

Coarse-grained sediments in incised valleys



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It is debatable of the idea that incised valleys always contain coarse-grained sediments. Incised valleys have been recognized and studied for over 70 years. Before the advancement of radiometric dating, the formation of terrestrial valleys was of much interest to geologist, this is because it was believed that the rate at which valleys were incised could be used in assessing the age of earth (Lyell, 1853). As a result of this notion attention were drawn to the study of erosional unconformities (Grabau, 1906; Blackwelder, 1909). In Spite Of the interest in unconformities not a lot of detailed attention was given particularly to incised valleys and their fill. For instance, Roy (1984) was of the view that Incised valleys, most of the time are filled at the base with fluvial deposits which were coarse grained during a lowstand and a fall in relative sea-level. Other studies by Zaitlin et al, 1994; Eberth, 1996; Chaumillon et al, 2006; Dalrymple, 2012 suggest that incised valleys could contain diverse grain-sized sediments and some incised valleys do not contain any fluvial sediments at their base at all (Pattison, 1991). Coarse grained sands contained in incised valleys may have the potential to be ground water aquifers and hydrocarbon reservoirs (Wright and Marriott, 1993; Dalrymple et al., 1994). It is therefore essential to examine whether incised valleys always contain coarse-grained sediments. A comparison of studies on the sedimentary-fills and morphology of incised valleys are discussed below.

An incised valley is created when a floodplain or a strata beneath a river is cut into by the river itself such that even during flood, the banks are not over flowed (Slat, 2013). The incision of valleys occurs as a result of the fall of the base level, tilting of alluvial plain due to tectonic event, and or the reduction

in the rate of discharge from streams (Slat, 2013). The filling of an incised valleys can be complicated, vertically and laterally. Filling usually occurs during base level rise. According to Zaitlin et al, (1994) there are two main types of incised-valley sediment fills: the simple and compound fill. The simple fills refer to when there is a single depositional sequence whereas compound fills involve numerous, overlaid, cycles of incision and deposition of sediments. The facies of these incised valleys fill depend on the depositional setting, sediment supply, tectonic setting, accommodation space, climate and the segment of the valley fill (Zaitlin et al, 1994).

Studies were carried out by Chaumillon et al. (2008) in the eastern and northern Bay of Biscay incised valleys to find out about the nature of their sedimentary fills. The north and east regions of the Bay of Biscay shows a wide variation in the nature of the valley-fills ranging from incised valleys which are mud dominated (the Pertuis d'Antioche, Vilaine, Lorient and Concarneau incised-valleys), mud and mixed sand valley fills (the Gironde, Etel, Charente, and Loire incised valleys) and sand dominated valley fills (Lay-Sevre and Leyre incised valeys) (Chaumillon et al., 2008). All these incised valleys are situated in the same basin and hence underwent same climate and relative sea level conditions. The variation in the valley fills from sand to mud dominated and a mixed sand-mud intervals are attributed to marine supply of sediment and marine-related processes as needed for the filling of estuaries (Chaumillon et al., 2008). The incised valleys which are mud dominated is composed of interval of estuarine mud and their abundance is influenced by the tidal prism which is in turn influenced by shape of the valleys when they were drowned and turn into estuaries

(Chaumillon et al., 2008). The sand dominated incised-valleys such as the Lay-Sevre and Leyre is filled by the transgression of coarse-grained sands and gravels (Fenies and Lericolais, 2005). The abundance of coarse-grained sands in the sand dominated valley is as a result of hydrodynamic procedures that took out sediments of both lowstand and highstand system tracts and then filled the valley with tidal channel sediments of higher energy (Fenies and Lericolais, 2005). The mixed sand and mud incised valleys such as Etel and Loire are also as a result of wave and tidal influence. Despite the different conditions in which these valleys were filled, the upper intervals of all the valley fills studied by Chaumillon et al. (2008) indicated an upward fining trend which matches up to the change from transgressive coarse-grained sediments to highstand mud. It can therefore be deduced from this study that incised valleys even when mud-dominated, some portion contains coarse grain sediments.

A paper by Eberth (1996) also discusses the source and importance of mud-filled incised valleys (MFIVs) in south of Alberta, Canada. Several mud-filled incised valleys that were studied in the Dinosaur Park and Horseshoe Canyon formations indicated that there are two preservation geometries that do happen: a simple U-shaped geometries and complex internal geometries. These two categories of the MFIV are deposited in an estuarine environment where there is low energy. The presence of sharp erosional bases marks the simple, U-shaped MVIFs which are dominated by mudstone heterolithic fills. The simple MVIFs are described as having a simple cut and fill record which are also associated with fall and rise cycle of relative sea level (Eberth, 1993). The complex Mud-filled incised valleys which are rare contained finely

laminated sandstone, very fine sandstone and silt stone the other (Eberth, 1996). These Mud-filled incised valleys described so far in the Horseshoe Canyon and Dinosaur Park formations by Eberth (1996) are also referred as 'paleochannels'. They are created in low gradient regions ($\leq 0.03\%$) that spans over a wide distance of kilometers. There are uncertainties about the simple MFIVs being considered as an incised valley but rather paleochannel. Interpretations associating the simple MFIVs to tidal channel is turned down because of nonmarine vertebrates found in the basal lag sediments and the existence of brackish clam fossils which are indicative of freshwater linkage. Simple MFIVs may be considered as incised valleys that were filled up in an estuarine condition. The simple MFIVs are mainly associated with paralic facies such as finely laminated mudstones representative of lagoon-restricted marine setting, muddy sandstone of transgressive deposit (Koster et al., 1987; Wood et al., 1988). These descriptions would have disregarded the notion incised valleys always contained coarse-grained sediments, but it is still unclear whether to classify these 'paleochannels' as incised valleys because they do not strictly fit the definition of incised valleys by Zaitlin et al. (1994).

A paper written by Weissmann et al. (2004) on the impact of incised-valley fill deposits on hydrogeology, discusses the nature of incised-valley deposits in a stream dominated alluvial fan system; The Kings River alluvial fan of Fresno, California where the alluvial fan system was incised during interglacial periods (Weissmann et al., 2004). The supply of sediments which were higher during glacial period led to quick aggradation (Weissmann et al., 2002). The continuous deposition as result of high rate of sediment supply to

discharge through glacial period fill up the incised valleys. The kind of filling led to what is known as an open fan deposition or an unconfined deposition across the surface of the alluvial fan. The grain sizes of this open fan deposits are a mixture of distinct coarse-grained sediments within fine grained, and a silt dominated deposits at the overbank. The incised valley was initially filled with an upward fining succession of coarse-grained sediments and the fine overbank deposits. The sediments of this incised valley fill were confirmed by well core to contain a variation of grain-sized deposits with cobbles, very coarse-grained matrix of sand at the base, fine-grained deposits and silt-dominated sediments at the overbank (Weissmann et al., 2004). The position of the coarse-grained unit at base of the incised valleys and the absence of fine-grained sediments at that level suggest of a deposition in a high energy river. It can therefore be deduced from the study that incised-valley sediments in a stream-dominated alluvial fan contain predominantly coarse-grained sediments among other different grained-sized sediments.

From the papers discussed above, it is noted that in a system of incised valley, different geomorphic bodies and sedimentary processes happen which lead to the regional and local architecture being preserved. In a coastal framework, incised valleys show an upward depositional trend of alluvial, to estuarine to open marine (Zaitlin et al., 1994; Dalrymple and Choi, 2006). This trend suggests of an incision created mainly by a fluvial environment, where fluvial deposits are found at the bottom of the incised valley. Afterwards, the transition to wave and tidal settings suggest the shoreline trajectory moving landwards. The kinds of channels which can be

found in valleys are meandering, braided and straight low sinuous channels (Dalrymple et al., 1992, 1994; Dalrymple and Choi, 2006). These channels deposit sediments including mudstone, sandstone, carbonate and paleosol of varying grain sizes (from coarse to fine). According to Zaitlin et al, (1990, 1994), Dalrymple et al, (1992, 1994), facies model tells a seaward to landward movement of tidal sand bars and flats deposited during dominant tidal currents conditions, and tidal deposits of meandering channel most of the time do occur under conditions of mixed-energy. Facies model in a wave dominated incised valley predicts shoreface deposits with barrier islands and tidal inlets, where of fine-grained sediments and mud can be found (Zaitlin et al., 1990, 1994). The analysis of the papers again shows that the preserved incised valley morphology and architecture occur in response to variation in the formation of accommodation. Deposits of central valley are very heterogenous and dominated by mud. Tidal-fluvial deposits which are coarse-grained sands are found in widening valleys with fluctuations in accommodation. This therefore suggest that incised valleys system respond to the amount of accommodation increase, the interaction that occur between the supply of sediment and accommodation space, changes in the morphology of the coast as well as the valley throughout the evolution of the valley.

In conclusion, although some incised valleys are mud-dominated in estuarine settings, they were flanked by coarse-grained sand rich fluvial and tidal-fluvial sediments. This therefore means that notion of incised valleys always contain coarse grained sediments may not be far-fetched as coarse-grained

sediments has been recognized among the various incised valleys discussed in papers so far.

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