Quartz crystals in the stomach of fossil bird complicates the mystery of its diet

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A reconstruction of the bohaiornithid Sulcavis, a close relative of Bohaiornis guoi, hunting an insect. Credit: © S. Abramowicz, Dinosaur Institute, Natural History Museum of Los Angeles County.

It's hard to know what prehistoric animals' lives were like—even answering seemingly simple questions, like what they ate, can be a

challenge. Sometimes, paleontologists get lucky, and pristine fossils will preserve an animal's stomach contents or provide other clues. In a new study in *Frontiers in Earth Science*, researchers investigating the fossil of a bird that lived alongside the dinosaurs got more questions than answers when they found quartz crystals in the bird's stomach.

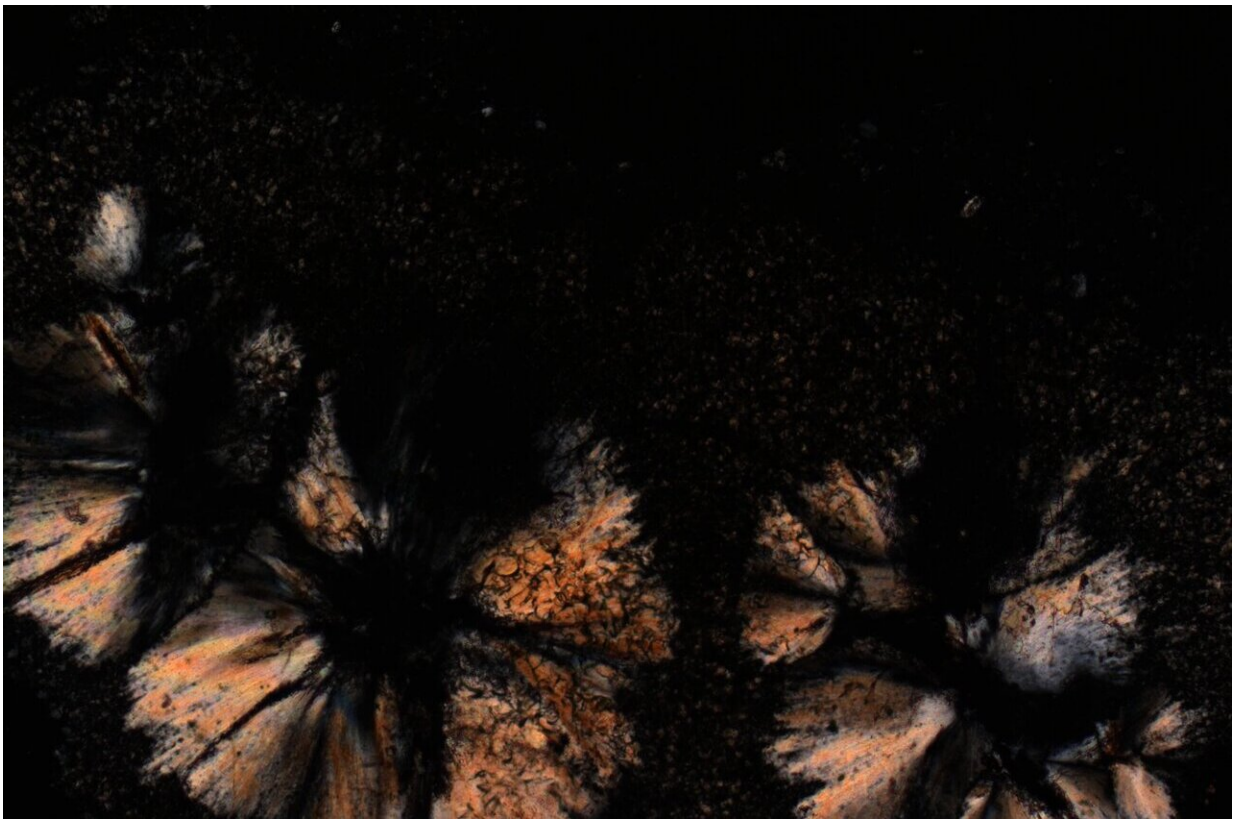
"I would say it's some kind of bizarre form of soft tissue preservation that we've never seen before," says Jingmai O'Connor, the associate curator of fossil reptiles at Chicago's Field Museum. "Figuring out what's in this bird's stomach can help us understand what it ate and what role it played in its ecosystem."

"This paper tells us that the Enantiornithes, one important clade of fossil birds, still have no direct stomach traces or evidence," says Shumin Liu, a student at the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, and the paper's first author. "I was excited, it is a breakthrough about them."

The fossil bird the researchers focused on is a specimen of *Bohaiornis guoi*. "They're part of an early lineage of birds from the Cretaceous, about 120 million years ago," says O'Connor, who worked on the paper while at IVPP, where Liu was her Master's student. "They still retain teeth and claws on their hands, but they're small, about the size of a pigeon, so they're not particularly terrifying." Bohaiornis was part of a group called the enantiornithines that were once the world's most common birds; thousands of enantiornithine specimens have been found in northeastern China's Jehol Group deposits.

Despite the vast number of finely preserved enantiornithines, none have been preserved with traces of food in their stomachs that could tell researchers what these birds ate. "We can identify the diet and reconstruct the digestive system for all these other groups of birds found in the deposits that record the Jehol Biota, except the enantiornithines,

even though you have more enantiornithines than any other group," says O'Connor. "For these guys, we have no specimens or preserved evidence of diet, which is really weird." In the specimen O'Connor and her colleagues examined in this new paper, though, there was a clue: a previous study pointed out the presence of small rocks in its stomach.



X-ray image of crystals in the stomach of Bohaiornis guoi. Credit: © Liu et al, IVPP.

Many living birds have an organ called a gizzard—a thick, muscular part of the stomach helps them digest food. They swallow small rocks, called gizzard stones, and these rocks make their way to the gizzard, where they help to crush up tough food. These gizzard stones, called gastroliths,

have been found in some dinosaur and bird fossils, providing clues about what those animals ate—they've been associated with diets of tough plant materials and seeds.

But rocks in an animal's stomach aren't necessarily a sign that it's using them to crush up food. Some modern birds of prey swallow rocks called rangle to help dislodge matter from their digestive tract to clean it out. And sometimes, rocks have been found near the stomach cavities of dinosaur fossils that the creature swallowed accidentally, or the stones were just coincidentally near the fossil. "You have to make a differentiation between just a gastrolith and a gastrolith that's used as a gizzard stone," says O'Connor.

While there's no clear evidence of gastroliths in the enantiornithine birds, a paper published in 2015 posited that a specimen of *Bohaiornis guoi* contained rocks in its stomach used as rangle (gastroliths ingested by raptorial birds to clean the stomach, but not to digest food). O'Connor was skeptical; the photos of the rocks didn't look right. Gastroliths are usually made of different kinds of rock and are slightly different colors and shapes; these rocks were all similar in composition to each other and to the fossilized bone itself. They also didn't seem to be shaped or grouped quite right—they were too round and too scattered. "I didn't know what they were, but I was like, they're not gastroliths," she says. So, she and her colleagues set out to figure out what these rocks were and compare them with gastroliths from other fossil birds and dinosaurs.

The researchers extracted a sample of the rocks in Bohaiornis's stomach and examined them under a scanning electron microscope. They then exposed the rocks to X-rays to determine which wavelengths the rocks absorbed. Since each mineral absorbs different wavelengths, this helped the researchers narrow down what these rocks were made of.

"We found that those pieces of rock that had been called gastroliths were

chalcedony crystals," says O'Connor. "Chalcedony is basically quartz crystals that grow in sedimentary rocks. There hasn't been any evidence of this in the Jehol but there's plenty of evidence of it within the fossil record where chalcedony crystals will form within a clamshell, or sometimes chalcedony will replace the minerals making up the bones in a fossil." What's more, the chalcedony was all interconnected in one thin sheet of crystal, rather than separate rocks that the bird had swallowed.

The fossil specimen of Bohaiornis with crystals in its stomach. Credit: © Liu et al, IVPP.

The amount of chalcedony present was wrong, too, if it were used to help with digestion. Scientific literature suggests that the rocks that birds

consume as rangle account for about 3% of their body mass; since Bohaiornis was likely about 300 grams, the team would be looking for up to 9 grams worth of rangle. O'Connor says, "We weren't able to extract the entire sample and figure out how much it weighed, but Shumin was really clever, and she took a piece of chalcedony that weighed 3 grams, and it was huge" —way bigger than the combined size of the bits of chalcedony in Bohaiornis's stomach.

The combined evidence suggests that Bohaiornis didn't have gastroliths for helping crush food or rangle to help clean out its stomach after all. Or, at least, this specimen of Bohaiornis doesn't contain those gastroliths.

"We just have this absence of evidence, and paleontologists always say absence of evidence is not evidence of absence. But I always counter with, whoever came up with that adage never imagined having thousands of specimens that are complete and articulated, some preserving soft tissue," says O'Connor. If Early Cretaceous enantiornithines did employ gastroliths, it's awfully strange that none of the thousands of fossils show them.

O'Connor notes that while none of the enantiornithine birds from the Jehol Formation show evidence of stomach contents, there's one from Spain with bits of freshwater shellfish in its stomach. But the mystery of what Bohaiornis ate, and why none of the Jehol enantiornithines have anything in their stomachs, remains.

"This study is important because this fossil is the one and only fossil record of Enantiornithes containing possible gastroliths, even possible real stomach traces in the Jehol. What's more, only this clade of fossil birds don't have stomach traces so far, whereas most other clades have these traces," says Liu.

"We're always trying to find some evidence, and the specimens that have

been suggested to fill this gap just unfortunately don't do it," says O'Connor. "It's just part of the paleo game, part of science—constantly correcting. I'm happy when we don't understand things, because it means there's research to do, it's exciting."

Provided by Field Museum