

Molecular hydrogen and the process of thermochemical sulfate reduction

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The process of thermochemical sulfate reduction (TSR) refers to the abiotic conversion of sulfate sulfur to a more reduced sulfur species, most often hydrogen sulfide. It is well documented for a variety of natural environments. The process itself involves the oxidation of a reduced compound. Despite the knowledge of a number of possible redox partners for sulfate that might be relevant under natural conditions, all experimental and modelling studies during the past years have been directed towards the direct interaction of reduced organic carbon compounds and sulfate. The experimental approaches under relatively inert conditions – in sealed gold capsules or in flexible Dickson-type gold-titanium hydrothermal cells – have resulted in interesting new data on the kinetics of the overall reaction (e.g. [1]), that are in broad agreement with data from modelling studies. But the detailed understanding of the reaction itself is not adequate.

Studies reporting a more comprehensive analysis of gases evolved during the reaction document significant amounts of molecular hydrogen as byproduct (e.g. [2]). Based on existing thermodynamic data the direct reduction of sulfate by hydrogen is possible at natural temperatures.

In addition to this finding of hydrogen production during TSR under experimental conditions, a puzzling discrepancy of reaction rate in experiments with differing water/rock ratios calls for alternative explanation avenues. For example [1] reported a variation in H₂S production of more than two orders of magnitude for water/rock ratios of 0 to 20. And “dry” experiments focussing on the reaction between e.g. methane and solid sulfate at elevated temperatures resulted in high H₂S production rates.

Therefore this study investigates the possible role of molecular hydrogen as direct reduction agent for sulfate sulfur in the process of TSR – using both experiments with sealed gold capsules and flexible Dickson-type gold-titanium cells. In all experiments a significant production of molecular hydrogen was documented. This is true for the sealed gold capsules – even after prolonged acid-cleaning of the inner gold surface to remove possible traces of metal contaminants – and for the gold-titanium cells.

[1] Zhang *et al.* (2008) *Org. Geochem.* **39**, 308-328. [2] Zhang *et al.* (2007) *Org. Geochem.* **38**, 897-910.

Solar system formation hypothesis: Why the chemical compositions of the planets are so different?

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The current interpretation of the data on the interplanetary-dust isotopic ratios is ambiguous. Planet-formation hypothesis should include a simplest conceivable evolution pattern, which is rather possible to be multiply repeated in the Universe and is capable of explaining the principal features of the Solar System (SS) current state. We subdivide the SS bodies into the physically formed objects (PFO) located in the SS cold region (from the outside to the today Main Asteroid Belt) and chemically formed objects (CFO) located in the SS hot region. After the Supernova explosion, nebula expanded quickly and cooled steadily; H₂ and other two-atom molecules and hydride radicals formed. With time, nebula transformed to a flat thin disk composed of concentric diffusely-bounded rings; the more peripheral they were, the lighter molecules they tended to contain. PFO formation started, when the nebula began to collapse after its outer H₂ and He rings cooled to the H₂ condensation temperature; H₂ droplets absorbed light Li, Be, B, LiH, and BeH atoms and molecules, which formed the agglomerate cores and increased their size competing with each others for the mass and gravitational attraction. Heavy atoms and hydrides remained in that nebula section in which the temperature was too high for their physical agglomeration and in which their concentration was too low for chemical reactions to proceed. As the nebular-disc compressed, CFO formation started: combination reactions in the diffusive regions of the neighboring disc rings, heat evolution, and local concentration of matter accelerated exponentially and local giant compressible vortexes arouse. Within them, hot cores of the present sky objects localized. The reaction heat was capable of melting the cores. The pressure depletion in the vicinities of the vortexes and the gravitational attraction of the last stimulated flows of light cold vaporous and gaseous substances and the asteroid-like agglomerates from the outer space and also of asteroid-like agglomerates of not so light substances from the intermediate regions of the space to the hot cores within the vortexes. The flows precipitated over the hot core surfaces of the CFO and cooled them. The sandwiches obtained as a result of this precipitation became steadily the young terrestrial planets and their satellites.