MICAS IN CROSS-BEDDED SANDSTONES AND THEIR ABRASIONAL TRENDS

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ABSTRACT

We have noted micas (mostly muscovite) in several classic cross-bedded eolian sandstones. We have searched for micas in modern eolian settings, but have only found them near crystalline igneous sources. We set out to test the survival of muscovite flakes in the conditions known to produce cross-bedding in sandstones. Our goal was to experimentally test the survival of mica in both eolian and subaqueous environments.

Simulated eolian experiments were carried out in a 4 liter pickle jar with a remote control airplane propeller attached through the lid. Air circulation velocity was controlled so that a small dune continually migrated around the bottom of the jar. Samples were removed at various time intervals over the course of 20 days, and were made into thin sections. Results showed that micas deteriorate quickly in such conditions, within a matter of a few days. Very few pieces of visible mica could be found after 96 hours of agitation (about 483 km of travel), even when examined in microscopic thin section. In this time, most of the mica had degraded into silt- and clay-sized particles.

Simulated subaqueous experiments were carried out in a 1.5 liter pickle jar. The jar was rotated by a rock tumbler at constant speed, so that the sand continually climbed the rising side of the jar, resulting in a continuous dune. After 2853 hours of agitation, the average long axis length of mica particles had only decreased from 1.82 mm to 1.41 mm. Even after 26 weeks (about 3500 km of travel), mica flakes were still large enough to be seen with the naked eye (still > 1 mm in size). Thus, subaqueous conditions do not appear to significantly accelerate muscovite deterioration.

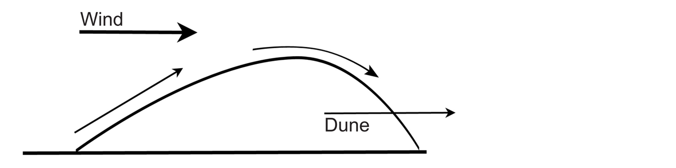
In the experimental conditions we tested, micas persisted for an excess of 26 weeks in a subaqueous environment, but little more than 4 days in an eolian environment. As one possible explanation, the water may be acting as a cushion, reducing the violence of grain-to-grain collisions. Air provides almost no cushioning effect and allows for more forceful collisions. Quartz has a Mohs hardness of 7, while muscovite has only a 2.5. Harsh impacts between these two minerals would account for the rapid decrease in the softer mineral's size. Micas may be a reliable trace mineral in order to determine whether a sandstone is eolian or subaqueous in origin.

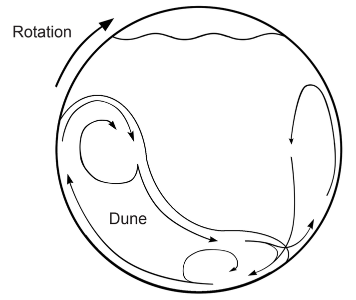
METHODS

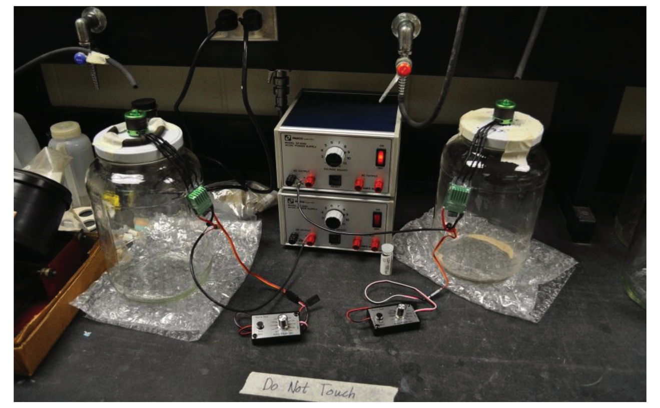
The same mica-rich Carolina Sand Hills sand was used for both experiments and fines were removed by decantation.

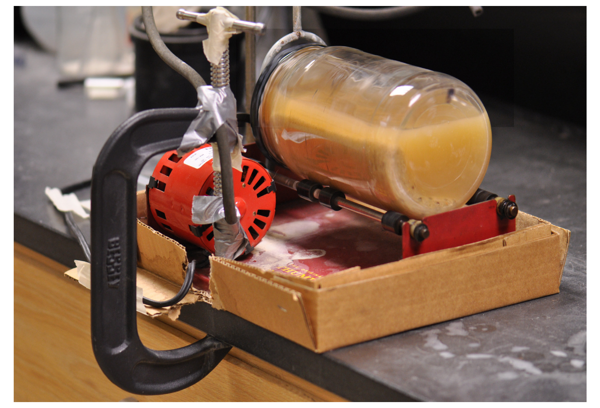
Eolian environment was simulated in a special wind chamber designed to apply a controlled wind. The chamber itself consisted of a 4 liter, wide-mouth glass pickle jar with lid. A small, brushless 20 amp DC motor from a remote control airplane was mounted with the propeller inside the lid and was connected to an electronic speed controller and servo tester. A constant wind speed of about 4.78 kph maintained a dune which migrated by saltation around the base of the container.

Subaqueous environment was carried out in a similar wide-mouth glass pickle jar. A 1.5 L jar was filled with water and laid sideways on a rock tumbler assembly. A rotation speed of approximately 0.87 kph simulated a saltating dune on the rotational upslope. The particle circulation paths are represented in the drawing below.

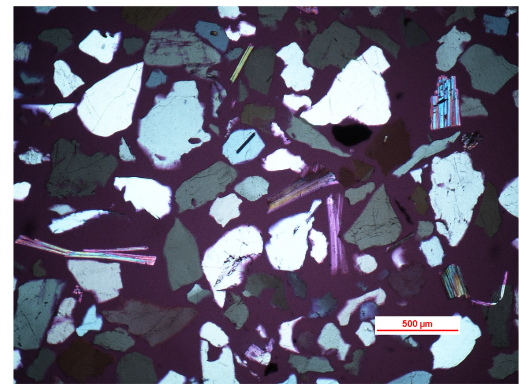


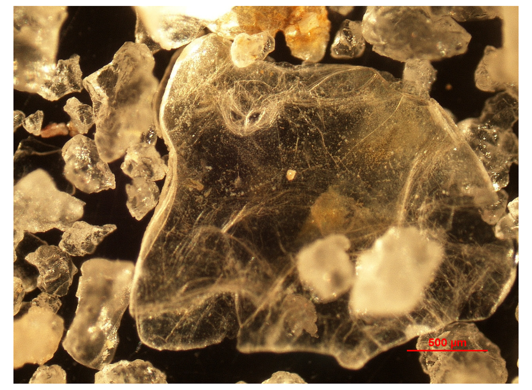




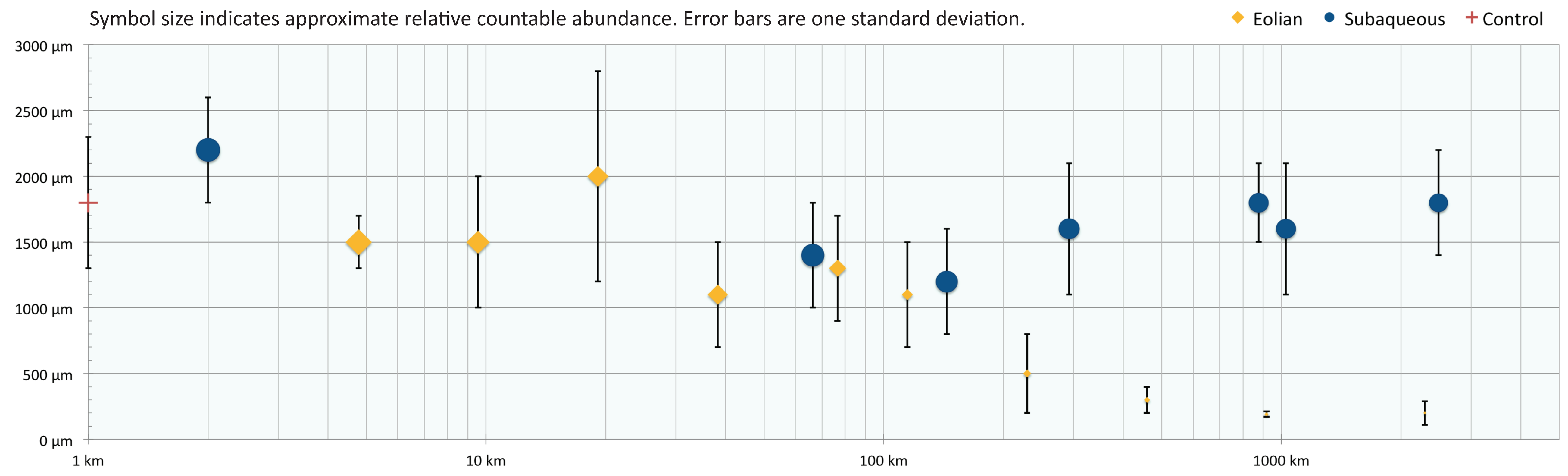


Original micaceous sand



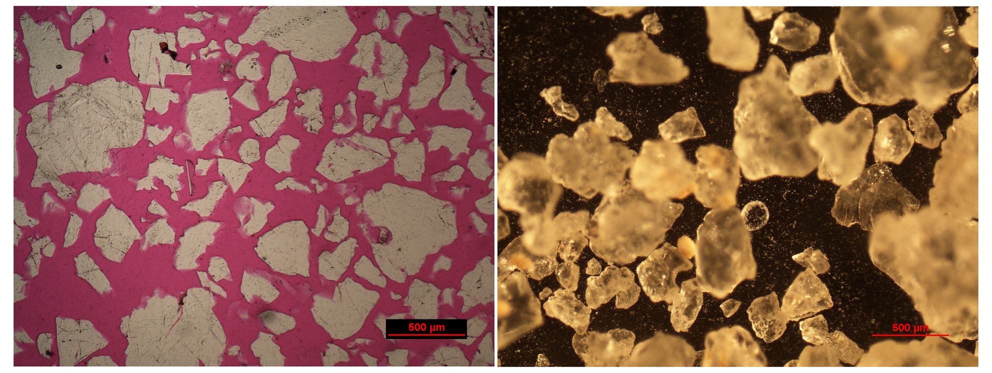


Maximum Muscovite Size vs. Transport Distance



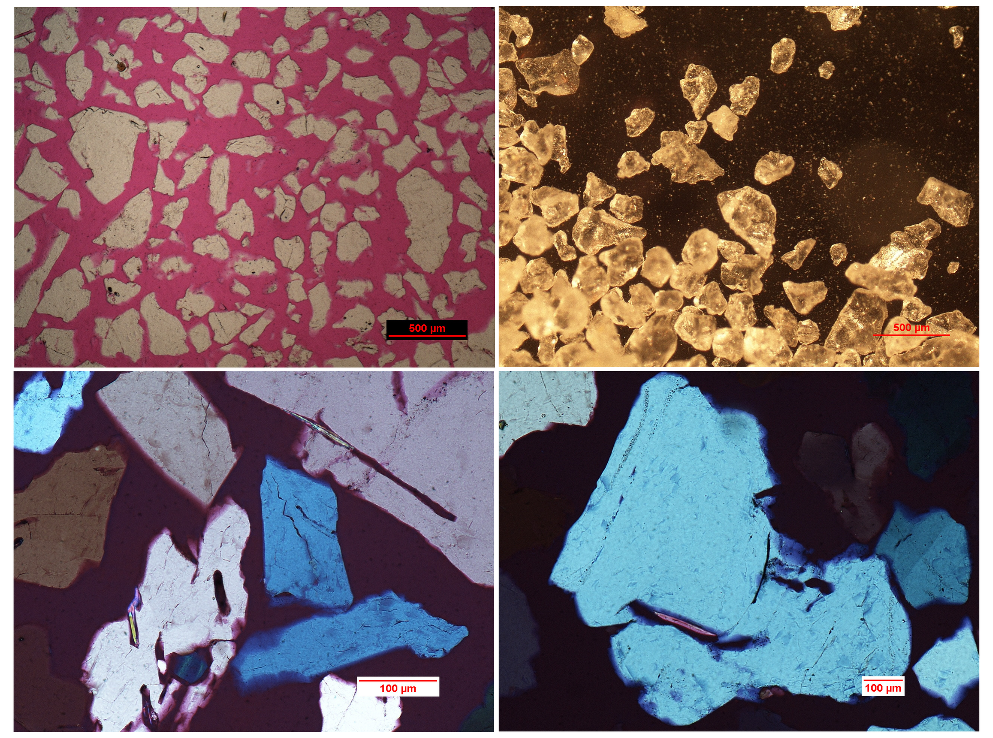
Simulated Eolian Environment

460 km



Micas were much smaller than those in the original sand, but a few loose flakes were still visible. However, the muscovite pieces were significantly more difficult to find, and with only a few exceptions, all loose micas were between 50 and 150 microns.

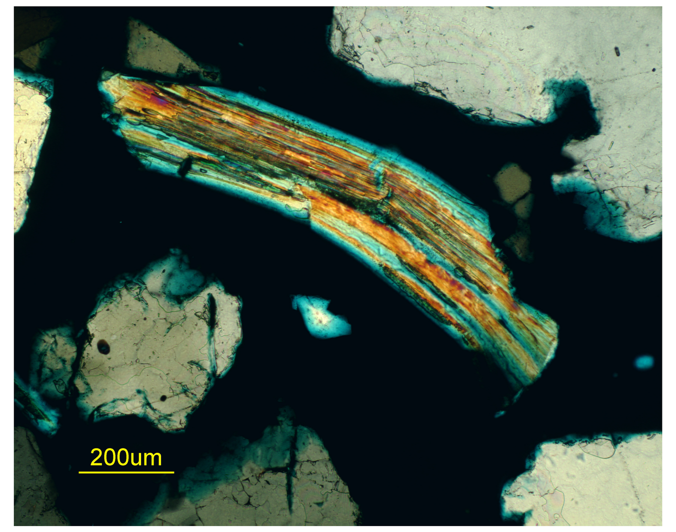
2300 km



No loose micas could be found in thin section. The only observed muscovite were small pieces tucked away in little crevices and "lagoons" within individual sand grains. These sequestered crystals likely enjoyed protection from abrasive collisions. While a few were greater than 100 microns in length, at least 60% of all micas present were less than 50 microns long.

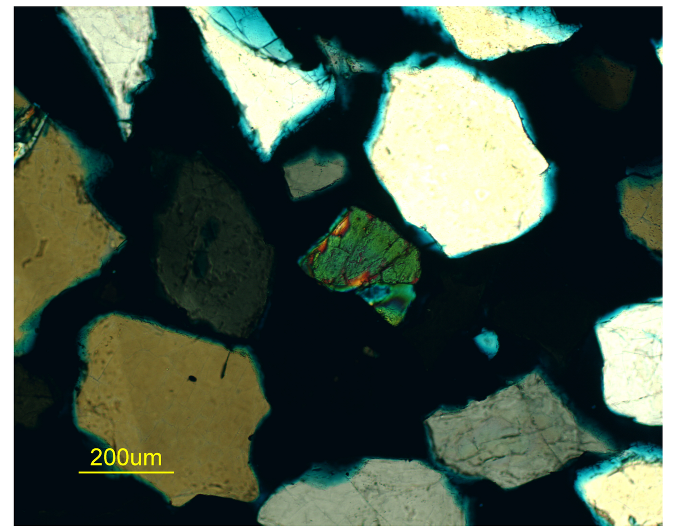
Simulated Subaqueous Environment

0 km



Micas were abundant and large enough to be extracted by hand. This thin section slices through a mica typical of the sand. Note that the length exhibited here likely does not represent the maximum long axis.

4200 km



Although loose micas were difficult to find in thin section, large micas could still be found easily in the apparatus. Most micas in the thin section were about 200 µm in maximum diameter.

The subaqueous samples can be easily distinguished from the eolian samples at comparable distances. It is important to emphasize that loose micas remain in subaqueously transported sand, even after distant transport.

ACKNOWLEDGEMENTS

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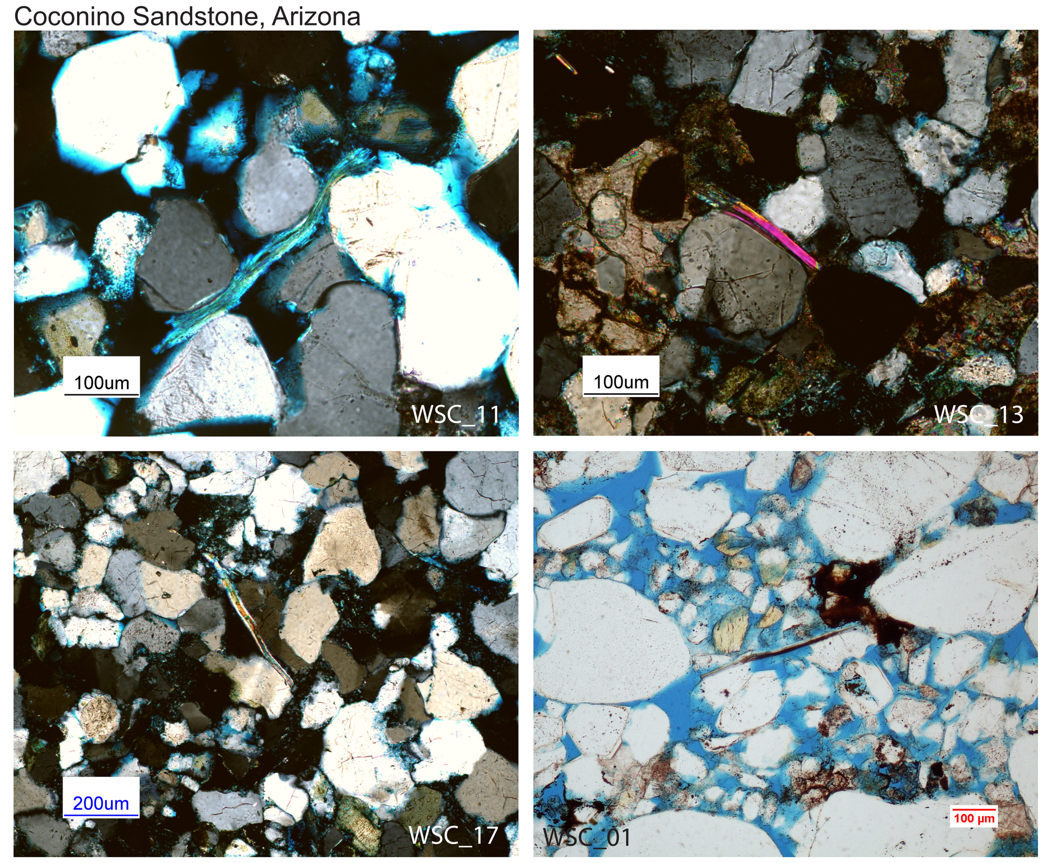
DISCUSSION

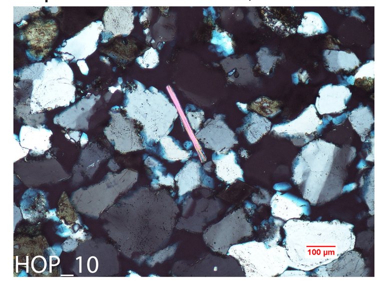
Gehrels et al. (2011) showed that the zircons found in Permian rocks of Grand Canyon have U-Pb signatures which closely match those of the Appalachians. They concluded that these zircons are consistent with being transported from the Appalachian orogen, and by implication this would include at least some of the other grains. They suggest the necessary transport in excess of 3000 km could be accomplished by "large rivers bringing detritus across the continent and northeasterly trade winds, reworking this material into widespread eolian units (e.g., Coconino Sandstone)."

However, our results demonstrate that micas (such as those shown below) could not reasonably have been transported more than 500 km by eolian processes. Even this estimate is quite generous, considering that our initial sand contained remarkably large micas, some greater than 4000 microns in diameter. Given that the Coconino sand sheet and Coconino equivalents stretch several hundred to thousands of kilometers wide and several thousand kilometers across, it seems that an eolian deposit of this magnitude should contain virtually no micas at all. Below, we demonstrate that this is not the case in the Coconino, and in several other classic eolian sandstones. It is important to note that the micas seen here are situated among the grains, rather than within individual grains.

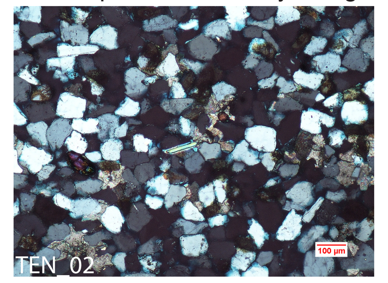
Coconino Sandstone, Arizona



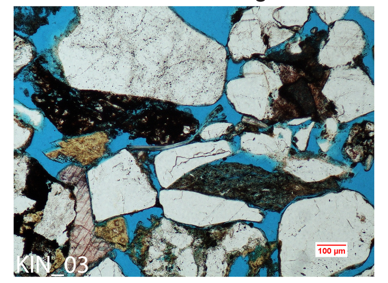
Hopeman Sandstone, Scotland



Tensleep Sandstone, Wyoming



Kinver Sandstone, England



Significance of these findings

Our experiments in eolian settings show micas become quickly reduced both in size and abundance with short transport distance. Our experiments in subaqueous settings show micas can remain large and abundant over long transport distances. Therefore, sandstones that contain significant amounts of mica are likely to have been transported in subaqueous environments based on this study.

REFERENCES

Gehrels, G. E., R. Blakey, K. E. Karlstrom, J. M. Timmons, B. Dickinson, and M. Pecha. 2011. Detrital zircon U-Pb geochronology of Paleozoic strata in the Grand Canyon, Arizona. Lithosphere vol.3:no.3:183-200.