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2D Geochemical Characterisation of Late Carboniferous Concretions: Constraints for 3D Fossil Preservation

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Because of their potential to perfectly preserve fossils in three dimensions, concretions and nodules from various stratigraphic positions and different geological settings have been the subject of intense investigations in the past. The results of these studies aided to elucidate the fine- and ultrastructure of fossilised materials, and gave detailed insights into the anatomy of many plants and animals of the geological past. Nodules have been described as concretionary bodies which are formed by the precipitation of authigenic minerals. They are sometimes monomineralic and homogenous, but polymineralic nodules are characterised by concentric zones of different mineralogical compositions (such as chert, barite, phosphates or manganiferous ores) around a mostly biogenic core. Several factors have been recognised which are thought to play an important role for the formation of nodules. These include [1] the availability of nucleating materials, [2] presence of metals in the water column and sediment, [3] favourable tectonic and physiographic features, [4] favourable sediment-water interface, [5] low rate of sedimentation, [6] presence of nutrient rich bottom water mass and [7] an oxidizing/reducing environment. Up to now, no consistent generic model has been proposed to address the complex geochemical interactions between these factors in the course of nodule formation. With the aim, to describe the different geochemical reactions that lead to nodule generation and hence fossil preservation, a ferromanganese nodule was extracted from the Upper Carboniferous sequences at Broadhaven, Pembrokshire, UK. The geology of this area consists of cyclothems, which contain cyclic sequences of limestones, sandstones and shales. Within this sequence, the nodules are located in the shale beds. The extracted ferromanganese nodule was cut in half using a diamond rock saw and is 7.1 cm in height and 9.8 cm in width. For the analysis of major and trace elements a Niton XL3t X-ray fluorescence instrument was used. A grid of 3mm by 3mm was then drawn onto the cut surface of the nodule in graphite pencil. A graphite pencil was chosen as graphite (Carbon) is too light to interfere with the incident x-ray beam of the XRF. A total of 1052 data points produced by this grid formed the points at which the XRF analysis was undertaken. Elements analysed were Ag, Al, As, Ba, Ca, Cl, Cd, Cr, Cs, Cu, Fe, Hg, K, Mn, Nb, Ni, P, Pd, Rb, S, Sb, Sc, Se, Si, Sn, Sr, Te, Th, Ti, U, V, Zn and Zr. This geochemical data has been modelled into 2D contour maps and 3D elevation models which have shown significant and systematic enrichments (Ag, As, Ba, Ca, Cd, Cr, Cs, Fe, Hg, Mn, Ni, P, S, Sb, Si, Sn, Sr, Te, Th, U, V, Zn) and depletions (Al, Cl, Cu, K, Nb, Pd, Rb, Sc, Se, Ti, Zr) of elements across the extent of the nodule.

The geochemical data obtained were used to establish the types of geochemical reduction/oxidation-reactions that were involved during the formation of the nodule. A new model, based on non-linear disequilibrium quasi-Belousov-Zhabotinsky reactions, for nodule formation is presented and will be discussed.