

Carbon Dioxide and Climate in Jewel Cave

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ABSTRACT

Elevated concentrations of carbon dioxide (CO₂) in Jewel Cave present a challenge for the maintenance of safe working conditions for cave guides. To characterise and manage the problem, 12 months intensive monitoring and targeted investigations of carbon dioxide and cave climate were undertaken.

Carbon dioxide was present year round in concentrations ranging between 0.5 – 2.8 %, including short-term fluctuations (day - week intervals) of +/- 1 %. There is a distinct seasonal cycle in CO₂ which is influenced by the annual temperature cycle on the surface. Carbon dioxide levels build up through spring-summer when the surface temperature has been consistently higher than the cave temperature, then decline through winter-spring when surface temperature has been consistently lower than the cave temperature. To remain within national safe work exposure limits, the duration underground for cave guides is limited to 1.6 hours per day during the peak summer season.

The atmosphere in the main chamber of Jewel Cave is extremely stable, due to thermal stratification in the air column and the CO₂ gradient, which inhibits mixing between upper and lower air masses. During winter when the external temperature is consistently 1.5 to 2 degrees cooler than the cave temperature, then deep ventilation displaces CO₂ laden air in the bottom of the cave. This winter flushing effect may also occur to some extent on cool nights during summer, especially when assisted by a barometric pressure gradient.

The cave climate model for Jewel Cave system invokes gravity-driven air flows, barometric pumping, stability in the entrance chamber, and winter flushing effect on CO₂. The natural ventilation rate of Jewel Cave is likely to have been reduced by the modification and blocking of some entrances. The climate model predicts that increasing passive ventilation in the entrance chamber may help to lower CO₂ levels by a 'trickle -down effect' to deeper parts of the cave. An experiment is being undertaken in an attempt to improve passive ventilation and lower CO₂ levels within the tourist sections of Jewel Cave, by removing the air-lock door and restoring some entrances to their previous natural condition.