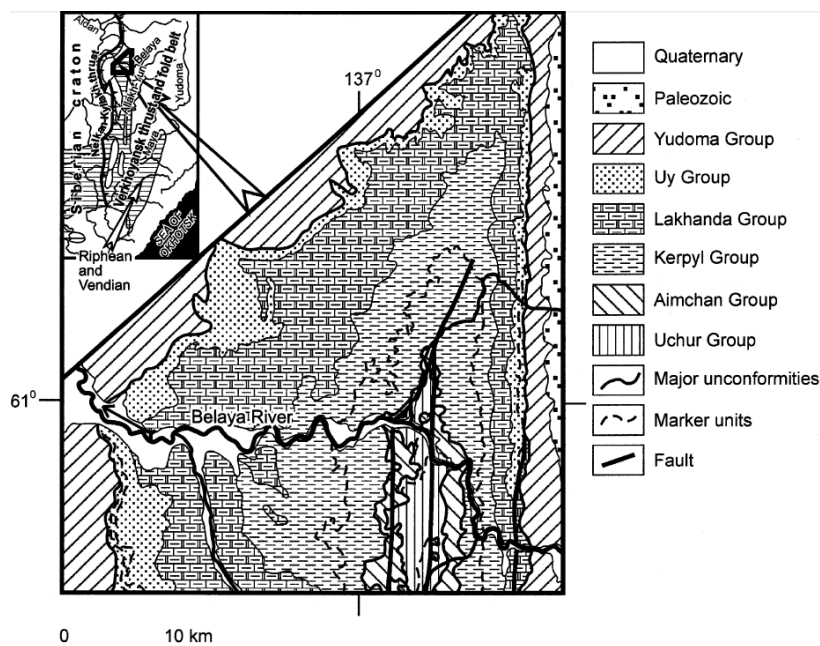


## American Philosophical Society – Lewis and Clark Fund for Field Exploration and Research Project Report

### SUMMARY OF PROGRESS

The main goal of the project was to sample a section of carbonate across the Mesoproterozoic and into the Neoproterozoic. These samples were then to be measured for weathering proxies to better understand the impact of tectonics on the early evolution of Eukaryotes, and the rise of oxygen. I first travelled to Eastern Russia working on the Gornostakh anticline on the Aldan Shield to sample the Ryphean carbonates. Sections were measured and sampled in the field. In addition, I then travelled to Northern China to sample the Yanshan Basin, a well dated carbonate basin north of Beijing, China. I sampled drillcores which penetrated most of the Mesoproterozoic sections, a few hand samples were taken which spanned sections not sampled by drillcore.

The proposed step-leaching method, which would better limit contamination of isotope signals from non-carbonate phases, has been successful on Mesoproterozoic samples from a variety of basins. Those results will be presented in August at the international Goldschmidt conference in Prague, Czech Republic (Bellefroid et al., 2015). Samples from both basins have been analysed for Li isotopes to set a baseline for the Mesoproterozoic. Samples from Russia and China have been prepared for bulk carbonate trace analysis, once complete, samples will be selected for step-leaching analysis followed by Sr isotope analysis.



### RYPHEAN SECTION, ALDAN SHIELD, SOUTH-EASTERN SIBERIA

The Riphean sections consist of a group of Mesoproterozoic and Neoproterozoic sedimentary passive margins which wrap around the Siberian craton in eastern Russia. Often reported as a single unit, the Riphean sections are better described as a series of diachronous sedimentary groups intersected by significant depositional hiatuses. In July 2014 I travelled to Ryphean aged sections exposed in the Uchur-Maya region of the south-eastern Siberian craton (Fig. 1). The Gornostakh anticline along with the Yudoma-Maya depression further to the south

comprise the most complete and best exposed sections containing up to 14 km of stratigraphy. While the Yudoma-Maya section is mostly comprised of siliciclastics, the Gornostakh anticline is dominated by carbonates and presents a better

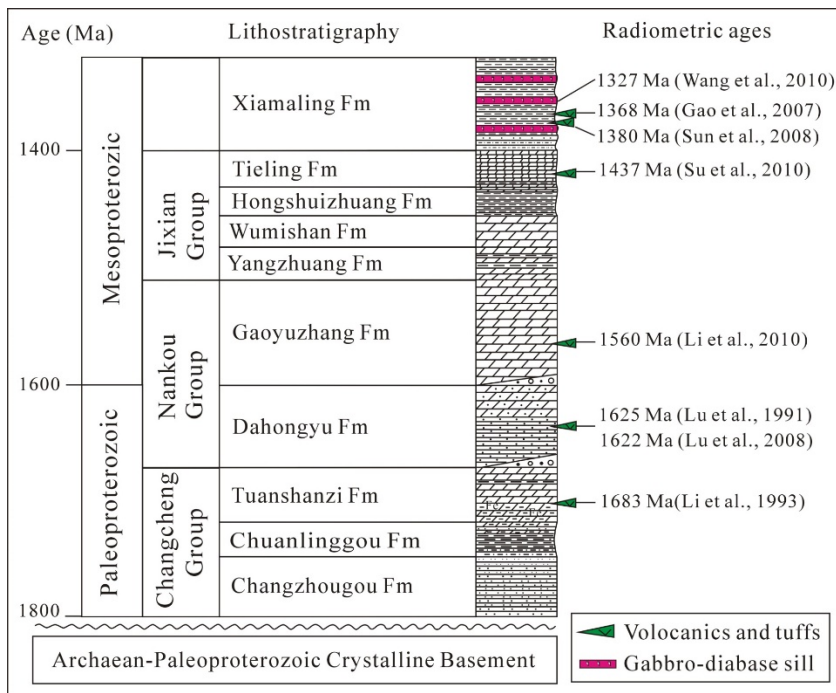
*Figure 1: A simplified geological map of the Gornostakh Anticline. Samples were collected along the Belaya River. Taken from Khudoley et al. (2015).*

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target. Samples were collected through the majority of the exposed carbonate sequence including the Aimchan, Kerpyl, Lakhanda and Ui groups. I collected 265 samples over roughly 1700 m of measured carbonate section. Each group has been dated using a combination of Glauconite-Illite ages and detrital zircon ages. The sampled sections cover a range of ages from roughly 1.6 Ga to 0.87 Ga covering the early rise of eukaryotes and the break-up of the supercontinent Nuna. Glauconite-Illite and detrital zircon ages can be very unreliable, thus our team also samples black-shales for Re-Os analysis to confirm those ages. Precise GPS coordinates for each section can be sent upon request.



## YANSHAN BASIN, NORTH CHINA

The North China craton, which is the Chinese part of the Sino-Korea platform, consists of a variety of exposed rock types and exposes a time transect from the Archean to the late Proterozoic. Mesoproterozoic carbonate dominated strata are well exposed on the northern edge of the craton within the Yanshan basin exposing the Jixian, Changcheng and Qingbaikou groups. The Yanshan basin sediments consist of a mix of limestones, dolomites and fine grained

siliciclastics. In addition, the Yushan basin sediments contain multiple ash beds which have been dated using U-Pb geochronology on zircons constraining the age (fig. 2).

Figure 2: A generalization of the Yanshan Basin Mid-Proterozoic Stratigraphy. Drills and hand samples were collected from the Xiamaling Fm, the Tieling fm., the Wumishan fm., the Yangzhuang fm and the Gaoyuzhang fm. Figure from Zhang et (2009), see references therein.

I travelled to North China and working with Prof. Chunjiang Wang from the China University of Petroleum, Beijing, I sampled a selection of drill cores as well as hand samples from outcrop which crosscut the majority of the basin. Precise GPS coordinates can be sent upon request.

## GEOCHEMICAL ANALYSIS

In an attempt to reconstruct the impact of tectonics on climate and geochemical cycles, I am developing and applying two weathering proxies to the Mesoproterozoic and early Neoproterozoic. The first is strontium isotopes ( $^{87}\text{Sr}/^{86}\text{Sr}$ ), a well-developed weathering proxy which measures net weathering rates.  $^{87}\text{Sr}/^{86}\text{Sr}$  has been attempted in the mid-Proterozoic previously (Shields and Veizer, 2002), however it suffers from poorly preserved samples and contamination from clays. Prior to the full application of Sr isotopes on Mid-Proterozoic carbonates, a re-analysis of alteration tests and new dissolution techniques is required. I am presenting on a new geochemical technique which attempts to separate altered phases and clay dissolution from primary carbonate phases in August at the international Goldschmidt

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conference in Prague, CZ (Bellefroid et al., 2015). New alteration tests are currently being developed and I hope to present these in the late fall. Samples from both Siberia and China are cut and powdered and prepared for analysis in the lab. Bulk analysis will be performed first to identify samples with limited alteration, once complete samples will be selected for multi-leach analysis and measured for Sr isotopes.

In addition to Sr isotopes, I am developing Li isotopes ( $\delta^7\text{Li}$ ) for the Precambrian. Another weathering proxy,  $\delta^7\text{Li}$  measure weathering intensity and coupled with  $^{87}\text{Sr}/^{86}\text{Sr}$  allows for a two dimension view of Mid-Proterozoic weathering. Samples were selected based on visual criteria and measured for  $\delta^7\text{Li}$ .  $\delta^7\text{Li}$  has not been attempted in the Mid-Proterozoic before with only a single previous attempt in the Precambrian (Pogge von Strandmann et al., 2014). The current study is meant to form a baseline for the Mid-Proterozoic, to both know the range of values expected and the variability. I will be presenting these results this fall at GSA and hope to publish these results in the late fall or early winter.

#### CONCLUDING REMARKS AND FUTURE WORK

The samples collected using funds from the Lewis and Clark Fund for Field Exploration and Research in Astrobiology forms the basis to a growing collection of Mid-Proterozoic carbonates in my possession. They will be important for the development and application of Sr and Li isotopes to better understand the impact of weathering. However, these will also be used for a number of other proxies to better understand this crucial time period in earth history, including Nd isotopes, Zn isotopes and possibly Cr isotopes.

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