LARGE ISOTOPIC DATABASE ON LACUSTRINE CARBONATES OF THE HORSE SPRING FORMATION CHARACTERIZES THE EXTREME VARIABILITY OF CONTINENTAL RIFT LAKES

POMERLEAU, CRYSTAL1, HICKSON, THOMAS2, AND LAMB, MELISSA2, (1) GEOLOGY DEPARTMENT, UNIVERSITY OF ST. THOMAS, 2115 SUMMIT AVE, ST. PAUL, MN 55105, POME3692@STTHOMAS.EDU, (2) GEOLOGY, UNIV OF ST. THOMAS, 2115 SUMMIT AVE, ST. PAUL, MN 55105

1. Introduction

The Oligo-Miocene Horse Spring Formation (HSF) in the Lake Mead region of southern Nevada (Figure 1) comprises a thick and diverse suite of continental clastic and chemical sediments that formed in pre- and synextensional basins. Paleozoic marine limestones and dolomites encompassed these basins (Figure 2), providing a vast carbonate source. As a result, lacustrine carbonates form thin (1-5 m) to very thick (100-200 m) accumulations in the HSF that show microbally-influenced calcite precipitation and a lack of higher-order organisms. Thus, these carbonates formed in alkaline lakes that were inhospitable to multi-cellular life.

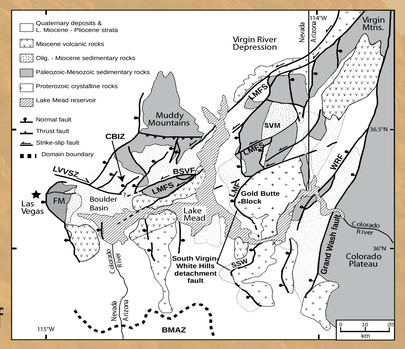

Figure 1. Basin reconstruction of the HSF indicating location.

Figure 2. Carbonate limestone in the HSF. The photo was taken in the Lovell Wash Member and is an example of the rocks sampled and analyzed.

2. Methods

We have lithologically and isotopically characterized four stratigraphic intervals in the HSF, yielding a database of >740 isotopic observations (Figure 2) that highlight temporal and lateral variation in these significant lacustrine units.

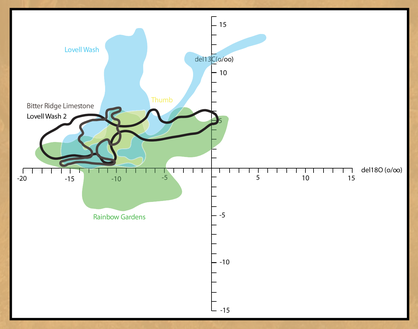

Figure 2. (Top) All isotopic points from the Bitter Springs Formation, characterized by member. Lovell Wash 2 represents locations that are thought to be of Lovell Wash Member but could potentially be of Thumb.

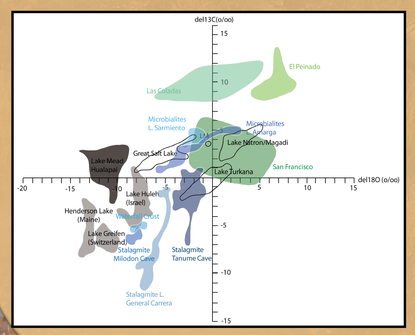

Figure 3. (Bottom) Comparison against other isotopic data, both ancient and modern. Faulds et al. (2000) in shades of grey, Solari et al. (2010) in shades of blue, and Valero-Garces et. al. (1999) in shades of green.

3. Rainbow Gardens

δ180 of pre-extensional lakes range over 19‰, from -18 to 1‰, with δ13C ranging from -5 to 6‰, reflecting a complex range of groundwater and meteoric inputs and a patchwork of ephemeral, short-lived lakes and wetlands.

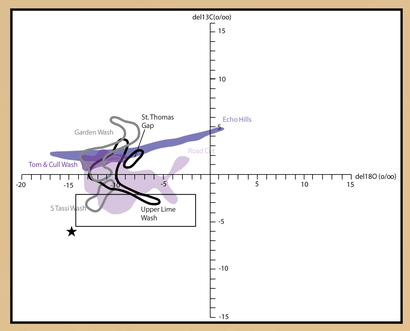

Figure 5. (Above) Part 1 Isotopic values for the lakes of the Rainbow Gardens sub-member; S Tassi Wash, Upper Lime Wash, and Road Cut display lower δ13C values.

Figure 6. (Right) Part 2 Isotopic values for the lakes of the Rainbow Gardens sub-member; divided solely for visual ease and interpretation. δ180 is similar throughout all of RG. Displays large similarities to the Faulds et. al. data.

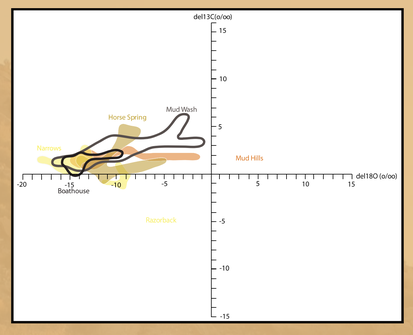

Figure 7. Photograph of a Rainbow Gardens outcrop, Lake Mead Area. Carbonate limestone packages can be seen protruding from the slopes near the top.

4. Thumb

Peak extension is recorded by the second stratigraphic interval, the Thumb Member. Lacustrine carbonates are limited in lateral extent and show less isotopic variability, but are enriched with respect to δ13C, suggesting either higher primary productivity and/or a spring-fed source.

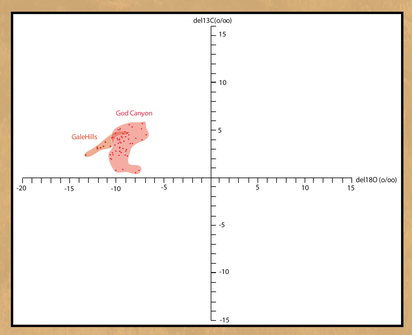

Figure 8. Isotopic values of the Thumb sub-member; God Hills and God Canyon. δ13C closely resemble those of modern Lake Mead (Faulds et. al., 1999).

5. Bitter Ridge Limestone

As extension evolved into transtension, a large lake formed, exemplified by the third interval the Bitter Ridge Limestone Member. This unit is isotopically similar to earlier lakes in terms of δ13C, but shows a strong (3-4‰) δ180 depletion that we interpret as potentially climatically forced, with a shift toward more aridity.

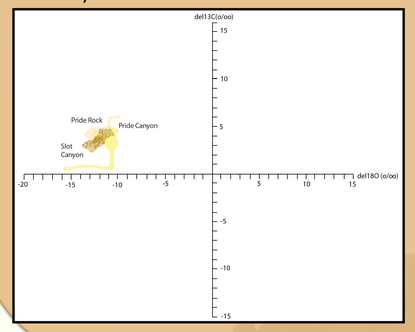

Figure 10. Photograph of a Bitter Ridge Limestone outcrop.

Figure 9. Isotopic values for the lakes of the Bitter Ridge Limestone sub-member; Pride Rock, Pride Canyon, and Slot Canyon. (The tight fit of Slot Canyons isotopic points could be due to their proximity in measured section.)

6. Lovell Wash

The final stratigraphic interval shows a return to smaller lakes that are isotopically similar to those of the Thumb Member with respect to δ180, but have a very wide range and strong enrichment in δ13C (0 to 14‰). Interbedded tuffs are common in this unit and the River Mountain volcanic field, located nearby, was active during this time interval. We attribute the carbon enrichment to hydrothermal activity associated with this magmatism, although there is a lack of travertine facies that might be expected if hot springs were more prevalent.

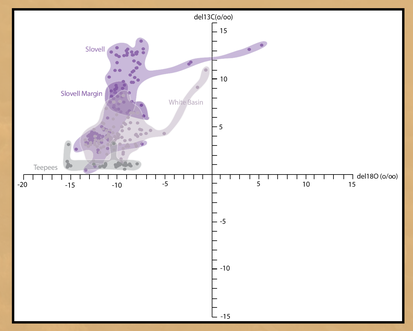

Figure 11. Isotopic values of the Lovell Wash sub-member. The values of the Slovell locality reflect the excursion, or episode of abnormally high δ13C, due to hydrothermal activity.

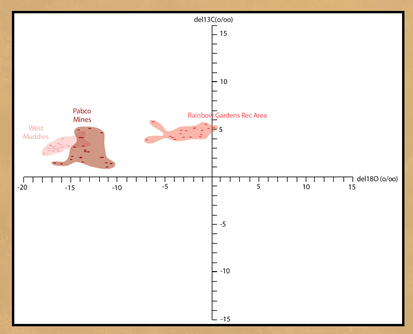

Figure 12. Isotopic values of what is believed to be the Lovell Wash sub-member.

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