Segmentation, Growth and Linkage of Normal Fault Arrays: A Three-Dimensional Numerical Analogue of Rift Evolution

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Active and ancient normal fault arrays comprise fault zones that are discontinuous along strike and consist of a number of distinct segments at a variety of scales. It is known that the progressive growth of normal faults ultimately results in linkage of originally isolated fault segments to form large (25-50 km) fault zones. Current understanding of the development of such zones, however, is restricted by an inability to resolve the temporal evolution of relationships between the spacing, length and along-strike segmentation of natural faults in three dimensions over geological time scales.

One of the biggest problems in investigating these large-scale earth systems by numerical methods is the dimension of the media required to accurately simulate crustal processes and the need for a large amount of computational time for simulations to be representative of geological time scales. With the assistance of members of CSAR, a three-dimensional numerical analogue of extension is being developed to investigate the effect of thickness of the brittle crust (seismogenic layer) on the growth and linkage of faults during tectonic extension. The model uses a discrete element technique that represents the crust as spherical particles that interact through physically realistic forces in a two-layer, brittle/ductile system. Terms for gravitation and isostatic flotation are also included. Currently, the models are running using regular particle distributions in small media (~30,000) to ensure that the code is stable. Figure 1 illustrates the surface topographic profile of a medium at 16% extension of the crust in one such numerical simulation. Here, the topography scales from deep (light coloured) to high (dark coloured) terrain. Examples of faults are indicated on the figure, the pale grey surface represents a sea-level added to aid visual acuity. The work is already beginning to throw light on questions from geology regarding the relationship between the growth and linkage of faults and their spatial distribution within the brittle crust.

Figure 1 shows that regular geometries lead to preferred orientations for failure within the simulations. It is planned that further development of this code will permit investigation using media that consist of greater than 10^6 elements in a random distribution. It is hoped that results from these experiments will provide templates for interpretation of structures imaged in 3D subsurface datasets and allow investigation/ prediction of the distribution of sub-seismic fault populations. The code is also applicable to the investigation of earth surface processes and collaboration is currently underway to couple this 3D model with landscape evolution models that are being developed by Dr. Stuart Hardy in the Department of Earth Science, Manchester.

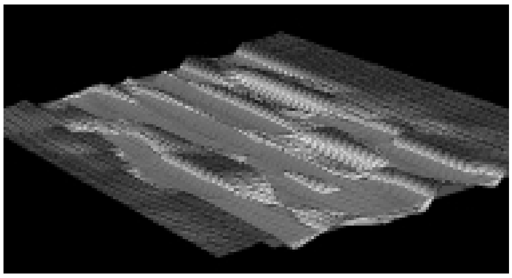

Figure 1; Example of the upper surface topography of the 3D model after 16% extension to the left. The crests of a number of faults are indicated by white circles.

This work has recently been presented at the American Geophysical Union Fall Meeting in December, 2000 and further analysis of the data will be presented at the American Association of Petroleum Geologists in June, 2001. The work was funded for one year by EPSRC.

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