

Fluid–rock interactions in Chalk groundwater systems: an initial investigation into the geochemical composition of Upper Cretaceous chalks from SE England

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The aim of this project is to obtain reliable inorganic geochemical data on the compositions of chalks and their associated groundwaters in order to develop models of fluid–rock interactions. Initially, chalk samples (Cenomanian–Turonian) from outcrop at Eastbourne, Sussex are being analysed for major and trace elements.

The ground and homogenized chalk samples were fused with a lithium metaborate flux. Samples were analysed in triplicate by ICP–AES and in order to assess data quality, four carbonate reference materials were also analysed. The sequence sampled included marly chalk from the base of the Cenomanian (Chalk Marl) up to pure ‘white’ chalk from the top of the Turonian (Middle Chalk). Calcium carbonate varied from 58–98% (base Cenomanian to top Turonian), while silica values ranged from 27– <0.5%, a change of two orders of magnitude. Most of the other major elements determined showed a similar trend to silica with the exception of manganese which exhibited a peak in the Melbourn Rock sample (upper Cenomanian–base Turonian). This is a nodular hardground facies and, as such, elevated levels of certain elements are expected. It is not known if this type of facies is a source of manganese, or if enhanced uptake occurs after deposition and consolidation. Determination of the minor and trace element content of these samples confirms the importance of the clay mineral phases as sites of reaction and exchange. Groundwater compositions change with increasing depth and length of time of flow, as a result of interactions with the solid phase, but it is not known whether or to what extent the ratio of the carbonate to the non-carbonate fraction within the solid phase affects the overall fluid chemistry.

Each phase may act independently as a sink or source of a particular element. This type of process would obviously be more pronounced in the Lower Chalk successions.

Separation of the carbonate and non-carbonate fraction is desirable to facilitate the determination of the element distribution between the two phases, as well as constraining the whole-rock data. The geochemical variations within the chalk sequence can thus be identified more accurately, and compared to the mineralogical changes. However, routine methods of calcite dissolution such as suspension in a buffered acidic medium can solubilize other fractions, particularly iron oxyhydroxide phases. Several dissolution methods have been studied, including direct titration of a suspension of the sample with dilute nitric or acetic acid, while monitoring and controlling the pH. The effectiveness of these as compared to established methods is being considered.

Using the methods already developed to characterize these chalk samples, a similar approach will be used on material from a hydrogeologically well-defined borehole. Integration of the resulting data set with that obtained from the fluid phase should allow existing hydrological models to be refined so that the effects of recharge and anthropogenic inputs on the Chalk aquifer may be predicted more accurately. In the light of the current emphasis on more responsible use of groundwater resources, better understanding of the processes governing groundwater compositions is required. Little work has been carried out on the nature of the solid phase, and this project will provide invaluable information towards that end.