First results on jovian lightning

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The geometric reduction of the discovery picture of lightning on the dark side of Jupiter relates the positions of the lightning flashes to visible cloud structure.

THE observations of the dark side of Jupiter were taken at 1979 March 4 d 17 h 52 min 30 s UT (time at the spacecraft) [see Fig. 10 in ref. 1]. A total of 13 stars appeared as double images and were used to establish the direction and orientation of the camera. The lower bound of the aurora establishes the position of Jupiter's limb which matches that found from the best ephemeris of the spacecraft. Longitudes and latitudes of the 20 lightning flashes are plotted in Fig. 1, while adjacent flashes are grouped together.

These positions also appear plotted on the first quadrant of a polar stereographic projection centred on Jupiter's north pole in *Plate 13*, Fig. 2. This projection was made from images obtained on 1 February 1979 at the spacecraft. We believe the mechanisms of generation of lightning on Jupiter and Earth may be similar. The most plausible mechanism is convective electrification[2]. Convection in the clouds distorts a pre-existing background charge distribution and thus collects the charges into a distribution which is discharged by lightning strokes. This mechanism requires a conductor some distance beneath the clouds. On Earth this is often the solid planet itself. However, the surface and a sufficiently conducting layer of cloud-free air will serve as well, as in the case of thunderstorms above warm fronts. This situation may also apply to the atmosphere of Venus in which lightning has also been detected[3] and where the atmosphere is clear of clouds in the lowest 35 km. The extension of this concept to Jupiter requires a sufficiently conducting atmosphere below the observed clouds, which may include a cloud-free region.

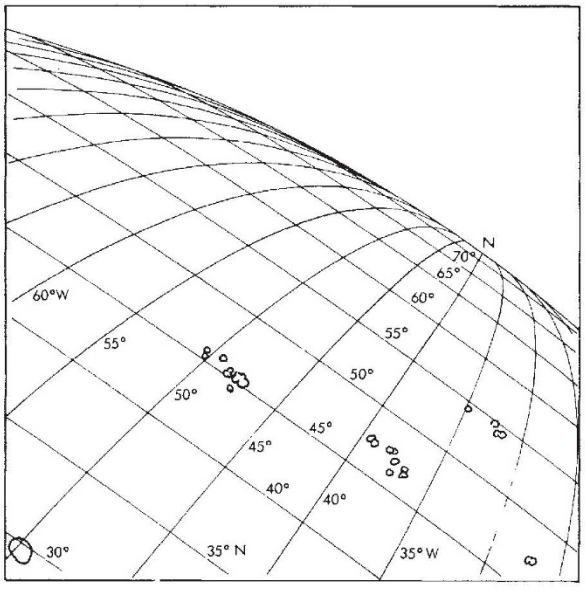

Fig. 1 The arrangement in the television field of Jupiter and the flashes of lightning. Latitudes are jovicentric.

The association of thunderstorms with upwelling in regional circulations is well known on Earth and also occurs on Jupiter. Consequently, observations of lightning may be used as a tracer of upwelling in the jovian circulation. The observations in *Plate 13* indicate that these lightning flashes are concentrated in certain jovian latitudes, and atmospheric features which are located at the two lower latitudes (+30°, +46° jovicentric; +33°, +50° jovigraphic) are cloud structures in the form of bands between herringbone patterns of varying degrees of distinctness. In our case, at the lower latitude the lightning is associated with a northern branch of this band which can be double or triple but rejoined at another longitude. These bands are associated with unstable westward moving jets[4]. In the northern hemisphere (Fig. 2 in ref. 4) these jets occur at latitudes of 18°, 30° (with northward and southward branches) 36°, 45°, 50° and possibly by extrapolation, 54° and 58°N. At the time of these observations, lightning appeared at the second, fourth and sixth of these jets and not at the third and fifth which were also in view. This comparison leads us to suggest that lightning is a tracer of upwelling in the jovian atmosphere. The observation of these lightning flashes at high latitudes is consistent with the concept of internal heating generating convective cloud systems. Further support for this idea must await analysis of images from Voyager 1 and Voyager 2. Note that the detection of whistlers from Jupiter by the plasma wave instrument indicates the presence of lightning in the polar regions[5].

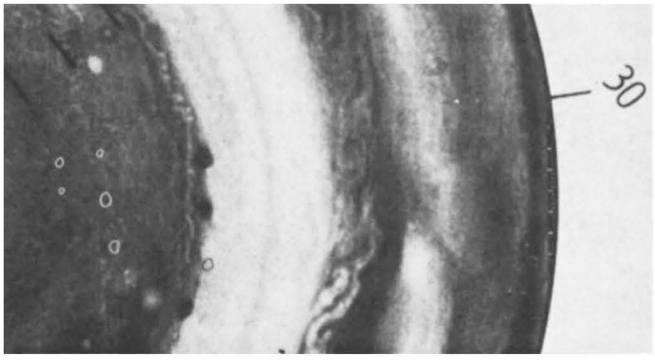

Fig. 2 Locations of lightning flashes in Jupiter's northern hemisphere (from *Plate 13*, p. 793).

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