# ALKALI SILICA REACTIVITY A PROBLEM ON EARTH, A SOLUTION ON MARS

D. H. Graham[1], and J. C. Cawley[2], [1]Professional Geologist, CQS, Inc. 2021 Continental Drive Harrisburg, PA 17110, [2]Research Geologist, Center for Earth and Planetary Studies - National Air and Space Museum, Smithsonian Institution, Independence Avenue at 6th Street SW MRC 315, PO Box 37012, Washington DC. 20013-7012, grahamhbg@msn.com, cawleyj@si.edu

**Introduction/Discussion:** While working in the private sector some 30 years ago, the Authors were introduced to the concept of Alkali-Silica Reactivity hereafter referred to as ASR. On earth ASR is manifested in concrete made after 1970. Analogous situations may have occurred in geologic history on Mars.

**What is Alkali-Silica Reactivity:** ASR is basically a pozzolonic reaction, which is a simple acid-base reaction between calcium hydroxide or ($Ca(OH)_2$), and silicic acid ($H_4SiO_4$, or $Si(OH)_4$). This reaction [1] [2] can be schematically represented as following

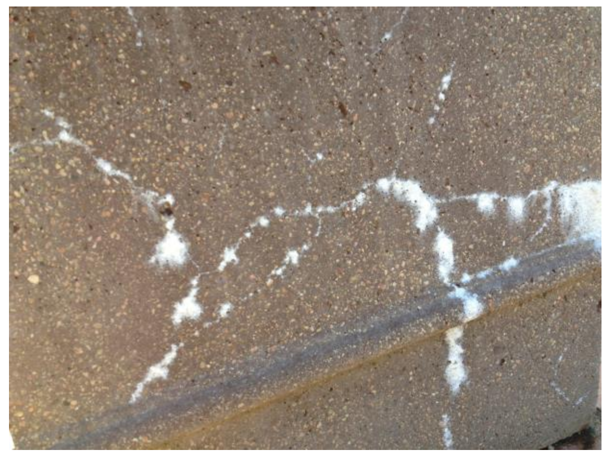
$Ca(OH)_2 + H_4SiO_4 \rightarrow Ca^{2+} + H_2SiO_4^{2-} + 2\ H_2O \rightarrow CaH_2SiO_4 \cdot 2\ H_2O$

On Earth the mechanism of ASR causing the deterioration (of concrete) can be described as having four basic steps as follows:

The alkaline solution attacks the siliceous material (generally aggregate), converting it to viscous alkali silicate gel.

1. Consumption of alkali by the reaction induces the dissolution of $Ca^{2+}$ ions into the pore water. Calcium ions then react with the gel to convert it to hard C-S-H.
2. The penetrated alkaline solution converts the remaining siliceous minerals into bulky alkali silicate gel. The resultant **expansive** pressure is stored in the aggregate.
3. The accumulated pressure cracks the aggregate and the surrounding cement paste when the pressure exceeds the tolerance of the aggregate.

The following image depicts the white gel typical of terrestrial ASR in a fabricated wall having susceptible aggregate and quite likely low pH concrete.



**How Alkila-Silica may be helpful in identifying Specific Time Periods, and/or Erosional Features on Mars:**

Because ASR occurs under very specific conditions it might become a valuable tool in determining the time period during which specific geologic events occurred. Additionally, if ASR, or more properly, its bi-products are found to be wide spread on Mars, it is possible that ASR may have been significant in the weathering [3] and erosional process.

It is our opinion that there may be substantial deposits of silica gel [4] and hydrated silica and opaline mineralization by-products in hydrothermal metamorphic and weathering locations [5] in the Martian regolith, which were formed in the following manner;

During the pre- and early Noachian Epoch, Mars was “resurfaced” by lava flows. These lava flows contain virtually no quartz. Mars subsequently underwent a substantial impactor period. During this period the surface was shattered which mined up material from the subsurface. As the basalt, at depth, weathered, it likely created alkali solutions in the subsurface water. These solutions then move preferentially along fracture zones associated with the impact craters [6]. In the areas of an impactor a great deal of heat was likely generated locally. As a result, local groundwater would potentially be heated to near or beyond the typical hydro-thermal temperatures.

In addition to warming, fracturing, and materials brought to the surface, the impactors also imply a certain amount of “glassification”. These newly formed glasses, along with the likely presence of alkali solutions in the subsurface water, are likely to produce varying quantities of silica gel. The amount of gel produced would be dependent on the amount of silica present, the amount and degree of alkalinity of the subsurface water, and the temperature of the materials undergoing the ASR reaction.

There exists a body of engineering science and literature on ASR in human construction and civil engineering, which we feel may prove useful toward understanding potential ASR reactions and their signatures in the Martian environment.

This poster is dedicated to Richard H Howe PG/PE (d. 2008) who spent much of his professional career understanding the role of ASR in construction and infrastructure.

[1] FHWA (2010-06-22). "*Alkali-Silica Reactivity (ASR)-Concrete-Pavements-FHWA"*. ASR Development and Deployment Program. [2] "Publication Details for Alkali-Reactivity (AAR) Fact Book - Pavements - FHWA. dot.gov [3] R.S. Perry et.al, (2006) *Geology*, 34 (7), pp. 537-540. ISSN 0091-7613. [4] D.L. Evans and J.B. Adams (1980) *LPSC Volume 1.* (A82-22251 09-91), [5] Ehlmann, B. L., et al. (2009), *J. Geophys. Res.*, 114, E00D08, doi: 10.1029/2009JE003339. [6] A.K. Davatzes, GSA Abstracts (13-16 March 2010) Paper No. 74-11