Channels: Size Matters

Dr. Franz L Kessler, *Curtin University Miri, Sarawak*

In channelized sandstone deposits it is often challenging to establish a realistic estimation of reservoir connectivity, which is a highly important parameter governing oil recovery. This paper describes NW Borneo shallow-marine sandstone deposits. These were formed on a shallow shelf characterized by strong long-shore currents, tidal action and a large quantity of freshwater outflow.

Field studies focus on the Miocene Belait Group (Malaysian Borneo) - a good reservoir in several oil fields. The objective is to establish parameters for assigning connectivity to individual channel bodies and amalgamated channel complexes by measuring width, thickness, plus the amount of observed reservoir amalgamation. In the Belait, the width/thickness ratio of channel bodies is commonly 10: 1. Channels with a ratio of 5:1 are often products of seamless amalgamation. While doing the field measurements it became apparent that large channel bodies interconnect with smaller channels far more often, than smaller channel bodies link-up with other small channels. This is inferred to be a result of mainly three facts:

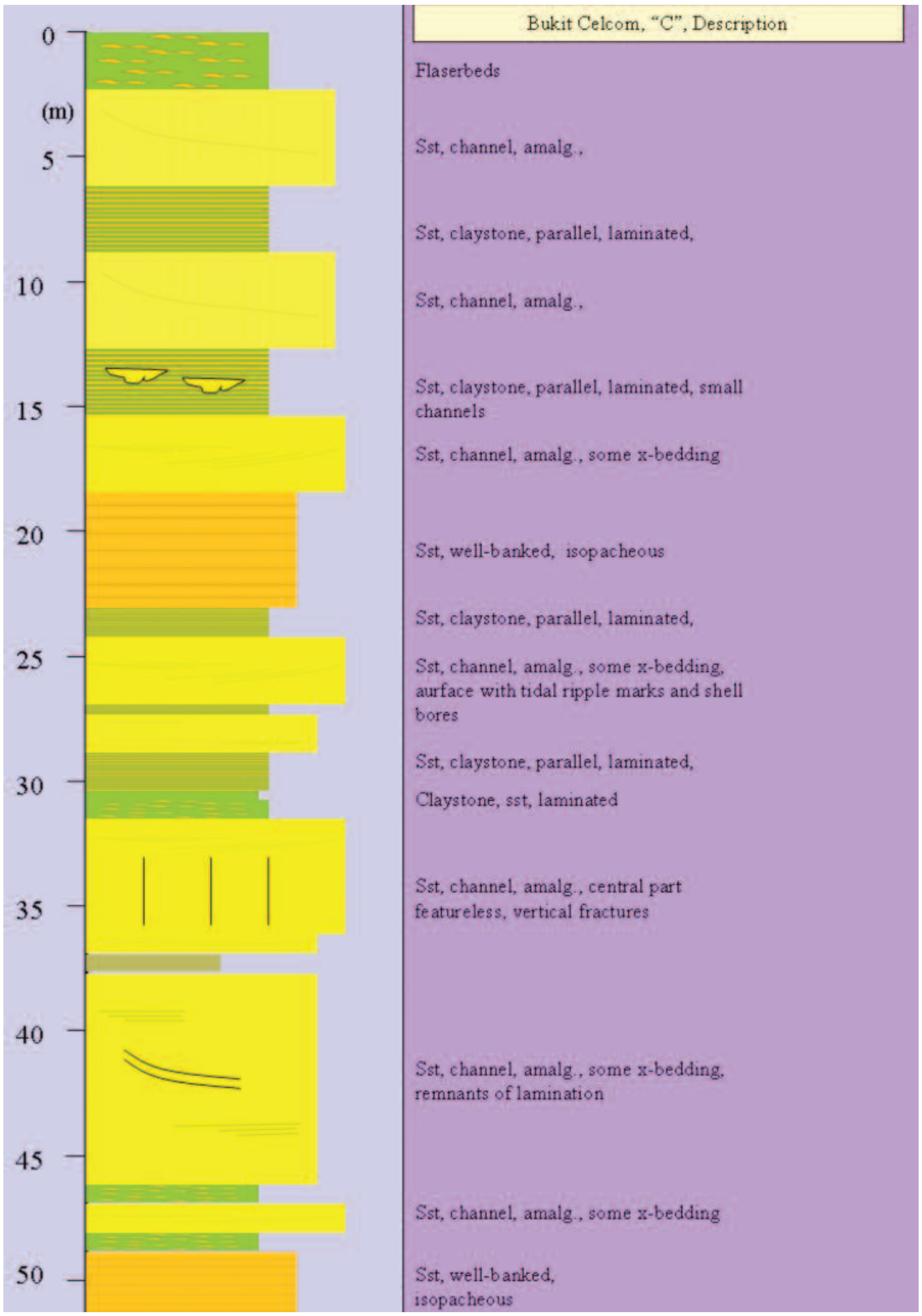

Figure 1. A typical Belait outcrop, near Marudi, Sarawak, Malaysia.

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1. Large sandy channel bodies, being more voluminous, intersect larger areas of rock, compared with smaller channels;

2. Large sandy channel bodies (often ribbons or shoestring sands) occur in facies that are simply more sand-prone and populated with many smaller channels. Some tidal mudflats contain only a little sand, located in a few small shoestring channels that tend to be isolated; and

3. An envelope of high quartz sand content levees can inter-link pockets of channel core facies – significant sandy levees being absent in clay-dominated facies belts such as mangrove swamps.

A typical Belait sequence is exposed near Marudi (Figure 1).

From Facies Model to STOOIP and GIIP

To the chagrin of any oilfield geologist or explorer, seismic data do not contain as much high frequency and hence resolution, as these data may contain if optimally processed. Sandy channels below a thickness of some 10 m usually are not imaged, or not fully imaged, because the high-end of the seismic frequency spectrum has not been preserved.

In order to quantify the amount of sand connectivity at a sub-seismic scale, one may try to 'gross-up' visible channels with invisible sub-seismic pay. Given one can count the amount of amalgamation interfaces, one may upscale or downscale them to a theoretical outcrop surface of 100 m width and 25 m height. One can then derive a number of channel interconnections for each channel body. Assuming that this also holds in the orthogonal direction, one can estimate the interfaces in an area of 100 m x 100 m and of 25 m thickness (= 16 voxel @ 25 x 25 x 25 m cubes). Since big channels are more rare than small channels, it means that big channels will interconnect with a moderate number of medium-size channels and a large number of small channels either directly or through blankets of hi-Qz-content-levees (facies B, Figure 2).

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A barely visible (on seismic) shoestring channel body of 80 x 8 meters would equate, in the outcrop example, to a pay rock volume = 80 x 8 x 120 m = 76800 cubic meters (allowing for some sinuosity). This equates to almost five voxel cubes of 25 m.

This pay rock volume however, if connected to some 25 smaller sub-seismic channels, will yield = 25 x (20 x 2.5 x 120 m) + big channel = 226800 cubic meters = almost 15 voxel cubes of 25 meters.

Therefore the total (directly or indirectly) connected sand pay

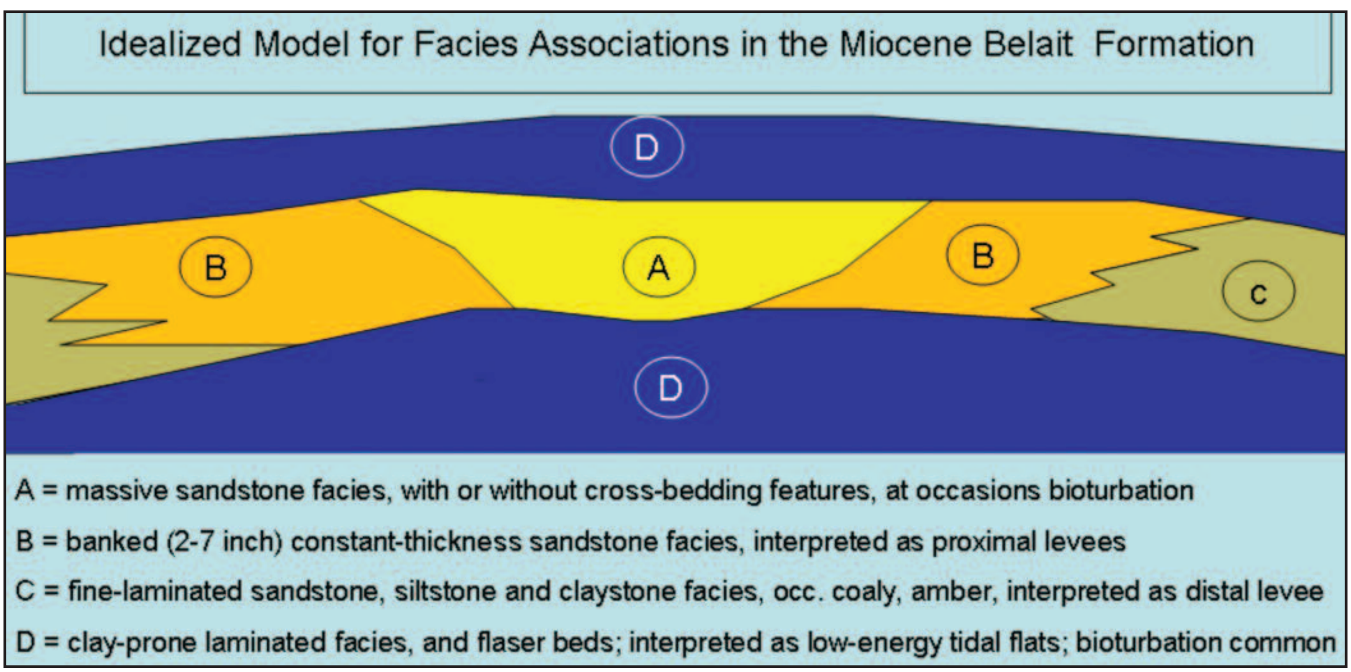

Figure 2. Facies model for a Belait shoestring sand.

volume could be three times as large as the 'visible' channel rock volumes would suggest on seismic. The context of several Belait sub-seismic channel bodies and their measured and upscaled connectivity estimates is illustrated in a matrix of field observations (Figure 3). Using this line of thought an existing seismic-derived static model (such as PETREL) can easily be upscaled to incorporate invisible connected pay sands. In this example (Figure 3) it would simply mean to increase the number of reservoir voxels by three.

In conclusion, large sandy channels bodies have a far higher probability to be connected with populations of smaller channels. Small channel bodies are more likely to be either isolated or poorly connected, and might be entirely discounted in both static and dynamic flow models. Simple statistical relationships between bigger (seismically visible) channels and smaller amalgamated channels can be used to predict the amount of 'invisible' connected pay. ■

Biographical Sketch

After 24 years of petroleum exploration and development with Shell, Franz is lecturing Petroleum Geology, Applied Geophysics and Reservoir Engineering in Curtin University, Miri, Sarawak. Author's address: Dr. Franz L Kessler, PHD in Sedimentology. Curtin University, Miri, Sarawak 98009, CDT 250.

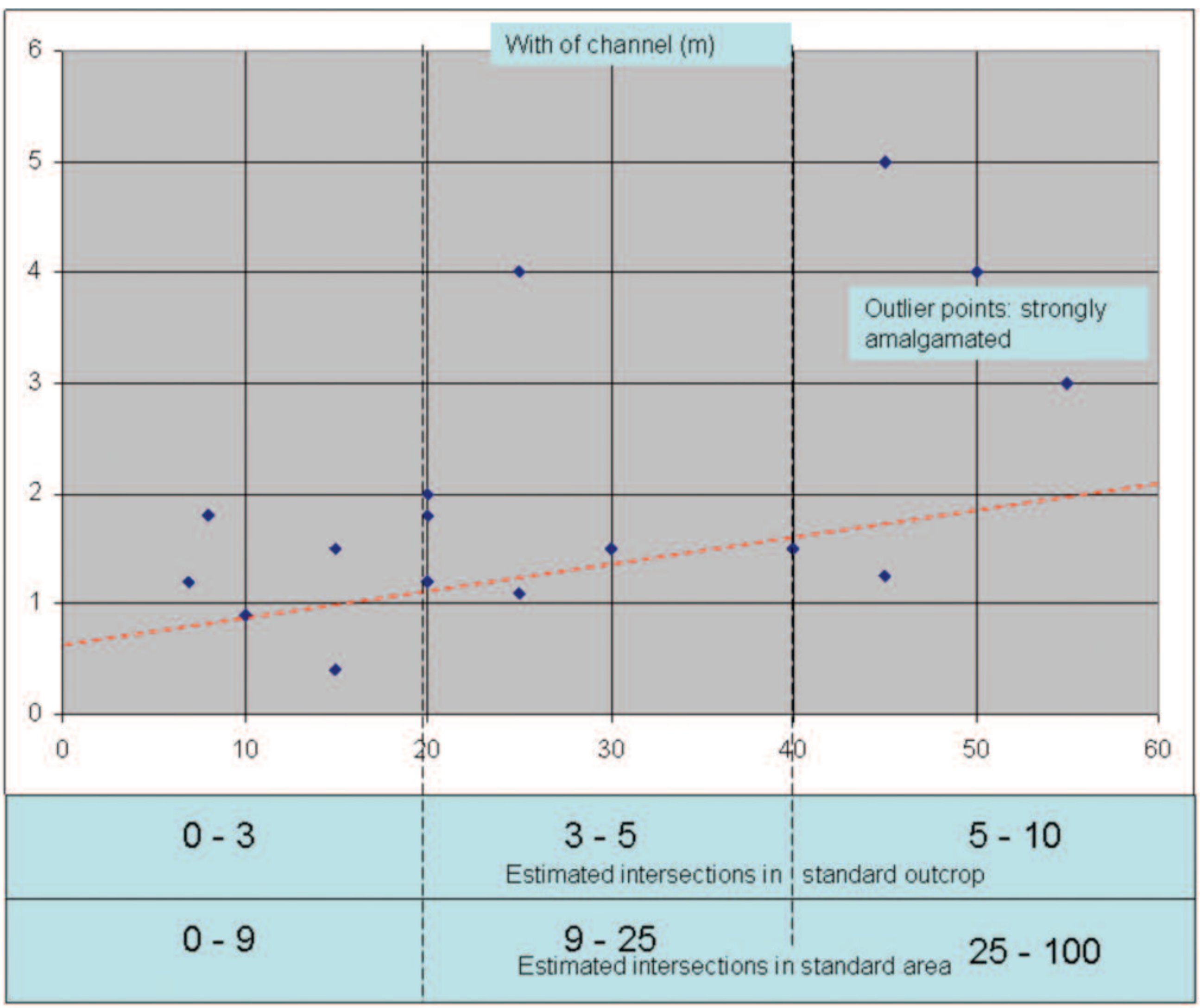

Figure 3. Matrix of field observations, model upscaling from X-Z to X-Y-Z