DISCUSSION

D. COATES (Canada):

Can you suggest a definition and description of joints so that they can be identified on a rock face? It is often difficult to distinguish a joint plane from a plane which has been formed by blasting. Some material property aside from bedding provides a preferential surface for such breaking.

M. FRIEDMAN (in reply):

Certain trivial cases can easily be recognized. For example, there is little doubt about the origin of fractures that radiate from blast holes or of fractures that are filled with natural vein material. However, consider two situations where such obvious features are not developed. In the first, let us assume it is possible to move away from the blasted face to some structurally similar location where only the natural fractures can be observed. In the second, we will assume it is impossible to observe an unblasted exposure.

In the former situation, it is possible to map the natural fracture geometry, the average spacing for each of the fracture sets, and any markings that might exist on the natural fracture surfaces (e.g., plumose or conchoidal structures) in the region unaffected by blasting. These can then be traced back into the blasted area and compared with the observed fracture array. At the blasted face, one could then detect the development of new fracture sets (recognized by their geometry or perhaps by the presence or absence of surface markings) or changes in the spacing between natural fracture sets.

In the second situation, where one cannot move away from the blasted area, my first inclination is to say that one could not differentiate between the natural and the induced fractures. After all, they are fractures in rock, and the only difference between them is the energy source used to initiate them. However, if you can measure the residual strain gradient away from the fracture surfaces you may find that the gradients associated with paleo-fractures are different from those adjacent to induced fracture surfaces. The nature of this difference, if any, would have to be determined under controlled conditions. As far as

I am aware, the measurement of such gradients has not been attempted, but it should be possible by use of resistance foil gages, photostress methods, or X-ray diffractometry.

R. P. TRUMP (USA):

I have a question for Dr. Friedman. In your talk on the fold, you show a rather high amplitude fold having the neutral axis within the fold. If this fold is developed by thrusting or buckling, the neutral axis is not contained in the fold in the early stages of the process. Now, the question is, do you believe that your correlation with the neutral axis means that what you are seeing is a late stage deformation after the wave length has already been determined and, in turn, that the lateral pressure was relatively low at the time of initial fold development?

M. FRIEDMAN (in reply):

I do not think this question can be answered from study of the fractures alone. However, in the course of studying fractures on folds we have also investigated the deformed calcite in limestones. In many cases the same orientations for the principal stresses are derived from the calcite twin lamellae as from the fracture geometry. As the critical resolved shear stress to initiate twin gliding in calcite is low (less than 100 bars), I visualize the calcite as beginning to deform rather early in the development of the fold. Accordingly, as both the calcite and the fractures reflect the same principal stress orientations, I conclude that some fractures also were initiated early in the folding history.