Initiation and rise of salt walls: Finite-element modeling on deformation, stresses and overpressures

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ABSTRACT

We develop new finite-element models to simulate initiation and rise of a salt wall during sedimentation under drained conditions and in transient analysis. We investigate deformation, stresses and overpressures. Our results show that 1) overpressures are different through the profiles across the minibasin; 2) overpressures predicted by finite-element models and the uniaxial model match well at far field, but mismatch in the minibasin due to horizontal shortening here; 3) minimum principal stress (leak-off stress) increases close to overburden at the flanks of the salt wall and in the minibasin due to salt-wall horizontal pushing out, but drops near the base of the salt wall and at the bottom of the minibasin.

Our results in this study provide insights into understanding near-salt stresses and overpressures, and implications for wellbore drilling programs.

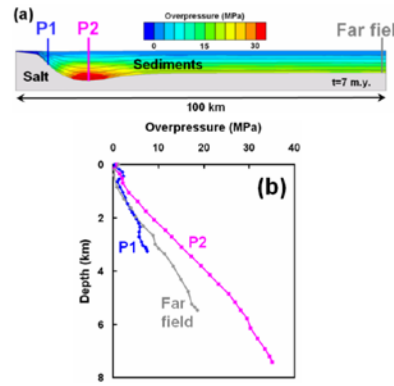

Fig. 1: (a) Finite-element model overpressures in sediments during sedimentation. (b) Finite-element model overpressures through different profiles across the model.

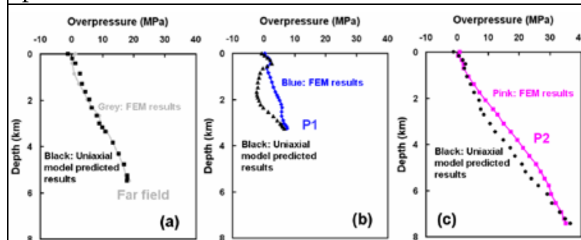

Fig. 2: Comparison of finite-element model (FEM) predicted overpressures with the uniaxial model predicted overpressures through far-field profile (a), near-salt P1 profile (b), and minibasin-center P2 profile (c). Profile locations are shown in Fig.1a.

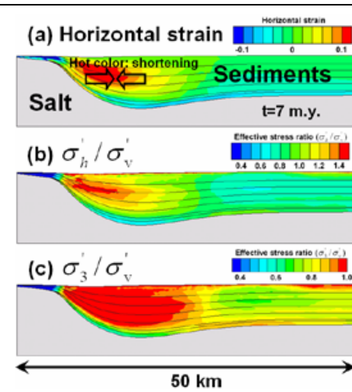

Fig. 3: Finite-element predicted horizontal strain (a), ratio of horizontal and vertical effective stresses (b), and ratio of minimum principal effective stress and vertical effective stress (c).

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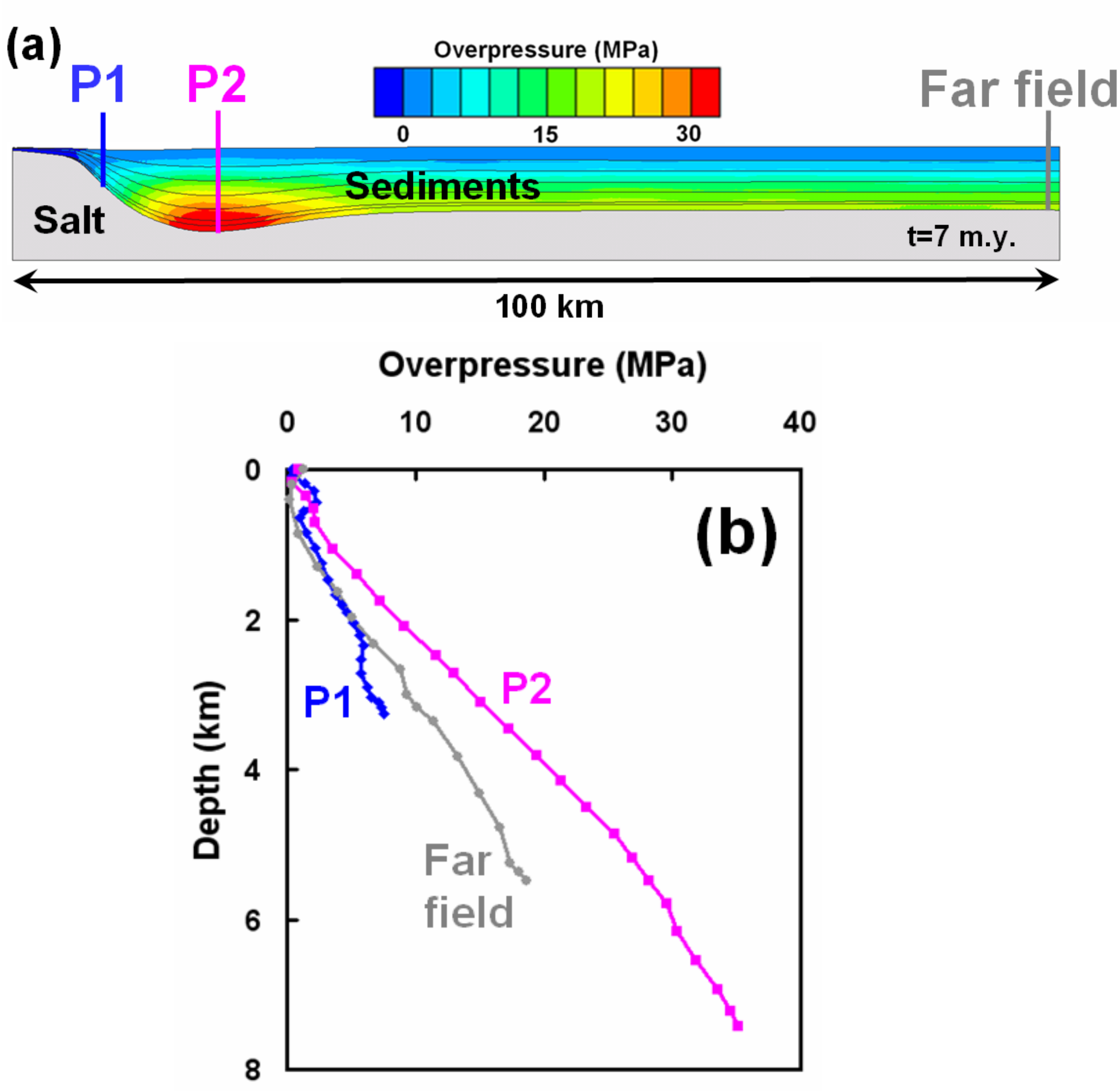

Fig. 1: (a) Finite-element model overpressures in sediments at 7 m.y. during sedimentation. Overpressures are concentrated at the bottom of the minibasin center. P1, P2 and far field show the locations of overpressure profiles in (b). (b) Finite-element model overpressures are different along different profiles across the minibasin. Depth on vertical axis: below sea floor.

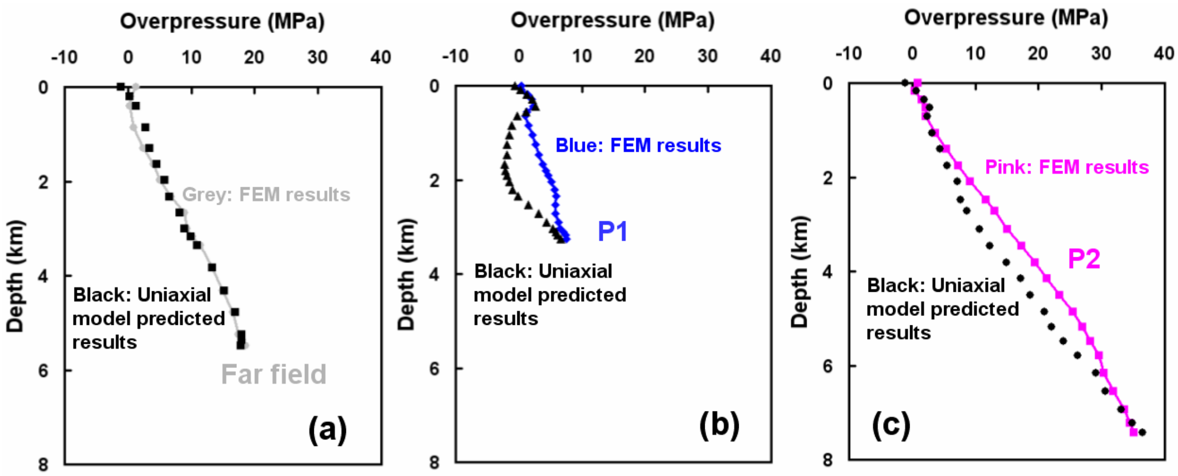

Fig. 2: Comparison of finite-element model (FEM) predicted overpressures with the uniaxial model predicted overpressures through far-field profile (a), near-salt P1 profile (b), and minibasin-center P2 profile (c). Profile locations are shown in Fig.1a. We input finite-element model porosity results into uniaxial model to predict overpressures. Overpressures predicted by the uniaxial model match well with finite-element model results through far-field profile (a), but they are lower than finite-element model results through P1 profile (b) and P2 profile (c). These mismatches through P1 and P2 profiles are caused by horizontal shortening (or additional lateral loading) at the flanks of the salt wall and in the minibasin due to horizontal pushing out of the salt wall to the minibasin (see Fig. 3). The uniaxial model assumes no horizontal strain, but it is horizontal shortening at the flanks of the salt wall and in the minibasin (see Fig. 3). Hence the uniaxial model is violated through P1 and P2 profiles. Depth on vertical axis: below sea floor.

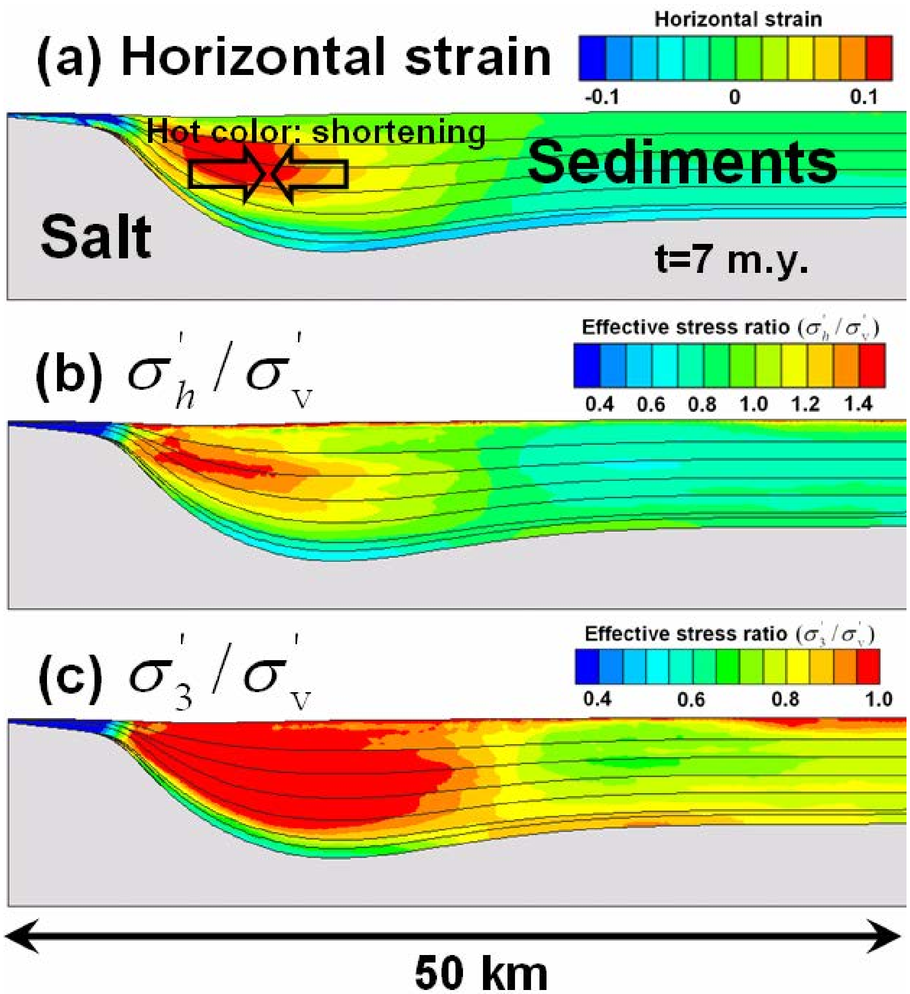

Fig. 3: (a) Horizontal strain predicted by finite-element models. Hot color (positive) shows horizontal shortening. It is horizontal shortening in the minibasin due to horizontal pushing out of the salt wall to the minibasin. There is no horizontal strain in far field. (b) Ratio of horizontal and vertical effective stresses predicted by finite-element models. Horizontal stress increases much even higher than vertical stress in the minibasin due to horizontal pushing out of the salt wall to the minibasin. Far-field stresses are not perturbed and the effective stress ratio is 0.8. (c) Ratio of minimum principal effective stress and vertical effective stress predicted by finite-element models. Minimum principal stress is close to vertical stress in the minibasin due to horizontal compression here.