Continuous monitoring techniques of fault displacement caused by geothermal fluid extraction in the Cerro Prieto Geothermal Field (Baja California, Mexico)

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Abstract Since 1973, fluid extraction, from the depth range of 1500–3000 m, at the Cerro Prieto Geothermal Field (CPGF), has influenced deformation in the Mexicali Valley (northwestern Mexico) area, accelerating the subsidence and causing slip along the traces of tectonic faults. Subsidence and fault rupture are causing damage to infrastructure, such as roads, railroad tracks, irrigation channels, and agricultural fields. The Mexicali valley is an area with high tectonic deformation, recent volcanism, and active seismicity. The subsidence area is bounded by tectonic faults, as evidenced from field mapping along the Cerro Prieto and Morelia faults to the NW and the Imperial and Saltillo faults to the SE, which limit the Cerro Prieto pull-apart basin. Since 1996, geotechnical instruments installed by CICESE have operated in the Mexicali Valley, for continuous recording of deformation phenomena. To date, the network includes three crackmeters and eight tilmeters; all instruments have sampling intervals in the 1 to 20 minutes range. Data from a 3-D witness, installed by the Cerro Prieto fault in the CPGF area since 2004, show vertical displacement of 3.1 cm/year, in the form of continuous creep, along the 3-m span of the instrument. The crackmeter, installed in a vertical position in 2007, 2 km south from the witness, shows vertical displacement ~1.3 cm/year, and the presence of small episodic slip events. Vertical slip on the Saltillo fault, 5 km outside the CPGF, measured by the crackmeter since 1996, and by 2 tilmeters, corresponds to about half of the total subsidence, and occurs as continuous creep and episodic slip events, with ~50% of the slip being released during the episodic events. The vertical slip rate on the fault increased from 5.3 cm/year to 7.3 cm/year around the second half of 2003. The distance and time relation between extraction changes in the CPGF and displacement rate changes on the Saltillo fault suggests that extraction affects the fault through diffusive transmission of pore pressure changes with a characteristic hydraulic diffusivity. The paper shows how the fault displacement monitoring techniques applied can be used to monitor subsidence changes and to model subsidence mechanisms.

Key words Cerro Prieto, Mexico; geothermal field; subsidence monitoring; subsidence modelling