Rocky Mountain storms lead to new findings about hailstones

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Rocky Mountains. Credit: Public Domain

Hailstones from three Rocky Mountain storms formed around biological material, then bounced around the clouds picking up layers of ice, according to a new Montana State University study.

The discovery of a biological embryo extends previous findings about

the formation of snow and rain, applies to hailstones globally and provides basic information about a little-studied topic, said the researchers who published their findings Nov. 6 in the *Journal of Geophysical Research: Atmospheres*.

"This is the first paper to really show that biological material makes hailstones," said John Priscu, a renowned polar scientist and professor in MSU's Department of Land Resources and Environmental Sciences. "Despite the millions in dollars of damage the storm caused in Bozeman (Mont.), the damaging hailstones provided us with a better understanding of hailstone formation, which will help us understand the role of aerosol particles in the formation of precipitation."

Alex Michaud - MSU doctoral student and first author of the paper—normally studies Antarctic microorganisms with Priscu, but he took on a side project after hailstones pummeled Bozeman, Mont., on June 30, 2010.

"If it weren't for his inquisitive nature of how things work, no good would have come from the devastating storm," Priscu said.

Once the storm subsided, Michaud collected hailstones and stored them in an MSU freezer at minus 22 degrees Fahrenheit. The hailstones averaged 1.5 inches in diameter. Then Michaud gathered hailstones from two more area storms that occurred in 2010 and 2011. Those averaged about half an inch in diameter.

Examining some 200 hailstones in MSU's Subzero Science and Engineering Research Facility showed that the hailstones formed around a biological embryo, Michaud said. Analyzing stable isotopes of water in an Ohio State University laboratory showed that most of the hailstone embryos froze at relatively warm temperatures, generally above 6.8 degrees Fahrenheit, which corroborates freezing temperatures of

biological embryos recovered from the middle of hailstones.

Two different research methods showed that a warm temperature of ice nucleation indicates biological material is the likely nuclei, Michaud said. He added that hailstones grow in such a way that makes them a nice model system for studying atmospheric ice nucleation and cloud processes.

Among those providing direction and advice to Michaud were Priscu and David Sands, both co-authors on the published paper and internationally known researchers.

Priscu was chief scientist and one of three directors of a historic U.S. expedition that drilled through half a mile of Antarctic ice and found microorganisms living in a subglacial lake in January 2013. Michaud was part of the Whillans Ice Stream Subglacial Access Research Drilling project (WISSARD) and is about to head to Antarctica for its next phase.

Sands, a professor in MSU's Department of Plant Sciences and Plant Pathology, conducted and published previous research that gained widespread attention for showing that active airborne bacteria were involved in the formation of rain and snow over several continents. Michaud's hailstone study builds upon his work.

Co-author John Dore, associate research professor in MSU's Department of Land Resources and Environmental Sciences, conducted low-level phosphate analyses to validate hailstone decontamination procedures. The presence of phosphates indicates contamination that originated on the ground. Dore also analyzed stable isotope data and developed temperature calibrations for the hailstone layer formation, and participated in many discussions about hail and how the research pieces fit together.

Co-authors outside of MSU were Deborah Leslie and W. Berry Lyons in the School of Earth Sciences and Byrd Polar Research Center at The Ohio State University. Lyons is a long-time collaborator of Priscu's, and Leslie received her Ph.D. in Lyons' lab. She analyzed stable isotopes from the melted hailstone embryos to estimate the temperatures that the hailstone embryos froze in the clouds.

In addition to his co-authors, Michaud said former MSU postdoctoral researcher Brent Christner and MSU affiliate Cindy Morris provided important assistance by helping him develop ideas and discuss data. Christner is also part of the WISSARD project. Morris collaborated with Sands on previous research about the formation of rain and snow.

Michaud also consulted with fellow hailstone researcher Tina Santl Temkiv, a postdoctoral researcher at Aarhus University in Denmark. She is in the university's Department of Bioscience where Michaud was last spring through the National Science Foundation's Integrative Graduate Education and Research Traineeship (IGERT) program.

"It was very coincidental that she published two hailstone microbiology papers two years before me and we ended up at the same university for a few months. Plus, we are the only ones to work on hailstone microbiology since a 1973 paper in Nature," Michaud said, noting that the two jokingly established the first hailstone microbiology research center at Aarhus.

More information: Alexander B. Michaud et al: Biological ice nucleation initializes hailstone formation. *Journal of Geophysical Research*: Atmospheres 2014; DOI: 10.1002/2014JD022004

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