Comparing and Contrasting Oil Field-Scale and Sedimentary Basin-Scale Data

Pore pressure/stress coupling is observed at both the oil field- and the sedimentary basin-scales. However, there are significant differences between the two scenarios:

- pore pressure and minimum horizontal stress decrease in the oil field case and increase in the sedimentary basin case;
- limited range of depths, ages, lithologies, and material properties sampled at the field-scale;
- different techniques for determining pore pressure and stress at the field- and basin-scale, and;
- anthropogenic timescale of field development versus geological timescale of overpressure development.

As illustrated below, field-scale data are obtained from the same depth, and pore pressure/stress coupling can be demonstrated by plotting the two variables directly against one another. Sedimentary basin-scale data are from a range of depths, and must be normalised as pressure gradients in order to analyse pore pressure/stress coupling.

Comparing Oil Field- and Sedimentary Basin-Scale Data from the Ekofisk Region

The differences in the spatial and temporal scales of field- and basin-scale pore pressure/stress coupling beg the question whether the same processes operate in the two scenarios.

In order to address this, Teufel et al.'s (1991) Ekofisk field-scale data are compared with exploration pressure measurements from the surrounding area of the North Sea.

The Ekofisk field-scale data come from repeated hydraulic fracture-type measurements of minimum horizontal stress as pore pressure was depleted from ~45 MPa in 1975 to ~25 MPa in 1990. The basin-scale data are from exploration wells in Norwegian quadrants 1 & 2, with minimum horizontal stresses proxied by leak-off pressures and pore pressures by drilling-ahead by mud weights.

Given the different spatial and temporal scales at which field- and basin-scale pore pressure/stress coupling occur, the two datasets from the Ekofisk region are remarkably consistent.

Field-scale: \( \frac{\Delta \sigma_h}{\Delta P} = 0.8 \)  
\( (k = 0.20 \text{ or } m = 5.0; \text{Teufel et al., 1991}) \)

Basin-scale: \( \frac{\Delta \sigma_h}{\Delta P} = 0.73 \)  
\( (k = 0.27 \text{ or } m = 3.7) \)

Conjugate normal faults, tensile fractures and hybrid tensile-shear fractures with infillings of calcite and bitumen in the Miocene Monterey Formation, Arroyo Burro Beach, California (Sibson, 1996). Fault-fracture meshes of this type may be generated by overpressured fluids and provide important conduits for primary and secondary migration and seal breaching. The degree of overpressure required to generate such meshes and the elements that dominate (shear versus tensile versus hybrid) are strongly influenced by pore pressure/stress coupling.