Stresses and Pore Pressures at the Crest of Dipping, High-Permeability, Structures

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ABSTRACT

We calculate the stresses and pore pressures that develop at the crest of dipping, high-permeability structures, due to a regional over-pressured field, and demonstrate that elevated pore pressures, very low strength and localized fracture zones are encountered. We use a coupled poro-elastic model. We show that the flow field at the tip of the structure increases the total horizontal stress and locally elevates the pore pressure. The magnitude of the stress changes can be bounded by two limit solutions: the uniaxial and the single-source flow solutions. We also explore how the stress field is affected by permeability anisotropy and the structural relief. Higher horizontal permeabilities lead to more significant changes in the horizontal stress. In the case of high relief structures, the pore pressures converge on the lithostatic stress at the crest, leading to zero effective stress conditions and therefore fracture openings (tensile failures; Figure 1).

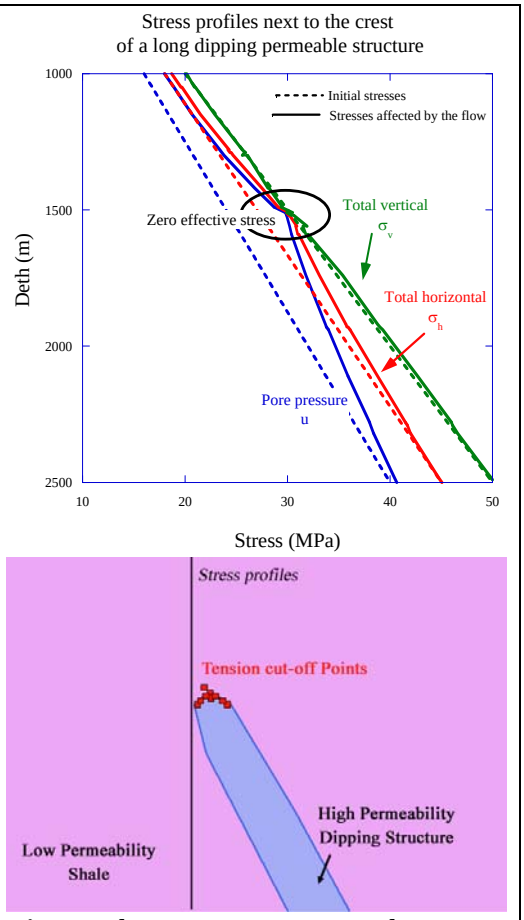
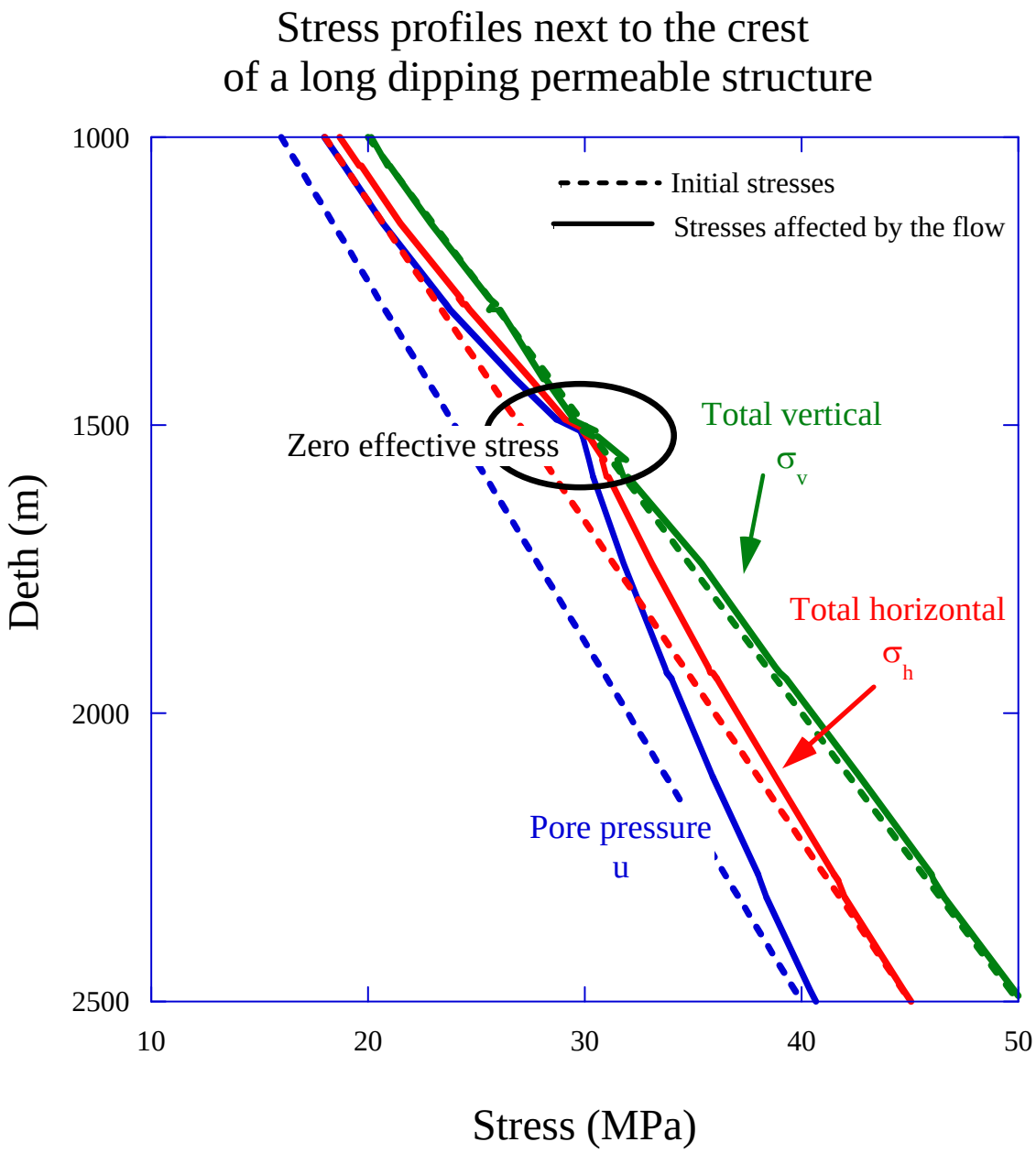
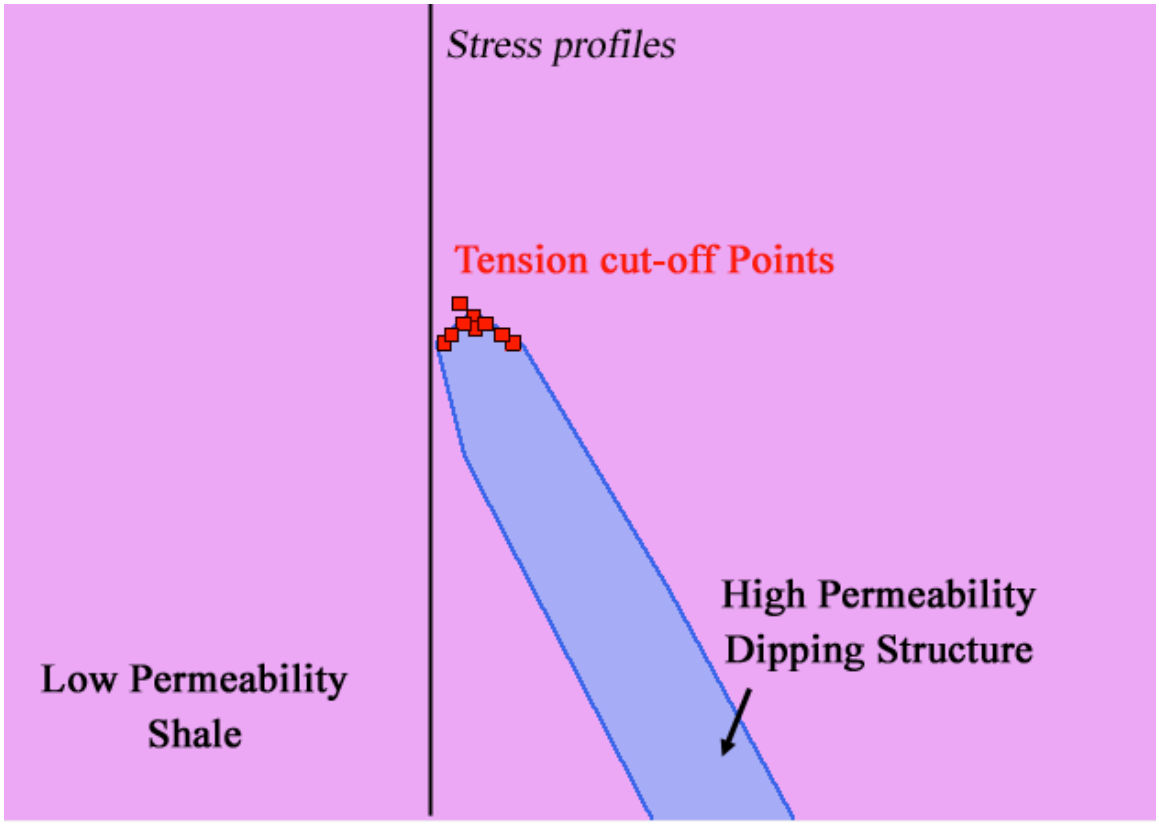


Fig. 1: The pore pressures at the crest of a high relief structure converge on the lithostatic stress. The horizontal stress also becomes equal to the lithostatic one. As a result, the effective stresses become zero, and fractures may open.


Stress profiles next to the crest
of a long dipping permeable structure
Initial stresses
Stresses affected by the flow
Zero effective stress
Total vertical
σv
Total horizontal
σh
Pore pressure
u
Deth (m)
1000
1500
2000
2500
10
20
30
40
50
Stress (MPa)



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