REPORT ON INTERNATIONAL SYMPOSIUM ON THE OKLO PHENOMENON
LIBREVILLE, GABON, JUNE 1975
The meeting was attended by 73 participants from 19 countries.

The Oklo Phenomenon

A scientific conference about the Oklo phenomenon took place in Gabon in West Africa on 23–27 June this year. The conference was arranged jointly by the International Atomic Energy Agency, the Gabonese Authorities and the French Atomic Energy Commission, CEA. The Oklo phenomenon, which is named after a uranium mine in Gabon, is of considerable interest to geologists, isotope geochemists and reactor physicists, as it has been discovered that nuclear reactions took place within the rich uranium ore body over a period of at least 100 000 years, some 1800 million years ago.

DISCOVERY OF THE FOSSIL NUCLEAR REACTOR

In September 1972, the world's scientific community was told of a discovery made by researchers of the French Atomic Energy Commission which indicated the existence of old fission chain reactions in the uranium deposit at Oklo in Gabon. The reaction site consisted of several bodies of very rich uranium ore and more than 500 tonnes uranium had been involved in the reaction with a quantity of energy released of close to 100×10^9 kWh. The integrated neutron flux at certain points exceeded 1.5×10^{21} n/cm^2, and samples have been found in which the concentration of the isotope ^{235}U is as low as 0.29% (as compared with 0.72% in natural uranium). The nuclear reaction control mechanism which allowed such high rates to be attained must have been quite exceptional.

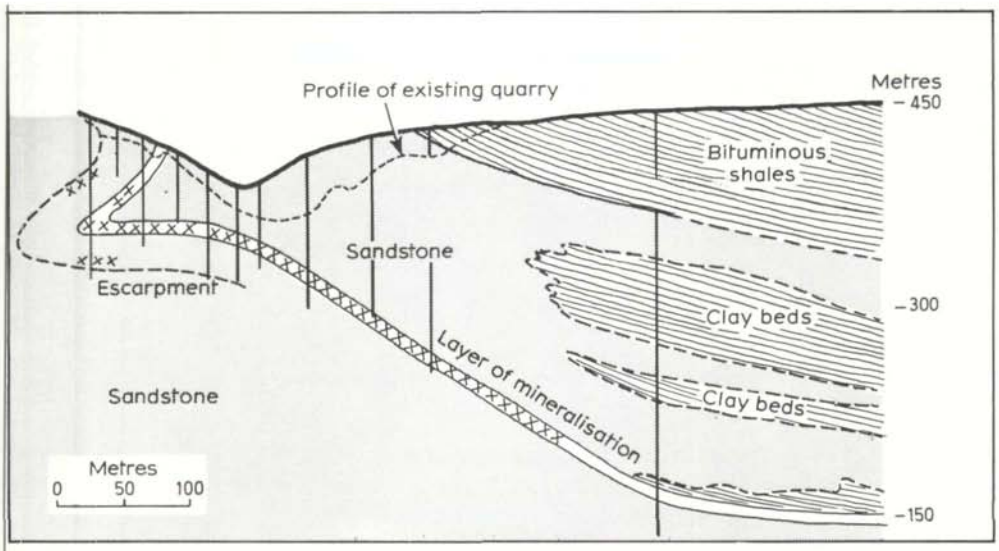
The state of preservation of the fossil nuclear reactions is exceptionally good and the uranium has retained its configuration of the time so faithfully that reaction rate distribution across the formations can be interpreted in terms of neutron physics. In fact, an entire episode in geological history can be studied, thanks to the numerous 'tracers' emanating from the nuclear reactions, beginning from the deposition of very high uranium concentrations some 1800 million years ago up to recent alterations.

The IAEA felt that the Oklo phenomenon was an excellent subject for international co-operation on fundamental research and welcomed the proposal made by the Government of Gabon and the French AEC to convene a symposium and make known the results already available, compare their interpretation and prepare possible programmes for joint research work.

The programme of the symposium which had been largely organized by the Centre d'études nucléaires de Saclay, was divided into three subject headings: — Earth sciences, Isotope geochemistry and Reactor Physics.

EARTH SCIENCES

At the meeting the general location of the Precambrian sedimentary series in which the Oklo deposit lies in relation to the African continent was first outlined, and then more



Scale drawing of the Oklo mine formation. Credit: New Scientist

general data on the Franceville basin to establish the age relationship of the various geological units and the setting of the Oklo uranium deposit in detail were discussed. The mineralogy and petrology of the gangue minerals and country rock have been examined and the spatial distribution of any effects which have been retained by the minerals at and around the area of the Oklo fossil reactions have been described. The record of the mineralogical additions was shown to have been affected by the heat generated in the reaction. Other papers discussed the micro-distribution of radiation damage, the carbon chemistry and the noble gas distribution all as part of a multidisciplinary analysis of the Oklo uranium ores.

ISOTOPE GEOCHEMISTRY

The scientific sessions on isotope geochemistry opened with a description of the discovery of the anomaly and the isotopic analytical methods which were employed, both prior to the discovery and subsequently for checking the constituents and to verify the existence of the anomaly. Further papers dealt with the age of the uranium ores and the date of the nuclear reactions. It was shown that the uranium and/or fission product data are highly discordant at the edges of the reactor zone. This portion of the reactor may have been subjected to rather drastic physical and chemical changes compared to the central region of the ore body. The relevance of nuclide migration at Oklo to the problem of geologic storage of radioactive waste was discussed and it was indicated that in the Oklo geochemical environment during the past 1800 million years the fission product elements which migrated significantly were Kr, Xe, Cs, Sr, Ba, Mo and I. Two of the mobile elements are important from a nuclear waste storage point of view, Sr and Cs, and it has been indicated that the mobility of Sr was not sufficiently great to result in its total displacement. It is possible that the rate of dispersal was sufficiently low with respect to the half-life of $(^{90})$Sr(29y) that little or no radioactive Sr escaped in the reactor zone.

REACTOR PHYSICS

Papers were presented covering the reactor physics of the reactions and included studies of the neutron balance of the nuclear reactions in Oklo, studies of the fluence distribution by isotopic analysis of rare earths, neutron-based interpretation of the reaction rate distributions, models of uranium and fission product behaviour and problems posed by mechanisms for regulation of the reactions.

PANEL SESSIONS

Panel sessions on the three principal subjects and on future research requirements discussed a number of questions such as, in relation to earth sciences:

(1) whether the uranium reconcentration which gave rise to the reaction ore bodies was contemporary with the uranium accumulation in the rest of the deposit, or whether it occurred subsequently

(2) whether the accumulation of uranium was due, primarily, to sedimentological or to tectonic factors

(3) what was the role of organic substances and how is their absence explained in the reaction zones

(4) whether the mineralogical differences observed between the ore in the reaction zone and in the surrounding area are related to the accumulation to the uranium, or are a consequence of the nuclear reactions

(5) how is it possible to reconcile the facts which prove both a stability of uranium and at the same time the restructuring of the gangue minerals

(6) what is the probable extent and time scale of the diagenesis which followed the nuclear reactions and what were the primary pressures and temperatures during the different phases.

The following questions were discussed in relation to isotope geochemistry:

(1) conclusions about the stability of the uranium in the aureol of contamination and the problems of the lead ratios and how different results can be reconciled, particularily an explanation of the constant deficit of lead within the reaction zones

(2) the migration of the rare earths relative to the uranium

(3) the problems of the alkalines and the interpretation of the results of geo-chronological dating based on the alkalines

(4) the information available which concerned the date of the reaction

(5) conclusions concerning the stability and migration of other elements, such as Pu, and finally,

(6) the discussion turned to whether any useful lessons could be learned in regard to current waste disposal problems.

Under the subject of reactor physics, three questions were discussed:

(1) a study of the mechanisms which made possible the triggering, the continuation, the control and, finally, the cessation of the nuclear reactions; related to this subject were the changes caused by the reactions, the effect of propagation, the role of poisons, the role of water and the impact of temperatures

(2) the duration of the reactions and the measurements required for determining them and the changes in reaction intensity over the time period

(3) the possible value of thermohydrogeological studies were considered and also whether the repetivity of the phenomenon was exceptional or predictable.

FUTURE RESEARCH

The future of the site and the steps which have already been taken to preserve it were discussed and it was agreed that additional sampling should be carried out so as to provide material for future research.

The desire of all participants at the meeting for a continuation of technical panels of this sort was made evident and it was requested that, if possible, the Agency should consider giving its support to sponsorship of the three specialised technical working groups.

The complete proceedings of the symposium are expected to be published by the Agency before the end of 1975.

INTERNATIONAL SYMPOSIUM, OTANIEMI, 30 JUNE–4 JULY

The Symposium on "Radiological Impacts of Releases from Nuclear Facilities into Aquatic Environments" was attended by about 150 scientists and specialists from 26 countries and 4 international organizations. Thirty-three papers were presented in ten sessions.

The Aquatic Environment

The rapid increase in technological development and the broad societal benefit it has brought has been accompanied by a corresponding increase in environmental and societal problems. This has established a need to asses the impacts of new technologies, including nuclear industries. We are now entering an age which will see a rapid proliferation of nuclear power plants all over the world.

As long as man continues to utilize nuclear energy, some releases of radioactive materials to the environment seem to be inescapable consequences. The problem therefore is to limit and control such releases, so that adverse effects on man and his environment can be reduced to acceptable levels. We can now draw on three decades of experience of the environmental impact of radioactive materials. To review this experience and to survey recent results of studies related to the safety of releases of nuclear facilities into fresh water, estuaries and sea water, the International Symposium on "Radiological Impacts of Releases from Nuclear Facilities into Aquatic Environments" was held at Otaniemi, near Helsinki, Finland.