

NATURAL SOURCES OF RADIOACTIVE WASTES

Many people are surprised to learn that a large producer of radioactive waste is Nature itself. An enormous reservoir of primordial radioactive material lies on the surface and beneath the terrestrial crust. Natural processes, like volcano eruptions, mineral water springs, erosion and movements of sand, can bring fractions of this huge radioactive inventory into the human habitat.

At Oklo, Gabon, 1.8 billion years ago, a spontaneous fission process in a rich uranium deposit produced the same type of radioactive waste generated in nuclear power plants.

Mining, Milling, & Processing of Naturally Occurring Radioactive Materials. Natural processes have been accompanied by industrial activities such as mineral production that extract primordial radioactive materials from the Earth, use part of them, and leave the rest as radioactive residues. The mining, milling, and industrial use of naturally occurring radioactive materials (generally referred to as *NORMs*), cover a range of mineral resources and industrial activities. The main industries include elementary phosphorus production; phosphoric acid production; fertilizer production; primary iron and steel production, coal tar processing; coke production; coal- and gas-fired power plants; extraction of coal, peat, oil and gas; cement production; the ceramics industry; mineral sand;

titanium pigment production, and uranium and thorium mining. In some of these industrial processes, the concentration of radioactive materials in the product and in the waste can be much higher than in the ore. (See box, pages 38 & 39.)

The world inventory of radioactive waste that has been accumulated by natural processes and generated by industrial processing of *NORMs* is largely unknown. The known amount of such natural radioactive waste is formidable, however, and it has not drawn the same level of interest as radioactive waste from human activities. This is the case even though the levels of public radiation exposure attributable to some natural waste can be up to two orders of magnitude above the limits established in international safety standards for radioactive waste generated by human activities.

In many parts of the world, natural barriers have isolated *NORMs* for remarkably long time periods. At the Cigar Lake uranium mine in Canada, for example, containment has been so effective that neither a chemical nor radiological indication of the ore deposit exists at the earth's surface. At the Alligator Rivers mine in Australia, uranium and its decay products have moved only tens of meters from the ore body although it is located in geological formations with relatively rapid groundwater flow.

RADIOACTIVE MATERIALS IN NATURE

■ Radium-226 from Natural Waters.

The map shows areas of the Caspian Sea near the city of Ramsar, Islamic Republic of Iran, where spring waters rich in radium-226 emerge and deposit "tailings" of precipitates; these tailings have radioactivity levels that can deliver high radiation exposures to residents. They can be more than 100 times above the international exposure limit applicable to radioactive waste disposal (currently one millisievert per year). (Source: *5th International Conference on High Levels of Natural Radiation, Munich, 2000*)

■ Monazite Sand in Coastal Areas.

Sand deposits in the states of Rio de Janeiro and Espirito Santo, Brazil, may deliver radiation exposures that, on average, are 3.6 times higher than the international limit, and in some cases more than 30 times higher.

The same type of deposits in Kerala and Tamil Nadu, India, may deliver radiation exposures that on average are about nine times more than the limit, and in some cases are more than 30 times higher.

■ **Volcanic Deposits.** Volcanic deposits in Minas, Gerais, and Goias, Brazil, may deliver radiation exposures that on average are 13 times higher than the limit, and in some cases more than 80 times higher. The same type of deposits on Niue Island may deliver exposures above five times the limit.

■ **Thorium-Bearing Carbonate.** Deposits in Mombasa, Kenya deliver radiation exposures that can be more than 30 times higher than the limit.

