geoconvention
Calgary • Canada • May 12-14 2025

Geology's Grip on Baseball: A Geological Characterization of Baseball Rubbing Mud

Dallin P. Laycock[1], Paul M. Bremner[2], Emily Vanderstaal[3], Cory Twemlow[3], Sean Fletcher[4], Richard Mackenzie[5], Erin Pemberton[1] , Han Byul Woo[2]

ConocoPhillips[1], NASA Marshall Space Flight Center[2], AGAT Laboratories[3], Strathcona Resources[4], BOEM[5]

Introduction

Major League Baseball (MLB) prepares 156 baseballs for each game by rubbing each ball with a specific mud, sourced from a single company. Lena Blackburne Baseball Rubbing Mud has been the sole supplier of this mud since the 1950's ("Our Story"), and is stated to be sourced from a tributary of the Delaware River ("Our Story"). The mud is intended to add grip to slippery new baseball leather, and the company describes the consistency as a "cross between chocolate pudding and whipped cold cream" ("Our Story").

Recent studies have attempted to characterize the aerodynamics of mud-rubbed baseballs, as well as to quantify the frictional forces between fingers and baseballs (Kinoshita et al. 2017, Smith. 2019, and Yamaguchi et al. 2022), but do not adequately address the detailed texture, composition or impact of this specific rubbing mud. Another study by Pradeep et al. (2024) studies the rheology of the rubbing mud, but does not adequately characterize the sedimentological characteristics of the mud itself or fully assess the changes to the surface of the baseballs. Presented here is a multi-scale geological characterization of the Lena Blackburne Baseball Rubbing Mud, and its impact to the surface of a baseball.

Methods and Results

Three baseballs of legal MLB size and material were leveraged for this study including: 1) An official game-used MLB baseball (used April 7, 2024); 2) A new MLB baseball applied with Lena Blackburne Baseball Rubbing Mud, following MLB mud application procedures (REF for this?); and 3) A new MLB baseball used as a control sample. Laboratory analysis was performed at AGAT Labs in Calgary, and included X-Ray Diffraction (XRD), Particle Size Distribution (PSD), and Scanning Electron Microscopy (SEM) of the mud itself, and SEM on all three baseballs.

XRD of the mud showed that the largest portion of the mud is comprised of clay minerals, making up 53% of the sample by weight percentage. This clay fraction includes mostly low-swelling clays such as chlorite, kaolinite, and illite/mica. The next most common mineral was quartz, approximately 42% by weight. Minor amounts of feldspar and hornblende were also found to be present.

SEM analysis of the baseballs showed that the mud has a multi-faceted effect on the surface of the baseball. The surficial leather of the baseball contains pores, which routinely become partially or completely filled with mud. The pore-filling material is generally clay, with feldspars also commonly observed. Quartz grains were rarely observed within the pores. The game-used

baseball also commonly displayed salt crystals growing on the outside of the pore-filing mud. Outside of the pores, the leather appears to become lightly scoured by the rubbing mud, displaying erosion, micro-cracks, flaking, and occasional scratches. SEM analysis of the mud itself also showed that there are abundant diatoms present throughout the mud, which are composed of silica.

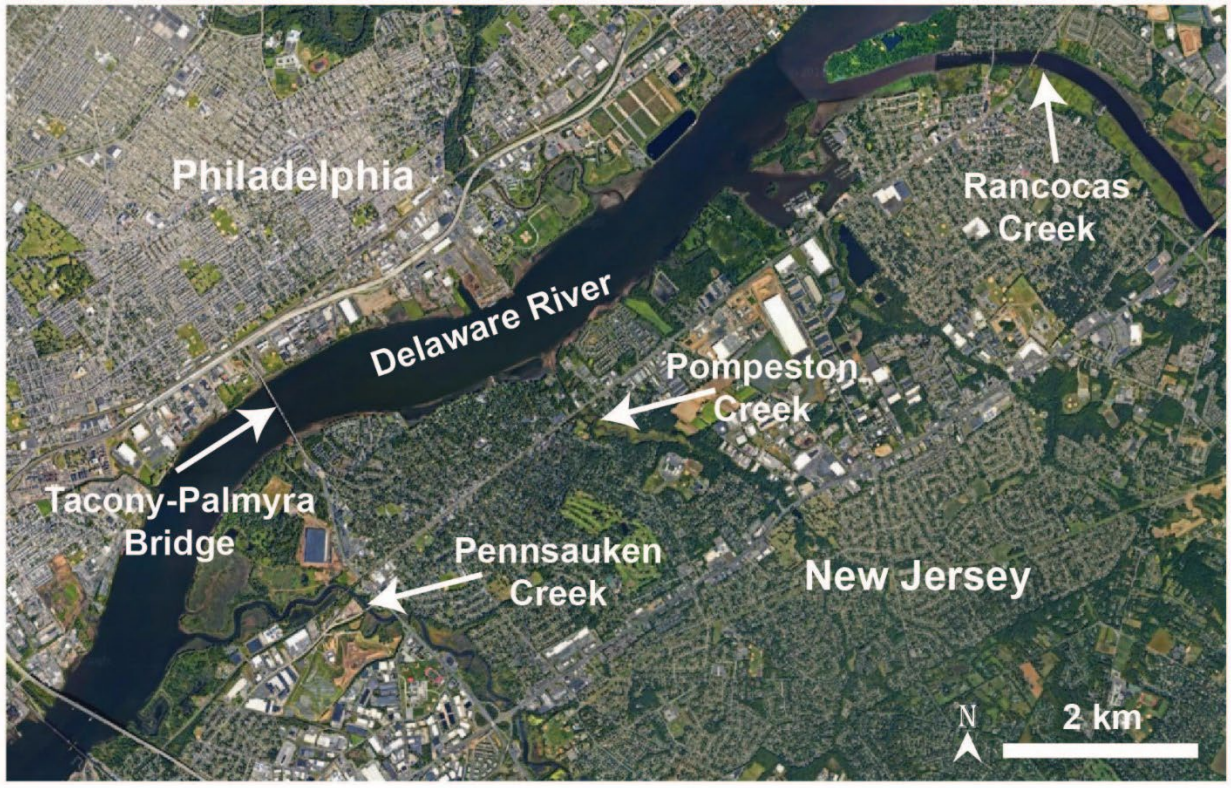

Figure 1: Map showing the area from which the mud sample was likely sourced.

Discussion

These data yield interesting information about the impact of the traditional rubbing mud on the surface of a baseball, as well as the distinctiveness of the mud itself. The mineralogical assemblage of the mud is a product of its depositional environment and the geology in the catchment area of the Delaware River basin. The exact location of mud collection is not disclosed by the company, but has been described as being located on a tributary of the Delaware River in Burlington County NJ, near the Tacony Palmyra Bridge ("Baseball's Dirty Little Secret") (see Figure 1). This location is within a low-sinuosity portion of the Delaware Bay estuary, with a tidal range of ~1.5 to 2 m ("Station ID: 8545240"). The composition of the mud collected from the banks of this river will be a product of mineralogy within the Delaware River watershed, as well as reflecting the salinity of the brackish water within the estuary. Higher flow rates would winnow

finer grains and deposit sandier sediment. As such, if the mud collection location were changed, it could change the relative abundance of mud and sand, and affect the performance of the final product.

The rubbing mud itself appears to have modified new MLB baseballs in several important ways, including: 1) Light scouring to remove the glossy surface on the leather of a new baseball. 2) Deposition of sediment within the pores of the baseball leather, with lesser accumulation of sediment on the unpored portion of the leather surface and the laces. 3) Development of salt crystals on top of pore-plugging clays.

Evidence of leather scouring by the mud includes scratches, micro-cracks, and flaking (Figure 2). The rougher surface texture suggests that the glossy surface of a new ball could be removed by the rubbing of mud on the ball, which may likely have an impact on the grip of the ball. The pore plugging clays would likely not have a significant impact on the grip of a ball, and might actually provide an overall decrease in surface topography as pores are filled. Feldspar grains were observed on the outer surface of the ball, which could increase grip of the ball. The precipitation of salt crystals on pore-filling clays could be remnants of the brackish water from which the mud was harvested, or possibly from human sweat, which could also serve to potentially increase the grip of the ball.

Of note was the lack of both the siliceous diatoms and quartz grains noted both on the surface of the ball and within the pore-filling material, even though being present in the mud. It is hypothesized that these serve as abrasion materials, but do not stick to the surface of the ball, as the platy clays and feldspar grains would be more prone to adhering to the ball. As such, the efficacy of this particular mud appears to be in its' relative mix of materials, and not the product of a single mineral. Likely, it is gritty enough to lightly scour the ball without overly damaging the leather, yet containing enough clay to adhere to the ball without being too sticky or overly darkening the balls.

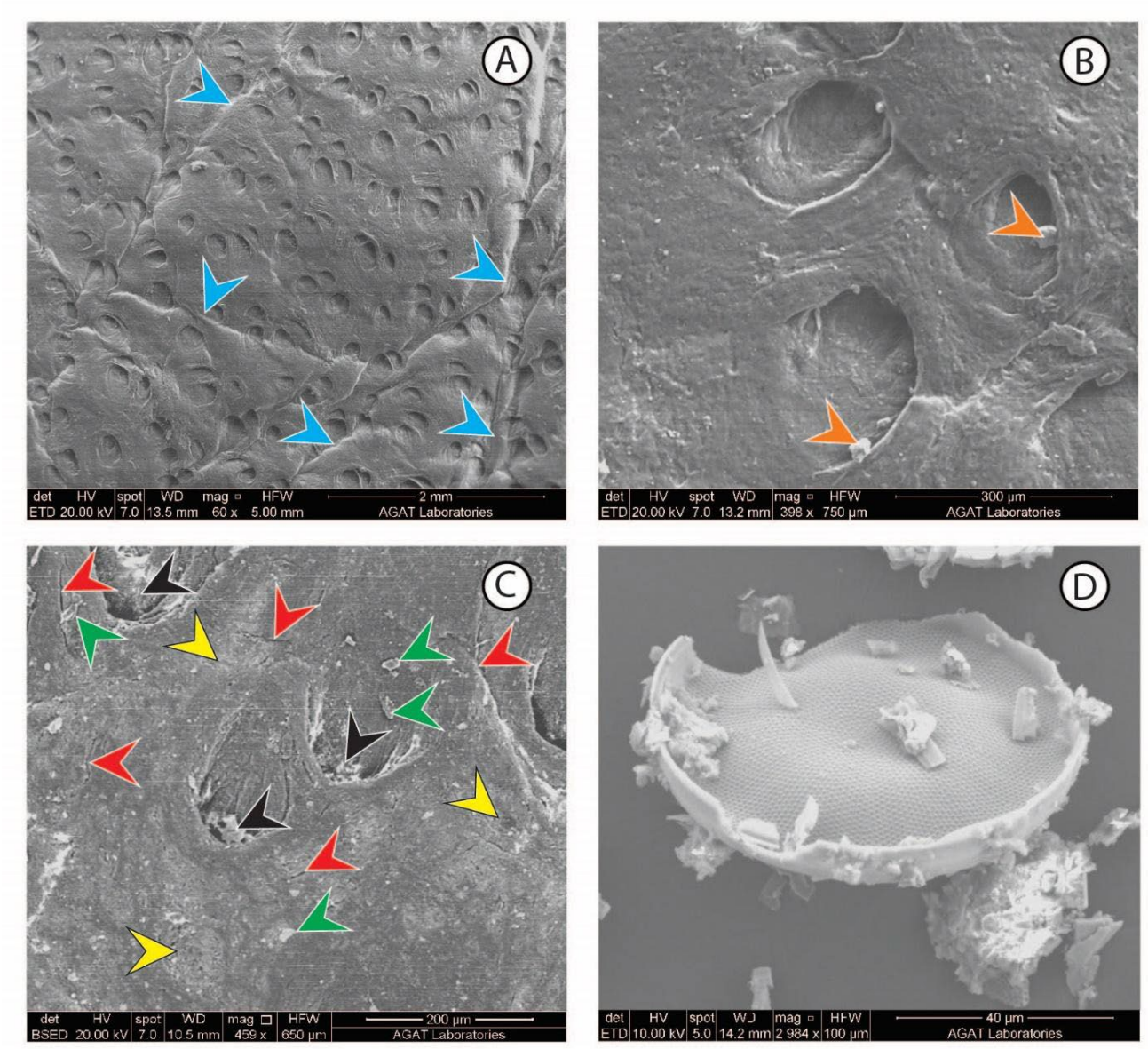

Figure 2: A) SEM image of the surface of a new baseball with no rubbing mud applied, and pores clearly visible. Blue arrows show folds in the leather from removing the leather from the ball. B) Closer view of clean baseball. Pink arrows show small mineral particles of various compositions. C) The surface of a new baseball after applying the rubbing mud. Red arrows indicate micro cracks. Yellow arrows indicate areas of visible erosion. Black arrows show pore-filling clays. Green arrows indicate feldspar grains adhering to the surface of the leather. D) Diatom particle from the rubbing mud.

Conclusion

The application of Lena Blackburne Baseball Rubbing Mud to MLB baseballs is a unique tradition in sports. But beyond the sentimental value of traditions, there is scientific merit to this mud being the rubbing mud of choice. Its unique blend of clays, quartz grains, diatoms, and other minerals serves as a balanced blend of exfoliating elements and sticky clay minerals that serves to provide consistent results. The relative abundance of these minerals, presence of diatoms, and salinity of the interstitial water is a product of the depositional environment and geologic setting in Burlington County NJ. As such, geology will continue to play a significant role in baseball history, transforming a simple natural resource into a simple tool that enhances performance and preserves tradition.

Acknowledgements

Thank you to the entire Geology in Motion research group, ConocoPhillips Canada, Mashrur Zaman, Graham Spray, AGAT Laboratories, and Ethan Penner.

References

Baseball's Dirty Little Secret. https://www.youtube.com/watch?v=flrWvnhPmng

Kinoshita, Hiroshi, et al. "Finger forces in fastball baseball pitching." *Human movement science* 54 (2017): 172-181.

"Our Story" From Lena Blackburne Baseball Rubbing Mud. https://baseballrubbingmud.com/index.html

Pradeep, Shravan, et al. "Soft matter mechanics of baseball's Rubbing Mud." *Proceedings of the National Academy of Sciences* 121.47 (2024): e2413514121.

Smith, Andrew. 2019. Baseball Rubbing Mud and its Effect on Roughness: Post #25. https://baseballaero.com/2019/07/10/baseball-rubbing-mud-and-its-effect-on-roughness-post-25/

Station ID: 8545240. Philadelphia PA Tidal Information. https://tidesandcurrents.noaa.gov/

Yamaguchi, Takeshi, Daiki Nasu, and Kei Masani. "Effect of grip-enhancing agents on sliding friction between a fingertip and a baseball." *Communications Materials* 3.1 (2022): 92.