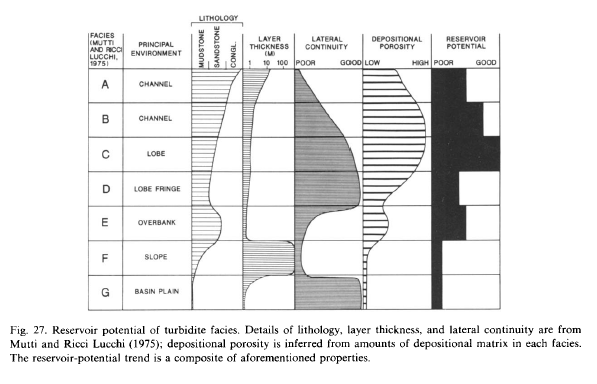
**Submarine fan**

* Deposited by sediment gravity flow processes ( channelized turbidity currents, debris flow)
* Components:
  + Upper fan – contains a major feeder channel
  + Middle fan – contains a network of distributary channels and associated overbanks
  + Lower fan – contains lobes or sheet sand
* Reservoir potential: channels and lobes

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|  | **Transport processes** | **Lithology** | **Sedimentary features** | **Turbidite facies** | **Grain size trend** | **Bed thickness trend** |
| **Canyon / Channel** | Slumps, debris flows, turbidity currents | Conglomerate, sandstone, mudstone | Erosive bases, rip-up clasts, lenticular sand bodies | A (Sediments deposited from cohesive debris flows),  B (Coarse-grained sandy turbidites) | fining upward | thinning upward |
| **Lobe complexes: lobe and lobe fringe** | turbidity currents | Sandstone, mudstone | Complete and partial Bouma sequence, continuous sand bodies | C (Medium-grained sandy turbidites) - Lobe,  D (Fine-grained sandy/muddy turbidites)- lobe fringe | coarsening upward | thickening upward |
| **channel lobe transition zone** | Suspension |  | Erosional/bypass features  such as furrows, scours and sand waves | E |  |  |
| **Levee** |  |  |  | E |  |  |
| **Slope** |  |  | Slump | F |  |  |
| **Basin plain** |  | Hemipelagites |  | G |  |  |

**Facies classification** (Mutti and Ricci Lucchi, 1972,1975):

* Facies A –
  + conglomerate, course-grained pebbly sandstones, pebbly mudstone
  + Bed thickness > 1m, but frequent lateral variation in thickness
  + Scour and channeling are common
  + Most commonly associated with facies B and E
  + Individual flow units can be identified
  + Occurs in upper and middle fan
  + Moderate reservoir potential because of abundant depositional matrix
* Facies B –
  + course – to medium- grained sandstones, in thick, massive and often composite bed sequences
  + lateral bed continuity is better than facies A
  + occurs in channelized settings, particularly in upper and middle fans
  + Better reservoir than facies A, are better sorted and more continuous
  + High-density turbidity current
* Facies C –
  + Course- to fine-grained sandstone, commonly interbedded with thin layers of mudstones
  + Sandstone beds represent the classical turbidite of Bouma sequence
  + Sandstone beds have thickness of 0,25 – 2, 5 m, and have uniform thickness for great lateral extent
  + Normal grading is common
  + Associated with the upper part of the channel fill sequences, and in non-channelized settings like middle fan and lower fan.
  + Best potential for reservoir development (having high depositional porosity)
  + High-density turbidity current
* Facies D –
  + Thin interbedded sandstones and mudstones
  + Great lateral extent
  + Each sandstone bed is normal graded and represent the upper part of the Bouma sequence (Tcde or Tce).
  + Occurs in all parts of a submarine fan
  + Moderate reservoir potential
  + High-density turbidity current
* Facies E –
  + Thin interbedded sandstones and mudstones
  + Ripple laminated and lenticular sandstones
  + Sandstones are courser than in facies D with the same thickness
  + Higher sand/shale ratio than facies D
  + Thinner but numerous sandstones beds than facies D
  + Associated with channelized settings
    - Facies B/E are specific for upper and middle fan
    - Facies E with D, G and F are specific for overbanks and levee deposits
  + Slightly better reservoir potential than facies D
  + Low-density turbidity current
* Facies F –
  + Remobilized deposits showing mass slumping
  + Typically found near the lower slope or along channel margin in upper and middle fan
  + Minimum potential for reservoir development
* Facies G –
  + pelagic and hemipelagic
  + best developed in interchannel settings
  + Minimum potential for reservoir development
  + Low-density turbidity current



**Architectural and morphological characteristics:**

**Channels**

* display sinuous, ribbon–like geometries in plan–form and overall concave morphologies with irregular/erosional bases in vertical profile

**Lobes**

* generally show lobate geometries in plan–form and overall convex–up morphologies with flat bases in vertical profile
* have much higher width to thickness ratios than turbidite channels
* have great lateral extent and continuity yet relatively limited thickness ( unconfined environment)
* sand amalgamation increases the connectivity od the sand bodies
* Lobe complexes are bounded by pelagic/hemipelagic shales, several meters to tens of meters thick, implying long sedimentation hiatus.

**Factors controlling the turbidites:**

**Geometries** of turbidite are strongly controlled by the shape of the basin:

* Low slope to basin relief – specific to continental margins
  + Show pragradation of the turbidite system
* High slope to basin relief – specific to areas tectonically controlled
  + Show aggradation and retrogradation of the turbidite system
* Sea level is the primary factor controlling the growth of submarine fans. Submarine fans are associated typically with periods of low sea level.

Based on **efficiency to transport sand**, there are 2 types of fan system:

* Highly efficient
  + Turbidity currents of a *mud-rich system* transport sand efficiently over long distances
* Poorly efficient
  + The transport efficiency of a *sand-rich system* is relatively poor

|  |  |  |
| --- | --- | --- |
| **Characteristics** | **Highly efficient (Eocene Hecho system, Spain)** | **Poorly efficient** |
| **Sediment** | Mud rich | Sand rich |
| **Source area (size)** | Large | Restricted |
| **Sediment feeding system** | River - delta | Beach-canyon |
| **Size of fan** | Large (hundreds of km) | Small (tens of km) |
| **Gradient (slope)** | Low | High |
| **Distance of transport** | Long | Short |
| **Amount of fine in suspension** | Large | Small |
| **Channels** | Detached from lobes  Higher sinuosity | Attached to lobes  Low sinuosity |
| **Sandstone lobes** | Large | Small |
| **Lobe cycles** | Well developed, thickening upward trends | Poorly developed, thickening upward trends |
| **Zone of bypassing** | Present | Absent |
| **Lobe fringe deposits** | Well developed | Poorly developed or absent |
| **Basin plain deposits** | Well developed | Poorly developed or absent |
| **Net to gross** | Low | High |
| **Vertical connectivity of sand bodies** | Multiple reservoir – seal pairs | Amalgamation, vertical connectivity |