# COMMENTS ON A PAPER BY E. G. BOWEN ENTITLED "THE INFLUENCE OF METEORITIC DUST ON RAINFALL". 1*

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In a paper recently published in this Journal E. G. Bowen (1953) has proposed that meteoritic dust is an important factor in stimulating rainfall. This hypothesis is advanced as a result of a study of daily rainfall statistics over a long period for Sydney and other places which reveal features, it is claimed,

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not readily explainable in terms of known meteorological processes. It is then argued that these characteristics are attributable to dust entering the atmosphere during meteoric showers.

The speculation that some extraterrestrial influence other than solar might affect rainfall is so important that a critical review of the evidence leading to any such proposal is called for.

In effect the paper raises two issues for consideration : do the rainfall data presented contain such unexpected features as to demand special explanation and, if they do, is that offered by the author acceptable? It is proposed here to discuss the paper under these headings, and it will be contended that, for the first part, some of the evidence is inadmissible and the remainder inconclusive, and, for the second, the supposed influence of meteoritic dust is groundless.

The author begins by presenting diagrams showing the total rainfall at Sydney, day-by-day, for January and early February, for two consecutive 40-year periods. Attention is drawn to a marked " peakiness " in the distribution, in particular in respect of two dates, common to both periods, and a third which occurs only in one. In fact if the two periods are combined this last is effectively removed. Bowen states that the pattern shown in the diagrams is repeated year after year, and it is this which, in part, leads him to seek the explanation in meteoric showers. But this is not so, for the peaks are due to a few days of heavy rain and not to a greater frequency of rain on these particular dates. This point is important and will be referred to again.

Significance in the magnitude of the peaks is then implied by comparing them with the standard deviation of the remaining fluctuations from the mean. Departure from normality, however, often extreme, is commonplace in meteorological statistics, and the normal distribution is not applicable as a standard for the consideration of such an element as rainfall, for obvious reasons. A more plausible approach would be to examine the distribution of the logarithm of the rainfall. When this is done it is found that there is no significant departure from normality, and this in itself is an interesting feature.*

When reference is made to Figure 1 of the paper it becomes clear that a rainfall approaching 10 in. in one day, which is not unknown in Sydney, will dominate the statistics over the whole 40-year period and elevate that date to a major peak in the rainfall pattern. Examination of the data does, in fact, show that the peaks in the diagrams are due to heavy falls of this nature. But this feature of daily rainfall statistics has long been known and the heavy falls of rain that cause them can readily be explained by accepted dynamic processes and current theories of rain formation.

The most important link in the argument is the claim that many stations over a wide area show peaks of similar magnitude to Sydney's on " *nearly the same days* ". This is the crux of the case and, if really established, would undoubtedly point to some influence on rainfall hitherto unsuspected. Bowen

* And shows that the marked troughs are as important a feature of the distribution as the peaks. They cannot be attributed to the *absence* of meteoritic dust.

states that the synchroneity of peak dates applies to many places, but presents data from eight only for January and early February in a diagram showing a grouping of peak dates, the interval between the groups being about 9 days and the spread of each group about 5–6 days. With such an interval and spread it is obvious that many stations would fit into the grouping pattern, though their peaks might be due to quite unconnected causes.

Though not stated, it is implied that the data shown for the eight stations are typical of those for the many places referred to. But the only three places for which this type of rainfall statistic has been found in the literature, Melbourne (1872–1948), Madras (1891–1940) (Ramakrishnan 1953), and Nagapattinam in south-east India (1901–1950) (Ramakrishnan and Narayanan 1953), all fail to conform.

And, if the Sydney period (1900–1949) used in Figure 3 had been extended to 1951, a fall of 224 points on January 18 in that year would have caused this date to emerge as a major peak, midway between the groups for the 13th and 23rd.

Furthermore, it is well known that as storms move they may cause rainfall intensive enough to provide major peaks at different places on successive days over an interval of several days. Clearly such events cannot fit into a pattern showing marked grouping of rainfall peaks at intervals of about 9 days.

Altogether it would seem that the most that can be said for this section is that the inference is doubtful, and that the case for synchroneity of peak dates must remain open until Figure 3 has been supplemented by the inclusion of many more stations.

In the second part of the paper the author presents evidence to show that the claimed peculiarities in rainfall at Sydney and other places, particularly the grouping of peaks, can be explained by the accession of dust to the atmosphere during meteoric showers.

Bowen states that meteoric showers have been chosen as a likely explanation because they recur year after year on the same dates. But recurrence alone would not cause the variation in rainfall pattern from one year to another, which is due to a few occasions of heavy rain. Now there is also great variation in the intensity of meteoric showers. If they exert the influence claimed it should be possible, by considering sufficient places, to demonstrate a tendency for rainfall peaks to be established in years of intense showers. The evidence shown points against this, for it is stated that rainfall peaks at different places are due to heavy falls in different years.

The relationship between meteoric showers and rainfall peaks shown in Figure 4 can, at best, only be described as slender, and almost certainly without significance. It affords no support for the assertion that peaks follow showers at Sydney after an interval of 29 days. (Note that the peak for January 31 does not appear in the 1859–1901 period.)

Consideration is next given to the physical processes by which meteoric particles might influence rain formation, and Bowen suggests that they might provide condensation nuclei, though their composition is uncertain. He quotes a likely concentration of one particle per cubic metre, and this should be compared with the number of droplets in the average cloud, which is of order $10^8/m^3$. It is true that modern ideas on rain formation envisage the dominating influence of a relatively few large nuclei, but even so this concentration seems altogether too meagre and one cannot agree with the author that " meteoritic dust exists in adequate quantities . . . ".

Having claimed an interval of 29 days between meteor showers and rainfall peaks (as evidenced by Fig. 4) Bowen then states that this period agrees with the time of fall of the meteoritic particles into the upper troposphere. Calculation shows that, for a $4\mu$ diameter particle of assumed density $2 \cdot 0$, the time is in fact about 50 days. Estimates published in the literature vary from about 50 days for the larger particles to a year or two for the smaller ones. In view of these long periods, and their range, it is clearly fruitless to seek in the time of fall support for an explanation of rainfall peaks which occur at approximately 10-day intervals.

It is important to note that, in consequence of the great range in time of fall of the different sized particles compared with the interval between showers, variations in their concentration in the upper atmosphere will be very much reduced in the upper troposphere. This tendency will be strongly supported by the influence of turbulence. Variations in concentration, such as it is, at these levels are in fact more likely to be caused by atmospheric motions and to be quite unconnected with meteor showers.

This review has so far been concerned with matters directly emerging from Bowen's paper. There are other considerations which also point to the unlikelihood of meteoritic dust affecting rainfall in the manner claimed. The peaks in the rainfall pattern, it has been stated, are due to heavy individual falls which, in the case of Sydney, may exceed 10 in. and elsewhere even more. Now the total amount of precipitable water held in the atmosphere is a small number of inches, one or two say in the latitude of Sydney. In order to produce 10 in. of rain, therefore, the whole troposphere must be replaced, by vertical movement, something more than five times. For tropical places this figure could be increased to 10 or more. Even if one is prepared to accept that meteoritic dust can upset the colloidal stability of the upper troposphere, it is inconceivable that it can also influence dynamic processes on this scale. Indeed it seems likely that, if the dust is to influence rainfall at all, it would be in respect of frequency and not intensity. On the average about 2 days in 5 in Sydney are rain days and therefore over a period of 40 years there would be indication enough of any such effect. But none has been shown, and Bowen himself states that the peaks are not due to more frequent rain on those dates.

One other line of evidence can be drawn from the after effects of such enormous eruptions as Krakatoa (1883), Mont Pelé (1902), and Katmai (1912). Brilliant sunsets and unusual twilight glows on a world-wide scale long after these events, particularly in the case of Krakatoa, indicated the continued presence in the atmosphere of tiny volcanic dust particles. A measure of the size of the particles was afforded through the frequent appearance of the corona round the sun called Bishop's Ring, the angular width of which corresponded to a particle size of about 2 $\mu$ diameter. This is comparable with the size of meteor particle quoted by Bowen, and their persistence for many months is confirmation of the times of fall for such particles given above. It is not certain that the volcanic particles were the same as the meteoritic dust, but it is known that their compositions have much in common, and one would be as likely as the other to act as condensation nuclei. But examination of the rainfall data for many stations for a considerable time after Krakatoa reveals nothing unusual, and no reference to any of these eruptions affecting rainfall has been found in the literature.

*References*

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