Abstractions

LAST AUTHOR

Batteries have come a long way since their invention more than 200 years ago, but they still have limitations. On the plus side, they tend to have a high energy density — that is, they last a long time. However, they also have a low power rate, making them slow to both charge and discharge. This means that they cannot deliver bursts of power, such as those needed for rapid acceleration of a car. Gerbrand Ceder, a materials scientist at the Massachusetts Institute of Technology in Cambridge, and his graduate student Byoungwoo Kang wanted to see whether they could create high-energy-density lithium batteries that also have a high power rate. Rapid charging and discharging was thought to be possible only using a device called a supercapacitor, but these have lower energy densities, and are costly and large, typically 50 to 100 times the size of a battery. Through theoretical modelling, the two calculated that they could get high power from a battery (see page 190). Ceder tells *Nature* how they tested their theory.

How did you get from theory to reality?
When you charge or discharge a lithium battery, you're moving lithium ions back and forth between two electrodes inside it. According to our model, using a common lithium ion as the charge carrier was very fast. But in our experiment, the lithium's movement was really slow. So it was being limited by something. We found that the surface reaction by which the lithium transfers from the electrolyte — an electrically conductive medium that the ions flow through — into the active material that stores the charge was the slow part. So we needed to increase the rate at which the lithium could move across the electrolyte's surface.

How did you accomplish that?
We changed the composition of a common electrode, lithium iron phosphate. Our calculations indicated that we needed a different ratio of iron, phosphorus and oxygen, and that the mix needed to be heated.

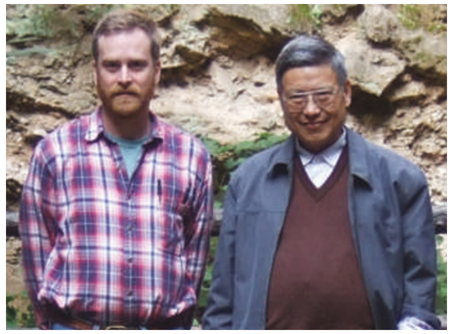
What was the result of these changes?
We ended up with a glassy top layer of lithium pyrophoshate that allowed the lithium ions to move around ultrafast. I didn't believe the results when I first saw them. I don't think I've ever seen anything do that, and I've been working with batteries for 14 years.

What does this mean for commercial batteries?
Hybrid cars could have smaller, lighter engines because their smaller batteries could deliver more energy and accelerating power. Less weight in the car would also mean better fuel economy. ■

MAKING THE PAPER

Guanjun Shen & Darryl Granger

Isotopes in quartz reveal the age of China's Peking Man.



Darryl Granger, left, and Guanjun Shen.

The excavation of numerous 'Peking Man' fossils in the 1920s and 30s at Zhoukoudian, the site of a collapsed cave near Bejing, laid to rest disputes about whether previously discovered *Homo erectus* fossils were primitive humans or deformed apes. But the question of Peking Man's precise age has remained a puzzle.

Efforts to date the fossils have been hindered by a lack of suitable methods, but Guanjun Shen of Nanjing Normal University in China and his colleagues have found a solution to the problem. In collaboration with Darryl Granger at Purdue University in West Lafayette, Indiana, they have determined that *H. erectus* lived in northern China as far back as 770,000 years ago — much earlier than had previously been assumed.

The Zhoukoudian site comprises 17 distinct sedimentary rock layers that have been deposited over time. The age of the top — and so most recent — 11 layers, in which hominin fossils and tools have been found, provides an estimate of the time period in which *H. erectus* lived. The most reliable methods for dating rocks rely on the decay of radioactive isotopes such as uranium. But, Shen explains, uranium-series dating is limited to the past 600,000 years or so, which means it can be applied only to layers one to five. "We therefore looked for ways to extend that limit," says Shen, who has been analysing Zhoukoudian rock samples since 1989.

The solution came in the form of a new isotopic dating method, published by Granger and co-workers, that measures the ratio of aluminium-26 and beryllium-10 isotopes. "The idea," says Granger, "is that while rocks are at Earth's surface, they are exposed to cosmic rays and obtain a particular inventory of isotopes. When new sediment collects on top, the original rocks are buried and that inventory decays over time." Determining a rock's isotopic content thus reveals the time at which it was buried.

In 2003, Shen approached Granger to see whether the burial dating method could be used to determine the age of quartz-containing rocks and tools at Zhoukoudian. The first batch of samples yielded no useful data. Further study revealed that the original samples contained a mix of pure white quartz and smoky quartz. The smoky quartz is high in the stable isotope aluminium-27, and the researchers realized that this had masked the small amount of aluminium-26 present.

Shen came up with a painstaking solution — his group literally hand-picked the grains of quartz that appeared purest. "It took about eight hours to select just a few grams, and we needed 40 to 60 grams for analysis," says Shen. "We had to mobilize all of the students at the lab here in Nanjing."

In the end, their analyses revealed that *H. erectus* lived in northern China during a mild glacial period (see page 198). "Hominins living in glacial conditions would have been adapted to the cold, either biologically or culturally," says Granger. "Would they have used fire? The evidence for that is shaky." What is clear, however, is that burial dating is an effective method for determining the age of older rocks and artefacts. Shen and Granger have already started work on sites in the Nihewan basin in northern China, home to the oldest known assemblage of hominin tools in East Asia. ■

See also News & Views, page 153.

FROM THE BLOGOSPHERE

Climate scientists may soon be taking their work home and checking out their neighbours' lab notebooks. "Uncle Sam wants your observations of flowering and fruiting American plants," notes Anna Barnett on the Climate Feedback blog (http://tinyurl.com/bfcq3v). The USA National Phenology Network tracks the seasonal cycles of plants and animals, and monitors what effect climate change is having on them, and they need help from 'citizen scientists'.

The consortium of universities, non-profit organizations and government agencies will eventually be seeking help from the public with tracking animal migration data as well as gathering historical phenological records. (For more details, see http://www.usanpn.org/.)

Barnett, assistant editor at Nature Reports: Climate Change, notes that "if they round up enough recruits, they may get striking results" — such as those of a recent Audubon Society study. This used four decades of amateur bird-watching survey data to show that more than half of North American bird species have already started to move northwards to cooler climes. ■

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