SUMMARY of SCIENTIFIC RESEARCH PROJECTS at YARRANGOBILLY CAVES, NEW SOUTH WALES

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Speleothems are excellent archives of paleoenvironmental information, often preserving tens of thousands of years of scientific record. Environmental monitoring of caves is an important process towards understanding this information and relating it to cave and climate processes. Monitoring typically involves chemical and physical characterization of drip water (e.g. pH, drip rate, temperature, chemistry, isotopes etc) and logging of the cave atmosphere including CO_2, to understand how the cave atmosphere interacts with the outside environment.

As part of long-term environmental monitoring at Yarrangobilly Caves, a team of scientists from the Australian Nuclear Science and Technology Organisation, University of New South Wales, University of Melbourne, University of Newcastle and the University of Birmingham are undertaking a number of collaborative projects to better understand the relationship between drip water chemistry and climate history as well as assessing the potential of relatively new methods of paleoenvironmental reconstruction, such as aerosols and organic biomarkers.

The majority of this monitoring is taking place in, and above, Harrie Wood Cave, and we are grateful for the support of the Department of Environment and Climate Change (DECC) NSW.

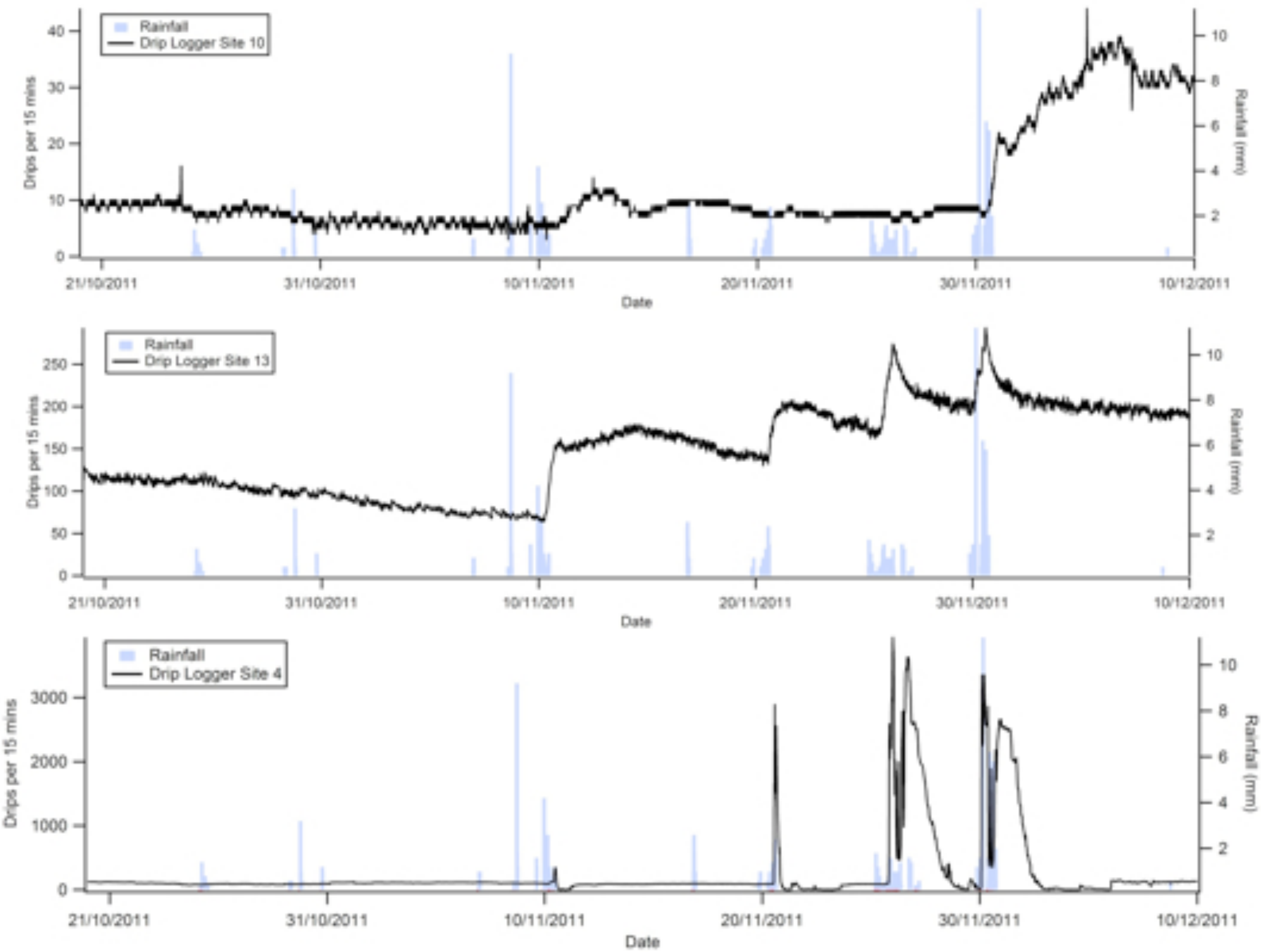

Figure 1. Hydrographs of three monitoring drip sites in Harrie Wood Cave. In order, Site 10exhibits an overflow response, Site 13 is responsive to most rain events and exhibits slow steady declines in drip rates post rainfall and Site 4 shows quick dramatic responses to rainfall events indicating fracture flow.

Research team photograph December 2011. From left: Monika Markowska, Adam Hartland, Andy Spate, Pauline Treble, Cath Jex, Regina Roach, Andy Baker

HYDROLOGY

Fortnightly collection of drip water is conducted to track seasonal variability in carbonate chemistry, oxygen isotopes, minor and trace elements. This information is being used to characterize the climatic information obtainable from drip water, as well as karst hydrological information. For example, by measuring oxygen isotopes in both rainfall events and drip water, we can assess how we may use oxygen isotopes in speleothems to reconstruct natural rainfall variability and air mass history.

The pathways of drip waters into caves can be quite complex. As a result, drip rate and temperature are being continuously logged at over 15 sites in Harrie Wood Cave. This will enable the temperature signal to be used as a tracer of rain events and to better understand the connectivity of surface water to cave water drips, including the potential mixing of different age waters. Drip rates are being recorded using stalagmite drip loggers, as featured in ACKMA Journal 81. Drip water temperature is being recorded using a novel application of a micro-T logging device originally designed for marine studies of fish.

Sampling for aerosol deposition.

Preliminary results have already shown that there is a number of different hydrological drip flow path regimes within the Harrie Wood cave. In fact, some drip sites that are less than a metre apart can show very distinctly different hydrological pathways. The figure below shows the responses of several drips in the cave to rainfall events. Site 10 shows little response to rainfall until a large event at the end of November tips a 'threshold' amount which triggers a steady rise in the drip rate. This could be representative of a water store above the drip which has filled and 'overflows' thus resulting in an increase in drip rate. In contrast site 13 shows a 'stepped' response to rainfall events, exhibiting small changes in drip rate after almost each rain event. After the initial response, drip rates stay higher and decline very slowly. This could indicate multiple drip sources. Lastly, site 4 shows a large rapid response to rainfall events which is short lived. This could represent a large fracture or fissure that is exploited in rainfall events and exhibits strong surface to groundwater connectivity.

SURFACE/SOIL MONITORING

Logging moisture, temperature and conductivity in the soils directly above Harrie Wood enables tracking of rainfall events into the soil and epikarst. Rainfall and other meteorological variables are monitored via a weather station.

BIOMARKERS AND THE SOIL CARBON CYCLE

Novel methods are being investigated to use lipid and lignin biomarkers to reconstruct records of past temperature and vegetation changes recorded in stalagmites. A branch of lipids called GDGTs, which are found in the cell membranes of naturally occurring bacteria and archae, are ubiquitous in the natural environment, but the relative distribution of different types of GDGTs has been shown to relate to air temperature. Lignin is a large organic molecule comprising the woody tissue of all plant material, and so can inform of vegetation types and water sources. As a relatively new area of scientific research, there are many unknowns about the exact environmental controls on the development of different types of lipids and their distribution, and the potential of lignin is yet to be fully realized as a palaeoproxy and tracer for water sources. The use of both of these proxies to study past environments and climates in karst regions is still very much in its infancy. Yarrangobilly is now the main site of investigation for these projects and the first in Australia. Specifically, routine collection of water, soil and cave samples will be made for analysis of these organic compounds. Routine characterization of these samples

Long-term monitoring of dripwater chemistry in Harrie Wood. Results have shown that drips located within 1 m are sourcing water from different hydrological pathways

and the modification of these compounds from the surface, through the karst aquifer into drip water, the cave environment and ground water during different environmental conditions (seasons and soil types) will prove to be a major global contribution to this area of research, and vital to development of these compounds as proxies of environmental change in speleothems.

In a related study, carbon isotopes including radiocarbon, are being measured on soil CO_2 gas and drip waters. These data will be used to understand soil carbon cycling at this site, as well as understand the processes that determine the amount of carbonate derived from limestone. The latter will enable more accurate speleothem chronologies to be developed using the radiocarbon dating technique.

FIRE HISTORY

Blackened layers preserved in the speleothems of Jersey Cave are well-known to visitors to Yarrangobilly. These layers are thought to be derived from smoke being drawn into the cave during fires. Aerosol transport into Jersey and Harrie Wood Caves is being studied to better understand the nature of these deposits. It is hoped that this information may be employed to use the black layers preserved in the speleothem record to create a history of bushfire events through time, thus helping us understand how climate and fire interactions have change over hundreds of thousands of years.

SUMMARY

Yarrangobilly is thus a key site for further understanding paleoenvironmental signals preserved in speleothems as well as a setting for testing new methods such as biomarkers and aerosol transport. It serves as a natural laboratory for one of the most well-monitored cave sites in Australia. As well as filling knowledge gaps in interpreting past environmental change from the speleothem scientific record, it will also provide a host of new information such as improved understanding of the hydrogeological characteristics of karst systems, aerosol transport, and soil carbon cycling in cool climate regions of Australia. Ultimately, the speleothem scientific record at Yarrangobilly will be used to create a history of climate change, soil and vegetation changes and forest fire events for the region extending tens or possibly hundreds of thousands of years.

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