ARCHAEOLOGY

An oasis in time

Today's Sahara is arid and inhospitable, but this was not always the case. In the early Holocene (between about 10,000 and 4,500 years ago), monsoon rains created a lush savannah rich in animal and plant life. Complex human societies settled there beside ancient lakes, as demonstrated by a recently reported archaeological site documenting nearly 5,000 years of human occupation (P. C. Sereno *et al. PLoS ONE* **3,** e2995; 2008).

The site, named Gobero and situated in central Niger, contains about 200 burial sites, which, along with several rubbish dumps, provide a record of two distinct periods of human settlement. It was originally occupied 9,500 years ago by a tall, well-muscled people who fished the lake for Nile perch and large catfish with the use of bone harpoons and hooks. These people abandoned the site a little over 8,000 years ago when an extended arid period dried up the lake.

Gobero was recolonized 1,000 years later by a slighter and shorter people who ate clams and small catfish from the now much shallower lake, as well as antelope and other vertebrates from the surrounding savannah. This population had sophisticated burial practices involving jewellery and grave goods, and what appear to be ritual poses. One grave, dated to be about 5,300 years old, contained a woman and two children buried together with clasped hands (pictured). Pollen found in this grave suggests that they were buried on a bed of wool flowers (*Celosia*).

Occupation of the Gobero site came to an end around 4,500 years ago, when changing climate returned this region to the arid desert conditions that persist to this day.

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method of identifying metabolically active cells, the data suggest that consistent application of FISH remains a challenge. To achieve a similar goal of studying only 'living' cells, direct extraction of rRNA followed by reverse transcription to DNA has been successful[13], but attempts to make this approach quantitative face major hurdles.

Theoretically, there are fewer challenges when examining DNA or lipids. Quantitative amplification of extracted DNA by using the polymerase chain reaction (qPCR) allows rRNA genes to be counted, rather than seeking ribosomes directly. Even after accounting for the variable copies per cell of these genes in Bacteria and Archaea, early results from qPCR invariably declared the winner to be Bacteria[11,15]. How, then, is it possible that Archaea could have been underestimated?

The key word is 'extracted' — Lipp *et al.*[1] resolve the qPCR dilemma, showing that a more aggressive approach to obtaining total DNA is essential. It is revealing to view their Supplementary Fig. 3: depending on the method used, as many as 80% or as 'few' as 15% of cells escape lysis, the latter under optimized conditions. The implication is that DNA from these escapees would be overlooked during qPCR, and most of them would be Archaea with their more durable cell envelopes.

Improved extraction brings estimates from qPCR in line with earlier claims of archaeal abundance as derived from IPLs[13]. Polar lipids are presumed to reflect living biomass, because their labile (often phosphate-containing) head groups are quickly lost after cell death. Lipp *et al.* also offer expanded IPL data covering seven different locations. Nearly 90% of IPLs below a depth of 1 metre are specific to Archaea, and the total abundance is proportional to the total organic carbon content of the sediment in which they are found. This suggests that archaeal production fundamentally scales to the available organic resources, whatever the type of metabolism involved.

In considering Archaea and Bacteria, it has been proposed that Archaea are united by a universal ecological ability to cope with energetic stress[16]. It is therefore reasonable that in a sub-seafloor world, where it has been estimated that cell turnover times could be centuries or longer[8,9], organisms with honed strategies to conserve energy would dominate.

Nevertheless, Lipp and colleagues' results will be controversial. Much of their argument rests on the interpretation that all IPLs represent living cells — that is, that the degradation time of IPLs after cell death is infinitely fast relative to other processes in the system. Although IPLs degrade rapidly in experiments, little is known about their persistence in complex communities with extraordinarily low rates of enzymatic activity. Specifically, it is the persistence of archaeal IPLs relative to bacterial IPLs that is of particular importance. This requires further study of the turnover of both Bacteria and Archaea in sediments, especially with regard to specific rates of synthesis, alteration and degradation of lipids. For microbes, the boundary between alive and dead is fuzzy, and the extent to which any category of biomolecule can define it remains unclear. Progress on all fronts of culture-independent and culture-dependent techniques will be necessary to tackle these uncertainties. ■

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1. Lipp, J. S., Morono, Y., Inagaki, F. & Hinrichs, K.-U. *Nature* **454,** 991–994 (2008).
2. Zobell, C. E. & Morita, R. Y. in *Galathea Report* Vol. 1, 139–154 (Danish Science, 1959).
3. Parkes, R. J. *et al. Nature* **371,** 410–413 (1994).
4. Parkes, R. J., Cragg, B. A. & Wellsbury, P. *Hydrogeol. J.* **8,** 11–28 (2000).
5. Froelich, P. N. *et al. Geochim. Cosmochim. Acta* **43,** 1075–1090 (1979).
6. Jørgensen, B. B. *Nature* **296,** 643–645 (1982).
7. Oremland, R. S., Culbertson, C. & Simoneit, B. R. T. in *Initial Reports of the Deep Sea Drilling Project* (eds Curray, J. R. *et al.*) 759–762 (US Government Printing Office, 1982).
8. D'Hondt, S., Rutherford, S. & Spivack, A. J. *Science* **295,** 2067–2070 (2002).
9. D'Hondt, S. *et al. Science* **306,** 2216–2221 (2004).
10. Mauclaire, L., Zepp, K., Meister, P. & McKenzie, J. *Geobiology* **2,** 217–223 (2004).
11. Schippers, A. *et al. Nature* **433,** 861–864 (2005).
12. Whitman, W. B., Coleman, D. C. & Wiebe, W. J. *Proc. Natl Acad. Sci. USA* **95,** 6578–6583 (1998).
13. Biddle, J. F. *et al. Proc. Natl Acad. Sci. USA* **103,** 3846–3851 (2006).
14. Jørgensen, B. B. & Boetius, A. *Nature Rev. Microbiol.* **5,** 770–781 (2007).
15. Inagaki, F. *et al. Proc. Natl Acad. Sci. USA* **103,** 2815–2820 (2006).
16. Valentine, D. L. *Nature Rev. Microbiol.* **5,** 316–323 (2007).

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