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## Different Types of Disturbances Appearing on Iowa Seismological Records

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## DIFFERENT TYPES OF DISTURBANCES APPEARING ON IOWA SEISMOLOGICAL RECORDS.

MRS. M. M. SEEBURGER

The interpretation of seismograms presents numerous problems and offers unlimited opportunities in the field of research. To the geologist it offers means of studying the interior structure of the earth, and familiarity with the unstable regions of the earth.

A pre-requisite to successful interpretation is the thorough understanding not only of the characteristics of earthquake waves as they are transmitted through the earth at various depths and distances, but also such other disturbing factors as tilt, wind tremors, traffic, and the ever-present little trembles called microseisms.

Having all this in mind, it then becomes necessary for the seismologist to familiarize himself with the appearance of these seismic waves and other disturbances as they appear on the grams of his particular station. To this end Des Moines Station is compiling an atlas of typical records of earthquake shocks from different distances and localities, and also typical records of other types of disturbances. A few of these are shown as examples of different types of seismic movements and miscellaneous disturbances appearing on Des Moines grams.

The shocks vary from a "near-by" shock, originating at Tecumseh, Nebraska, 230 kilometers distant, to a Bay of Bengal shock, 15,600 kilometers distant. They range from normal depth, originating within the outer crust of the earth, to a deep-focus shock originating 590 kilometers below the surface. All have been recorded at Des Moines Station since December 1, 1934. Earlier records were mechanically recorded on smoked paper, and have a magnification of 15. Those since January 15, 1937, were recorded photographically, and have a magnification of 125.

Before beginning the examination of different types of shocks, examples of other disturbances will be given.

The first is tilt. (Figures 1 and 2) Tilting of the pier, with consequent displacement of the line, or trace, is caused, at the Des Moines Station, chiefly by moisture in the ground, outside of the basement vault in which the instrument is housed. Thus the spring thaws, or a rainy spell following a drouth, play havoc with the records. Tilt appears on the grams in a widening or narrowing of

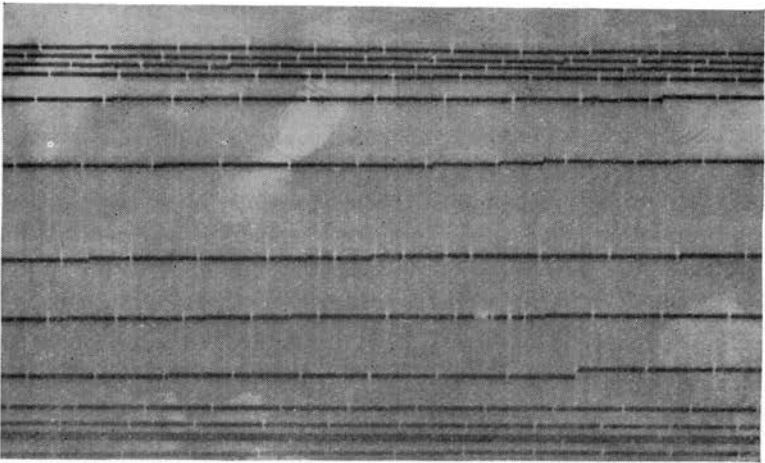


Fig. 1. Tilt, shown in the widely spaced lines. This was caused by a cloudburst in Des Moines.

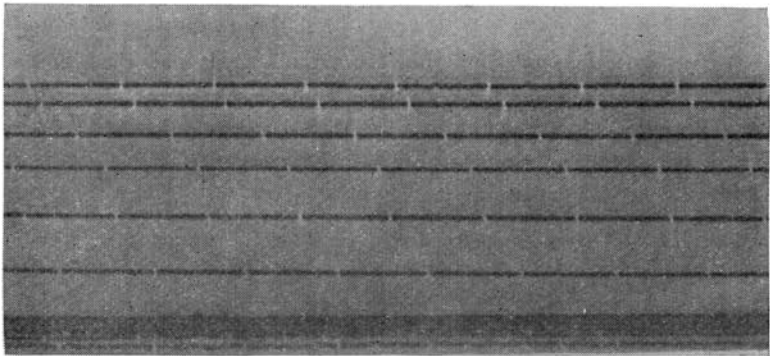


Fig. 2. Tilt caused by moisture pressure during heavy spring rains.

the space between the hourly lines. Frequently the change in pressure on the piers, caused by prolonged rains may cause the lines to overlap each other so that they cannot be read. Later, as the moisture disappears and the pressure on the piers is relieved the lines again appear with normal spacing. An interesting phenomenon occurred on June 29, 1935, when heavy rainfall followed a season of drouth. At that time two instruments were recording on opposite ends of the same drum, one showing east-west movement, and the other north-south. Tilt on one pier caused the lines to separate widely, while on the other they drew closer together. On another occasion the tilt was more rapid than the lateral pro-

gress of the drum, so that the lines appeared backward on the gram.

Rapid change of temperature causes some trouble with tilt, but is not serious at Des Moines Station. Tilt problems become more acute as the magnification of movement increases. In Des Moines it would be impractical to operate at a greater magnification than 125 without installing tilt compensation.

Our next most serious obstacle is wind. Wind, striking the house sets up vibrations, which are transmitted to the foundation and from the foundation to the earth, appearing on the grams as irregular groups of rapid vibrations corresponding to the gusts of wind. While they cannot be mistaken for earthquake phases, they handicap the interpretation of a record by obscuring the early seismic phases. For this reason instruments give better service when housed in low buildings. (Figure 3).

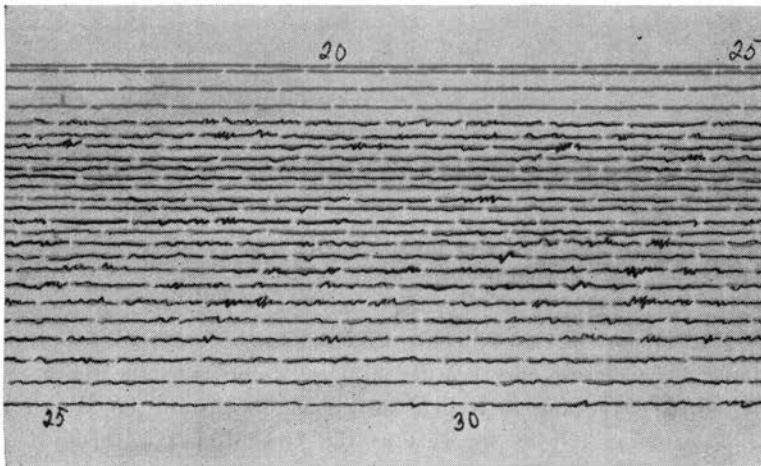


Fig. 3. Wind tremors, showing vibrations in the house, due to gusts of wind, transmitted to the foundation, and thence to the earth and therefore to the seismograph pier.

Traffic appears on the records as small, very rapid vibrations resembling a blur in the record. Since Des Moines Station is not on a heavily-traveled street, that is not a serious obstacle.

Microseisms are nearly always with us. They are the little ripples in the earth, usually of 3 to 6 seconds in period in Des Moines grams. Their amplitude varies, but they are rhythmic in appearance. Since microseisms are often larger than the beginning phases of distant earthquakes they complicate the interpreter's

task very greatly. A "P" (first preliminary) phase of an earthquake is sharper than a microseism, but great familiarity with the habits of microseisms and earthquake preliminaries is needed to distinguish between the two. Microseisms are more prevalent at times, appearing almost continuously for days or weeks, and then becoming less conspicuous for a time. Hurricanes on the Atlantic and Gulf coasts often are accompanied by microseism storms. The cause of microseisms, has been the occasion for much research. The theory held by Dr. Beno Gutenberg is that microseisms are caused by the passing of areas of low barometric pressure. (Fig. 4).

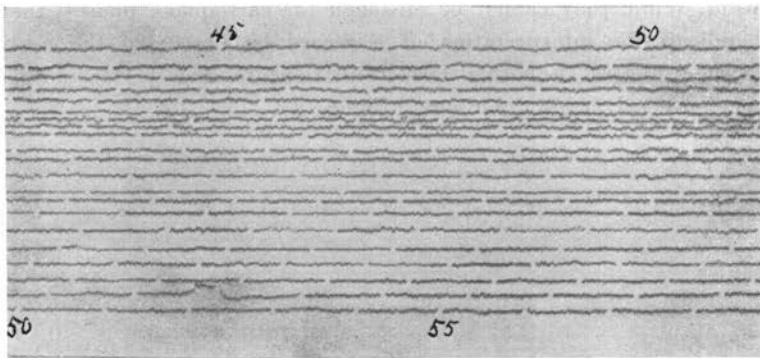


Fig. 4. Microseisms. Always present on the records of sensitive instruments, but more prominent at some times than others.

Earthquake shocks will be considered in the order of their distance. The closest one recorded at Des Moines was the shock originating at Tecumseh, Nebr., 230 kilometers distant, on March 1, 1935. It was felt as far east as the Des Moines River in Des Moines. (Figure 5). A near earthquake appears as a very small trace, consisting of rapid vibrations very close together. A large earthquake close at hand would dismantle the instrument. Special instruments of the shock recorder type are needed for local earthquakes.

Shocks occasionally occur in the Rock Island area, but are usually very small, and scarcely discernible on Des Moines records. New Madrid, Mo., 650 kilometers away, is in the center of an earthquake area, and a shock there would show up on Des Moines records very clearly, since it is far enough away for the phases to be clearly separated. Yet even New Madrid is too close for best results, since all phases from the first preliminary to the

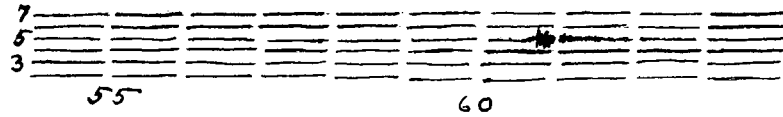


FIG. 5. Near-by earthquake shock, originating at Tecumseh, Nebr.

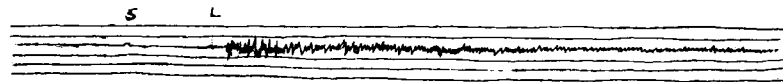


FIG. 6. Earthquake originating in the Southern California peninsula.

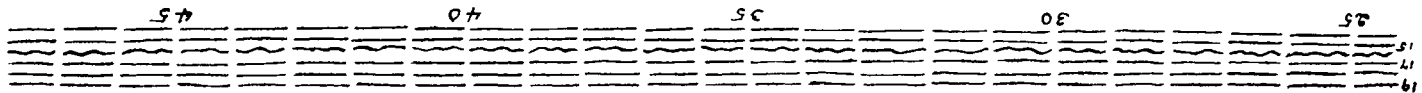


FIG. 7. Destructive earthquake originating at Quetta, India. 30,000 lives were lost.

large surface waves would require only two minutes of space on a Des Moines gram.

A shock in Ohio, 820 kilometers away, showed up well in Des Moines, but the Canadian shock of Nov. 1, 1935, was still clearer. The Helena, Montana, shocks in the fall of 1935, were very distinct, eight of them being of sufficient intensity to register at the Des Moines Station. They were 1560 kilometers away. Salt Lake City, Imperial Valley, and California shocks are a good distance to be clearly recorded here. They vary from 1900 to 2200 kilometers in distance—far enough to show the “P”, “S” and “L” waves clearly separated, but not far enough to encounter the numerous reflections and refractions that are apparent in the distant earthquakes.

The two first earthquakes ever recorded at Des Moines Station, in December, 1934, are excellent examples of California Peninsula quakes, 2260 and 2320 kilometers distant. (Figure 6). Mexico contributes a number of shocks to the annual earthquake catalog. One good example is shown on a sharp shock near the heart of Mexico. It now takes approximately  $6 \frac{2}{3}$  minutes for the first preliminaries to reach Des Moines station, and probably 20 minutes will elapse before the cauda of a strong earthquake will finish recording. A number of shocks are recorded each year from Central America; Honduras, Guatemala, Salvador, and Panama being well represented on the Des Moines earthquake map.

The next group of earthquake shocks, in order of distance, are those occurring in Alaska and the Aleutian Islands. These are quite numerous, and range from 4200 kilometers in Alaska to 6600 kilometers in the Aleutians. The waves now include “PR1” and “PR2” and “SR1” and “SR2” as well as the original “P”, “S” and “L” waves. The waves appear less sharp. A little farther off are the shocks in Kamchatka, and in the Argentine and other countries of western South America.

Now we come to Japan, a region extremely seismic, with many shocks each year. Those recorded at Des Moines have ranged from 8650 to 9660 kilometers. The preliminaries come in, on the average, about  $18 \frac{1}{2}$  minutes after the shock occurs, and may continue on the record for an hour in the case of strong shocks.

Beyond Japan, in distance, Des Moines-recorded shocks become longer and more sinusoidal in character, and the preliminaries harder to distinguish except in very strong shocks. Tonga Islands,

Thibet, and Baluchistan, ranging from 10,800 kilometers to 12,000, have recorded shocks in Des Moines. The latter was the destructive shock of May 30, 1935, which caused a loss of thousands of lives at Quetta, India. (Figure 7).

Numerous new waves begin to appear, due to reflections and refractions, and "P" disappears from the record, in what is called the shadow zone at 12,200 kilometers (about the distance of Calcutta). At 14,200 kilometers (about New Guinea), "P1" begins, and the shadow zone ends. The Philippine Islands fall within this shadow zone. Des Moines Station has recorded shocks from Solomon Islands, Calcutta, New Guinea, Philippine Islands, and the Celebes Sea, within this zone.

Beyond the shadow zone very few preliminaries may be identified, except on extremely strong shocks, but the long, sinusoidal L waves come in clearly and continue for a long time, so that the entire record may require two hours to come in. Such were several shocks near Sumatra, which have been recorded here.

Of special interest are the deep focus quakes, which have been the subject of much research. They differ materially from the shocks occurring within the earth's crust, which have very large surface ("L") waves, in proportion to the preliminary waves. With plutonic earthquakes (those originating below the discontinuity at the base of the earth's crust) the surface, or "L" waves are reduced in size, their size diminishing as the depth of the earthquake increases. Travel times for earthquake waves are different for deep focus earthquakes and a graphic chart for the determination of the focal depth, time of occurrence, and epicentral distance, is used. A number of deep focus shocks have been recorded at the Des Moines Station, including one in Argentine, on January 14, 1936, which originated 590 kilometers below the surface. A Tonga Island shock, April 16, 1937, originated 400 kilometers below the surface.

Earthquakes recorded at Des Moines average about sixty a year. During the last nine days five have been recorded, all originating outside the United States.

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