

Basin Floor Fans—Part 1 of 4

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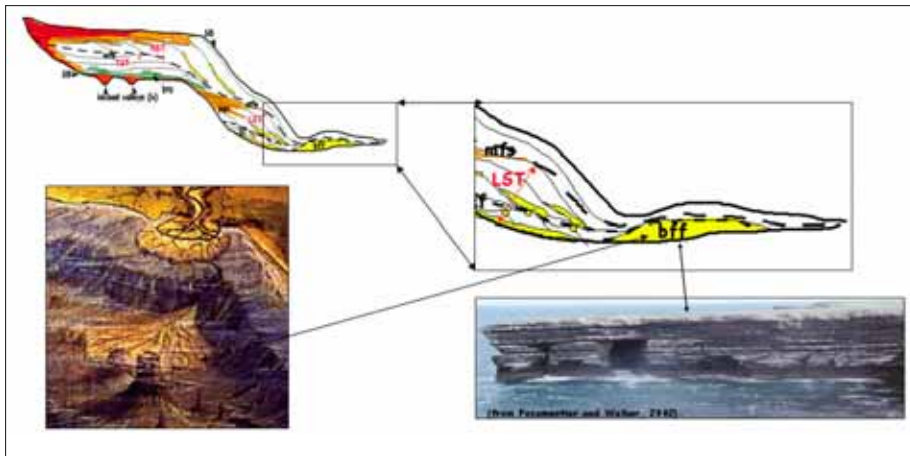


Fig. 1. Basin floor fans, deposited during lowstands on basin floor and slope minibasins.

This article will discuss some of the geological and seismic facies aspects of models used to explore for submarine basin floor fans (Figure 1, the standard Exxon model), which we have seen in previous *Onlaps*.

The genesis of these units can be quite complex, as readers of Ben Kneller's work at Leeds University will attest to (Kneller, 2003). The '-ite' means a deposit, but does not necessarily mean that it traveled by turbid suspension for the entirety of its depositional cycle. Debris flows can change to turbid flow and deposit as a turbidite or many different variations on that theme—as shown in the continuum of Figure 2.

Kneller teaches us that we need to closely look at all the structures in core and outcrop to understand how the turbidite-debrite came to be deposited.

We study the classic 'Bouma cycle' (Bouma, 1985) at university (Figure 3), but do not always see it displayed as such in core or outcrop, and maybe we can consider it to be more typical of a fan's fringe, or distal portions.

A fan complex can build up to several 10s or 100s m thickness, but is made up of

many separate flows, each with a period of quiescence between them, and occasionally shales and silts may be deposited between flows to introduce complexities for later flow of hydrocarbons.

Accommodation versus sediment supply play a part and some fans are 'amalgamated', where fine parts of the upper deposit from each flow may be removed due to low accommodation.

The amount of fines between sandy flows creates a lot of problems in modelling a discovery, with some fields having a lot of field-wide seals while others may have a 'colander' of imperfect leaky seals.

Always build in more complexity to your fan than you can see as many fans have proved

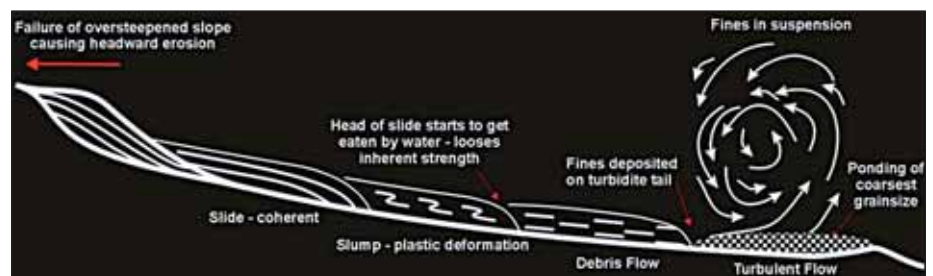


Fig. 2.

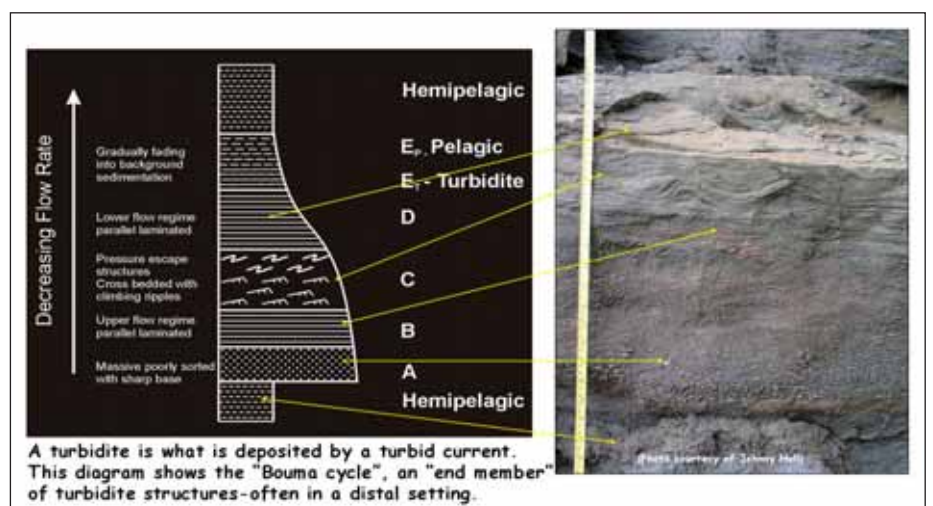


Fig. 3.

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to be uneconomic after facilities have been built. Cut cores! Also understand Ben Kneller's work, as it leads to some up- and down-dip predictability when you have cores.

The Exxon model (Figure 4) shows the 'standard' location of the basin floor fan out on the basin floor, away from the toe of slope (TOS).

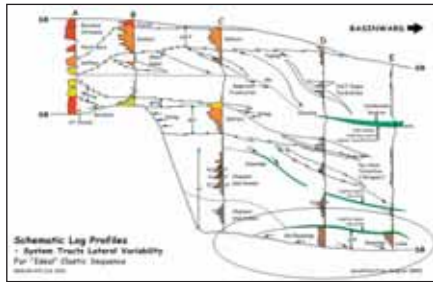


Fig. 4.

Fans are termed 'efficient' if they are deposited a long way from the TOS, and these are considered to have associated fines which somehow allow the turbid cloud to travel some distance from the shelf-edge (70 km in the case of the Scarborough fan in the Exmouth Basin of Western Australia).

An 'inefficient' fan may be dumped near the TOS (as seen in Figure 5 from West Africa). Such fans are considered to be sandy, with few associated fines. The energy loss at the TOS is called a 'hydraulic jump'.

Another sandy versus silty fan issue is the reliability of stratigraphic pinch-outs at the fan edge. It seems that sandy fans may have a more reliable pinch-out trap edge than fans with associated silts, as the latter tend to drape up the slope and allow the trap to leak.

In Figure 6 we see a variation on the Exxon model by Ward Abbott of Occidental Petroleum (Abbott, 1988).

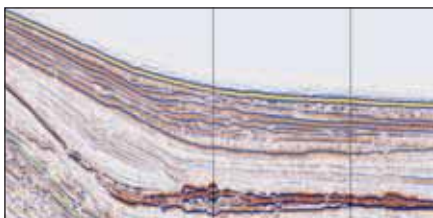


Fig. 5.

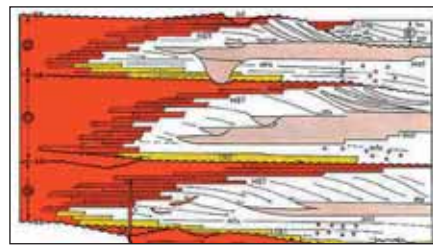


Fig. 6.

Note, in the three sequences shown above that Abbott has no lowstand fans, as in the Exxon model, but instead has highstand fans. This model was developed for tectonically active margins, such as in California, where shelves are narrow and rimmed by active mountains.

We may be able to consider the Neocomian Barrow shelves of Western Australia as similar margins—see the massive, slope-associated fans in Figure 7 (in green and yellow).

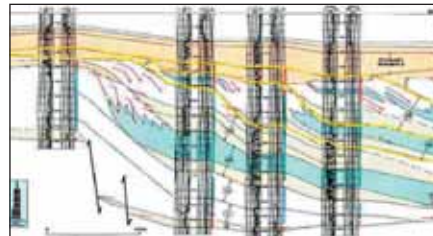


Fig. 7.

A useful paper by Reading and Richards in 1994 added some additional sophistication to the Exxon model (see Figure 8).

In this model grain size affects the resultant fan morphology. This has most impact for slope fans, which are not often seen in sandy systems,

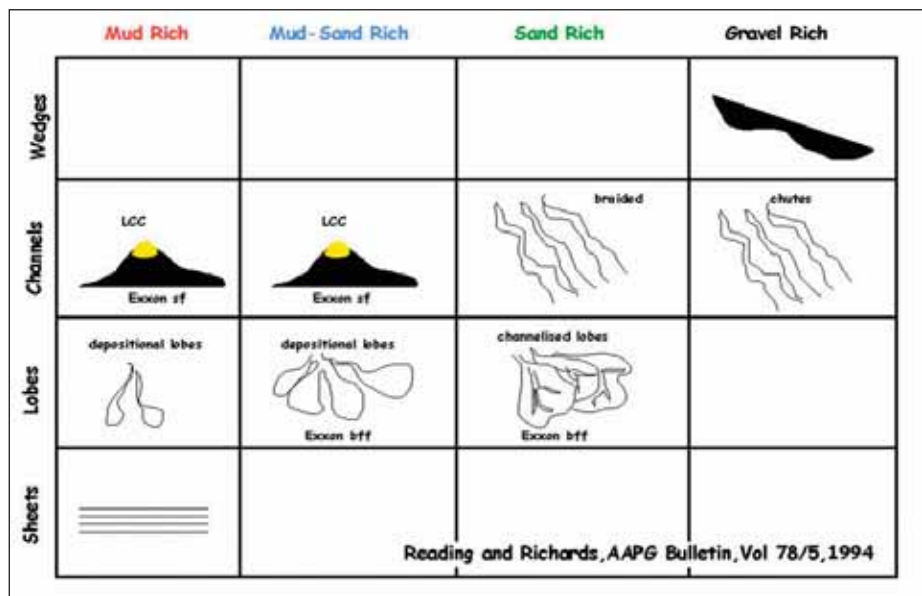


Fig. 8.

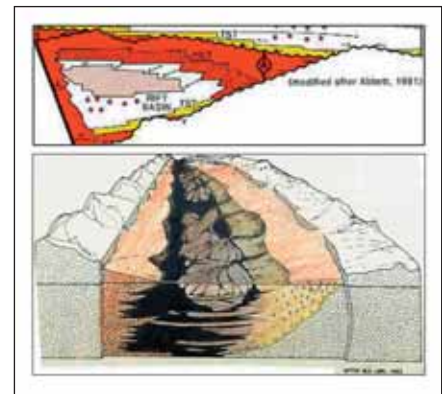


Fig. 9.

such as are mostly seen in Australia.

Another setting for fans is within rift basins [as shown in Abbott's model, Figure 9 (in brown)].

Fans are often found 'mid-cycle' in these large deep-water lakes, such as in China and Brazil.

Figure 10 shows fan turbidites in a rare outcrop example of an exhumed rift at the Ridge Basin, near Los Angeles, California.



Fig. 10.

As discussed in earlier *Onlaps*, there is often a lower-order cycle (termed '2nd order') driving the character of the third order 'sequence'.

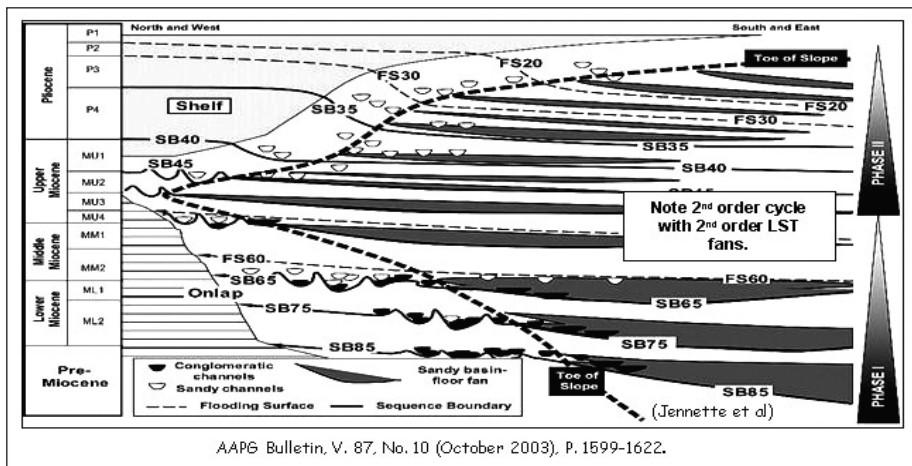


Fig. 11.

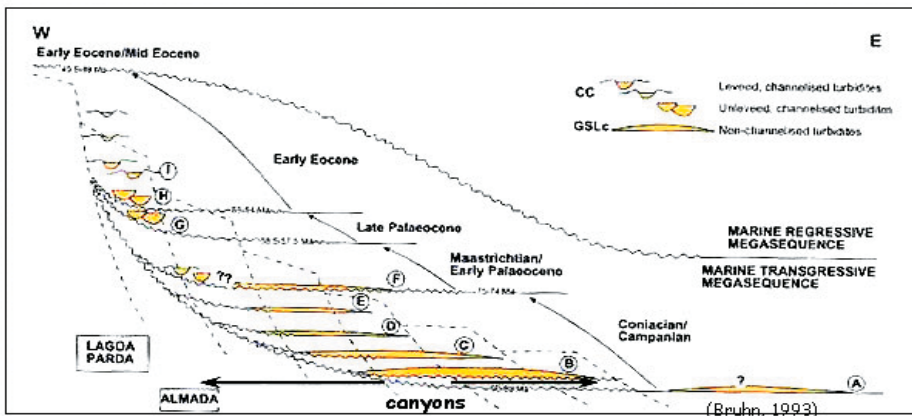


Fig. 12.

Figure 11 from Mexico (Jennette et al, 2003) and Figure 12 from Brazil show second-order cycles driving the stacking of successive third-order fans.

In Figure 11 the fans (dark polygons in the basin pinching out to the left) are better developed earlier, with large erosional canyons, when compared to later fans.

The same effect, but more dramatic, is seen in Figure 12 from the Campos and Espiritu Santo basins (from Bruhn, 1998).

Recognition of such second-order trends may allow for better 'prediction' in your area. These appear to be more and more common as one studies different basins, and you often get a feel for it by looking at the 2nd order Wheeler diagram (chronostratigraphic chart) for your basin.

In the second part of this look at fans, *Onlaps* will look at real world outcrop and subsurface fan examples from Africa and the USA.

Acknowledgements and references will be given in the fourth part of this series on fans. Figure numbering will be a single series from Fans 1 to Fans 4. ■



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