An Observation of Artificial Lithium Twilight Emission

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At 1821 CST on 27 February 1965, approximately fifty moles of lithium vapor were ejected by a Nike-Apache rocket between the altitudes of 80 and 160 km. The firing, which took place at Fort Churchill, Canada, was under the direction of the Geophysics Corporation of America.

Twelve hours later, in the morning twilight of 28 February 1965, a high abundance of Li was detected by auroral spectrographs at each of three observatories operated by the Geophysical Institute of the University of Alaska. A preliminary analysis of the available data gives an indication of the north-south extent, the duration of its existence, and an estimate of the Li abundance.

The spectrographs which detected the emission were stationed in the geomagnetic meridian (approximately 30E of N) passing through College, Alaska. The stations are:

	Geographic Coordinates N Lat.	W Long.
Ester Dome (College, Alaska)	64°53′	148°03′
Fort Yukon, Alaska	66°34′	145°17′
Bar I (Komakuk, Canada)	69°36′	140°11′

All three of the spectrographs are meridian instruments, i.e., each has a field of view of 2°×180° and resolves the north-south geomagnetic meridian along the spectrum lines in a direction perpendicular to its dispersion. The two northern spectrographs are mirror instruments (Clark and Romick, 1959) and the other is an IGY Patrol Spectrograph.

The exposures are held constant at 15 min in the mirror spectrographs and are graded to a minimum of 1 min in proportion to the solar depression angle on the patrol instrument. The spectrographs operate continuously during the night between civil twilights.

Fig. 1 shows two positive prints of spectrograms taken at Bar I on the morning of 28 February 1965. The exposures begin at approximately 0515 and 0530 AST (or 1515 and 1530 GMT). The change in the distribution of lithium along the meridian as shown by the two spectra follows roughly the behavior of the twilight sodium emission, and we may assume that the altitude of the emitting layer was about 100 km. This has been found to be the altitude range of the normal lithium layer in twilight (Sullivan and Hunten, 1964). The College and Fort Yukon spectra for the same period show that the lithium emission did not extend farther south than Fort Yukon. Thus the southern edge was located near 67N and the northern edge (not evident) was north of 75N. Estimates of the intensity of the lithium and the sodium (D_1+D_2) intensities at solar depression angle 6.5° are necessarily rough, but are close enough to relate this observation to others. The Na brightness was about 5 kR and that of Li was 0.5 kR. These intensities correspond to populations of about 10^{10} and 10^7 atoms cm^{-2}, respectively.

While the lithium abundance was above the natural background, it was not as intense as reported following the explosion of nuclear devices in the atmosphere (Sullivan and Hunten, 1964). The fact that it was only barely detectable on the morning of 1 March and not evident in the next day's spectra indicates that the lithium abundance had decreased by at least a factor of 5 in the intervening time. (The high threshold of detectability of this instrument is partially off-set by the

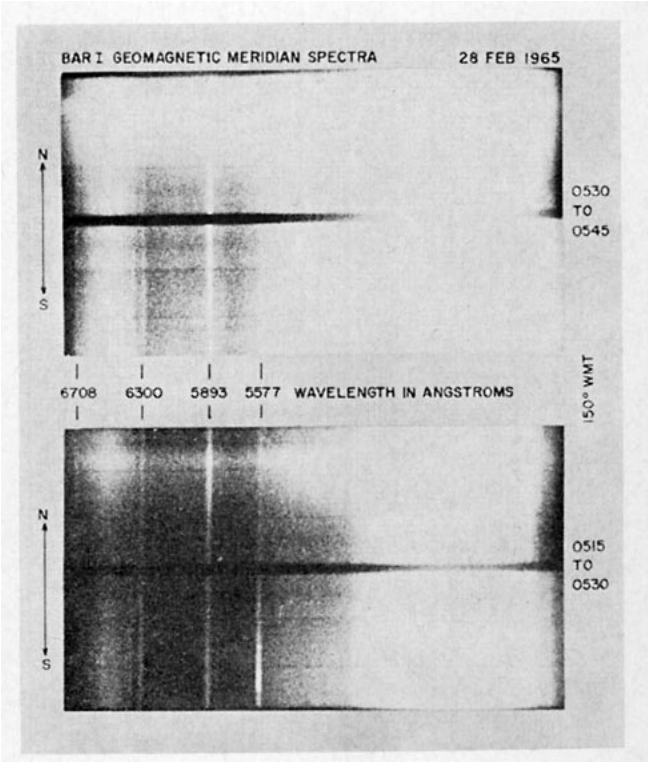

FIG. 1. Geomagnetic meridian spectrograms taken on the morning of 28 February 1965 at Bar I (69°36′N 140°11′W).

wavelength presentation, which leaves little doubt as to the authenticity of the observation.)

Of interest here, however, is that the main population of lithium atoms released at 58N 95W drifted into the polar region north of 67N 145W during the 12-hr period after launch. Thus, the distribution in latitude, as detected by the meridian chain of spectrographs indicates a northward drift into a polar vortex in the upper atmospheric circulation system.

The observation illustrates the feasibility of using trace elements in the study of large-scale upper atmospheric circulation. The possibility of using existing emitting elements is limited by a lack of knowledge of both the atmospheric dynamics and the chemical processes involved (see Vallance Jones, 1963).

A large-scale study of injected trace elements would result in sufficient knowledge to permit the separation of the apparent motion from the excitation mechanisms in studies of existing processes in the upper atmosphere.

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