Better constraining the geometry of faults in the Charlevoix Seismic Zone

Oluwaseun Fadugba, Charles Langston and Christine Powell
Center for Earthquake Research and Information, The University of Memphis, Tennessee, USA

The Charlevoix Seismic Zone (CSZ) is located along the early Paleozoic St. Lawrence rift zone in southeastern Quebec at the location of a major Devonian impact structure. The impact structure superimposed three major basement faults trending approximately N35°E. Previous work suggests two sets of geometries for the rift faults. One set has a uniform dip of 70°SE for all three faults while the other has 65°, 40°, and 40°SE, from north to south, respectively. Visual estimation of fault planes from over 1300 relocated hypocenters in the CSZ suggests more complex fault geometry. We apply a cumulative distribution of volume (CDV) of tetrahedra defined by closest neighbor events to remove unclustered hypocenters. The declustering algorithm involves comparing the CDV in the natural catalog to that of a randomized catalog within a spatial domain similar to the seismic zone. We apply a modified version of the Optimal Anisotropic Dynamic Clustering (OADC) algorithm to model realistic fault planes that best fit the clustered hypocenters. OADC method is a generalization of the k-means method using randomly-seeded planes to partition hypocenters into clusters. OADC uses the eigenvalue-eigenvector analysis of the covariance of hypocenter locations by minimizing the smallest eigenvalues of each cluster. The eigenvalues and eigenvectors of each cluster are related to the fault dimension and orientation, respectively. We extend the OADC method by incorporating high-quality source mechanisms of the earthquakes to specify seed planes rather than using randomly-seeded planes. Our fault models show a more complicated geometry than the simple three-faults model in previous studies, especially within the impact structure region, and support the along-strike variation in the fault dips suggested by recent studies.