Preliminary Report to the BCRA Cave Science and Technology Research Initiative

CASCE 2007 "set the stage" for science on Cambridge's annual caving expeditions. The wholehearted cooperation of expedition members and support from bodies including the Cave Science and Technology Research Initiative led to successful data collection for this year's three research projects. The purchase of new equipment and development of science infrastructure will foster the continuation of the microclimate project for years to come, and discussion of new science projects for next year has already begun.

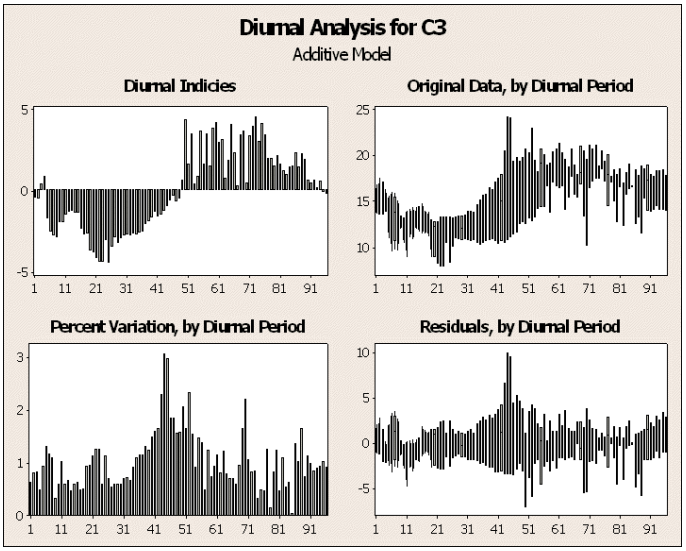

Figure 1. Autocorrelation analysis of Rundreisehöhle A entrance thermistor, showing diurnal variation of 10°C amplitude. Timescale is in 15-minute units, 1 day = 96.

The microclimate project was able to collect valuable data regarding cave atmospheres, despite many difficulties. Temperature data collected via thermistors in Rundreishöhle (105,500 temperature data points from 10 thermistors) provide insight into the penetration distance of diurnal variation (Figure 1), the scale of high-frequency temperature oscillations (2-3 degrees 15m into the cave), and the average summer conditions of the caves. The weather station placed outside the cave entrance (9,128 data points) allows these temperatures to be correlated with external variables. In Steinbruckenhöhle, 64,000 data points from 6 pairs of wet / dry thermistors showed wet-bulb temperature depressions which allow calculations of humidity at tens of thousands of points in time and space. Large volumes of condensation were observed visually in certain sections of cave (figure 2), in line with the expectations of Dublyansky and Dublyansky (1998).

Figure 2. Condensation in CSB passage.

As the original aim had included the observation of cave windspeeds, we undertook pre-expedition research into the likely cross-sectional variation of windspeeds through Rundreishöhle through computational fluid dynamics (CFD). By lofting between left-right-up-down (LRUD) cross-section data from the original Rundreishöhle survey, we constructed a 3d model of the cave in STAR-CD, a CFD package. Airflow models were run both treating one entrance as an air inlet and simulating pressure differences between the entrances. We aimed to place our anemometers at the points of maximum airflow for each cross-section along the cave using aluminum bars attached to cave wall anchors. The CFD model (figure 3) showed that at many points in the cave, simply placing them in the center of the passage would not necessarily give us the maximum airflow for that cross-section. Although anemometers were not installed in Rundreishöhle this year, as explained below, developing the

method for converting between our survey data and STAR-CD took time and can be used in future years' studies.

Unfortunately, applying models applied in earlier papers such as Freitas and Schmekal (2006) and Michie (1998) and to answer the original quantitative research question regarding contribution of condensation related latent heat transfer to the cave energy balance was complicated due to equipment difficulties. At the last minute, we were unable to loan the FLIR ThermaCAM P25 for observing cave wall temperature gradients because it was in for repair after developing a malfunction. The delicate micropsychrometer thermopile was damaged while attempting to connect the wet wick and could not be repaired in situ, so high resolution humidity measurements were impossible. While the HOBO dataloggers (figure 1) proved extremely robust, other elements of the HOBO system were less so. Two of the thermistors were rendered useless when their cables were sliced by rocks in the cave. Data is downloaded from the loggers using a mini-usb cable and a shuttle device. Keeping the USB cable and (non-weatherproofed) shuttle free of mud and water proved very difficult, and as a result dataloggers had to be removed from the cave to be downloaded in some cases. Valuable firsthand knowledge of how to prevent and deal with these problems in the future was gained, and will be passed on to next year's expedition.

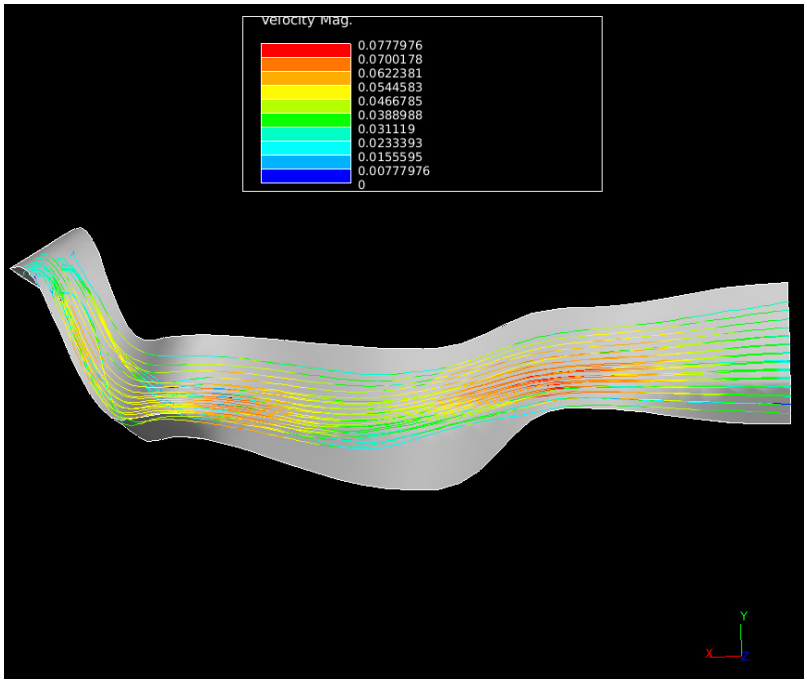

Figure 3. CFD model of Rundreishöhle for a pressure difference between the entrances.

A functioning sonic anemometer was constructed using a circuit adapted from Campbell and Unsworth (1979), and mounted on an adjustable aluminum frame which bolted directly into the cave wall. However, it required a path length very close to a whole number of wavelengths of the sensor pulses. Using an oscilloscope on the surface it was possible to tune the anemometer so that it functioned properly. However, the instrument failed to operate if the path length was varied by distances as small as ~0.5mm. It proved impossible to maintain this distance during transportation into the cave, and using an oscilloscope underground impractical. Improvements to the anemometer to reduce its sensitivity to path length are currently being attempted. Another possibility is to bring precise calipers underground.

We plan to continue the investigation this winter or spring by instrumenting British caves and applying a similar research question, after the anemometer has been improved, the micropsychrometer is fixed, and the thermal camera is available. Three HOBO dataloggers were retrieved from the Austria expedition for this purpose. A similar project is planned for next year's expedition to Austria, as well. The 2008 expedition will benefit from a year's worth of hourly logged temperature data from a datalogger which remains in Steinbruckenhöhle, which should put the seasonal variation into perspective.

Outside of the microclimate project, there were several other research and technology successes. Five hundred and eighty saliva samples were collected from expedition members for analysis of cortisol as an indicator of physiological stress, and a new radon detector technology was tested underground. This year, a survey instrument newly designed and constructed by expedition member Dr Phil Underwood was used for exploration and vastly improved the speed and accuracy of our surveying techniques, allowing 7 km of new cave passage to be explored and documented during the 6 weeks, shattering the record for distance surveyed

on a Cambridge expedition. The instrument contains an electronic compass, clinometer, laser pointer, and LCD display, and is capable of storing up to 1,000 survey legs. Further work to integrate a laser range finder is ongoing.

Work on several publications and presentations regarding the expedition is in progress. The 2006 A1-size plan survey of Steinbruckenhöhle and surrounding area will be replaced by two separate publications. Tunnockschacht, 505m long after the 2006 expedition, is now 3km long and requires its own sheet. The additions of the Silk Road and Convenience Series to Steinbruckenhöhle increase its N-S extent and vertical complexity (8 overlapping layers at one point) so that a new publication format is required. Work has begun on a "cave atlas" of Steinbruckenhöhle. An article regarding the expedition will be published in next issue of the BCRA's *Speleology*. As results are obtained for the stress and radon studies and the data from the microclimate project is further analyzed, we intend to submit papers to peer-reviewed scientific journals.

Expedition financial summary with research breakdown

Travel costs:	£ 3 487.64
Personal gear:	£ 1 526.04
Scientific Apparatus:	£ 2 221.61 (broken-down in table below)
Other:	£ 12 524.74
Total Expenditure:	£ 19 760.03
Total Income:	£ 20 360.03

This leaves a float of £ 600 for next year's expedition, as planned in advance of the expedition.

Amount	Description
-31.87	Jaycar Sensors and Components
-7.37	Stockholm Electronics Components
-809.58	Dataloggers and Interface from Tempcon
-27.53	ESR Electronic Components
-27.79	Sensor Mounts from Mackays
-85.35 (-172.08 Dollars)	PCBs from Olimex
-25.00	Box and Grommets from Maplin
-25.00	Batteries and Holders from Maplin
-5.00	Electronic Components from Maplin
-681.50	Remaining Instruments from Tempcon
-1.13	Postage of Spit Kit to Andy A
-3.50	Heavy Duty Spit Bags
-17.02	Two Waterproof Notebooks
-10.87	Ten D Batteries for Aaron's Gear
-8.08	Powerpoles for Aaron's Gear
-200.00	Extra Solar Panels from Adrian Smith
-200.00	Radon Detectors
-50.00	Fuel to Collect Spit Samples
-1.70	Bolts for Weather Station from Mackays
-1.94	Glue for Weather Station Repair

-1.38 Baseline Spit Postage

If you require more detailed financial information, please contact the Expedition Treasurer, Richard Mundy at: rcmundy@gmail.com