THE DIFFUSION OF SOME RADIONUCLIDES IN ROCKS COLLECTED FROM POTENTIAL REPOSITORY SITES IN SYRIA

I.Othman and J.Abou-Jamoos
Atomic Energy Commission
P.O.Box: 6091
Damascus -Syria

ABSTRACT

In this work the diffusivity of Cesium through marl, limestone, basalt and hardened cement paste slabs were measured in stationary and dynamic state. Rock samples were collected from potential repository sites in Syria. The effects of time, tracer concentration and flow state on diffusivity were measured.

INTRODUCTION

A significant attention has to be given to safety during the selection of radioactive waste repository. A detailed study of the site characteristics and the nature of the surrounding rocks must be carried out. It is expected that repository must conceal and reserve radionuclides which might migrate from its container as a result of damage due to aging or geological factors. Another possibility is flooding in the repository. As a result radioactive waste and radionuclides will migrate to the water bed, Then diffuse and contaminate the surrounding areas.

The migration speed depends basically on the type of reactions between migrated radionuclides and the surrounding rocks. In this study the diffusion of cesium through rocks and hardened cement pastes slabs has been measured in stationary and dynamic state. These experiments give directly the effective diffusion coefficients.

SITE SELECTION

Suitable site in Syria has to consider the geological, tectonical, hydrological and environmental factors. By making the geological and tectonical criteria in consideration, the basalt terrain found in the southern part of the country have been excluded. This is despite their vast outcrops since it lies in the unstable parts of the Arabian plate. In addition it has many and spread volcanic cones. The entire western part of the country also has been excluded since it is located close to the very famous Syrian, Lebanon faults. Similarly, Algazera and the highly populated strip extending from Damascus to Aleppo have been exclude on hydrological and ecological criteria.

Essentially, four areas in different parts of the country meet the criteria of selection and need to carry primary evaluation and further investigations. These sites are:

Site 1: It is neogene terrain in the south east of Homs. It might serve as a temporary disposal for low and intermediate level of radioactive waste.

Site 2: It lies at 50 Km to the south of Maskanah.

Site 3: This site is 35 Km south of Der - Alzor. It justify final repository of medium level radioactive wastes. It is gypsum formation of the neogene.

Site 4: This site located in the same gypsum formation of Site 3.

EXPERIMENTAL

The measurement of the diffusivities is carried out in experimental arrangement as shown in Fig. 1. A tracer solution is circulated on one side of the rock piece and a tracer free solution is in contact with the other side of the rock. The tracer diffusions through the sample and part of it may sorbe in the sample.

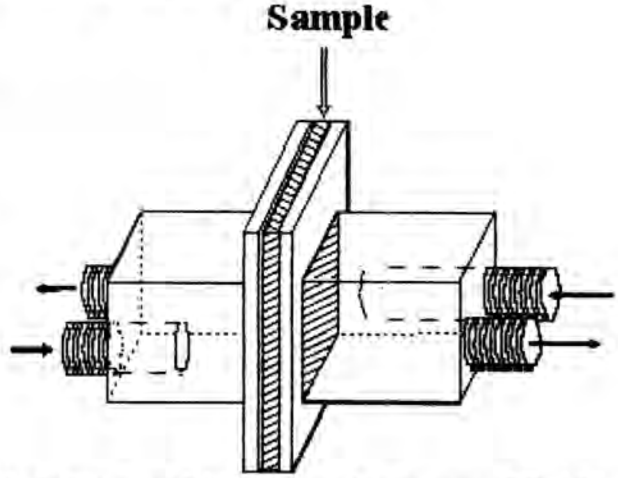

Fig.1. Experimental arrangement to measure diffusivities.

The rate of change of concentration at a point in one dimensional system is given by Fick's Second Law.

The effective diffusivity is calculated as follows:

$$D_e = Q \cdot Z / A \, (C_{w2} - C_{w3})$$

where:

Q	The total diffusion rate through the sample ($Bq.s^{-1}$).
Z	The sample thickness (m).
A	The sample surface area (m2).
C_{w2}	The concentration of tracer on high concentration side ($Bq.m^{-3}$).
C_{w3}	The concentration of tracer on low concentration side ($Bq.m^{-3}$).

Rock samples studied in this work include basalt, marl, limestone and hardened cement paste. Commercial cement (Portland) was mixed with deionized water (water / cement ratio of about 0.4) to make the paste. The paste degassed for 10 minutes. It was then cured in 5 x 5 cm wood mold. Radioactivity were measured by using Na I detector. The total count from diffused radionuclides is recorded before removing a thin layer of the slab. Thin layers are removed and remaining activity is measured until we reached the background reading.

RESULTS AND DISCUSSION

The tracer radioisotope diffused through samples as a function of time are presented in Fig. 2 for limestone and Fig. 3 for marl. It was found that the effective diffusion with time is higher for marl than limestone.

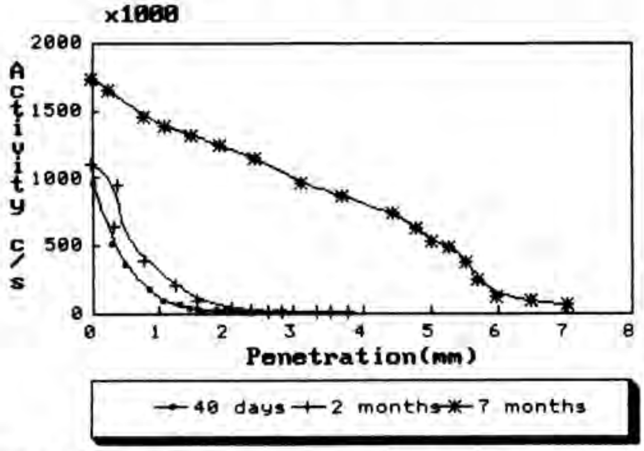

Fig. 2. Diffusion of radionuclides inLimestone as a function of time.

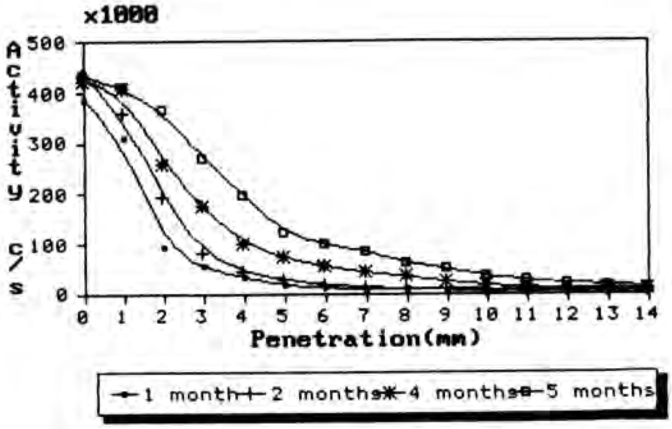

Fig. 3. Diffusion of radionuclides on March 1 as a function of time.

The study of the effect of flow direction on the diffusion of Cesium in limestone slab is presented in Fig. 4.

A perpendicular flow on the slab surface for 30 days has an equal affects as to 90 days of parallel flow. Table I - gives the effective diffusion coefficient values for marl and limestone in stationary and dynamic states.

The sorbing in rock slabs increase with the increasing of the concentration of tracer solution. The diffusion in marl is deeper with the concentration than in limestone.

The diffusion of Cs-137 in different types of rock slabs are presented in Table II It is found that the least diffusion of tracer solution is in hardened cement paste followed by basalt, limestone and marl respectively.

As a conclusion; time and flow direction have a significant effect on diffusivity, whereas, concentration did not have the same effect. Further investigations are required before reaching the decision on the suitability of these sites.

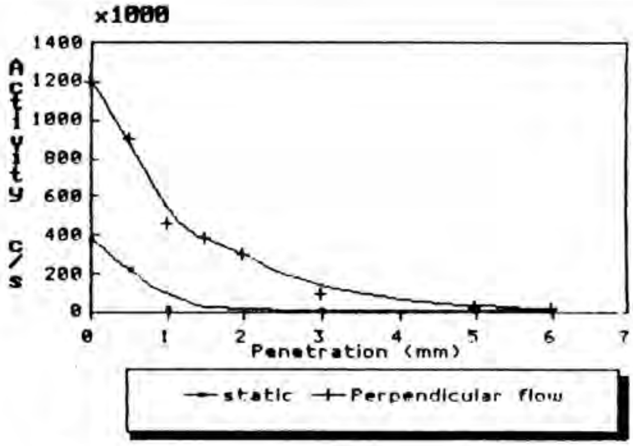

Fig.4. The effect of flow direction on diffusion of radionuclides on March 1.

TABLE I

Effective Diffusion Coefficient ($m^2 \cdot s^{-1}$) in Stationary and Dynamic States of Tracer Solution

	Stationary	Dynamic
Limestone	8.7×10^{-9}	19.6×10^{-9}
Marl	2.3×10^{-8}	5.2×10^{-8}

TABLE II

The Effective Diffusion Coefficient in Different Rocks ($m^2 \cdot s^{-1}$)

Rock Slab	Effective Diffusion Coefficient
Hardened Cement	9.6×10^{-10}
Basalt	3.3×10^{-9}
Semi-crystalized limestone	8.6×10^{-9}
Limestone	19.6×10^{-9}
Marl	5.2×10^{-8}

ACKNOWLEDGEMENT

The authors would like to thank the Director General of the AEC Prof. Dr. I. Haddad for his support, and Mr. M. Kheto and Mr. A.Ali for their technical assistance.

REFERENCES

1. RAMUSON, A. and NERETTIEKS, I., Migration of radionuclides in fissured rock, the influence of micropore diffusion and longitudinal despersion. J.Geophysics Res. 86, 3749 (1981).
2. GRANK, J. The mathematics of diffusion. Oxford University Press(1975).
3. MUURINEN, A., HILTUNEN, P.P. and RANTANEN, J.Diffusion Mechanisms of Strontium and Cesium in Compacted Sodium Bentonite. Mot. Res. Soc. Symp. Leoc. Vol.84, 803 (1987).