Problems and Prospects in the Preservation of Late Pleistocene Cultural Sites in Southern Oregon Coastal River Valleys: Implications for Evaluating Coastal Migration Routes

Michele L. Punke and Loren G. Davis

1Department of Geosciences, Oregon State University, 104 Wilkinson Hall, Corvallis, OR 97331
2Department of Anthropology, Oregon State University, 238 Waldo Hall, Corvallis, OR 97331

Early human migration into the New World is hypothesized to have occurred along the northwest coast of North America as early as the Late Pleistocene. Following initial coastal occupation, humans may have moved inland following coastal rivers where their sites would presumably be easier to find. However, evidence of such inland mobility is lacking. The paucity of early sites in coastal river valleys is due, in part, to the dynamic geomorphic evolution of the northwest coast landscape during and after the Late Pleistocene. Three case studies from the southern Oregon coast illustrate the complex relation between tectonics and geomorphic processes along an active margin coast, such as Oregon’s Cascadia subduction zone. Local, upper-plate tectonic structures play a major role in the preservation and accessibility of Pleistocene-age stream terrace deposits and, in turn, the cultural deposits they may contain. A better understanding of the tectonogeomorphic setting of active margin coasts will allow archaeologists testing a coastal migration hypothesis to focus their efforts on landforms of the appropriate age on a subregional scale, such as the Oregon coast. © 2006 Wiley Periodicals, Inc.

INTRODUCTION

Determining the route of initial human migration into the Americas has been a contentious issue among archaeologists for decades (Dixon, 2001). Since the 1970s, attention has shifted away from the traditionally held model involving an overland migratory route eastward across Beringia and southward between the Laurentide and Cordilleran ice sheets (Haynes, 1969; Griffin, 1979) and has focused on evaluating the possibility of a Pacific coastal route of migration (Fladmark, 1979; Gruhn, 1988, 1994; Easton, 1992). Recently, perspectives from geology, paleobiology, and archaeology have helped to evaluate whether a coastal migration route was ever available to Pleistocene hunter-gatherers (Barrie et al., 1993; Mann and Peteet, 1994; Heaton et al.,

*Corresponding author; E-mail: punkem@geo.orst.edu.

Published online in Wiley InterScience (www.interscience.wiley.com). DOI:10.1002/gea.20107
1996; Dixon et al., 1997; Josenhans et al., 1997; Dixon, 2001; Mandryk et al., 2001) and geoarchaeological studies have been designed to locate Late Pleistocene sites on the northwest coast (Fedje and Christensen, 1999; Fedje and Josenhans, 2000; Davis et al., 2004). Initial results of this research have shown that Late Pleistocene-age archaeological sites do exist on the northwest coast, but their preservation and accessibility depend upon their specific geomorphic setting (Davis et al., 2004; Fedje et al., 2004).

Hypotheses of initial coastal migration often include an element of inland mobility along coastal rivers following initial colonization of coastal areas (Dixon, 2001; Mandryk et al., 2001). To date, no archaeological evidence of late Pleistocene human occupation of the northwest coast has been discovered from coastal river valleys. The lack of early sites along coastal rivers is partly due to the effects of dynamic geomorphic forces acting on the northwest coast during and after the Late Pleistocene. Although the rate of postglacial marine transgression is well known (Hanebuth et al., 2000), the specific effects and timing of postglacial fluvial adjustment along the northwest coast are not. Drawing on examples from the Oregon coast, we will address issues of landscape evolution and site preservation in northwest coast river valleys as a means of bringing attention to the particular geoarchaeological challenges associated with these dynamic geomorphic settings.

ESTUARIES, EMBAYMENTS, AND SEA-LEVEL RISE

Research on several active-margin embayments and estuaries in Oregon and Washington reveals how fluvial environments have adjusted to sea-level fluctuations, tectonic uplift, and sediment infilling of coastal river basins (Glenn, 1978; Peterson et al., 1984; Peterson and Phipps, 1992; Witter, 1999; Byram and Witter, 2000; Kelsey et al., 2002). Typically, shallow fluvial environments are recorded in the depositional record from ∼10,000 to 7500 yr B.P. A shift to deeper, estuarine conditions followed as sea level rose and river valleys drowned. By ∼5000 yr B.P., stability in sea level, sediment infilling, and continued localized tectonic uplift produced new conditions in fluvial depositional environments. Shallow-water estuaries, tidal flats, and salt- and fresh-water marshes appeared along Oregon's modern shoreline after 5000 yr B.P. Taken together, these studies present a generalized model of regional geomorphic response to marine transgression, sedimentation, and incremental tectonic uplift. However, the timing and nature of fluvial-system response to marine transgression varies from basin to basin and must include a consideration of other non-marine aspects. Interbasin variability in late Quaternary fluvial geology can be related to the timing, rate, and magnitude of sedimentary and structural factors operating at local scales along a coastline. A database of relative sea-level rise and associated sediment accumulation has been assembled from radiocarbon dating of deep cores extracted from several river basins along the Oregon coast and is discussed below to illustrate differential patterns of postglacial fluvial behavior.

Stratigraphic evidence from Alsea Bay on the central Oregon coast (Figure 1) indicates that nearly 55 m of sediment accumulated during the Holocene (Peterson et al., 1984). From 10,000 to 7500 yr B.P., sedimentation rates ranged between 4 and 7 mm per year. From 7500 to 5000 yr B.P., an average of 11 mm of sediment accu-
mulated in the bay per year. After 5000 yr B.P., sedimentation rates dropped to approximately 2.1 mm per year, reflecting a decline in the rate of eustatic sea-level rise and the associated decrease in sediment accumulation (Peterson et al., 1984). Stratigraphic records from Tillamook Bay, located on the northern Oregon coast (Figure 1), indicate that about 32 m of sediment accumulated during the Holocene (Glenn, 1978). Prior to 7000 yr B.P., rates of sediment accumulation were 20 mm per year, but slowed to ~2 mm per year after 7000 yr B.P. (Glenn, 1978).

In 2002, the authors recovered a 27-m-long continuous sediment core from an abandoned meander along the lower Sixes River, which is located immediately north of Cape Blanco and about 35 km south of Bandon, Oregon (between SR and ER on Figure 1). A charcoal sample from the base of this core, Core 4, dated to 10,190 ± 60 yr B.P. (Beta-173811) (Punke and Davis, 2004). Prior to this work, Kelsey et al. (2002) conducted sediment coring at the same abandoned meander locality. Their efforts produced stratigraphic sediment columns 7 meters deep, which represent ~6000 years of depositional history. Based on preliminary analysis of Core 4 sediments and comparison with previous investigations (Kelsey et al., 2002), 21 m of fine- to coarse-grained sediments were deposited between 10,190 and 6000 yr B.P., suggesting a sedimentation rate of approximately 5 mm per year. During the last 6000 yr B.P., the Sixes River added nearly 7 m of fine-grained, organic-rich sediments (Kelsey et al., 2002), with a considerably lower sedimentation rate of just over 1 mm per year. The rates and amount of sedimentation recorded at the Sixes River since the Late Pleistocene appear to be typical of Oregon coastal river valleys.

Undoubtedly, Late Pleistocene inhabitants of the northwest coast used river valleys, and probably occupied estuary margins and river terraces. However, based on the data presented above, Late Pleistocene deposits are deeply buried in many river valleys and hinder efforts to find early coastal sites. This situation promises to make archaeological discovery of early coastal riverine sites a difficult task and must be considered an inherent aspect of testing the coastal entry hypothesis. Despite these obstacles, there are indications that some river terrace deposits may have escaped complete inundation due to complexities in the local tectonogeomorphic context of some coastal settings. At certain localities, uplift on local, upper-plate tectonic structures coupled with regional positive vertical displacement may have allowed isolated landforms to remain exposed through time and/or relatively accessible to modern archaeological exploration. Understanding where these early sites may be found in the modern landscape is a critical first step toward their discovery and requires knowledge of the structural geology of Oregon’s coast.

REGIONAL AND LOCAL TECTONICS OF COASTAL OREGON

Coastal Oregon lies within the central portion of the Cascadia subduction zone, a shallow reverse fault extending over 1200 km from offshore northern California to southern British Columbia (Figure 1). This zone has been subjected to significant tectonic deformation during the Quaternary as the Juan de Fuca Plate underrides the North American Plate at a rate of 3–4 cm per year (Heaton and Hartzell, 1987). Subduction of the Juan de Fuca Plate produces slow interseismic uplift of portions
of the overriding North American Plate where the plates become seismogenically locked (Figure 2). Periodic and abrupt movement between locked plate segments produces an earthquake accompanied by coseismic movement of the overriding plate. This movement is expressed as subsidence or uplift, depending on the landscape's spatial relation to the zero isobase (Plafker, 1969, 1972). Deposits on the trench side of the zero isobase will incur coseismic uplift, while deposits on the upper-plate side...
of the trench will be subject to coseismic subsidence (Figure 2). During periods between earthquakes, vertical movement relative to the zero isobase is of the opposite sign, with trenchward areas incurring interseismic subsidence while land on the upper-plate side gradually uplifts.

The continental margin of Oregon is on the upper-plate side of the zero isobase (Darienzo and Peterson, 1990; McNeill et al., 1998), incurring gradual interseismic uplift periodically interrupted by coseismic subsidence. Modern-day, interseismic uplift rates along the Oregon coast range from 0 to 5 mm per year (Mitchell et al., 1994), and average long-term uplift rates for the region based on marine terrace data range from 0.1 to 0.9 m per thousand years (Muhs et al., 1990; Kelsey, 1990; Kelsey et al. 1996). Evidence of coseismic subsidence and tsunamis accompanying great plate-boundary earthquakes is revealed at numerous terrestrial locations along the Pacific northwest coast and counters gross uplift rates to varying degrees (Atwater, 1987; Darienzo and Peterson, 1990; Clarke and Carver, 1992; Atwater et al., 1995; Nelson et al., 1996; Nelson and Personius, 1996; Atwater and Hemphill-Haley, 1997; Kelsey et al., 2002; Witter et al., 2003).

Small-scale, upper-plate faults and folds within the broader Cascadia subduction zone also deform sediments of the forearc and accretionary wedge region, including portions of the Oregon coast mainland (Figure 1). The Cascadia fold and thrust belt is a series of north and north-northwest trending faults and folds that deform sediments of the continental slope and shelf off of Oregon's coast (Goldfinger et al., 1992; MacKay et al., 1992; Goldfinger et al., 1997; McNeill et al., 2000). Active folds and faults on the inner-continental shelf generally trend perpendicular to the coastline and deformation front (Goldfinger et al., 1992; Goldfinger, 1994) and have a significant influence on the formation of raised marine terraces, headlands, estuaries, and bays (Kelsey, 1990; Kelsey et al., 1996; McNeill et al., 1998; Kelsey et al., 2002; Witter et al., 2003). Many prominent embayments along the Oregon coast are associated with synclinal folding or lie on the downthrown sides of high-angle faults, whereas headlands and differentially uplifted marine terraces generally correlate with anticlines or the upthrown side of high-angle faults (Muhs et al., 1990; Kelsey, 1990; Kelsey et al., 1996; McNeill et al., 1998). Latitudinal variations in long-term uplift rates along the central and southern Oregon coast depicted in Figure 3 were derived through the mapping, dating, and correlation of uplifted marine terrace suites along the coastal margin (Kelsey, 1990; Muhs et al., 1990; McNelly and Kelsey, 1990; Bockheim et al., 1992; Kelsey and Bockheim, 1994). Offshore multichannel seismic-reflection profiling reveals seafloor warping and faulting in areas adjacent to onshore topographic highs and lows (McNeill et al., 1997; McNeill et al., 1998).

Deformation of local, small-scale, upper-plate tectonic structures represents a major force in the preservation and accessibility of Pleistocene-age landforms along Oregon's coastal streams. While the association of topographic lows with synclinal downwarping or fault downthrow is generally consistent (Kelsey et al., 1996; McNeill et al., 1998), there are locations at estuaries or embayments where positive vertical deformation occurs in association with local faults or anticlinal folds. Such local structures allow for the preservation of stream- or bay-side terraces despite a transgressive depositional setting.
To illustrate the complex relationship between local, upper-plate tectonic structures and the formation and preservation of Late Pleistocene/Early Holocene stream terraces, we present three case studies from the southern Oregon coast. These case studies provide a basis for contemplating the geoarchaeological context of early sites in northwest coast settings.

The Cape Blanco Anticline

The Cape Blanco anticline (Figure 4) is an east-striking, eastward plunging fold formed during ongoing compression of the forearc region of the Cascadia subduction zone (Kelsey, 1990). This upper-plate structure is an onshore extension of the Cascadia fold and thrust belt mapped by Goldfinger et al. (1992) and McNeill et al. (1998). Onshore evidence of active deformation of the anticline is preserved in the underlying Cenozoic bedrock, as well as in the warped Cape Blanco, Pioneer, and Silver Butte marine terrace platforms at Cape Blanco (Kelsey, 1990). These marine terraces have been correlated to the 80 ka, 105 ka, and 125 ka high sea stands, respectively (Kelsey, 1990; Muhs et al., 1990), indicating active uplift during the Late Quaternary.

Witter (1999) and Kelsey et al. (2002) cite contrasting relative sea-level curves between areas nearer to versus further from the anticline axis as evidence for active fold deformation during the Holocene. Kelsey et al. (2002) compare amounts of tidal mud and peat accretion between localities 0.9–1.6 km and 2.3 km away from the anticline axis. They hypothesize that if coseismic slip occurred on a blind reverse fault underlying the anticline at the same time that a larger subduction-zone earthquake
took place, then contraction and uplift of the anticline would produce less net subsidence at areas nearest the anticline axis versus areas farther away. This would result in higher net sediment accretion over time at the areas further from the fault. Between ~5000 and 3000 yr B.P., over a meter more sediment accumulated in the area further from the axis (i.e., 2.91 m vs. 1.62 m), suggesting that areas nearest to the fold axis incurred over a meter less net subsidence (i.e., a meter more net uplift) than areas further away from the axis (Kelsey et al., 2002).

It is unclear whether displacement of this upper-plate structure is always coupled with slip of the larger-scale Cascadia subduction zone fault or whether it operates independently of other tectonic structures (Kelsey et al., 2002; Witter et al., 2003). In either case, interseismic upper-plate deformation appears to produce larger amounts of relative uplift in areas closer to the axis of the anticline, as well as in areas on the western end of the eastward plunging fold (Figure 4). Over the long term, the combined effects of interseismic uplift and coseismic subsidence yields ~0.85–1.25 meters of net uplift per thousand years in the Cape Blanco area (Muhls et al., 1990). Based on the information from Kelsey et al. (2002), it is clear that regional data must be examined more closely to fully understand where and at what rate the land is incurring the largest amount of uplift. These areas will have a higher likelihood of preserving river terraces and the sites they may contain than other areas because of the local structures that uplift them faster and lead erosional forces away from their deposits (Figure 5).
The earliest cultural site reported thus far in the Sixes River valley is found along the south side of the valley entrance where a small deposit of Holocene dune sand ramps up the side of an uplifted marine terrace (Figure 4). Cultural deposits within a weakly developed soil underlying the dune sand date to 5200 yr B.P. (Minor and Greenspan, 1991). During the time that this Holocene site was occupied, local relative sea levels were 1–3 meters lower than today (Kelsey et al., 2002). In the 5000 years that followed, many portions of the valley were inundated as the Sixes River adjusted to a marine transgression (Glenn, 1978; Peterson et al., 1984; Kelsey et al., 2002; Punke and Davis, 2004), burying any other sites closer to the river. However, perhaps because of the higher relative amount of uplift on the western end of the anticline axis, the landform within which the Holocene cultural site is located was preserved.

In addition to topographic deformation in the Sixes River valley, the Cape Blanco anticline also affects the topography of adjacent areas (Figure 4). The Elk River valley lies 6 km south of the Cape Blanco anticline axis. In the lower portion of this valley on the northern side of the river, a series of three alluvial terraces descend from higher marine-terrace deposits (Figure 6). Stratigraphic profiles cut into each of the terraces revealed alluvial facies corresponding to channel and floodplain deposition. Radiocarbon dates on charcoal and wood from the upper and lower alluvial terraces returned ages of 35,500 ± 730 yr B.P. (Beta-171007) and 190 ± 50 yr B.P. (Beta-171006), respectively. These three terraces are unpaired to the south of the river mouth (Figure 6), leading us to hypothesize that the differential uplift of areas closer to the axis of the Cape Blanco anticline has forced the Elk River to shift southward through time, preserving alluvial deposits along the northern valley margin. Terraces on the south side of the river that formed before the last glacial maximum marine lowstand were subsequently destroyed as the river eroded laterally and vertically in response to marine regression and regional and local interseismic uplift. By the time the Elk River began to aggrade to match the pace of postglacial marine transgression, north-side alluvial terraces had been uplifted beyond the limits of val-
ley inundation. Any cultural deposits located within these alluvial terraces would have been preserved due to the effects of the differential uplift of areas closest to the upper-plate Cape Blanco anticline, those areas on the north side of the river.

Pioneer Anticline

The Pioneer anticline deforms sediments bounding the Coquille River on the southern Oregon coast (McNelly and Kelsey, 1990). The north–northwest striking axis of this north–south plunging anticline lies approximately 8 km inland from the river’s mouth (Figure 7) and is an onshore extension of the broad fold-and-thrust belt which deforms offshore sediments of the accretionary wedge (Goldfinger et al., 1992; McNeill et al., 1998). Because the fault does not appear to warp underlying bedrock in the area, it is thought to be a relatively young structure (McNelly and Kelsey, 1990; Personius et al., 2003). Deformation of 105 ka Pioneer-terrace sediments indicates tightening of the anticline during the Late Quaternary, although no average slip rates over this time have been reported. Based on the elevations of local marine terraces, maximum long-term uplift rates range from 0.3 to 0.6 m per thousand years since the Late Pleistocene at the latitude of the Coquille estuary (McNelly and Kelsey, 1990).

Alluvial terraces along the margins of the lower Coquille River valley may have escaped inundation due to the differential uplift of areas closest to the Pioneer anticline axis. Figure 7 depicts elevation contours of the area surrounding the axis of the anticline. Based on the contours, it is clear that areas closest to the anticline have experienced more uplift relative to other areas along the margin of the river.

Trenching of terraces preserved on the northern edge of the Coquille River valley suggests that uplift along the Pioneer fault during the Late Quaternary may have helped preserve a series of fluvial terraces along the northern margin of the Coquille River valley (Figure 8). Most areas along the margins of the Coquille River incurred lateral and vertical erosion during the period of marine regression of the last glacial maximum. In some cases, however, alluvial terraces on the river’s margin were preserved when fluvial downcutting caused by rapid sea-level fall and local and regional tectonic uplift outran the pace of river meandering and lateral planation. When sea level began to rise ~21,000 years ago, streamside terraces that experienced the greatest amount of uplift, including those areas nearest the axis of the Pioneer anticline, escaped complete inundation and burial. These areas, with cultural deposits dating to the Late Pleistocene or Early Holocene, are most likely to survive.

Coquille Fault

As with the Cape Blanco and Pioneer upper-plate tectonic structures, the Coquille fault (Figure 7) is associated with the offshore fold-and-thrust belt that deforms sediments of the accretionary prism (Goldfinger et al., 1992; McNeill et al., 1998). The onshore portion of the Coquille fault is thought to be a northwest-striking fault or fault-propagation fold overlying a blind, southwest-dipping reverse fault (Witter et al.,
The southern, upthrown side of the Coquille fault offsets sediments of the 80 ka Whiskey-Run marine terrace vertically by \( \sim 50 \) m near Coquille Point (Figure 9a), whereas marine terrace sediments are at sea level on the downhill side of the fault (McInelly and Kelsey, 1990).

Long-term uplift rate estimates for the upthrown side of the Coquille fault (up to 0.8 m per 1000 years) are higher than uplift rates for the coast north and south of the Coquille estuary, which are at a more modest 0.3–0.6 m of uplift per 1000 years (McInelly and Kelsey, 1990). Contemporary interseismic uplift rates for Coquille Point exceed 4 mm per year (Mitchell et al., 1994), which is 5 to 13 times higher than the long-term regional rate (McInelly and Kelsey, 1990; Witter et al., 2003). As seen in Figure 7, the topographically higher south limb of the Coquille fault has differentially uplifted 80 ka marine-terrace sediments from the axis just north of Coquille point, descending in amount of uplift to near sea level at Bradley Lake to the south (McInelly and Kelsey, 1990; McNeill et al., 1998; Witter et al., 2003). Although there is no unequivocal evidence of Holocene slip on the Coquille fault, there are indications that continued tectonic uplift of the southern limb of the fault has occurred during the Holocene (Witter et al., 2003).

Evidence for Holocene movement along the Coquille fault may be seen at the Devils Kitchen site, located on the southern edge of Bandon, immediately north of Crooked Creek (Figure 9a). The Crooked Creek drainage is located on the uplifted, southern limb of the Coquille fault and flows into the ocean \( \sim 3.5 \) km south of Coquille.
Figure 9. (a) Coast-parallel profile along the region north and south of the Coquille River showing offset of 80,000-year-old wave-cut platform sediments (McNelly and Kelsey, 1990) used to infer location of Coquille fault axis (Witter et al., 2003). Greatest amount of vertical deformation occurs on southern, up-thrown side of fault. Adapted from “Great Cascadia Earthquakes and Tsunamis of the Past 6700 Years, Coquille River Estuary, Southern Coastal Oregon,” by R.C. Witter, H.M. Kelsey, and E. Hemphill-Haley, 2003, Geological Society of America Bulletin, 115(10), 1289–1306, Figure 3, p. 1292. Copyright 2003 by the Geological Society of America. (b) Detail of coast-parallel profile showing the modern-day location of Crooked Creek and cultural site in relation to late Pleistocene and early Holocene alluvial deposits.

Point. On the north side of the creek mouth, marine, alluvial, and eolian deposits overlying uplifted bedrock contain a stratified series of cultural occupations beginning some time between approximately 11,000 yr B.P. and 6000 yr B.P. and ending at ~3000 yr B.P. Today, Crooked Creek lies approximately 12 m below its northern bank (Figure 9b); however, site stratigraphy and topographic contouring of the landscape near the stream suggest that between 11,000 yr B.P. and 3000 yr B.P., the stream flowed north of the Devils Kitchen site. After ~3000 yr B.P., alluvial facies were buried beneath extensive dune deposits. Continual positive vertical displacement on the Coquille fault may have diverted the course of the stream further south when sea-level rise slowed (Witter et al., 2003), followed by downcutting of the stream through its banks to reach its present position.
Alternatively, Crooked Creek's change of course and cessation of alluvial deposition at the Devils Kitchen site may have been caused by abrupt, coseismic deformation of the Coquille fault. If the fold tightened coseismically, northern areas nearer to the axis of the fold may have risen higher relative to southern areas away from the fold axis. Witter et al. (2003) postulate seismic activity around 3300 yr B.P., 2900 yr B.P., and 1700 yr B.P. based on evidence recovered from sediment cores extracted from the Coquille River basin. Slip on this upper-plate structure may have occurred independently or in association with a larger, Cascadia subduction-zone earthquake. In either case, uplift along the axis of the Coquille fault to the north may have driven Crooked Creek south. In the process, stream-side sediments were left untouched by the erosional action of the creek and cultural deposits within this alluvium were preserved.

CONCLUSIONS

Geoarchaeological study along the Northwest Coast, and in other New World areas with tectonically active continental margins, must consider the cumulative effects of subduction-zone tectonism, styles of upper-plate deformation, and their geomorphic influence on coastal landscapes during a period of postglacial marine transgression. Our research along the Oregon coast reveals some repetitive themes in how certain modes of upper-plate deformation can influence fluvial systems to preserve, obscure, or destroy late Pleistocene-age deposits during post-glacial marine transgression. Through this work, we show that the differential preservation of late Pleistocene-age terrestrial deposits in Oregon's coastal landscape, and the early cultural sites they may contain, is not random but can be closely related to larger tectono-geomorphic processes that have been ongoing throughout the Late Quaternary. Armed with these geoarchaeological perspectives, archaeologists will be able to focus their efforts on temporally relevant landscape sections in a search for early coastal sites. This approach meets the call made by Mandryk et al. (2001) that geoarchaeology conducted in the service of testing a Late-Pleistocene coastal-migration hypothesis must concentrate on subregional scales (i.e., 1000 km²), such as the Oregon coast.

This research was funded by the NOAA Office of Sea Grant and Extramural Programs, U.S. Department of Commerce, under grant numbers NA76RG0476 and NA16RG1039 (project number R/CC-04) held by Roberta Hall, and by appropriations made by the Oregon State legislature. Michele Punke was also funded through a Geological Society of America graduate student research grant. Special thanks to the people of the Coquille Indian Tribe for their support and enthusiasm for this research. Thanks also to Roberta Hall, Andrew Meigs, and Julia Jones for their enlightening discussions and continued support. Comments by Daniel Muhs and an anonymous reviewer greatly improved this paper.

REFERENCES


Received May 27, 2004
Accepted for publication October 20, 2005