Rapid Climatic Signal Propagation from Source to Sink in a Southern California Sediment-Routing System*

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Abstract

Terrestrial source areas are linked to deep-sea basins by sediment-routing systems, which only recently have been studied with a holistic approach focused on terrestrial and submarine components and their interactions. Here, we compare an extensive piston-core and radiocarbon-age dataset from offshore southern California to contemporaneous Holocene climate proxies in order to test the hypothesis that climatic signals are rapidly propagated from source to sink in a spatially restricted sediment routing system, including the Santa Ana River drainage basin and Newport deepsea depositional system. Sediment cores demonstrate that variability in rates of Holocene deep-sea turbidite deposition is related to complex ocean-and-atmosphere interactions, including enhanced magnitude and frequency of the North American monsoon and El Niño-Southern Oscillation cycles, which increased precipitation and fluvial discharge in southern California. This relationship is evident because, unlike many sediment-routing systems, the Newport submarine canyon-and-channel system was consistently linked to the Santa Ana River, which maintained sediment delivery in spite of evidence of Holocene tectonic uplift and significant sea-level rise. Results of this study demonstrate the efficiency of sediment transport and delivery through spatially restricted, consistently linked routing systems, as well as the utility of deep-sea turbidite depositional trends as paleoclimate proxies in such settings.

Selected References

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Normark, W.R., D.J.W. Piper, B.W. Romans, J.A. Covault, P. Dartnell, and R.W. Sliter, 2009, Submarine canyon and fan systems of the California continental borderland: GSA Special Paper 454, p. 141-168.

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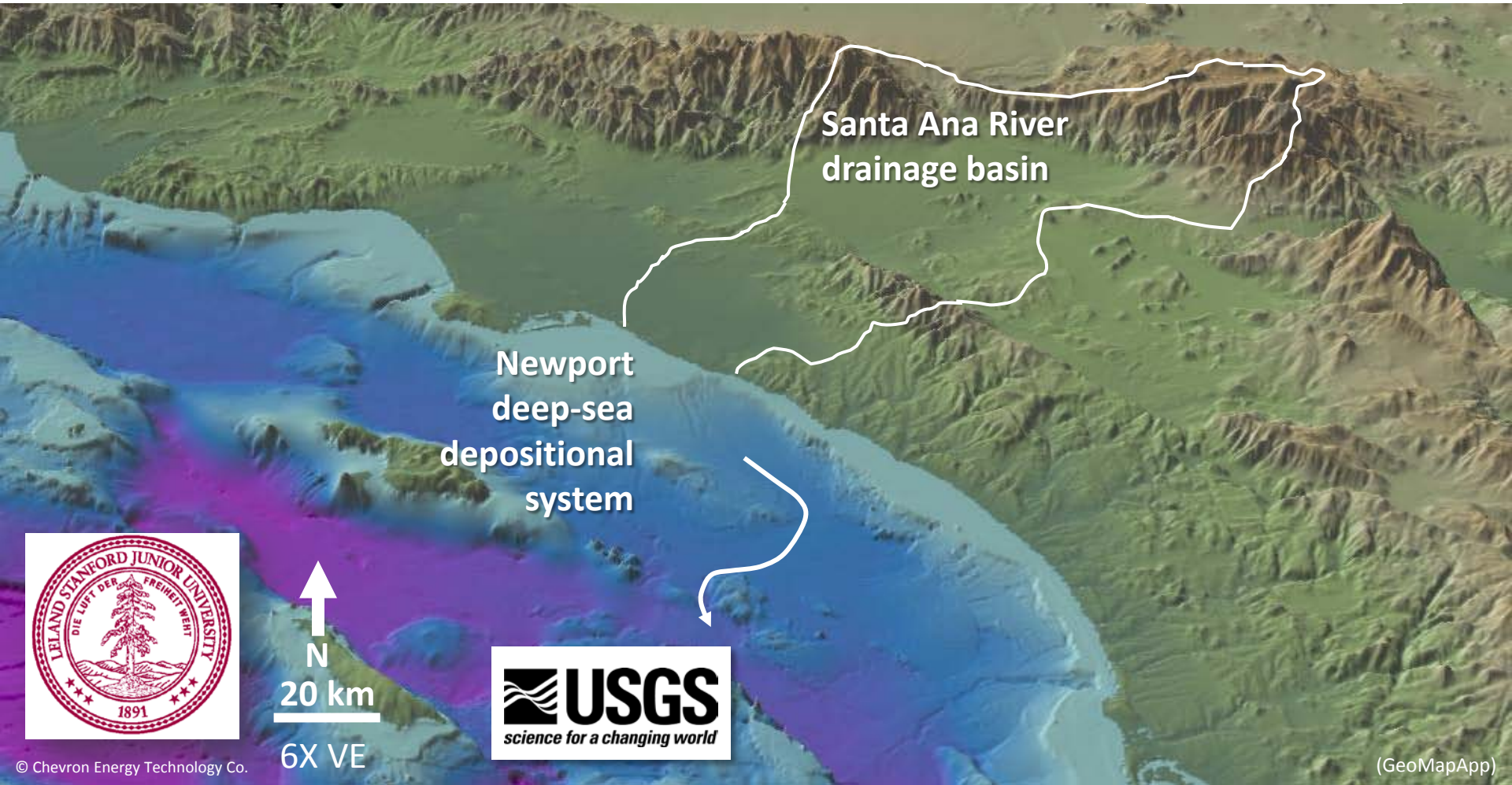
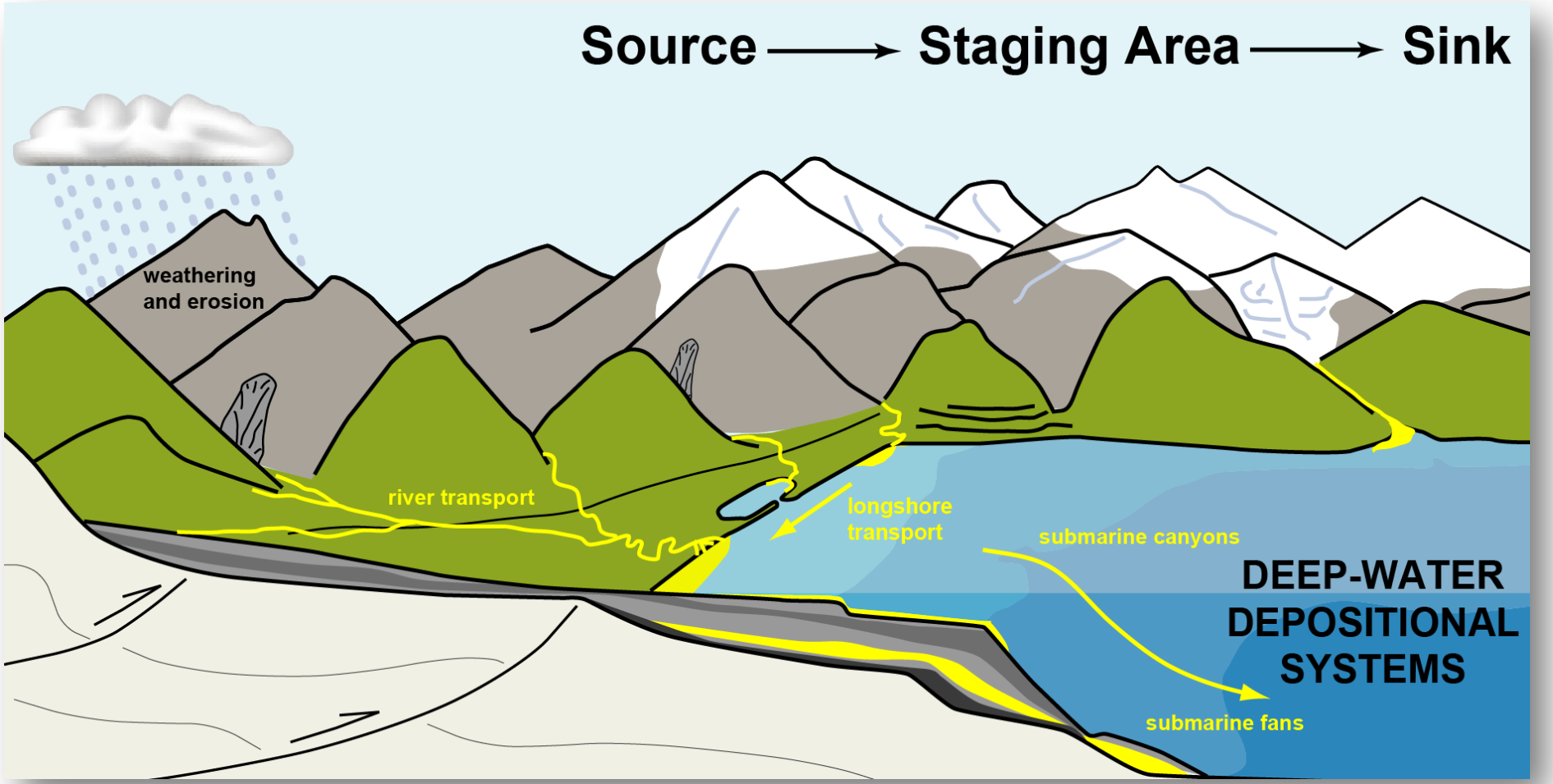
12 April 2010 AAPG Annual Meet.



Integrated sedimentary systems predictions from source… to staging area… to sink

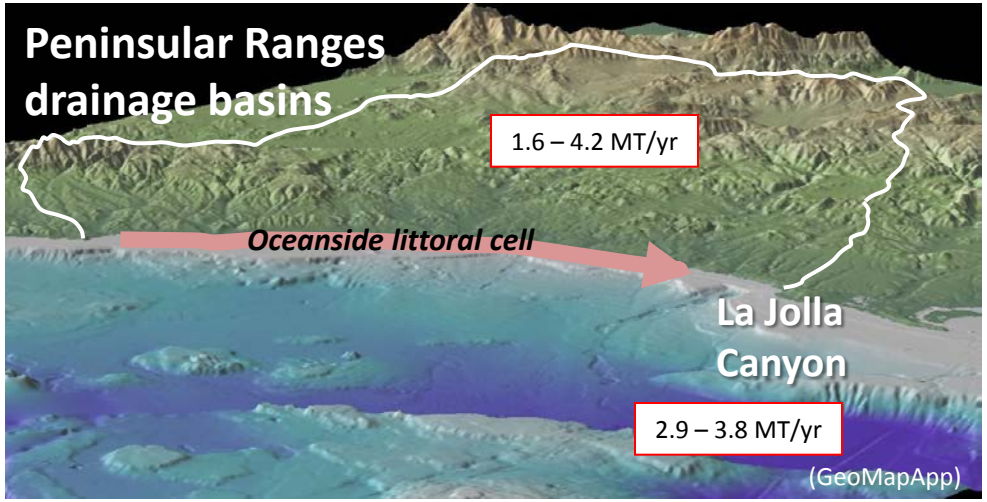
Generalized continental margin

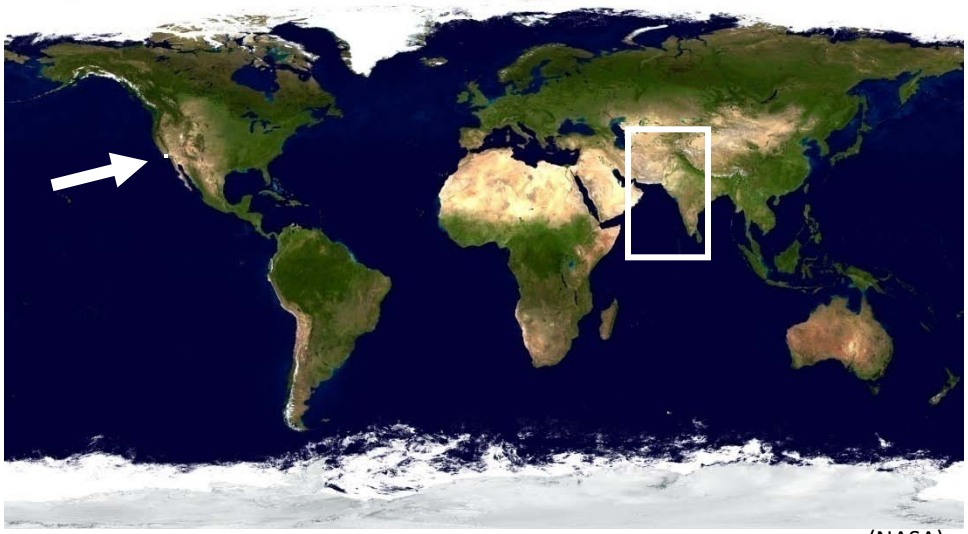


(http://www.nsf-margins.org; modified by Brian Romans)

Buffered versus reactive systems

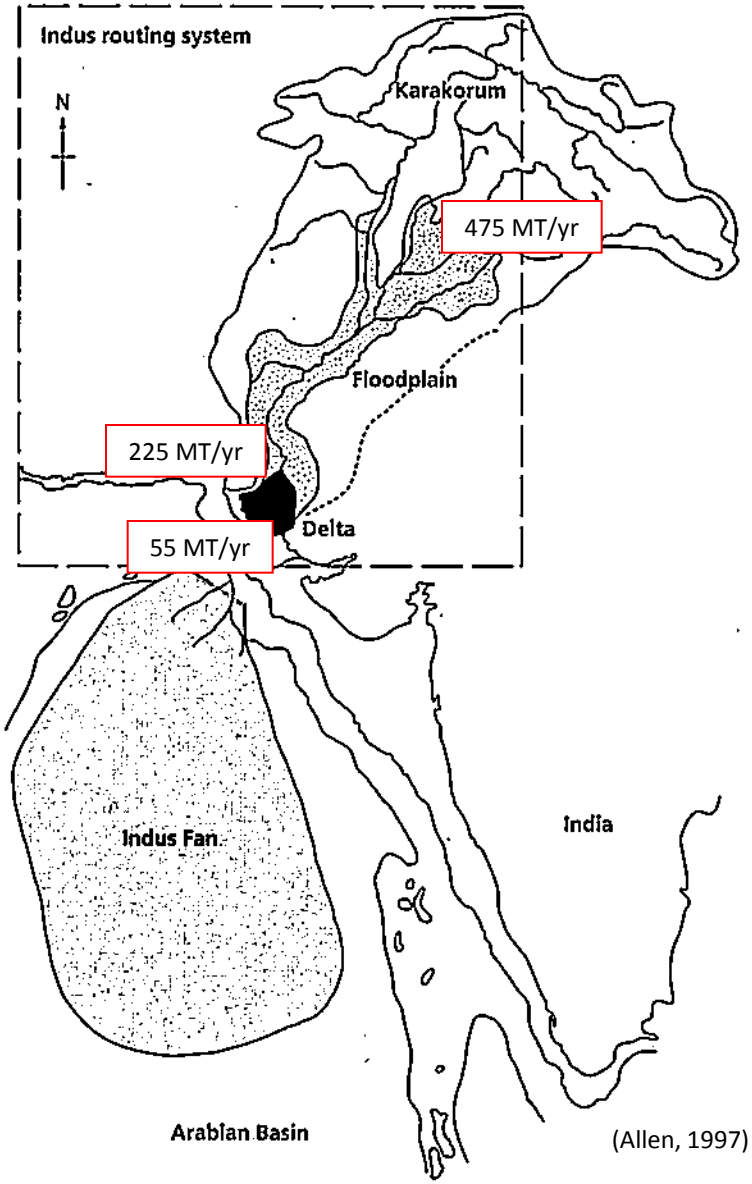
"Reactive" California Borderland





(NASA)

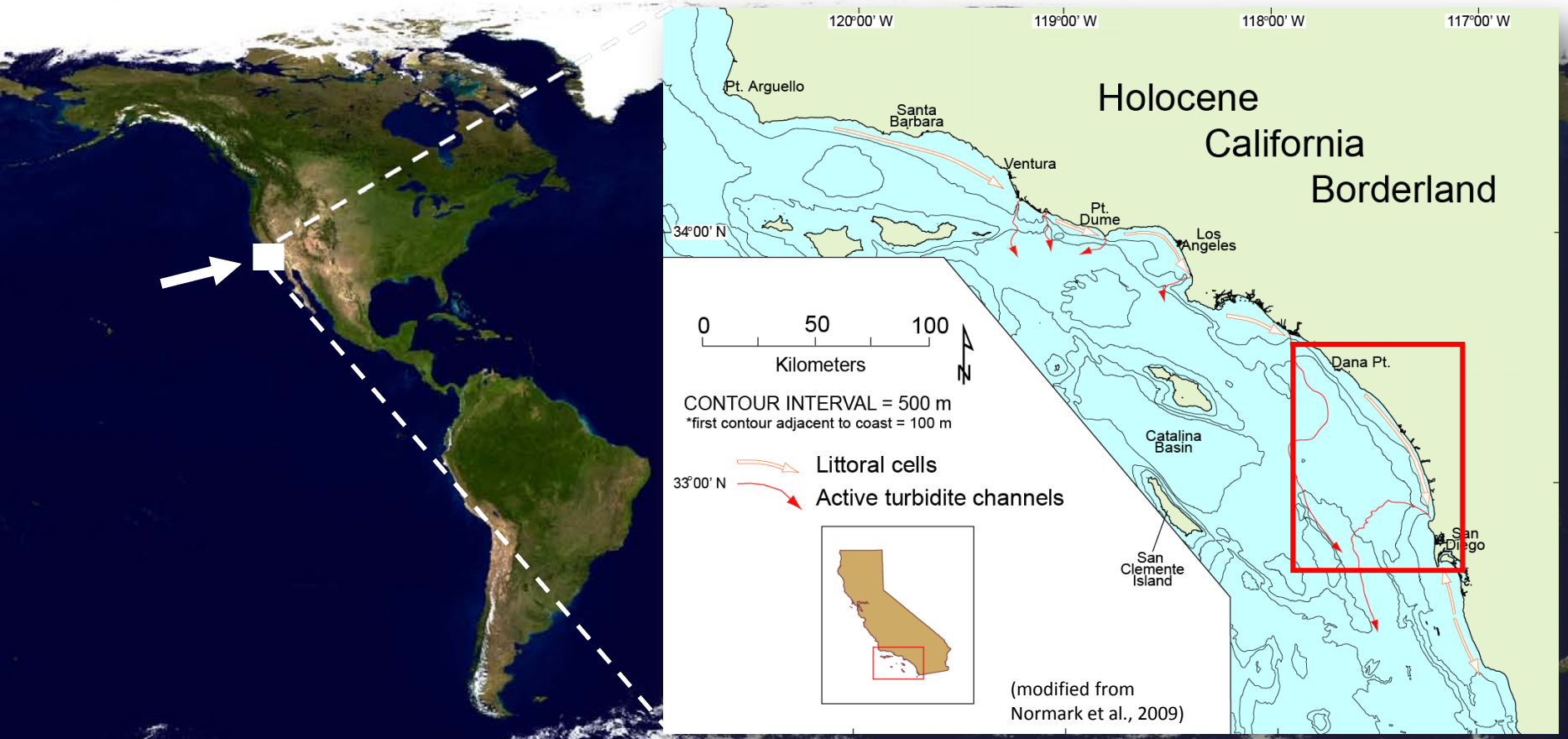
"Buffered" Indus routing system



(Allen, 1997)

Latest Quaternary California Borderland

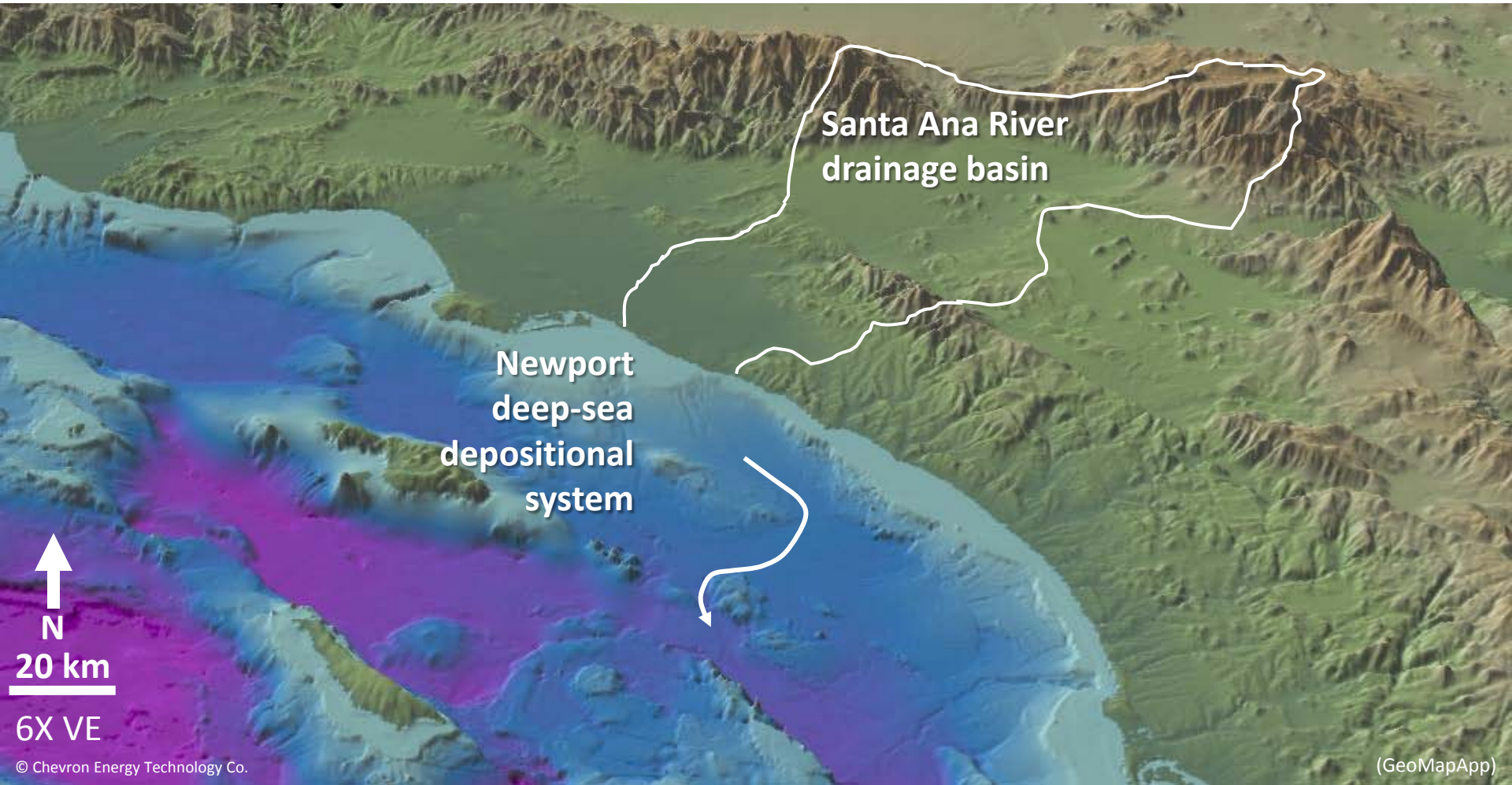
- Why the Borderland? Data availability, proximity, small sediment-routing systems.



(NASA)

Climatic signal propagation from sediment source to sink

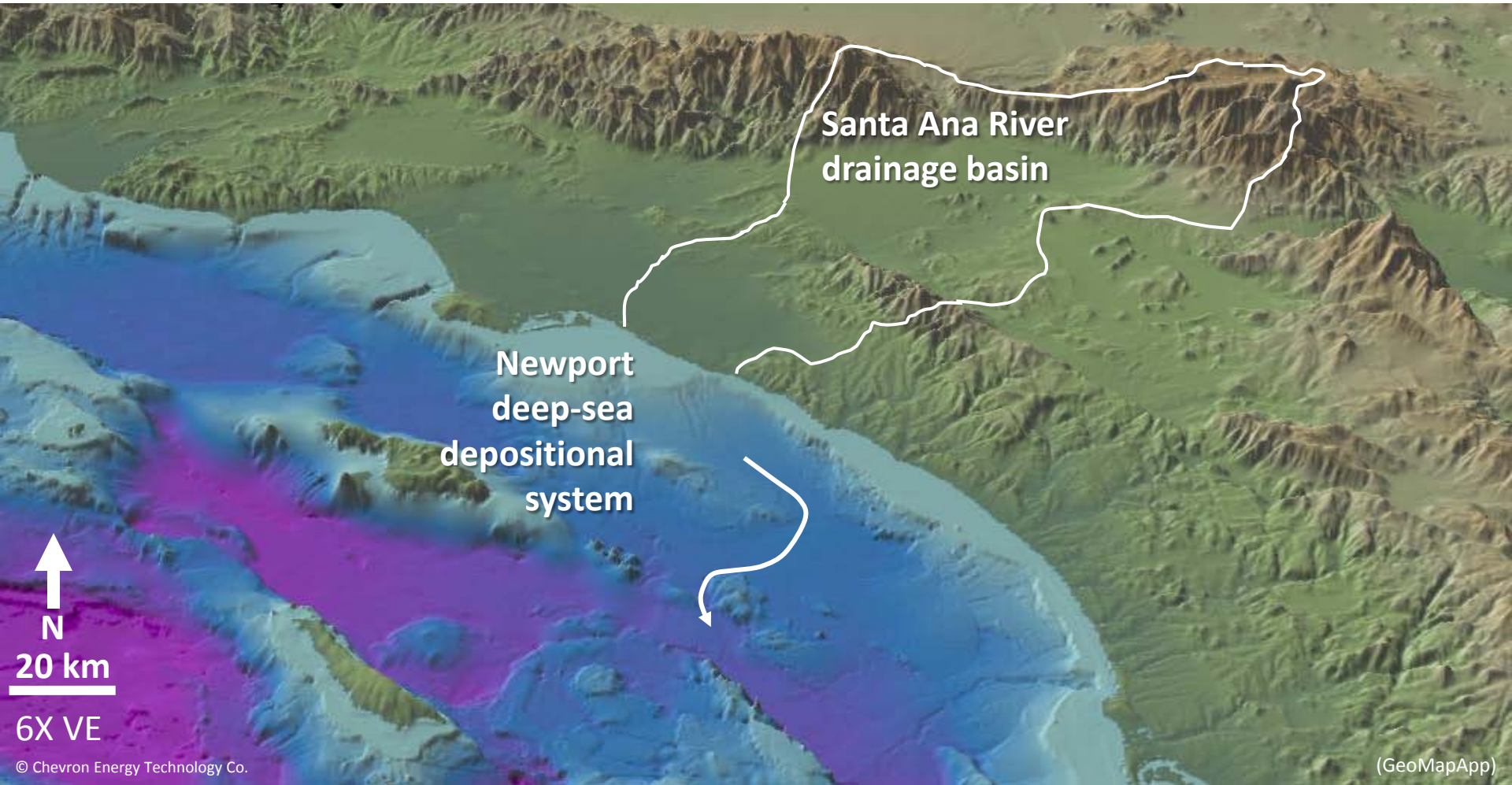
Question: Are climatic signals manifested in deep-water fan deposits in spatially restricted systems? Sequestered en route?



Climatic signal propagation from sediment source to sink

Dataset: Terrestrial and marine climate proxies vs. deep-sea fan deposition

Results: Variability in rates of deep-sea turbidite deposition linked to climate proxies … rapid climatic signal propagation in such spatially restricted settings

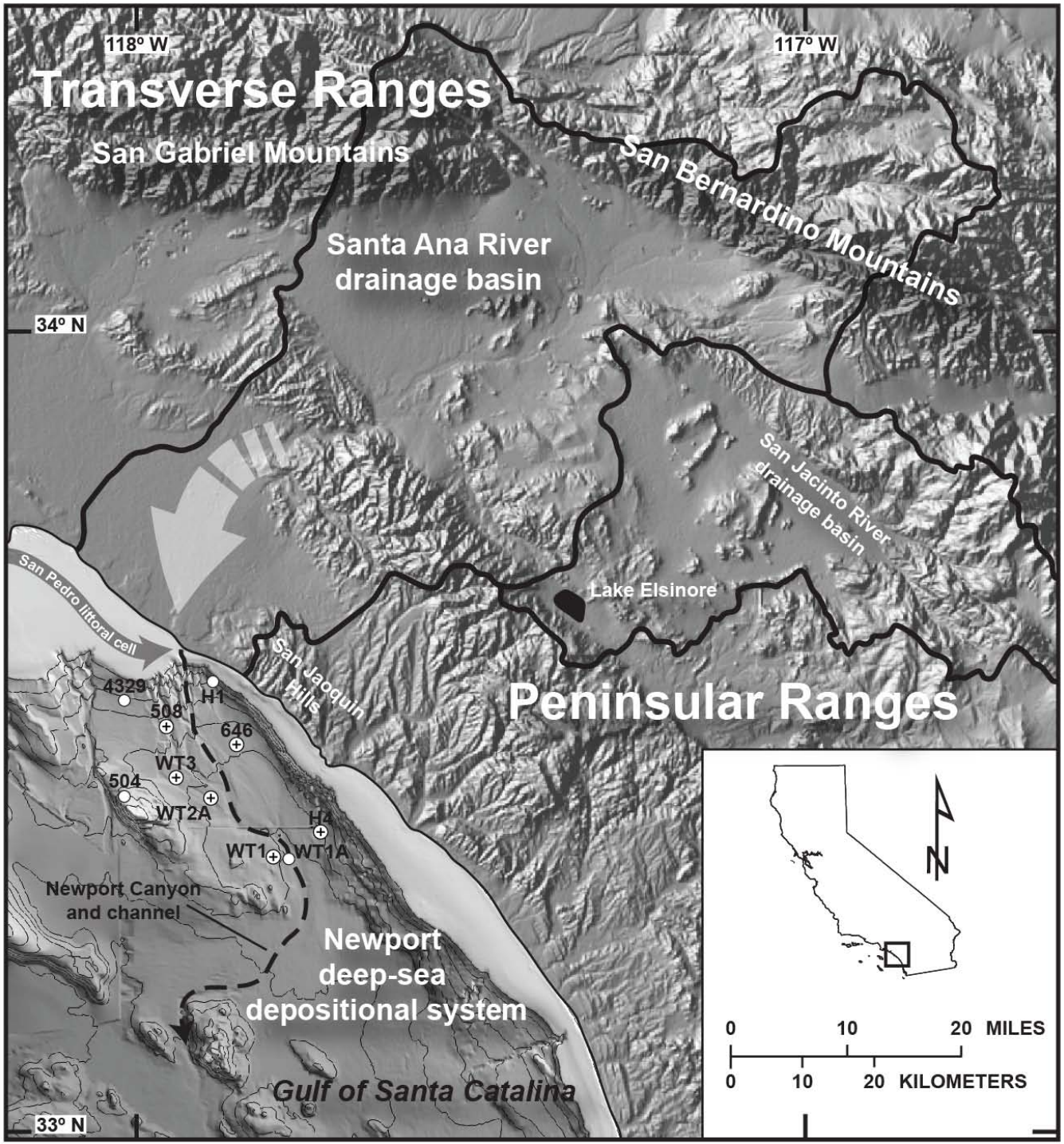


Santa Ana River-Newport deep-sea fan routing system

USGS piston cores

Nearby Lake Elsinore drill cores for terrestrial climate information

Marine climate proxies from ODP Site 1019



California climate proxies

Lake Elsinore data

Magnetic susceptibility-
decr. represents diminished flux of magnetic minerals/sediment during drying

Al & inorganic P-
decr. represents diminished flux of sediment during drying

Organic matter-
incr. during drying/low lake levels by wind-driven resuspension & bioturbation in shallow lake regions

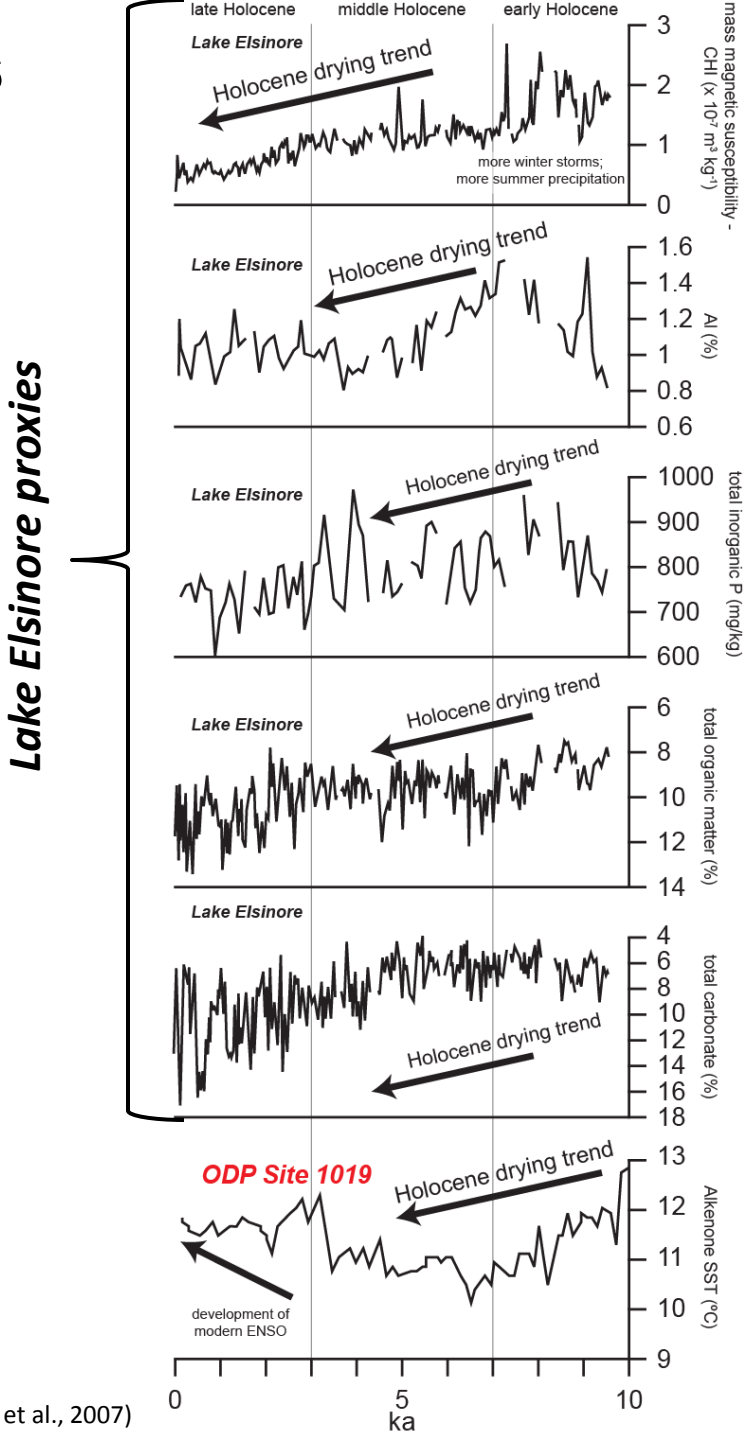
Carbonate-
incr. during drying/low lake levels by CaCO3 saturation of lake

Indicate progressively diminishing Holocene precipitation and consequent fluvial discharge

ODP 1019 data

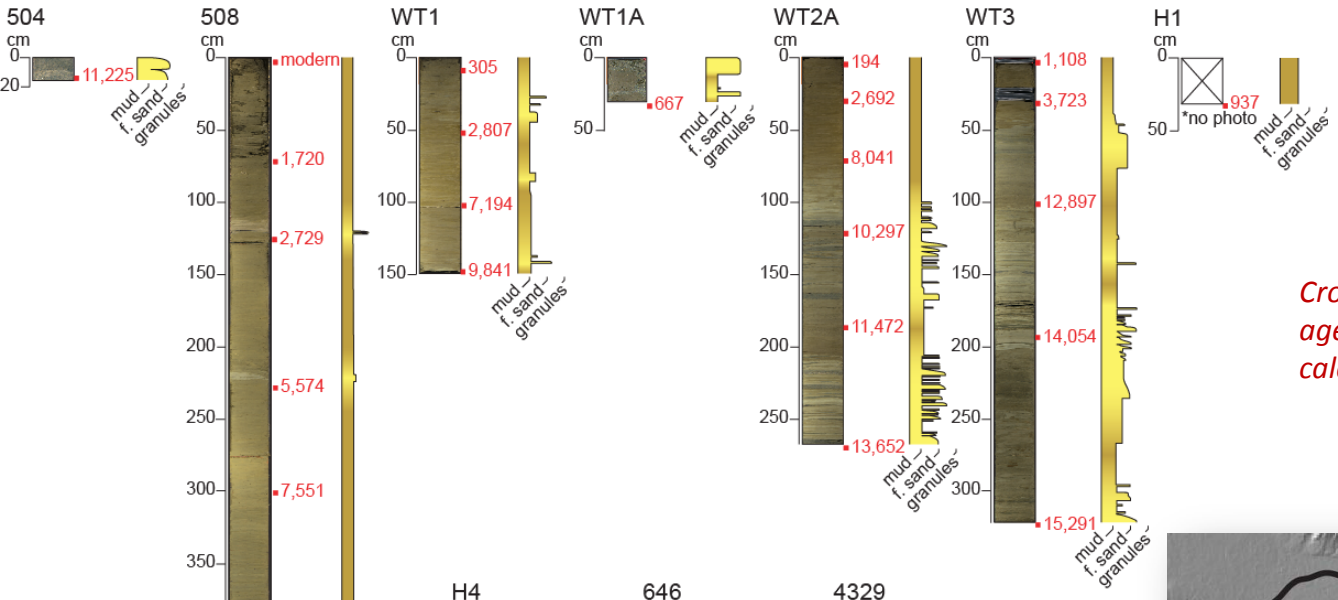
Alkenone SST (among other proxies)-
Biomarkers synthesized in surface ocean from algae… linear relationship btw SST and algal growth

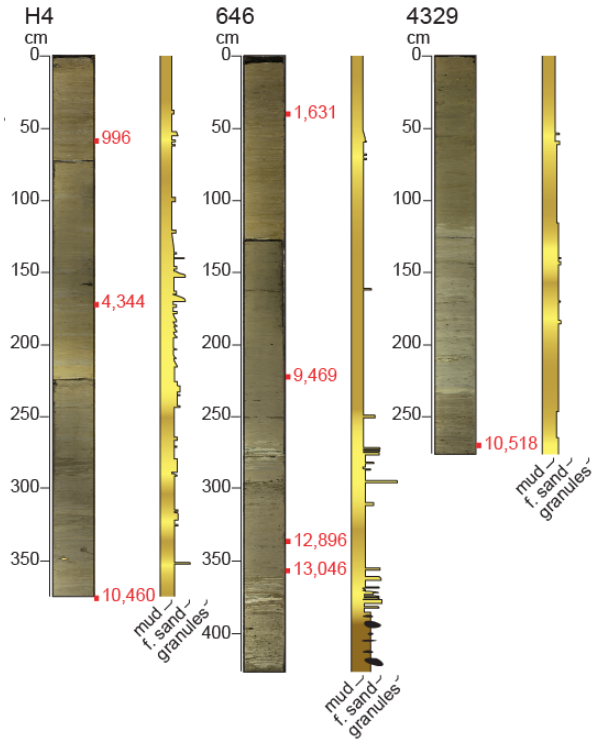
Indicate heightened early and late Holocene SST's and consequent heightened precipitation and fluvial discharge



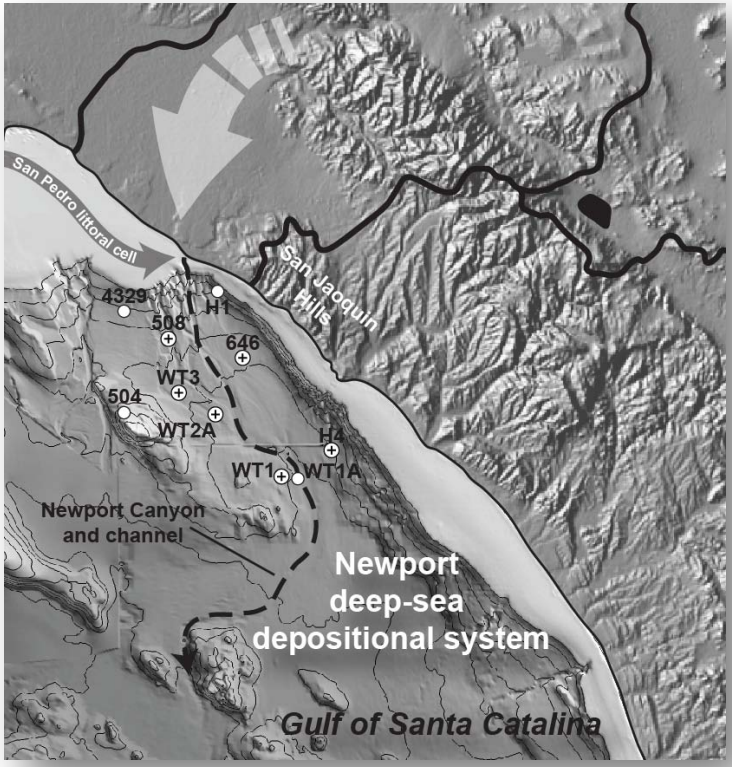
(Barron et al., 2003; Kirby et al., 2007)

USGS piston cores

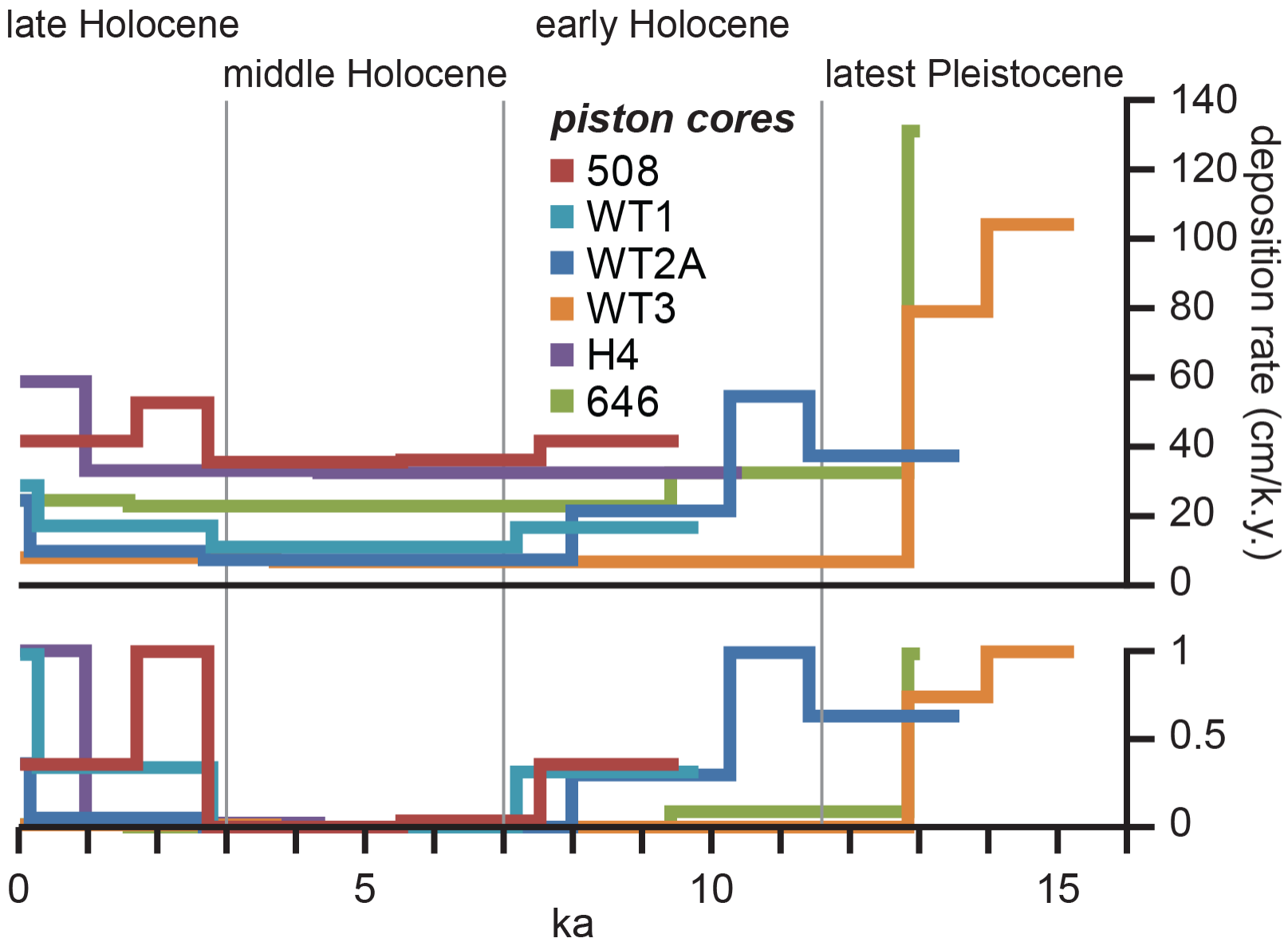




Crosses are cores w/ >3 radiocarbon ages used for deposition rate calculations



Deep-sea turbidite deposition



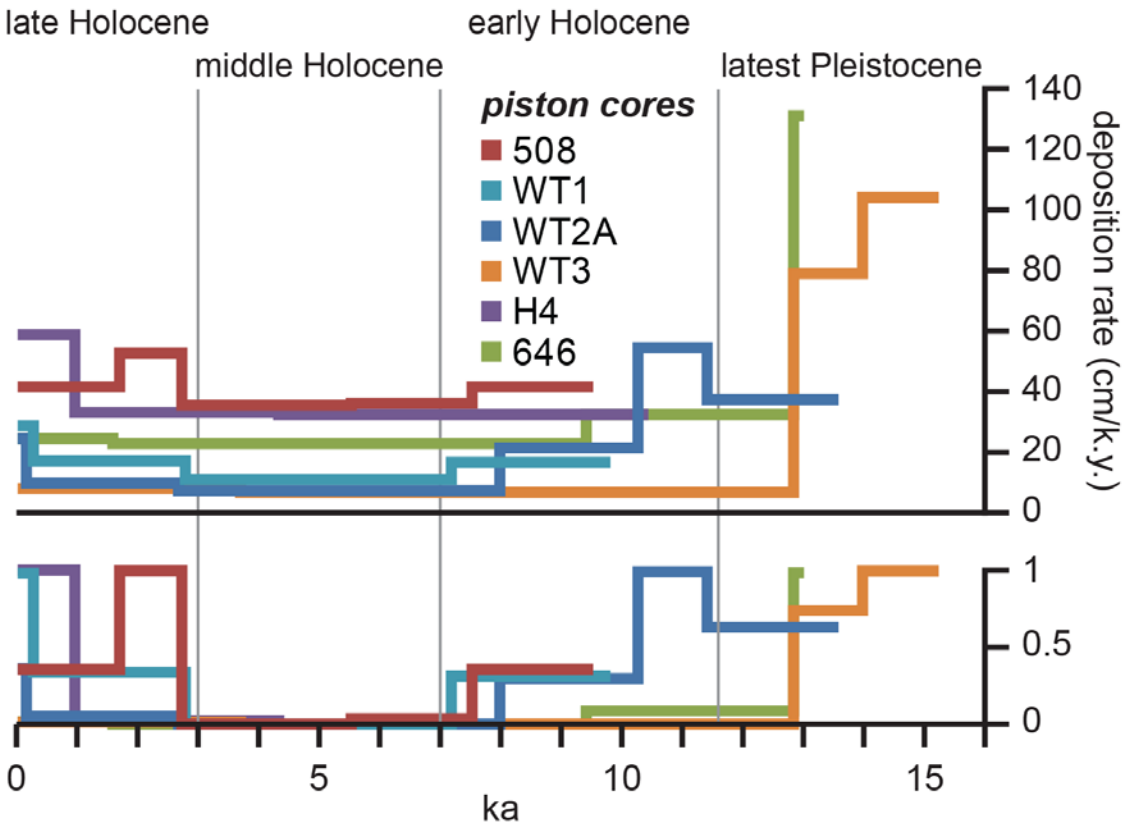
Climate proxies vs. deep-sea turbidite deposition

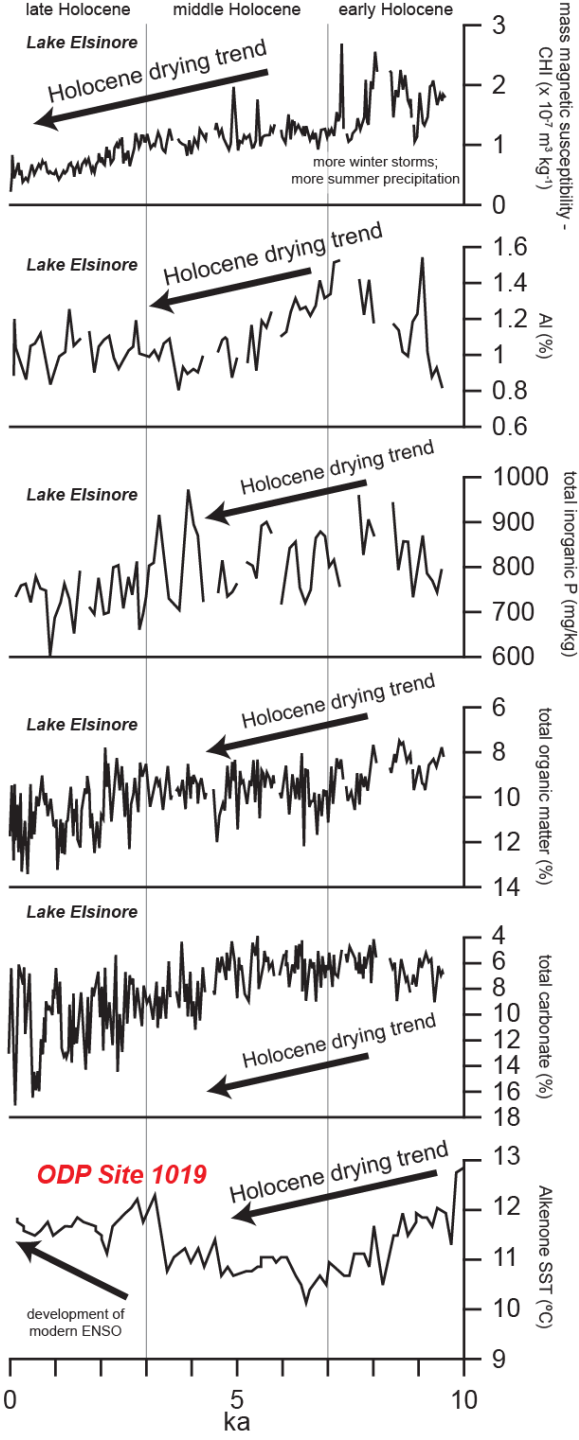
Focus on Holocene deep-sea deposition

Although, larger pre-Holocene rates are interesting …

Lake Elsinore records lack evidence of wet late Holocene

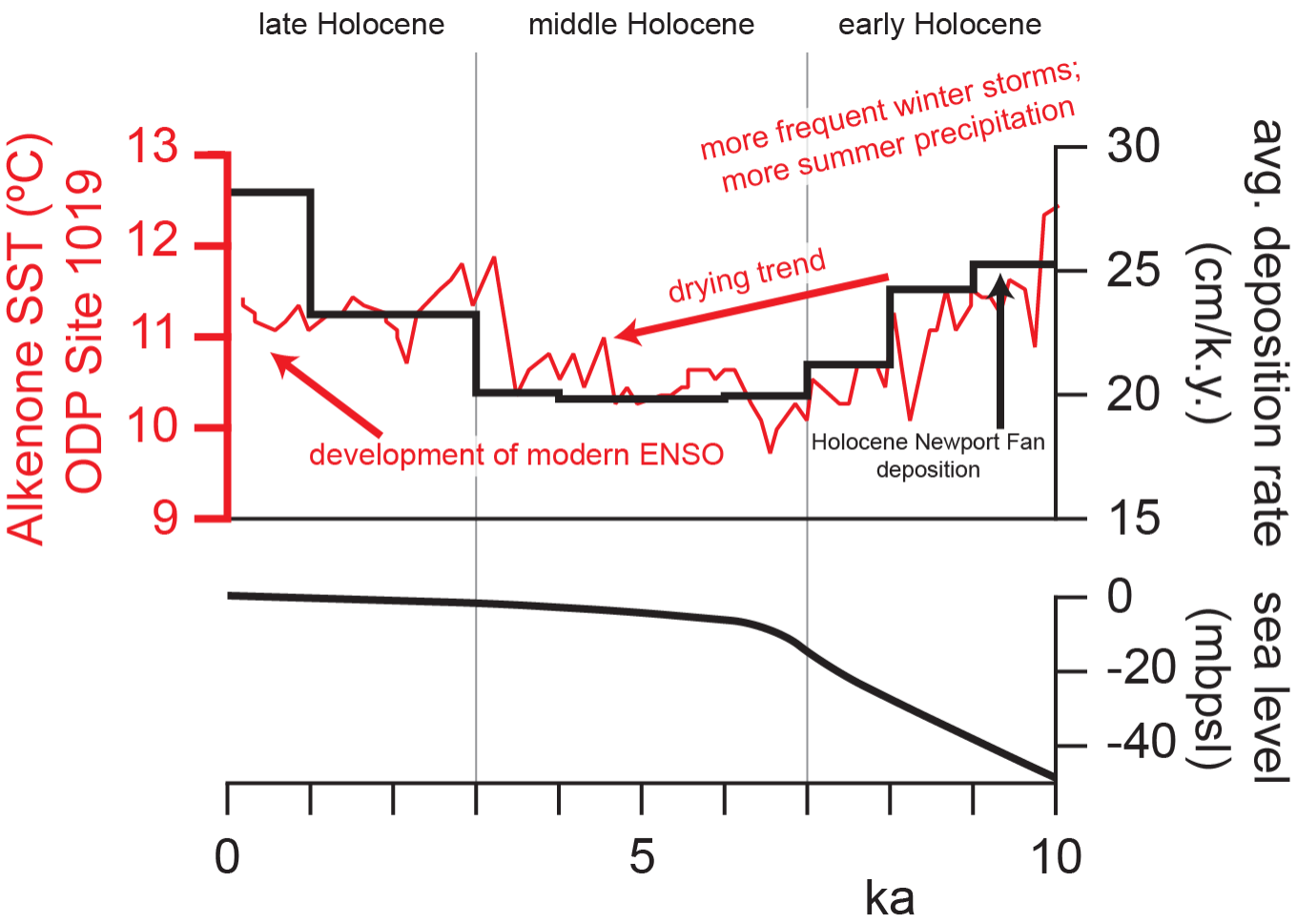
Possibly a result of more local climate effects





(Barron et al., 2003; Kirby et al., 2007)

Climate proxies vs. deep-sea turbidite deposition

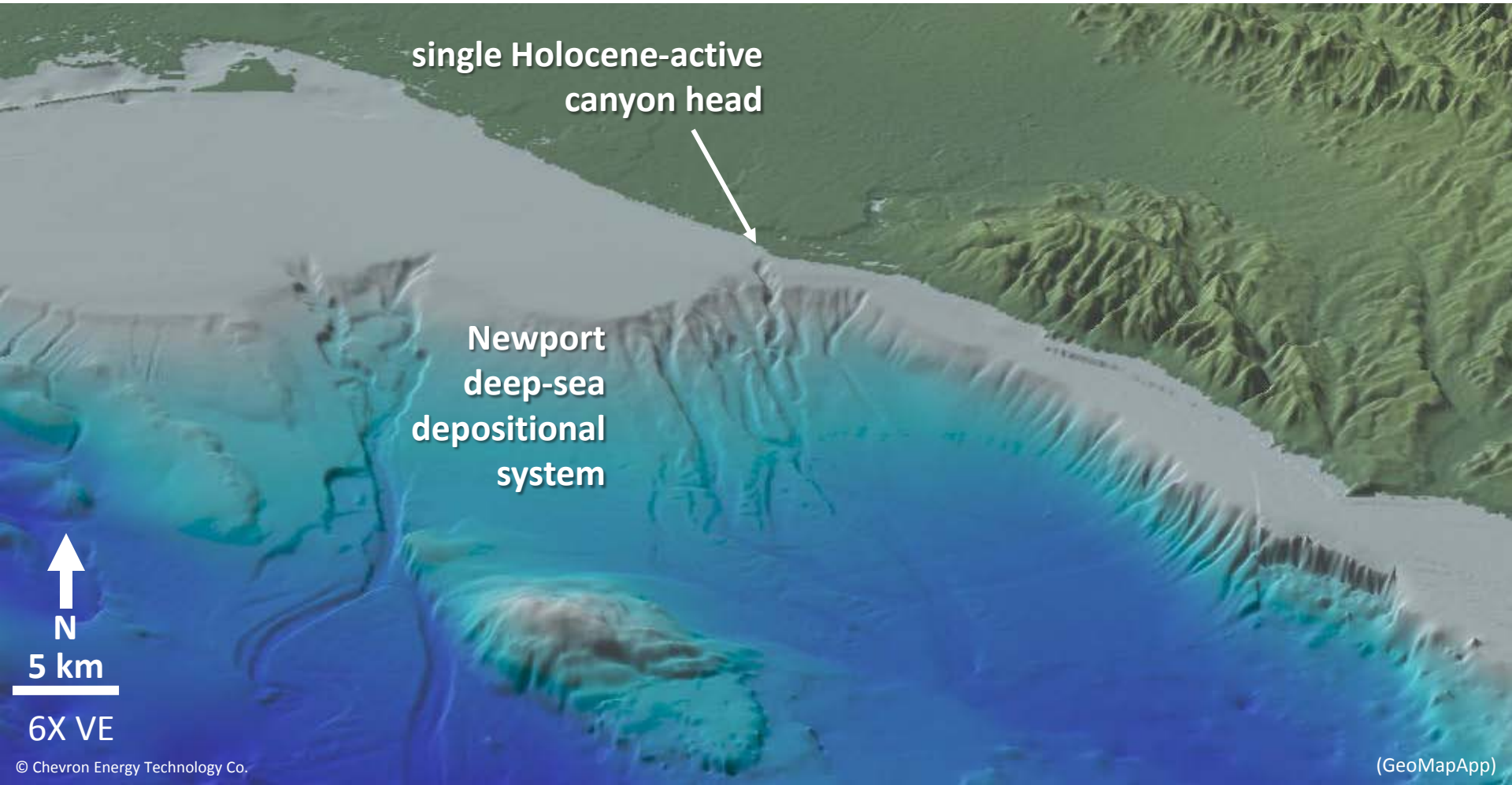


(Lambeck & Chappell, 2001; Barron et al., 2003)

Rapid climatic signal propagation in small routing system

Small, reactive sediment routing system consistently linked

Heightened pre-Holocene deposition possibly related to lower sea level and more active deep-sea canyon tributaries



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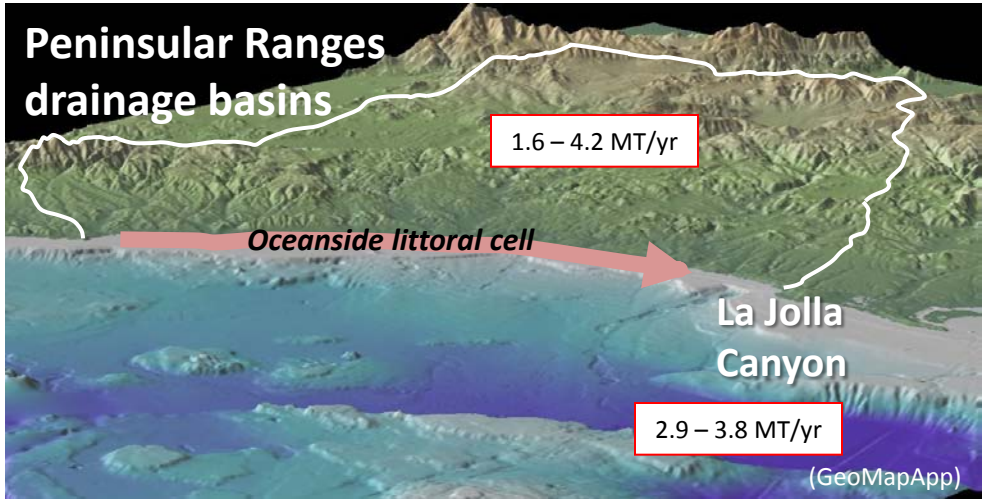

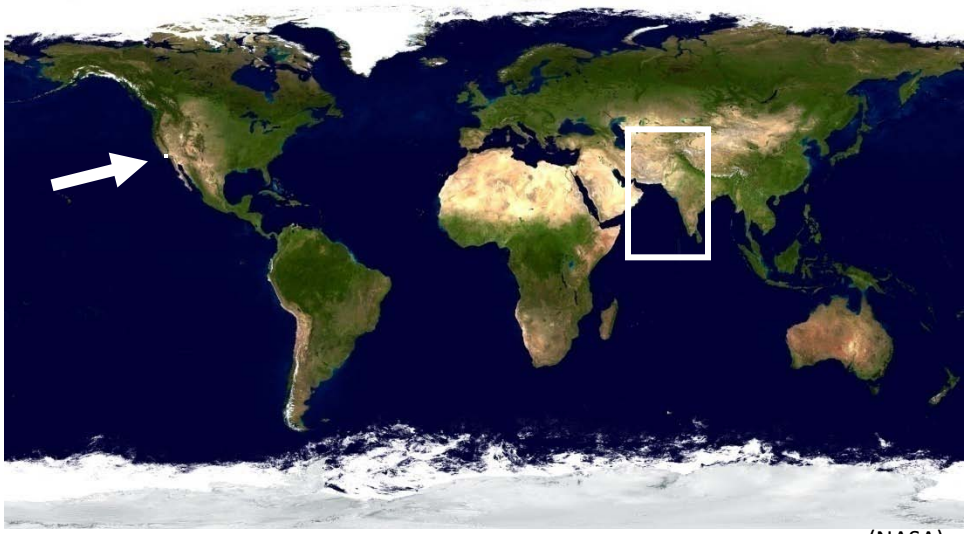

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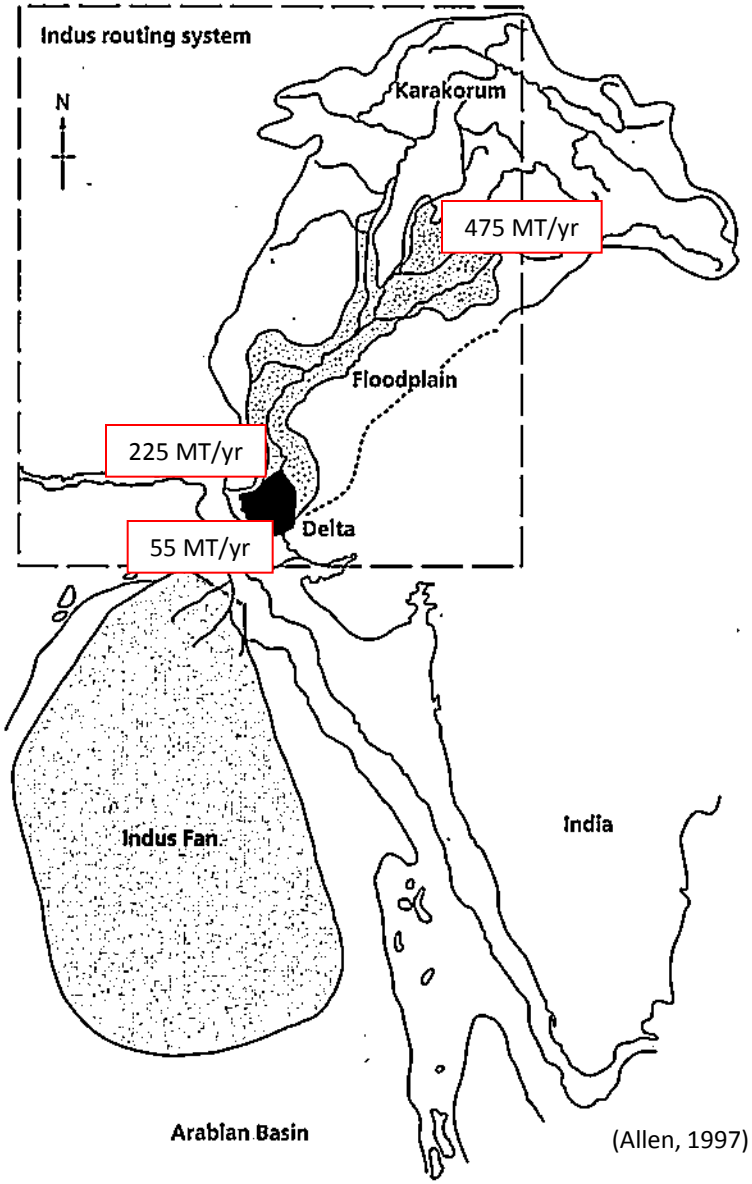

(Allen, 1997)

Rapid climatic signal propagation from sediment source to sink

Results: Variability in rates of deep-sea turbidite deposition linked to climate proxies … rapid climatic signal propagation in such spatially restricted settings

Implications: timing and character of sediment delivery across routing systems; examine the ultimate sink- deep-sea fans- for evidence of paleoclimate fluctuations