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Some observations of atmospheric luminosity as a possible earthquake precursor

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RESUMEN

Algunas mediciones de radiación solar obtenidas en la ciudad de México indican que pueden producirse valores anormales varios días antes de un sismo fuerte. Las anomalías se presentan tanto en la parte verde como en la roja del espectro. Las emisiones parecen ser intermitentes y se traducen en una mayor varianza de la intensidad horaria medida en el actinómetro. Antes y después del sismo de Petatlán, México del 14 de marzo de 1979 (M7.4), se observaron fuertes fluctuaciones en la luminosidad del cielo. En algunos casos la intensidad de la radiación excedió el valor esperado para una atmósfera transparente. Se propone que las observaciones altas se deben a una radiación en el espectro visible que se origina en la tierra, y que es reflejada por la capa de nubes y por la contaminación atmosférica.

PALABRAS CLAVE: Radiación sísmica, predicción, precursores.

ABSTRACT

Some sky radiation measurements in Mexico City suggest that anomalous values occur several days before a strong earthquake, both in the red and the green parts of the spectrum. The emissions appear to be intermittent and are chiefly detected by an increased variance of the hourly light intensity. Before and after the March 14, 1979 Petatlán, Mexico earthquake (M7.4), large fluctuations in sky luminosity were observed. In several instances the radiation intensity exceeded the standard value for a transparent atmosphere. We suggest that the high readings are due to radiation in the visible spectrum which originates in the earth and is reflected by the haze and the cloud cover.

KEY WORDS: Seismic radiation, prediction, precursors.

1. INTRODUCTION

We have often observed that large earthquakes in Mexico are preceded by an abnormal brightness which causes the images of outdoor objects such as trees or shrubs to appear crisper and more brilliant even on cloudy days. Specifically, the contrast of different colors is increased. This is a commonplace observation in Mexico. In our case we both have heard it mentioned from childhood on, and in our experience it often seems to work as an earthquake precursor.

Sky luminescense and other electromagnetic phenomena have been frequently mentioned as possible earthquake precursors (see, e.g., references cited in Lomnitz, 1994, p. 137). These phenomena are commonly observed from two weeks to two hours before the earthquake. Most observations refer to lights observed during the night, but this is difficult in the case of large urban areas such as Mexico City because the effect is confused with reflections due to street lighting, both of which shine on the cloud cover from below. In daytime, on the other hand, there might be a way of distinguishing between transmitted light from the sun and reflected light from the earth.

Measurements of solar radiation are conducted at the Institute of Geophysics of the National University of Mexico (UNAM). These measurements provide an opportunity of attempting to check the visual observations instrumentally. Unfortunately, the measurements are not systematic and there are frequent gaps in the data. However, some periods of fairly regular observations occurred around the time of large earthquakes, notably the 1979 Petatlán earthquake.

In this paper we present some observational data of radiation in the visible spectrum before and after some large Mexican earthquakes.

2. OBSERVATIONS

The intensity of radiation is read on an hourly basis and the optical atmospheric thickness τ is estimated from the formula

$$I = I_0 e^{-\tau m} \tag{1}$$

where I is the measured irradiance in W m^{-2}, I_0 = 1450 Wm^{-2} is the standard irradiance for a completely transparent and cloudless atmosphere, and m is the optical mass, usually approximated as the secant of the vertical angle of incidence of the solar rays.

During the dry season (October-May), Mexico City is nearly windless. The intensity of photochemical haze or "smog" tends to increase gradually during the day. Thus

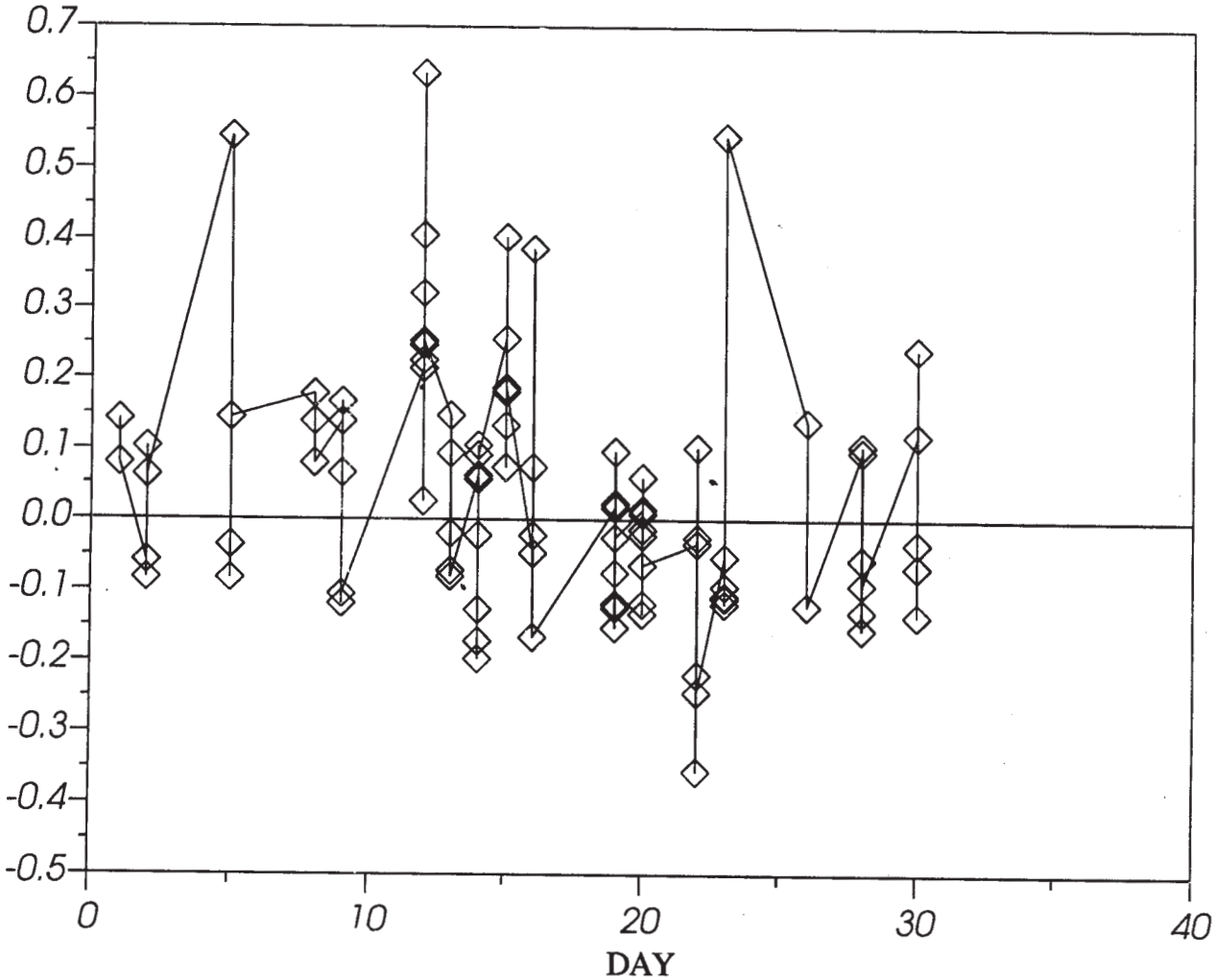

Fig. 1. Values of the optical thickness τ in the red band of the spectrum, for March, 1979. Note the occurrence of negative values.

successive hourly measurements of I tend to vary smoothly and I tends to peak in the early afternoon.

Figure 1 shows the computed values of optical atmospheric thickness τ for the red part of the spectrum during the month of March, 1979. Each point represents a measurement. In the red part of the spectrum there are altogether 43 negative values of τ. In other words, the light intensity which reaches the meter is higher than the standard intensity for a totally clear sky thus indicating a negative atmospheric thickness. No calibration errors were found.

In the green (Figure 2) and blue (Figure 3) parts of the spectrum the effect is less intense. No negative values are obtained but there are many low values and the variability during the day is quite large as compared with a typical day. It was also noticed that episodes of peak brightness occurred at different times of day, including around noon when the "smog" cover is heaviest.

In the red, the largest daily variances of τ occurred on March 5, 12 and 23, 1979. A large variance also occurred in the blue and the green on March 15, 1979 (Figure 4). Note that a large aftershock (M6.0) occurred on March 16, 1979, and many other aftershocks of similar magnitude during the rest of the month.

Consider now the variance of hourly measurements for the month of September, 1985 (Figure 5). Unfortunately there were many missing days of data. Two days after the great Michoacán earthquake of September 19, 1985 (M8.1) there was a day of large variance especially in the green and red parts of the spectrum, while the day before the earthquake was normal.

3. DISCUSSION

The data set shown here could be expanded with examples of peaks in the variance of τ preceding earthquakes of magnitude around 6 but these events are fairly frequent in Mexico so that the relationship may be less convincing. The 1985 earthquake was followed by 10 years of relative seismic quiescence.

The observed periods of disturbance of the radiation field, as measured by the incidence of anomalously high

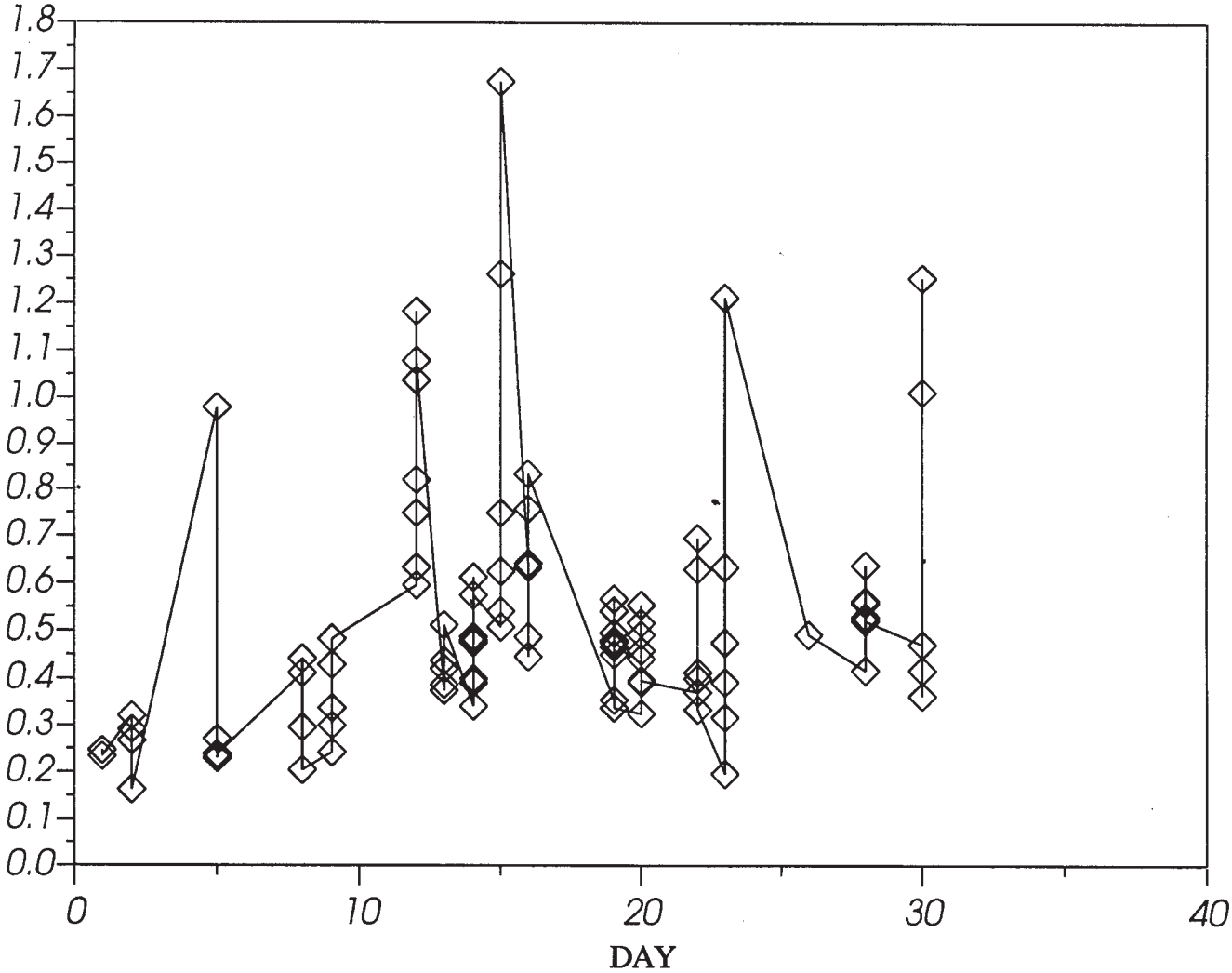

Fig. 2. Values of the optical thickness τ in the green band of the spectrum, for March, 1979.

instantaneous values of irradiance and a high variance of the hourly values of the optical atmospheric thickness, lasted for up to one month. The 1979 earthquake occurred in the middle of such a disturbed period. The case of the 1985 earthquake is doubtful: though it was preceded by very high values of variance in τ there are many data gaps.

We tried unsuccessfully to detect sources of error which might explain the negative values of τ in the record. Negative values occurred mainly in the red part of the spectrum. They clearly suggest that there is an extra-solar source of illumination. This source of illumination must have a terrestrial origin; it is unlikely to come from space.

As to the origin of the radiation, several mechanisms have been proposed from time to time (e.g., Brady and Rowell, 1986; Meunier, 1991). Any mechanism must account for the fact that the emissions are intermittent. This intermittence is presumed to be the cause of the increased variance in the hourly values of the optical thickness. Rapid changes in the thickness of the cloud cover (or of the photochemical haze) occur less frequently in Mexico City than almost anywhere else, because of the low wind velocities.

Large fluctuations in τ occur both before and after the main shock. The post-seismic fluctuations might be attributed to the aftershock sequence but they could equally be due to other postseismic effects having to do with stress changes in the earth. Note, however, that the days immediately preceding and following the 1979 earthquake were normal in terms of luminescence. As for the 1985 earthquake, the day preceding the earthquake was one of strong variance but no readings are available for the day of the earthquake.

4. CONCLUSIONS

An attempt was made to confirm or reject the hypothesis that strong earthquakes are preceded by emissions of electromagnetic radiation in the visible spectrum. The records of sky luminescence at Mexico City were used.

(1) During the month of March, 1979 a significant number

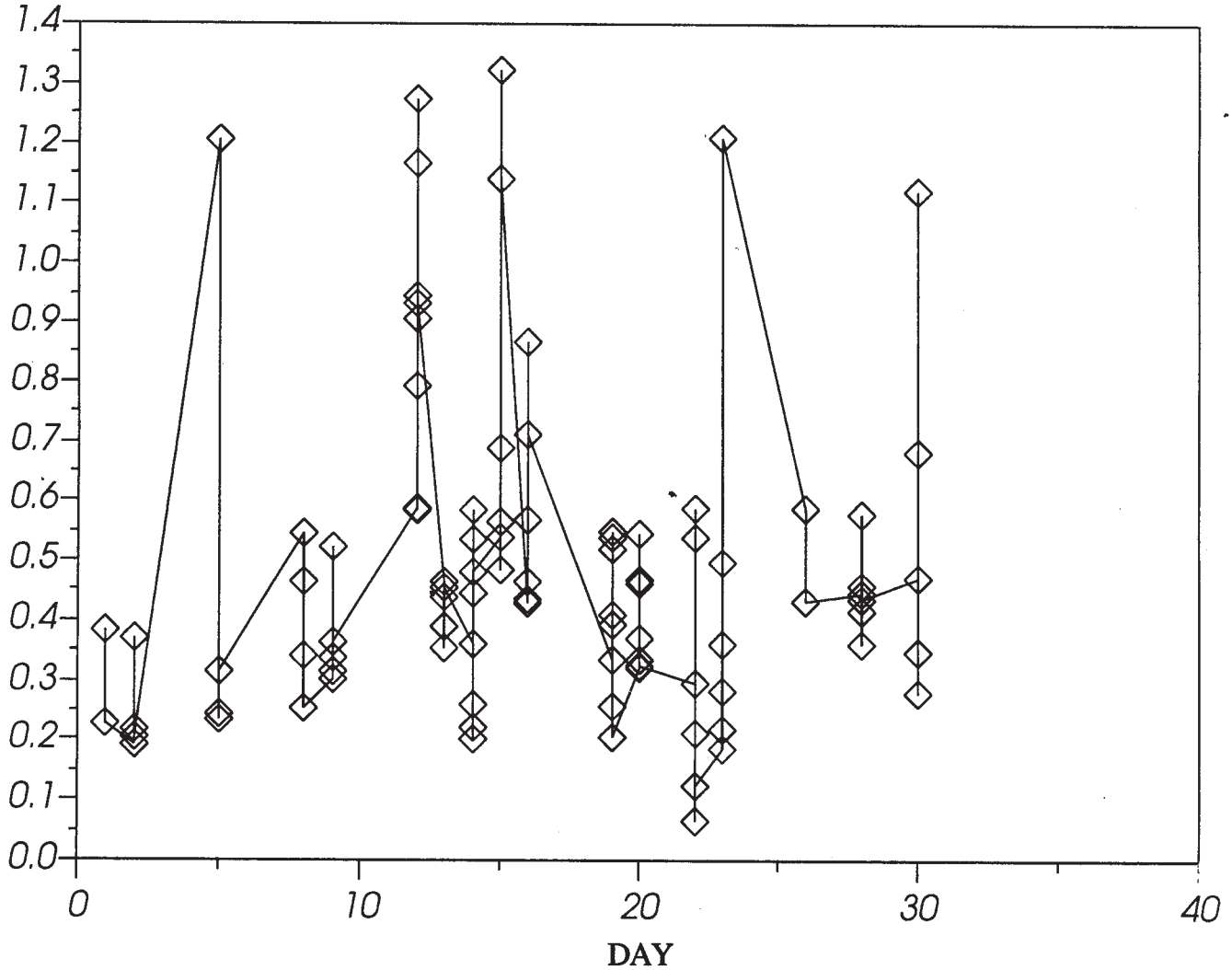

Fig. 3. Values of the optical thickness τ in the blue band of the spectrum, for March, 1979.

of negative values of the optical thickness τ were detected. A large earthquake (M7.4) occurred on March 14, 1979.

(2) The unexplained negative values of τ suggest the presence of an extra-solar source of illumination of the cloud cover and/or the shroud of photochemical haze ("smog").

(3) The periods containing negative values of τ were also periods of large variance of the hourly values of τ during certain days.

(4) These anomalous periods may have a duration of up to one month and may extend beyond the date of the main shock.

(5) The data record contained many gaps. Thus, though a day of high variance of τ immediately preceded the 1985 earthquake (M8.1), too many days (including the day of the earthquake) are missing.

In conclusion, the anomalies in solar radiation and sky luminescence appear to be promising in terms of providing a valuable precursor of earthquake activity. This study should not be restricted to nighttime observations alone, since daytime fluctuations in irradiance may provide a sensitive and accurate means of detecting extra-solar sources of radiation.

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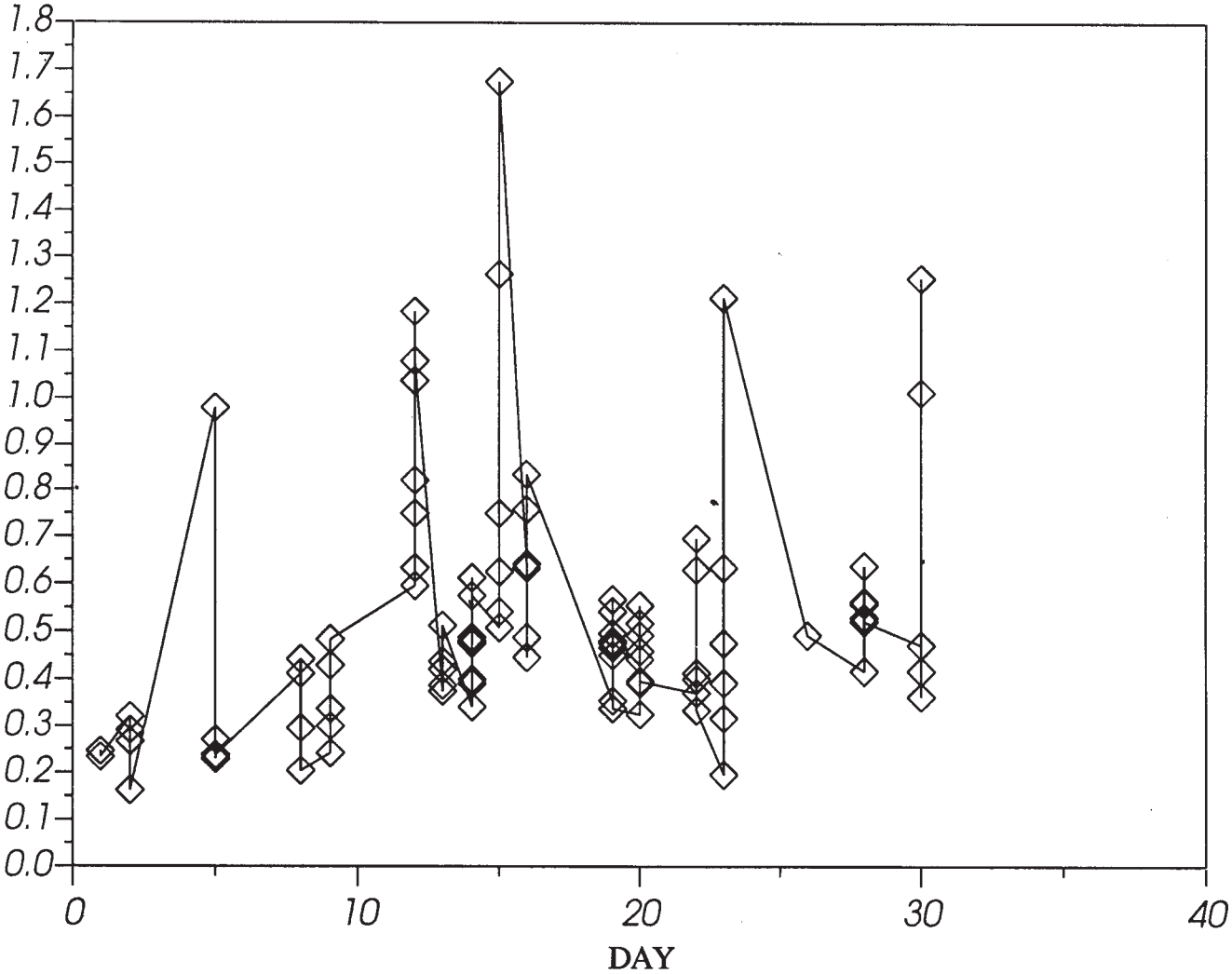

Fig. 2. Values of the optical thickness τ in the green band of the spectrum, for March, 1979.

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BIBLIOGRAPHY

BRADY, B. T. and G. A. ROWELL, 1986. Laboratory investigations of the electrodynamics of rock fracture. *Nature, 321*, 488-492.

LOCKNER, D. A., M. J. S. JOHNSTON and J. D. BYERLEE, 1983. A mechanism to explain the generation of earthquake lights. *Nature, 302*, 28-33.

LOMNITZ, C., 1994. Fundamentals of Earthquake Prediction, John Wiley & Sons, New York, 326 pp.

MEUNIER, J. M., 1991. Are some earthquakes triggered by the strong reversals of the atmospheric electric field? Proc. Int. Conf. Earth. Prediction, Strasbourg, EMSC, 344-348.

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