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World's largest hoard of carbon dates goes global

Scientists hope pooled records could answer major archaeological questions and map human migration patterns.

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The world's largest radiocarbon database includes information from archaeological sites near Fort Macleod, Canada.

Radiocarbon dating has long been used to reveal the age of organic materials — from ancient bones to wooden artefacts. Scientists are now using the amassed dates for wider applications, such as spotting patterns in human migration. And a Canadian database is poised to help researchers around the world to organize this trove of archaeological and palaeontological data, and to address problems that have plagued carbon dating for years.

Set up in the 1980s, the Canadian Archaeological Radiocarbon Database (CARD) is undergoing an expansion that began in 2014. The database currently holds 70,000 radiocarbon records from 70 countries. The latest effort aims to make the software behind the site open source, making it easier for other research groups to set up their own version of CARD while still contributing core information to the main database. The first such site should come online within the year.

There are other radiocarbon databases out there, but CARD is by far the largest, says Robert Kelly at the University of Wyoming in Laramie, who is collecting data to contribute to CARD. It's also the only one so far with global ambitions, he says. "This is big data. That's where the action is," says Kelly. "We've spent 60 years running radiocarbon dates, and you can do a lot with them if they're all in one place."

Preparing for the future

Radiocarbon dating uses the ratio of stable carbon atoms to a radioactive isotope called carbon-14 in the material to determine the age of a once-living specimen. Researchers need to consider a host of factors during their analyses, including the type of material tested and variations in the rate at which the organic matter incorporated different carbon isotopes, in order to produce an accurate age.

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In the past, this information wasn't often published alongside carbon dates, says Thomas Stafford, a radiocarbon-dating consultant in Lafayette, Colorado. A global database would ensure that this kind of information accompanies every data point, so that if dates have to be recalculated in the future, they can be, he says.

A centralized database would also make it easier to find previously published radiocarbon data. "I've been working in my area for 20 years, and just last month I found a data set I didn't know existed," says Andrew Martindale, an anthropological archaeologist at the University of British Columbia in Vancouver and director of CARD.

But the most compelling reason for a single large data set, says Kelly, is that it enables data mining. Given enough properly dated archaeological finds, some experts argue that they can start to make careful population estimates and trace how human populations moved over space and time. It's a new and controversial idea, however.

Others argue that such data sets can be biased by archaeologists' interests in particular areas or time periods: an abundance of radiocarbon dates in a given spot or time might reflect a researcher's focus rather than real demographic change. But the CARD database is getting large enough to iron out such factors, says Kelly.

In 2015, Martindale and his colleagues used CARD to make the first continent-wide map of human occupation of the Americas over the past 13,000 years[1]. Martindale plans to mine the data to confirm and quantify North American population changes due to wars or settlement relocations that are currently known only through indigenous traditional storytelling.

Database clones

Expanding CARD has its difficulties, however, says Martindale. Some information, such as precise site locations, must be kept secret in some countries to avoid looting. And metadata, including the context of an archaeological find or the exact testing methodology, are hard to standardize.

"There is a lot in a date. It's not just a number," says Tom Higham, deputy director of the Oxford Radiocarbon Accelerator Unit in the United Kingdom. He worries that squeezing all this information into a single database, and wrangling permissions from the people who own the data, may make the mission "worthy but fruitless".

Funding is also an issue. "Everyone agrees we should have a global archive, but granting agencies are always looking for specific research questions," Martindale says. To sidestep the problem, he will make the CARD software open source, so that other groups can create clones of the site tailored to their needs. The core data can then be sucked into the CARD database. "That decentralizes the funding," says Martindale.

The University of Ottawa's high-precision isotope lab, the A. E. Lalonde Accelerator Mass Spectrometry Laboratory (AMS), is now working with Martindale to organize their own data using the first such clone. They hope to have something up and running within the next year, says Carley Crann, a lab technician at AMS who is heading the effort.

“The data belong to the people who paid for it,” says Martindale. “But if we make it easy for them, just a button they can push that says ‘yes, upload my data to CARD’, then we think they will.”

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References

1. Chaput, M. A. *et al*. *Proc. Natl Acad. Sci USA* **112**, 12127–12132 (2015).
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