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An experimental study of iron release from red sandstones

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An experimental study has been conducted to better understand the features of a natural CO_2 –rich system at Saltwash Graben, Utah, USA. This site is associated with numerous CO_2 rich springs linked to faults and fractures. In this area, a key feature of the red Entrada sandstone formation is the presence of significant rock bleaching (iron reduction and mobilisation) that occurs subparallel to bedding, typically at the base of large sandstone units and adjacent to some subvertical fractures. The difference in total iron content between the bleached and unbleached sandstones is very small, with the bleached sandstone containing slightly less total iron. In contrast to widely-reported regional bleaching, attributed to hydrocarbon accumulations towards structural crests, it has been suggested that the bleaching may be associated with the presence of modern day CO_2 in the area and we sought to test this.

Laboratory experiments were conducted to assess reaction processes that may have caused the observed iron reduction and mobilisation. Fixed volume batch reactors, containing either small cores of red or bleached sandstone were exposed to representative local ground waters (a dilute or a saline fluid), which were pressurised with either CO_2 or N_2 (the latter as a control) to 50 bar and placed inside an oven at 40˚C to simulate subsurface conditions . The experiments ran for up to nine months with fluids being sampled periodically, though solids were only analysed once experiments were completed. Very little reaction was found to occur in the presence of CO_2. It seems possible therefore that the modern CO_2 rich fluids were not the cause of the sandstone bleaching.

The study therefore assessed how the presence of reducing agents such as methane (CH_4) and hydrogen sulphide (H_2S) may result in the bleaching of the bulk sandstone. H_2S was introduced into the experiments as a breakdown product of thioacetamide (0.1% v/v fluid containing thioacetamide was added to the experiments). CH_4 was added at a 5% concentration in the CO_2 gas (or N_2) used for pressurisation. The presence of H_2S caused a significant release of iron (II) from the sandstone into solution, even in the absence of CO_2, though the reaction did not progress far enough to cause bleaching of the sandstone cores. It seems possible therefore that sandstone bleaching may have been a consequence of ancient flow of highly reducing water.

It is therefore proposed that reducing sulphur-rich fluids migrated along fractures, and mobilised iron from the rock, resulting in the bleaching observed. Further evidence from petrographical observations of fracture mineralisation from the centre of bleached zones have also supported the experimental observations and hence the proposed model.

It has been demonstrated that laboratory experiments can help to improve understanding of fluid-rock interaction processes within this natural CO_2 –rich system. The results also have wider implications for longer-term CO_2 trapping mechanisms within CO_2 storage schemes.

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