LUTETIUM-HAFNIUM AND URANIUM-LEAD SYSTEMATICS OF EARLY-MIDDLE ARCHEAN SINGLE ZIRCON GRAINS. Yu. Amelin[1] , D.-C.Lee[2], and A. N. Halliday[3], [1]Department of Earth Sciences, Royal Ontario Museum, Toronto, ON M5S 2C6, Canada (yuria@rom.on.ca), [2]Department of Geological Sciences, University of Michigan, Ann Arbor MI 48109, USA (dclee@umich.edu), [3]Department of Earth Sciences, ETH, Zurich, CH-8092, Switzerland (halliday@erdw.ethz.ch).

Introduction: The Lu-Hf system in zircon is an excellent isotopic tracer of mantle depletion and crustal growth recorded in ancient rocks. It was successfully used to examine the degree of early Archean mantle depletion [1,2] and appears to give tighter constraints than the Sm-Nd system in whole rock samples. High sensitivity multiple collector ICPMS permits precise analysis of Hf from single zircon grains [3], which was impossible to do previously using TIMS.

One problem that remained unresolved in previous studies is the complexity of zircon populations, which adds uncertainty to initial Hf ratios. Multiple episodes of zircon growth and ancient Pb loss, common in early Archean rocks, result in $^{207}Pb/^{206}Pb$ ages that are variable between and within zircon grains. Using biased age values produces inaccurate $\varepsilon_{Hf}(T)$ by as much as 2.2-2.5 ε-units per 100 m.y.

Results: We have studied zircons from 15 rocks from four early-middle Archean areas. In order to evaluate the role of heterogeneity of zircon populations and to obtain the most reliable $\varepsilon_{Hf}(T)$, we have analyzed several abraded zircon grains (from two to eight) from each sample for both Lu-Hf and U-Pb. Hf isotopic analyses with precision better than 1-1.5 ε-units (2σ) were obtained from grains weighing 0.003-0.010 mg. The $\varepsilon_{Hf}(T)$ values are calculated using $^{207}Pb/^{206}Pb$ ages of the same grains measured by ID-TIMS.

Itsaq Gneiss Complex, W. Greenland. Three gneiss samples from the Isua area contain zircons with little discordance (0–5%) and $^{207}Pb/^{206}Pb$ ages of ca. 3690 Ma. Their $\varepsilon_{Hf}(T)$ are relatively uniform (internal variations less than 1.5 ε-units) and have average values from +1.3 to +2.7. One of the samples also yielded 3730 Ma grains with $\varepsilon_{Hf}(T)$=+2. An augen gneiss sample from the Nuuk area yielded 3620-3600 Ma zircon grains with $\varepsilon_{Hf}(T)$ between +1.6 and +3.0.

Acasta Gneiss Complex, NW. Canada. U-Pb zircon data (0-15% discordant) from four tonalitic and amphibolitic gneisses and a granite form scattered linear arrays with upper concordia intercepts at 3600-3540 Ma, and lower intercepts at 1000-2100 Ma. Older grains with $^{207}Pb/^{206}Pb$ ages up to 3790 Ma are present in some samples. The Hf isotopic systematics of the Acasta gneisses is far more complex than that of zircons from other studied areas. The $\varepsilon_{Hf}(T)$ values have internal variations of 3-5 ε-units. In two samples $\varepsilon_{Hf}(T)$ correlate with degree of discordance. The predominant zircon populations have $\varepsilon_{Hf}(T)$ between 0 and -3. In addition, two amphibolite samples contain zircon grains with $\varepsilon_{Hf}(T)$= -4.6 to -5.

Barberton Mountain Land, S. Africa. Zircons from tonalitic-trondhjeimitic gneisses are characterized by large and variable discordance of 3-40%. Discordia lines with excess scatter have upper intercepts of 3520-3510 Ma for two gneisses of the pre-Onverwacht stage, and 3440 Ma for two gneisses of the Onverwacht stage. Lower intercepts close to zero suggest that recent Pb loss (due to tropical weathering?) is the main cause of discordance. $\varepsilon_{Hf}(T)$ in some samples vary with discordance. The $\varepsilon_{Hf}(T)$ values of the gneisses, based on least discordant zircon grains, are between +1.5 and +3.6.

Pilbara Craton, W. Australia. Two samples of felsic volcanics contain uniform 3450 Ma zircon populations with little discordance (0-7%). Their $\varepsilon_{Hf}(T)$ are internally homogeneous with average values of +1.9 and +4.3. The third felsic volcanic rock is 3320 Ma old with $\varepsilon_{Hf}(T)$=+1.9.

Discussion: Application of U-Pb and Lu-Hf methods to the same zircon grains and analysis of small samples (single grains or grain fragments) are crucial for finding closed geochemical systems and thereby obtaining reliable Hf isotope data from early Archean rocks.

Our data suggest that the Itsaq, Barberton and Pilbara complexes were formed by a crust derived from depleted mantle. These complexes grew over 100-200 m.y. periods mainly by addition of juvenile crust, while reworking of older crust was less significant. The higher $\varepsilon_{Hf}(T)$ values in the 3520-3440 Ma Barberton and Pilbara rocks compared to the 3690 Ma Itsaq gneisses is consistent with uniform or increasing mantle depletion during the early Archean.

In contrast, the Acasta Gneiss Complex was probably formed of very old crust (>3800–4000 Ma) that was extensively reworked by several events at 3750–3540 Ma [4]. This supports the similarity between the Acasta Gneiss Complex and the source of 4200–3400 Ma Jack Hills detrital zircons [3].

References: [1] Vervoort J. D. et al. (1996) *Nature, 379,* 624–627. [2] Vervoort J. D. and Blichert-Toft J. (1999) *GCA, in press.* [3] Amelin Yu. et al. (1999) *Nature, in press.* [4] Bowring S. A. and Williams I. S. (1999) *CMP, 134,* 3–16.