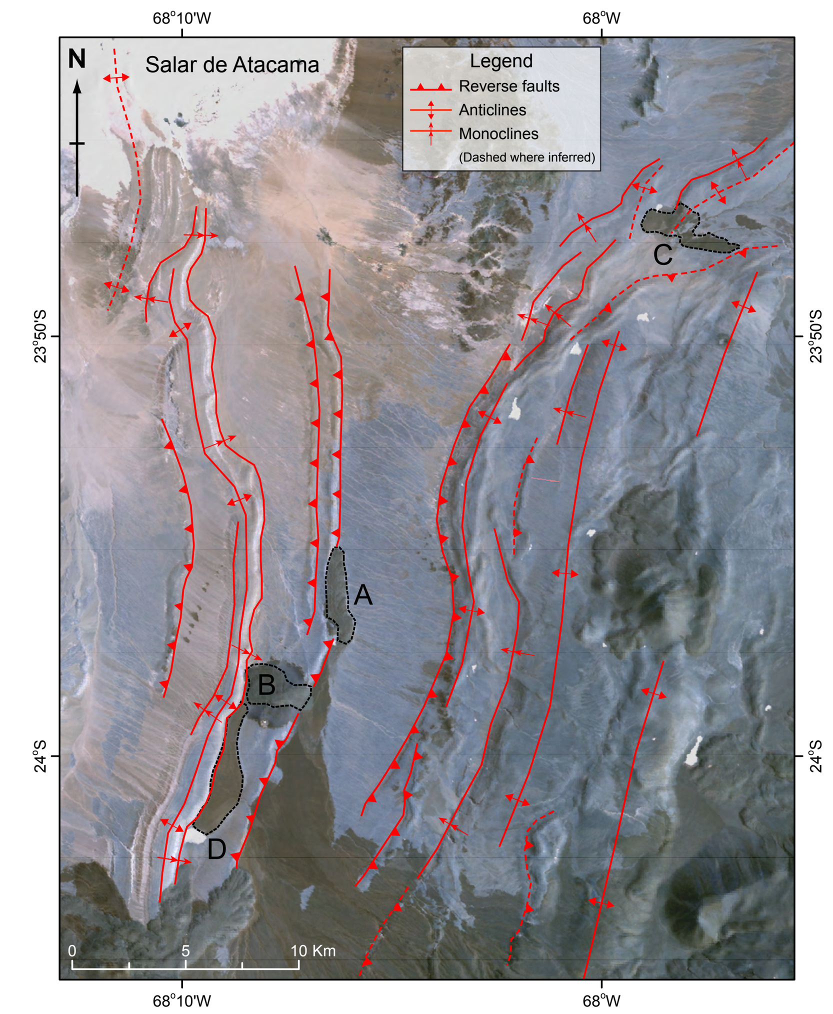


Figure 11. A detailed map of active structures of potential target area D. This area is located at the southeastern corner of the Atacama Basin, and has a series of reverse faults and related folds. An anticline appears to extend into the bed of the Salar de Atacama. Lava flows (A-C) and cinder deposits (D) may be potential dating targets to determine the ages and slip rates of the structures.

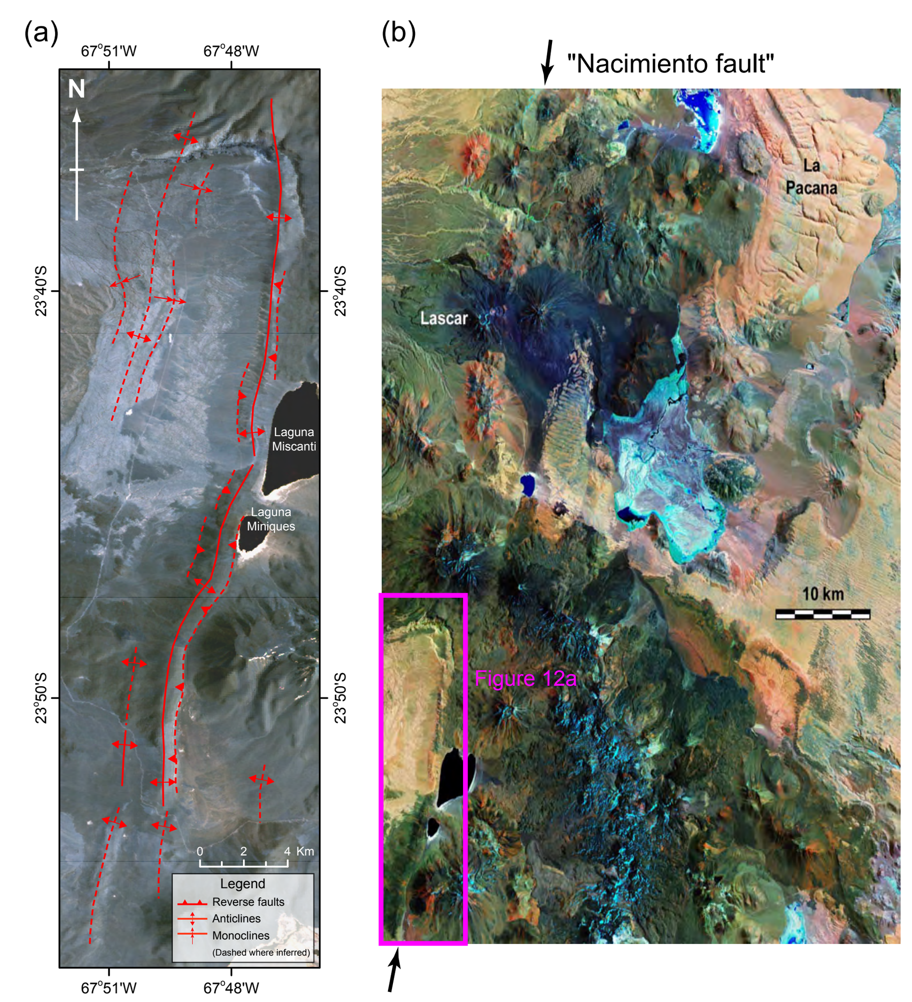


Figure 12. (a) A detailed map of active structures of potential target area E. This area is located just to the east of the Atacama Basin, and appears to be the only segment of the suspected "Nacimiento fault" that is most likely to be active. Along this segment, a series of reverse faults are producing an anticlinal ridge that dams the Laguna Miscanti and the Laguna Miniques. (b) Satellite image for the suspected "Nacimiento fault," taken from website of Randy Marrett (http://www.geo.utexas.edu/faculty/marrett/CentralAndes.htm). Although the "fault" appears as a prominent lineament in this image, we did not find a continuous active structure north of target area E.

REFERENCES

Allmendinger, R. W., G. Gonzalez, J. Yu, G. Hoke, and B. Isacks (2005), Trench-parallel shortening in the Northern Chilean Forearc: Tectonic and climatic implications, Geol. Soc. Am. Bull., 117, 89-104.

Dunai, T. J., G. A. Gonzalez Lopez, and J. Juez-Larre (2005), Oligocene-Miocene age of aridity in the Atacama Desert revealed by exposure dating of erosion-sensitive landforms, Geology, 33, 321-324.

Gonzalez, G., J. Cembrano, D. Carrizo, A. Macci, and H. Schneider (2003), The link between forearc tectonics and Pliocene-Quaternary deformation of the Coastal Cordillera, northern Chile, J. South Am. Earth Sci., 16, 321-342.