For Oral Presentation

Greenstones as a source of Hydrogen in Sedimentary Basins

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'Greenstones' are presented as a source of hydrogen by serpentinisation in sedimentary basins. They are formed by igneous (both extrusive and intrusive) and sedimentary rock sequences of Archaean and Proterozoic age as part of granite-greenstone belts, often forming the basement to younger intra-cratonic basins. Significantly the igneous rocks include ultramafic extrusive rocks (e.g. komatiites) and intrusives (e.g. peridotites and dunites), which are olivine-rich and constitute the protolith (source rock) for serpentinisation. Greenstones are usually metamorphosed to greenschist grade and are complexly structured with 'primitive' fold thrust belts whose synclinal keels tend to be dominated by volcanics and their cores by sediments.

A potentially-commercial hydrogen discovery has been made at Bourakebougou in the southern margin of the Taoudeni basin of Mali (Prinzhofer *et al.* 2018). The Taoudeni Basin is an intra-cratonic basin overlying the West African Craton. The most likely source of the hydrogen is currently-active serpentinisation of a greenstone protolith within the 2.2-2.1 Ga Birimian Greenstones of the West African Craton. Where exposed these greenstones are seen to be comprised of metamorphosed peridotites, gabbros and basalts overlain by quartzites, andesites and rhyolites.

Serpentinisation requires an effective supply of water interacting with the olivine protolith at optimum temperatures of 250-310^{o}C. The importance of the basin setting is that extra-basinal 'source rocks' can achieve the required temperatures by burial under a 'normal' continental basal heat flow regime. The key to generating significant volumes of hydrogen in the subsurface is for meteoric water to access basement along the basin margin ('topographically-driven system') and/or via fault systems within the basin ('fault-driven system'). Major, neo-tectonically-active fault systems are recognised traversing the southern Taoudeni Basin proximal to the hydrogen occurrences.

Hydrogen is expected to migrate and accumulate in basin sediments in the same way as gaseous hydrocarbons. However due to the mobility of hydrogen an important function of the basin setting is that the sediments act as a blanket in slowing down the migration of hydrogen from the source to dissipation in the atmosphere. In this regard 'older' more diagenetically-altered basin sediments (Proterozoic-Lower Palaeozoic), as in the Taoudeni Basin, are likely to be more retentive. Early Jurassic intrusives, common in the southern part of the Taoudeni Basin, have played an important role in sediment diagenesis and probably in forming seals or aquitards to vertically-diffusing hydrogen. However, despite the effectiveness of the seal, retention (preservation) times are expected to be shorter for hydrogen (i.e. on human time-scales). This is important because, unlike for hydrocarbons, the hydrogen source is thereby required to be currently active. This also means that hydrogen resources are potentially replenishable.

Prinzhofer, A., Cisse, C. S. T. & Diallo, A. B. 2018. Discovery of a large accumulation of natural hydrogen in Bourakebougou (Mali). Int. Jour. of Hydrogen Energy, 43, pp. 19315-19326.