Stabilizing boreholes in shale formations through osmotic back-flow

Stabilizing Boreholes in Shale Formations through Osmotic Back-flow

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Borehole Stability

To access and continuously produce the large natural energy resources of oil and gas found in the earth's crust, the petroleum industry drills numerous wells each year.

Before a well is drilled, compressive in-situ stresses (Fig.1) exist within the rock formations.

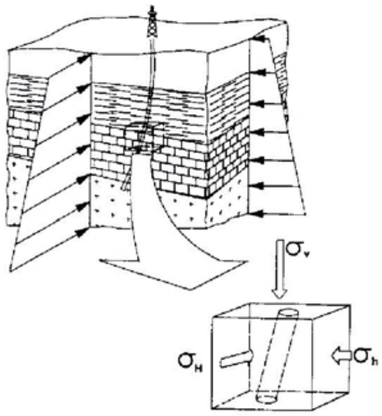

fig. 1 *In-situ stresses on borehole*

Redistribution of the in-situ stresses around the borehole wall causes stress concentrations in the vicinity of the borehole.

These stress concentrations may exceed the elastic range causing elasto-plastic deformations. If the rock is not strong enough the borehole may fail and ultimately become unstable.

During production, the borehole is stabilized using casings and cement. During active drilling however, support can solely be provided by the *drilling fluid pressure*, which only partly replaces the support originally offered by the drilled out rock.

Stabilizing Shales

Borehole instability in shales is a major technological problem area in oil and gas well drilling.

When the drilling fluid invades the shale, this causes a strength reduction. If the strength reduction becomes critical the hole becomes unstable and collapses.

The *chemical composition* of the drilling fluid can be adopted to create an osmotic back-flow to reduce this invasion rate.

4-Phase FE Model

To describe the behaviour of shales, an FE-model is derived from mixture theory [1]. In this model four components following different kinematic paths are defined;

solid fluid cations anions.

The model is able to describe many of the observed flow phenomena in shales, such as streaming potentials, electrophoresis and *electro-osmosis*.

Osmotic Back-flow

Fig. 2 shows the results of an osmosis experiment for shales and the results of a FE-simualtion.

The drop in the downstream pressure occurred when the upstream fluid was exchanged for a *KCl-solution*, while the pressure is constant. The observed pressure drop arises entirely from the change of chemistry of the upstream fluid and is evidence of osmotic backflow.

Discussion

Both the experiment and the simulation show that the effects of the osmotic back flow wears off in time [2]. The stability is thus only waranted for a *limited time*, but this could be just enough to drill and complete the well.

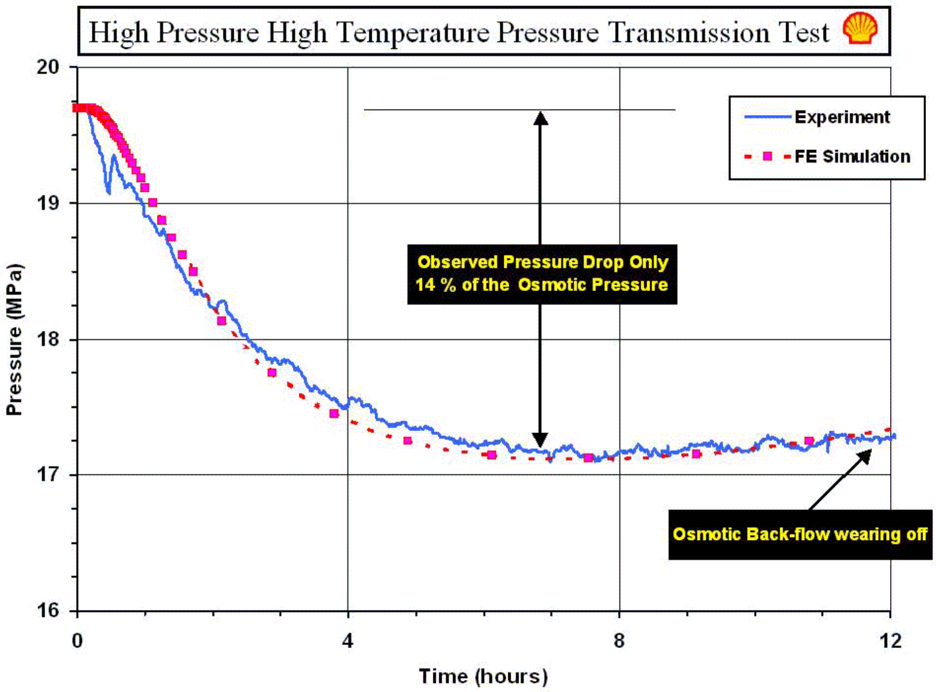

fig. 2 *Experimental and numerical simulation of osmotic back-flow in shale*

References:

[1] Molenaar M.M., Huyghe J.M. and Baaijens F.P.T.: IUTAM Symposium, Stuttgart, Germany, Sept. 5-10, 1999.

[2] Molenaar M.M., Huyghe J.M. and Baaijens F.P.T.: Int. Symposium on Coupled Phenomena, Sanya, China, Nov. 1-3, 1999.