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Continuous fault motion: implications for deformation behaviour in a complex crust and for plate-tectonic driving forces

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There are many open questions revolving around active faults, such as the nature of the earthquake cycle, and the strain partitioning in a complex crust, and whether that partitioning changes with time? Resolution of these and other important issues requires observations of deformation that are long-term and in the ideal case made continuously. GPS and INSAR observations will eventually be very valuable in that context, but for now the temporal duration of those data sets is still rather limited. Another dataset that has not yet been fully exploited is that of continuous fault motion on creeping faults. In fact there are datasets of this kind with a length of up to half a century. These observations let us illustrate some of the issues that will eventually be addressed by GPS once there is a comparably long record of measurements.

Fault creep data also have a strong value in themselves since continuously deforming faults on Earth place important constraints on crustal dynamics. In fact, creep-rate changes directly reflect changes among the forces that act on the fault. We focus on the creeping section of the San Andreas fault, and show that it constitutes an important laboratory for long-term fault behaviour, with a temporal record of almost 50 years.

Fault motion shows a wide range of deformation behaviour. In particular, transient deformation occurs over time scales ranging from seismic events (seconds) to long-term transients (tens of years and beyond). We focus on systematic changes in long-term creep rate over time scales of decades. In principle, such variations may be caused by changes in either the resistive forces acting within the fault zone or by variations in plate-tectonic driving forces. We test a recent prediction (Pollitz et al., 1998) of a transient in plate-tectonic driving forces due to the giant earthquakes in the Aleutians

throughout the 1950s and 60s that should show up in the creep observations in Central California, in principle. However, they don't! There are no indications of transients in plate-tectonic driving forces.

On the other hand, there are clearly other long-term transients in the data, and we address them using a force-balance approach. We suggest that the most likely explanation for most of those changes is elastic reloading of the adjacent locked portion of the San Andreas fault produced by large earthquakes and possibly aseismic strain release that occurs before the earthquakes. There are clear changes in creep-rate associated with the Loma Prieta earthquake, and several moderate-size earthquakes in the area. The higher creep-rate after Loma Prieta is due to a reloading of the adjacent locked Loma Prieta section, and it may take several decades before the creep-rate approaches the background rate. Perhaps the most interesting feature of the creep-rate changes is that they begin a few years before the earthquakes. We can only speculate whether this is a general feature of larger earthquakes in the area. If it is indeed true it would have important implications to the question of earthquake nucleation and it would constrain models of earthquake behaviour.