REVIEW OF GEOCHEMICAL CONSTRAINTS ON THE FORMATION AND COMPOSITION OF THE LUNAR CORE. E. S. Steenstra[1] and W. van. Westrenen[2], [1]Faculty of Earth and Life Sciences, VU University Amsterdam, The Netherlands (e.s.steenstra@vu.nl).

Introduction: The pressure (*P*) – (temperature) *T* conditions during lunar core formation and core composition provide constraints on key processes during the initial interior thermal and chemical evolution of the Moon. For example, PT conditions of core formation yield estimates for the depth of the lunar magma ocean. The chemical composition of the lunar core controls its physical properties (e.g., density, liquidus), crystallization path, and therefore affects the onset and duration of a lunar core dynamo [1-3]. It will also affect the metal-silicate distribution of heat producing elements between the mantle and core [4]. Since the publication of New Views of the Moon 1, siderophile element depletions in the lunar mantle have proven to be an important tool to investigate the *P-T* conditions during lunar core formation [5,6] and provide independent constraints on the composition of the lunar core [5,7]. Here, we provide a brief summary of recent work that studied the *P-T* conditions that prevailed during core formation in the Moon, as well as constraints on lunar core composition.

Lunar mantle siderophile element depletions: The stepwise depletion pattern of siderophile elements in the lunar mantle, relative to its building blocks, strongly suggests full equilibration between metal and silicate (Fig. 1). As the metal-silicate partitioning of siderophile elements is dependent on *P*, *T*, oxygen fugacity (fO_2) and composition, the extent of their depletions in the lunar mantle reflect the conditions that prevailed during lunar core formation.

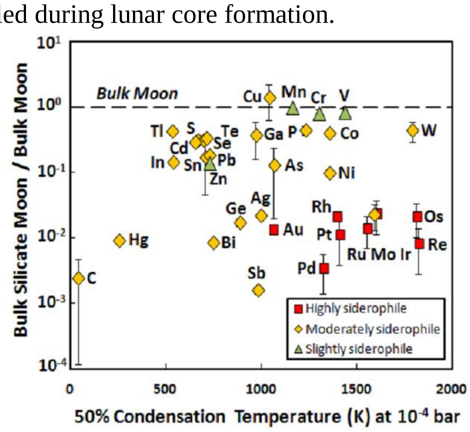

Fig. 1: Siderophile element depletions in lunar mantle

Core formation in the Moon: Siderophile elements depletions in the lunar mantle, in conjunction with models based on experimental data that predict their metal-silicate behavior as a function of P-T-X-fO_2, have been used to argue for a deep lunar magma ocean implying the Moon was fully molten after it formed [5-7]. Rai and van Westrenen [5] showed that for temperatures between the solidus and the liquidus, all 7 considered siderophile element depletions can only be reconciled with segregation of a 2.1±0.4 mass% lunar core, that containts at least 6 wt% sulfur (S). Steenstra et al. [6] showed that the depletions of 15 refractory and (highly) volatile siderophile elements (VSE) can be matched with formation of a pure Fe 2.4±0.1 mass% core, at superliquidus conditions in a fully molten Moon. Therefore, the siderophile element depletions in the Moon do not require the formation of a S-rich lunar core. This study also showed that the Moon experienced only minor loss of some VSE, because their depletions do not require additional devolatilization.

Composition of the lunar core: The existence of one or more light elements in the lunar core is inferred from lunar seismograms [2] and the existence of a lunar core dynamo [3]. S seems unlikely given its low abundance in the lunar mantle and moderately siderophile behavior at the *P-T-X* conditions relevant for lunar core formation. Instead, geochemical evidence point to carbon (C), which also agrees with current geophysical constraints (Fig. 2).

Outlook: Future work should test if the lunar mantle depletions of other volatile siderophile elements can be reconciled by core formation only, and if they can be explained by formation of a C-rich lunar core.

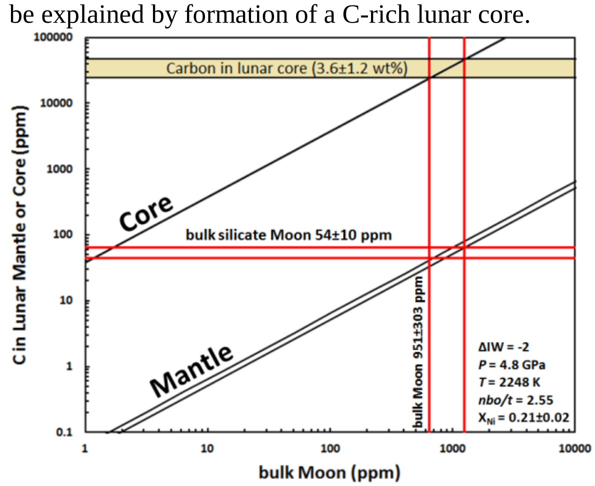

Fig. 2: Abundance of C in the lunar core and mantle assuming a deep lunar magma ocean [8]

References: [1] Dasgupta et al (2009) *GCA 73* [2] Weber et al (2011) *Science 331* [3] Laneuville et al (2014) *EPSL 401* [4] Murthy et al (2003) *Nature 423* [5] Rai & van Westrenen (2014) *EPSL 388* [6] Steenstra et al (2016) *EPSL 441* [7] Steenstra et al (2016) *LPSC*