DEEP WATER CHANNELS AND THEIR POTENTIAL VALUE IN PETROLEUM LOCALIZATION

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Sand-shale sequences are common products of inner and middle neritic environment deposition; however, sand-sized sediments in outer neritic, bathyal, and abyssal depositional environments are relatively rare. The coarser sediments that are found in the outer neritic and deeper environments exist either in channels or as blanket turbidite deposits. The forming of suitable potential reservoir objectives in such environments requires mechanisms that can concentrate the available coarse sediment.

The clastic debris transported from the continents and continental shelves first becomes concentrated in the prime pathways funneling terrigenous material into the deeper parts of the ocean basins. These are submarine canyons, deep-sea fan channels which branch into distributary channels in their distal parts, and deep ocean channels. Much of the terrigenous debris transported through submarine canyons is deposited in deep-sea fans formed at the reduction in gradient at the base of the continental slope. Figure 1 is a southeast to northwest crossing of the Amazon Deep-Sea Fan (Deep Sea Drilling Project Leg XIV). The profile is approximately 1,000 kilometers long and at an approximate water depth of 4,000 meters. This profile shows the general cross sectional shape of the distal portion of a deep-sea fan. On the margins it merges with the Demerara (north) and Ceara (south) Abyssal Plains. Bulges of sediment on the cross section (suprafans) indicate the active depositional areas. The suprafan commonly contains a number of channels, some active, others buried. In detail, the individual channels generally are lenticular in cross section, acoustically transparent due to their sand content, and bordered by natural levees. A distributary channel system northwest of the suprafan is indicated on the profile, but due to mechanical difficulties its complete characteristic was not obtained. The longitudinal gradient is approximately 1:400, while the gradients across the fan (Fig. 1) approximate 1:1,000.

Many investigators have reported sand-sized sediments in these deeper marine environments. Bottom sampling and DSDP coring have recovered gravel- and sand-sized clastics; PDR and reflection seismic profiling surveys have mapped the morphology and subbottom structures of these canyons and channels; and *in situ* submarine current measurements, photographs, and observations by divers and from submersibles document water movement, erosion, and sediment transport and deposition in them. Active channels and canyons more or less normal to the continental shelves form parts of essentially continuous systems extending to the abyssal plains. The canyons are usually normal to the continental slopes, but the channel trends on the continental rise may not be.

Processes within submarine canyons and channels (such as turbidity currents, sand falls and slumps, and water currents capable of transporting sediment) result in a

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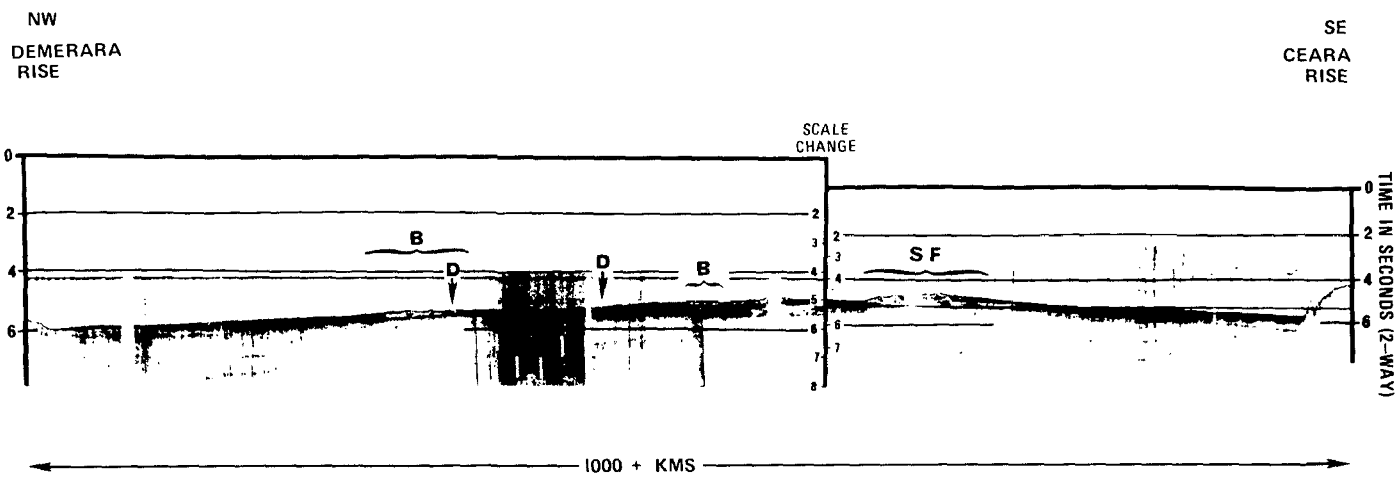

FIGURE 1—Southeast-northwest air gun seismic profile across the distal part of the Amazon Deep-sea Fan. This crossing shows the overall morphology of the fan including its upward-convex profile, the principal active channel system or suprafan (SF), distributary channels (D), and formerly active channel systems which are now being buried (B). This profile was recorded by the GLOMAR CHALLENGER on Leg XIV of the Deep Sea Drilling Project and is reproduced through their courtesy.

variety of erosional and constructional features. In general, the channels have the same characteristics as subaerial ones, including natural levees, meanders, and distributary channel systems on the lower parts of deep-sea fans. Another important characteristic of submarine channels (like subaerial ones) is that they migrate. After the suprafan is built up, the main channel complex eventually moves and begins development of a suprafan in another area, which leads to overall growth of the fan.

Abandoned sand-carrying channels are eventually buried by fine-grained pelagic debris and interchannel deposits. Such channels are particularly well displayed in east-west crossings near the apex of the Bengal Deep-Sea Fan (Curray and Moore, 1971).

The active channel (A) shown in Figure 2 connects in a landward (N) direction with the Swatch of No Ground—the submarine trough off the mouth of the Ganges-Brahmaputra river system. Some of the numerous buried channel deposits (B) are indicated. Natural levees are apparent adjacent to both active and buried channels and in

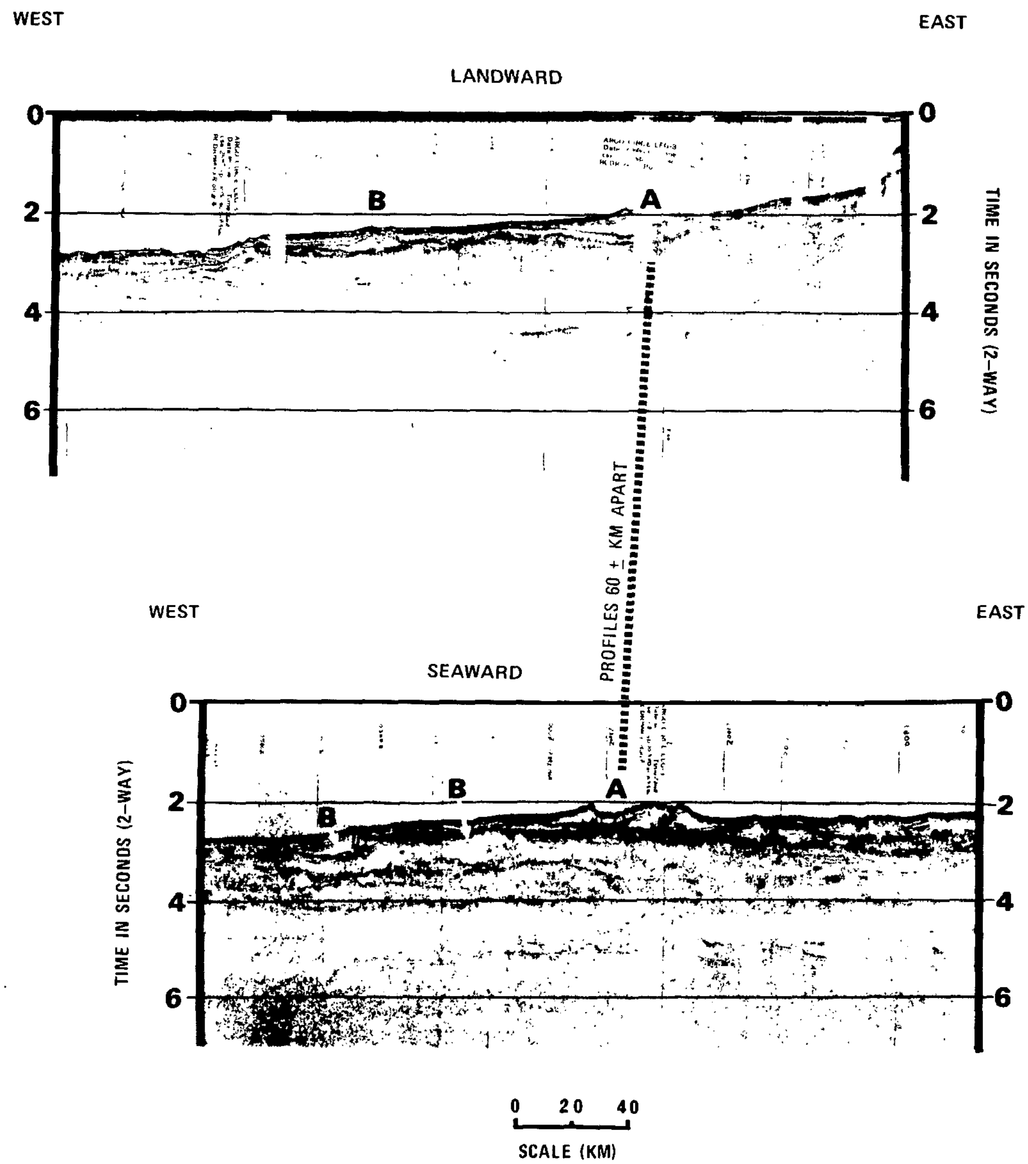

FIGURE 2—East-West air gun profiles near the apex of the Bengal Deep-Sea Fan.
The profiles are subparallel, about 60 km apart. The upper profile is landward of the lower. "A" indicates the active upper fan channel connected with the Swatch of No Ground; its continuity from one profile to the other is indicated by the dashed line. "B" indicates some of the abandoned, buried channel deposits; Vertical exaggeration: Upper profile, water 34X, sed 26X; Lower profile, water 27X, sed 21X. These profiles were recorded by the Scripps Institution of Oceanography research vessel ARGO on expedition CIRCLE Leg 3 and are reproduced with the permission of Drs. J. R. Curray and D. G. Moore.

the case of the buried channel (B) in the upper profile, the levees are still reflected in the overlying fine-grained sediments at the sediment-water interface.

Structural deformation in sediments of modern depocenters include: slumping, whether initiated by a catastrophic event (e.g. an earthquake) or by instability resulting from excessive local sedimentation; growth faulting, usually subparallel to the bathymetric contours; and shale or evaporite diapirism. Such tectonism, particularly growth faulting and diapirism, can disrupt or offset these channels and form up-dip seals.

As the Petroleum Industry carries on operations in progressively deeper water, it is paramount to understand the depositional mechanisms, history, and subsequent deformation associated with the coarser clastic units in this environment. Ancient counterparts of these channel systems apparently are not limited to any specific geologic interval. Gas, condensate, and oil are produced from Cenozoic reservoirs genetically related to such environments of deposition.

REFERENCE

Curray, J. R. and D. G. Moore, 1971, Growth of the Bengal deep-sea fan and denudation in the Himalayas: Geol. Soc. America Bull., v. 82, p. 563-572.