MECHANIC EXPLANATION TO VARIATION OF FAULT DIPS UNDER NORMAL FAULT REGIME AT SHALLOW LEVELS

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Summary: In this paper, we give an example of low angle normal faults from Queretaro City in Mexico. A mechanism of fault interaction is proposed by our observation.

Anderson´s model (1951) predicts that normal faults can only form at an angle larger than 45° (Jaeger et al., 2007), and will rotate down to 30° during continuous activity. New evidences have shown that low angle normal faults (less than 30°) do slip and they may act more like weak faults. The proposed mechanical theories for the low angle normal faults (LANFs) include (a) Passive rotation; (b) Isostatic adjustments; (c) Stress rotations; (d) Subhorizontal shear stress at the base of the brittle upper crust; (e) Fault weakening.

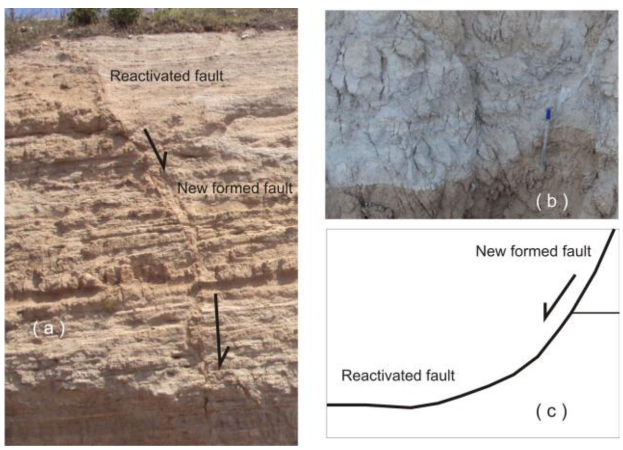

Figure 1. (a) Normal fault observed in the ignimbrite located in the vicinity of Queretaro City. The upper part was formed due to reactivation of pre-existing unconformable contact. The lower part is a new formed fault. (b) and (c) Listric normal fault. The lower part was formed due to reactivation of pre-existing layer-contact. The upper part is a new formed fault

In this paper, we study dip changes of normal faults from an example of normal faults from Queretaro City, Mexico, located in central Mexico. The main fault system in the study area is the NNW Taxco–San Miguel de Allende fault system described. Neogene fault activity has been documented for this fault system. The activity produced many tensile fractures and normal faults (Figs. 1). From Fig. 1a, we can see that one normal fault can show different fault mechanisms. In the upper part, the fault was formed due to reactivation of local unconformity plane, and fault dip is low-angle. In the lower part, the fault is new formed, and fault dip is high-angle. This feature can be also observed from Figs. 1b, 1c. The lower part of the faults was formed in the contact between layers, which can be considered as pre-existing weakness plane. The upper part was a new formed fault

These examples indicate that one normal fault can include reactivated parts and new-formed parts.
On the other hand, we can see that fault dips vary considerably in Figs. 1b, 1c. The maximum dip is about 90°, and the minimum dip is 0°. The dips for the reactivated fault can be less than 30°. This paper will offer an explanation of slip on LANFs by mechanic interaction between interacting normal faults. As known, low angle normal faults are commonly associated with high-angle normal faults. That is to say, LANFs are usually linked with high-angle normal faults. It has been documented that near the intersection line of interacting faults, the shear stress increases considerably (Maerten, 2000, Figs. 2a, b) as well as occurs rotation in the stress field (Pollard et al., 1993). These two factors: stress increase and stress re-orientation can produce slip on the LANFs. This process can be expressed by Mohr diagram in 3D (Figs. 2c, 2d).

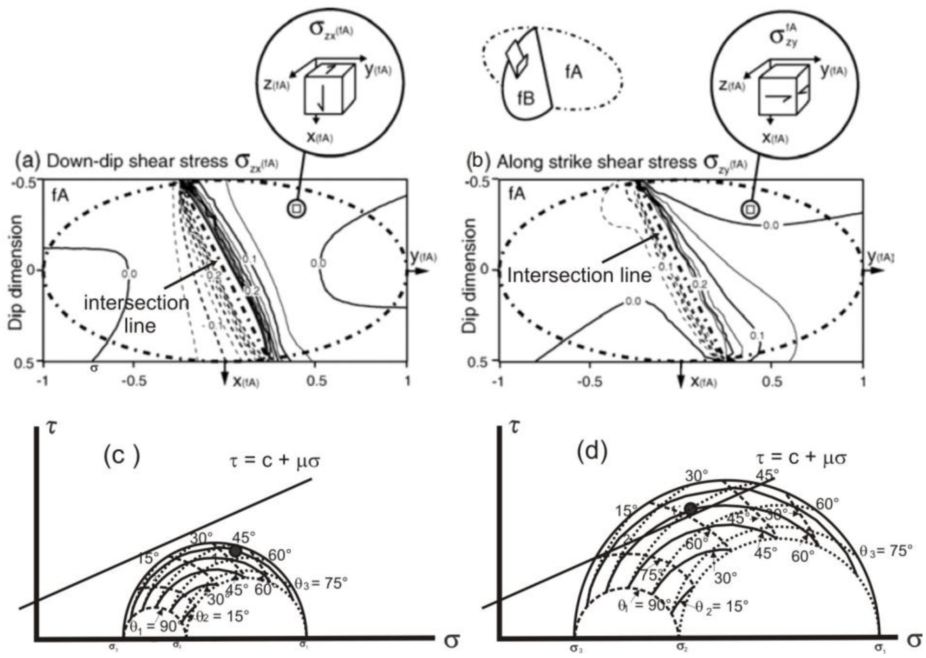

Figure 2. (a) and (b) showing increase of shear stress in the vicinity of intersection line of two intersecting faults (from Maerten 2000). Number of contours indicates percentage of increase of shear stress. (c) Mohr diagram in the case of no fault interaction. (d) Mohr diagram in the vicinity of intersection line of two intersecting faults.

Comparing Fig. 2d with Fig. 2c, stress increase causes the increment of Mohr circles. In this way, the Coulomb-Navier slip criterion can be through the Mohr circles (Fig. 2d). On the other hand, the stress rotation can change the location of low angle planes on the circles. Because of these two mechanic changes, the stress on the low angle planes can fall above the Coulomb-Navier slip criterion on the Mohr diagram (Fig. 2d), and finally the low angle planes could initiate slip. This mechanism indicates that one normal fault may be linked result of faults with different dips, which can be both new formed fault and reactivated faults.

References

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