THE "LATE VENEER" ON EARTH: EVIDENCE FROM EOARCHEAN ULTRAMAFIC SCHISTS (METAKOMATIITES). E. A. Frank[1,2,*], W. D. Maier[3], and S. J. Mojzsis[1,2,4], [1]University of Colorado, Geological Sciences, Boulder, CO, 80309-0399 USA; [2]NASA Lunar Science Institute, Center for Lunar Origin and Evolution (CLOE); [3]University of Oulu, Linnanmaa, 90014 Oulu, Finland; [4]Laboratoire de Géologie de Lyon, Université Claude Bernard Lyon 1, Villeurbanne, France. [*]elizabeth.frank@colorado.edu

Introduction: During planetary differentiation, the highly siderophile elements (HSEs) are expected to have partitioned strongly into growing Ni-Fe cores; the HSEs include Au, Re, and the Platinoids (Ru, Rh, Pd, Os, Ir, and Pt). This dynamic process should have resulted in pronounced HSE mantle depletion relative to CI compositions, but contemporary peridotites show higher than expected HSE concentrations. One explanation for this enhancement is via a belated accretion event termed the "Late Veneer", which may have augmented ~1% of Earth's mass subsequent to core closure [1, 2]. Evidence also exists for Late Veneers on the Moon and Mars based on meteorites and Apollo samples [3, 4]. We report here how the evolution of this HSE signature in the terrestrial mantle can be tracked using the trace metal compositions of komatiites – a class of ultramafic extrusive rocks that sourced from the lower-mid mantle – back to Eoarchean (ca. 3.85 Ga) time.

Delivery: Dynamical models of planet formation predict that after the Giant Impact (GI) formation of Earth's Moon, sufficient unaccreted mass remained in the inner solar system to provide for Late Veneers [5]. Notably, HSE enhancements in Earth as well as lunar and martian meteorites seem to be in chondritic relative proportions [3, 4]. Two endmember scenarios have been proposed to account for the delivery of an HSE payload to the mantle: (i) one large, differentiated impactor or (ii) many small, undifferentiated impactors. Assuming CI composition, the cumultative mass required to reconcile the terrestrial mantle's HSE enhancement corresponds to a single differentiated body ~ 2700 km in diameter (or about the size of Neptune's moon Triton) [5].

If there had been one large, differentiated Late Veneer impactor, its core had to have either been suspended in the mantle and/or broken up and emulsified to avoid reaching the core. Suspension is deemed unlikely [6]. Alternatively, the single impactor could have accreted to the primordial Earth as a "fiery rain" somewhat akin to a miniature version of the Giant Impact [e.g. 7], as a "hit-and-almost-run" collision from a shallow-angle grazing trajectory. This scenario is currently being investigated. Having multiple small, undifferentiated impactors helps to overcome the core suspension problem, but requires a sizeable population of leftover planetesimals from accretion at this time.

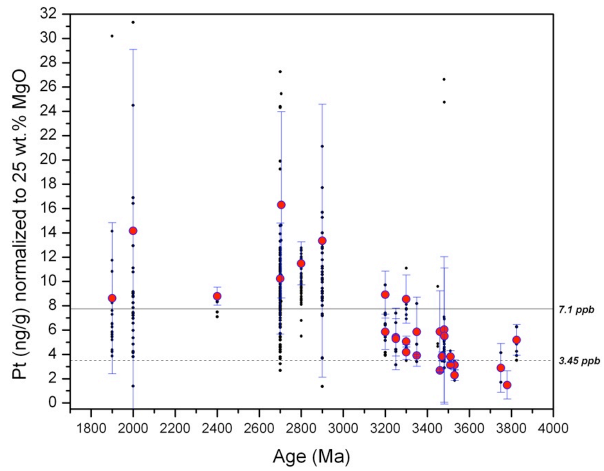

Figure 1: Pt komatiite data from various locales plotted by age; the three points 3600 Ma are data since [12]. The mean modern peridotite Pt concentration is 7.1 ppb, while the mean Pt concentration of these points is 3.45 ppb.

Timing: The Giant Impact occurred 30-100 Myr after solar system formation [8-10] and it should have geochemically reset the core [6]. Although a supplementary delivery of 1% of Earth's mass by the Late Veneer is a relatively minor contribution compared to the GI, such an influx should have nevertheless effectively destroyed and re-melted the crust. Hadean zircon analyses from the Narryer Gneiss Complex in Western Australia indicate that the first continental crust solidified ~90-160 Myr after the GI [11]. Hence, these two events place temporal bounds on when the Late Veneer might have taken place.

Geologic Record: Komatiites have been used to track the evolution of mantle HSE abundances. Platinum and ruthenium data in particular suggest a progressive mixing-in of HSE-enhanced mantle over time, until reaching present-day peridotite abundances [12]. We present new HSE data of ultramafic schists of komatiitic composition (**Figures 1 and 2**) – some with relict pillow structures – collected from supracrustal enclaves of the Færinghavn terrane, southern Itsaq Gneiss Complex in West Greenland (~3.77-3.83 Ga), and the Nuvvuagittuq supracrustal belt in northern Québec (Canada; 3.75-3.78 Ga). Our new data for these komatiites reveal low Pt and Ru abundances compared to more recent komatiitic rocks [12]. Our interpretation of these data is that the original HSE concen-

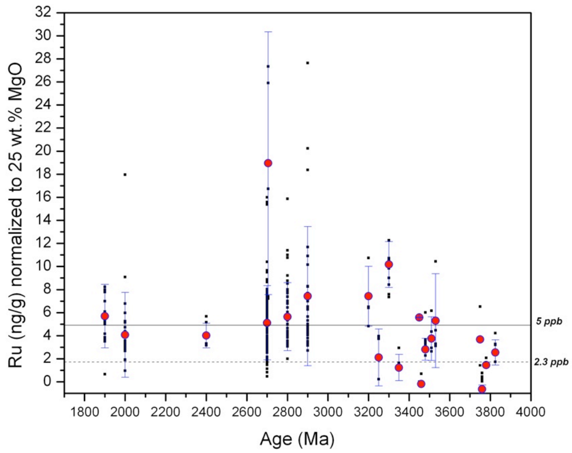

Figure 3: Ru komatiite data from various locales. The mean peridotite Ru concentration is 5 ppb, and the mean Ru concentration of the new data >3600 Ma is 2.4 ppb, showing a similar trend to Pt.

tration in the mantle source of Eoarchean and Paleoarchean komatiitic lavas was at least a factor of 2 lower than post-Archean values. These data for the oldest komatiitic rocks record HSE abundances prior to the mixing-in of a "Late Veneer" and homogenization of the mantle. We also postulate that the pre-Archean mantle preserved strong chemical heterogeneities in HSEs.

Volatile Inventory: An outstanding problem in planetary science is how Earth acquired its volatiles. The GI is expected to have depleted Earth of volatiles [7]. Because the Late Veneer followed the GI, it could have been an important means by which Earth obtained its water.

Implications: The elevated HSE concentrations in the terrestrial, lunar, and martian mantle samples may be evidence that the Late Veneer was an event that occurred across the entire inner solar system. Indeed, it has been suggested that a Late Veneer impactor may have caused Mars' Borealis Basin [5]. Mercury and Venus could have experienced Late Veneers as well. MESSENGER observations show komatiites on Mercury's surface [14], and Venus has evidence for a history of plume-driven volcanism. This could dredge up material from the lower-mid mantle, but without rock samples we must search for evidence of a Late Veneer in its atmosphere [15].

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