Quantification of waste silicates for mineral carbonation

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Historic Production

Silicate minerals are an ubiquitous component of some anthropogenic material streams (cement, construction waste, slag, fuel ash etc.). Generally, they are produced by calcining carbonate minerals in the presence of silica (mine/aggregate waste is composed of naturally occuring silicates). We estimate that humans have produced approximately 89-103 billion tonnes (Gt) of silicate material since the early 1800's (Table 1; [1]). The fate of this material is likely one of several namely, disposal in the ocean or in lanfill, spread onto land, or material in engineering. While some of this material has carbonated in the environment [e.g. 2], it is possible that a substantial quantity remains available for carbon capture (with a total potential in the order of 10^3 MtC).

Material	Current (Mt a^{-1})	Historic (Mt)
Aggregate fines	3, 300	unknown
Mine waste	2, 000-6, 500	unknown
Cement kiln dust	420-568	9, 000-12, 000
C & D waste	1, 400-5, 900	*
Slag	380-500	12, 100-15, 900
Fuel Ash	198-383	76, 000-14, 600

Table 1: Global production estimates for anthropogenic silicates since the early 19th century. *historic production of C&D waste is unknown, but the upper limit is based on the historic production of cement (60 Gt). See [1] for more details.

Current production

Current annual production of silicate material is estimated to be approximately 7.6-17.2 Gt. With an estimated carbon capture potential of around 190-332 Mt of carbon. Production of silicates is increasing by approximately 2 % a^{-1}, largely in China, carbonation of which is likely to an increasly important role for mitigating some of the associated carbon emissions.

[1] Renforth, *et al.* (2011) *Environ Sci Technol* ***45****(6), 2035-41*. [2] Manning (2001) *Min Mag* **65**(5), 603-10.

Further progress towards synchronizing geochronometers

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A recent calibration of the $^{40}Ar/^{39}Ar$ system [1] has largely reconciled the $^{40}Ar/^{39}Ar$ and $^{238}U/^{206}Pb$ geochron-ometers, but reveals several apparent inconsistencies with previous results. For example, recalculating a previous result [2] for the Cretaceous/Paleogene boundary (KPB) produces an age of 66.236 ±0.060 Ma (1σ here and throughout), slightly older beyond stated errors than an astronomically tuned age of 65.957 ±0.040 Ma [3] for the KPB at Zumaia (Spain). To investigate this disparity, renewed analysis of circum-KPB events has been initiated. Arguably the most definitive age for the KPB would be that for the Beloc (Haiti) tektites. Previous results for these tektites are consistent with a KPB age though not with sufficient precision to advance the present discussion. With rigorous attention to neutron fluence monitoring via the Fish Canyon sanidine (FCs) standard, a suite of Beloc tektites was irradiated along with sanidine from a Z-coal tonstein (stratigraphically ~60 cm above the KPB) from the Hell Creek area of Montana (USA). Three positions of the standard closely bracketing the samples yielded an average *J*-value with 0.02% precision. Seven tektites with Ca/K between 2.8 and 4.8 heated incrementally in 14-18 steps with a CO_2 laser and analyzed with a single collector MAP 215 mass spectrometer all yielded 100% concordant age spectra. The weighted mean of the seven plateau ages, calibrated per [1], is 65.946 ±0.067 Ma, indistinguishable from the astronomical age [3]. Combined with previous results [4, 5] a weighted mean age of 66.043 ±0.049 Ma is obtained for the Beloc tektites. Additional work in progress will further refine the age of the tektites and enhance their importance to a precise age for the KPB. Calibrated per [1], 71 single crystals of sanidine from the Z-coal yielded an age of 65.926 ±0.066 Ma. No xenocrysts are evident in the data, justifying step-heating analysis of multigrained aliquots currently in progress. These results disfavor the possibility raised by [1] that the astronomical age [3] of the KPB is miscalibrated by a 405 ka eccentricity cycle and serve to validate intercalibration between the Ar/Ar, U/Pb and robust astronomical chronometers.

[1] Renne *et al.* (2010) *GCA* **74**, 5349–5367. [2] Swisher *et al.* (1993) *CJES* **30**, 1981–1996. [3] Kuiper *et al.* (2008) *Science* **320**, 500–504. [4] Izett *et al.* (1991) *Science* **252**, 1539–1542. [5] Swisher *et al.* (1992) *Science* **257**, 954–958.