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A Brief History of the Study of Non-Double-Couple Earthquake Source Mechanisms

Foulger G R

Dept. Earth Sciences, Durham University, Durham DH1 3LE, UK,
g.r.foulger@durham.ac.uk

Although non-double-couple (non-DC) earthquake mechanisms were treated theoretically prior to 1980, it was not until 1983 that convincing observations were reported, for two 1980 M ~ 6 Long Valley caldera, California, earthquakes, which had almost pure CLVD mechanisms (Julian, 1983), and were interpreted as representing dyke injections. This was followed swiftly by report of small earthquakes from the Hengill geothermal area, Iceland, which had large positive volumetric components (Foulger and Long, 1984). These were interpreted as resulting from thermal contraction cracking in the geothermal heat source.

Subsequently, the seismological community was reluctant to accept the conclusions. Scientists struggled to believe that cavities could open at several kilometres depth in the Earth, where overburden pressures are large. Considerable work was done to test whether the observations could be explained by errors. However, by the late 1980s non-DC earthquakes were reported from diverse environments, including volcanoes, subduction zones, and mines. It gradually became accepted that natural earthquakes can have non-DC mechanisms.

Today it is common to calculate full moment tensors rather than fault-plane solutions, which were traditional for over half a century. The results have greatly enhanced our knowledge of the causes of deep-focus, volcanic, geothermal and mine earthquakes. They have also been utilised as a commercial and hazard-reduction tool. Nevertheless, we are still far short of fully understanding what many moment tensors represent. Progress has recently been made by combining moment tensors with highly accurate relative relocations. This may be a promising way forward, given the high-quality data sets that are emerging from industrial work in geothermal, oil and gas fields.

Foulger, G.R. and Long, R.E., 1984. Anomalous focal mechanisms; tensile crack formation on an accreting plate boundary. Nature, 310(5972): 43-45.

Julian, B.R., 1983. Evidence for dyke intrusion earthquake mechanisms near Long Valley caldera, California. Nature, 303(5915): 323-325.