**Supplementary material S3: Integrated litho-, chemo- and sequence stratigraphy of the Ediacaran Gametrail Formation across a shelf-slope transect in the Wernecke Mountains, Yukon, Canada**

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***Carbon and Oxygen Isotope Geochemistry***

Carbonate powders analyzed at Dartmouth College were reacted with phosphoric acid (H3PO4) at 70°C on a Gasbench II preparation device attached to a ThermoFinnigan DeltaPlus XL continuous flow isotope ratio mass spectrometer. δ13C and δ18O were measured simultaneously and isotopic data are reported in standard delta notation as the per mil difference from VPDB (Vienna Pee Dee Belemnite). Precision and accuracy were monitored by running a total of 12 standards for every 76 samples using 11:3 sample/standard bracketing. The standard set includes two external standards (NBS-18 and Elemental Microanalysis (EM) Carrara Marble), as well as an internal marble standard. Samples are measured relative to an internal CO2 gas standard and then converted to the VPDB scale using the known composition of NBS-18 (δ13C = -5.01; δ18O = -23.20) and the EM-Carrara Marble (δ13C = 2.10; δ18O = -2.01). Measured precision was 0.1-0.15‰ (1σ) for δ13C and 0.15-0.2‰ (1σ) for δ18O.

***Calcium and Magnesium Isotope and Trace Element Geochemistry***

Selected samples were also analyzed at Princeton University for Ca and Mg isotope and trace element analyses. Isotope analyses were performed using an automated high-pressure ion chromatography system (IC, Dionex UCS-5000+) to isolate either Ca or Mg in agreement with methods outlined in Blättler and others (2015), Higgins and others (2018), and Husson and others, (2015). The purified samples were analyzed for δ44/40Ca and δ26Mg values on a Thermo Scientific Neptune Plus MC-ICP-MS (Multicollector Inductively Coupled Plasma Mass Spectrometer). These analyses were performed using standard sample-standard bracketing methods to correct for instrumental mass bias. The Mg isotope measurements also included a blank correction. Measurements were carried out at low resolution for Mg and medium resolution for Ca to resolve ArHH+ interferences on mass 42. All samples were diluted to match standard concentrations within 0-10% to ensure comparable levels of ArHH+-based interference across samples and standards and to minimize concentration-dependent isotope effects. All samples were measured twice within the same run and a subset of samples were remeasured in subsequent runs. All data are reported in delta notation relative to a known standard: for Ca isotopes, the measured δ44/42Ca values are converted to δ44/40Ca values relative to modern seawater assuming mass dependent fractionation with a slope of 2.05; for Mg isotopes, measured δ26Mg values are reported relative to Dead Sea Metal (DSM-3). Long-term external reproducibility for each isotopic system is determined based on the standard deviation of known standards taken through the full chemical procedure with each batch of samples. For δ44/40Ca values, the external reproducibility for SRM915b relative to modern seawater is -1.21 ± 0.14‰ (2σ, n = 39). For Mg isotopes, the long-term external reproducibility for Cambridge-1 and seawater are -2.57 ± 0.11‰ (2σ, n =25) and -0.80 ± 0.10‰ (2σ, n = 17), respectively.

Sr/Ca (mmol/mol), Mn/Ca (μmol/mol), U/Ca (μmol/mol), and Mg/Ca (mol/mol) ratios were measured on aliquots of dissolved powders analyzed for δ44/40Ca and δ26Mg isotopes using a Thermo Finnegan iCAP Q Inductively Coupled Plasma Mass Spectrometer (ICP-MS). The metal to calcium ratios were determined using a set of matrix-matched in-house standards spanning the sample range. The external reproducibility of the ratios is estimated at <13% from replicate measurements of SRM-88b.

***Re-Os Geochronology***

All radioisotopic analyses were performed at the Yale University Metal Geochemistry and Geochronology Center. Weathered surfaces were removed with a diamond-encrusted rock saw and samples were then hand-polished using a diamond-encrusted polishing pad to remove cutting marks and any potential contamination from the saw blade. The samples were dried overnight at ~40 °C and then crushed to a fine (~30 μm) powder in a SPEX 8500 Shatterbox using a zirconium ceramic grinding container and puck to homogenize any Re and Os heterogeneity in the samples (Kendall and others, 2009). The Re and Os isotopic abundances and compositions were determined following methodologies described in Selby and Creaser, (2003) and Cumming and others, (2013).

Between 0.15 and 1 g of sample was digested and equilibrated in 8 ml of CrVIO3-H2SO4 with a mixed tracer (spike) solution of 190Os and 185Re in carius tubes at 220 °C for 48 hours. Rhenium and Os were isolated and purified using solvent extraction (NaOH, (CH3)2CO, and CHCl3), micro-distillation and anion column chromatography methods as outlined in Cohen and Waters (1996) and Birck and Barman (1991). The CrVIO3-H2SO4 digestion method was employed as it has been shown to preferentially liberate hydrogenous Re and Os, yielding more accurate and precise age determinations (Kendall and others, 2004; Rooney and others, 2011). Total procedural blanks during this study were 38.3 ± 1.0 pg and 0.15 ± 0.1 pg for Re and Os respectively, with an average 187Os/188Os value of 0.25 ± 0.1 (1σ, n = 3). The major source (>90%) of Re blank is from the CrVIO3-H2SO4 solution.

Isotopic measurements were performed using a ThermoFisher TRITON PLUS thermal ionization mass spectrometer in negative mode at the Yale University via static Faraday collection for Re and ion-counting using a secondary electron multiplier in peak-hopping mode for Os (Creaser and others, 1991; Volkening and others, 1991). The Os samples were loaded onto 99.995% Pt wire (H-Cross, NJ) in 9 N HBr and covered with a saturated solution of Ba(OH)2 in 0.1 N NaOH as activator and analyzed as oxides of Os. Interference of 187ReO3 on 187OsO3 was corrected by the measured intensity of 185ReO3. Mass fractionation was corrected with 192Os/188Os = 3.08261 using the exponential fractional law. Measurement quality was monitored by repeated measurement of the DROsS standard solution, which yielded 187Os/188Os values of 0.16096 ± 0.007 (n=2) over the course of the measurement campaign, in agreement with values obtained by other laboratories (Luguet and others, 2008; Liu and Pearson, 2014). The Yale University Re standard solution (measured on faraday cups during analytical sessions) yields an average 185Re/187Re value of 0.59755 ± 0.0008 (1σ, n = 3), in agreement with previously published values (Gramlich and others, 1973). The measured difference in 185Re/187Re values for the Re solution and the accepted 185Re/187Re value of 0.59738 (Gramlich and others, 1973) are used to correct the Re sample data for instrument mass fractionation and blank and spike contributions.

Uncertainties for 187Re/188Os and 187Os/188Os are determined by error propagation of uncertainties in Re and Os mass spectrometry measurements, blank abundances and isotopic compositions, spike calibrations, and reproducibility of standard Re and Os isotopic values. The Re-Os isotopic data, 2σ calculated uncertainties for 187Re/188Os and 187Os/188Os, and the associated error correlation function (rho) are regressed to yield a Re-Os date using Isoplot V. 4.15 with the λ 187Re constant of 1.666 x 10-11a-1 (Smoliar and others, 1996; Ludwig, 1980, 2008). Elemental concentrations and isotopic compositions for the Re-Os geochronology samples presented herein are listed in Supplemental S4.

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