Geophysical Research Abstracts
Vol. 12, EGU2010-3651-5, 2010
EGU General Assembly 2010

Carbon and oxygen isotope variations in late Archean carbonate rocks in South Africa

Baiquan Xu (1), Christoph Mayr (2,3), and Wladyslaw Altermann (1)

(1) Department für Geo- und Umweltwissenschaften Sektion Geologie, Ludwig-Maximilians-Universität München, Luisenstrasse 37, 80333 München, Germany (wlady.altermann@iaag.geo.uni-muenchen.de), (2) Department für Geo- und Umweltwissenschaften Paläontologie & Geobiologie, Ludwig-Maximilians-Universität München, Richard-Wagner-Strasse 10, 80333 München, Germany (c.mayr@lrz.uni-muenchen.de), (3) Institut für Geographie, Friedrich-Alexander-Universität Erlangen-Nürnberg, Kochstr. 4/4, 91054 Erlangen (c.mayr@lrz.uni-muenchen.de)

The Campbellrand Subgroup in South Africa persisted for >80 myr from >2588 ± 6 Ma to at least 2516 ± 4 Ma[1] and comprised tidal flat and shallow marine deposits followed by sub-tidal carbonates. The carbonates were deposited in a basin transgressing from southwest to the northeast for a distance of over 400 km, with abundant stromatolites[2,3]. The transgression trend has changed the depositional conditions with time, including water depth, sediment influx and mixing with meteoric water as recognised in field observations of lateral and vertical facies changes and of altering stromatolite morphology, and from microfacies studies on thin sections.

C and O isotopes were measured in the different (micro)facies, in order to establish whether they follow stratigraphic and depositional changes. The δ^{13}C values show a shift of -1‰ to 0‰ from the lower (Monteville and Reivilo Formations) to the upper (Gamohaan Formation) parts of the over 2000m thick Campbellrand Subgroup and experienced temporal fluctuations with two maxima during the middle interval of carbonate deposition (Fairfield, Klipfontein Heuwels, Papkuil, Klippan and Kogelbeen Formations). The cause of these δ^{13}C excursions most likely reflects increases in organic productivity and/or organic-carbon burial rates.

Oxygen isotopic analyses suggest that the temperature during the formation of carbonates was relatively high at 50 ± 20°C[4]. Comparing to the Phanerozoic oxygen composition (-6‰ to 0‰)[5,6], our results show low δ^{18}O values (-8‰ to -15‰). This could be caused by elevated temperature or post-depositional equilibration with meteoric and/or warm basinal waters. Our results show lack of co-variance in a crossplot of δ^{18}O and δ^{13}C and are characterized by a wide spread of δ^{13}C, combined with a narrow range of δ^{18}O values. The carbon isotopic composition is close to the Phanerozoic record[7]and records the evolution of the sea-water. The observed δ^{18}O values (∼ -10‰) in the Campbellrand Subgroup are in the range of previously reported Neoarchean values and therefore could also reflect the original isotope signature of these carbonate rocks. Alternatively, the low oxygen isotope values are influenced by isotopic exchange with meteoric waters in the course of diagenesis. Further studies are needed to disentangle these potential effects.

This study demonstrates the potential of using carbon isotopes as a tool recording the variations of depositional facies changes including water depth, sediment influx and carbonate productivities in Precambrian carbonates, depending on the metabolism of involved microbes.

References

1. Altermann, W. and Nelson, D.R., 1998. Sedimentation rates, basin analysis and regional correlations of three Neoarchaean and Paleoproterozoic sub-basins of the Kaapvaal craton as inferred from precise U–Pb zircon ages from volcaniclastic sediments. Sedimentary Geology 120, 225–256.

2. Altermann, W. and Wotherspoon, J., 1995. The carbonates of the Transvaal and Griquanland West Sequences of the Kaapvaal craton, with special reference to the Lime Acres limestone deposit. Mineralium Deposita 30, 124-134.

3. Altermann, W. and Siegfried, H.P., 1997. Sedimentology and facies development of an Archaean shelf: carbonate platform transition in the Kaapvaal Craton, as deduced from a deep borehole at Kathu, South Africa. Journal of

African Earth Science 24 (3), 391-410.

4. Kim, S.-T., O'Neil, J. R., Hillaire-Marcel, C. and Mucci, A., 2007. Oxygen isotope fractionation between synthetic aragonite and water: Influence of temperature and Mg^{2+} concentration. Geochimica et Cosmochimica Acta 71, 4704-4715.

5. Des Marais, D.J., 2001. Isotopic evolution of the biogeochemical carbon cycle during the Precambrian. Reviews in Mineralogy and Geochemistry 43, 555-578.

6. Frauenstein, F., Veizer, J., Beukes, N., Van Niekerk, H.S. and Coetzee, L.L., 2009. Transvaal Supergroup carbonates: implications for Paleoproterozoic δ^{18}O and δ^{13}C records. Precambrian Research 175, 149-160.

7. Veizer, J., Plumb, K.A., Clayton, R.N., Hinton, R.W. and Grotzinger, J.P., 1992. Geochemistry of Precambrian carbonates: V. Late Paleoproterozoic seawater. Geochimica et Cosmochimica Acta 56 (6), 2487–2501.