Jacob N Cammack Received: 8/4/2014

SIMS Microanalysis of the Strelley Pool and Dresser Formations. Insight into Fluid Sources and Paleoenvironments.

Project Summary:

My thesis research employs SIMS *in-situ* microanalysis to unravel the $\delta^{18}O$ and $\delta^{13}C$ variations in the micro-textural, and generational quartz and carbonate varieties of the Paleoarchean Pilbara cherts in the Strelley Pool (SPF) and Dresser Formations. The enticing outcome of this research may include locating micron-scale cements and domains within the cherts and carbonates which preserve clues pertaining to their original paleoenvironmental conditions of formation. Knowledge of the paleoenvironments surrounding ancient biospheres aids in delineating the ever expanding parameters for life's persistence, providing further constraints for exploration and identification of extraterrestrial life. Initially, research will center on the 3.4 Ga Strelley Pool Formation located in the Pilbara Craton of Western Australia. The Strelley Pool Formation contains the best preserved putative stromatolites in the region . These rocks are well mapped and characterized by geologists, providing an excellent springboard for further discovery within the probable Paleoarchean biosphere (Van Kranendonk et al., 2002, 2003, 2007; Van Kranendonk and Barley, 2010; Wacey et al., 2010; Hickman et al., 2012; Hickman, 2008).

Many authors have characterized Paleoarchean cherts based on , trace element, $\delta^{18}O$, $\delta^{30}Si$ and Si/Ge, via bulk analysis methods (Knauth and Lowe, 1978; Hamade et al., 2003; Van Kranendonk et al., 2003; Jaffrés et al., 2007; Robert and Chaussidon, 2006; van den Boorn et al., 2010). Others have characterized Paleoarchean carbonates $\delta^{18}O$, $\delta^{13}C$, $^{87}Sr/^{86}Sr$ and trace elements via bulk analysis (Shields and Veizer, 2002; Prokoph et al., 2008; Van Kranendonk et al., 2003; Jaffrés et al., 2007). Very few have attempted in-situ analysis techniques and no studies to date have focused on the SPF (Marin-Carbonne et al., 2014; Heck et al., 2011). Our study will build on bulk analyses of $\delta^{18}O$ from samples collected from the 3.4 Ga Strelley Pool Formation conducted by Valley and Cavosie, which yielded $\delta^{18}O$ values up to 25.7 ‰ VSMOW using bulk analysis techniques - some of the highest values measured in the Paleoarchean (unpublished data). Using the petrographic microscope and SEM (BSE & CL) this study has identified several quartz and carbonate textures and generations. We are providing *in-situ* measurements conducted via SIMS to delve into the microtextural $\delta^{18}O$ and $\delta^{13}C$ variations within the cherts and carbonates from the 3.4 Ga Strelley Pool Fm., and the 3.5 Ga Dresser Fm. Recently collected SIMS $\delta^{18}O$ data reveals isotopic variation exists between several quartz textures and generations. This data has provided evidence that these differences may reflect unique temperatures and fluid sources pertaining to the respective quartz textures (this study, unpublished). $\delta^{30}Si$ and Si/Ge *in-situ* data may lend strong evidence to the uniqueness of fluid sources (Hamade et al., 2003; Heck et al., 2011; van den Boorn et al., 2010; Marin-Carbonne et al., 2014) of the cherts' respective textures and generational differences on the micron scale. Carbonates span several varieties including ankerite, dolomite, and calcite. *In-situ* $\delta^{18}O$ and trace element data may reveal contrasts between carbonate varieties or their petrographic relationship within the cherts. $\delta^{18}O$ & $\delta^{13}C$ will further the case for unique or homogenous sources for the carbonates and add evidence to their temperature histories. In the case of equilibrium, the quartz-carbonate $\delta^{18}O$ geothermometer may be applied to determine the local temperatures of their respective textures. The micron scale *in-situ* analysis capabilities of the SIMS are essential for measuring meaningful thermometry in zoned samples such as these.

Fieldwork Summary:

We located our samples with expert guidance from Martin Van Kranendonk and Arthur Hickman who have characterized the regional geology working for the Gelogical Survey of Western Australia (GSWA). Samples were primarily collected and described from four locations of the Strelley Pool Formation and Dresser formation cherts and carbonates: South of the Trendal Locality, Unconformity Ridge, Strelley Pool type locality and Dresser Cherts. Samples were also collected from the ABDP-8 drill-core at the GSWA core library in Perth, Australia. A total of eighty-six samples were collected from the region. Figure 1 shows the regional geology and sampling locations. Table 1 reviews the members of the Strelley Pool Formation.

Samples were collected from weathered rocks (member 5) and carbonaceous stromatolites (member 2) on strike with the Trendal Locality to the South of the Trendal Reserve. The primary purpose of the sampling this area is to test whether the $\delta^{18}O$ values of lateritic quartz in member 5 the area are similar to $\delta^{18}O$ obtained from other Trendal Locality samples (Figure 2A). This will allow for testing the lateritic $\delta^{18}O$ values and whether their textures are similar to or different from Trendal samples we have already analyzed via SIMS. Stromatolitc carbonate samples without obvious quartz replacement laminae were collected to test if these carbonates contain earlier textures pre-dating nearly-pervasive regional silicification and recrystallization (Figure 2B).

Unconformity ridge samples were collected to test their relationship to the ABDP-8 drilled in the subsurface below the local outcrop. We collected a representative sample set both from the surface outcrop and subsurface ABDP-8 core (Figure 2C). This will allow for a comparison of $\delta^{18}O$ at the surface and at depth at a single locality. It is possible that the ABDP-8 core may have experienced less diagenetic and lateritic alteration and may have preserved early diagenetic cherts and microcrystalline quartz cements deposited in member 1 sandstones (table 1) during the Paleoarchean. These cements will offer ideal SIMS targets for paleoenvivironmental signals contemporaneous with putative Archean stromatolitic life in the region.

Samples were collected from the basal sandstone and conglomerate (member 1) from the Strelley Pool Fm. type locality. These samples were collected to compare with the $\delta^{18}O$ values of the Trendal locality and to search for early diagenetic cements in the sandstones and conglomerates in this area (Figure 2D).

Our Dresser Fm. samples are from a hydrothermal vein system (Figure 2F) which terminates in bedded sediments (Figure 2E) at different horizons and permeates laterally suggesting that the sediments and hydrothermal activity were simultaneous during their deposition. $\delta^{18}O$ of these vein systems and silicified sediments will be tested for trends that may reveal Paleoarchean hydrothermal zones with temperatures within the tolerance range of hyperthermophillic archaea (Figure 2c) (Vankranendonk, 2006).

Ongoing work on the samples we collected during this fieldwork includes processing the samples for thin sections, and $\delta^{18}O$ surveys via laser fluorination (Spicuzza et al., 1998). These steps will help to identify the most promising samples to be analyzed via SIMS for early cements, and microtextural domains which may reveal paleoenvironmental signals from early earth.

Figures and Tables:

Member 5:
Upper clastics: breccio–conglomerate with subangular to rounded clasts of lithologies from lower in the formation, including black cherts, laminated silicified carbonates, crystal fan fragments, megaquartz, green-grey cherts and jaspilitic cherts

Member 4:
Upper cherts: subdivided into banded, fine-grained black-white-jaspilitic chert, very fine-grained green ashy chert, fine grained stratiform dark grey-light grey-white chert with laminae less than 5mm wide, and concordant massive black chert

Member 3:
Stromatolite-bearing chert interbedded with crystal fans

Member 2:
Grey-white chert: fine grained silicified laminated carbonates

Member 1:
Sandstone: discontinuous basal sandstone and conglomerate

Table 1: Members of the Strelley Pool Formation used in above descriptions. Member 1 is the oldest stratigraphic unit.

(Wacey et al., 2010)

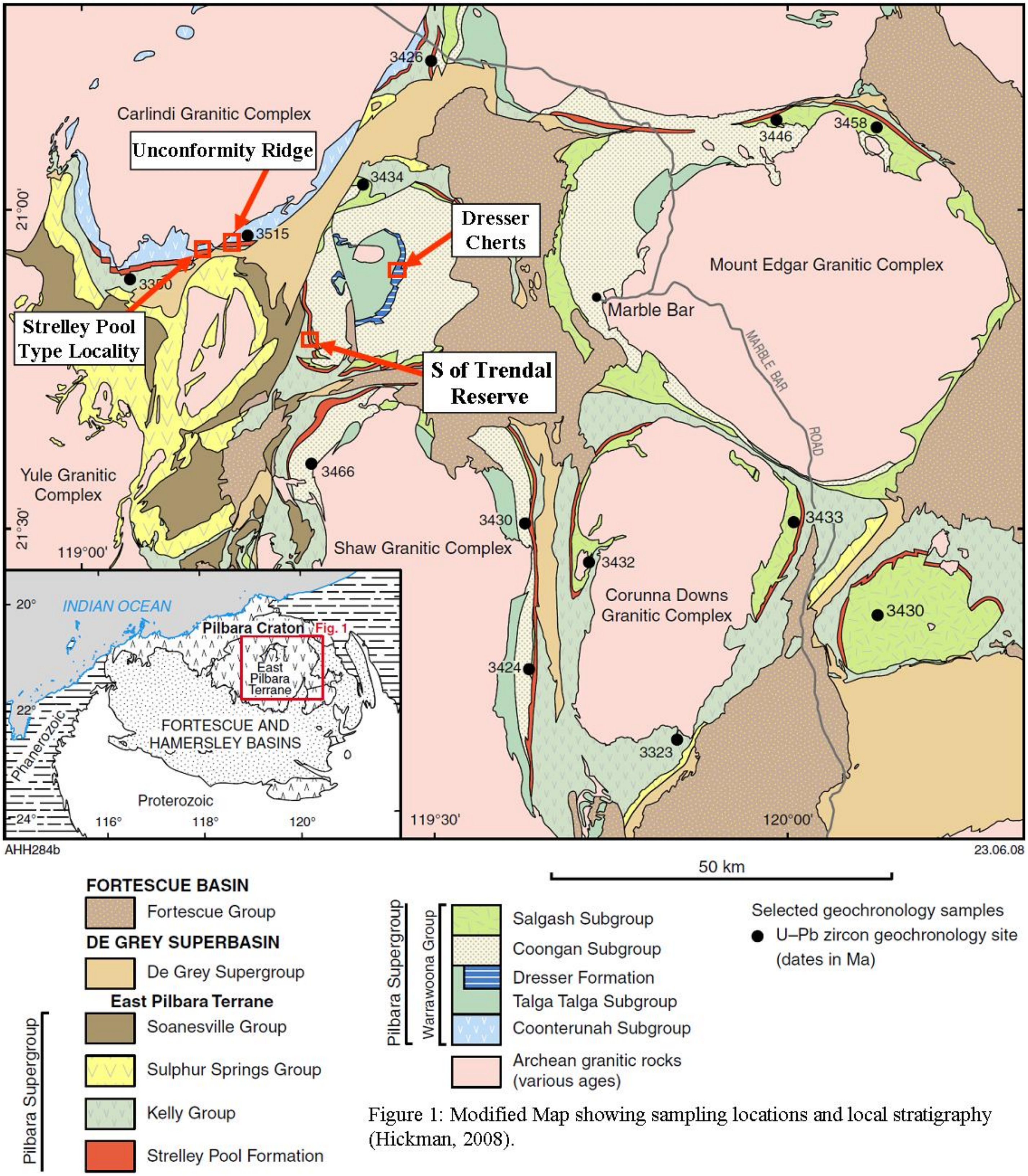

Figure 1: Modified Map showing sampling locations and local stratigraphy (Hickman, 2008).

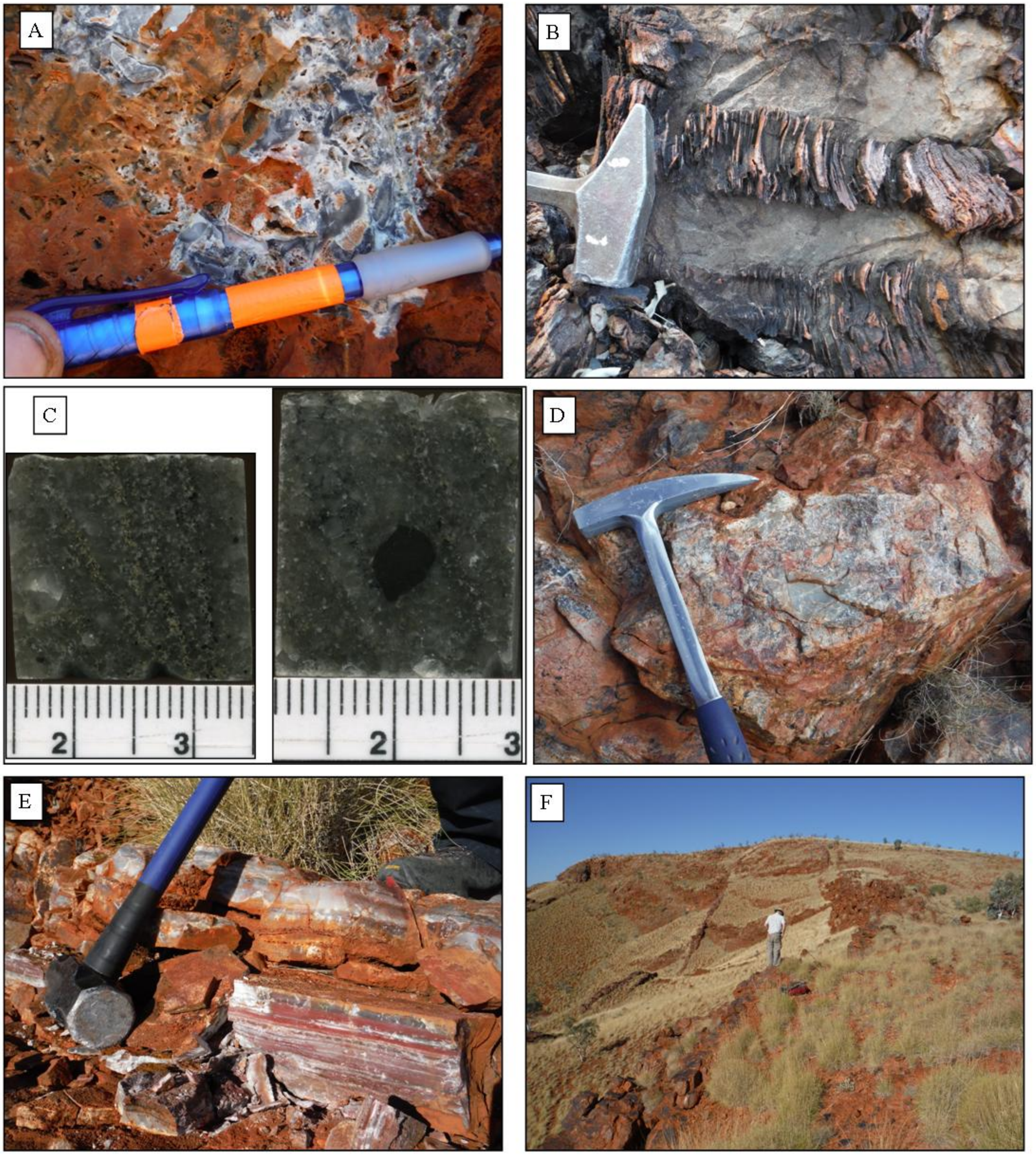

Figure 2: Photos of Field areas and selected samples.

A: Lateritic weathering on the member 5 breccia near the Trendal Locality.

B: Dolomotized Stromatolites S. of the Trendal locality. Flat grey areas are not apparently silicified.

C: Basal sandstone of the ABDP-8 drillcore. Often contains detrital pyrite and black chert clasts.

D: Basal conglomerate of the Strelley Pool Formation at the Strelley pool type locality.

E: Bedded chert sediments over the hydrothermal vein system at the Dresser Fm.

F: Looking east up hydrothermal vein system stratigraphically beneath the Dresser Fm. forming resistant ridges

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