Modern Fluvial Sandy Gravels of the Canterbury Plains and Their Immediate Post Depositional Modifications: Implications to Ancient Coarse-Grained Reservoirs

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Abstract

Texture and composition in sedimentary deposits are corner stones for interpreting ancient deposition processes in the geological record. After all, it is hard to image what was present in an ancient depositional environment if the evidence is not there for us to observe! This paper explores how sedimentary components which are part of modern fluvial depositional systems are quickly modified and removed immediately (hours/weeks) after a fluvial sandy gravel is deposited, and equally how fines are introduced into deposits over slightly longer time frames (years/kilo years). Both processes create a resultant geologic fluvial deposit, which is considerably different from the texture and composition of the sediment, which was laid down. Examples used come from modern river systems of Canterbury, Marlborough and Wairarapa, and their ancient equivalents in New Zealand.

Rivers are effective agents in the sorting sediment sizes at numerous scales. New Zealand, given our tectonic influence on topography, has numerous coarse-grained rivers. The rivers of the Canterbury Plains for example, transport large volumes of fines in suspension, together with the sand and gravel bedload components. Although much of the suspended load continues downstream, a large proportion is deposited together with the coarse-grained clastics, especially during flood events. Immediately post deposition though, the fines are remobilised either by 1) drying and eolian transport, or 2) by downward and lateral percolation through the coarse-grained bed.

The first process, eolian transport of fines is very common and widely appreciated by fluvial geologists, though perhaps not fully appreciated by those working in ancient petroleum reservoirs. The second process, downward percolation, happens largely by rainwater landing on, and infiltrating the bed, carrying fines to lower levels within the fluvial deposit. Because the permeability of such deposits is high, the fines are largely free to migrate downward, until they meet permeability barriers/baffles, which will cause them to migrate laterally. Evidence for this process can be seen both in the surficial gravel deposits, as hallows of fines beneath gravel clasts (Figure 1), and in ancient fluvial deposits as layers of silt intercalated with coarse-grained clastics (Figure 2). In the latter, the fines often define clay intervals or laminae or inclined clay-rich layers, depending on the permeability contrasts that exist within the gravel. In the extreme case, such fines can dominate the bed, what old time geologists often referred to as “clay-bound gravels” (Figure 3). To have clay within fluvial gravel is in terms of sedimentologic process unlikely. Where clay-bound gravels occur in the ancient, post depositional introduction of fines is a likely explanation. Temperate climates such is in New Zealand may extenuate such processes, but they are probably common in many parts of the world.

In terms of reservoir qualities, the first process, eolian removal of fines, will improve porosity and promote framework support. Percolation redistributes the fines resulting in barriers or baffles to hydrocarbon flow, and these may not always be defined by primary stratification or depositional processes.

Figure 1. Photos from the modern day surface of Hapuku River, Marlborough, showing a cobble clast (centre view) in the top photo, and the same clast rolled to the left in the bottom view. A small hallow of silt appears in the lower image where the cobble was sitting. Such silt is the remnant of more widespread silt deposited during deposition, but preserved below the clast because it has been protected by the cobble from subsequent rains. Scale is 50 cm with 10 cm divisions.

Figure 2. Light coloured mud layers with late Quaternary Burnham Formation gravels, Canterbury Plains. Such layers follow zones of higher permeability (such as foreset stratification), and are introduced into the bed through percolation of fines downward and laterally through the deposit. Scale is 50 cm with 10 cm divisions.

Figure 3. Clay-bound gravels in the Pliocene Moutere Gravels, Nelson. Most of the matrix in this unit is silt introduced after deposition of the fluvial gravel deposit. Pen for scale (left).