Coulomb Stress Analysis for 21 February 2008
M_w= 6.0 Wells, Nevada Earthquake

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Abstract

We calculated static Coulomb stress changes associated with the February 21, 2008 Wells, Nevada earthquake, using a rectangular source fault consistent with the Dreger and Ford (2008) variable-slip rupture model. We resolved stress changes on nearby faults; their geometry was defined by the Frankel et al. 2002 National Seismic Hazard Map active fault database. We also mapped Coulomb stress changes at 9 km depth by using the strike, dip, and rake of surrounding faults. Both the largest increase (0.3 bar) and largest decrease (-0.7) in Coulomb stress are calculated on the Independence fault. Other faults have stress change < 0.01 bars, which is likely insignificant.

Introduction

The Wells, Nevada, earthquake struck in the middle of the East Humboldt Range, near the southern end of the Snake Mountains and Wood hills (Figure 1). The main tectonic extension direction in this region is thought to be N30°W to N40°W. The active faults in the study dip about 60° and have normal slip. The Ruby Valley fault dips to the east, and the rest of the faults dip to the west. The Ruby A and B faults are about 15,000 years old (Frankel et al., 2002; USGS, 2006) and have a slip rate of 0.25-0.49 mm/year (dePolo, 1998). The Ruby Valley, Northern Butte and Independence are about 130,000 years old (Frankel et al., 2002; USGS, 2006) and have a slip rate of 0.25-0.49 mm/year (dePolo, 1998). The Spruce fault is 130,000 years old (Frankel et al., 2002; USGS, 2006) and has a slip rate of 0.1-0.249 mm/year (dePolo, 1998). We used Coulomb 3.1 software (Toda et al., 2007, Toda et al., 2005, Lin and Stein, 2004) to calculate static Coulomb stress maps (Figure 2) and static Coulomb stress change on active fault planes (Figure 3 and 4). We use a friction coefficient of 0.4 in an elastic halfspace.

The source fault and aftershocks

We used a rectangular source fault which lies in the NE – SW direction, between 7 and 11 km depth. It is a 34˚ striking and 40˚ SE-dipping normal fault centered at 41.153˚ N and 114.867˚ W. The source fault is divided into 56 patches and variable slip values are assigned consistent with the Dreger and Ford (2008) rupture model. Most of the aftershocks (until 18 March 2008) lie the NW part of the 2008 Wells source (Figure 4). Without better depth accuracy, we cannot analyze whether aftershocks lie in regions of Coulomb stress increase.

Coulomb stress changes on active fault planes

The Independence fault is located to the east of the source fault. It is an 180˚ striking and 60˚ west-dipping normal fault. As shown in Figure 2, the northern portion of the fault primarily shows a stress drop of -0.7 bars. The southern portion has an average stress increase of 0.2 bars. The maximum stress increase exists on the northern lower corner of the Independence fault, near the source fault with 0.3 bars.

The Ruby Mountains fault system consists of two fault planes located to the west of the source fault (Figure 1). The longer one which we call Ruby Mountain fault system A, is a 226˚ striking and 60˚ west-dipping normal fault. The maximum stress change is positive at 0.01 bars and gradually decreases with distance from the source fault (Figure2).

We call the second plane Ruby Mountains fault system B. It is a 222˚ striking and 60˚ west-dipping normal fault. The maximum positive stress change is 0.08 bars for the upper 3 km depth. The maximum negative stress change is -0.05 bars (Figure2).

The only east-dipping receiver fault is Ruby Valley, which is a 31˚ striking and 60˚ east-dipping normal fault. The maximum stress increase is negligible, less than 0.003 bars (Figure2).

The Spruce Mountain Ridge system is located on the south of the source fault. It is a 202˚ striking and 60˚ west dipping normal fault. Maximum Coulomb stress change is positive but less than 0.01 bars (Figure2).

The Northern Butte Valley is a 200˚ striking and 60˚ west dipping normal fault. The Coulomb stress change is less than 0.001 bars (Figure2).

Conclusion

The greatest effect of Wells Earthquake is to inhibit Coulomb failure on the Independence fault, largely because of fault clamping. Modest promotion of failure is seeing along the middle and southern part of the Independence fault, the Spruce fault and the Ruby Mountain B. The stress increase on the southern part of the Independence fault is relatively low to trigger seismicity (about 0.2 bars). With the improvement of the fault database, it is going to be possible to make additional Coulomb stress analysis for the Wells earthquake.

References

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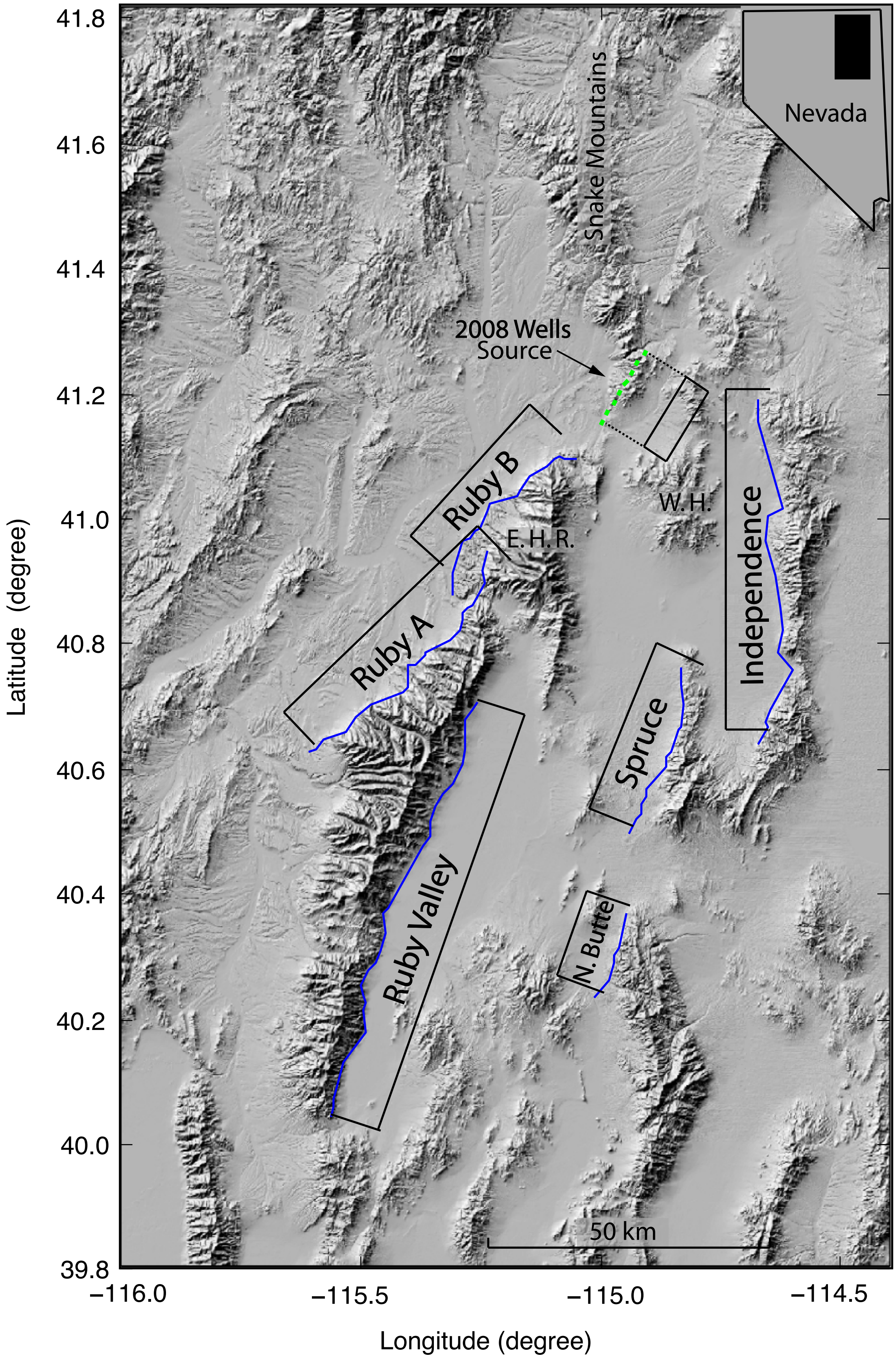

Figure 1. Coulomb stress change on active fault planes. Blue lines are surface traces of active faults. Black lines are vertical projection of model receiver faults. Green line is surface projection of 2008 Wells Source. Red grid is vertical projection of fault planes. E.H.R is East Humboldt Range. W.H. is Woods Hills.

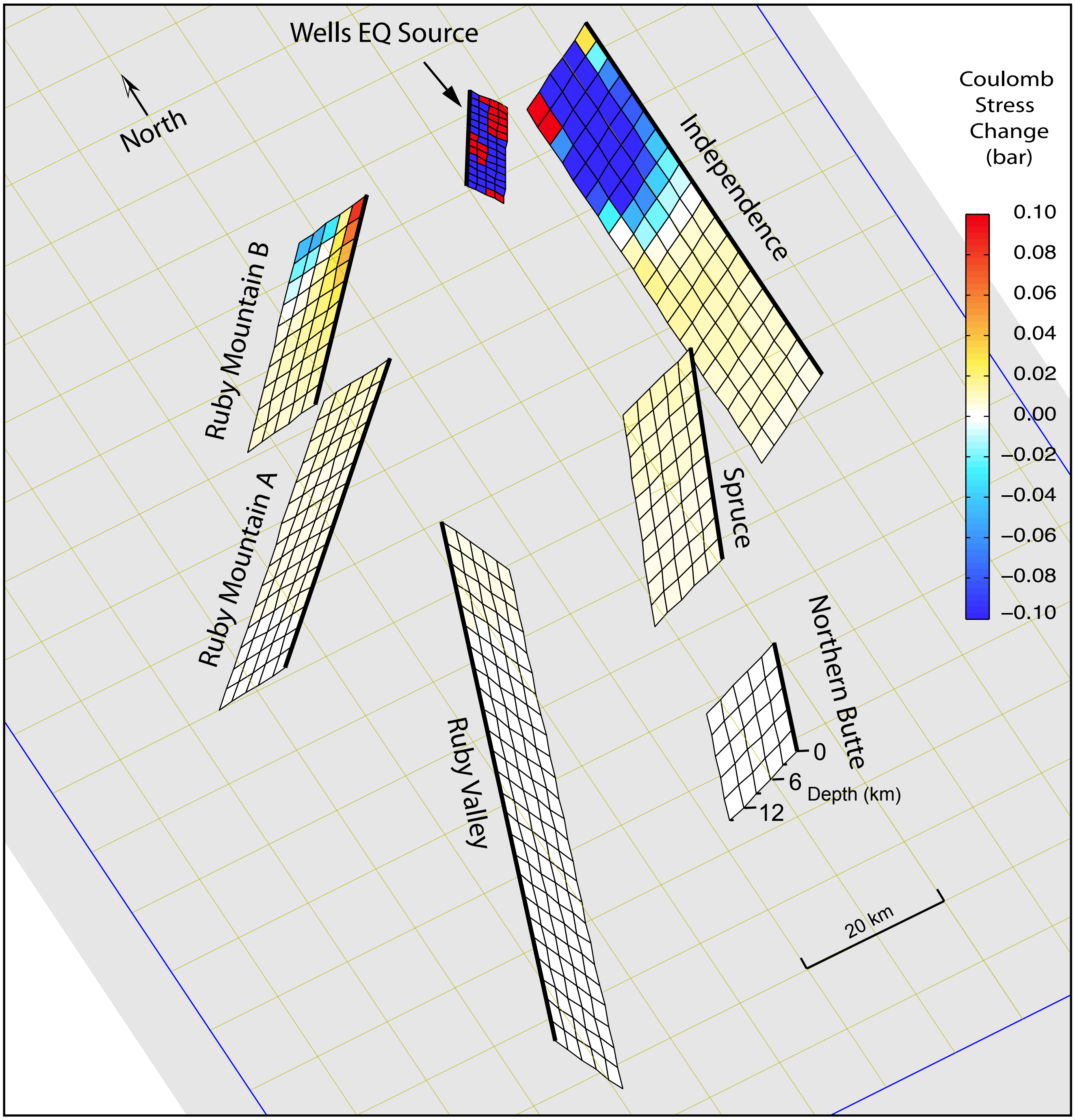

Figure 2. Coulomb stress change on active fault planes. Black line is the top of the faults. Wells EQ source fault lies between 7 and 11 km depth. receiver faults lie from the surface to 15 km vertical depth. The friction coefficient is 0.4.

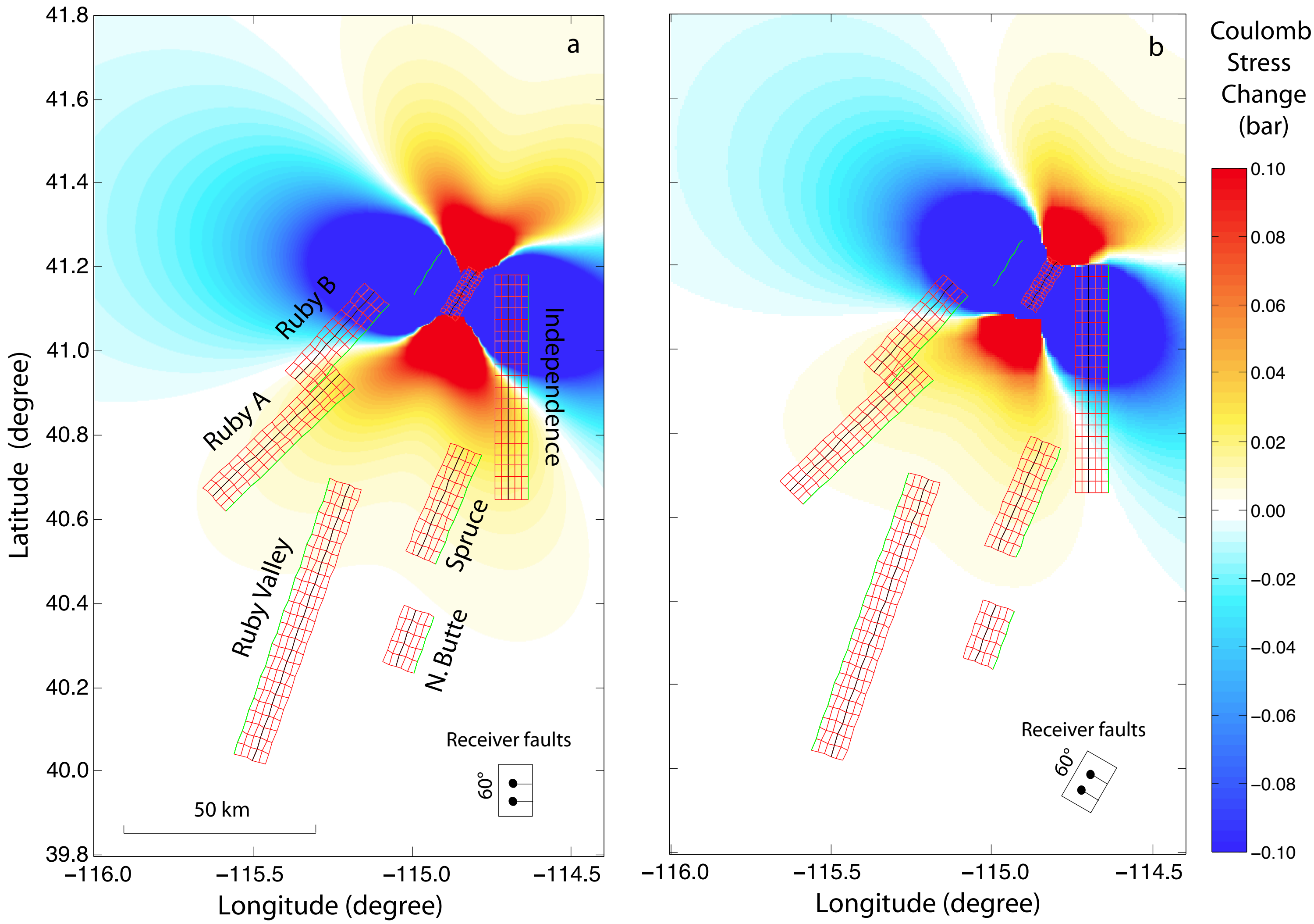

Figure 3. (a) Coulomb stress change on north-south striking 60°-dipping normal faults such as the Independence fault. (b) Coulomb stress change of the average strike (210°) of the Ruby A, the Ruby B. , the Spruce and N. Butte faults. For Both figures, calculation depth is 9 km and friction coefficient is 0.4.

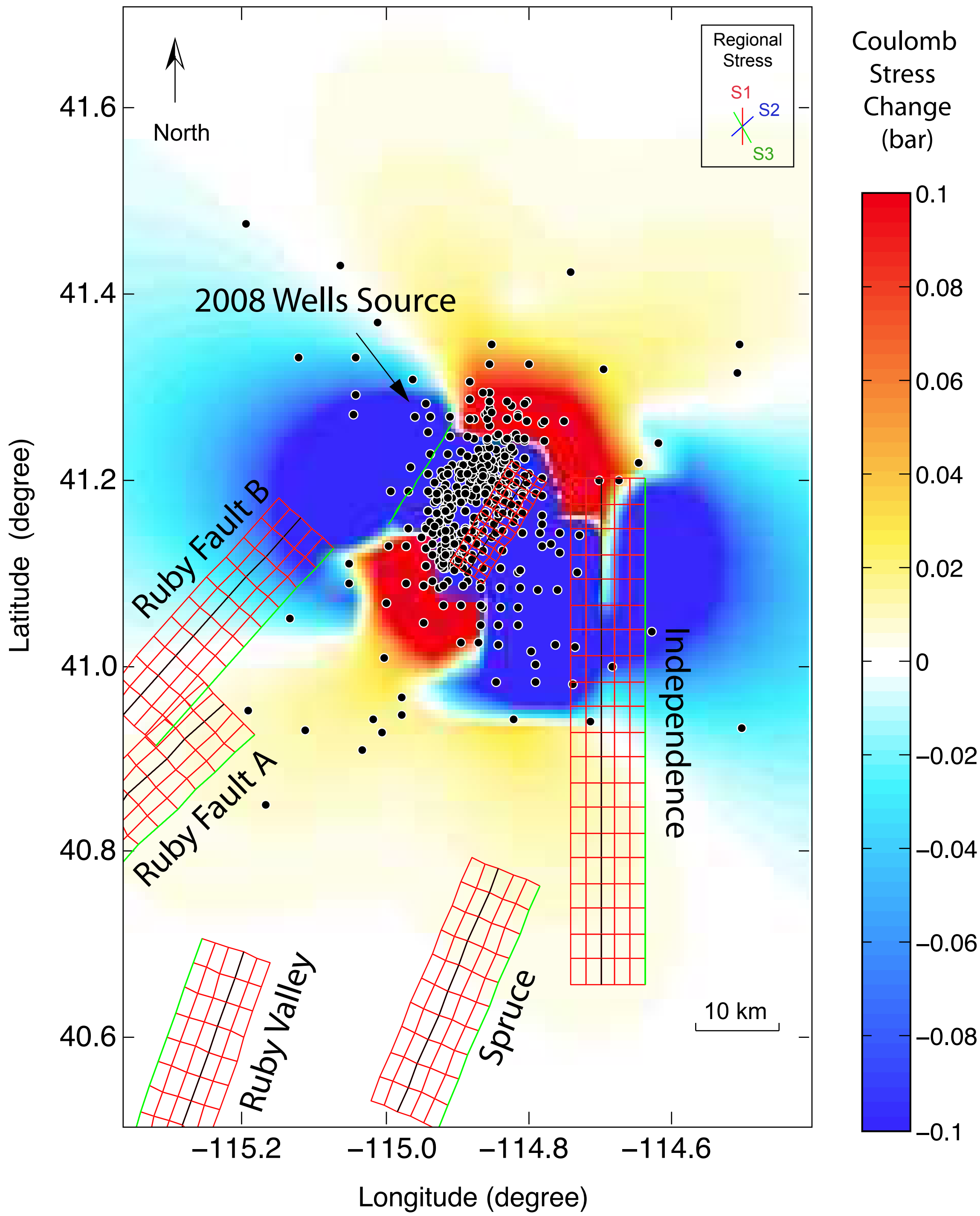

Figure 4. Coulomb stress change on optimally oriented normal faults. Friction coefficient is 0.4. Calculation depth is 9 km. Regional stress direction (extension) is used as S3 with -100 bars. Black circles represent aftershocks. Green line is a surface projection of the Wells Earthquake source.