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Interactive comment on "Quartz dissolution associated with magnesium silicate hydrate cement precipitation" *by* Lisa de Ruiter et al.

Anonymous Referee #2

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Overall, I find the paper to contain interesting new observations on dissolution-precipitation reactions during interaction of till with high-pH fluids. The paper is thorough, uses appropriate methods, and is well written. On this basis, I estimate the revisions required for publication to be minor to moderate.

My main concern is the balance between observations and interpretations: Quite a few observations presented in the Results section are interpreted in terms of their significance straight away (i.e., within the Results). The Discussion, then starts with the statement that 'quartz grains with a diameter of 50 μm within the cemented rocks are completely dissolved and (partly) replaced by magnesium silicate hydrate cement' (L. 203-204). The latter interpretation may well be correct, but should follow on from discussing the observations. The paper would be stronger if the Results contained

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only minimal interpretations, and he Results started with a section that pulls together the key observations and comes to the conclusion as quoted above.

Protolith: A bit more detail on the nature of the protolith would be useful: the different components are provided, but little detail on their relative abundance and size (other that 'large'). As a result, it is difficult for the reader to form a mental image of what the till and cemented rock look like.

Deformation history: L. 125-126: 'Many quartz fragments are characterized by small equigranular polygonal new grains with straight grain boundaries together with large old grains with undulose extinction and sometimes subgrains'. Neoblasts (for new) and unrecrystallised (for old) may be more appropriate terms? L. 128-130: 'In addition, essentially all quartz grains, including the dynamically recrystallized grains, show undulose extinction, which indicates that the quartz was plastically deformed by dislocation processes again in a later stage'. It's not clear to me why undulose extinction requires a separate, later phase of deformation; could this not simply relate to the initial recrystallisation process itself? Fig. 2c: this is a histogram of 1730 quartz grains in the cemented rock, implying an upper grain size limit of 45 micron. It is not clear to me how this relates to the photomicrograph shown in panel a, where there are clearly visible grains of up to $\sim$300 micron. Panel A is from a non-cemented rock, but what would have happened to the large grain during cementation? Presumably they would be more resistant to reaction than the small neoblasts?

Microtextures:

L. 148-151: 'When the cement has replaced the outer few μm of the grains, the dissolution is commonly no longer accompanied by cement precipitation, as indicated by the presence of honeycomb-like pore spaces, after the shape of quartz grains, in which sometimes relicts of quartz can be observed (Fig. 3c)'. Is there a possibility that these pore spaces did in fact contain quartz but that these grains have been plucked out of the sample during sample preparation?

L. 182-184: ‘the etch pits density is 1010 cm-2 with the reacted surface being larger than the non-reacted surface’. Two questions: 1) the text provides the etch pit density, but in the caption to figure 6 the same number is quoted as the dislocation density. Please clarify. 2) Is the sentence trying to say that the etch pit density is larger on the being larger on the reacted surface than on the non-reacted surface, or is it referring to the actual physical size of the reacted vs non-reacted surfaces?

Time line: ‘these cemented rocks occur in the mine tailings of mines that were active until about 100 years ago, indicating that the grains dissolved in less than 100 years’ (L. 205-206). This is only demonstrably true if the cement occurs between different rocks of the tailings pile, rather than within the individual rocks on the pile. Please link back to the description of the occurrence of the cement (e.g., on the wall of the tunnels) and provide a robust time line.

Reaction history: ‘the fluid can still access the quartz surface since the cement is porous’ (L. 363-364). Isn’t the amorphous silica in the way? It has already precipitated in step 3 of the process as described.

One of the aspects that is not discussed is a possible volume change during reaction. Do you have any constraints on this? It is possible that the honeycomb texture of MSH between polygonal grains is in part due to a positive volume change creating pathways for the reactive fluids to penetrate the quartz? This may provide an additional way in which the reaction proceeds, and could also contribute to the high reaction rate.

Figures:

Fig. 5: In the caption, please describe the type of image this represents (SE/BSE/TEM), and whether or not this is a polished surface.

Fig. 7: In the text, it is written that ’these fibres of the cement are attached to and partly intergrown with the amorphous layer’ (L. 191). Please highlight those areas in Fig. 7 where the reader can make this observation.

Writing: L. 14: as a result L. 45-47: ‘Also, the recent findings of De Ruiter and Austrheim 45 (2018) indicate dissolution of quartz in natural high pH conditions that is much faster than experimental studies and rate equations predict for the relevant conditions.’ Suggested phrasing: ‘Also, De Ruiter and Austrheim (2018) recently found that the dissolution of quartz in natural high-pH conditions is much faster than experimental studies and rate equations predict for the relevant conditions.’ L. 51, 90, 104, 206, 209, 217, 228, 241, 353, 359, 388: please use subscripts and superscripts where appropriate L. 94: where=were L. 93-95: ‘It is furthermore unlikely that the cementation started before the mines where abandoned in the 1920’s, as this would influence the mine tailing in which the trench is present and would have made it unlikely that the cement is only present on the outer few cm of the trench.’ This sentence is unclear to me; please rephrase.

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