Source process of the Colima, Mexico, earthquake of Jan. 22, 2003, obtained by joint inversion of teleseismic and near-field data

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On January 22, 2003, a powerful earthquake struck southern and central Mexico, killing at least 29 people and causing heavy damage mainly in the state of Colima. The earthquake information initially provided by the U.S. Geological Survey was as follows: origin time = 22/01/2003 02:06:35 (UT); epicenter = 18.807 N, 103.886W; depth = 30 km; moment magnitude = 7.8. This earthquake occurred near the triple junction of Rivera, Cocos, and North American plates, where three great earthquakes had occurred on June 3, 1932 (Ms 8.1), June 18, 1932 (Ms 7.8) and on October 10, 1995 (Mw 8.0). In this study, we constructed the detailed source model of this earthquake, using the near-field records obtained by Universidad Nacional Autonoma de Mexico (UNAM) and the teleseismic data collected by the Data Management Center of the Incorporated Research Institutions for Seismology (IRIS-DMC). We compare its source process with that of the past great earthquakes.

We retrieved teleseismic body wave data recorded at IRIS-DMC stations via Internet. Twelve P-wave components were selected from the viewpoint of good azimuthal coverage. The teleseismic waveforms were band-passed between 0.01 and 0.8 Hz and converted into ground displacement with a sampling time of 0.25 sec. We also used 12 components of strong motion data obtained from 3 accelerographs and 1 broadband seismograph at UNAM stations. The acceleration data were band-passed between 0.01 and 0.5 Hz and numerically integrated into ground velocity with a sampling time of 0.25 sec, and the broadband velocity data were band-passed between 0.01 and 0.5 Hz with a sampling time of 0.25 sec. Applying a multi-time window inversion to the above data, we determined the time and space distribution of fault slip. To perform stable inversion, we incorporated prior information into the observed data, and determined the optimal relative weights of information with prior constraints from the proper Akaike's Bayesian Informa tion Criterion (ABIC). We used the crustal structure obtained by Pacheco et al. [1997]. We adopted the fault mechanism: (strike, dip, slip) = (300, 20, 93), and the epicenter determined by Colima University [Latitude = 18.63N; Longitude =104.13W]. This fault mechanism is modified slightly from Harvard CMT solution to be consistent with the amplitude of P-waves and with the geometry of the plate boundary determined by focal mechanism and seismicity [Pardo and Suarz,1995]. We varied the hypocenter depth form 10 to 30 km with an increment of 2.5 km in the inversion procedure, and found its minimum variance at 20 km.

The derived source parameters are as follows: the seismic moment, Mo = 1.6e20 Nm; the source duration = 30 sec; the fault length = 50 km; the fault width = 70 km. The rupture area of the 2003 Colima earthquake is located southeast of the ruptured zone of the 1995 Colima-Jalisco earthquake (Mw 8.0). We found that the rupture process can be divided into three stages: the rupture nucleated at the western end of the aftershock area (stage I), it triggered to break the first asperity centering about 10 km SE from the epicenter (stage II); the rupture propagated to the NW direction, and two asperities were broken (stage III). Our results and the isoseismic map of June 18, 1932 earthquake suggest that the 2003 Colima earthquake may have broken a part of the source area of the June 18, 1932 earthquake.