Quantifying natural fault geometry: Statistics of fault branch angles

Ryosuke Ando[1]; Bruce E. Shaw[1]; Christopher H. Scholz[1]

[1] Columbia Univ.

http://www-solid.eps.s.u-tokyo.ac.jp/˜ando/

With improvements in computer simulations and seismic observations, we become aware of that the detailed structures of non-planar and network-shaped fault system geometry affect dynamic rupture processes significantly. On the other hand, although the geometry of individual natural faults has been traced precisely by geological and geophysical observations, we still have had many open questions in terms of general and statistical characterization of natural fault geometry as well as the physical modeling to explain their formation and evolution. For instance, statistics on lengths of fault segments and separations between them have been evaluated, however, as far as we know, similar characterization in fault branch structures have not made yet although they were another basic feature in natural fault geometry. One of the difficulties in such study might be that we tend to rely on visual observations and manual procedures when we analyze observed data; therefore it is hard to treat a massive amount of data objectively and quantitatively. In order to expand the study of fault geometry from a level of individual case studies into the construction of general theory, it is critical to develop an objective and efficient method to analyze fault geometry. Here, we introduce a computer-based analysis applying pattern recognition methodology. This new method enables us to locate branch structures in given fault systems, and measure the sizes of the structures and angles between these branches; the beauty of the angle is what is independent of scale and the two dimensional quantity. We apply this method to a fault database for the entire California cataloged by USGS and CGS. As the results, we observe: (1) a well defined peak in the frequency distribution of the branch angles; (2) this peak appears at an almost same angle regardless of the scales of branch structures, which suggests the branch structure is not self-affine but self-similar; (3) each branch structure is asymmetric composed by a main-fault and a splay fault (i.e. not symmetric fork like shape); (4) the number of the branch structures is a decreasing function of their scales; (5) no obvious correlation between the branch angles and slip rate on these fault segments. These observations can be used to constrain physical models of fault evolutions and earthquake dynamics.