

## Persistent slip rate discrepancies in the eastern California (USA) shear zone

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The slip rate discrepancy on the Garlock fault can be explained by a combination of left slip on the fault and clockwise rotation. This is kinematically equivalent to dextral shear, and renders the Garlock fault geodetically invisible relative to the surrounding eastern California shear zone.

The paper by Evans et al. (2016) is a perceptive and innovative analysis of the discrepancies between geodetic and geologic estimates of slip rates on the faults in the eastern California shear zone (ECSZ), and will inform future discussions of this problematic issue. This Comment concerns the most egregious example of the problem, which is the Garlock fault (GF), as it is quite different from the other faults, and illustrates a simple physical process that can cause apparently large discrepancies between geodetic and geologic slip rate estimates (Platt and Becker, 2013).

Unlike the other examples of discrepant slip rates, the geodetic estimate of the slip rate on the GF is much less (almost zero) than the geologic estimates, which average ~5 mm/yr (Ganev et al., 2012). It is also a left slip fault, unlike all the others, which are right slip. The central section of the GF, which is ~90 km long, trends close to normal to the ECSZ, and cuts across an array of northwest-trending faults that accommodate at least 9 mm/yr of right-lateral shear. If these faults cut the GF, as suggested by Evans et al., then the GF should be being progressively offset and disrupted. Given the ~11 m.y. life span of the faults in the ECSZ, these offsets should individually be on the order of 10 km or more. This is clearly not the case: the GF forms a conspicuous and continuous morphological feature, without significant offsets. Given the well-documented slip rate on the GF over this same period (Monastero et al., 1997), the simplest solution to the problem is that the GF is accommodating right-lateral shear in the ECSZ by a combination of left slip and clockwise rotation, both of the fault itself and the rocks surrounding it. The equivalence of these two modes of deformation can be simply expressed in terms of the velocity gradient tensors, taking the trend of the ECSZ as the x1 direction, with dextral shear at rate  $\gamma$ , and assuming that the GF trends normal to the ECSZ:

$$\begin{bmatrix} 0 & 0 \\ -\gamma & 0 \end{bmatrix} = \begin{bmatrix} 0 & -\gamma \\ 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & +\gamma \\ -\gamma & 0 \end{bmatrix}, \quad (1)$$

where dextral shear on ECSZ = sinistral shear on GF + clockwise rotation.

Shear on faults is, of course, localized, so we have to treat the GF and its surroundings as a rigid rotating block containing the actively slipping fault. The right-slip faults in the ECSZ have to die out at the boundaries of this block, which is what we observe, and transfer their displacements onto the margins of the

block. Geodetically, this mode of deformation appears as dextral shear parallel to the ECSZ, so that the GF is geodetically invisible, though Platt and Becker (2013) showed that interseismic elastic strain accumulation on the GF should produce a residual signal equivalent to ~1 mm/yr left slip, which is what we actually see.

Dextral shear in the ECSZ requires that any material line cutting across it rotate in a clockwise sense, so that rotation of the GF is inescapable (Savage et al., 2001; Gan et al., 2003). The model proposed by Platt and Becker (2013) reconciles the geologic and geodetic evidence, and highlights the importance of understanding the kinematics of intersecting fault sets in geodetic analysis. It also conveniently avoids proposing large amounts of right-slip on faults cutting the GF, which demonstrably do not exist. The same model can be applied to the panels of left slip faults in the Fort Irwin area and in the eastern Transverse ranges; in both these cases, large clockwise rotations have been demonstrated paleomagnetically (Carter et al., 1987; Schermer et al., 1996), and in the eastern Transverse ranges, this model also avoids the need to propose large amounts of right slip on non-existent faults. Paleomagnetic evidence for rotation is unfortunately largely lacking for the GF, in large part due to the absence of suitable rock types.

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