LATE-PLEISTOCENE AEOLIAN ACTIVITY ON THE COLORADO PLATEAU CORAL PINK SAND DUNES, UTAH

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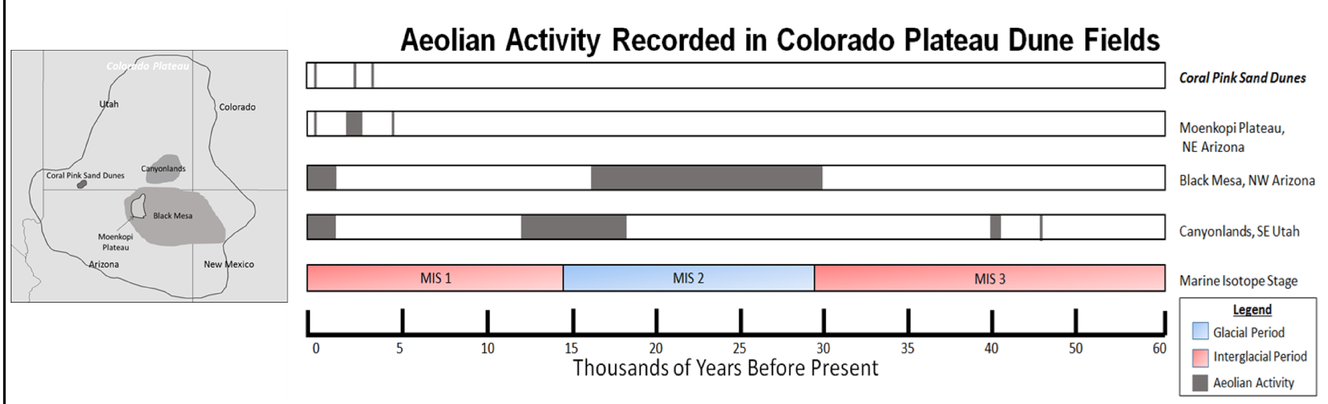
Purpose

How does climate change influence landscapes?

- Past landscape change preserved in the geomorphic record can help to better understand how landscapes respond to climate change
- This research investigates the timing and source of aeolian activity preserved in topographically-controlled sediment aprons in the Coral Pink Sand Dunes (CPSD)

Colorado Plateau Records of Aeolian Activity



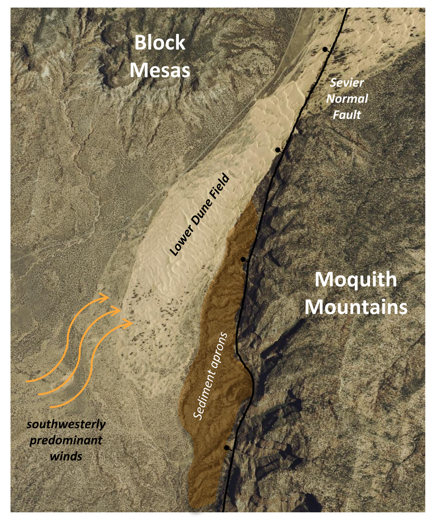
Aeolian activity on the CP has occurred under a range of climate conditions:

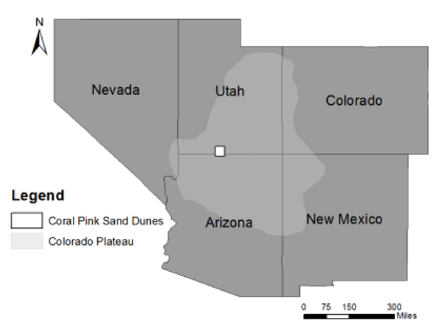
- Holocene → arid conditions → increased sediment availability
- MIS 2 and 3 → wetter, windier conditions → increased sediment supply

- The Colorado Plateau is highly susceptible to extreme climate variability because of its location in the dry, continental interior at a boundary between subtropical and mid-latitude atmospheric circulation patterns
- Preservation of deposits has limited our understanding of how this landscape responded to earlier periods of climate change
- Topographic controls preferentially preserve longer and older records

Study Region Background

Topographic Controls in Coral Pink Sand Dunes





- Semi-arid, steppe environment on the northwest Colorado Plateau
- Two distinct fields separated by the Sevier Fault
- The Lower Dune Field exists within a structurally controlled graben
- This study focuses on the relict sediment aprons at the base of the Sevier Normal Fault scarp

Research Questions

Geomorphology of the CPSD sediment aprons

1. Do the structurally-controlled sediment aprons preserve a longer record of aeolian deposition than the main dune field? When were these features active in the past? And when did they become relict/stop accumulating sediment?
2. Has the sediment source changed over time?

Climate implications

3. What can these dunes tell us about landscape change? Do they represent local geomorphic change within the CPSD system or regional landscape change influenced by climate?

Methods

Describe stratigraphy

- Describe stratigraphy exposed in channels incised though sediment aprons
- Identify depositional setting (aeolian, fluvial, or alluvial/hillslope)

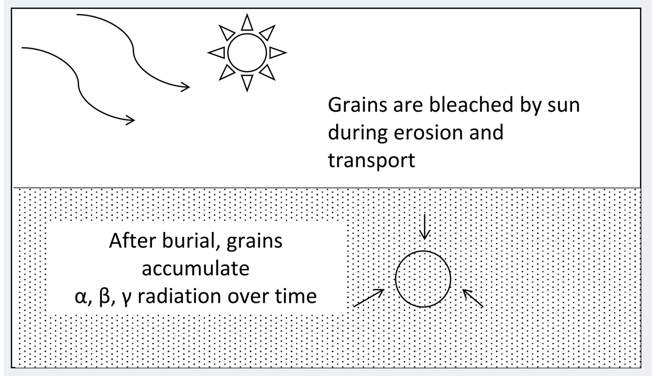
Geochronology of Aeolian Deposits

- Optically stimulated luminescence (OSL) dating
- Grain size analysis by laser light diffraction

Geochemistry of Aeolian Deposits

- Analyze by ICP-OES
- Compare trace elements between dated deposits, and to other dune fields

How does OSL work?



$$Age\ (Ka) = \frac{D_E\ (Gy)}{D_R\ (\frac{Gy}{Ka})}$$

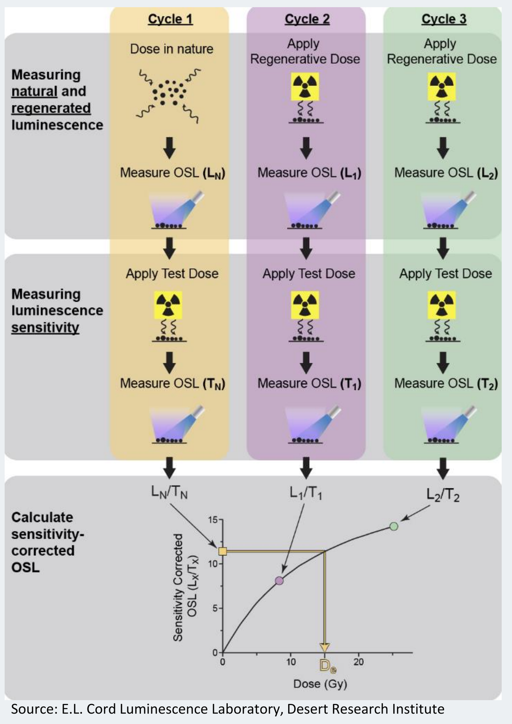
D_E Equivalent dose rate is the amount of laboratory radiation needed to induce a luminescent signal equal to the natural luminescent signal of the sample.

D_R Dose rate is the dose per unit time received by the sample while it was buried, and is calculated from the elemental radioisotopes in surrounding sediment.

Sample Collection

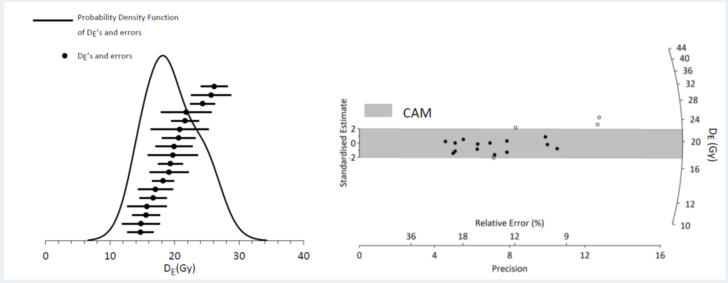
1. Describe stratigraphy
2. Identify aeolian deposits
3. Collect D_E in light-proof container
4. Collect D_R sample from a 15 cm radius around D_E sample

Laboratory Analysis and Age Calculation

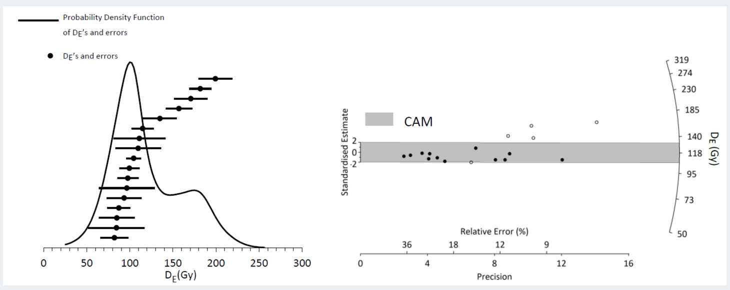


Source: E.L. Cord Luminescence Laboratory, Desert Research Institute

D_E Distributions



CPSD-Site 4

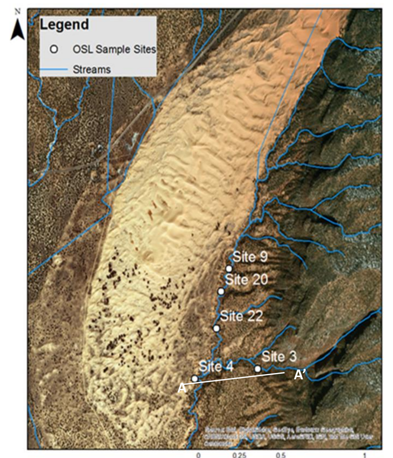


CPSD-Site 3

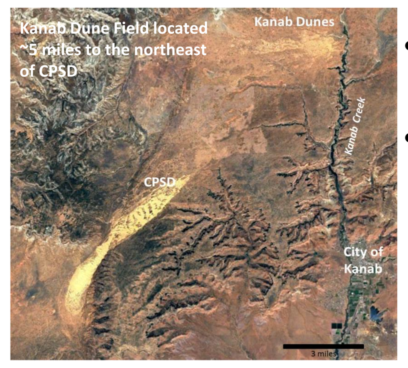
Results

An Extended Record of Aeolian Activity

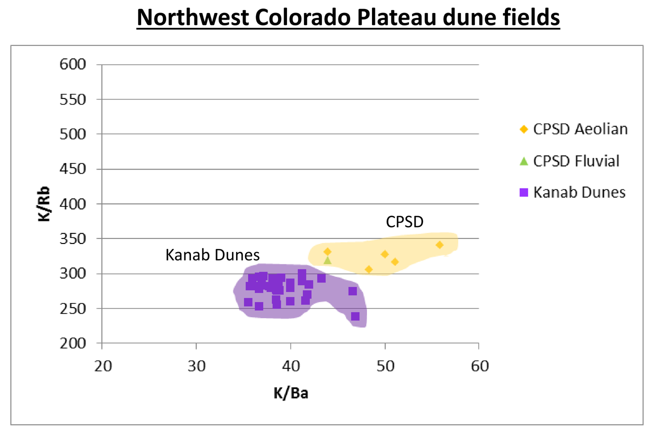
Site ID	Elevation (ft)	Location	Grain size (um)	# disks	Dose rate (Gy/ka)	Equivalent dose (Gy) DE 2± 2σ	Overdispersion (%)	OSL age, 2SE (ka)	Inferred Dune Type from Paleowind Direction
4	5671	Sand Wash	150-250	18 (27)	1.59 ± 0.07	19.74 ± 1.76	13.2 ± 4.3	**12.40 ± 1.65**	migrating
3	5801	Sand Wash	150-250	17 (26)	1.04 ± 0.05	118.98 ± 17.56	25.3 ± 6.1	**114.7 ± 20.6**	migrating
9	5758	Tributary to Sand Wash	150-250	14 (21)	0.88 ± 0.05	125.69 ± 12.92	13.8 ± 4.7	**142.7 ± 20.4**	climbing
20	5747	Sand Wash	150-250	19 (26)	0.74 ± 0.04	90.46 ± 10.08	20.4 ± 4.6	**123.0 ± 18.6**	migrating
22	5720	Sand Wash	150-250	18 (22)	1.21±0.06	180.76 ± 16.05	16.3 ± 3.6	**149.8 ± 20.0**	migrating



Sediment Source



- K/Rb and K/Ba values are a measure of K-feldspar composition
- Muhs (2017) and Muhs et. al. (2017) show that K/Rb and K/Ba are effective discriminators for K-feldspars derived from different source sediments across North American dune fields



Kanab Dunes trace element data from current study by H. Cornachione

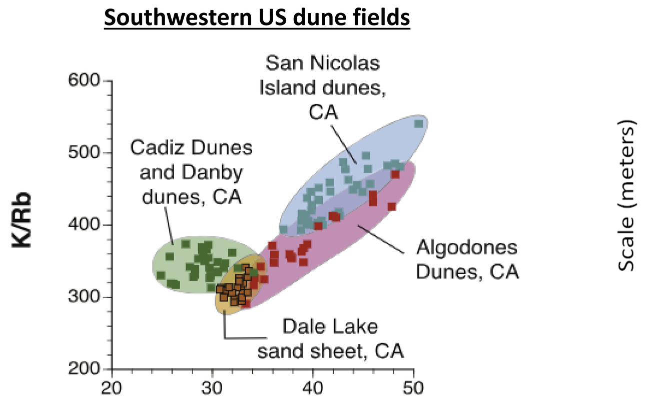
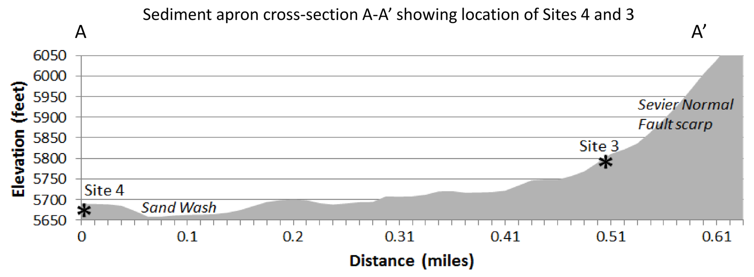
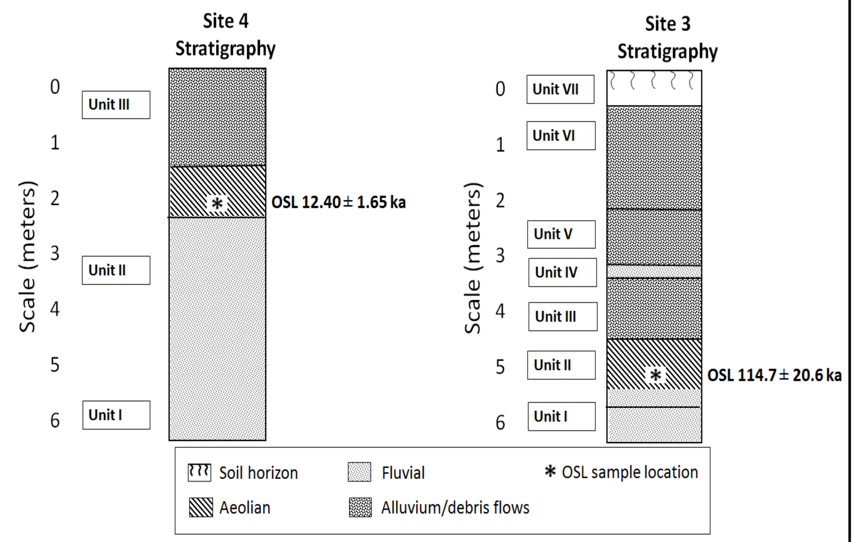


Figure Citation: Muhs (2017)

Sediment Apron Stratigraphy





Discussion of Results

Geomorphology and Geochronology of Sediment Aprons

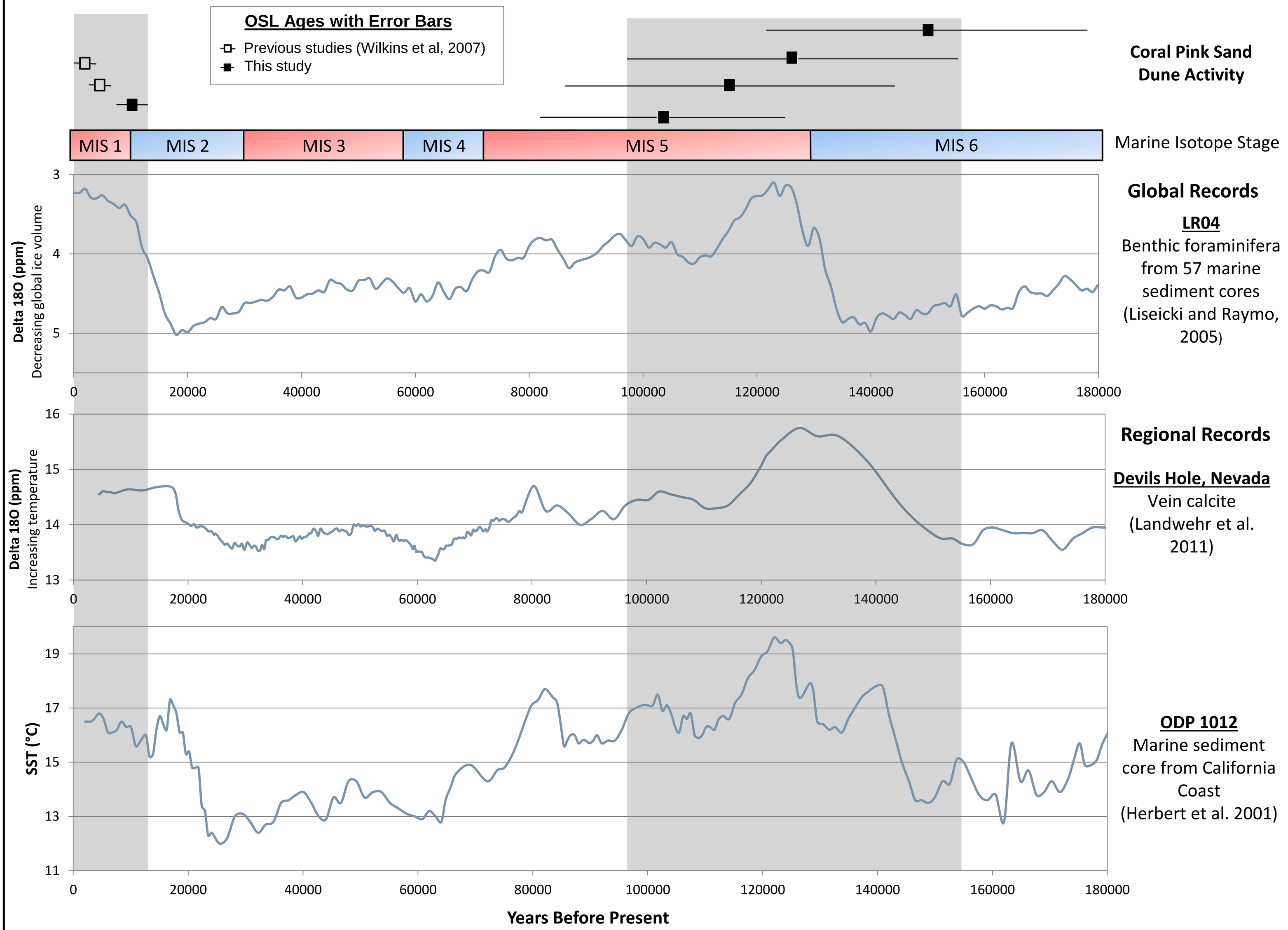
- The sediment aprons preserve aeolian activity from ~12 ka, and from ~110 to 150 ka
- Since ~12 ka Sand Wash has incised, dissecting the aprons from the main dune field and cutting off their aeolian sediment supply
- This study provides the first evidence of aeolian activity during the last major glacial period on the Colorado Plateau (MIS 6) and an opportunity to investigate hypotheses of landscape change during glacial-interglacial climate change

Sediment Source

- While the CPSD and Kanab Dunes are located about 5 miles apart and both overlay Navajo sandstone bedrock, their geochemical signatures are different, suggesting that they are derived from different sources
- Future work will include analyses of bedrock samples for comparison

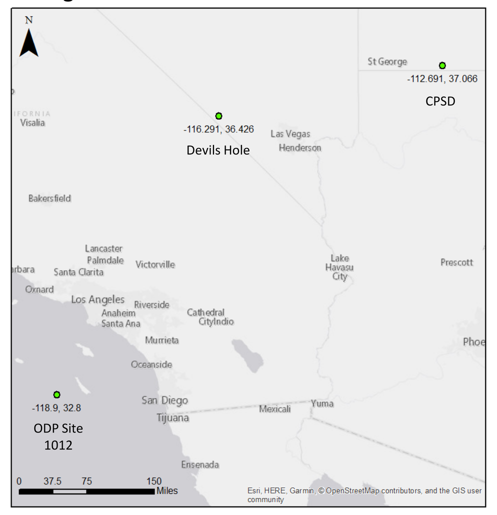
How has this landscape responded to past climate change?

Comparison of CPSD aeolian activity to global and regional paleoclimate records



- Arid southwestern US terrestrial climates are affected by changes in the California Current, for example El Nino increases SST, which lowers upwelling, and increases precipitation on land
- High correlation coefficient between ODP-1012 and Devils Hole record (higher than with global record) suggests regional climate signal (Herbert et. al., 2001)
- Regional feedbacks cause regional marine and terrestrial temperatures to diverge from global patterns
- Collapse of California Current and rise of SSTs along California coast occurred 10-15 ka before deglaciation of past 5 glacial maxima

Regional Paleoclimate Record Site Locations



Conclusions

- Topographic controls can preserve long records of landscape activity
- Landscape change corresponds to major climate change events
- Aeolian activity during MIS6/5 transition was most likely a result of increased sediment supply rather than aridity

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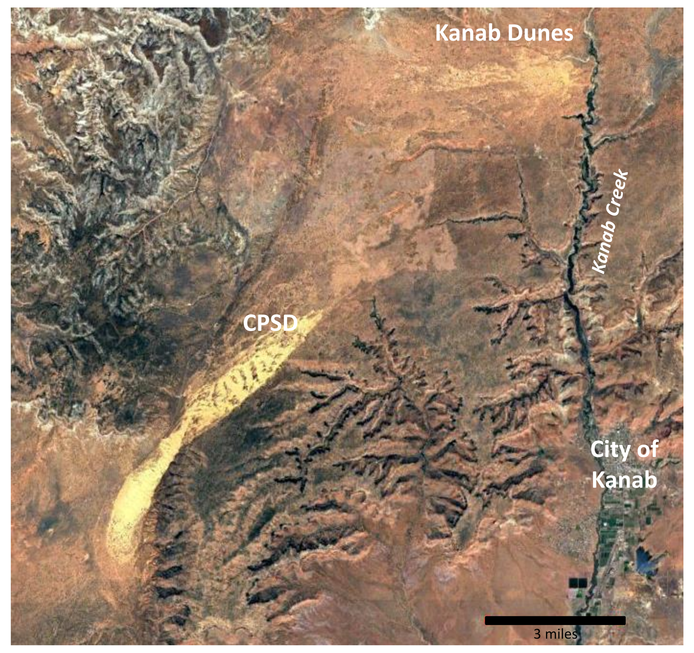
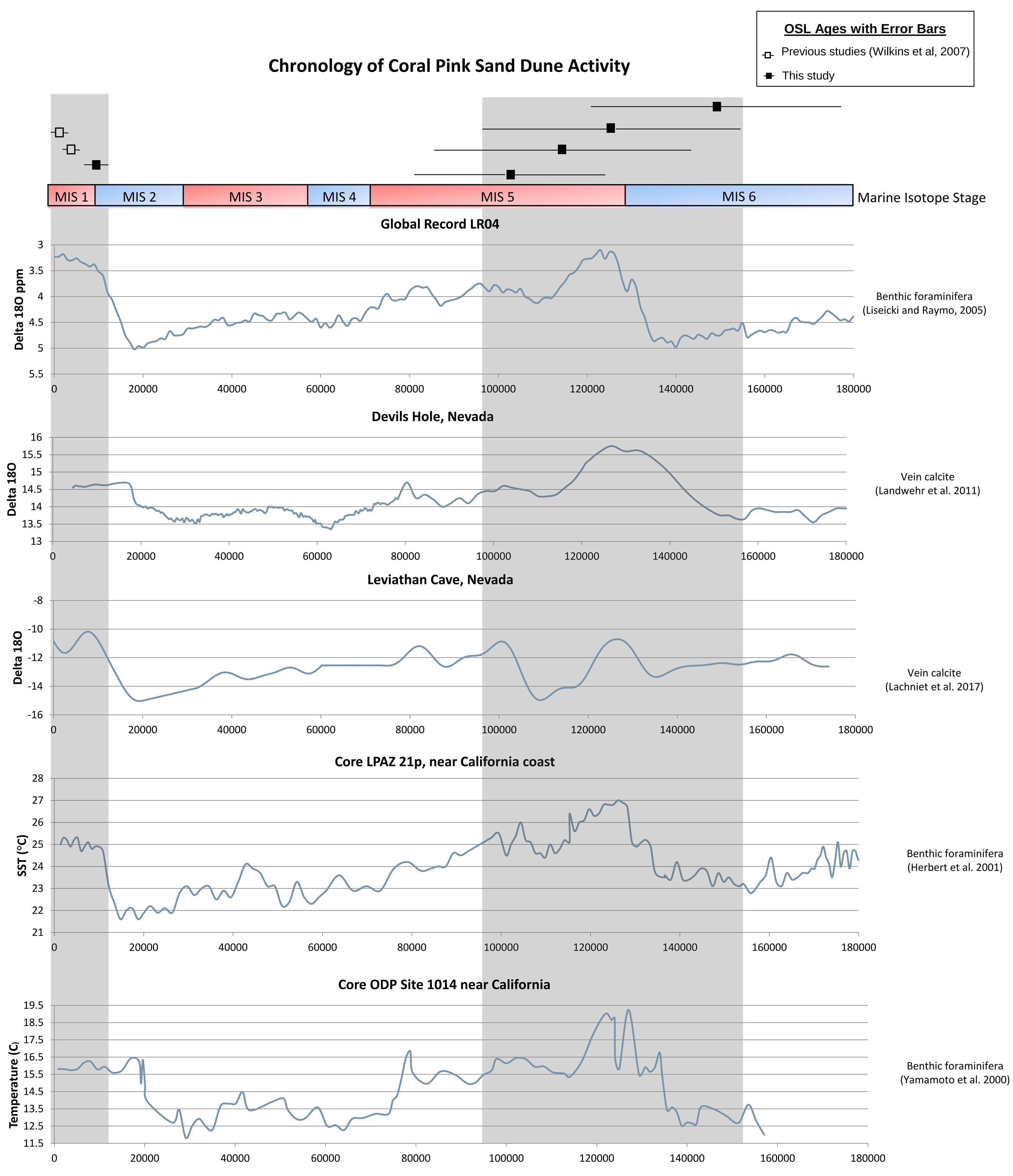
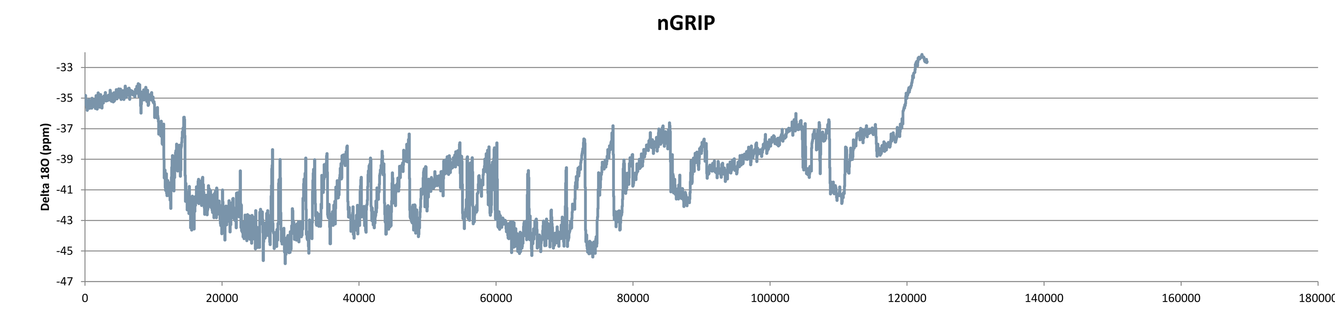
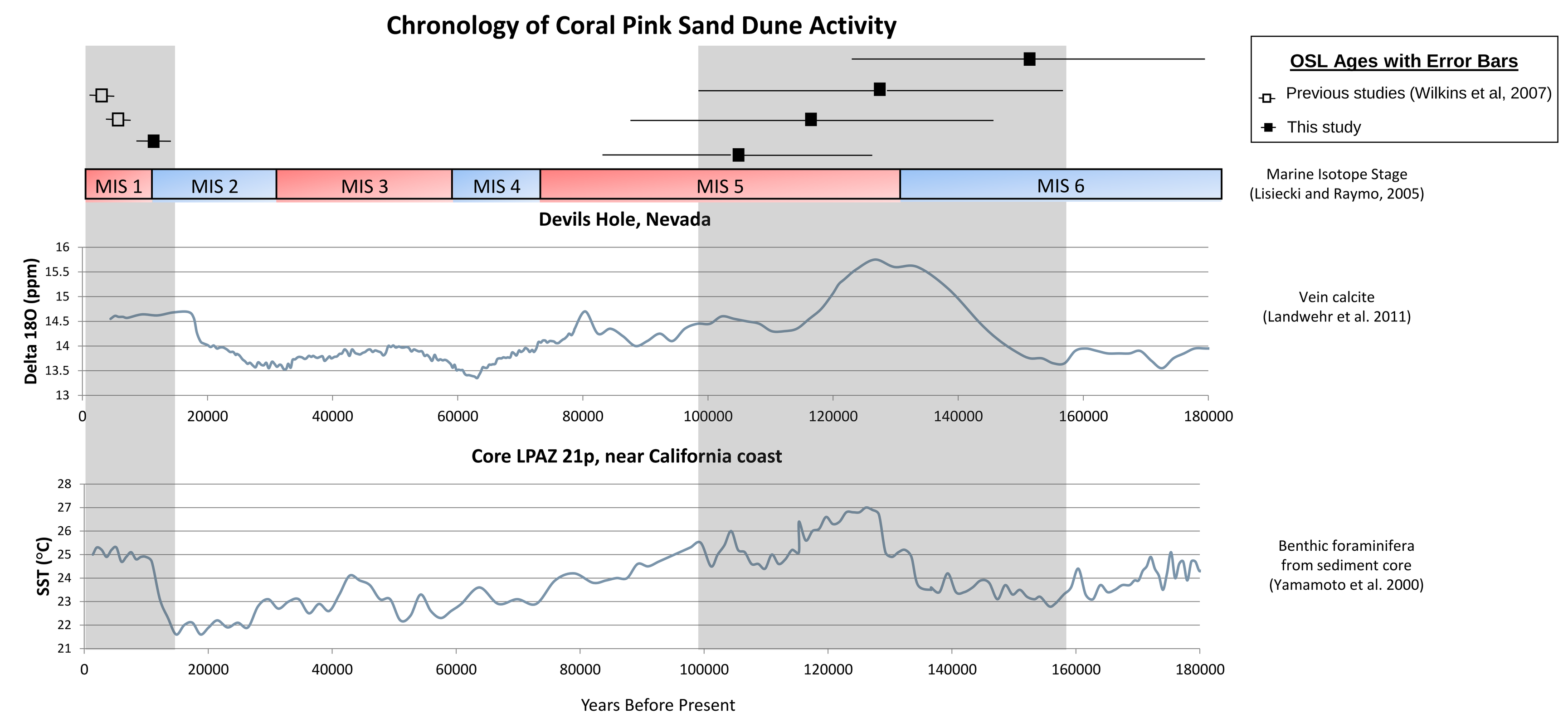
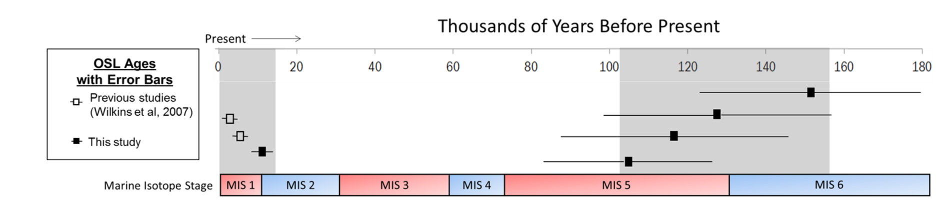


How has this landscape responded to past climate change?









Site ID	Elevation (m)	Location	depth (m)	grain size (μm)	# disks	dose rate (Gy/ka)	Equivalent dose (Gy) DE2 ± 2σ	OD3 (%)	OSL age, ka (2SE)	Inferred Dune Type from Paleowind Direction
Site 4	5671	Tributary to Sand Wash	2.5	150-250	18 (27)	1.59 ± 0.07	19.74 ± 1.76	13.2 ± 4.3	**12.40 ± 1.65**	**migrating**
Site 3	5801	Sand Wash	5.4	150-250	17 (26)	1.04 ± 0.05	118.98 ± 17.56	25.3 ± 6.1	**114.7 ± 20.6**	**migrating**
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Site 20	5747	Sand Wash	1.5	150-250	19 (26)					
Site 22	5720	Sand Wash	1.5	150-250	18 (22)					

Site ID	Elevation (ft)	Location	Depth from surface (m)	Grain size (um)	# disks	Dose rate (Gy/ka)	Equivalent dose (Gy) DE 2± 2σ	Overdispersion (%)	OSL age, 2SE (ka)	Inferred Dune Type from Paleowind Direction
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22	5720	Sand Wash	1.5	150-250	18 (22)	1.21±0.06	180.76 ± 16.05	16.3 ± 3.6	**149.8 ± 20.0**	migrating

Concentrations of trace elements

Site ID	Type	Ba (ppm)	Zr (ppm)	Hf (ppm)	Rb (ppm)	U (ppm)	Th (ppm)	Pb (ppm)	La (ppm)	Sc (ppm)
4	aeolian	240	16.9	0.5	39.4	0.3	0.97	5.5	3.4	0.6
3	aeolian	170	13.3	0.4	26	0.2	0.76	4.1	2.6	0.6
9	aeolian	120	13.5	0.4	19	0.3	0.88	3.5	2.7	0.5
20	aeolian	100	11.4	0.3	13.3	0.2	0.61	3.2	1.9	0.4
21	fluvial	50	10.4	0.3	6.9	0.2	0.73	1.5	1.9	0.3
22	aeolian	180	18.7	0.5	29.1	0.2	0.96	5.2	3.1	0.7

CPSD trace element concentrations

Site ID	Type	Ba (ppm)	Zr (ppm)	Hf (ppm)	Rb (ppm)	U (ppm)	Th (ppm)	Pb (ppm)	La (ppm)	Sc (ppm)
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3	aeolian	170	13.3	0.4	26	0.2	0.76	4.1	2.6	0.6
9	aeolian	120	13.5	0.4	19	0.3	0.88	3.5	2.7	0.5
20	aeolian	100	11.4	0.3	13.3	0.2	0.61	3.2	1.9	0.4
21	fluvial	50	10.4	0.3	6.9	0.2	0.73	1.5	1.9	0.3
22	aeolian	180	18.7	0.5	29.1	0.2	0.96	5.2	3.1	0.7

How has this landscape responded to past clin