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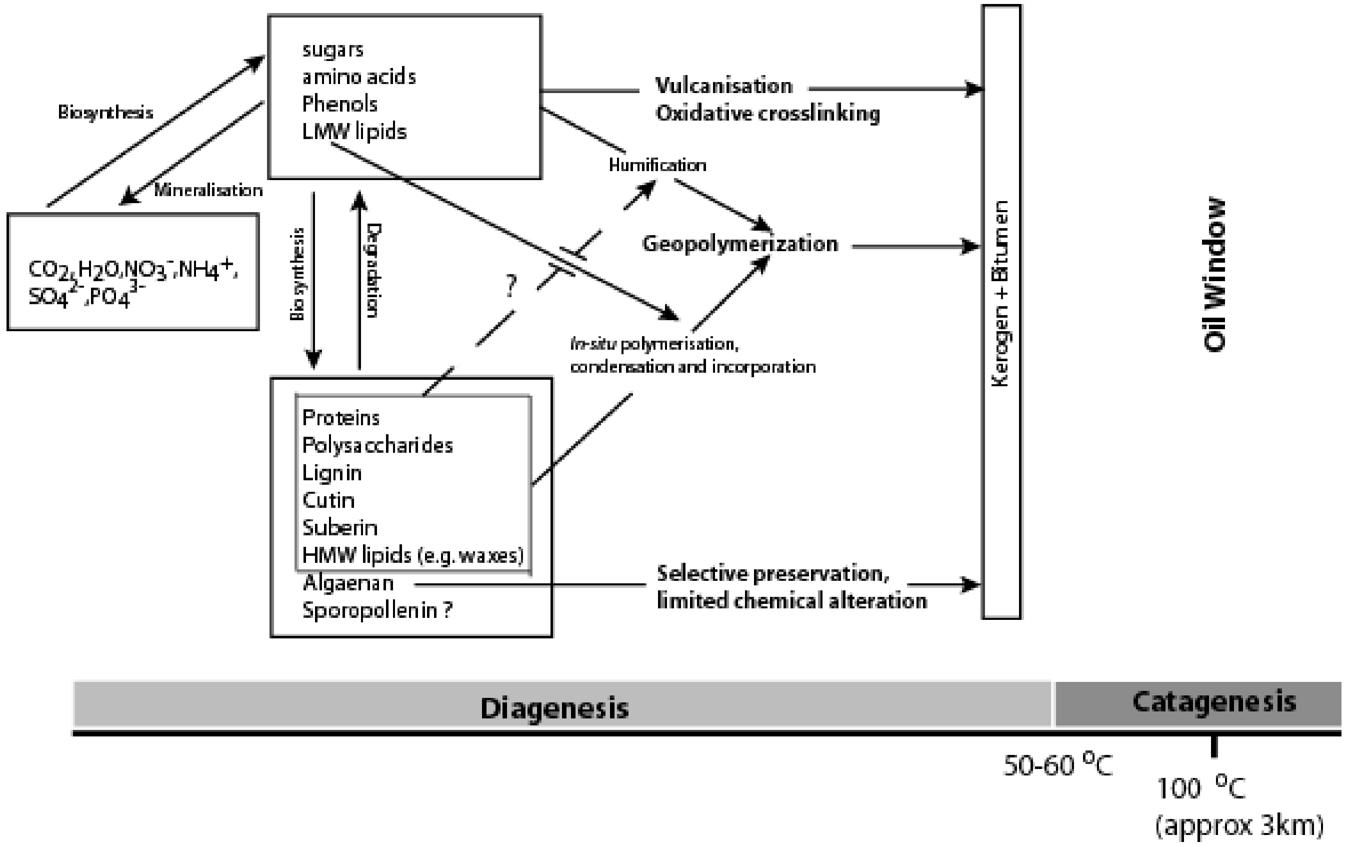
Preservation and sequestration of organic carbon in oil shales: origin of petroleum

Organic matter preservation and formation of coal and kerogen is typically attributed to selective preservation of resistant biomolecules, random polymerization of diagenetically degraded biomolecules (i.e. neogenesis) or in situ polymerisation of labile aliphatic components (Briggs, 1999); selective preservation is widely accepted as the most important paradigm as revealed by research in the last two decades (Tegelaar et al., 1989). To evaluate these processes and test the selective preservation model, we investigated the morphology, ultrastructure and chemical composition of diverse plant and animal fossils that contribute to organic matter in energy resources such as coal and oil shales, complementing it with experiments. Fossil leaves from the Ardeche diatomite (Miocene, France) revealed the presence of a recalcitrant (non-hydrolysable) geopolymer consisting of lignin, pristenes and an aliphatic component; the latter made partly of fatty acyl subunits ranging in carbon number from C_8 to C_{32} with an abundance of C_{16} and C_{18} units (Gupta et al., 2007c). Chemical degradation of the modern plants failed to reveal the presence of the aliphatic biomacromolecule cutan (Gupta et al., 2006b) that had been assumed to be ubiquitous in leaves earlier and the primary source of aliphatics in fossil and sedimentary organic matter. In contrast, fatty acyl units predominant in the cutin, phospholipids fatty acids and free fatty acids from epicuticular waxes contributed to the formation of the aliphatic component. Analysis of fossil conifer and beetles and associated sediment from the Enspel formation, Germany (25 Ma) revealed that chitin is preserved in the insects and lignin in the conifer, along with a significant aliphatic component in both (Gupta et al., 2007b). Structural analysis of these and associated sediment using thermochemolysis revealed that the aliphatic component of the sediment and fossil were crosslinked via fatty acids of differing chain lengths indicating that the aliphatic component in the fossils is not derived from the sediment as postulated before. Such an aliphatic composition is detected in graptolites (Gupta et al., 2006a), eurypterids and cephalopod beaks as well. Gold cell confined pyrolysis experiments using modern arthropods, leaves and constituent biopolymeric compounds at 350 ºC, 700 Bars revealed that lipids are the source of the generated aliphatic component confirming the results obtained from analysis of natural samples (Gupta et al., 2007d). This process involving in-situ lipid incorporation into macromolecular organic matter, observed by tracking the fate of organic fossils and by experiments with diverse initial composition reveals that such a process contributes significantly to organic matter (kerogen and coal) formation alongside selective preservation, especially where recalcitrant organics are absent. Based on this current research a revised model for preservation of organic carbon in energy resources such as oil shales and coal is proposed (Gupta et al., 2007a).



Revised model of fluxes in organic matter preservation to form kerogen and coal

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