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Earthquake Research in Eastern California and Western Nevada

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Our efforts so far in this project have focused on a comparison of seismic and geodetic scalar moment rates across the Basin and Range province. This project is being performed by Aasha Pancha, a graduate student at UNR, in conjunction with John Anderson. Scalar moment rates estimated from a 151-year seismicity catalogue have been compared with geodetic scalar moment rates within the Basin and Rang Province, western United States. The Province is an actively deforming region of Cenozoic extension and shear, dominated by normal faulting throughout and strike-slip deformation superimposed primarily along the western side. In our project, we include regions in the Mojave Desert where deformation is more associated with the northward motion of the Sierra Nevada mountains than with the main motion of the San Andreas system going through the big bend and on towards San Francisco.

Seismic moment rates have been estimated from a new catalog of earthquakes intended to be complete for M>=5. The catalog was compiled from 15 preexisting catalogs, supplemented by the review of 39 published journal articles. Throughout the catalog compilation, care is taken to obtain the best estimate of the moment magnitude or a reasonable, and not inflated, equivalent. 80% of the moment release occurred during 10 earthquakes of magnitude Mw 6.95 or greater. Thus small events do not significantly release the accumulating strain.

Much of this seismic moment release occurs along the western boundary of the region, which we take as a line approximately along the crest of the Sierra Nevada mountains, extended south to 34^{o}N latitude. About 75% of the seismic moment has been released within a strip of about 100 km width along the western edge of the Province. Geodetic deformation is also fastest within the same strip, with slower deformation farther to the east. The curves of cumulative strain and cumulative seismic moment as a function of distance from the western boundary of the Basin and Range region follow a similar shape. The geodetic data are from east-west transects across the northern Basin and Range (Bennett et al, 1998; Thatcher et al, 1999; Wernicke, 2000), with the increase in deformation coinciding with the locality of the Northern Walker Lane. Some of the seismic moment release is associated with large earthquakes in California, somewhat south of the geodetic profile.

Several techniques, ultimately traceable to Kostrov (1974) or Brune (1968), are used to translate the geodetic strain rates into rates of seismic moment release. Following the methods of Anderson (1979) and Anderson & Brune (1999), we make a first attempt in the determination of the scalar moment rate, $\dot{M}_o$, by the summation of the scalar moment rate due to shear and extension. The shear component of the scalar moment is represented by

$$\dot{M}_o = \mu L_1 W V_1 ,$$

where L_1 is the length of the region parallel to the shear motion (taken parallel to the San Andreas fault in central and northern California), W is the thickness (depth) of the seismic zone, V_1 is the component of the geodetic strain rate parallel to the shear direction, and μ is the shear modulus. The estimate for this component of the moment rate thus assumes that shear is distributed on faults parallel to V_1. The scalar moment rate due to extension is expressed by

$$\dot{M}_o = 2\mu L_1 W L_2 \, e/k = 2\mu L_1 W V_2 / k ,$$

where the strain rate is given by $e = V_2 / L_2$, and L_2 is the width of the seismic zone measured perpendicular to the western boundary. The parameter *k* is an empirically determined constant equal to the ratio of the total moment in the direction of maximum horizontal deformation to the total moment for all earthquakes, and thus is regionally dependent. For Asia as well as southern California, *k* = 0.75 (Anderson, 1979; Chen and Molnar, 1979), while a value of *k* = 0.81 had been derived for Utah as a whole, with *k* = 0.96 and 0.83 for southern and northern Utah respectively (Doser and Smith, 1982). V_1 is the plate parallel velocity component, while V_2 is the plate perpendicular motion. In this study we take the shear modulus to be $\mu = 3 \times 10^{11}$ dyne/cm^2 (Anderson, 1979).

The moment tensor can be resolved into the superposition of two or more double couples. However, as stressed by Savage and Simpson (1997), this resolution can be achieved in many ways, each with its own scalar moment rate. Thus the representation of the moment tensor as a scalar quantity, and hence the correspondence of as scalar moment rate with a given surface strain accumulation rate, is non-unique. Resolution for a region containing a major fault is that in which at least one double couple corresponds with the prevailing slip, thus Savage and Simpson suggest the preferred resolution is that which produces the smallest scalar moment rate. We therefore also calculate the geodetic moment rate via Savage and Simpson's (1997) preferred resolution, which gives the smallest scalar moment, $M_o^{(\min)} = 2\mu HAMax(|\varepsilon_1|,|\varepsilon_2|,|\varepsilon_1 + \varepsilon_2|)$, where ε_1 and ε_2 are the principle surficial extension and contraction rates, H is the seismogenic thickness, and A is the surface area of the region.

Relative strain rates between stations at the ends of the geodetic region were applied, assuming homogeneous deformation field between the two observation points. From the geodetic data obtained across the Basin and Range (Bennett et al, 1998; Thatcher et al, 1999; Wernicke, 2000), it is clear that this assumption is not valid. In order to account for the inhomogeneity of the strain field, the geodetic region was divided up into smaller rectangular sections, bounded by geodetic stations at which major changes in the strain field are observed. Again homogeneity was assumed across the intervening area between stations. The scalar moment rates calculated for each sub-region are summed to obtain the total scalar moment across the geodetically deforming region.

The geodetic moment rates compare well with rates determined from seismicity, within error bounds. Moment rates from seismicity range from 6.70e+25 to 1.04e+26 dyne-cm/year, while geodetic estimates range from 6.50e+25 to 1.09e+25 dyne-cm/year. This agreement suggests that within uncertainties, the rate of historic earthquakes within the Basin and Range Province, taken as a whole, provides a reasonable estimate for the rate of seismicity that should be expected in the future.

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