FLUVIAL SANDSTONE RESERVOIR CONECTIVITY

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Introduction

Most reservoirs exhibit complex variations of continuity, thickness and of pore-space attributes (porosity, permeability, and capillary pressure properties), controlled by processes within the original environments of deposition (Le Blanc, 1977). The reservoir interval is commonly subdivided vertically and laterally into 'pay zones', which are separated by impermeable rock units. Some sedimentological processes produce interconnection of "pay zones' which generally help the hydrocarbon recovery. Low energy conditions of the environment generally produce impermeable fine-grained deposits, which act as barriers to hydrocarbon recovery. The heterogeneity of the reservoir rock, caused by the composition of the permeable and impermeable beds, controls the hydrocarbon recovery, The effects of the impermeable beds depend on their distribution. In many cases the occurrence of the barrier beds helps the hydrocarbon recovery. On the other hand, some conduits can cause problems in oil and gas production.

In general fluvial reservoirs are formed by sandstone despoists in aluvial fans, channel system, and aeolian deposit. These systems were depoisted close to the sediment source (provenance) and influenced by highe nergy processes so called proximal. The processes produce sedimentary deposits with highly lateral changes.

This essay discusses the conduits and partitions of the fluvial reservoir rocks which are controlled by the depositional origin. Some reservoirs of producing hydrocarbon fields are reviewed to show some cases of the hydrocarbon recovery processes.

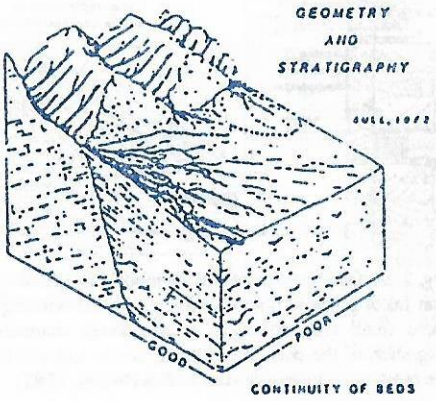


Fig. 1. Schematic block diagram showing thick sediment wedge formed by coalescing and overlapping alluvial fan deposit

Alluvial Fans

Alluvial fans are the largest scale morphological features build-up by bed-load streams and, more rarely, by streams with a higher suspended load. The also occur in semi-arid settings where additional processes, in particular mass-flow, are important. The alluvial fan deposits consist largely of poorly sorted clastics deposited by drainage systems that commonly form braided streams. However, the drainage system may also discharge their sediment loads during intermittent periods of sheet run-off (Conybeare, 1976).

An alluvial fan deposit within the Barrancas Formation in the Mendoza area, Argentina, shows extremely large variations in permeability. The porosity and permeability development in these formations are governed primarily by the abundance of detrital clays (Simlote et al, 1985). The continuity of individual sandstone beds

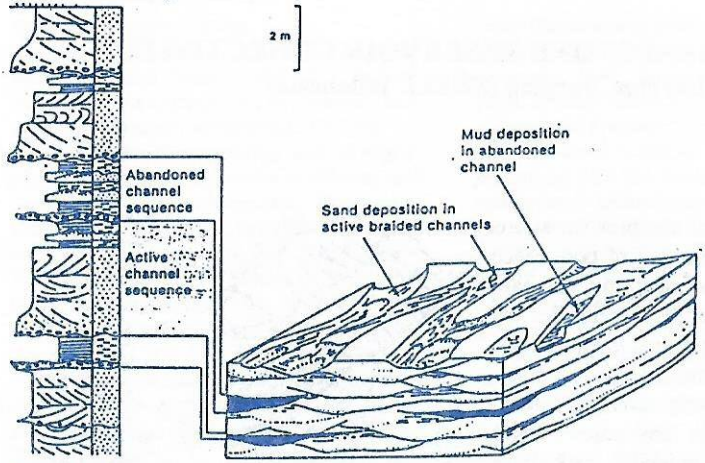


Fig. 2. Surface features and facies model of a braided channel system. Sedimentation takes place almost entirely within the shifting complex of channels with some small silt deposition in abandoned channels. No flood plain exists; migration of the channel complex, due to tectonic tilting, for example, leads to the creation of extensive sand bodies (Selley, 1982)

within alluvial fan sequences is poor in a cross fan direction and better in the direction of sediment transport (Fig. 1; Bull, 1971). However, the individual beds in this type of deposit are quite discontinuous. This heterogeneity makes the prediction of well-to-well flow patterns quite difficult and causes a major problem in the EOR processes.

Braided Stream

Braided streams are complex networks of low sinuosity channels that flow on alluvial plains with slopes greater than 1.5° to 2°. Discharge through the channels is normally low, but during a year sporadic floods carry enormous volumes of water and sediments into the system. As existing channels are overloaded with deposits during a flood, new channels are cut and quickly filled with coarse debris (Richardson et al, 1987a). This process causes interconnections of sandstone bodies.

In the inter channel environment where the energy is low, mud deposits are very common. The inter-channel mud and the overbank deposits produce barriers within the reservoir. Generally, the lateral continuity of braided-stream reservoir pay is usually good to excellent and the vertical continuity is fair to good (Fig. 2).

Prudhoe Bay field is and example of a giant reservoir which is composed of braided stream deposits. The reservoir quality is mainly controlled by sedimentary facies. At the reservoir scale, grain size is the primary control of permeability. A decrease of grain size shows a facies change from proximal to distal. This variation is generally accompanied by decreasing permeabilities. The heterogeneity which occur within the braided stream system is due to the shale intervals. Some studies have shown that the relative extent of a shale interval in the reservoir is linked to its depositional environment. These shale intervals act as the most effective vertical permeability barriers and commonly divide the oil column into isolated production intervals (Atkisnon, et al., 1990). Locally shale barriers can assist in increasing production rates by preventing both gas coning and water influx. Elsewhere, their presence can be detrimental. First they may reduce pressure support from the gas cap if production takes place blow these shales. Second, shale can promote gas underrunning where production-induced pressure sinks develop below them when they are continuous updip into the gas cap (Geehan

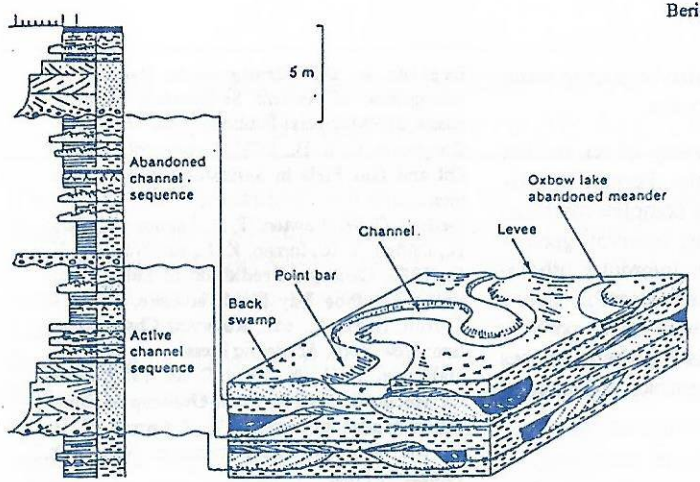


Fig. 3. Surface features and facies model of a meandering channel system. showing how lateral migration of a channel generates upwards-fining grain size on its inner point-bar bank. (Selley, 1982)

et al., 1986; Haldorsen & Chang, 1986).

Meandering Streams

Meandering high-sinuosity channels are found on flat alluvial plains with slopes less than 1.5 (Richardson, et al, 1987b). These rivers have wide ranges of discharges from low-water flow to flood stage. Two main processes are responsible for the development of sand bodies. The are point-bar deposits left by channel migration, and oxbow-lake deposits left in loops of the river course abandoned when the stream cuts a new course during flooding. Extremely high floods spill over the banks and produce the crevasse splay deposit.

The meandering stream produces extensive sheets of sand, in the form of coalescing bars, over a relatively short period of geological time. These sand sheets are not as continuous as those of braided stream origin (Fig. 4) The clay plugs in oxbow lakes and the last channels of rapidly abandoned meander belts comprise numerous discontinuities within the sheets of sand (Le Banc, 1977).

Reservoir quality of rocky Ridge Field (north Dakota) is best developed in the channel-fill facies of meander-belt system. Chute modification of point-bar sands created a relatively homogeneous sequence of sandstone. This sandstone has few vertical barriers to flow among stacked channel-fill units. Lateral flow barriers, however, are also important in some part and are caused by local shale channel plugs, mudstone drapes, and authigenic cements. These barriers limit the drainage areas of individual wells (Hastings, 1990)

Aeolian Dunes

Aeolian dune deposits of windblown sands are important reservoirs in some parts of the world. This type of deposit requires large volumes of dry sand and sufficient wind velocities to move the sand. Such conditions are usually found in desert areas and along coastal beaches (Richardson et al, 1988).

Aeolian deposits are often described as clean, homogeneous blankets of sandstone with little or no shale and uniform reservoir performance (Krystinik, 1990). However, the predominant direction of wind transport during the deposition of a Paleozoic or Mesozoic aeolianite can directly control the orientation of preferred permeability in that aeolian reservoir today. The occurrence of horizontal laminae of interdune clay/silt deposits in some aeolian formations may be preserved as vertical barriers (Fig. 5; Richardson, 1988). Lateral

communications may also be poor in some low permeability reservoirs.

The hydrocarbon recovery of an aeolian deposit of the Norphlet Formation, Alabama, is affected by a complex combination of factors including reservoir geometry and heterogeneity. Interdune lithofacies within the aeolian reservoir has a higher heterogeneity with lower porosity and permeability. This lithofacies causes partitions within the reservoir (Mancini et al, 1990).

Conclusion

Every environment has its typical processes. The processes produce heterogeneities in the reservoir rock. Lithology and rock characteristic changes are the main factors of heterogeneity due to depositional processes.

Partitions and conduits in fluvial reservoir resulting from the heterogeneities affect hydrocarbon recoveries. In some cases they might help but in others they cause some problems. Therefore, the study of the distribution and dimensions of the partitions and conduits are very important

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