



Continuous multichannel monitoring of cave air carbon dioxide using a pumped non-dispersive infrared analyser

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The concentration of CO₂ in cave air is one of the main controls on the rate of degassing of dripwater and on the kinetics of calcite precipitation forming speleothem deposits. Measurements of cave air CO₂ reveal great complexity in the spatial distribution among interconnected cave chambers and temporal changes on synoptic to seasonal time scales. The rock of Gibraltar hosts a large number of caves distributed over a 300 meter range in altitude and monthly sampling and analysis of air and water combined with continuous logging of temperature, humidity and drip discharge rates since 2004 reveals the importance of density-driven seasonal ventilation which drives large-scale advection of CO₂-rich air through the cave systems. Since 2008 we have deployed automatic CO₂ monitoring systems that regularly sample cave air from up to 8 locations distributed laterally and vertically in St Michaels Cave located near the top of the rock at 275m asl and Ragged Staff Cave located in the heart of the rock near sea level. The logging system is controlled by a Campbell Scientific CR1000 programmable datalogger which controls an 8 port manifold connected to sampling lines leading to different parts of the cave over a distance of up to 250 meters. The manifold is pumped at a rate of 5l per minute drawing air through 6mm or 8mm id polythene tubing via a 1m Nafion loop to reduce humidity to local ambient conditions. The outlet of the primary pump leads to an open split which is sampled by a second low flow pump which delivers air at 100ml/minute to a Licor 820 CO₂ analyser. The software selects the port to be sampled, flushes the line for 2 minutes and CO₂ analysed as a set of 5 measurements averaged over 10 second intervals. The system then switches to the next port and when complete shuts down to conserve power after using 20 watts over a 30 minute period of analysis. In the absence of local mains power (eg from the show cave lighting system) two 12v car batteries will power the system for analysis at 4h intervals for about 1 month. Two logging systems sampling cave air from 13 locations over a vertical range of 275m have run continuously for up to 5 years and return a very detailed picture of cave ventilation patterns and their responses to local weather and seasonal change.