A Geoarchaeological Assessment of Alluvial Valleys at Camp Pendleton With an Overview of the Important Natural Site Formation Processes

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Abstract

Alluvial environments are the principle locations at Camp Pendleton where deposition has occurred during the Holocene, and hence, are of considerable interest to archaeologists. However, alluvial deposition, erosion, and stability are intricately linked to other factors, including sea level change, tectonic activity, climate change, vegetation, and human impact. Recent geoarchaeological projects at Camp Pendleton have begun to examine these factors. This paper presents a synthesis of some of the most recent data and proposes an alluvial chronology for mid-size drainages at Camp Pendleton.

Introduction

One of the difficulties of archaeological research in Southern California, and indeed many other parts of North America, is that most archaeological sites are at, or near, the surface and have undergone significant disturbance due to burrowing animals and other processes which has resulted in a mixed substrate. There is a sincere need to find buried archaeological sites where the occupations are not disturbed and have not been mixed. In 1997 we initiated a large-scale study for ASM Affiliates and the Camp Pendleton Marine Corps Base of the depositional history of the floodplain sediments of the coastal valleys in an effort to develop a model to predict the location of buried archaeological resources at the Camp Pendleton Marine Corps Base (Pearl and Waters 1998). We chose alluvial depositional environments because floodplain sediments of the coastal valleys are the major environments where deposition has occurred during the late Quaternary at Camp Pendleton. Therefore, these are where buried archaeological sites are most likely to occur. This paper presents a synopsis of the depositional history of Camp Pendleton and discusses some of the most significant natural site formation processes that continue to affect archaeological resources along the Southern California coastal zone.

The 1997 Study

The sixteen drainages selected for study are shown in figure 1. Many of these are ephemeral though some, like the Santa Margarita, are perennial. Interpretations were based primarily on the analysis of aerial photographs. Color stereograms were used that completely covered each

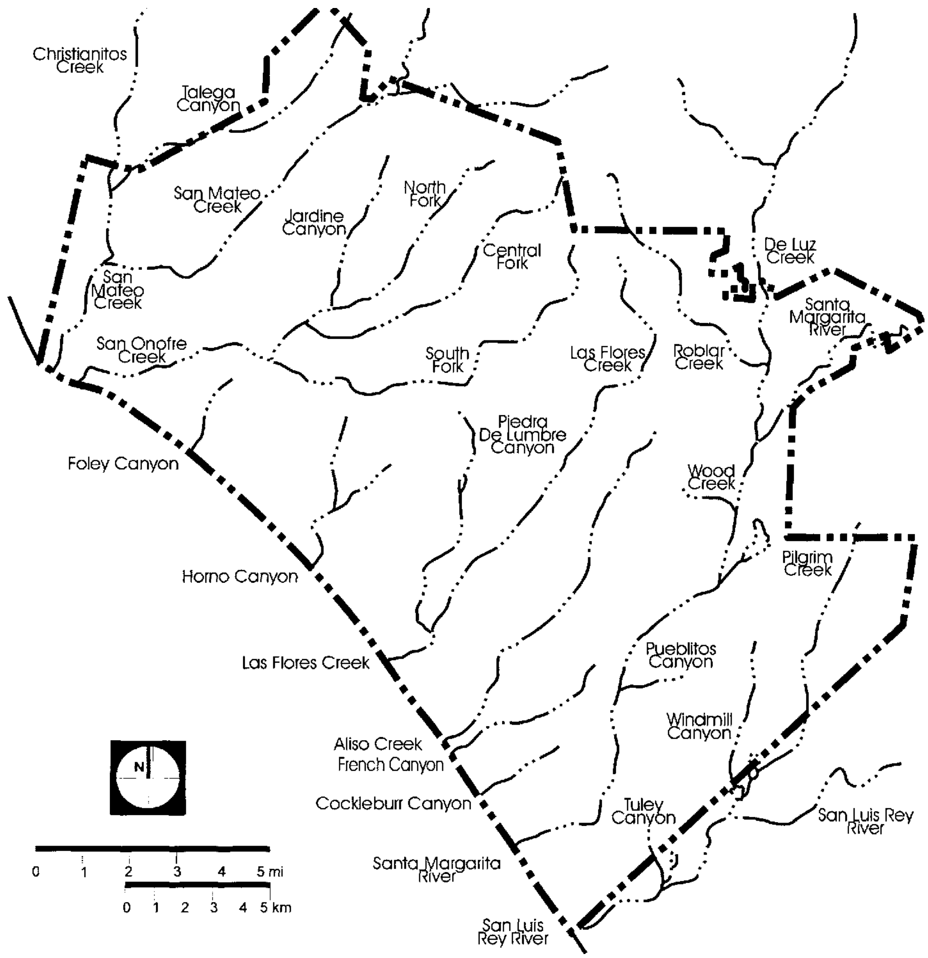

Fig. 1. Map of the drainages investigated on Camp Pendleton, California.

drainage. The photographs were flown in 1993 and are approximately 1:16,000. Interpretations based on these photographs were then compared with geologic and soils maps of the area and transferred to USGS 7.5 minute topographic maps. This study resulted in a large scale geomorphic map of the sixteen drainages utilizing five broad geologic units. These include bedrock (which is Precambrian through Tertiary), Quaternary marine terraces and associated sediments (which are early and middle Pleistocene), late Pleistocene and Holocene stream terraces, late Pleistocene and Holocene colluvium and fans, and modern streambed alluvium.

Field survey by Waters on prior projects (1996a, 1996b) indicated that the Holocene terraces could be differentiated more finely with ground survey. Field survey is also important because it has provided the radiocarbon ages that form the basis of the regional alluvial chronology presented hereafter. The study was also important because it demonstrated the existence of a stratified record of human occupation preserved in Holocene stream alluvium. By looking in multiple places, Waters (1996a, 1996b) discovered at least four paleosols representing prehistoric periods of stability. The oldest buried surface is at least 4000 years old, while several younger soils lie over it.

The Importance of Ongoing Natural Site Formation Processes Along the Southern California Coastline

This project was dedicated largely to the mapping and understanding of the major drainages occurring on Camp Pendleton. Fluvial landforms are the most prominent components of this study, but fluvial landforms are the result of many ongoing natural formation processes that are a part of a complex system. While fluvial processes create the terraces and bars which make up much of the project area, erosion, deposition, and stability are largely systemic responses to other variables, including sea level change, tectonic activity, climate change, vegetation, and human impact. Discussed herein are some of the major processes reflecting the long-term development of the landforms mapped for this project. This list of processes is by no means exhaustive, but it does encompass the major variables presented in the model of regional drainage basin evolution presented later.

Fluvial Processes and Deposits

Fluvial processes are those directly associated with the flow of water. They are the most basic erosional and depositional processes observed in the project area. Fluvial landforms include the modern streambed and adjacent terraces.

Transport of sediment by water occurs when stream power (usually characterized by its velocity) exceeds the cohesiveness and/or mass of the sediments. Later, as velocity decreases, the heaviest particles are the first to become deposited. This results in a sequence of sediments that grade from coarser at the bottom to finer at the top as the velocity of a stream decreases after a flood. Equally important is the notion that the sediments in the stream must have come from somewhere—either from weathered bedrock or from the erosion of unconsolidated terrace sediments upstream. A drainage basin is an extremely dynamic place. Any point on the landscape must be in one of three states: deposition, erosion, or stability. Older sediments become redeposited to create younger terraces or are eventually washed out to sea. In between those times, stability may dominate a region allowing it to be colonized by vegetation and for soils to develop. The combination of these processes over time results in terraces with distinct textural compositions, often with soils buried within them. These stratigraphic subdivisions might be traced from terrace to terrace and even from stream to stream. However, deposition and erosion are responses to an overall system. A decline in sea levels will cause streams to cut into their own floodplains to adjust to the new base level. Conversely, a rise in sea level will cause deposition to occur, potentially burying older terraces. Terrace remnants are often seen along valley walls as step-like landforms. Terrace levels are usually consistent through a drainage network, and if they are able to be dated, a chronologic framework outlining the ages of the terraces can be developed. Holding other factors such as bedrock, climate, and vegetation constant, there might be a great deal of regional correlation in a drainage network. For example Nordt (1992), in a study of the drainage network at Fort Hood Military Reservation in Central Texas (Base similar in size to Camp Pendleton), found a very high degree of correlation between the ages and numbers of terraces throughout the post. At Fort Hood, a majority of the known archaeological sites were found on eroded upland surfaces where ten thousand years is compressed on or near the surface. By focusing his attention on fluvial landforms, Nordt directed attention to where deeply stratified deposits were likely to be found. Efforts at Camp Pendleton might produce similar results.

The significance of alluvial deposits has long been recognized in the San Diego area. The earliest recognition of a cultural chronology in San Diego came from a deeply stratified alluvial chronology at the C. W. Harris Site (Warren 1966). At one time there may have been many such “Harris Sites” in San Diego County, but since the 1930s most of the natural drainages in coastal Southern California have been disturbed by urban development. Camp Pendleton represents a significant grouping of streams that have large volumes of alluvium that may contain deeply stratified materials.

Colluvium and Fan Deposits

Colluvium and fan deposits are formed by a combination of alluvial and mass movement processes. Colluvium is often referred to as “slope wash” resulting from “sheet erosion.” The loosely consolidated materials that make up much of the California Coastal Plain are particularly subject to erosion. As such, colluvium is common. Unlike colluvium, which is generally found at the base of a slope or forming a slope, fans are usually the result of flow from higher gradient tributaries, spilling into a lower gradient one, or onto some other geologic “floor.” The fans observed at Camp Pendleton generally are derived from ephemeral flow. These are also known as “dry fans” (Schumm 1977). Colluvium is often thought of as being accumulated over time. In the Camp Pendleton area, dry fans are likely to be well drained, and potentially good locations for archaeological sites. Fan deposits will generally interfinger (become stratified) with sediments being deposited in adjacent environments if both are undergoing deposition at roughly the same time. Fans thus might often have a deep and well stratified subsurface profile. Because of the higher gradient and velocity of colluvial and fan systems, they are often much coarser than interfingering fluvial deposits. This pattern of deposition was indeed the general sequence noted at the Harris Site on the San Dieguito River south of the current project area. That site was interpreted as having formed under varying fluvial conditions (Warren 1966). At Camp Pendleton, similar circumstances will most likely create interfingering fluvial and colluvial deposits. Because fans are constantly forming and reforming, they need to be taken seriously from an archaeological perspective. Fans which are adjacent to important resource areas should be considered as candidate locations for buried archaeological sites.

Sea Level Change

Although the California coastal zone has been relatively stable for several thousand years, the record for the Quaternary is quite different, showing a very dramatic shift in sea level. During the Quaternary, worldwide sea levels rose and fell, roughly synchronized to the appearance and disappearance of the continental ice sheets (Flint 1971). During the periods of glaciation, large amounts of water were locked up in the North American ice-sheets, depressing world-wide sea levels, thereby exposing vast amounts of coastline. During the interglacial stages melting icecaps returned sea levels to higher levels. Relative sea levels during interglacial periods would have been higher or lower depending on the severity of the climate change, resulting in multiple differing sea level high stands.

Various sea level curves have been reconstructed using a variety of evidence such as coring and dating elements in glaciers, ice sheets, and the continental shelf. These curves are not identical largely due to localized differences in tectonic activity as well as the dating techniques employed. However, a comparison of worldwide sea level curves for the past 12,000 years show remarkable conformity (Kraft et al. 1985). This is probably because the effects of tectonic activity during this time are not as pronounced and dating techniques are more reliable for this period. These curves all show rapid sea level rise until about 6000 years BP. Because there is some regional variation in sea level curves, it is important to utilize the best and nearest curve to the project area when discussing sea level change. A sea level curve has been developed by Nardin et al. (1981) for the Santa Monica shelf showing changes in sea level over the past 18,000 years. Their curve is based on radiocarbon ages, seismic data, and data from deep sedimentary cores. They show that sea level has risen about 117 m over the past 18,000 years, rising to within 10 m of its present level approximately 8000 years ago. Since that time there has been a slow but steady rise punctuated by a brief episode of rapid transgression of several meters approximately 4000 years ago.

Tectonics and Marine Terraces

Southern California is very active tectonically. Camp Pendleton has several faults shown on the USGS maps. The southern coast of California has experienced a great deal of tectonic uplift during the Quaternary as evidenced by an extensive suite of raised marine terraces (Dupré et al. 1991; Shlemon 1987). Measurements indicate that the Southern California coast has experienced long term uplift rates that range from 10 to 40 cm/1000 years. At San Diego, uplift of the coast has been measured to be between 16 and 20 cm/ 1000 years.

Bedrock Erosion/Rate of Cliff Retreat

A great deal of research has been done on determining the rate of cliff erosion in San Diego County, and much of that research has been conducted between San Onofre and the Santa Margarita River. As such it is directly relevant to the current study. Kuhn and Osborne (1987) showed that even though conventional methods of measuring sea level retreat have shown little change since 1947, these estimates have severely underestimated the degree of mass wasting and gullying above the cliff toes. One documented landslide was over 1700 ft long and 320 ft wide. This punctuates the earlier conclusions that sea cliff erosion is highly episodic (Kuhn and Shepard 1979). Additionally, cliff retreat appears to have become accelerated during the past twenty years due to urbanization and the channeling of runoff beneath U.S. Highway 101 and now Interstate 5 (Kuhn and Osborne 1987). Shoreline retreat has been measured between 0.01 and 0.5 meter per year (m/yr) in southern California (Muhs et al. 1987). Everts (1991) estimates the current rate of seacliff retreat to be between 0.02 and 0.09 m/yr. This generally concurs with the values modeled by Reach of 0.08 m/yr for the Camp Pendleton area (Reach 1988, reported in Everts 1990). Along the shoreline of Camp Pendleton the bedrock is composed of highly erodible Tertiary sandstone. In this area, Kern (1995) believes the shoreline retreats at a rate of between 0.125 to 0.25 m/year. This rate is somewhat higher than others in the county as the vegetation cover is mostly native, and the resistance of the cliffs to scour is low. Whether or not the modern rate of seacliff retreat should be higher, lower, or equivalent to prehistoric long-term rates of retreat is a matter for theoretical debate. The rate might generally be increased due to decreased sediment yield resulting from urbanization. Everts suggests that long-term rates were probably higher, especially during the more rapid rates of sea level rise initiated 18,000 years ago (Everts 1990).

During the Holocene the ongoing processes just discussed have dramatically altered the landscape. Ten thousand years ago the coast was hundreds of meters farther out to sea, sea level was about 20 meters lower than at present, and the continent may have uplifted somewhat since that time. The fluvial response to these changes is now discussed in light of the observations made for this report.

Alluvial Chronology for Medium-Sized Streams

We will now briefly discuss the specifics of the generalized depositional history of San Mateo and Las Flores Creeks on Camp Pendleton as a model for other medium-size drainages in this region. Both San Mateo Creek and Las Flores Creek had a similar geologic history (Fig. 2). Both have two Holocene terraces at about the same elevation above their respective creek beds and both have sediments of similar age making up these terraces (Waters et al., 1999). Within the geological records of San Mateo Creek and Las Flores Creek three major geologic events are recorded during the late Quaternary: (1) initial cutting of deep valleys during the late Pleistocene; (2) a long period of aggradation which culminated during the Holocene creating a thick pile of sediments beneath Terrace 2; and (3) a period of channel instability with channel incision (creating Terrace 2), followed by deposition, and incision of the channel again (creating Terrace 1) during the late Holocene.

The first event, the deep entrenchment of San Mateo Creek and Las Flores Creek, coincides with a worldwide drop in sea levels from about 24,000 to 18,000 years ago. In the study area,

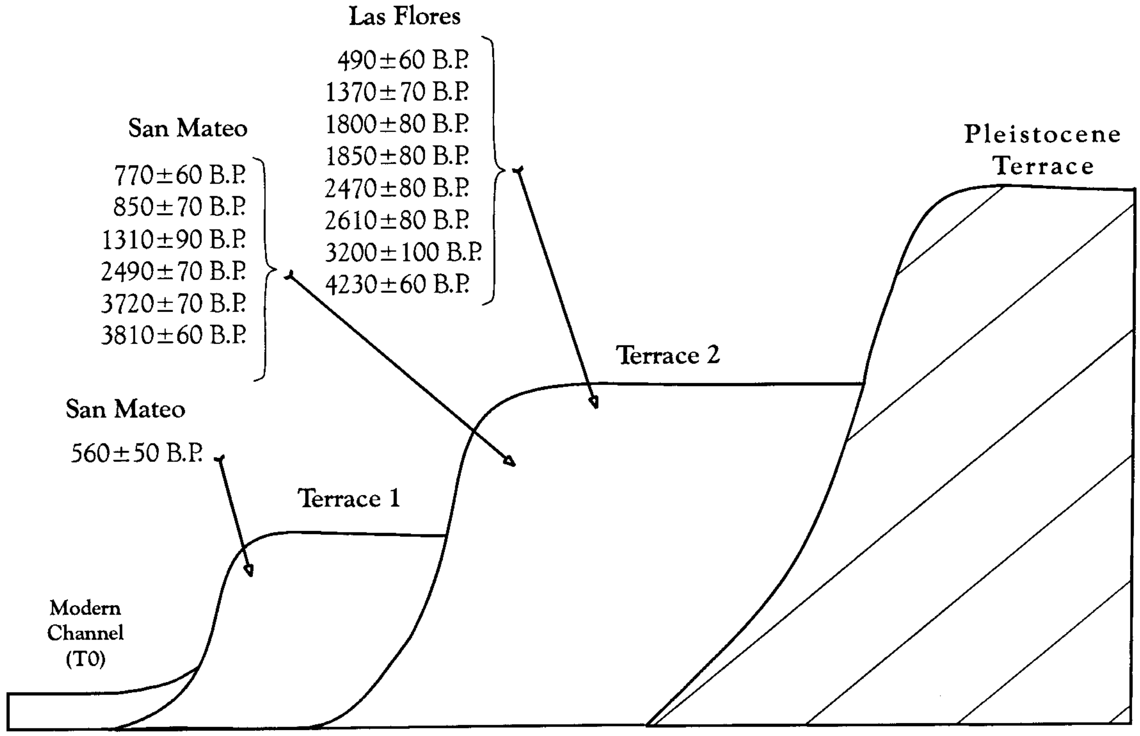

Fig. 2. Generalized terrace sequences for San Mateo and Las Flores Creeks. Radiocarbon dates obtained from the terrace sediments are indicated (from Waters et. al. 1999)

sea level fell at least 120 meters below its present position (Nardin et al. 1981; Inman 1983; Masters 1988). As a result of this drop in base level, streams entering the Pacific Ocean downcut and created deep valleys (Inman 1983; Shlemon 1992).

The second geologic event, aggradation within the valleys of San Mateo and Las Flores Creek, coincides with the rise in sea level which began at the end of the Wisconsin around 18,000 to 20,000 B.P. Nardin and others (1981), Inman (1983), and Masters (1988) showed that by 8000 B.P. sea level was approximately 16 meters below its modern position. From 5000 to 3000 B.P. sea level rose rapidly followed by a slow rise in sea level to its present position. As the base level continued to rise, the valleys of San Mateo Creek and Las Flores Creek filled with channel and floodplain sediments that now underlie Terrace 2 (Fig. 2).

The third geologic event included the incision of both channels into their respective floodplains creating Terrace 2 followed by aggradation, and then followed by renewed channel incision and the creation of Terrace 1 (Fig. 2). Based on the available radiocarbon ages from both streams, these events appear to have occurred sometime around 500 B.P. The reason for these two episodes of channel downcutting in what would have been an aggrading stream system seems puzzling. These changes appear to be unrelated to the slow tectonic changes along the coast and what is known about the low and consistent transgression of the oceans (Muhs et al. 1987; and Dupré et al. 1991). More likely, these late Holocene channel changes are probably a complex response of the fluvial system (Schumm 1977) to climatic perturbations along the southern California coast. Schimmelmann and others (1998) have shown that a major flood occurred along the southern California coast about 400 years ago. This flood event is correlated with an El Niño-Southern Oscillation event in the historic record. Quinn (1992) has documented numerous El Niño-Southern Oscillation events over the last 500 years based on historic records. These data show that El Niño events regularly affect southern California. It is perhaps during one of these events that flooding triggered channel downcutting. This resulted in the transport of sediment from the headwaters which were eventually deposited as Terrace 1 in the downstream portions of the channels. This surface was then entrenched as the stream reestablished its base level as the normal flow regime returned.

The preceding chronology is based on the studies of Las Flores and San Mateo Creeks (Waters et al. 1999). This depositional scenario may also hold true for other medium-sized drainages at Camp Pendleton. However, additional fieldwork will be required before this can be determined. Further, it is difficult to speculate on how much different a large drainage such as the Santa Margarita River or San Luis Rey River might be. Further field studies will be necessary to demonstrate their depositional histories.

Significance

Understanding the evolution of coastal drainages will allow us to better understand the distribution and limitations of the archaeological record. Clearly, portions of the archaeological record are deeply entombed and not accessible for study, portions are submerged and eroded from the continental shelf, and portions are visible in limited cutbank exposures.

Anthropologists have come to realize the complete interdependence of humans on the environment or habitat in which they live. Archaeologists have been particularly keen to understand this relationship, and virtually no archaeological report these days is without the mandatory section on the environment. Yet surprisingly little attention is paid to the prehistoric environment. It is often assumed that the paleoenvironment is reflected by, or very similar to, the modern environment. This reflects a general lack of appreciation for the power and dynamics of geomorphic agents. The Holocene has seen major changes in the local environments. This is not to say that geomorphology has been ignored, for indeed it has not. Archaeologists working on the coast now recognize that due to fluctuating sea level, tectonic activity, and erosion, the coastline of San Diego County was much farther out to sea 10,000 years ago. Archaeologists working on the coast can quickly appreciate the significant impact this retreat has had on the preservation of the record of Paleoindian and Archaic archaeological sites. Yet the effect of these changes on inland habitats has been inadequately addressed. Inland stream networks are intricately tied to coastal systems and the rise and fall of relative sea levels and changes in distance to the sea can initiate complex responses in stream systems as they downcut or build up their alluvium, sometimes destroying cultural resources, but other times burying them deeply. Clearly also, if human beings were involved in some sort of systemic relationship with the local ecology, it makes good sense to find out what kind of ecosystems existed at that time. Geoarchaeology is a major part of that process of reconstruction.

The practical significance of geoarchaeological studies is apparent from this perspective. Survey crews have virtually no chance of discovering deeply buried archaeological resources unless they examine natural exposures or employ subsurface testing. Land managers must be aware that areas within their jurisdiction have the potential to contain significant buried archaeological resources. Similarly, many areas in and around San Diego County have not experienced deposition, and in those places pedestrian surface surveys can be very thorough in documenting all archaeological sites. A thorough knowledge of depositional processes and an understanding of the geoarchaeological history of a region give cultural resource managers an abundance of pertinent information prior to prospective impacts. Thus, geoarchaeological studies are helpful in protecting cultural resources.

Considering the pre-4000 B.P. archaeological record, it should be clear that only a portion of this record is available for study. Any sites that were on the floodplains of the coastal streams are deeply buried within the thick Holocene and Pleistocene alluvium underlying Terrace 2. In contrast, the post-4000 B.P. archaeological record and settlement pattern is more complete and accessible. Paleoindian and Archaic sites can be found on the elevated Pleistocene landforms overlooking the floodplains and shoreline, but can also occur within the alluvium underlying Terrace 2. The potential for discovering and the importance of these buried sites has been overlooked until recently in the formulation of settlement models to explain changing occupation along the coast of southern California. When floodplain sites were recognized and investigated, they have yielded a pattern of large sites that were occupied for multiple seasons and that heavily exploited marine resources (Byrd 1996, in press; Byrd et al. 1995; Reddy et al. 1996). Many more sites surely lie buried within the great volumes of Pleistocene and Holocene alluvium (Gross 1992). Future surveys and studies along the coast of California should include a geoarchaeological assessment of buried archaeological sites so that accurate inferences can be made about human behavior.

Conclusion

Geoarchaeology has been a part of San Diego County archaeology for perhaps as long as anywhere in the country. In the beginning there was Malcolm Rogers, perhaps rightfully considered the father of San Diego archaeology. His training, however, was not in archaeology, but rather, he was a mining engineer. In addition to his well-received work on the Indian cultures of the Far West, he is well known for his role in developing the collections of California Indian artifacts at the San Diego Museum of Man. Perhaps what he is best known for, however, is one particular excavation at one particular site. That, of course, is the Harris Site. The significance of this site was that it was the first deeply and succinctly stratified multi-component archaeological site encountered in San Diego County. The results of these excavations shaped Rogers' view of the local cultural chronology, and indeed, has forever shaped our view of regional chronology as well. Only much later did we begin to integrate Rogers' geological approach with an ecological one to help sort out the really interesting specifics about local cultural chronology.

In this paper we have summarized some of the most recent geoarchaeological studies at Camp Pendleton, including the large scale survey of alluvial depositional environments and the defining of a regional alluvial chronology. The principle factors contributing to landscape evolution at Camp Pendleton are fluvial processes, sea level change, tectonic activity, and coastal erosion. These factors have resulted in periods of sediment deposition, erosion, and surface stability, creating a remarkable stratigraphic record that is preserved in some locations. Characteristically, medium-sized streams have up to two terraces formed through these processes. Studies have shown that it is the sediments beneath the upper terrace (Terrace 2) that represent the longest periods of deposition, erosion, and stability during the Holocene, with sediments ranging from about 490 B.P. to at least 4230 B.P. (Waters et al.1999). Consequently, these sediments are most likely to contain buried archaeological sites that may escape notice by surface survey techniques. Identification of these sediments, and other landforms and sediments should rightfully be an important part of the planning process.

Through the systematic geoarchaeological study of the existing alluvial sequences at Camp Pendleton, we have shown the profitability of geoarchaeological research. No longer can it be claimed that San Diego County sediments lack stratigraphy. Camp Pendleton provides an ideal research area because streams have suffered less impact from development than elsewhere in the County. However, we are certain that if geoarchaeological investigations are expanded beyond Camp Pendleton that buried sites will be discovered.

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