Report of research results on Balcones Canyonlands Preserve Scientific Research Permit No. Banner-2011

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The growth rate and composition of cave calcite deposits (speleothems) is often used as a proxy for past environmental change. There is, however, the potential for bias in the speleothem record due to seasonal fluctuations in calcite growth. The growth rate of speleothem calcite in Texas caves has been proposed to vary seasonally in response to density-driven fluctuations in cave-air CO_2, with lower growth rates in the warmer months when cave-air CO_2 is highest. We monitored CO_2 in three undeveloped caves and three tourist caves 130 km apart in central Texas to determine 1) if seasonal CO_2 fluctuations are unique to tourist caves, which have been modified from their natural state, and 2) the extent to which cave-air CO_2 is controlled by natural variations in cave geometry, host rocks, cave volume and soils. Nearly 150 lateral transects into six caves over three years show that CO_2 concentrations vary seasonally in five of the caves monitored, with peak concentrations in the warmer months and lower concentrations in the cooler months. The caves occur in six stratigraphic units in lower Cretaceous marine platform carbonate rocks and vary in volume (100 to >100,000 m^3) and geometry. Seasonal CO_2 fluctuations are regional in extent. Seasonal fluctuations are independent of cave geometry, volume, depth, soil thickness, and the hosting stratigraphic unit. Our findings indicate that seasonal variations in calcite deposition may introduce bias in the speleothem record, and should be considered when reconstructing paleoclimate using speleothem proxies. Carbon isotope measurements on CO_2 in cave air is applied to trace the sources of CO_2 that is transported to the cave environment. The sources include outside atmosphere, C3 plants, C4 plants, and humans.

Publications resulting from CO_2 studies in central Texas caves (* = student author)

Articles in peer-reviewed journals

Cowan, B.D, *Osborne, M.C., and Banner, J.L., 2011, Temporal variability of cave-air CO_2 in central Texas, Journ. Caves and Karst Research, submitted.

*Wong, C., Banner, J. L., Musgrove, M., 2011, Seasonal dripwater Mg/Ca and Sr/Ca variations driven by cave ventilation: Implications for and modeling of speleothem paleoclimate records, Geochimica et Cosmochimica Acta 75, 3514–3529

*Wong, C., Banner, J. L., 2010, Response of cave air CO_2 and drip water to brush clearing in central Texas: Implications for recharge and soil CO_2 dynamics, J. Geophys. Res., 115

Banner, J., *Guilfoyle, A., James, E., Stern, L., Musgrove, M., 2007 Seasonal variations in modern speleothem calcite growth in Central Texas, U.S.A.: Journal of Sedimentary Research, v. 7, p. 615-622

Conference proceedings papers

James, E.W., Banner, J.L., 2009, Factors promoting preservation bias in speleothem growth, *Proceedings of the 15th International Congress on Speleology*, p. 1025.

*Wong, C. and Banner, J.L., 2009, Investigating controls on non-linear drip rate and drip-water composition in central Texas karst, USA, *Proceedings of the 15th International Congress on Speleology*, p. 1071-1077.

*Cowan, B.D., *Osborne, M., and Banner, J.L., 2009, Temporal variability of cave-air CO_2 in central Texas, *Proceedings of the 15th International Congress on Speleology*, p. 1018-1023.

Abstracts of presentation at national meetings

*Heinz Fry, A. L., Feng, W., Banner, J. L, and *Casteel, R. C., 2011, Oxygen isotope relationships between rainfall, dripwater and speleothem calcite from Westcave, central Texas, USA: Possible implications for paleoclimate study, Abstract to be presented at 2011 Fall Meeting, *AGU*, San Francisco, Calif.

*Meyer, K., Breecker, D. O., Banner, J. L., and *Guilfoyle, A., 2011, Carbon in karst: investigating sources, transport and isotopic fractionation to better inform the interpretation of speleothem climate records of central Texas caves, Abstract to be presented at 2011 Fall Meeting, *AGU*, San Francisco, Calif.

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*Ball, C.E., Breecker, D. O., Banner, J., 2010, Where does cave-air CO originate? Evidence from stable carbon isotope ratios, Geological Society of America Meeting, Denver, CO, Paper no. 182-10.

*Casteel, R., and Banner, J.L., 2010, Relating variations in rainfall to variations in cave drip water geochemistry as a precursor to paleoclimate application, *Geological Society of America Meeting*, Denver, CO, Paper no. 229-16.

Feng, W., Banner, J.L., Musgrove, M., and James, E.W., 2010, Mechanisms of oxygen isotopic fractionation between drip water and speleothem calcite: evidence from a 10 year monitoring study, central Texas, USA, *Geological Society of America Meeting*, Denver, CO, Paper no. 229-14.

*Wong, C.L., Banner, J., Musgrove, M., 2010, Using a conceptual model to elucidate controls on high frequency Mg/Ca and Sr/Ca speleothem variations, *Geological Society of America Meeting*, Denver, CO, Paper no. 229-13.

*Quinn, A.E., Breecker, D.O., Banner, J.L., and *Cowan, 2009, Investigating cave ventilation in central Texas using seasonal variations in the $\delta^{13}C$ value and concentration of cave-air CO_2, *Geological Society of America Meeting*, Portland, OR, Paper no. 178-3.

*Cowan, B., Osborne, M. and Banner, J.L., 2008, Temporal Variability of Cave-Air CO_2 in Central Texas [abstract]: Geological Society of America, Annual Meeting, Abstracts with Programs, v.40, p. 166.