Lawrence Livermore National Laboratory

NUCLEAR SYSTEMS SAFETY PROGRAM

L-196

October 16, 1987

Mr. M. E. Blackford, MS-623ss
Project Officer, WMGT
Technical Review Branch
Division of High-Level Management
Office of NMSS
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Transmittal of Letter Report on Normal Faulting
FIN A0297

Reference: "Displacement Geometry in Volume Containing a Single Normal Fault," AAPG Bulletin, vol. 71, no. 8, p. 925-937 (1987) by J.A. M. Barnett et al.

Dear Mr. Blackford:

Transmitted herewith, please find a review letter report on the reference paper by Barnett et al. (1987). The authors propose a model for a single, ideal normal fault. One feature of the model is a zone of ductile deformation which could affect the porosity and permeability of the rocks surrounding the fault. These authors also point out the ductile deformation results in changes in bedding dip which can be mistaken for block rotation associated with listic faulting.

If you have any questions, please let us know.

Sincerely yours,

/S/

Dae H. (Danny) Chung
Project Leader

DHC/ic

Attachment as stated.

cc: C. Abrams, NRC/WMGT

LLNL Document Review Sheet

Review Document Number: HLM 87-1

Topic: Structural Geology

Site Applicability: NNWSI

Document: Barnett, J. A. M., Mortimer, J., Rippon, J. H., Walsh, J. L., Watterson, J. (1987) Displacement Geometry in Volume Containing a Single Normal Fault, AAPG Bull., v. 71, no. 8, p. 925-937.

Reviewer: H. L. McKague/D. H. Chung

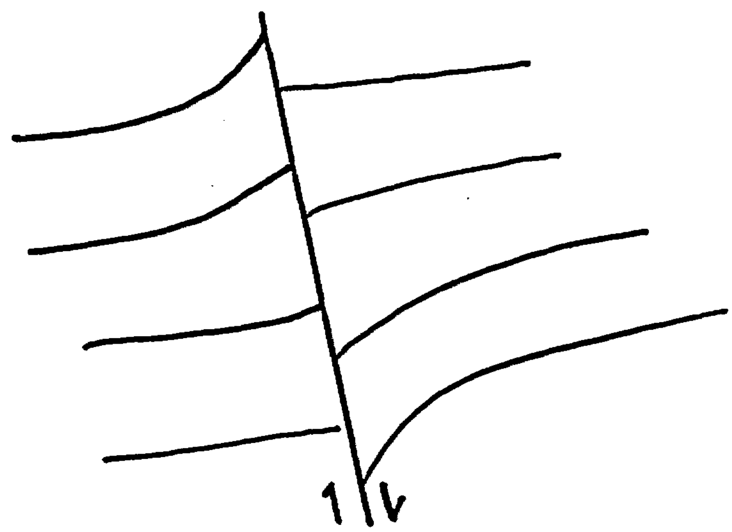
Date Review Completed: 10/12/87

Brief Review of Document:

The authors used measured displacements along faults in U.K (United Kingdom) coal mines and seismic data on U.K. offshore faults to develop their model describing near-field displacements associated with an ideal, single normal fault. The model is best suited to faults with strike length of less than 20-30 km and maximum displacements of less than 200m. On a blind fault (one not expressed at the surface) the displacement ranges from a maximum at the center to zero at the tip-line. The tip line is elliptical along the fault surface. The shorter axis of the ellipse is parallel to the displacement direction.

For faults that break the earth surface, it is assumed, according to the authors, "On faults intersect a free surface, the maximum displacement and and maximum dimension generally occur at the surface."

Ductile* deformation occurs in a volume of rock on either side of the fault. This deformation is often shown as reverse drag features, resulting in rollover in the hanging wall and rollunder in the footwall. If the sedimentary rocks are horizontal and the fault plane vertical, the ductile deformation will be symmetrical across the fault plane. When the fault plane is inclined, the resultant ductile deformation will be expressed as asymmetric structures across the fault plane. The amount of deformation on the rollunder structure will decrease downward and the amount of deformation on the rollover structure will increase downward. This results in dipping beds on downthrown side of the fault across from non-deformed beds on the hanging wall (see sketch). Such configurations have been interpreted as evidence for listric faulting. Block rotation resulting from listric faulting can be proved only if the dipping beds occur beyond the volume of rock affected by near field ductile deformation.



*Ductile is defined by the authors as deformation in which macroscopic discontinuities either are not developed or are centimeter scale only.

Significance to NRC Waste Management Program:

The authors model describes near-field displacements associated with normal faulting. The model relates fault length to displacement along the fault and to deformation in a volume of rock surrounding the fault. The latter is a zone of ductile deformation.

While the model is still very preliminary and has been tested only in sedimentary basins, it may have some applicability to faults at Yucca Mountain, especially the Ghost Dance fault.

One characteristic of the model is that it allows prediction of the radius of ductile deformation that surrounds the fault. This volume of rock is referred to as the fault volume and it comprises those rocks along and surrounding the fault surface, which are affected by near-field displacements due to fault movement. Ductile deformation most often shows up as reverse drag and could affect the porosity and permeability in the rocks surrounding the fault. For example, the Ghost Dance fault using a displacement of 60 m (Scott and Bonk, 1984, A-A' cross section) and an r/D ration of 20 (for faults with maximum displacements (D) of less than 10 m), the perceptible drag radius (r) would be 120 m. Thus the authors model would estimate the zone of ductile deformation extending to 120 m perpendicular to the Ghost Dance fault. There are several caveats on this: (1) the r/D ratio is for rocks in sedimentary basins and would vary inversely with the ridigity modulus of the rock, and would vary for different volcanic tuffs depending upon the degree of welding; (2) the amount of deformation decreases outward from the fault and (3) even very near the fault changes in porosity and permeability may be insignificant with regard to hydrology.

When the width, W, i.e., the longest horizontal distance along the fault, is plotted against the displacement D, the Ghost Dance fault falls within the field of faults from British coal fields. For the Ghost Dance fault W is 885m and D is 6m. As can be seen in Figure 1, the Ghost Dance faults plots with the faults measured in the coal fields, suggesting the length and accompanying displacement are consistent with those measured on other normal faults.

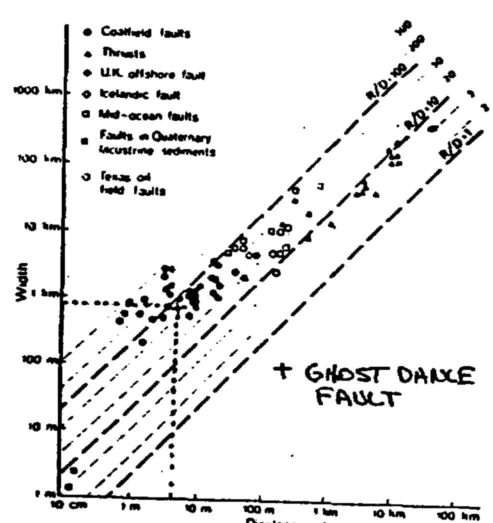


Figure 1—Logarithmic plot of width (W) against depth (D), for coalfield faults (Rippon, 1985), Icelandic fault scarp (Gudmundsson, 1980), mid-ocean ridge fault scarps (Laughton and Searle, 1979; Searle, 1983), thrusts (Elliott, 1976), Quaternary faults (Muraoka and Kamata, 1983), Texas oilfield faults (Lahee, 1929), and United Kingdom offshore fault. Contours of R/D also shown (R = W/2).

The authors also point out how some features considered by geologists to be characteristic of listric faults can also be explained resulting from ductile deformation along simple normal faults. According to the authors "Hanging wall rollovers and tilting of the seismic reflectors cannot be used to distinguish listric from planar normal faults; even where fault block rotation can be demonstrated, neither listric faults geometry nor a flat detachment surface is geometrically necessary." This statement may be correct, but it is not clearly illustrated in the text of the article.

In summary this paper makes several points that are of significance to the NRC: (1) authors identify a near field volume of rock in which ductile deformation occurs, which can effect the porosity and permeability of the rock , (2) ductile deformation results in rollover and rollunder structures so that bedding dips can change as the fault is approached, and (3) such changes in bedding dip can be misinterpreted as resulting from listric faults.

Problems, Deficiencies or Limitations of Report:

Some parts of paper are not clearly written making understanding the paper difficult. Probably has limited applicability, because there are very few ideal single normal faults at Yucca Mountain. However the Ghost Dance fault may meet that definition.

Action Taken:

Submitted to NRC.

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WM Project 10, 11, 16
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