Controls on Alluvial Architecture on Intermediate Time Scales

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Abstract:

The process of river avulsion, and how it behaves over a range of time scales, exerts primary control on the architecture of alluvial basins.

Avulsions typically involve abrupt abandonment of channels and recur on time scales of millennia or less. Interpreting alluvial architecture that forms on time scales of 103-105 years requires understanding why avulsions occur when they do and where new flow paths go as a result of avulsion.

Unfortunately, avulsions are infrequent and unpredictable events so that studies of modern rivers are of limited use for observing and monitoring many avulsion events. Hence, well-exposed ancient sequences provide one way to collect data from many realizations of fluvial channel belts that can be used to constrain the avulsion process.

River avulsion is a direct consequence of channelization and sedimentation. Rates of sediment deposition tend to be highest near the channel axes, so that continued deposition raises the channel above its surroundings. This "superelevation" makes the channel increasingly susceptible to flow diversions into lower-lying areas. Of course, deep channels require commensurately more superelevation than do shallow channels, but this can be factored into the analysis. Data collected from avulsed channels exposed in NE Spain (Caspe Fm., Oligocene) and western Colorado (Wasatch Fm., Eocene) suggest that, on average, rivers avulse once the channel has perched so that ~60% of it sits above the adjacent flood plain. It is uncommon for a channel ever to reach the point that its entire flow depth sits above the elevation of the nearby flood plain. Once avulsion takes place, the new channel begins to incise into underlying flood plain deposits. Local incision into the flood plain was always less than three times the channel's flow depth.

Observations in the Spain sequence, as well as in Maastrichtian-Paleocene deposits of the Wind River, Hanna, and other Wyoming basins (Lance, Ft. Union, Ferris formations) suggest that there is a larger-scale organization to how avulsion deposits are distributed in at least some alluvial basins. Avulsion clusters are groups of individual avulsive sand bodies separated from other clusters by muddier basin fill that only contains sporadic channel-belt bodies. Where observed clusters record up to a few tens of individual sand bodies dispersed over a cross-valley width of a kilometer or less. Vertically, individual clusters are separated by muddy lanes of dominantly flood plain deposits.

Where described elsewhere these features have been interpreted as controlled by changes in relative sea level. In this view, the cluster-lane succession is tied to varying rates of aggradation controlled directly by rates of relative sea-level rise. However, where seen in long cross-strike sections in Wyoming, muddy lanes appear to run laterally into avulsion clusters, suggesting there is always an avulsion cluster somewhere in the basin. Lateral spacing of clusters is on the scale of kilometers and, thus, may be missed in outcrops or in subsurface observations of more local extent.

In contrast, we interpret clusters to be composed of local avulsions in one part of the alluvial basin that built topography to the point that regional avulsion occurs, moving the river channel to a lower part of the basin. In this view avulsion clusters are autocyclic events that occur less frequently and over larger areas than the local avulsions that compose the cluster. As such, these events are not necessarily tied to sea level. The recognition of groups of avulsions clusters, however, may provide a useful way to describe the intermediate time-scale architecture of alluvial filling in basins.

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