International Reservoir Technologies Inc.

Training by Modeling Professionals

Flow Unit Basal Shale Barrier Treatment Tips and Trick No. 1

The Problem

The treatment of vertical barriers between flow units is important in model simulation due to their effects on fluid movement and pressure. These barriers are identified from core, log, pressure, and field dynamic data. Examples include tight limestone and shale beds that the geologist can correlate around the field but may vary in thickness considerably. There are two common approaches (Figure 1): 1) treat the barrier as a separate deterministic layer and 2)include the barrier in one of the flow units and model the shales stochastically.

If shales are treated as individual layers the vertical flow behavior will be explicitly addressed (Figure 2). The simulation model will calculate the communication or transmissibility between the active flow units based on the properties assigned to those units. The shale layers will have zero permeability vertically and areally. In those areas where the shale pinches out, vertical flow will be allowed between the active layers.

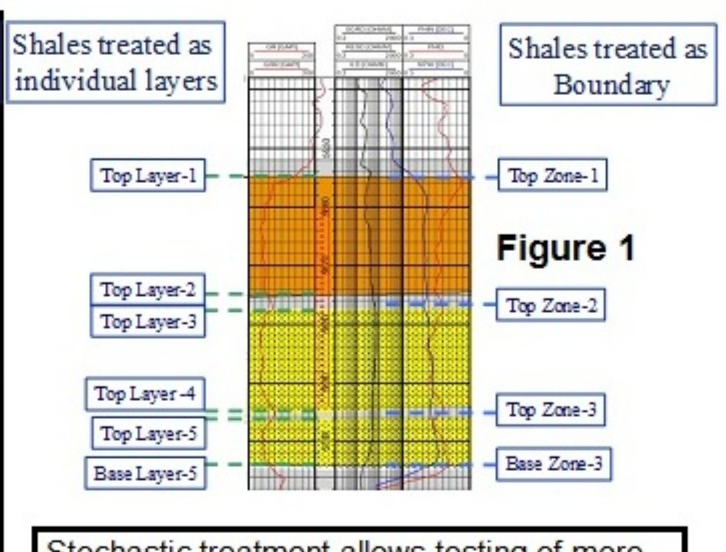

Figure 1

Stochastic treatment allows testing of more geologically realistic shale object distributions. The weakness of the traditional stochastic approach can be seen in the simple example (Figure 3) with three example simulation layers, each corresponding to five layers in the geological grid shown by the thin lines. Traditional upscaling would result in a reduced Kz for the layer containing the shale, which wrongly impacts transmissibility within flow unit 2 and between flow unit 1 and 2. With the basal shale approach, Kz is calculated for the sand only. Then the impact of the shales is modeled by a Z transmissibility multiplier as a function of shale thickness.

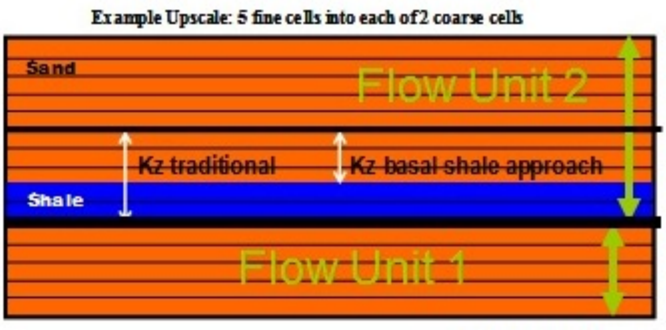

Figure 3

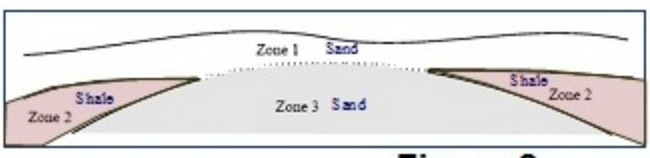

Figure 2

The Solution

Scripts can be written for the leading geocellular modeling packages that examine the facies realization and identify the vertically continuous shale values between congruent flow units. Figure 4 shows a vertical facies proportion curve (top) for sand (orange) and shale (blue) and 3 layers from and example realization. This would be typically of a prograding shoreface flow unit with net to gross increasing from bottom to top. Layer 3 is dominated by shale.

The scripts can flag the basal unit shales as shown in the cross sections of Figure 5 and sum their thickness. This thickness can then be used to estimate vertical transmissibility.

Figure 5

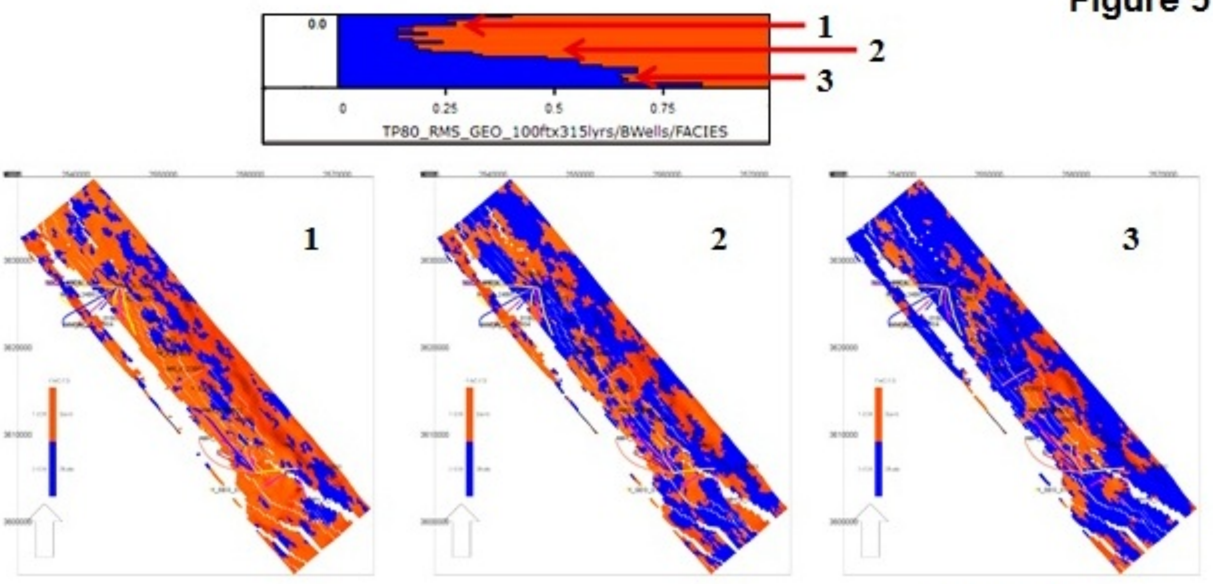

Figure 4

The Solution

Figure 6 shows an example Z transmissibility array where red indicates zero vertical transmissibility and Blue indicates good vertical transmissibility. This figure would resemble the calculated basal shale thickness map where shales are thick in the red areas and thin or absent in the blue areas. It is highly unlikely that a deterministic layer approach would reproduce a heterogeneous solution similar to this stochastic solution. The deterministic approach would likely produce a more continuous looking solution with fewer shale pinchouts between flow units.

IRT would recommend that when using either the deterministic layer or stochastic basal shale approaches that multiple cases (minimum, most likely, maximum) be developed as a function of shale thickness. For example, vertical transmissibility is scaled exponentially from 1.0 to 0.001 for shale thickness from 0 to 10 ft.

These multiple cases can then be run through the production history to determine which case best matches the actual field performance.

Figure 6