

## Coupled high-resolution $\delta^{13}\text{C}_{\text{carb}}$ and $^{87}\text{Sr}/^{86}\text{Sr}$ chemostratigraphy on the North American craton: Identifying the source of the Late Ordovician Guttenberg Isotopic Carbon Excursion

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The Guttenberg isotopic carbon excursion (GICE) is a ~2‰ positive excursion in  $\delta^{13}\text{C}_{\text{carb}}$  found in Late Ordovician (Early Katian) strata on three different continents and represents a major perturbation of the global biogeochemical carbon cycle. We applied  $\delta^{13}\text{C}_{\text{carb}}$  chemostratigraphy to two Missouri (MO) sections containing the GICE in the Decorah Formation. Our data show the Kings Lake Member of southern MO and the Guttenberg Member of northern MO are coeval rather than successive, thereby revising the erosional and depositional history of Late Ordovician sediments in MO.

The cause of the GICE remains uncertain. Although enhanced burial of organic carbon is often invoked, definitive evidence for this has yet to arise. We couple  $\delta^{13}\text{C}_{\text{carb}}$  and  $^{87}\text{Sr}/^{86}\text{Sr}$  chemostratigraphy with biogeochemical cycling models of C and Sr to constrain possible causes for the GICE. Parallel variation in  $\delta^{13}\text{C}_{\text{carb}}$  and  $^{87}\text{Sr}/^{86}\text{Sr}$  suggest a change in oceanic weathering inputs as the most likely explanation for the GICE. Modelling results indicate that a single mechanism, a drop in the total weathering flux ( $F_w$ ) and/or proportion of silicates being weathered, can explain the apparent inverse relationship between  $\delta^{13}\text{C}_{\text{carb}}$  and  $^{87}\text{Sr}/^{86}\text{Sr}$  in our two sections from MO. The drop in  $F_w$  could have resulted from flooding of the North American craton, which thereby lowered the amount of exposed land. Significant stratigraphic evidence of sea level rise is found across the North America craton and is coincident with the onset of the excursions in both isotopic systems. However, a widespread drowning surface at the end-GICE across the Upper Mississippi Valley suggests a decoupling between  $\delta^{13}\text{C}_{\text{carb}}$  and sea level or the presence of more than one mechanism. Despite the challenges of non-uniqueness in reconciling chemostratigraphy and model results, we are able to show that coupling multi isotopic systems and elemental cycling models can constrain the range of possible source mechanisms, while precluding others. Furthermore, our results suggest that small excursions in  $^{87}\text{Sr}/^{86}\text{Sr}$  may exist over relatively short periods of time (<1 Myr) in Paleozoic deposits.

## Characteristics and origin of the Lala iron oxide Cu-Co-(U, REE) deposit: Sichuan, Southern China

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Cu-Co-REE-U mineralization at the Lala mine is multistage, controlled by the geologic-tectonic evolution of the region. The deposit has been interpreted as volcanic-hosted massive sulfide [1], metavolcanic-sedimentary with hydrothermal remobilization [2], or IOCG-type mineralization [3, 4]. The ore deposit is hosted by a Middle Proterozoic volcano-sedimentary succession, metamorphosed at upper-greenschist to amphibolite-facies conditions, early during the Sibao Orogeny (~1 Ga). Mineralization occurred during the Neoproterozoic at ca. 830 Ma [5].

The host rocks are metamorphosed and hydrothermally altered intermediate to mafic volcanics and mica schist. The main alteration styles include albitization and sericitization. Textural evidence allows recognition of 3 modes of sulphide mineralization with a distinct sequence of formation, indicating a complex and multiphase genetic evolution. There are strong indications that the mineralization is essentially epigenetic-hydrothermal in origin and the formation of hydrothermal breccias may be attributed to fluid release from an underlying magma. While there is no strict statistical correlation between La and Cu, Cu-rich samples are always enriched in REE elements. Other characteristic features include the abundance of iron-oxides and Cu-sulfides, a low-Ti magnetite chemistry, REE-mineralogy, and the presence of uraninite.

These new data lend evidence to the conclusion that, in contrast to previously proposed ore genesis models, the mineralization at Lala possesses many features that warrant its inclusion within the global IOCG deposit class.

[1] Zaw *et al.* (2007) *Ore Geol. Rev.* **31**, 3–47. [2] Baoyong & Zhengnan (1986) *J. Min. Pet.* **6**, 111–121. [3] Wang *et al.* (2005) *GCA* **69**, 573. [4] Li *et al.* (2002) *Bull. Chin. Soc. Min Petr. Geochem.* **21**, 258–260. [5] Sun *et al.* (2006) *Geochim.* **35**, 553–559.