researcher in life sciences, and they cannot ignore genomics.

Klaus Ammann emphasized that the principle of the symmetry of ignorance (experts and non-experts have different types of knowledge, yet both have equal status) must be accepted in discussion of the environmental concerns regarding the GMOs. Referring to the transgenic crop plants, he said, 'the situation in 1998, where tens of thousands of field releases have been undertaken, there is still no trace of any hazard, which has been clearly defined, despite the numerous disasters having been supposed by our friends from the protest industry.'

There were panel discussions on each session, and a general round table discussion – *Biotechnology: promises and concerns*, Chaired by Bernard Dixon, EFB-TGPPB. The distinguished panellists included social scientists, representatives from NGOs, policy makers and scientists from academia and' industry. Besides biosafety, the issues raised were related to globalization and its impact. The conference certainly helped in better understanding of the different view points, and perhaps narrowed the gap between the promoters and opponents of the recombinant DNA technologies.

Last, but not the least, the organisers are commended for their painstaking efforts in arranging an excellent meeting.

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RESEARCH NEWS

Evidence of oil formation during Archaean times

A. V. Sankaran

Discoveries in earth science, in the past few decades, have often modified or enriched many existing views in diverse areas such as the beginnings of life on earth and its periodic extinction and explosion, about extra-terrestrial agencies and their roles in influencing evolution, climate and ecology, about the earth's interior zones and their physics and chemistry, plate tectonism, volcanism and earthquakes. Now, a recent contribution to petroleum geology has widened current textbook beliefs on the subject by bringing out evidence of oil in ~ 3 billion-year-old rocks, in very early Precambrian (Archaean) times, a period hitherto considered unlikely to harbour oil.

Petroleum, natural gas and coal, the three essentially biologic products, are fossil fuels produced by transformation of organic material buried in inland seas or in coastal marine basin sediments accumulating around continents. Molecular palaeontological studies[1] have identified several organic compounds present in the cell membranes of early life such as plankton, bacteria and other sea-floor dwelling organisms as the precursor chemicals for the genesis of oil. The teeming presence of organisms, their burial in suitable sedimentary environment and initiation of chemical changes leading to transformation of organic material are therefore basic criteria for the generation of oil. The slow *in situ* chemical conversion of the buried organic material to liquid and gaseous hydrocarbons takes place over millions of years, under increasing temperature with the removal of oxygen and other elements. Compaction of the loose host sediments in course of time forces out the hydrocarbons to migrate outward into favourable structural traps in porous sedimentary rocks where they are preserved for long geologic periods, provided these host formations escape high-grade metamorphism and the associated high temperature which, if it exceeds 200°C, will destabilize the hydrocarbons and convert them to black carbonaceous material.

For a long time it was believed that rocks older than 400 million years lacked the prolific life needed to form the organic detritus and this was considered a reason for the absence of petroleum deposits in old rocks. Besides, there was little continental shelf and rise available for sediments to accumulate around the single large continent like Pangea till its breakup at the end of Triassic, some 190 m.y. ago. The steady parting of land masses thereafter provided fresh continental edges and marine basins as repositories for erosional and organic debris. Apart from the paucity of abundant life forms and basins for sediments to accumulate, the greater potential of hydrocarbons to be destroyed by erosion, deformation or metamorphism in very old rock formations explains why 60% of the world's oil come from Cenozoic, during the last 70 million years, and progressively less (25%) in Mesozoic (225–70 m.y.) and Palaeozoic (570–225 m.y.).

Though most of the world's oil comes from post-Palaeozoic strata, a few older occurrences (> 570 m.y. or Proterozoic and Archaean periods) are also known (Table 1). The oil fields of Oman, China and Siberia belong to the late Proterozoic, while the small occurrences of hydrocarbon reported from rocks of MacArthur Basin in Australia, vein pyrobitumen found in Precambrian sedimentary sequence of North America and bituminous nodules in the rocks of Transvaal sequence of South Africa all belong to middle to late Proterozoic times[2,3]. The Australian occurrence in the MacArthur Basin (1400–1700 m.y.) coincides with the appearance of eukaryotes – the unicellular organisms constituting the chief source of oil. Geologists Roger Buick (University of Sydney, Australia), Berger Rasmussen and Bryan Krapez (both from University of Western Australia, Nedlands, Australia) have now found evidences for occurrence of oil still further back in time during the Archaean period[3,4]. They have found petroleum generation and migration in ~ 3.0–~ 2.75 b.y. old non-marine sandstones and ~ 3.25 b.y. old deltaic sediments in

Australia; and in South Africa, in the > 3.46 b.y. old cherts of Warawoona Group. These rocks are associated with mudstones, which were rich in organisms and served as the source of oil generation. They had also observed relics of pyrobitumen in the shallow marine sandstones (~ 2.8– ~ 2.6 b.y. old) of the Kaapvaal Craton of South Africa along with methane accumulation believed to have been derived from Archaean rocks[3]; and in Canada in early Palaeoproterozoic sandstones of Superior Craton.

In an effort to find any trace of original liquid hydrocarbon in any of the above sites in Australia, South Africa and Canada, Dutkiewicz and colleagues examined the drilled cores of the sandstones in these places. Surprisingly, they could locate oil occurring as < 5–10 µm size tiny inclusions inside detrital grains of quartz present within laminae of bituminous nodules in the sandstones[4]. According to the authors, the hydrocarbons that had originally migrated into the sandstones were later converted (polymerized) to bituminous nodules by alpha-bombardment from the associated radioactive minerals (uraninite, monazite, thorite and zircon) even before the sandstones underwent a mild metamorphism during mid-Palaeoproterozoic times. They have identified the inclusions as oil by non-destructive ultraviolet epifluorescence microscopy by their characteristic fluorescent emission at 330–380 nm wavelength and their chemical composition established as aliphatic hydrocarbons by Fourier transform infrared spectroscopy (FTIR). The inclusions were abundant in the Canadian and Kaapvaal samples (some showing even gas bubbles floating inside the liquid oil) and less in samples from Pilbara. The preservation of these fluid inclusions, in their original state, till today indicates that either they were never subjected to temperatures beyond 200 or 300°C or any intervening metamorphic episode did little to alter them. The authors infer that the migrating hydrocarbons must have been trapped within grain-cracks or microfractures (1–50 µm wide) and later sealed by silica during a subsequent low-grade metamorphic event or diagenesis and thus protected from further degradation. Oil entrapment in all the cases are believed to have taken place before 1850 m.y. ago; in the case of Pilbara occurrence, during Archaean itself and for Kaapvaal 2380–2330 m.y. ago.

In their assessment of these finds, Dutkiewicz *et al.* point out that there must have been substantial burial of organisms and that hydrocarbon generation and migration must have been widespread in Archaean and early Palaeoproterozoic basins even in the 3 b.y. period. This view, they claim, is supported by surveys carried out to evaluate organic carbon content in Archaean sedimentary rocks which have indicated that 'after accounting for metamorphism decarbonation, kerogen levels in many Australian mudrocks were high enough to have yielded significant quantities of hydrocarbon on thermal maturation[4],' a finding substantiated by isotopic mass balance data also, which reveals that at least 12% of all buried Archaean carbon was organic[5]. That the oil survived for about 3 billion years, the authors say, indicates that 'post-depositional trauma did not always destroy all traces of petroleum fluids' and such destruction is possible only in open systems under low pressure such as those present in oil reservoirs and pore network, where circulating fluids and catalytic substrates can interfere with petroleum liquids and alter them to pyrobitumen and methane around 200°C. The authors argue that this is highly unlikely in high pressure closed systems within inert minerals like quartz where the degradation of the included hydrocarbon is extremely slow allowing their survival over millions of years. They cite the classic case of the survival of long-chain hydrocarbons present as fluid inclusions in the Devonian (395–345 m.y.) tin–tungsten deposits in Tasmania, Australia[6] which were briefly subjected to temperatures of 300 to 450°C and contend that the 'fluid inclusion can shelter complex hydrocarbons for about a billion years under core cratonic thermal regimes and hence time can no longer be considered as a parameter for petroleum degradation and that its upper temperature stability limit is much higher than commonly assumed'.

Table 1. Evidences of oil in Proterozoic and Archaean rocks

Country	Group/Formation	Age (b.y.)	Evidence
South Africa	Cherts of Warawoona Group	> 3.46	Bitumen relics
Australia	Deltaic sediments of Musquito Creek, Pilbara Craton	~ 3.25	Bituminous nodules
Australia	Sandstones, Lalla Rook Formation of the Pilbara Craton	~ 3.00	Bitumen nodules and oil as fluid inclusions
South Africa	Sandstone Witwatersand Group, Kaapvaal Craton	~ 2.85	Bitumen nodules and oil as fluid inclusions
Australia	Non-marine sandstones, of the Fortescue Group, Pilbara Craton	~ 2.76	Bitumen nodules and oil as fluid inclusions
South Africa	Sedimentary rocks of Black Reef Formations, Transvaal Supergroup	~ 2.6	Bitumen nodules and oil as fluid inclusions
Canada	Sedimentary Rocks of Superior Creek in the Huronian Supergroup	~ 2.45	Bitumen nodules and oil as fluid inclusions
Australia	Sandstones, MacArthur Basin, Pilbara Craton	~ 1.4– ~ 1.7	Bituminous nodules
Siberia	Sedimentary rocks of Lena–Tunguska Province	Late Proterozoic	Crude oil
China	Sichuan Basin rocks	Late Proterozoic	Crude oil

Data from refs. 3 and 4.

The recent findings in Australian, S. African and Canadian rocks indicate that the hydrocarbon generation by thermal maturation of biogenic kerogen must have been extensive in Archaean sedimentary basins, since prokaryotic organisms started flourishing in early Precambrian times. Convincing evidence of existence of simple life forms in periods as early as 3.8 to 3.85 billion years are also presently known, from findings on samples of apatite grains separated from banded iron formations (BIF) belonging to this age span in Greenland. These grains were found to enclose carbon in the form of graphite unalterably locked up inside them and the isotopic $^{13}C/^{12}C$ ratio of these graphite inclusions showed enrichment of the lighter ^{12}C isotope, a feature typical of biologically derived carbon[7]. Even though the reported occurrence of oil as fluid inclusion in Archaean rocks is interesting and strengthens grounds for existence of flourishing life very early in the earth's history, commercially the finds are not viable breakthroughs, though the extent of the relics suggest that large deposits of oil must have existed in those early times. Undoubtedly, this discovery points to the need for a revision of some of the long established criteria considered necessary for oil formation and their preservation. Scientifically these well-preserved samples are bound to be much sought after as important source materials to study the primeval aquatic biota and other aspects of the early earth.

1. Ourisson, G., Albrecht, P. and Rohmer, M., *Sci. Am.*, 1984, **251**, 34–41.
2. Jackson, J., Powell, T. G., Summons, R. E. and Sweet, I. P., *Nature*, 1986, **322**, 727–729.
3. Buick, R., Rasmussen, B. and Krapez, B., *Bull. Am. Assoc. Petrol. Geol.*, 1998, **82**, 50–69.
4. Dutkiewicz, A., Rasmussen, B. and Buick, R., *Nature*, 1998, **395**, 885–888.
5. Hayes, J. M., in *Earth's Earliest Biosphere – Its origin and Evolution* (ed. Schopf, J. W.), Princeton University Press, 1994, pp. 291–301.
6. Hoffmann, C. F., Henley, R. W., Higgins, N. C., Solomon, M. and Summons, R. E., *Chem. Geol.*, 1988, **70**, 287–299.
7. Mojzsis, S. J., Arrhenius, G., McKeegan, K. D., Harrison, T. M., Nutman, A. P. and Friend, C. R. L., *Nature*, 1996, **384**, 55–59.

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SCIENTIFIC CORRESPONDENCE

Nematicidal principle from the fungus *Pleurotus sajor caju*

Cultivation of white button mushroom, *Agaricus bisporus* Lange-Imbach, is catching on in India because of its huge demand in the country itself and in the export market. An important limitation in its cultivation is the attack by myceliophagous nematodes. These nematodes find their way into mushroom houses through various sources, especially water. These nematodes, once introduced, multiply rapidly and cannot be managed with chemicals. Use of nematode-trapping fungi for their management is an attractive possibility[1]. Baron and Thorn[2] suggested the use of *Pleurotus*, an edible mushroom, for destruction of nematodes. In India *Pleurotus sajor caju*, commonly called Dhingari, has shown promise in managing myceliophagous nematode, *Aphelenchoides compositicola*: a serious pest when grown in combination with *A. bisporus*[3]. Here we report the results of experiments on isolation and characterization of a toxin from *P. sajor caju* responsible for toxicity to nematode, *A. composticola.*

The toxin from *P. sajor caju* was isolated following the technique of Frederick *et al.*[4], and toxicity was tested after every step using laboratory culture of *A. composticola* in water. Straightening of nematodes immediately after addition of 0.1 ml of aqueous extract to one ml suspension of nematodes was taken as a positive reaction. Culture filtrate of *P. sajor caju* (200 ml), having nematicide activity, was concentrated *in vacuo* and dialysed against water with two changes. The two outside fractions containing activity were pooled and once again concentrated in vacuum. This extract was precipitated by adding 10 volumes of methanol and the resulting precipitate was centrifuged off. The supernatant was concentrated and precipitated with 20 volumes of acetone. Precipitates were filtered and dissolved in methanol. The methanol solution was purified by passing it through a column of charcoal. Most of the nematicidal activity was present in this fraction. Toxin was further purified by preparatory TLC on silica plates developed with a mixture of acetone, water, methanol and chloroform in the ratio of 75 : 5 : 10 : 10. It showed entire activity in a spot corresponding to muscarine. Results were confirmed by developing silica plates with a mixture of butanol and dioxane (saturated with water) in the ratio of 4 : 1, and again the toxin spot corresponded with that of muscarine.

Purified toxin was colourless crystalline, highly hygroscopic, thermostable and showed negative reaction with ninhydrin. We suspect this toxin to be muscarine: a toxin commonly present in several mushroom species. This conclusion draws support from the fact that the mushroom *P. sajor caju* is susceptible to insect pests and not to nematode pests[3] as there are differences in their nervous systems. In insects nicotinic effects are predominant[5], whereas in nematodes it is muscarinic effects[6] that are predominant.

1. Cayrol, J. C., Frantowski, J. P., Laninc e, A. D. and Hardmare, G., *Rav. Hortic.*, 1978, **184**, 20–30.
2. Baron, G. L. and Thorn, R. G., *Can. J. Bot.*, 1987, **65**, 774–778.
3. Sharma, V. P., *Mushroom Res.*, 1994, **3**, 15–20.
4. Kurhl Frederick, A., Lebel Jr. Norman and Richter John, W., *J. Am. Chem. Soc.*, 1995, **577**, 6663–6665.
5. Eldefrawi, M. E., Eldefrawi, A. T. and O'Brien, R. D., *J. Agric. Fd. Chem.*, 1970, **18**, 1113.
6. Lee, D. L., in *The Physiology of Nematodes*, Oliver and Boyd, London, 1965, pp. 154.

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