

Applications of stable and radiogenic isotopes to tracing hydrologic processes in karst systems

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Karst aquifer systems, which provide approximately 40% of the U.S. groundwater drinking water supply, are dynamic, vulnerable to groundwater contamination, and sensitive to growing demands and impacts of human use. Understanding hydrologic processes in karst systems is critical to ensure the availability of future water resources. The application of stable and radiogenic isotope systems can provide an improved understanding of karst system behavior.

The application of isotopes in modern groundwater systems such as the Edwards aquifer of central Texas and the Pleistocene aquifer of Barbados demonstrate the range of their utility as natural tracers. Stable isotopes systems such as oxygen and hydrogen provide insight into the seasonal timing of recharge in tropical island karst aquifers in the Caribbean and Pacific. Radiogenic isotope applications, such as Sr isotopes, can provide insight into processes of flow paths, residence time, the source and contribution of dissolved constituents, and the role of soils in controlling groundwater composition.

Carbonate cements deposited from vadose water in caves (speleothems) can be used to understand the mechanisms and timescales that link climatic and hydrologic processes over recent geologic time. These ancient analogs provide insight into modern groundwater systems and provide a framework for assessing the controls of factors such as climatic variations on aquifer and karst development, long-term patterns of recharge, and changes in flow regimes. Speleothems are precisely dateable over a range of timescales for the Pleistocene and Holocene using U-series isotopes. Constraints on growth rates in speleothems have provided insight into the timing of glacial/interglacial periods and related variables such as recharge. Ground-truthing the behavior of these isotopic tracers in modern systems provides a clearer understanding of the mechanisms that control these ancient groundwater systems.