***Geological Magazine,* Testing the early Late Ordovician cool-water hypothesis with oxygen isotopes from conodont apatite. Authors:** Page C. Quinton, Stacey Law, Kenneth G. MacLeod, Achim D. Herrmann; John T. Haynes, and Stephen A. Leslie

**SUPPLEMENTARY FILE**

**Table 1.** Brachiopod oxygen isotopic results the Red Mountain Expressway section in Alabama, the Decorah section in Iowa, and the Rochester section in Minnesota. Averages are calculated from δ18O values of replicate analyses of silver phosphate crystals. One standard deviation (σ) is calculated for samples with replicate analyses.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample ID** | **meters\*** | **Avg.** | **δ18O** | **δ18O** | **δ18O** | **σ** | **Description** |
| **Decorah** |  |  |  |  |  |  |  |
| -10 | 15.49 | **18.9** | 18.9 |  |  |  | Brachiopod |
| -9 | 13.94 | **18.1** | 18.1 | 18.1 |  | 0.0 | Brachiopod |
| -8 | 12.34 | **17.8** | 17.8 |  |  |  | Brachiopod |
| -7 | 8.91 | **17.0** | 16.7 | 17.3 |  | 0.4 | Brachiopod |
| -6 | 6.55 | **18.1** | 18.1 |  |  |  | Brachiopod |
| -2 | 3.99 | **18.5** | 18.5 | 19.1 | 18.0 | 0.5 | Brachiopod |
| -1 | 3.89 | **19.4** | 19.4 |  |  |  | Brachiopod |
| 1 | 3.75 | **18.0** | 17.9 | 18.2 |  | 0.2 | Brachiopod |
| 2 | 3.70 | **18.5** | 18.1 | 18.8 |  | 0.5 | Brachiopod |
| 3 | 3.65 | **18.7** | 18.7 |  |  |  | Brachiopod |
| 4 | 3.61 | **18.4** | 18.4 |  |  |  | Brachiopod |
| 3-1L | 2.90 | **18.5** | 18.4 | 18.6 |  | 0.2 | Brachiopod |
| 3-0.5M | 2.82 | **18.6** | 18.5 | 18.6 |  | 0.1 | Brachiopod |
| 3-2L | 2.52 | **18.7** | 18.7 |  |  |  | Brachiopod |
| 3-1.0M | 2.40 | **18.7** | 18.7 |  |  |  | Brachiopod |
| 3-2LB | 1.38 | **18.1** | 18.1 |  |  |  | Brachiopod |
| 3-2.0M | 1.34 | **19.1** | 19.1 |  |  |  | Brachiopod |
| 3-2.5M | 0.69 | **19.6** | 19.6 | 19.5 |  | 0.1 | Brachiopod |
| 3-5L | 0.25 | **19.1** | 19.2 | 19.0 |  | 0.2 | Brachiopod |
| 3-3.0M | 0.22 | **18.7** | 18.7 |  |  |  | Brachiopod |
| Grainstone | -0.70 | **19.3** | 19.3 |  |  |  | Brachiopod |
|  |  |  |  |  |  |  |  |
| **Rochester** |  |  |  |  |  |  |  |
| 2-0.5m | 8.3 | **17.6** | 17.5 | 17.7 |  | 0.1 | Brachiopod |
| 2-1.0m | 8.2 | **17.7** | 17.8 | 17.6 |  | 0.1 | Brachiopod |
| 2-1.5m | 7.4 | **17.4** | 17.4 |  |  |  | Brachiopod |
| 2-2.0m | 7.0 | **16.8** | 16.6 | 17.0 |  | 0.3 | Brachiopod |
| 2-2.5m | 6.5 | **17.5** | 17.6 | 17.4 |  | 0.2 | Brachiopod |
| 2-3.0m | 6.0 | **17.9** | 17.9 |  |  |  | Brachiopod |
| 2-4m | 5.0 | **18.5** | 18.4 | 18.6 |  | 0.1 | Brachiopod |
| 2-5.0, 2-5.5m | 3.8 | **19.1** | 19.1 |  |  |  | Brachiopod |
| 2-6.0m | 2.6 | **18.8** | 18.8 |  |  |  | Brachiopod |
| 2-6.5m, 2-7.0m | 1.7 | **18.0** | 18.1 | 17.9 |  | 0.2 | Brachiopod |
| 2-7.5m, 2-8.25m | 1.0 | **18.2** | 18.3 | 18.1 |  | 0.2 | Brachiopod |
| 1.17 | 0.0 | **18.7** | 18.6 | 18.8 |  | 0.1 | Brachiopod |
| 1.16 | -0.1 | **16.7** | 16.7 |  |  |  | Brachiopod |
| 1.15 | -0.4 | **18.3** | 18.3 |  |  |  | Brachiopod |
| 1.14 | -0.5 | **18.0** | 18.0 |  |  |  | Brachiopod |
| 1.12 | -0.9 | **17.7** | 17.6 | 17.5 | 17.9 | 0.2 | Brachiopod |
| 1.11 | -1.1 | **17.9** | 17.9 |  |  |  | Brachiopod |
| 10 | -1.3 | **18.1** | 18.1 |  |  |  | Brachiopod |
| 1.7.3 | -1.6 | **17.8** | 17.8 | 17.8 |  | 0.0 | Brachiopod |
| 1.7.2 | -1.8 | **17.8** | 17.8 |  |  |  | Brachiopod |
| 1.7.1 | -1.8 | **18.0** | 17.9 | 18.1 |  | 0.2 | Brachiopod |
| 1.5 | -2.0 | **17.5** | 17.5 | 17.5 |  | 0.0 | Brachiopod |
| 1.4 | -2.2 | **19.5** | 19.5 |  |  |  | Brachiopod |
| 1.3 | -2.6 | **17.2** | 17.2 | 17.3 |  | 0.1 | Brachiopod |
| 1.2 | -3.0 | **16.6** | 16.6 |  |  |  | Brachiopod |
| 1.1 | -3.4 | **17.3** | 17.3 | 17.2 |  | 0.0 | Brachiopod |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| **Red Mountain** | |  |  |  |  |  |  |
| RM 10.5 | 7.1 | **15.0** | 15.1 | 14.8 |  | 0.2 | Brachiopod |
| RM 9.5 | 6.1 | **14.4** | 14.2 | 14.5 |  | 0.2 | Brachiopod |
| RM 8.97 | 5.6 | **14.4** | 14.4 |  |  |  | Brachiopod |
| RM 8.9 | 5.5 | **14.3** | 14.3 |  |  |  | Brachiopod |
| RM 8.5 | 5.1 | **16.6** | 16.6 |  |  |  | Brachiopod |
| RM 8 | 4.6 | **15.6** | 15.7 | 15.4 |  | 0.2 | Brachiopod |
| RM 7.5B | 4.1 | **16.3** | 16.3 |  |  |  | Brachiopod |
| RM 7.5 | 4.1 | **16.5** | 16.5 |  |  |  | Brachiopod |
| RM 7.05 | 3.7 | **16.2** | 16.2 | 16.2 |  | 0.0 | Brachiopod |
| RM 7 | 3.6 | **16.8** | 16.8 |  |  |  | Brachiopod |
| RM 7 | 3.6 | **16.8** | 16.8 |  |  |  | Brachiopod |
| RM 6 | 2.6 | **15.6** | 15.4 | 15.7 |  | 0.2 | Brachiopod |
| RM 5.25 | 1.9 | **16.7** | 16.7 |  |  |  | Brachiopod |
| RM 5 | 1.6 | **15.9** | 15.8 | 16.0 |  | 0.1 | Brachiopod |
| RM 4.55 | 1.2 | **17.3** | 17.3 |  |  |  | Brachiopod |
| RM 4 | 0.6 | **15.6** | 15.6 | 15.7 |  | 0.1 | Brachiopod |
| RM 3.55 | 0.2 | **17.0** | 17.0 |  |  |  | Brachiopod |
| RM 3.5 | 0.1 | **16.9** | 16.9 |  |  |  | Brachiopod |
| RM 3.45 | 0.1 | **16.4** | 16.3 | 16.5 |  | 0.1 | Brachiopod |
| RM 2 | -1.4 | **16.3** | 16.3 | 16.2 |  | 0.1 | Brachiopod |
| RM 1.5 | -1.9 | **15.8** | 15.8 |  |  |  | Brachiopod |
| RM 0.9 | -2.5 | **16.2** | 16.0 | 16.4 |  | 0.3 | Brachiopod |
|  |  |  |  |  |  |  |  |

**Table 2.** Bulk carbonate δ13Ccarb and δ18Ocarb and trace organic matter δ13Corg results from Decorah and Rochester. Weight percent total organic carbon (TOC) is calculated from CO2 yield and weight lost during the decarbonation process. Carbon isotopic results for Red Mountain Expressway are published in Quinton et al., (2016).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sample ID** | **(meters)\*** | **δ13Ccarb** | **δ18Ocarb** | **δ13Corg** | **TOC** | **Description** |
| **Decorah** |  |  |  |  |  |  |
| -10 | 15.49 | -0.12 | -5.42 | -29.39 | 0.05 | Limestone |
| -9 | 13.94 | -0.48 | -5.39 | -28.14 | 0.06 | Limestone |
| -8 | 12.34 | -0.32 | -5.87 | -28.39 |  | Limestone |
| -7 | 8.91 | -0.01 | -4.82 | -29.29 | 0.04 | Limestone |
| -6 | 6.55 | -0.66 | -5.33 | -28.88 | 0.10 | Limestone |
| -5 | 4.99 | -0.25 | -5.12 | -27.31 | 0.17 | Limestone |
| -4 | 4.64 | 1.02 | -4.48 | -26.66 | 0.19 | Limestone |
| -3 | 4.29 | 0.73 | -4.66 | -27.41 | 0.16 | Limestone |
| -2 | 3.99 | 0.70 | -4.90 | -27.53 | 0.13 | Limestone |
| -1 | 3.89 | 0.49 | 0.49 |  |  | Shale |
| 1 | 3.75 | 0.99 | -4.73 | -27.16 | 0.14 | Limestone |
| 2 | 3.70 | -0.17 | -4.64 | -27.04 | 1.22 | Shale |
| 4 | 3.61 | 0.37 | -5.10 | -26.83 | 0.69 | Shale |
| 4 | 3.61 | 0.19 | -4.96 |  |  | Brachiopod Shell |
| 5 | 3.54 | -0.13 | -5.90 |  |  | Limestone |
| 5 | 3.54 | 0.39 | -5.06 |  |  | Limestone |
| 6 | 3.33 | -0.36 | -5.33 | -28.81 |  | Shale |
| 3-1L | 2.90 | 0.06 | -5.54 | -28.40 | 0.08 | Limestone |
| 3-0.5M | 2.82 | -0.30 | -6.31 | -28.66 | 0.14 | Shale |
| 3-2L | 2.52 | -0.36 | -5.38 | -29.03 | 0.02 | Limestone |
| 3-2L | 2.52 | 0.24 | -6.62 |  |  | Brachiopod Shell |
| 3-2LB | 1.38 |  |  | -29.18 | 0.04 | Limestone |
| 3-2.0M | 1.34 | -3.94 | -11.22 | -29.11 | 0.23 | Shale |
| 3-2.0M | 1.34 | -3.81 | -13.27 |  |  | Shale |
| 3-4L | 0.69 | 0.11 | -4.96 |  |  | Limestone |
| 3-4L | 0.69 | -0.38 | -4.61 | -29.20 |  | Brachiopod Shell |
| 3-2.5M | 0.69 | -0.34 | -5.10 |  |  | Brachiopod Shell |
| 3-2.5M | 0.69 | -0.68 | -5.82 |  |  | Limestone |
| 3-5L | 0.25 | -0.69 | -5.01 | -28.90 | 0.18 | Limestone |
| 3-3.0M | 0.22 | -2.47 | -4.69 | -29.30 | 0.41 | Shale |
| Grainstone | -0.70 | -1.30 | -6.99 | -29.52 | 0.23 | Limestone |
| Carimona | -0.75 | -1.20 | -4.72 | -29.30 | 0.19 | Limestone |
|  |  |  |  |  |  |  |
| **Rochester** |  |  |  |  |  |  |
| 2-2L | 8.5 | -1.28 | -8.23 | -27.64 | 0.02 | Limestone |
| 2-2L | 8.5 | -1.57 | -7.87 |  |  | Limestone |
| 2-3L | 7.4 | -0.89 | -9.05 | -26.54 | 0.03 | Limestone |
| 2-4L | 7.1 | -0.92 | -7.96 | -27.15 | 0.02 | Limestone |
| 2-5L | 6.7 | -1.23 | -7.67 |  |  | Limestone |
| 2-6L | 6.0 | -1.18 | -8.51 | -28.17 | 0.02 | Limestone |
| 2-7L | 5.8 | -1.43 | -7.38 | -25.43 | 0.06 | Limestone |
| 2-7L | 5.8 | -0.90 | -7.85 |  |  | Limestone |
| 2-8L, 2-3.5m | 5.4 | -0.81 | -7.46 | -27.14 | 0.03 | Limestone |
| 2-9L | 5.3 | -1.08 | -8.24 | -26.76 | 0.03 | Limestone |
| 2-9L | 5.3 | -0.88 | -8.43 |  |  | Limestone |
| 2-10L | 2.6 | -2.11 | -6.09 |  |  | Limestone |
| 1.17 | 0.0 | -1.67 | -6.51 | -30.00 | 0.26 | Limestone |
| 1.16 | -0.1 | -2.86 | -4.45 | -29.98 | 0.18 | Limestone |
| 1.15 | -0.4 | -1.41 | -5.50 | -29.22 | 1.39 | Shale |
| 1.15 | -0.4 | -1.26 | -5.76 | -29.22 | 0.58 | Shale |
| 1.12 | -0.9 | -1.16 | -5.21 | -30.05 | 0.93 | Limestone |
| 1.11 | -1.1 | -0.50 | -5.08 | -29.65 | 0.24 | Limestone |
| 10 | -1.3 | -1.09 | -4.70 | -29.91 | 0.14 | Limestone |
| 1.7.3 | -1.6 | -1.33 | -5.54 | -30.17 | 0.36 | Limestone |
| 1.7.2 | -1.8 | -1.93 | -4.53 | -30.81 | 0.37 | Shale |
| 1.7.1 | -1.8 | -2.14 | -5.12 |  |  | Limestone |
| 1.5 | -2.0 | -2.04 | -4.92 | -30.67 | 0.50 | Limestone |
| 1.4 | -2.2 | -1.51 | -4.89 | -30.43 | 0.10 | Limestone |
| 1.3 | -2.6 | -1.46 | -3.97 | -30.08 | 0.16 | Limestone |
| 1.2 | -3.0 | -1.39 | -4.74 | -30.57 | 0.05 | Limestone |
| 1.1 | -3.4 | -1.51 | -5.08 | -31.74 | 0.50 | Limestone |

**\*meters above the Millbrig K-bentonite**