SEDIMENTOLOGY OF THE BRAE OILFIELD AREA, NORTH SEA: A REPLY

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I should like to thank Harms and McMichael (1983) for their comments on the paper by Stow *et al.* (1982) and for the interesting points they raise. I welcome this opportunity to reply to these specific points and, at the same time, to re-emphasise some of the important sedimentological aspects of this Upper Jurassic sequence.

1. I am pleased to see that Harms and McMichael agree that much of the Upper Jurassic succession in this part of the Viking Graben was most likely deposited in submarine fans or related settings. I would certainly agree with them that shallow water and fluvial environments co-existed, particularly in areas immediately adjacent to the Graben margin, but I am not convinced by their arguments for interpreting the South Brae field (which is clearly within the Viking Graben) as a fan-delta.

2. As Harms and McMichael stated, the scales of our respective studies were different. Stow *et al.* (1982) examined 13 Brae Field wells in detail, as well as more than 1,000 m of core from neighbouring wells to the north, south and east. Our interpretation does not generalize these data but is improved, I believe, by the broader perspective gained and the important similarities that exist between the different wells and areas. I assume, from their discussion, that Harms and McMichael have only considered 5 wells (8, 10, 11, 12 and 13 of Fig. 2, Harms *et al.*, 1981; or I, K, L, M, N, of Stow *et al.*, 1982).

3. In their very important discussion of the differences between fan deltas and submarine fans, Harms and McMichael have unfortunately fallen into the trap of comparing fan deltas with the deep oceanic fans that have been best-documented at the present day. These latter do indeed have low gradients, muddy sediments and sometimes, though not always, complete Bouma sequence turbidites. However, the submarine 'fans' of the Upper Jurassic Viking Graben were not equivalent to deep-ocean fans. The basin was small and probably relatively shallow and there was a strong tectonic control on sedimentation. There are few good modern analogues (e.g. Faugeres and Gonthier, 1983) although several similar sequences have been described from ancient sequences (Van de Kamp *et al.*, 1974; Surlyk, 1978). Such sequences clearly differ in terms of slope, facies and facies distribution from many deep-ocean fans.

4. In such a tectonically complex area with active synsedimentary faulting during the Upper Jurassic, it seems to rely heavily on dipmeter results, even after attempting to remove the structural component, to differentiate between delta-fan and submarine-fan environments. I would further caution that we do not yet know what dips to expect on a shallow basin slope-apron system (of overlapping fans), but that the radial dipmeter pattern observed in South Brae is consistent with either a subaerial or submarine fan.

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5. I am still surprised that, having admitted the presence of a mixed assemblage of pelagic and benthic marine fossils in the fine-grained sediments of the South Brae cores, Harms and McMichael continue to argue for a mainly subaerial delta-fan interpretation. Fossils are commonly absent in coarser-grained turbidites and associated facies on submarine fans, except where a particularly shelly shoreline or shelf deposit is being reworked. The Brae system appears to be no exception.

6. Finally, I do agree there are important differences in sand distribution between fan deltas and submarine fans. I would not dare recommend the use of our cartoon sketch (Fig. 14 of Stow *et al.*, 1982) to model reservoir distribution and facies boundaries, and I am surprised that Harms and McMichael consider their Figs 3 and 6 are any less schematic. It would be much better to extrapolate tentatively from the actual facies distributions as recorded carefully in our Figs 5 and 11, remembering of course the high degree of lateral variation between wells. These figures show clearly the widespread intercalation of fine-grained facies on South Brae; these are clearly marine and comprise about 60% of the sequence.

In the summary, from our earlier work on the facies and facies distribution of all the Brae wells and careful comparison with neighbouring wells in the Viking Graben, I would still maintain that South Brae is mainly a submarine turbidite system. We did observe in our earlier paper that the deepest and most conglomeratic parts of several Brae wells were difficult to interpret, and we suggested that they were clearly more proximal and perhaps of fan-delta origin prior to rapid subsidence along the active fault margin. There are two important aspects that the Brae field exemplifies which are worth re-emphasising here:

1. The whole Brae system is more appropriately termed a "faulted slope-apron" (Stow, in press) composed in part of small overlapping fans as we proposed in 1982, but also comprising other elements and facies distributions not strictly comparable with the classical submarine fan models;

2. Synsedimentary tectonics were clearly an important control on sedimentation during the Upper Jurassic. "Piano-key tectonics" (Fisher, pers. comm.) led to differential activity and sedimentation along the Viking Graben margin. East-west trending faults were probably important in separating the different "keys " of this system and may have acted to channel coarser sediments further eastwards into the basin. Isolated sandy lobes beyong the main slope-apron therefore present a possible exploration target.

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