Geophysics

Yu. A. Izrael, V. N. Kolesnikova, V. V. Romanov, V. N. Soifer

1964

SovietRxiv

Abstract

Full Text

Geophysics

Yu. A. Izrael, V. N. Kolesnikova, V. V. Romanov, V. N. Soifer

ON THE TRITIUM CONTENT IN GLACIERS

(Presented by Academician E. K. Fedorov, 9 XII 1963)

The question of the tritium content in glaciers has been studied extremely little —there is only one detailed paper in the world literature on the concentration of tritium in the glaciers of Greenland (⁀1). The concentration indicated there in layers for the period 1944-1951 was about 15 t.u.*, in 1954 200 t.u., and in 1955 100 t.u. Let us note that in a glacier, over many years, practically all products that have entered it are preserved, and it is one of the best natural reservoirs of atmospheric moisture. Therefore, studying the concentration of tritium in glaciers makes it possible to reconstruct the pattern of its accumulation in a given region of the globe over many years before the moment of sampling.

To determine the tritium content in glaciers and to establish the relation of its amount to the existing sources of tritium on the globe, in August 1961 ten ice samples were taken on the Fedchenko Glacier (Pamir). The elevation of the sampling site was about 5000 m above sea level. Sampling was carried out by annual layers and covered the period from 1951 to 1961. Each ice sample was completely converted to the liquid state, thoroughly mixed, and then a portion of 20 l in volume was separated from it for tritium analysis. The analysis was carried out by the method and apparatus described in works (⁀2-4).

Table 1

Ice layer	Layer thickness, cm	Tritium conc., t.u.	Ice layer	Layer thickness, cm	Tritium conc., t.u.
1960–1961	85	424	1955–1956	110	321
1959–1960	185	600	1954–1955	96	318
1958–1959	120	532	1953–1954	138	392
1957–1958	185	486	1952–1953	130	1090
1956–1957	153	975	1951–1952	134	378

Fig. 1. Course of accumulation of the total amount of tritium on the globe (1) and in the Fedchenko Glacier (2) over the period from 1952 to 1962.

Figure 1: Fig. 1. Course of accumulation of the total amount of tritium on the globe (1) and in the Fedchenko Glacier (2) over the period from 1952 to 1962.

Table 1 gives the measured concentration of tritium by layers (at the time of measurement in 1962), as well as the thickness of the annual layers. The error in determining the tritium concentration did not exceed 15%.

Below, the course of accumulation of tritium in the glacier is compared with the course of its formation on the globe during the period from 1952 to 1961.

It is known (⁀1) that the rate of formation of tritium in the atmosphere due to cosmic radiation is approximately $2 \cdot 10^{26}$ tritium atoms per year. During test nuclear explosions based on a fusion reaction of the type $H^3 + H^2$, 1 atom of tritium is released into the external environment per 180 MeV of energy, i.e. $1.45 \cdot 10^{26}$ tritium atoms per 1 megaton of yield of such an explosion (⁀5). The amount of tritium released in explosions based on a fission reaction (due to "triple" fission) is at least 3 orders of magnitude smaller than in the case indicated above ([6,7]) (per unit of energy released), and in the interaction of explosion neutrons with water (the oceanic underlying surface, water vapor in the atmosphere) approximately 6 orders of magnitude less tritium is formed, since the bulk of the neutrons is consumed in the formation of deuterium (⁀8).

Thus, it may be assumed that the main source of tritium formation on the globe during the period from 1952 to 1958 was tests of ther-

* t.u.—a tritium unit corresponding to a concentration equal to 10^{-18} atoms of tritium (H^3) per 1 atom of protium (H^1).

nuclear weapons (the amount of tritium formed in "ternary" fission may be neglected, since the total energy release due to the fission reaction over this period is comparable with the energy release in the fusion reaction ([9])).

The histograms shown in Fig. 1 illustrate the course of accumulation of the total amount of tritium on the globe due to nuclear-weapon tests $A(t)$ (curve 1) and the course of accumulation of tritium in the Fedchenko Glacier $\sigma(t)$ (2) over the period from 1952 to 1961 (for comparison, the curves are normalized by an arbitrary factor to 1960). In calculating $\sigma(t)$ from the data of Table 1, a correction was made for the thickness of the annual layer and the density of the ice, as well as for tritium decay. The density of the ice in the upper layer on the Fedchenko Glacier was taken to be 0.5 g/cm^3, and in the 1951 layer 0.85 g/cm^3 ([11]). The density of the ice in the layers of 1952–1960 was determined by us by interpolation. The data for calculating the accumulation of tritium in nature due to nuclear explosions were taken from works ([9, 10]).

Fig. 1. Course of accumulation of the total amount of tritium on the globe (1) and in the Fedchenko Glacier (2) over the period from 1952 to 1962.

It follows from Fig. 1 that the character of tritium accumulation in the glacier generally coincides with the character of tritium accumulation on the surface of the globe. However, two features of the curves $A(t)$ and $\sigma(t)$ may be noted. During the intensive release of tritium into the atmosphere (in 1958), the curve $A(t)$ lies above the curve $\sigma(t)$. One possible explanation of this is that the removal of tritium from the stratosphere to the Earth' s surface is probably a prolonged process (months, and possibly 1-2 years). Conversely, in the years preceding the intensive release of tritium, the curve $\sigma(t)$ is somewhat higher than the curve $A(t)$. This may be explained by the fact that meltwater with a higher tritium concentration (relative to the lower layers) could penetrate into deeper ice layers.

Assuming that during the period from 1952 to 1958, $1.25 \cdot 10^{28}$ tritium atoms ([8]) were released into the atmosphere, and supposing that the released tritium was uniformly distributed over an area equal to half the surface of the globe, we can make a rough estimate of the concentration of tritium accumulated on the Earth' s surface (per unit area). This quantity is $5 \cdot 10^9$ atoms H^3/cm^2, which is close to the value measured by us (the sum for the period 1952-1961), namely $2.4 \cdot 10^{10}$ atoms H^3/cm^2.

Institute of Applied Geophysics
of the Main Administration of the Hydrometeorological Service

Institute of Mathematics
Academy of Sciences of the Uzbek SSR

All-Union Scientific Research Institute
of Nuclear Geophysics and Geochemistry
of the State Geological Committee

Received
31 VII 1963

REFERENCES CITED

1. F. Begemann, *Zs. Naturforsch.*, **A 14**, 334 (1959).

2. F. A. Alekseev, V. N. Soifer et al., *Atomic Energy*, **4**, no. 3, 298 (1958).

3. F. A. Alekseev, G. R. Golbek et al., *Radioisotopes in the Physical Sciences and Industry*, Vienna, 1962, p. 519.

4. V. N. Soifer, in: *Proceedings of the All-Union Conference on the Use of Radioactive Isotopes in the National Economy of the USSR*, **4**, Riga, 1960, p. 133.

5. O. I. Leipunsky, *Atomic Energy*, **3**, no. 12, 530 (1957).

6. S. Katcoff, *Nucleonics*, **16**, no. 4, 78 (1958).

7. G. A. Mostovaya, *Atomic Energy*, **10**, no. 4, 372 (1961).

8. D. J. Hughes, R. B. Schwartz, *Neutron Cross Sections*, 1958.

9. Ch. L. Dunham, *Fallout from Nuclear Weapons Tests*, Hearings, 1959, **1**, Washington, 1959, p. 10.

10. K. Telegadas, ibid., **3**, p. 2517.

11. *Fedchenko Glacier*, collection edited by V. L. Shul' ts, **1**, Publishing House of the Academy of Sciences of the Uzbek SSR, 1962.

Note: Figure translations are in progress. See original paper for figures.