Sorption of biologically critical transition metals to the marine cyanobacterium Synechococcus sp. 7002

BA Bishop, SL Flynn, W Hao, TJ Warchola, LJ Robbins, DS Alessi, and KO Konhauser

Microbes play key roles in the cycling of trace elements in modern marine environments. Due to their overall negative surface charge at marine pH conditions, cyanobacteria and other plankton are capable of adsorbing an appreciable quantities of trace elements from seawater. First row transition elements play key roles in biological systems including incorporation into key metalloenzymes. There has been an increasing focus on elucidating the paleomarine abundances of these critical transition metals; particularly Ni, Zn, Cu, and Co. Despite this recent focus, the exit channels for these metals in ancient marine settings are not well constrained. The potential for trace metal accumulation in paleomarine sediments via the flux of microbial biomass to the ancient sea floor during shale and iron formation deposition is unclear. In this study we utilized the extant marine cyanobacterium *Synechococcus* sp. 7002 as an analogue for Precambrian planktonic biomass, and determined adsorption behaviour for Ni, Zn, Cu, and Co to the bacterial surfaces. Sorption edges for these transition metals onto cyanobacterium were experimentally derived over a pH range of 3-9, encompassing the best estimates for paleomarine as well as modern conditions. In these experiments the magnitude to which these metals adsorb to bacterial surfaces was measured which offers new insights into how ancient bacteria may have transferred trace metals from the seawater to the seafloor during the Precambrian.

Ferrihydrite surface chemistry and reactivity

N Brazzoni and KO Konhauser

The Great Oxidation Event (GOE) occurred ~2.4 GA, it has been proposed that this occurred due to a decrease in atmospheric methane and this an increasing in atmospheric oxygen is seen possibly due to a major decline in marine methanogen populations. It has been proposed by Konhauser et. al (2009, 458 Nature, 750-753) that this decline of methane was initiated by a drastic drop in dissolved Ni, which is essential as a cofactor in some enzymes in methanogens. Any theory to the occurrence of the GOE and the environment at the time must be reconciled with the rock record. Banded iron formations deposited in the Precambrian contain the elemental abundance and insight into the depositional environment and therefore the GOE. It has been suggested that the trace elemental composition of the ancient ocean is recorded in BIFs, and will aid in our understanding of what processes were important at the time. In order to understand how iron behaved with trace elements, we need to the reactivity of iron in anoxic conditions must be studied. The goal of this thesis is to study the surface chemistry and reactivity of different ferrihydrite solutions. This can then be applied to ferrihydrite precipitating to form BIFs, and the reactions that occur with trace elements during precipitation.

Relating soil respiration variability to Boreal ecological entities

N D'Souza and A Sanchez-Azofeifa

CO_2 transfer, movement, or flux from the soil is a key element of soil respiration. Soil respiration rates affect the rate of nutrient release from Soil Organic Matter (SOM) which is necessary in sustaining plant and other organism growth. Soil CO_2 flux is a measure of respiration rate, which in turn, is a measure of the ability of the soil to support plant, and other microorganism life. It has been postulated that there exists an exponential relationship between soil respiration and temperature. The objective of this study is to validate this relationship, and to evaluate the biological health of a system, in response to variances in soil respiration. In this study, the Li-Cor Li-8100 soil gas flux analyzer was set up, along with three long term gas chambers, at the study site in the Boreal forest in Peace River, Alberta. Flux measurements were made from early August to mid-October, to obtain records for diurnal and seasonal variations in efflux rates. Daily measurements show the carbon flux to be greater between noon to late evening. The efflux spikes are also visible where the changes in relative humidity are the greatest. In addition, flux rates were significantly greater during the summer test period, compared to the fall test period when the temperatures were cooler. The results highlight the correlation between the variability in soil respiration rates and their effect on plant life at the surface. This provides a good basis to understand the hidden ecological processes that exist in Albertan Boreal forests.

Examining ecosystem productivity and carbon flux for an Alberta grassland through remote sensing

S Harris and J Gamon

Anthropogenic carbon emissions are increasing the atmospheric CO_2 concentration, leading to climate warming. One mechanism for removal of CO_2 from the atmosphere is photosynthesis. Grasslands may act as carbon sinks or sources, depending on the productivity. Grasslands are also agriculturally important, particularly for their ability to support livestock populations. Understanding carbon flux will help better predict grassland yields, and implement proactive ecosystem management.

Eddy covariance is the standard method to measure ecosystem-atmosphere carbon flux, however it is costly and only applicable to flat, uniform landscapes. Remote sensing may offer a more scalable, affordable, and accessible method to measure flux over large areas, particularly if it can be "calibrated" against eddy covariance. Simple, low-cost optical sensors can calculate a proxy of NDVI (Normalized Difference Vegetation Indices; a measure of greenness/productivity) for comparison with eddy covariance.

This study examines the relationship between NDVI (from optical sensors) and net ecosystem carbon exchange (NEE, from eddy covariance). NDVI-NEE time series illustrate the relationship between remote sensing and flux data. Regressions showed the strongest relationship between NEE and NDVI when data are averaged over a 13-17 hour time period around noon. Therefore, the best approximation of NEE with NDVI is likely one that takes an average of optical values from the productive daylight hours. Determining the most accurate data aggregation method to correlate flux and NDVI is essential for remote sensing studies to upscale to larger regional studies. These methods could improve our ability to monitor ecosystem carbon flux and manage prairie grasslands.

Tectonic setting of igneous rocks of the Humber arm allochthon, western Newfoundland

NJ Holden and JWF Waldron

The geology of the Humber Arm Allochthon of Western Newfoundland records a complicated history of rifting, passive margin development, subduction, and thrusting. Chaotic bodies of fragmented, mainly sedimentary rock, are common in the allochthon, including mélanges that may be formed by tectonic, sedimentary, or diapiric processes. Blocks of highly altered volcanic rock are found amongst the mixed strata of the mélanges. To help determine the origins of these volcanic blocks, 16 samples from Bay of Islands and Port Au Port Peninsula of western Newfoundland were collected. Elemental compositions were determined using ICP-MS geochemical analyses and mineralogical and textural descriptions were made using petrography. Chondrite and MORB normalized multi-element (spider) diagrams, bivariate, and ternary diagrams were used to link the volcanic rocks with their igneous-tectonic environments of formation. The environments include mid-ocean ridge, arc-related, and ocean-island. Spatial analysis and textural relationships help to further confine the relationships between the volcanic rocks. Further investigation is required to associate the tectonic environments in which these igneous units were formed with geologic events of the eastern margin of Laurentia.

Characterization of the B2 upper McMurray channel, Grouse property, northern Alberta: implications for a distributary channel system

V Jia and M Gingras

The Lower Cretaceous McMurray Formation is deposited during an overall transgression evolving through three different stages. It initially starts with fluvial channels that carve the valley, upon transgression the rivers are succeeded by a tidally influenced estuary, and with further sea-level rise, the system grades into a tidally influenced coastal plain. The final stage involves three transgressive-regressive cycles separated by flooding surfaces. Channels formed during the deposition of the first regressive package are called B2 channels. Within the Grouse property located at the Athabasca Oil Sands, wire-line log data and core logs defines a localized B2 channel. The morphology of this channel is trending NW to SE, approximately 800 metres wide, and infilled with up to 40.3 metres of sediments. The purpose of this study is to examine if the features of this B2 channel can be linked with delta distributary channels or incised valley channels. Spatial correlation of well-log data displays the stratigraphic architecture of the B2 channel, as well as showing the vertical and lateral associations via cross-sections. Based on wire-line log data and core logging, this study suggests that the channel mainly consists of sand dominated IHS deposits and breccia deposits. The degree of bioturbation is minor to absent, indicating occasional fluvial influences during the deposition of the last stage. There is no evidence of sea level fall, which is an essential criterion for an incised valley fill. Therefore, these evidences present the B2 channel to be a distributary channel of a deltaic complex.

Process sedimentological analysis of the evolution and development of hyperpycnal and hypopycnal flows at a variety of conditions

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CJH Knudson, MK Gingras, and BR Sutherland

Density currents are apt to form where a fluid comes into contact with another of a different density and composition. The type of density current that develops may be hyperpycnal or hypopycnal, depending on whether the entrant fluid density is higher or lower, respectively, than that of the ambient fluid. In this study, lock-release laboratory experiments in which a freshwater sediment particle suspension is introduced to a uniform, saltwater ambient fluid were performed and recorded. The tank gradient, salinity of the ambient, type of sediment, and density of the sediment suspension were varied to ascertain the effects of each on the development and evolution of hyperpycnal and hypopycnal flows. The variety of natural and artificial sediments chosen encompasses a variety of flocculation behaviours. For each of the 27 permutations examined in this project, horizontal and vertical time slice images were taken and their respective current front images digitized. Position versus time plots were generated for each current front and linear functions were used to calculate the flow velocity, horizontal extent, and suspended particle settling rate for each of the flows. The quantitative relationships between the variables of interest are used to derive equations that may be applied to natural settings to more accurately model the interactions between fluvial and marine fluids on continental slopes, as well as to enhance the understanding of the nature of sedimentation associated with density flows.

High resolution UAV winter imagery as a proxy for summer meltwater drainage patterns

T Larocque and M Sharp

This poster showcases the results of using very high resolution photographic imagery collected during spring conditions with an unnamed aerial vehicle (UAV) to map the summer meltwater drainage network on Fox Glacier, Devon Island. The Canadian Arctic experiences high rates of ice loss due to climate change; positive feedbacks associated with surface melting and glacier flow rates are also impacted by changing climate. Determining the impact of these feedbacks demands a knowledge on meltwater transport throughout the glacier; marginal and terminus discharge have minimal impacts while increased water at the glacier bed likely effects the ice transport dynamics. The presence of meltwater systems creates a dangerous and difficult environment for data acquisition, even more so during the summer. Imagery from satellites such as Landsat can provide data at resolutions of 30m; too low to reconstruct surface drainage. If UAV imagery, gathered during winter when accessibility is more direct, can reconstruct meltwater structure at high resolution it has the potential to become a way forward for in-situ measurements. During the project, a Sensefly eBee drone collected 3467 images at a 3cm resolution. Through the use of Pix4D, ArcGIS and ENVI software the characteristics of the surface drainage system could be highlighted in areas where the surface structure had not been blanketed by snow cover. High resolution UAV winter imagery created a unique meltwater drainage system map which could potentially be used as a proxy in estimating water reaching the glacial bed and thus the potential flow rate change.

Investigation of impact melt in allochthonous crater-fill deposits of the Steen river impact structure

EA MacLagan, CDK Herd, and EL Walton

Drill cores from the Steen River impact structure pass through upper Quaternary and Cretaceous sediments consisting mainly of shale and sandstone that are underlain by a green breccia. One core (ST003) bottomed out in granite and gneisses of the Precambrian basement. This breccia is similar in texture, appearance, and mineralogy to "suevite", a polymict, melt-bearing impact breccia named after its type locality at the Ries crater in Germany. How this breccia forms is a topic of ongoing debate; as such, studies were carried out on the melt fragments in the Steen River suevitic breccia to determine their relationship to the breccia as a whole and to delineate the proportions of melted target rocks. Three drill cores at the mineral core research facility (Edmonton) were logged and sampled from which 72 thin sections were prepared. These thin sections were studied with the optical microscope and the electron probe microanalyzer, the latter to determine the major and minor element composition. The melt in the breccia is found in two main forms: 1) individual melt fragments in the matrix of the breccia and 2) enshrouding granitic clasts in the breccia. Some clasts are completely encased and are partly incorporated into a melt halo while others have no melt association. Both forms of melt were analyzed and their compositions compared. Using the electron probe X-ray element maps and scanned thin section images, a volume of melt was estimated at 15km3for the Steen River crater and compared to the Ries type locality.

Cryostratigraphy and stable isotope (δ18O and δ2H) characterization of late MIS 6 and MIS 4 conditions from relict permafrost

K Staniszewska, D Froese, B Jensen, and T Porter

In this study, late Marine Isotope Stage (MIS) 6 and early MIS 4 time are investigated using permafrost cores that preserve tephra, and meteoric waters in pore ice from the Klondike area, Yukon. Old Crow tephra (ca. 130 ka), Dominion Creek tephra (ca. 77 ka) and Sheep Creek tephra-K (ca. 80 ka), were identified in the cores using major-element geochemistry electron microprobe analysis. Pore ice stable isotope ratios ($\delta^{18}O$ and $\delta^{2}H$) were used to reconstruct the isotopic composition of ancient precipitation, and paleo-temperatures based on modern temperature-isotope transfer functions for continental Arctic/Sub-Arctic North America ($\delta^{2}H_{precip} = 3.1‰{\cdot}°C^{-1} \times T - 155‰$; $\delta^{18}O_{precip} = 0.41‰{\cdot}°C^{-1} \times T - 20.2‰$; Porter et al. 2016). During late MIS 6, ~130 ka, pore ice $\delta^{18}O$ and $\delta^{2}H$ values were ca. -30‰ and -230‰. The MIS 6 pore ice is isotopically consistent with Klondike transitional MIS 3/2 cold stage pore ice (Porter et al. 2016), and equates to a maximum temperature depression of ~19°C below modern. During early MIS 4, ca. 80 ka, pore ice $\delta^{18}O$ ranges from -27‰ to -30‰, and $\delta^{2}H$ from -211‰ to -227‰. Using the modern temperature-isotope relations, these values represent a maximum temperature depression ~12 to 17°C below modern. By comparison, modern pore ice in the region is characterized by $\delta^{18}O$ and $\delta^{2}H$ values of ca. -22.7‰ and -176‰. These results highlight the variation in regional hydroclimate between multiple cold stages (MIS 6, 4 and 2) in eastern Beringia, and the value of relict permafrost in reconstructing past environmental conditions.

Depositional model and stratigraphic framework of the Jurassic Gordondale member, Fernie formation

B Stoner and N Harris

The Gordondale Member is a highly radioactive, organic-rich shale, which comprises the basal portion of the Fernie Formation in West-Central Alberta and Northeastern British Colombia. The Gordondale was deposited on a platform around the edge of the North American Craton during the Early Jurassic. Recent research has shown that Gordondale Member is the primary focus of unconventional petroleum exploration efforts, as it has developed a reputation of being one of the most oil-prone source rocks within the Western Canadian Sedimentary Basin.

Despite the economic importance of the Gordondale Member, limited research has been published on the Gordondale. The geological relationship with the correlative Nordegg and Red Deer Members has never been fully explained. This study involves correlating 430 well-bore logs on geoSCOUT in order to trace the extent the Gordondale member and its 3 major subfacies. The data obtained from the well-bore logs is used to generate isopach maps of the Gordondale and its subfacies, in order to develop a depositional model, which includes its stratigraphic relationship with the correlative, basinal equivalent Nordegg Member. Early results of the study have shown the Gordondale Member extends further south, and further west than previous studies have shown. Results have have also shown the Red Deer Member (which serves as a transitional facies between the Nordegg and Gordondale Member) extends further NE than outlined by previous studies.

Seasonal and inter-annual changes in water isotopes (^{18}O and ^{2}H) from the North Saskatchewan River and Whitemud Creek

Z Tingxian and D Froese

Hydrogen and oxygen isotopes in river water can provide information about river hydrological processes and climatic change. Building on a previous study by Chamzuk (2015), a new $\delta^{18}O$ and $\delta^{2}H$ time series of the North Saskatchewan River (NSR) is reported between September 2014 and December 2015 based on samples collected twice weekly. To better characterize the Prairie tributaries of the NSR, isotope time series of Whitemud Creek (WMC), one of the tributaries, is also reported from weekly samples collected from April to November 2015. A Local Meteoric Water Line (LMWL) for the Edmonton area is estimated as $y = 6.9x - 17.1$, while Local Evaporation Lines (LEL) of $y = 6.9x – 17.0$ and $y = 6.0x - 39.5$ for NSR and WMC respectively are defined. The isotopic data display marked seasonality and reveal temporal variations of river hydroclimate conditions and processes over different timescales. As a small watershed, the WMC isotopic values are directly affected by individual rainfall events on diurnal to weekly timescales, and significant evaporation on seasonal timescales. In contrast, the NSR isotopic values are largely inherited from the isotopically depleted mountain headwaters and display modest seasonality. The most significant seasonal changes, ca. 1‰ in $\delta^{18}O$, result from river break-up and freeze-up, largely driven by changing contributions from isotopically enriched tributary discharge. Inter-annually, changes in regional hydroclimate conditions give rise to dynamics in source water contributions to the NSR, which are recorded in ca. 0.6‰ change in $\delta^{18}O$ values.