Floodplain Sediment Facies Analysis and Its Role in the Investigation of Archaeological Site Stratigraphy in the Midwestern United States

Introduction

Much archaeological research and fieldwork takes place in river valleys because prehistoric peoples frequently lived near rivers. The diversity and abundance of physical and biological resources in river valleys made them very attractive to people for settlement. Often, river valley deposits contain abundant archaeological sites. Within or outside of these sites, artifacts such as stone tools and pottery as well as larger archeological features such as burial mounds or building remnants can be found. Although river valleys are important because archaeological deposits are frequently found in them, channel migration and resulting erosion sometimes make it difficult to predict the location or specific environmental context of cultural features and artifacts in fluvial settings.

The study of fluvial erosional geomorphology and depositional processes in a river valley can yield important implications for archeological site preservation and stratigraphic location within river valley deposits. Geoarchaeological investigations are important in river valleys to accurately reconstruct paleoenvironmental and geomorphic contexts of archaeological deposits. One important geomorphic method that is often used in river valley settings involves the study of the sedimentary facies, or physical characteristics of the river deposited sediments. During the process of fluvial sedimentation, erosion, and deposition, various facies and buried soils are produced. Stratigraphic relationships among them and landforms composed of them are produced. Specific facies, once identified, can often be diagnostic of paleoenvironmental conditions at the regional (river valley) and archaeological site scale.
In addition, archaeological deposits that are found in river valleys deposits can often be used to date the deposits in context for a more accurate interpretation of the paleoenvironmental conditions. Charred wood from paleo-campfires, for example, can be carbon dated to obtain date ranges for the deposition of the sediment in context. Date ranges of artifacts from known archaeological time periods can also be used to date the deposition of the sediment.

The purpose of this paper is to describe the sediment facies, stratigraphic relations among them, and resulting landforms in river valleys in the Upper Midwest and explain their archaeological significance.

**River Morphology and Sedimentation**

Meandering rivers, common in the Midwest, exhibit a characteristic sinuous channel pattern (Bridge, 2003). This pattern is a function of channel discharge, sediment supply, slope, and underlying geology. Meandering rivers generally transport loads of mixed grain sizes ranging from gravels to suspended silts and clays. Meandering rivers develop their migrating channel pattern within an area referred to as a meander belt. Within this meander belt, much change in channel shape takes place over time along the river banks. During river meandering, sediment accumulates on point bars and floodplains and cut banks erode. The amount of bank erosion and rate of channel migration is, in part, controlled by the particle size distribution of the river sediments being transported, stream velocity, and the composition of the river bank sediments (Christopherson, 2003). Particles with smaller grains sizes such as clays and silts are more easily carried, once entrained, by channel flow than coarser-grained gravel and cobbles. More cohesive fine-grained silts and clays also require relatively higher stream velocities for them to be entrained as described by the Hjulstrum diagram (Herz and Garrison, 1998) (Figure...
1). When stream velocity decreases to the point that it can no longer carry certain grain sizes, the grains will be deposited.

![Hjulstrum diagram showing erosion, sedimentation, and transportation potential for various grain sizes.](image)

**Figure 1.** The Hjulstrum diagram showing the erosion, sedimentation, and transportation potential for various grain sizes. The upper left portion of line A indicates clays that are hard to erode while the middle portion of this line indicates that sands are more easily eroded with the same velocity. The reason for this is that sands are unconsolidated compared to clays. The left portion of line B indicates that finer-grained sediments stay in suspension and are hard to deposit compared to coarser-grained gravels as shown in the right portion of this line (from Herz and Garrison, 1998).

**Fluvial Facies**

Sedimentary facies are defined as laterally equivalent bodies of sediment with distinctive characteristics, and are important in studying the stratigraphy of river valley deposits (Boggs, 2006). Sedimentary facies are often distinguished by their composition, grain size, and formation process. These properties are acquired 1) from parent materials, 2) during transport, 3) as a product of the depositional micro-environment, and 4) from *in situ* post-depositional alteration (Gladfelter, 1977). The development of sediment facies within a meandering river is a
function of the river discharge, bedload, and sediment supply. During sediment deposition, the various facies are developed into separate identifiable stratigraphic layers that are horizontally continuous.

The facies observed in a meandering river include those composed of gravel, sand, those composed of fine-grained clastic sediments, and those composed of nonclastic sediments. Gravelly facies consists of coarse-grained gravels and cobbles that are deposited on the channel bed by traction or bouncing along on the bed. Gravels and cobbles originate further upstream as fragments of rock are eroded away through weathering processes. They are usually thick bedded and can be horizontally or cross stratified.

Channel margin facies within a fluvial system is mostly composed of sand and is the result of grain size, flow depth, and flow velocity. Depending on these factors, channel margin facies may be further divided into channel margins containing planar bedded or cross laminated sands. Planar bedded sands are deposited during the migration of sub-aqueous dunes (Miall, 1996). They form in sands ranging from very fine to coarse grained. Cross laminated sand are formed from ripples along the river bed. Due to constant physical sorting by water, these sands are often well sorted and well rounded.

Overbank facies consist of fine-grained clastic mud, silt, and very fine sand. They deposit primarily from the suspension load of rivers. Two sub-facies within overbank facies include alternating sand, silt and mud, and parallel laminated silts and clays. Alternating sand and silt layers represent deposition from suspension and weak traction currents (Miall, 1996). Thicknesses within this sub-facies can range from a few centimeters to many meters (Miall, 1996). Parallel laminated silts and clays are a function of sediment deposition from suspension
within the river. This sub-facies is distinguished from the previous one in that it does not contain sand beds.

**Fluvial Landforms**

Sediment facies within a river valley form in-channel deposits and floodplain deposits. In-channel deposits include channel beds and bedforms, and point bars. Floodplain deposits are known as levees, crevasse-splays, oxbows, and floodplain (overbank) deposits.

The channel bed of a meandering river undergoes significant changes through the erosion and deposition of various sizes of sediment over time. The rate of channel bed change is largely a result of the stream velocity and sediment supply. If the flow velocity is too low to carry a certain sediment grain size, then deposition of these grain sizes will occur in that particular location in the river bed. Over time of this process will result in deposition of bedload facies through lateral accretion of sands or gravels, while finer-grained silts typically remain in suspension.

During the process of channel migration a river will deposit sediments in the channel in the areas that have decreased stream velocity, usually on the inside of the river bends. This river deposit is known as a point bar. Stream velocity is slower in the inside of meanders as compared to the cutbank on the outside of the meander (Figure 2). The sediments that are deposited on the point bar near the channel bed are coarse grained gravels that are deposited in traction with decreased stream velocity. Cross bedded sands are then subsequently deposited on the point bar in an upward-fining sequence due to decreased stream velocity. The deposited sediment is typically coarser bedload near the channel and becomes finer towards the inside channel margin.
The point bar (D) is formed on the inside bend of the river while the cutbank (C) is eroded on the opposite side of the bank. The helical downturning of the river flow is shown in Figure 2. The fining-upward sequence in the point bar is shown in Figure 3 (modified from Brown, 1997).

As the sands and gravels are deposited, they form angled bedding surfaces that are known as point bars. This process is known as lateral accretion. The opposite side of the channel from the point bar undergoes erosion as the river migrates and is referred to as the cutbank (Figures 2 and 3). As water flows around the outside bend of the river it develops into a helical down-turning pattern that erodes sediment from the cutbank laterally. This sediment is carried downstream via suspension or saltation along the channel bed, depending on grain size. Large chunks of the cutbank sediment also might slide into the river and become deposited further down the channel as a lag deposit. This eroded sediment from the cutbank can also be carried from the base of the cutbank to the base of the point bar due to the helical flow of the water around the bend.

Sediment that arrives at the point bar is deposited laterally with the coarser sediments near the bottom and the finer ones near the top (Figure 3). The rate and thickness of lateral accretion taking place in a meandering river is highly dependent on the rivers sediment load, channel morphology, and river discharge.
Figure 4. A block diagram interpretation of some meandering river deposits. Note the sinuous lateral accretions deposits referred to as point bar (from Reineck and Singh, 1980).

Floodplain deposits are common in rivers that transport fine-grained sandy or silty sediments. These deposits form expansive floodplains within a river valley where recurrent flooding takes place. Floodplain (or overbank) deposits are vertically accreted onto the floodplain during floods to form a floodplain. The various types of overbank deposits include levee deposits, crevasse splay deposits, and floodplain deposits.

Levee deposits are ridges that run parallel to the river along its banks (Figure 4). These deposits form as a result of gradual influx of vertically accreted sediment aggrade the floodplain. Levee deposits are typically fine-grained silts and clays. Vertical accretion or floodplain deposits can accumulate to 10 m thick and form a tapering wedge of sediments that becomes thinner and finer texture away from the channel margin (Miall, 1996).

Crevasse-splay deposits somewhat resemble tributaries to a river but they are a result of overbank flow and incision (Figure 4). Crevasse-splays are small new river channels formed during erosion of floodplain deposits during floods and re-deposition of eroded material. Crevasse splay deposits are ribbon-like deposits typically consisting of fine- to medium-grained
sand with trough cross-bedding and ripple cross-lamination (Miall, 1996). Crevasse-splay deposits are finer-grained than the sediments in the main river channel because they are the result of an overbank deposition. This fine-grained deposition is due to the low-energy environment of a laterally extensive flood.

Floodplains are flat plains adjacent to rivers that are subject to flooding (Figure 4). They serve as settling basins for fine-grained overbank sediments that pass over levees and crevasse-splays during a flood. The areal extent of a floodplain is partly a function of the local topography as well as properties of the river itself. The maximum size of a floodplain is defined by the largest flood in the river valley. If the adjacent topography is very low and close to the elevation of the river, the floodplain will have great lateral extent. In contrast to this, narrow and steep river valleys confine the floodwaters and cause the river discharge to be greater and create floodplains at greater elevations than of low topographic areas.

Floodplain sediments are unconsolidated materials derived from lithic or organic sources that are deposited in a flood basin from suspension after the river tops its banks and recedes (Brown, 1997). These sediments constitute a large percentage of river deposits and are stratified in a horizontal sequence. Sands are deposited first, followed by silty-clays. The rate of sedimentation is generally very slow; usually 1 or 2 cm is deposited during a flood (Reineck and Singh, 1980). The stratigraphic sequence of floodplain sediments during a single flood begins with a sand layer deposited during the rising leg of flood discharge and gradually becomes siltier upward with the decreasing discharge rate (Reineck and Singh, 1980).

Abandoned floodplains located higher than the present floodplain are known as terraces. Terraces are composed of the channel and floodplain facies in the meander belt subsequently abandoned. A terrace consists of two distinct topographic components: (1) a tread, which is the
flat surface of the former floodplain, and (2) a scarp, which is the steep slope that connects the
tread to any surface standing lower in the valley, other terraces, or the modern floodplain (Dury,
1970).

**Fluvial Facies in the Midwest**

The temperate climate throughout much of the Midwest, in addition to the nearby
geology and sediment influx, greatly determines the variety and extent of fluvial facies that
develop. The relatively mild topographic relief and abundant precipitation in the Midwest are
some of the many factors that contribute to the meandering river channel pattern and associated
facies.

A good example of a meandering channel river in the Midwest is the Mississippi River.
This river, although much larger than most in the region, has several facies that are characteristic
of meandering rivers. Tributary streams introduce little coarse material into the Mississippi
River so most of its load consists of fine sands, silts, and clays (Fisk, 1947). Numerous meander
scars are present in the river valley and landforms that are common include levees, terraces,
floodplains and crevasse-splays.

**Stratigraphic Relationships of Fluvial Facies**

The migrations of meandering rivers in the Midwest and variances in sediment load and
deposition over time have often developed complex stratigraphy within those river valleys.
Abandoned river channels leave facies ranging from bedload deposits to floodplain deposits,
while subsequent overbank deposition from the modern river channel causes levee and overbank
aggradation. An entire stratigraphic profile from a river valley can then consist of multiple alluvial facies depending on proximity to the modern river channel.

Stratigraphic relationships in alluvial valleys of the Midwest have been thoroughly studied by a multitude of authors (Fisk, 1947; Gardner and Donahue, 1985; Van Nest and Bettis, 1990; Bettis, 1992; Stafford and Creasman, 2002; Stafford, 2004) because of the importance of the alluvial context for archaeological research. Stafford (2004) studied core samples taken in the Ohio River Valley and determined that there were at least 5 identifiable alluvial sequences. At the Ohio River levee he identified a shale bedrock unit at 24 meters depth, overlain by approximately 12 meters of glacial outwash and bedload sands and gravels, 4 meters of bar deposits, 2 meters of overbank deposits, and topped with .5 meters of historic (post settlement) alluvium. His conclusions are consistent with others (Fisk, 1947; Gardner and Donahue, 1985; Van Nest and Bettis, 1990; Bettis, 1992; Stafford and Creasman, 2002; Stafford, 2004) that suggest that there is generally a large amount of Holocene alluvium in Midwestern river valleys. This Holocene alluvium is a stratigraphic marker that is most important in studying the archaeological deposit potential within terraces.

**Archaeological Significance of Fluvial Landforms**

As discussed earlier, fluvial landforms are indicative of past and present river activity and are important stratigraphic markers for assessing archaeological deposit potential. River valleys have been popular destinations for paleocultures, but unfortunately the preservation potential for artifacts or features is sometimes very low near past and present river channels due to the constant reworking of sediment from river migration. Such associated landforms include river
channel facies such as pointbars, cutbanks, and bedforms. Overbank sediments, on the other hand, are more likely to preserve artifacts or features if they are deposited in low-energy floods.

**Interpretation of Floodplain Sediments**

**Paleoenvironmental Reconstruction**

Alluvial valleys can be important paleoenvironmental indicators. The fluvial environment is constantly changing over time and space as rivers migrate and sediments are eroded and deposited. The changes in the balance of the fluvial system are a function of climate change, tectonic activity, fluctuating sea level, and human land use. These changes are recorded in the stratigraphic record preserved in alluvium.

Much work has been done on paleoenvironmental reconstruction based on interpretation of fluvial deposits. Bettis (1992) used stratified sediment deposition sequences in terraces and floodplains in the Des Moines River Valley in Iowa to develop a model to be used for differentiating between fluvial deposits and landforms of Historic, late Holocene, and early and middle Holocene age. Early and middle Holocene alluvium, deposited prior to 4000 B.P., was generally located on low terraces and alluvial fans. These vertically accreted overbank deposits consisted of silts and loam. Late Holocene alluvium deposited after 3500 B.P. was usually found within the modern floodplain and consisted of vertically accreted clayey and silty loams. Historic alluvium deposits was located in the floodplain and in smaller tributary stream valleys and were generally finer-grained than the late Holocene sediments. The paleoenvironmental interpretation from the alluvium is that a drying trend occurred between 6500 and 5000 B.P. followed by increased precipitation and erosion after 4000 B.P. (Bettis, 1992).
Analysis of river terrace sequences can be used to interpret the paleoenvironmental conditions. River terraces are common throughout much of the Midwest and indicate abandoned floodplains. Terrace forming events in the Midwest likely occurred during the extended dry period in the mid-Holocene and can be related the location of potential archaeological sites. Sediment corings taken in the Little Platte River Valley of Missouri by Gardner (1985) indicate separate terraces with different compositions (Figure 5). When the cores were compared with other deposits in the drainage basin, a maximum age of the Illinoian or Sangamonian period was estimated for the highest terrace. This age is believed to pre-date any prehistoric occupation. Any archaeological deposit will therefore be found in lower terraces in the sequence.

Figure 5. A cross-sectional interpretation of terraces in the Little Platte River Valley of Missouri. Note the coring locations to determine the extent and composition of the terraces. The highest and oldest terrace is T₂ and the youngest is T₀. The T₂ terrace predates human occupation. Archaeological sites will only be found on the surface only. T₁ terraces are composed of a combination of T₂ alluvium and loess. These terraces are younger than T₂ and might contain archaeological deposits. The T₀ terrace is recent alluvium (450 +/- 150 yrs B.P.) and will not contain any prehistoric artifacts (from Gardner and Donahue, 1985).

Site Prediction Models
Meandering rivers channels that change location over time greatly affect the placement and preservation of archaeological sites in the Upper Midwest (Gardner and Donahue, 1985; Stafford, 2004). A study of sedimentary and stratigraphic data in an alluvial setting can provide clues to potential locations of archaeological sites. Although these methods are useful in piecing together a site history, thorough research must be done in the region or drainage basin to develop the best possible site prediction model. The reason for this is that drainage basins provide the most reliable framework for correlations of stratigraphic sequences between local environments and environments outside of the region (Gladfelter, 1977).

The following model proposed by Gardner (1985) for use in his research in the Little Platte Valley is one example (Figure 3):

1) Artifacts on uplands should be within the plow zone due to consistent erosion since the late Pleistocene.
2) Upper portions of the valley slopes have been subjected to erosion throughout the Holocene, and could contain artifactual assemblages.
3) The highest terrace pre-dated prehistoric peoples (Illinoian in age) so no artifacts will be found in these deposits, but only on the surface.
4) Low points on a lower terrace surface are Holocene in age and will contain artifacts.
5) The lowest terrace in the sequence (T₀) post-dates any prehistoric cultures because it is recent meander scar alluvium (radiocarbon age of 450 +/- 150 yrs B.P.).

Artifacts in river valleys have a low preservation potential due to constant floods and sediment deposition (Brown, 1997). Although several cultures may have lived in a particular river valley throughout history there may not be much archaeological artifacts remaining. In a river valley archaeological deposits will have the most preservation potential further away or at the highest point, possibly on a high river terrace or hill. Due to the occasional 100 or 500 year flood and river channel migration fewer artifacts will be preserved in lower areas near the river. There is a potential for preservation on point bars near the inside of a river bend however.
There can be some uncertainty in the provenience of a discovered artifact in alluvial settings. Although the surrounding sediments may be in identifiable and datable stratigraphic layers the artifact may not originate from that that specific area (Brown, 1997). The river may have carried the artifact for long distances before redepositing it at a particular floodplain location. With this in mind, care should be taken in the assumption of an artifact’s provenience and relationship to the surrounding sediments.

Although archaeological artifacts are susceptible to displacement by floods, archaeological features will tend to stay in place and become buried in overbank sediments. Much archaeological study on floodplains of the Midwest (Gardner and Donahue, 1985; Van Nest and Bettis, 1990; Bettis, 1992; Stafford and Creasman, 2002; Stafford, 2004) has shown that archaeological features are not as common in floodplains as on uplands. Paleo-indian sites in Midwestern river valleys usually contain evidence of temporary occupations such as campsites or food processing sites. The more permanent occupations took place on the uplands where the risk of flooding was much less.

Summary

The physical environmental context is very important for archaeological sites and artifacts discovered within alluvial settings. Alluvium contains valuable information about the physical setting of the archaeological site. Alluvium and fluvial landforms also indicate a lot about the paleoenvironmental context as well. Sediment deposition and paleoclimatic information can be inferred from analysis of stratigraphic profiles. Although sedimentary conditions and deposition are not always consistent throughout a particular river valley,
important information obtained by alluvial sediment studies can be used to infer settlement patterns and cultural attributes of a prehistoric group.

References Cited


Springer-Verlag, 551 p.


