

## Is There a Difference Between Supposed Eolian and Subaqueous Cross-bed Dips?

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# IS THERE A DIFFERENCE BETWEEN SUPPOSED EOLIAN AND SUBAQUEOUS CROSS-BED DIPS?

## Cedarville University Research and Scholarship Symposium, April 2021

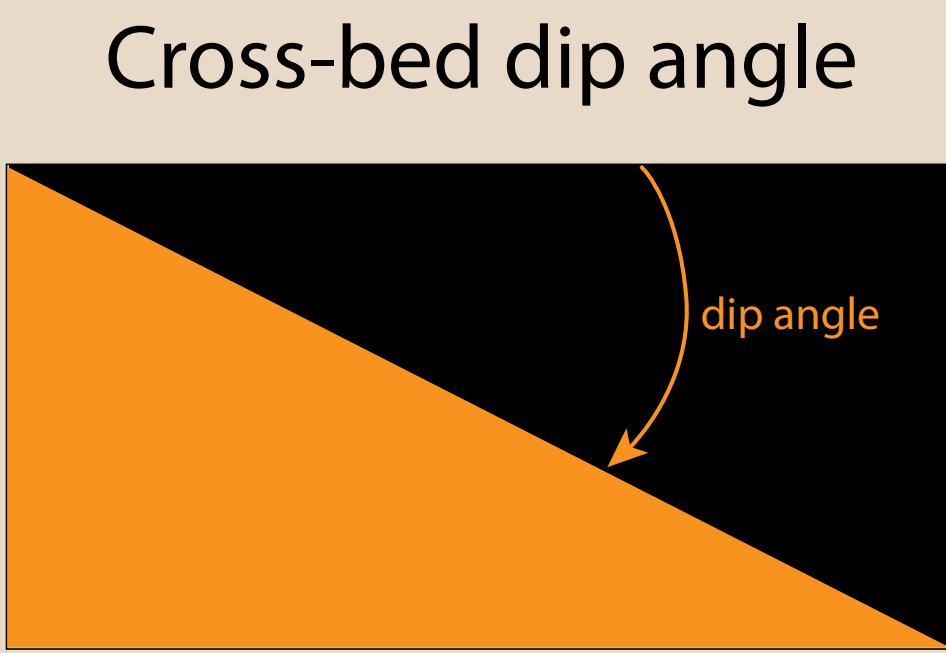
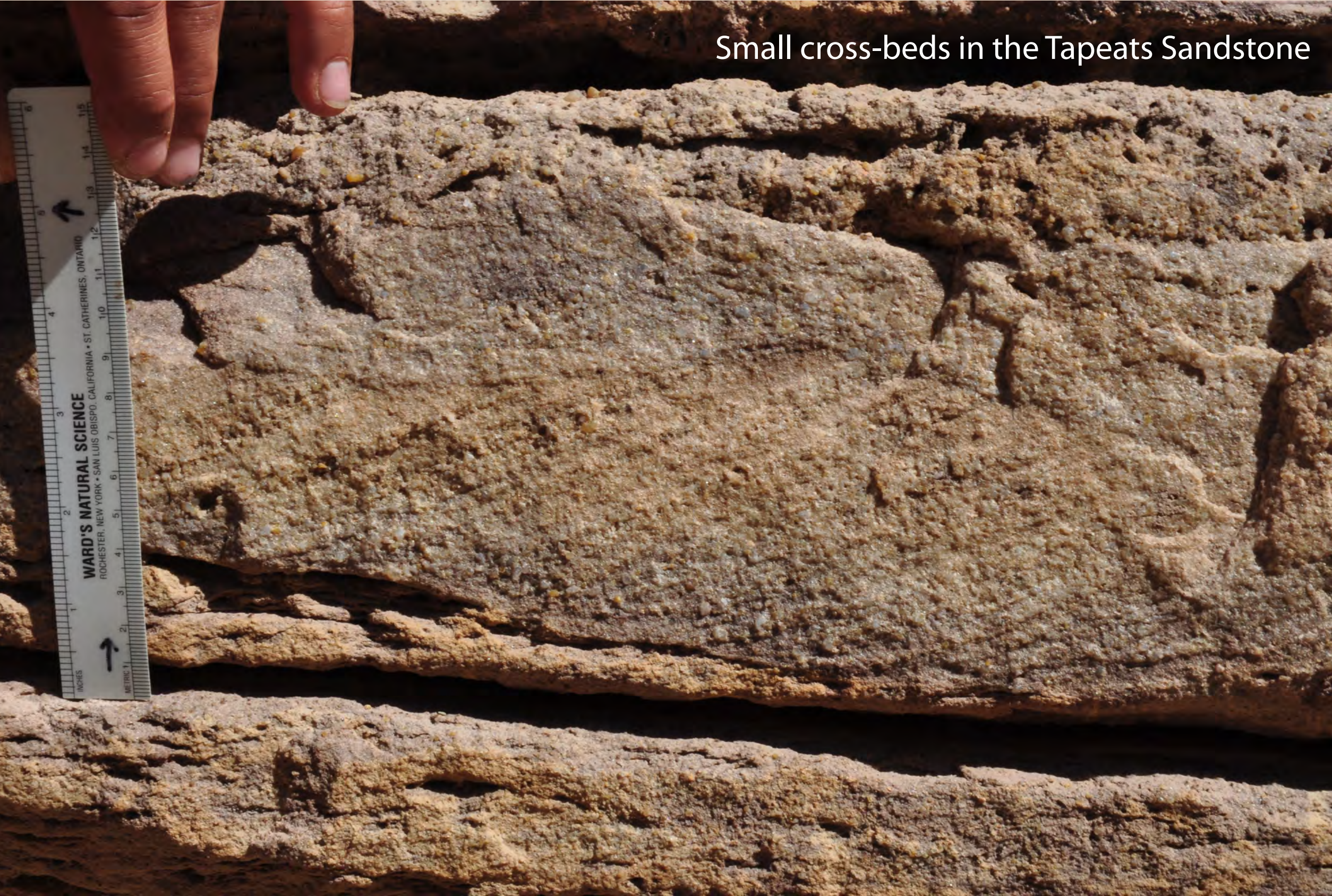
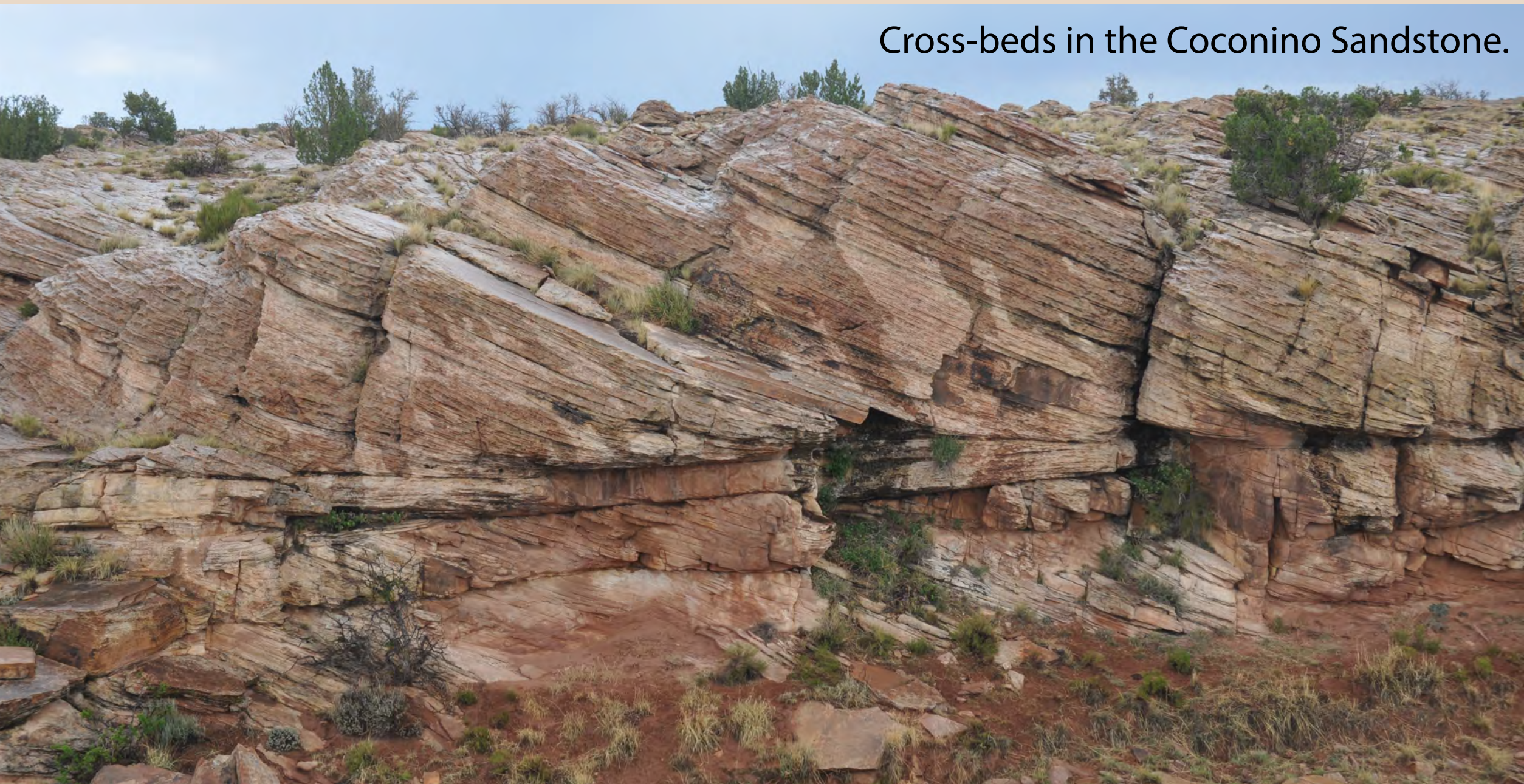
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### ABSTRACT

Edwin D. McKee (1906-1984) is widely recognized as the Grand Canyon's most distinguished geologist. His monographs on the Canyon's formations range from the Coconino Sandstone early in his career (1934) to the Supai Group late in his career (1982). Within his publications, extensive cross-bed dip data can be found for the Tapeats, Manakacha, Wescogame, Pakoon, and Esplanade units. McKee never published any of his own data on cross-bed dips of the Coconino (despite writing the seminal work on the topic), but he claimed in a 1979 publication that its dips mostly fell within the 25-30° range.

The purpose of this study is to statistically examine data published by McKee and Reiche to see if there is any difference in cross-bed dip angles between supposed subaqueous and eolian formations of the Grand Canyon area. McKee (1979) argued that "steep" cross-bed dips within the Coconino were one of the primary things that indicated it was an eolian sandstone. Many authors have argued that supposed eolian cross-beds are steeper than subaqueous ones. This project aims to test the validity of that claim.

Cross-bed dip data was gathered from papers by McKee and Reiche and then statistically analyzed with Excel and Grapher. Calculating ANOVA with Excel showed that the cross-bed dip angle populations of the Tapeats, Wescogame, and Coconino could not be distinguished from one another. Notched box and whisker plots drawn with Grapher visually confirmed these results. This is a significant and unexpected result because the three formations supposedly represent very different depositional environments within a conventional model: the Tapeats, a high-energy nearshore marine environment, the Wescogame, a high-energy fluvial environment, and the Coconino, eolian dunes deposited by wind. McKee's claim that most dips of the Coconino fall within the 25-30° range are not supported by the data. Similar cross-bed dip populations between these three formations, all having median dips of about 20°, is further evidence that the Coconino was not deposited by eolian processes. Work is ongoing to compare these results with the dips of other cross-bedded formations and the cross-bed dips of modern eolian dunes.



### BACKGROUND

- The author has known for sometime that cross-bed dips in the Coconino Sandstone average about 20° from some other research.
- It was brought to the author's attention that the Tapeats Sandstone has a similar average.
- Desert dunes have a wide range of cross-bed dips, including many near the angle of repose (~34°, photograph below).
- This data led the author to statistically compare some cross-bed data from the Grand Canyon area.



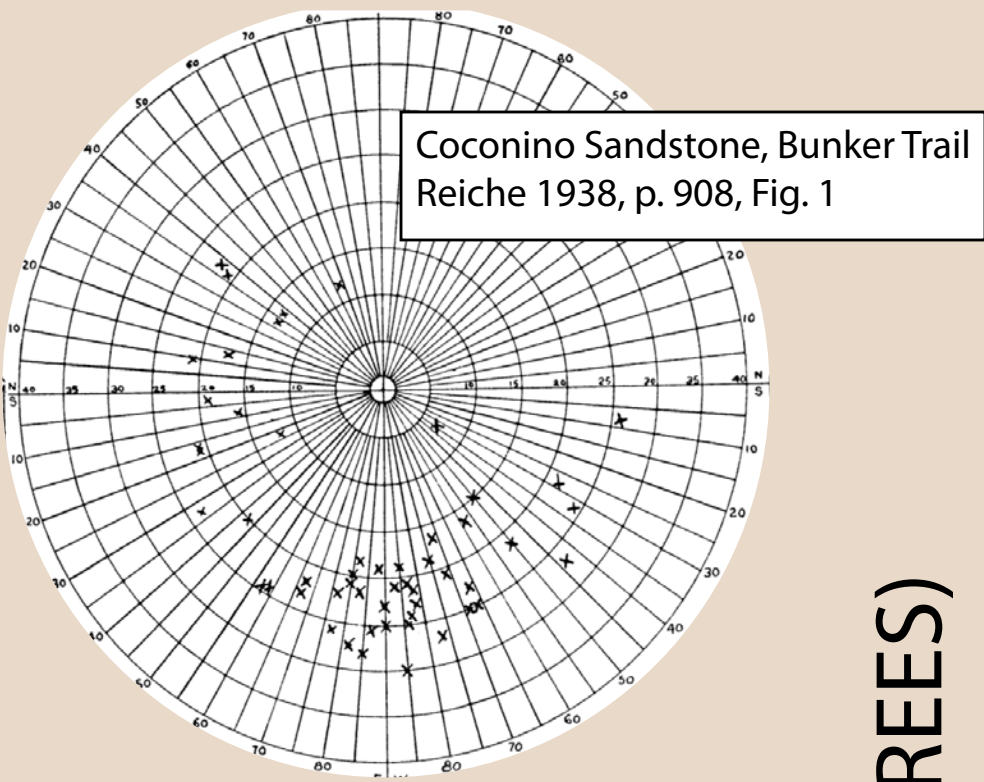
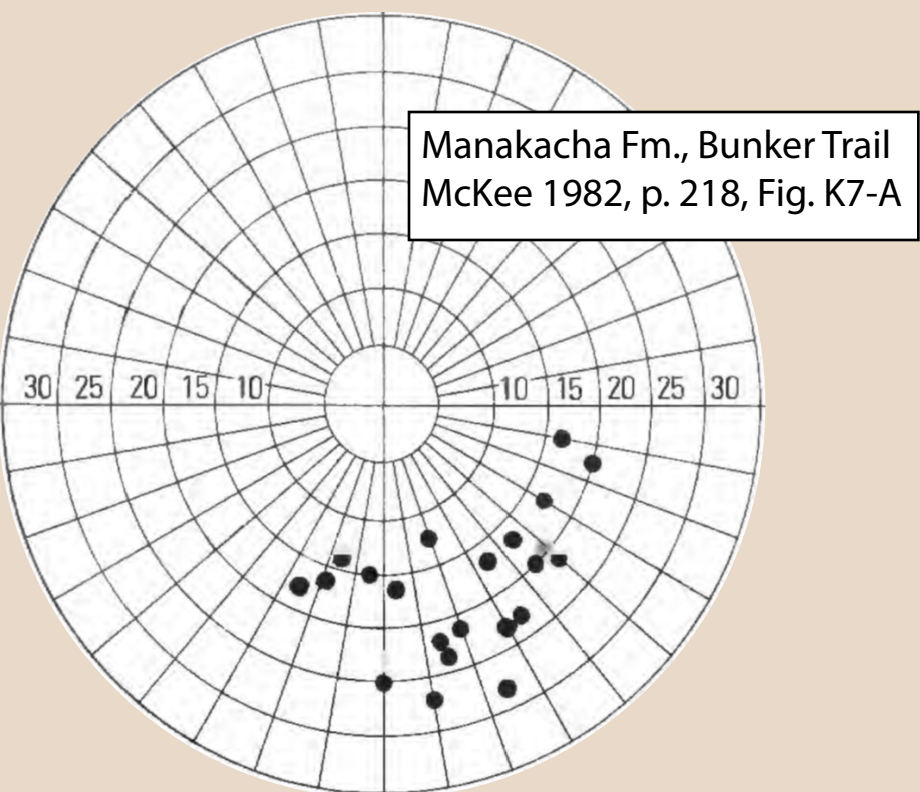
### METHODS

•Cross-bed dip data was gathered from McKee and Reiche. They published their data using polar plots, like those on the right (66 total plots).

•Data was collected from six different units that occur in or near Grand Canyon.

•Data was entered into Excel where ANOVA was calculated.

•Grapher was used to make notched box and whisker plots, so medians could easily be compared and outliers plotted.

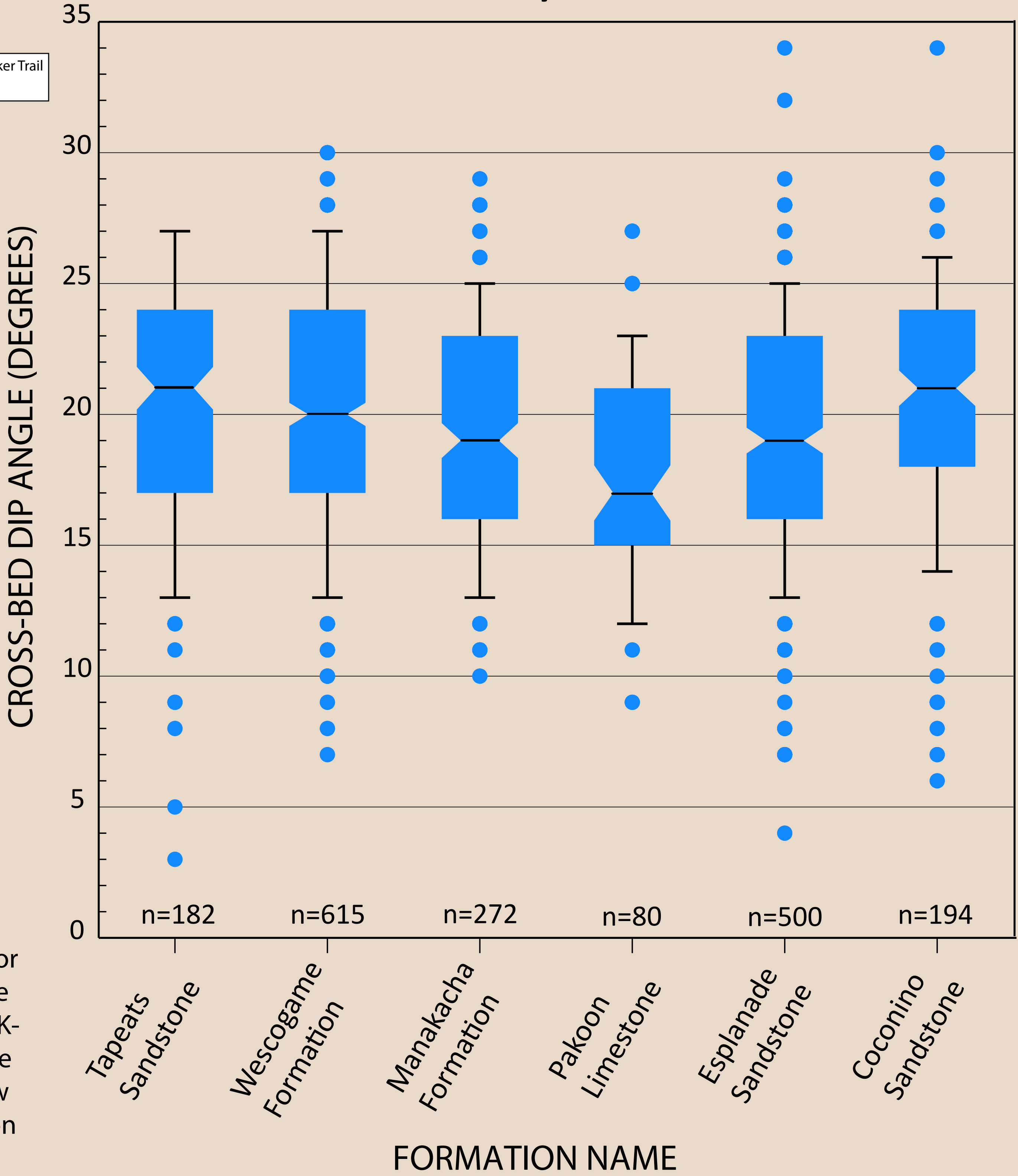


### RESULTS

ANOVA showed that the cross-bed dip populations from the Tapeats, Wescogame and Coconino could not be differentiated. This is significant because in a conventional geology model these three formations were all deposited in different depositional environments (shallow marine, fluvial, eolian). The expectation would be that the Coconino would be much different than the water-laid deposits.

SUMMARY: Tapeats Sandstone, Wescogame Fm, Coconino Sandstone						
Groups	Count	Sum	Average	Variance		
Tapeats Sandstone	182	3701	20.33516	25.38428	*A p-value > 0.05 indicates the groups cannot be differentiated	
Wescogame Fm.	615	12353	20.08618	21.77921		
Coconino Sandstone	194	3948	20.35052	24.08376		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	15.42276	2	7.711381	0.336891	0.714069	3.004834
Within Groups	22615.15	988	22.88983			
Total	22630.58	990				

### McKee and Reiche's Cross-Bed Dip Angle Data for Grand Canyon-Area Formations

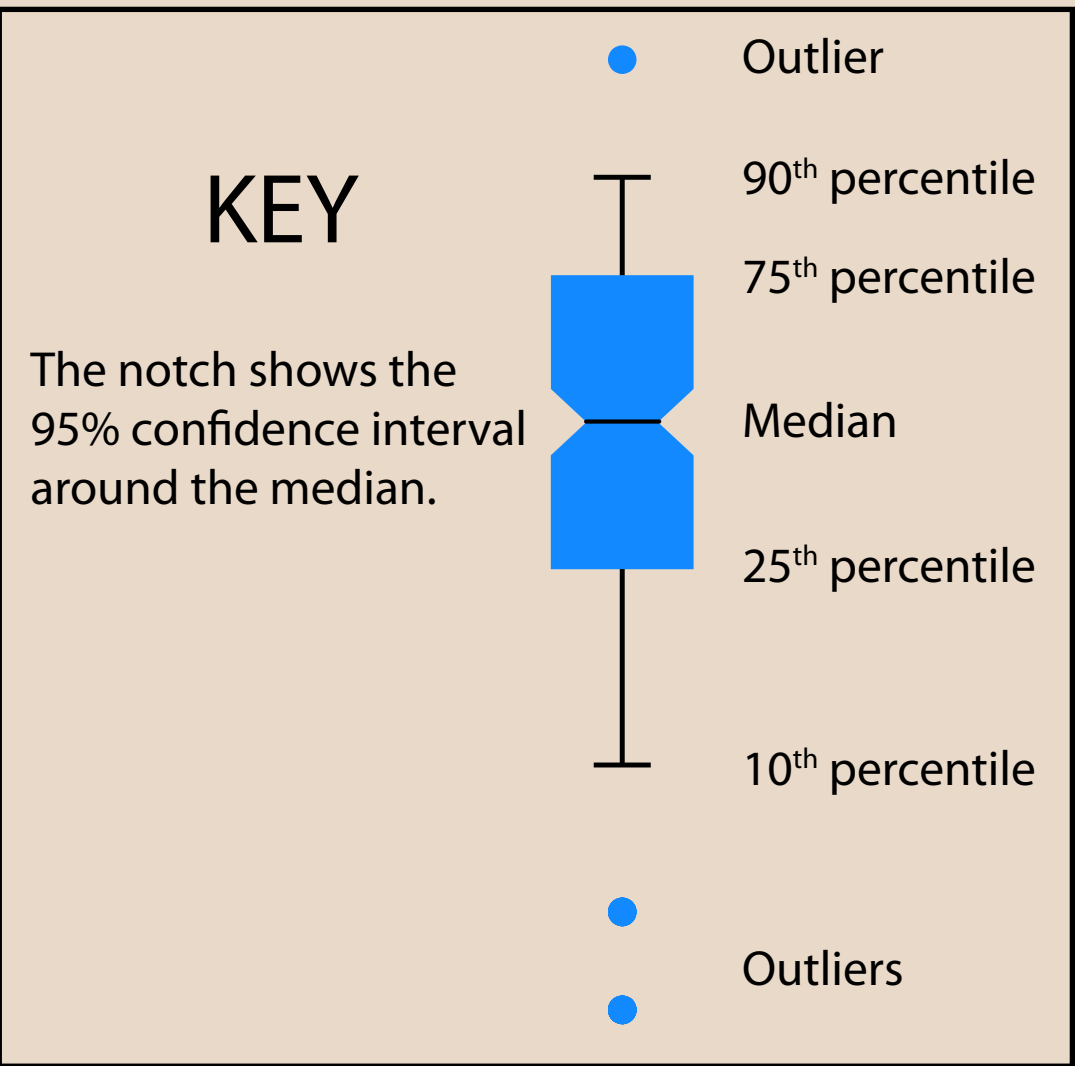


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### CONCLUSIONS

Showing that the Coconino has cross-bed dips that are very similar or even identical to, water laid deposits, is further confirmation that the Coconino was a water-laid deposit and did not form in a desert. McKee's (1979) estimate that most of the Coconino's cross-beds are in the 25-30° range is not supported by the data. In fact, the statistics show that most cross-beds in this range are outliers of the main population of cross-beds.



### FUTURE WORK

Work to compare these limited results with other cross-bedded sandstones, and with modern eolian dunes is ongoing. The work has the potential to be able to answer the question if compaction during lithification of eolian dune sand can produce the populations of cross-bed dips which are found in supposed eolian sandstones like the Coconino and Navajo.