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Observations on Pre- and Post-Earthquake Performance of Old Faithful Geyser

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The mean interval between eruptions of Old Faithful Geyser appears to be correlated with major earthquake activity. Two to 3 years before a major earthquake the interval begins to decrease uniformly and then suddenly increases at the time of the earthquake. The change in interval length is probably related to changing regional stresses that produce significant local strains.

The Icelandic people have observed for centuries that geyser performance is responsive to earthquake activity [*Einarsson*, 1967]. In Yellowstone National Park the closeby Hebgen Lake earthquake of August 17, 1959 (7.1 magnitude), had an immediate and profound effect on the behavior of many geothermal areas, including an effect on the average time interval between eruptions of Old Faithful Geyser, which increased about 5 min [*Marler*, 1964; *Fischer*, 1960].

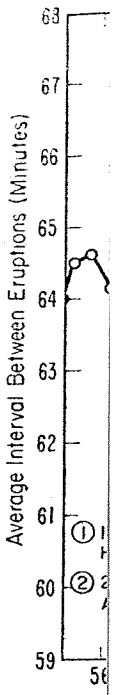
Figure 1 shows the variation in the seasonal mean values of the time intervals between eruptions of Old Faithful for the period from 1954 through 1967. The value of the mean time remained relatively steady from 1954 through 1957. After 1957 it began to decrease rapidly and during the succeeding 3-year period, from 1957 until August of 1959, went down from 64.0 to 61.3 min. After August 17, 1959, the interval began increasing suddenly, so that by the summer of 1960 it had reached a value of 66.5 min, the increase being spread over a period of several months. Numerous observations in midwinter 1959–1960 gave a mean of 64.2 min. The mean interval remained high, even increasing slightly through 1961, at which time it then began to decrease in a regular manner, so that by the end of the summer of 1963 it had dropped from 67.0 to 65.5 min. Sometime between the summers of 1963 and 1964 it increased noticeably to 67.1 min. It has dropped slightly since then, now remaining steady at 66.5 min.

Although the reasons for the fluctuations in mean time are not known, it is suspected that the pattern of steady decrease followed by an abrupt increase is associated with major earthquakes. The first and more pronounced pattern of decrease followed by an abrupt increase, occurring during the period from 1957 through 1960 can be associated with the 1959 Hebgen Lake earthquake. The more distant, but larger (8.4 magnitude), Alaskan earthquake of March 24, 1964, most likely caused the lesser fluctuations occurring during the period from 1961 through 1964.

It is not surprising that both earthquakes would affect the mean interval between eruptions. Extensive changes in Yellowstone geysers and hot springs after the Hebgen Lake earthquake have been thoroughly described by *Marler* [1964]. Furthermore, it is well established that the Alaskan earthquake influenced the water levels in wells located over a large area of the United States [*Vorhis*, 1967]. It would be expected that the Hebgen Lake earthquake, with its epicenter only 45 km from Old Faithful, would influence the geyser to a much greater extent than the more distant Alaskan earthquake. A priori it would be difficult to predict whether the mean of the time of intervals between eruptions would increase or decrease.

Detailed examination of the records clearly shows that ambient rainfall does not appreciably affect the performance of the geyser, nor are there systematic seasonal variations.

The surprising aspects of the curve are not the post-earthquake effects, but rather what appears to be a regular progressive change in



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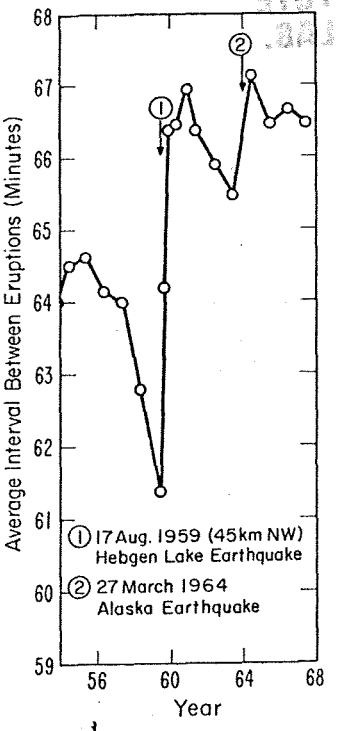

Fig. 1. Average interval between eruptions of Old Faithful as a function of year.

performance preceding each of the two major earthquakes. This steady decrease in mean interval begins 2 to 3 years before the earthquake. Although the decrease may be merely fortuitous, its very regular character and its close association to major earthquake activity suggests strongly a causative relationship.

It seems not unreasonable that regional stresses within the earth begin progressively changing 2 to 3 years before a major earthquake and that these regional stresses in turn produce highly localized but significant alterations in the fissures and other openings supplying the hot steam and water that heat and activate the geyser. Very little is known in detail about Old Faithful's plumbing system, water supply and sources of heat, so that it is almost impossible to anticipate the specific nature of these alterations or to determine how the eruption cycle would be affected.

It is interesting that the earthquakes seem to have little influence on the bimodal character of the distribution of intervals between eruptions described by *Rinehart* [1965]. The main change is a shift to the right of the upper mode from 70 to about 73 min, with the lower mode remaining essentially unchanged.

Whereas the data are not definitive in establishing a causative relationship between preearthquake activity and geyser performance, they are strongly suggestive that activity precursory to the major catastrophic seismic event begins to affect geyser performance 2 to 3 years before the event occurs.

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