

The Origin of O¹⁷

In the Physical Review of April 1 Harkins and Schuh have considered the possibility of all the o¹⁷ atoms in the earth's crust and atmosphere having been formed by close collisions of alpha-particles with the nuclei of nitrogen atoms as revealed by the cloud tracks. Assuming that the ratio O¹⁷:O¹⁶ atoms is the same in the crust as in the atmosphere and that the known nitrogen and radium contents are uniformly distributed in the crust they estimate that the necessary lapse of time would have been about 10¹⁸ years which is an impossibly great age for the earth.

At about the same time the writer made (Minnesota Technol. 10, 240 (1930)) a similar calculation for the atmosphere alone by using its known radon content of 10⁻¹⁰ curie per cubic meter. The result is about 10¹⁴ years required. Since this also represents an apparently excessive age one is inclined to seek auxiliary means of production. A former content of U-Ra-Rn higher than at present suggests itself but seems improbable as one would then expect to find higher Pb:U ratios than those actually found in nature.

From Harkins and Schuh's calculation it is evident that oxygen liberated from the crust would diminish the relative content of O¹⁷ in the atmosphere. However if instead of a uniform distribution of uranium and nitrogen in the crust we consider concentration in the form of high grade uranium ore and an enhanced concentration of nitrogen in the ore the rate of O¹⁷ production would be increased. Hillebrand ((W. F. Hillebrand U. S. Geol. Survey Bull. 78, 43 (1891); Am. J. Sci. 40, 384 (1890)) did find a striking association of nitrogen and uranium. Whether this could be a large source of O¹⁷ would of course depend on the size of such deposits. This would be difficult to estimate and it appears unnecessary to consider it further in this connection since the following simple considerations show it to be highly improbable that any important fraction of o¹⁷ in the atmosphere can have been

generated on the earth either in the crust or in the atmosphere itself by alpha-ray bombardment.

About 100,000 alpha-particles are required for each nuclear encounter with nitrogen. Therefore the ratio of He to O¹⁷ generated would be 100,000 He:1 O¹⁷. In the atmosphere the actual ratio is about 1 He:5 O¹⁷. We can hardly conceive any natural process that would have achieved a change of 500,000 fold in the ratio of the two gases.

If we reverse the calculation and assume with Jeans (Jeans' Dynamic Theory of Gases, 1921, p. 345-6) no diffusion of helium away from the upper atmosphere then for 100,000 He atoms there would be only one O¹⁷ atoms of the assumed origin, or only about two millionths of the O¹⁷ atoms actually found by the band spectrum method.

As a matter of fact there are good reasons for believing that at least several fold as much helium *has* diffused "out at the top" as now remains, since that many fold have been liberated into the atmosphere by erosion, etc. The writer would point out that Jeans' denial of loss by diffusion is based wholly on thermal diffusion; whereas light gases like hydrogen and helium in the upper atmosphere can absorb radiation which upon conversion into translational energy would give them a velocity quite beyond that corresponding to thermal equilibrium with the surroundings and thus allow their escape. This process would therefore raise the O¹⁷ ratio by lowering the helium. While it may have taken place to an extent several times the present helium content of the atmosphere, it would be difficult to believe that it might have occurred to an extent of 500,000 fold, which would be necessary to have established the present He:O¹⁷ ratio.

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Paschen-Back Effect on the Line Spectra of Solids

In a work which we shall publish soon,¹ we have been able to assign a number of the lines of the spectrum of Gd⁺⁺⁺ in the crystal GdCl₃·6H₂O to definite energy levels. These levels have been fixed by studying the spectrum under various conditions, namely, observing how the lines shift their position with the

temperature, observing their polarization, the corresponding lines of the crystal GdBr₃.

¹ Freed and Spedding, Nature 123, 525 (1929).

Freed and Spedding, Phys. Rev. 34, 945 (1929).

$6\text{H}_2\text{O}$, and the behavior of the spectrum in a magnetic field.

The lines that are decomposed by a relatively weak magnetic field invariably break up in two components which are equal in intensity and are symmetrically displaced from the position of the original line. However, dissymmetries occur with stronger fields when the levels produced by the magnetic field approach each other. The dissymmetry in the intensities is especially pronounced. Some of the lines become much stronger while others become weaker, practically vanishing in some cases. A number of the lines coalesce and it has been found impossible to force any crossing with the maximum field at our disposal.

This work was done with a crystal of

$\text{GdCl}_3 \cdot 6\text{H}_2\text{O}$ at room temperature. The dissymmetries would undoubtedly have been different at other temperatures as the intervals between the energy levels are then different² and consequently the intervals and the interactions between the magnetic levels would no longer be the same.

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² Freed and Spedding, *Phys. Rev.* **34**, 945 (1929).