

ARE INSOLUBLE BITUMENS FORMED BY THERMAL CRACKING IN PETROLEUM RESERVOIRS?

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Insoluble bitumen resulting from thermal cracking of reservoir hydrocarbons is a frequent and ubiquitous component of petroleum systems. Bitumens such as impsonite, anthraxolite, and Albertite were collectively known as pyrobitumens under the seminal bitumen classification scheme proposed by (Abraham, 1960). The pyrobitumen designation was, however, based uniquely on analytical criteria, namely insolubility (in CS₂), hardness, and fusibility. Many naturally-occurring types of bitumen which satisfy these criteria are thermally immature. This anomaly was rectified by Curiale (1986) who related solid insoluble bitumens according to their pre-oil (expulsion in the immediate vicinity of the source rock) or post-oil (derived from residues of formerly liquid petroleum) origins. Jacob (1989) also sought to define bitumens according to their origin and stage of thermal evolution, using reflectivity and elemental composition.

There are, however, some significant outstanding issues questioning the origin of insoluble reservoir bitumen. Sophisticated kinetic models of petroleum generation and secondary cracking predict that the latter is insignificant below a temperature threshold of 140-160°C (Schenk et al., 1997; Vandenbroucke et al., 1999). The precise range of activation energies required for secondary cracking is hotly contested amongst the different protagonists in the petroleum generation-degradation kinetics debate, but none would support the degree of cracking required for formation of insoluble reservoir bitumen at temperatures below ~140°C. Despite the kinetic predictions, there is widespread evidence of the occurrence of insoluble bitumen in petroleum reservoirs which have never been buried beyond temperatures in excess of 100-140°C. On the other hand, there is another hypothesis based on a large body of evidence, whose proponents are finding increasing resonance in the scientific community, which suggests that some hydrocarbons are thermally stable to temperatures far in excess of those predicted by current kinetic models (Price, 1997). What in Earth is going on??? Are hydrocarbons geologically and thermally stable (at least in the 100-200°C temperature range),

or are degraded insoluble petroleum residues more common than perceived because the insoluble part of petroleum remains undetected in reservoirs?

Our experiments concentrated on the role of bulk chemical composition in determining the insoluble bitumen formation potential of a petroleum accumulation. Individual isothermal pyrolysis of bulk SARA fractions of Boscan oil (Upper Eocene, Type II, asphaltic, immature) at 300-550°C led to formation of large amounts of pyrolytic pyrobitumen in the case of the NSO fractions (10%-58wt% from resins; 19-61wt% from asphaltenes) and lesser quantities formed at higher temperatures for saturate and aromatic fractions (0-32wt% from saturates; 2-57wt% from aromatics). Petrographic and structural properties of the neoformed insoluble pyrobitumen are also strongly controlled by bulk chemical composition. For example: reflectivity of the neoformed residue is significantly suppressed in the case of low and intermediate temperature asphaltenes but not in the other NSO component, the more labile resin fraction. Comparison of the geochemical characteristics of these neoformed pyrobitumens with a large suite of natural analogues found in published literature supports the case for compositional control on the preferential formation of insoluble bitumen from NSO-rich precursors, and the influence of asphaltenes on petrographic properties of the bitumen.

Given the apparent significance of bulk composition on pyrobitumen formation, the likelihood of encountering economically detrimental amounts of pyrobitumen in reservoirs, is probably determined by post-generation alteration processes (e.g. NSO enrichment by biodegradation, deasphalting), rather than initial oil type (e.g. paraffinic, naphthenic, asphaltic) e.g. Karpov et al. (2005).

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