

A hydrothermal plume remobilizes sedimentary organic matter

from Andrew S. Mackenzie

In this issue of *Nature*, Simoneit and Lonsdale¹ describe petroleum found in dredge samples containing hydrothermal minerals, taken near a hydrothermal vent in the Guayamas Basin, Gulf of California. This 'hydrothermal petroleum' has a quite different composition from 'commercial petroleum' and its distinctive features are related to the rather special circumstances of its generation and migration. There is no evidence that the hydrothermal petroleum has a deep-seated origin and has emanated directly from the vent. Instead, the results suggest that part of the biologically derived organic matter of sediments in the neighbourhood of the vent can be remobilized and transported by the hydrothermal plume.

The most striking feature of the hydrothermal petroleum is its chemical resemblance to the organic matter which can be extracted, with common organic solvents, from relatively immature sedimentary rocks. Indeed, in one sample, a number of organic molecules, whose carbon skeletons have unambiguous links with known biological molecules, are still present as their less stable forms. Within this immaturity, the authors have detected

certain components whose continued presence in large relative abundances is best explained by a relatively short-lived heating at temperatures well above those normally found in connection with petroleum formation. The evidence can best be accommodated in a model where the immature organic matter of the Quaternary sediments around the hydrothermal vent has come into contact with a hot hydrothermal plume and has then rapidly cooled as a result of migration in the hydrothermal flow and condensed at the seabed.

Organic geochemistry is much concerned with specific problems of petroleum geology, particularly those associated with thermal maturation². The present paper¹ and others from the same laboratory³ show some of the advantages of being able to study Earth processes at a specific organic molecular level and perhaps indicate the further contributions the field is poised to make in many other areas of the Earth sciences. Although a tremendous amount has been achieved in cataloguing a large number of specific but previously unknown chemical structures of the organic compounds occurring in sediments and petroleum⁴, most of the applications to date have been very empirical. Simoneit and Lonsdale have made use of the sciences of chemical

kinetics and thermodynamics in a descriptive sense to predict how the hydrothermal petroleum was formed. Large relative abundances of peri-condensed aromatic hydrocarbons and steroidal alkanes are said to reflect relatively short-lived contact with high temperatures (certainly greater than 250°C), because other reactions, which destroy the aromatic hydrocarbons⁵, add hydrogen to triterpenoid alkenes⁶ and isomerize triterpenoid and steroidal alkanes⁷⁻⁹, have been promoted to a lesser extent. This observation implies that the rates of the former types of reaction are accelerated to a greater extent by a major increase in temperature than those of the latter reaction types, and stems from the principles of chemical kinetics.

The chemical composition of the migrated hydrothermal petroleum also shows specific differences from organic matter found close to igneous sills³. Unsaturated hydrocarbons (alkenes) with carbon-carbon double bonds in the middle of the carbon chains occur in both environments, whilst those with double bonds at the end of the carbon chains are restricted to the organic matter next to sills. Simoneit and Lonsdale argue that the mid-chain alkenes can survive the migration in hot fluids, because of their higher thermodynamic stability, whereas the less stable terminal alkenes are completely destroyed.

Such descriptive integrations of physical chemistry into molecular organic geochemistry are welcome and valid. In the future, attempts will be made to derive more mathematical expressions for organic geochemical processes, particularly for those which can now be studied at a molecular level. Universally applicable expressions are more likely to emerge from the relatively simple interconversions between two known molecular structures than from the complex physicochemical processes which generate petroleum. These expressions will permit a more quantitative evaluation (what temperature and for how long) of the past geological events which have affected the organic mixtures being studied. In such a form molecular organic geochemistry will provide a new set of tools to Earth scientists. □

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The Thar.

100 years ago From *Nature* 25, 26 January, 297, 1882.

THE THAR (*Capra jemlaica*). — The peculiar Himalayan Goat, known to the Indian sportsmen as the Téhr, Thar, or Tahir, was first described in 1828 by Hamilton Smith, and named *Capra jemlaica*, from the district of Jemlab, to the north of Nepaul, in which his specimen was procured. It is found, however, as Dr Jerden tells us, throughout "the whole extent of the Himalayas at great elevations, generally above the limits of forest and not far from the snow. It frequents rocky valleys and very steep and precipitous ground, and is often seen perched on what appear to be inaccessible crags. If alarmed whilst feeding, these animals all go off at full speed with a clattering sound, but soon halt and turn to gaze on the intruder."

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4. For a recent example see McEvoy, J., Eglinton, G. & Maxwell, J.R. *Init. Rep. DSDP Leg 63*, 763 (1981).
5. Brassell, S.C. *et al. Init. Rep. DSDP Leg 56*, 57 pt 1 (1980).
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9. Mackenzie, A.S., Patience, R.L., Maxwell, J.R., Vandembroucke, M. & Durand, B. *Geochim. cosmochim. Acta* 44, 1709 (1980).