Differences between bulk and in-situ Cl isotope compositions of lunar materials

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The Cl isotope values of lunar materials range further than any other planetary material. Following the initial study of [1] which measured bulk and in-situ Cl isotope values, a number of studies have focused on in-situ analyses of apatite. The general consensus of these studies is that the high δ^{37}Cl values in lunar materials, particularly in KREEPy lithologies are related to early degassing of the lunar magma ocean [2]. The δ^{37}Cl values of apatites range significantly within individual thin sections by up to 10‰, but also between individual lithologies [2, 3]: low-Ti from 8-20‰, high-Ti from 2-18‰, high-Al from 14-40‰, and highlands from 25-35‰ [2-4]. Here we measured bulk-rock δ^{37}Cl values of lunar materials using gas source isotope ratio mass spectrometry on water-soluble (WSC) and structurally-bound chloride (SBC). The δ^{37}Cl values generally range from 0 to 12‰ in all measured lithologies, with exception of FANs which are the only material to exhibit δ^{37}Cl values >15‰. These bulk δ^{37}Cl values are far lower than those in apatite, most notably in low-Ti and high-Al basalts. These data suggests that 1) δ^{37}Cl values of lunar apatite are not representative of the bulk rock, and that another Cl-bearing phase exists with lower δ^{37}Cl values, and 2) apatite is heavily weighted towards high δ^{37}Cl values controlled by local rather than large-scale processes. From these data it is clear that there are two Cl reservoirs, one with high δ^{37}Cl values measured in late-formed apatite and a second with low δ^{37}Cl values closer to 0‰. We stress that this conclusion is not new, as in the initial study of [1] 12040 was measured to have a bulk δ^{37}Cl value of 0‰, with in-situ apatite measured at 17.2‰. Various candidates for sources of Cl other than apatite include Cl-rich glass and a pervasive nominally Cl-poor phase. If this relatively low δ^{37}Cl component is considered to more closely represent the Moon, then far less Cl loss is required to account for its isotopic composition.

REFERENCES: [1] Sharp et al. (2010), *Science* 54, 1050-1053, [2] Boyce et al. (2015), *Science Advances* 1, [3] Barnes et al. (2016), *EPSL* 447, 84-94, [4] Potts et al. (2018), *GCA* 230, 46-59