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Origin of Upper-Atmosphere Lithium Atoms responsible for the New Twilight Airglow at 6708 A.

A NEW emission line near 6708 A. has been reported recently by Delannoy and Weill[1] to be present on twilight spectrograms obtained in Adélie Land, Antarctica, during October 1957. Gadsden and Salmon[2] also report the appearance of the same line in twilight spectra photographed at Hallett Station, Antarctica, during August, 1958, and at Invercargill, New Zealand, on September 5, 1958. In both instances, the authors attribute the new line to resonance radiation from the 2^2S—2^2P transition in the neutral lithium atom at 6707·8 A.

In a further communication, Barbier, Delannoy and Weill[3] estimate the ratio of the number of neutral atoms of lithium to those of sodium at the level of twilight emission, taking into account the very different energy of the exciting solar radiation at 5893 A., and 6708 A. respectively. From an observed intensity ratio, $I_{6708}/I_{5890+5896}$, equal to 0·1 : 1, they compute an abundance ratio of $N_{\mathrm{Li}}/N_{\mathrm{Na}}$ of $\sim 0{\cdot}006$, about three times greater than that found in stony meteorites[4]. Since the lithium/sodium concentration ratio for oceanic waters[5] is only $\sim 2 \times 10^{-5}$, they conclude that both the sodium and lithium atoms in the high atmosphere are meteoritic, and not terrestrial in origin.

Gadsden and Salmon[2] infer from their intensity ratio measurements an even greater relative concentration of lithium, with a lithium/sodium ratio of $\sim 0{\cdot}05$, or some twenty-five times the expected value if both atoms are derived from meteoritic dust. They report also that altitude measurements of both the normal sodium and lithium twilight radiations revealed that, between August 13 and September 5, the height of the lithium emission (relative to that of sodium) decreased by $\sim 0{\cdot}4$ km. per day, the equivalent of a steady rate of fall of 0·46 cm. per sec. for the 'lithium cloud'.

On inserting this latter value in the classical Stokes's equation, together with the following adopted values for the remaining parameters, namely, air density at 80 km., $2{\cdot}5 \times 10^{-8}$ gm. per cm.^{3}; air viscosity at 190° K., $1{\cdot}2 \times 10^{-4}$ gm. per cm. per sec.; density of meteoritic dust, 3·5 gm. per cm.^{3}, a mean particle diameter of 5·4μ is obtained. According to Öpik[6], this is of the right order of magnitude if the particles in the cloud with which the lithium atoms are associated are derived from micro-meteors.

However, when such an origin is invoked, a major difficulty immediately arises in any attempt to explain the observed differential rate of fall of the lithium emission, since this would not be expected if both lithium and sodium atoms were associated with a falling cloud of meteoritic material.

The above argument, when taken in conjunction with the excess values of the lithium/sodium abundance ratio observed in 1957 and 1958, makes any hypothesis of a meteoritic origin for either element suspect. On the other hand, it lends credence to the recently published statement by the American Committee for the International Geophysical Year[7] that the presence of lithium in the upper atmosphere could be related, as was the recent artificial aurora[8], to nuclear (lithium bomb) explosions detonated at high altitude over the central Pacific Ocean during the period of the International Geophysical Year programme.

If the latter explanation is correct it is of interest to compute a revised value for the mean particle diameter in the descending cloud on the assumption that the radiating lithium atoms are trapped within a cloud of lithium oxide smoke of density 2·1 gm. per cm.^{3}. Taking values for the remaining Stokes's parameters as before, the average particle size is now $\sim 7{\cdot}0\mu$; and if the ejection of the lithium atoms occurred initially at a height of ~ 160 km. the twilight phenomena might be expected to be present for about 90 days after the nuclear explosion. During this interval the 'lithium cloud' would have fallen from the upper to the lower limit of resonance emission.

From the evidence of the August, 1958, observations it appears that there was a five-day lag between the time of the nuclear detonation on August 1 and the first appearance of twilight lithium radiation. Thus the initial rate of fall must have been considerably higher than the steady descent of 0·4 km. per day observed afterwards, a probable value being ~ 10 km. per day if the upper limit of twilight emission is taken to be 110 km.

Taking all the above facts into consideration, it appears highly probable that the lithium airglow emission observed in October 1957, and again in August–September 1958, was man-made, and thus wholly unrelated to the passage of meteoritic dust through the Earth's upper atmosphere.

If indeed this is correct, the hypothesis of a meteoritic origin for both lithium and sodium atoms suggested by Barbier, Delannoy and Weill[3] is invalidated, leaving the important question of the terrestrial, or extra-terrestrial, origin of upper-atmosphere sodium still unanswered.

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Magnetostriction and Palæomagnetism of Igneous Rocks

THE magnetization of dated igneous rocks has been much used for the study of the directions of the geomagnetic field in remote geological periods. This method is based on the supposition that igneous rocks become magnetized parallel to the field in which they cool. Its validity has been questioned