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Do stress-paleostress and deformation analyses provide similar or complementary information in brittle tectonics ?

J. Angelier

(1) Geosciences Azur, Observatoire de Villefranche & Institut Universitaire de France. BP 48,La Darse, 06235 Villefranche-sur-Mer, France (jacques.angelier@geoazur.obs.vlfr.fr)

Stress-paleostress analysis provide access to the mechanical behaviour of the brittle crust through measurements and inversion of tectonic data (faults, non-faults, pressure and tension structures) or double couple focal mechanisms of earthquakes. Using similar data with additional measurement of displacement amplitude on brittle features, or moment tensor for earthquakes, it is also possible to determine strain tensors, a familiar technique in geodetic studies of surface displacement. To illustrate these aspects, examples from Taiwan, Iceland, Colombia and Iran are provided based on the use of direct inversion methods. A basic question however arises: do these analyses provide results that can directly be compared ?

As a major difference, analyses of displacement and strain in brittle crust (where mechanical discontinuities play a major role so that deformation cannot be considered continuous at any real observation scale) require determination of displacement amplitudes (as do geodetic analysis), whereas analyses in terms of stress only require observation of directions and senses of slip on known faults (or pressure or tension on corresponding structures). Not only do this contrast result in a major difference in practice (because measuring amplitude displacements for large samples is much more difficult than measuring only orientation data), it also implies a major difference in the meaning of the inversion.

It is well known that in brittle media undergoing discontinuous deformation the directions of strain and stress do not coincide except in particular cases. In addition to classical theoretical analysis of strain-stress relationships, the example of seismotectonic analysis based on large numbers of earthquake data at the scale of a divergent

plate boundary offset by major transform faults indicates that at the regional scale the differences in trend between plate divergence and extensional stress reach about 40˚. The differences are largest in transform zones where strike-slip prevails. Furthermore, these results are consistent with a simple distinct-element numerical modelling analysis.

It is concluded that confusion between strain and stress analyses may be a source of major mistakes in tectonic or seismotectonic studies, and hence should be avoided. On the other hand, comparison between regional displacement and stress provides valuable insights regarding the mechanical behaviour of the crust.