I. Introduction

The early geological record, particularly between 4.5 and 2.5 Ga, provides most information pertaining to the origin and early evolution of the Earth. Os isotopes and highly siderophile element (HSE: Re, Os, Ir, Ru, Pd, and Pt) abundance systems provide valuable information about early Earth processes. The main goal of this study is to place additional constraints on the absolute HSE abundances and time-integrated Re/Os ratio of the early Archean mantle using ~3.3 Ga Ruth Well komatiites from the Pilbara Craton in Western Australia.

II. Background

The drill core samples were collected by Prof. Euan Nisbet in late 1970s at the Ruth Well locality (Fig. 1). They represent several sections of differentiated komatiite lavas flows.

III. Hypotheses

1. RW komatiites were derived from deep melting in the majority stable field, which resulted in depletions in Al and heavy REE. This source was also depleted in highly incompatible lithophile trace elements.
2. The mantle source of the RW komatiites evolved with long-term chondritic Re/Os due to the presence of late accreted component.
3. The mantle source of the RW komatiites was deficient in the HSE relative to modern estimates for Bulk Silicate Earth (BSE) as a result of incomplete homogenization of late accreted component within the mantle domain from which the komatiites were derived.

IV. Methods

• Powders for chemical analysis were prepared using diamond rock saw, alumina jaw-crusher, alumina shatter box and disk mill.
• Whole-rock major element concentrations were obtained via X-Ray Fluorescence (XRF) at Franklin and Marshall College, PA.
• Os in three samples was separated using solvent and back extractions, and then purified by micro-distillation. Os ratios were analyzed using Thermo-Fisher Trottin Thermal Ionisation Mass Spectrometer (TIMS).
• Rhenium, Ru, Pd, Ir, and Pt were separated using anion exchange chromatography. These elements will be analyzed via the Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

V. Results

Figure 2. BSE-normalized (Hofmann, 1988) abundances of lithophile trace elements in Ruth Well komatiites. The lavas are depleted in both LREE and HREE and show a positive U anomaly.

Figure 4. Comparison of Al abundances between late Archean and Ruth Well komatiites (%). Ruth Well komatiites are clearly depleted in Al compared to the late Archean komatiites.

Figure 5. Plot of Al/Ti vs. Gd/Yb for komatiites of different ages. The Ruth Well komatiites plot in the field of Al-depleted, or Barberton-type, komatiites indicating higher temperatures of magma generation in the early Archean and deeper melting in the mantle stability field. Data were compiled from Puchtel et al. (2009a, b; 2013, 2016a, b, 2018).

VI. Discussion and preliminary conclusions

• The RW komatiites are characterized by good preservation of their textural and chemical features.
• The RW komatiites were depleted in LREE and other highly incompatible lithophile trace elements, but show positive Th and U anomalies.
• The RW komatiite melt formed at a depth of >450 km in the mantle, in the stability field.
• Rhenium behaved incompatible during RW lava differentiation. This type of behavior is similar to that in the 3.55 Schapenbank komatiite system, although the RW source was richer in Os and possibly other HSE.
• The Os isotopic data obtained indicate a spread in 187/185Os sufficient to yield an isochron provided the Re was immobile during alteration.

VII. Next steps

1. Hypotheses 2 and 3 will be tested once the Re and other HSE abundance data are obtained. The chemical separations of HSE have been completed for the three pilot samples and the mass-spectrometry will be completed as soon as the new ICP-MS instrument (the Neptune) is up and running.
2. Trace element abundance data for the remaining samples will be obtained during the summer of 2018.
3. The chemical separations of HSE and mass-spectrometry for the remaining samples will be completed in the summer and fall of 2018.
4. The final version of the 394 senior thesis will be completed in the fall of 2018.

Figure 6. Hypothetical Re-Os isochron diagram for the three samples of the RW komatiites analyzed. Rhenium data have not been collected yet. Based on the Os isotopic data, the Re abundances have been calculated assuming the data plot on the chondritic evolution line at 3.35 Ga.