GEOPHYSICS

Lunar Tides in the Equatorial Electrojet and in the Ionosphere over the Magnetic Equator

AN abnormally large value of the solar daily range of the horizontal magnetic intensity, H, found at stations within a few degrees from the magnetic equator has been ascribed due to eastward electric currents flowing in the lower ionosphere during the daylight hours and known as equatorial electrojet[1]. A longitudinal effect in the strength of the electrojet with a maximum in the American zone has been shown by Rastogi[2].

Bartels and Johnston[3] showed the existence of abnormally large lunar tidal effects in the range of H at Huancayo. I (ref. 4) showed that the enhancement in the tidal effects in the range of H is confined, within a few degrees, around the magnetic equator very similar to the equatorial electrojet. I have also demonstrated a longitudinal effect in the lunar tides in range of H similar to that in the equatorial electrojet[5].

The existence of enhanced lunar tidal effects in the critical frequency f_0F_2 of the F_2 region of the ionosphere confined within a few degrees around the magnetic equator similar to the latitudinal variation of electrojet strength has been shown[6,7]. The amplitude of lunar tide in f_0F_2 over the magnetic equator was largest in American, intermediate in African and least in Indian zones, which is very analogous to the longitudinal variation of the equatorial electrojet.

To study further the relations between the lunar tidal effects in f_0F_2 and in the electrojet, analyses of midday (11–13 h mean) values of f_0F_2 at Huancayo over the years 1938–46 plus 1951–60 have been analysed by me and have been compared with the similar analyses of range in H by Bartels and Johnston[3].

In Fig. 1 are drawn the harmonic dials showing the seasonal variations in the coefficients of lunar semi-monthly variations in f_0F_2 computed by me and in the range of H derived from Bartels and Johnston's[3] paper. The phase of lunar tide is denoted in terms of lunar age when the maximum positive deviation is obtained. The data covering the period 1938–46 and 1951–60 are used for f_0F_2 and 1922–39 for range of H. Each point is thus derived from about 20 lunations. Probable error circles are drawn to show the statistical significance of each determination. It is seen that the errors are much smaller than the amplitude and each of the determinations may be taken as significant.

There is a remarkable similarity in the seasonal variations of the lunar tidal effects in the f_0F_2 and the range of H. The change of the amplitude of lunar oscillation in both f_0F_2 or in range of H from their greatest values in January to their smallest values in June or July is quite marked. The total change of L_2 amplitudes between the two seasons are 0·56 Mc/s and 19γ for f_0F_2 and the range of H respectively. The sum of probable errors in the smallest and largest values of L_2 amplitudes is 0·06 Mc/s and 5γ. The difference of L_2 amplitudes is thus about 5–10 times the sum of the probable errors.

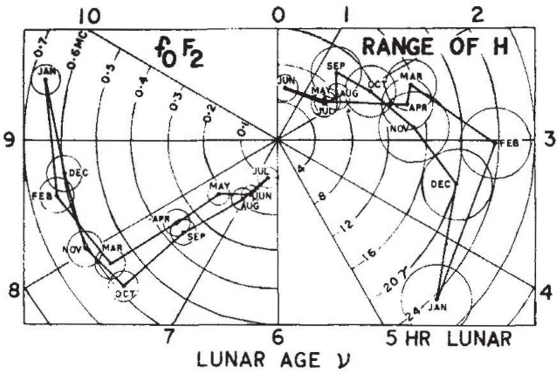

Fig. 1. Harmonic dials showing the coefficients of lunar semi-monthly oscillations in f_0F_2 and in the solar daily range of H during different months at Huancayo

Further, there is a systematic shift of the phase of L_2 oscillation with season for both f_0F_2 and range of H, the crest of the wave occurring earlier in June–July than in January. The difference of phase between the L_2 oscillations in f_0F_2 and range of H for any of the particular months, is very nearly 6 h, indicating an antiphase relationship between the two oscillations.

The seasonal and latitudinal variations in the lunar tidal oscillations in f_0F_2 close to the magnetic equator demonstrate a very close association between the higher regions of the ionosphere and the equatorial electrojet situated in the lower portions of the ionosphere. The exact mechanism of such an association is still to be worked out. A fuller paper describing the lunar variations in H and f_0F_2 at Huancayo will be published later.

R. G. RASTOGI

Physical Research Laboratory,
Ahmedabad,
India.

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SEISMOLOGY

Seismo-magnetic Effect and the Possibility of Forecasting Earthquakes

THE existence of a correlation between magnetic disturbances and seismic activity has been suspected for nearly a century; but so many of the early observations were due solely to the mechanical vibration of magnetometers by seismic waves that when Lapina[1] reviewed the subject in 1953 she concluded that no effect had been satisfactorily demonstrated. However, sufficient evidence had been accumulating in Japanese literature to justify a renewed examination of the problem.

The approach of Japanese scientists was summarized by Kato and Takagi[2], who compared magnetic surveys before and after earthquakes and plotted differences which they associated with the seismic activity. They presumed that the magnetic effects were due to thermal changes accompanying the earthquakes since a local rise in the Curie point isotherm (depth at which the temperature is equal to the Curie point of the dominant magnetic mineral) demagnetizes a certain volume of rock and causes a change of field at the surface. However, the required movement of the isotherm is much more rapid than thermal diffusion will allow.

The thermal explanation is untenable, but its acceptance has delayed recognition of the fact that seismomagnetic effects must be due to the piezomagnetic properties of rocks the magnetizations of which change reversibly with the stress applied to them. Kalashnikov[3] appears to have been first to consider seriously the piezomagnetic properties of rocks. He initiated laboratory experiments, the most significant of which are those of Kapitsa[4], who found that the susceptibilities of typical basaltic type rocks were reduced in the direction of an axial compression by $0·8 \times 10^{-4}$ to $1·3 \times 10^{-4}$ per 1 kg/cm^2 of stress, and increased by rather less than half this amount in the transverse direction. Using these results, Kalashnikov[3] calculated possible magnitudes of seismo-magnetic effects, but he made very unfavourable assumptions about the geometry of the stressed rocks in the region of an earthquake and his conclusion was discouraging. The maximum