

Slope fan model

Fig. 2.45 Model of submarine fans deposited at the foot of submarine slopes. Submarine fans have channels which sometimes meander. On the sides of the channels we find fine-grained levée

deposits resembling those along fluvial channels. The pattern of shifting depositional lobes resembles that of deltas. (Brown and Fisher 1977)

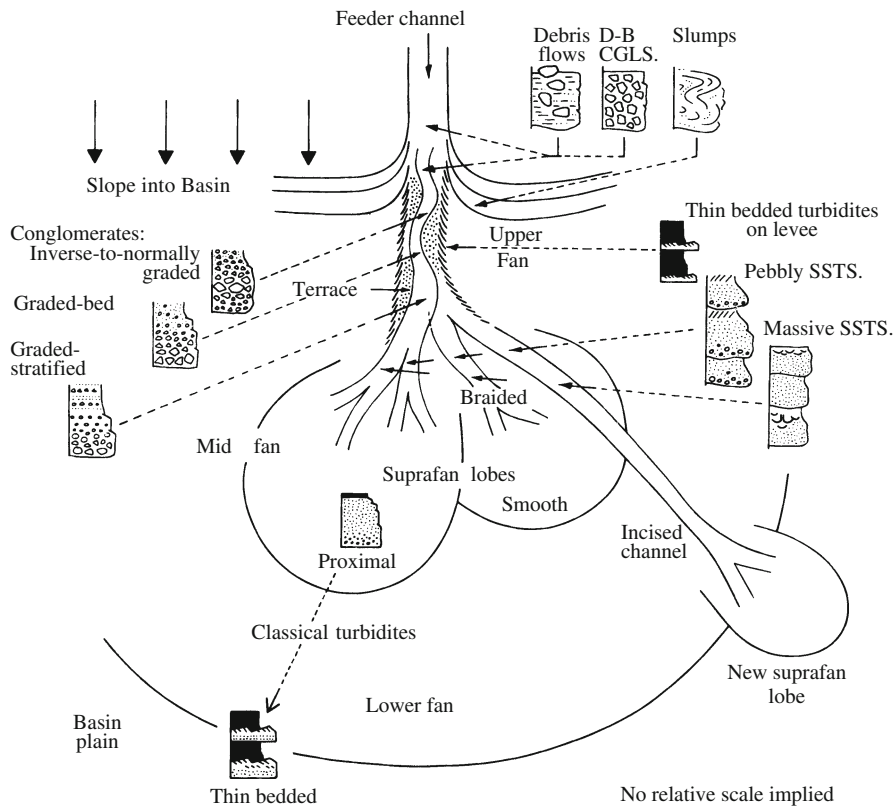


Fig. 2.46 Submarine fan model showing progradation and shifting of lobes similar to delta lobe shifting. One of the main differences between submarine fan and delta facies is the absence of wave reworking. (Walker 1984)

As the lobes build up, the gradient of the slope is reduced and a new channel will form in a part of the fan where there is a steeper slope (Fig. 2.46). This produces lobe-shifting similar to that observed in fluviially dominated deltas. Each lobe will tend to build a fining-upwards sequence, with conglomerate and coarse sand near the base. On the sides of the channels fine-grained material in suspension is deposited as thin-bedded turbidites. The levee builds up on both sides of the channel, and resembles a river levee. On the submarine Amazon delta slope there are well-developed meandering channels. The distal fan is also dominated by fine-grained sediments deposited as thin, graded fine sand, silt and clay. Progradation of submarine fans may also produce an upwards-coarsening sequence (Fig. 2.47).

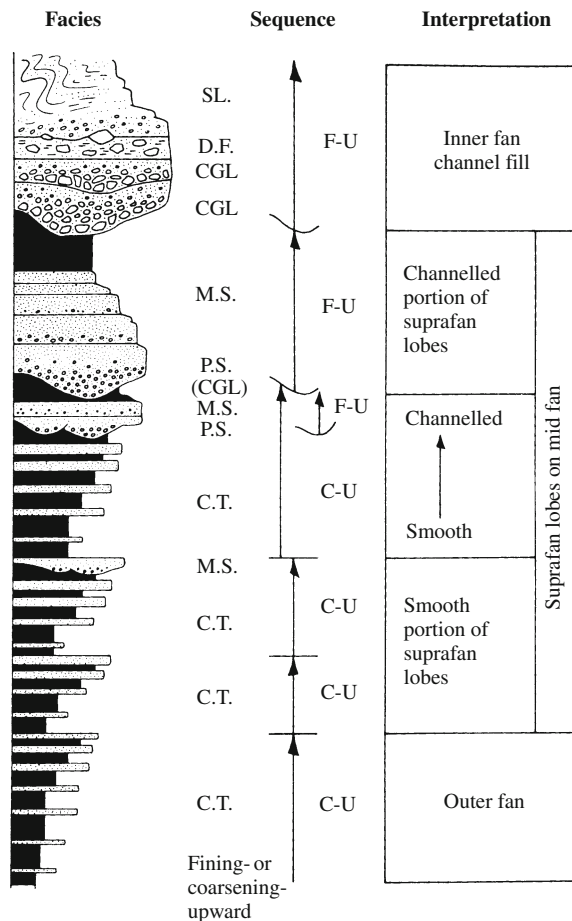


Fig. 2.47 Vertical sequence through a submarine fan (Walker 1984)

2.45 Sedimentation Along Continental Margins and in Epeiric Seas

As discussed above most of the sediment derived from land is deposited in river deltas and distributed relatively close to the shore line by longshore transport. There is, however, also significant sedimentation further away from the deltas and the coastlines. Turbidites and debris flows can in some cases transport sediments hundreds of kilometres offshore. Debris flows represent a very efficient type of sediment transport which can carry sediment far beyond the continental slopes because there is little internal shear deformation, only at the base and the top of the flow.

In fine-grained shales we may find evidence of ripples indicating traction currents. Storms and spring tides may produce rather high velocities (20–40 cm/s) on the seafloor far away from land and these currents are capable of transporting silt and fine sand. Clay should not produce ripples, but the clay is often composed of pellets of clay aggregates, often also with some organic matter. These clay particles behave like silt but they have lower densities and may be transported by traction currents forming small-scale ripple cross-lamination.

There may also be significant contributions of aeolian dust from deserts and of volcanic ash. In Palaeozoic times, before there were many land plants, aeolian dust was more important, but even today much of the sedimentation in the South Atlantic and Pacific Ocean is aeolian.

2.46 Sedimentation Along Island Arcs and Submarine Trenches

Submarine trenches form along converging plate boundaries where oceanic lithospheres are disappearing into a subduction zone. Along these converging plate boundaries sediment basins with very special deposition environments are formed. There are three main sources of sediment:

1. From the continent.
2. From island arcs, which may consist of continental crust, oceanic crust and/or volcanic rocks.
3. Pelagic sediment, including biogenic sediment and wind-blown volcanic ash.

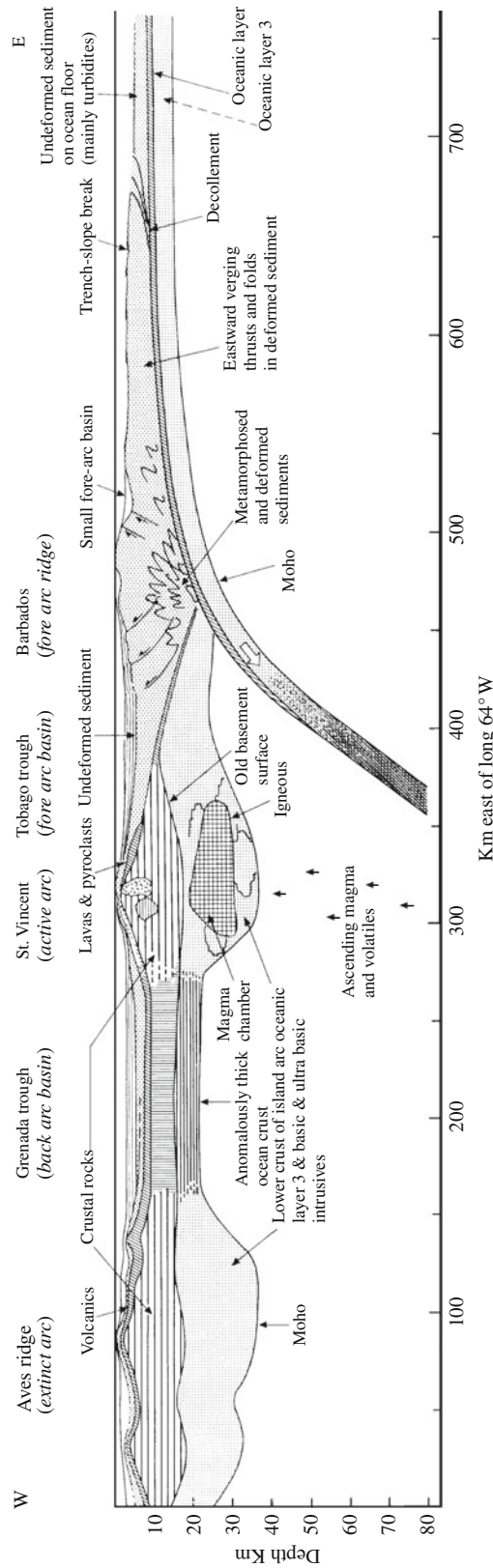


Fig. 2.48 Section through an area with converging plate boundaries in the Caribbean Sea. Note that sediments deposited on oceanic crust are scraped off the descending plate and imbricated in the accretionary prisms (see Fig. 2.49). From Leggett (1982)

These have quite different compositions. Sediment which is added from the continent is deposited in deltas and in turn fills the basin behind the arc (*back-arc basin*). Sediments which are formed on the island arcs are rich in volcanic material, and this will characterise deposits in small basins on island arcs and *fore-arc basins*. Back-arc basins may also receive volcanic sediments from the island arcs. During the initial subduction phase fore-arc basins will tend to be characterised by turbidites deposited in relatively deep water, but sediment filling may convert them into a shallow water environment which may include carbonate sediments. A structural high separates the fore-arc basin from the actual slope down to the submarine trench.

Beyond the deep sea trenches a significant amount of pelagic sedimentation takes place on a relatively flat ocean crust. Some of the sediments get scraped off the subducting volcanic crust and stacked up in what are called “accretionary prisms” (Figure 2.48). Some sediment may also be carried down with the subducting plates. The supply of sediment to the deep-sea trenches themselves is often very limited, which is why they do not fill up with sediment. They represent the greatest depths in the ocean (up to 10 km) and this can be explained isostatically by the fact that the oceanic plate which is undergoing *subduction* is cold, and therefore heavy. The downward movement acts against the direction of heat flow, resulting in low geothermal gradients and therefore dense crust.

The sediments may be pelagic oozes or distal turbidites. Since the oceanic plate is moving towards the island arc, the sediments on the oceanic crust have been deposited further away from the sediment source, and in consequence we do not normally have very thick sedimentary sequences in the subducting plate. The accretionary prism consists of a series of sliding faults which are steepest near the surface and have a lower gradient downwards. They are often draped with a blanket of pelagic sediments (Fig. 2.49).

Listric faults of this type are similar to those we find in plate boundaries with tension (rifting) but the relative movements are in the opposite direction (reverse faults). Sediments which are still not very consolidated tend to deform along the imbricated faults and develop various kinds of *drag folds*. Continued movements of the imbricated fault planes cause this slope to become very steep locally, and conglomerates and fan deposits may become unstable and slide. Lithified carbonates and sandstones will break up and form large blocks in a more clay-rich matrix. Volcanic rocks may also be included in this package of broken-up sediments and be incorporated into coarse conglomerates with large blocks called *olistostromes*. The blocks, which lie in a matrix of clay sediments, may be from a few metres up to several hundred metres across. The result is called a *tectonic melange*.

The sediments in an accretionary prism are subjected to strong tectonic deformation prior to deeper

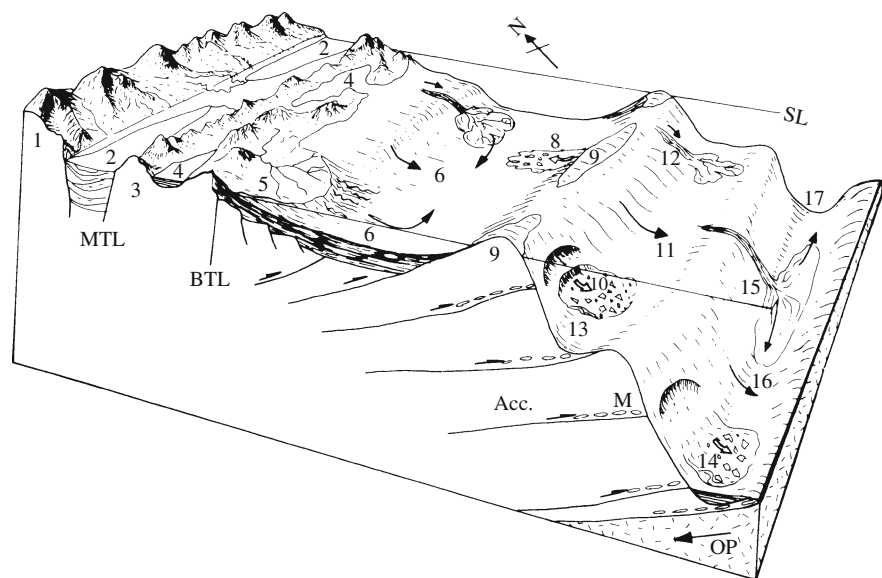


Fig. 2.49 Sedimentation in a submarine trench (accretionary prism) near Japan. Sedimentation is very much influenced by the relative movements (thrusting) of the rock units piled up in the prism (from Taira et al. 1982)