

The bacterial activity is confirmed by optical and instrumental methods (Kucha et al. 2001). The lightest sulphur (-31.6‰) is reported from late stage stalactitic botryoidally sphalerite. The origin of the sulfur isotope population which is characterized by a broad peak at -17‰ is multimodal: BSR, of pre-existing sedimentary iron sulphide or ore sulphide, mixing with hydrothermal sulphur (<-10‰) dominate in discordant ore structures. The hydrothermal sulfur probably originates from sedimentary iron sulphides of the basement or its cover. Sulphur isotope patterns of other carbonate-hosted Pb-Zn deposits in the Alps and anywhere support this assumption.

The detection of bacteriogenic activities during syndiagenetic sedimentary processes in sulphides from the most important ore horizons at Bleiberg deposit excludes the MVT-model, and confirms the model of Mid-Triassic age. The proposed model for the Bleiberg deposit corresponds with the interpretation of sulfur isotopes of the (Irish type) Lower Carboniferous giant lead-zinc deposit Navan in Ireland (Fallick et al. 2001).

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New applications of hydrogen isotopes in geo- and biochemistry

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In spite of the enormous hydrogen isotope fractionations that occur in nature, the applications of hydrogen isotope geochemistry have been limited, in part due to the difficulty in making the isotopic analyses. However, new continuous flow analytical techniques, developed in the last several years, have made analyses vastly easier and less time consuming than those in the past. Much smaller amounts of material can be analyzed with a minimum of sample preparation. As a result, large number of analyses can be made in a relatively short time. In this communication, I present a number of varied applications of hydrogen isotope geochemistry, archaeology and ecology in order to illustrate the types of problems that can be addressed.

δD values of bird feathers are related to their geographic location during molting (feather growing). An isotopic study of Wilson's warblers shows that birds migrating to the most northern latitudes in summer, also migrate to the most southerly latitudes in winter, 'leapfrogging' a second group of Wilson's warblers that migrate far less. This kind of migration information was unknown before our isotope study. In another study, the δD values of the Aconcagua Mummy sacrificed in the high Andes were measured. H, C, N and S isotope ratios all varied as a function of seasonality. We were able to show that the mummy child had not lived at high altitudes for a significant period of time prior to his death.

We have coupled the continuous flow hydrogen method with a laser extraction system to extract single fluid inclusions for δD determinations. We find that primary and secondary fluid inclusions have distinctly different δD values. Primaries have mantle values; secondaries have a strong meteoric component. We have also started a program of analyzing the δD of atmospheric water vapor. Unlike typical meteoric water measurements, which can only be made when it rains, we can analyze vapors at any time, and our data are consistent with the actual air, not the water modified by condensation-evaporation processes.

Because hydrogen is a major constituent of water and organic matter, and to a lesser extent, rocks, its applications are extremely varied. The advances of rapid turnover time, small amounts of material for analysis, and the high spatial resolution when coupled to a laser, means that a tremendous number of new applications will be seen in the coming years.

The stable isotopic composition of DIC in karst groundwater: Methodology and applications

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The stable isotopic composition of dissolved inorganic carbon ($\delta^{13}C_{DIC}$) is a useful parameter to trace the origin(s) of the bicarbonate ion, which is the dominant anion in shallow groundwater. In this setting, DIC has three main sources, soil carbon dioxide, dissolution of carbonate minerals, and atmospheric carbon dioxide exchanged through the air-water interface.

We use a gas evolution method that (a) avoids the use of toxic additives to prevent microbial activity, (b) requires only small sample volumes, and (c) works reliably and quickly even in difficult field conditions (e.g., caves). 10 ml sample vessels are preloaded with a few droplets of phosphoric acid, capped, and the head space is flushed with He. In the field, the sample is injected into the exetainer using a needle syringe. The amount of sample depends on the carbonate alkalinity and varies from fractions of a milliliter up to 2 ml. The CO_2 in the headspace of the exetainer is analyzed within a few days using a Delta^{plus}XL isotope ratio mass spectrometer operating in continuous-flow mode (GasBench II). We found no significant (i.e., > 0.1‰) C isotope shift during a few days of sample transport and storage (cf. Nelson, *Rapid Comm. Mass Spectrom.*, 14, 2000; Tu et al., *Rapid Comm. Mass Spectrom.*, 15, 2001).

Because there are no durable DIC standards available, we use the following procedure to calibrate the raw delta values against VPDB: DIC samples are run intermittently with calcite samples (DIC is measured during the working day, calcite runs over night). We use the calcite standard $\delta^{13}C$ values of the runs before and after a DIC measurement to correct and calibrate the DIC values. A linearity correction is performed using the slope $\delta^{13}C$ vs. intensity of mass 44