NATURE OF NOISES ON ICE SHEET IN EAST ANTARCTICA

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***Abstract*:** Two types of noise recorded in seismic explosion experiments around Syowa Station in Antarctica are discussed. One is wind-induced noise which is detected directly by a seismometer. This type of noise increases with a wind velocity, and when the wind velocity is over 15 m/s, seismic observations are not in success. With the object of noise reduction, seismometers buried in a hole at depths of 3, 5 and 10 m were examined, but the noise existed at 10 m. Seismometers should be buried deeper than 10 m. Another is electrostatic noise which frequently deranges a clock signal or destroys an electric circuit in the worst case. This noise is caused by drifting electrified snow, not by a seismometer itself. It was excited on a signal cable stretched on the snow surface from the seismometer to a recorder. To reduce this noise, the cable should be as short as possible and be laid in parallel with the direction of wind.

1. Introduction

In July 1980, the 21st Japanese Antarctic Research Expedition (JARE-21) conducted a preliminary explosion experiment. The main object was to test seismographs and boring machine to be used in the following long-range explosion seismic experiments (IKAMI *et al.*, 1983). Many papers on structure of ice sheets and the crust deduced by explosion seismic experiments in Antarctica have been published and reviewed by BENTLEY (1973), but no paper on the technical operating procedure has been published. For future explosion seismic experiments in Antarctica, it may be useful and instructive to present basic technical know-how and some technical problems in experiments. IKAMI *et al.* (1980) and ITO *et al.* (1983) reported the field-operation procedures of explosion seismic experiments in Antarctica by JARE-20 and -21. In this paper, we discuss unfavorable noises recorded in seismic explosion experiments in particular, which had put us in great trouble during the experiments. There is no artificial noise in Antarctica but microtremors caused by wind must be paid attention to. Our recording system was designed to be able to work continuously for 26 days, so it could record not only explosion seismic signals but also noises caused by wind during the whole period of observations.

In this experiment, seismometers were set on the surface of the ice sheet and, with the object of measuring a noise-depth relation, extra seismometers were set at the different depths of 3, 5 and 10 m in a hole at the two stations. In case of a blizzard with a wind velocity over 15 m/s, this noise intensity became too high to detect seismic signals. In addition to this noise, electrostatic noise increased considerably and caused erratic operation of electric circuits: clock signals were disordered by this noise, so the onset times of a signals could not be measured, and integrated circuits at the two stations were fatally damaged. In the following sections, we present typical examples and discuss the features of these noise.

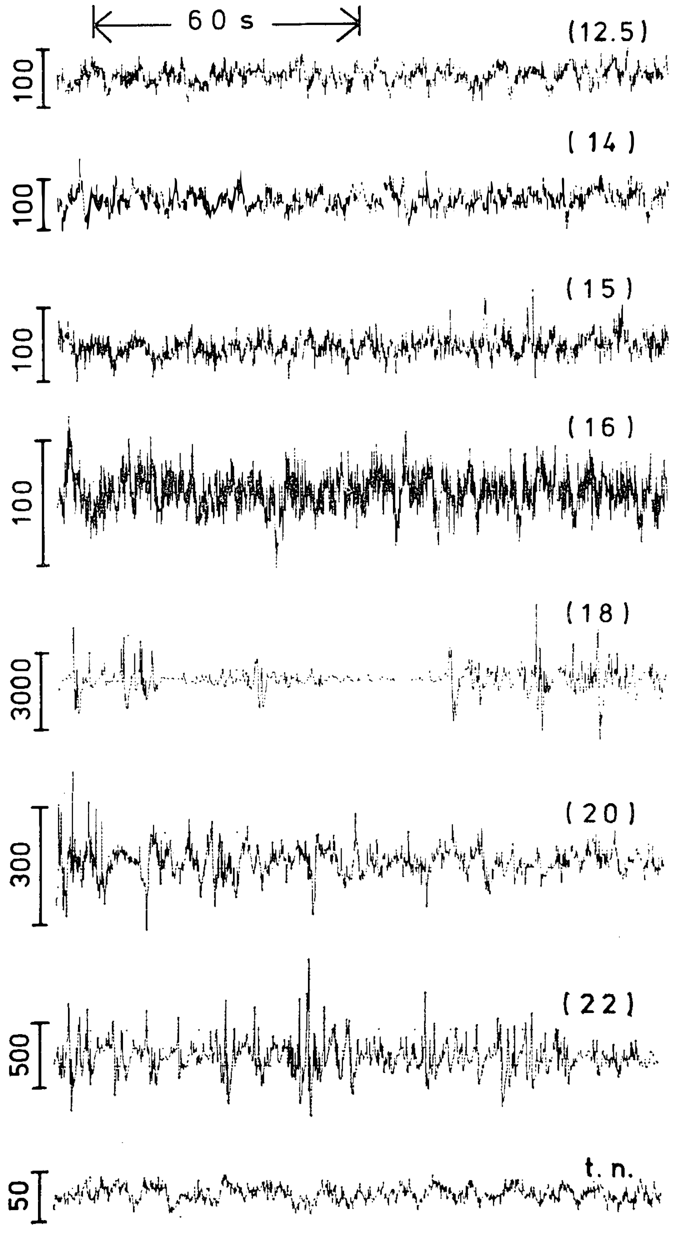

Fig. 1. Noise signals at various wind velocities. Numerals in parentheses mean the wind velocity (in m/s). The amplitude scale (in μcm/s) is indicated on the left of each noise. t. n. means the tape-out noise including the electric noise generated in a data recorder and its amplitude is calculated in terms of ground velocity.

2. Interdependence of Noise Intensity and Wind Velocity

In this experiment, wind velocity was measured several times a day at one point near the camping site, which is located at one end of the seismic profile with a length of 10 km. Noise signals recorded at the two stations were analyzed. Though distances from these two stations to the camping site were 0.62 and 2.07 km, respectively, the wind velocities at the two stations were expected to be the same with that at the camping site because there was no hindrance to the wind flow on the ice sheet. In Fig. 1, noise at various wind velocities are shown. Numerals in parentheses indicate wind velocity (in m/s) and signal-intensity scales were indicated at the left side of each seismogram (in μcm/s). At the bottom in Fig. 1, noise generated from electric circuits of recording and reproducing systems is shown for reference. This noise was recorded

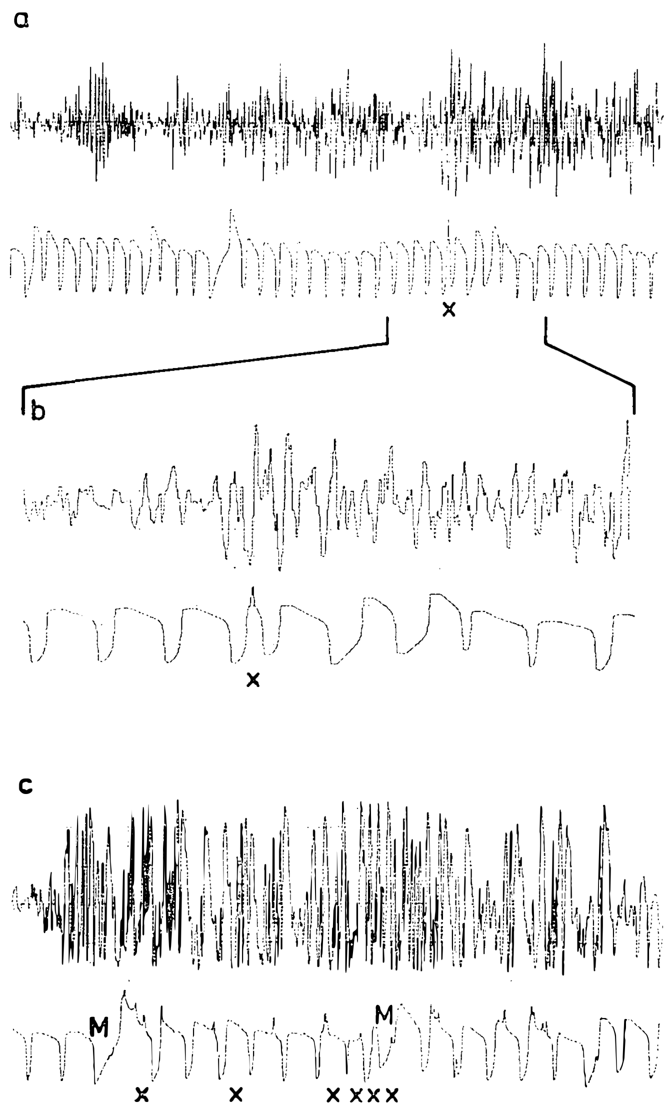

Fig. 2. Examples of deranged clock signals. × indicates an abnormal second pulse. M indicates a minute pulse. The bottom c shows only 8-s pulses between 2-min pulses. Maximum noise-amplitudes are out of the range.

by short-circuiting the input terminal under the conditions of the same magnification as those on the observation. Its amplitude was expressed in terms of ground velocity. It could be found from this figure that noises were almost similar in appearance under a wind velocity of 15 m/s. Over this wind velocity successful observations of explosion seismic signals could not be made, since noise intensity increased considerably. At wind velocity of 18 m/s, the noise seems to be abnormal. This abnormal noise might be due to electrostatic noise which will be discussed in the following section.

3. Fatal Damage to Electric Circuits

On the ice sheet in Antarctica, humidity is very low because of the low temperature. Under this weather conditions, electrostatic noise is easily generated. The intensity of electrostatic noise has a tendency to increase with the wind velocity. In the preliminary experiment, we paid no attention to this electrostatic noise. As a snow bank was formed on the lee side of a recording box, seismometers were not set behind the box to prevent them to be buried. A signal cable from the seismometer to the recording box, with a length of several meters, was stretched perpendicularly to the direction of wind. This setting arrangement of a seismometer and a recording box caused fatal damage to electric circuits. The reason may be as follows: when drifting electrified snow is flowing, the noise current is apt to be induced by Ampere's law in the cable stretched perpendicular to the direction of the wind. In the subsequent explosion seismic experiments, the cable was stretched parallel to the direction of the wind to suppress electrostatic noise. As a result, we had no trouble by electrostatic noise in the later experiments. In Fig. 2, examples of erroneous clock signal are shown. A part of Fig. 2a is enlarged in Fig. 2b. Maximum noise amplitudes in Fig. 2 are out

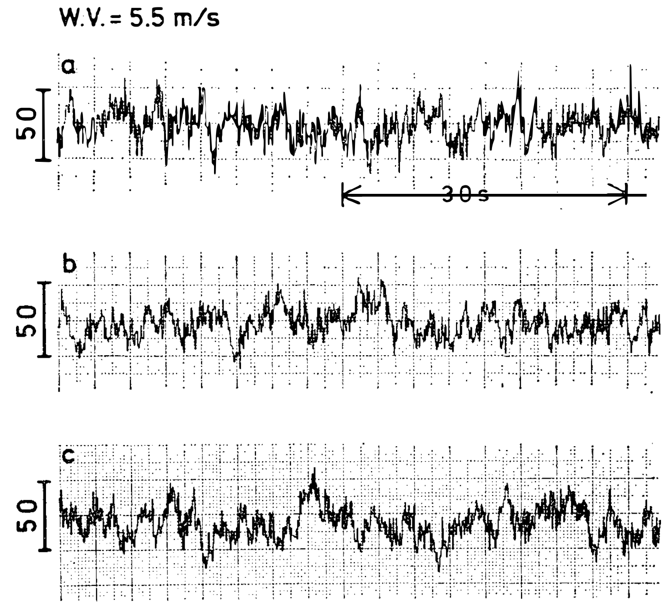

Fig. 3. Noise signals at various depths under a wind velocity of 5.5 m/s. a, b and c are recorded at depths of 0, 3 and 5 m, respectively. On the left side of each signal, amplitude scales (in mV) are indicated, which are measured on reproduced signals.

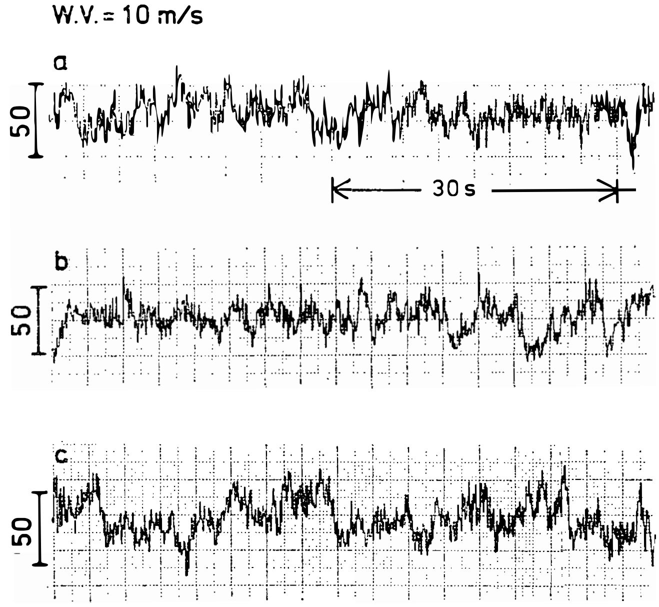

Fig. 4. Noise signals at various depths under a wind velocity of 10 m/s. See caption of Fig. 3.

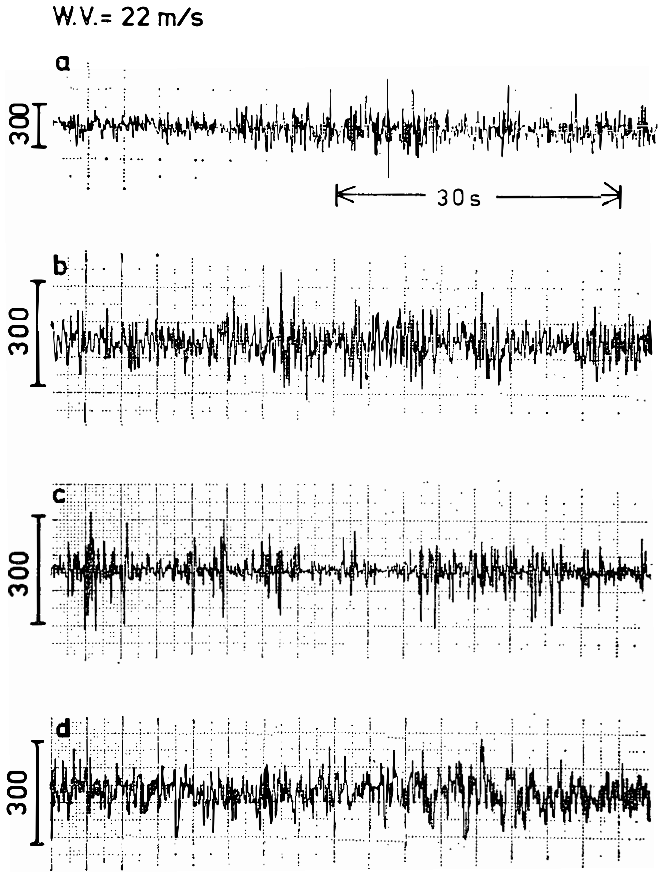

Fig. 5. Noise signals at various depths under a wind velocity of 22 m/s. d is recorded at a depth of 10 m. See caption of Fig. 3.

of the range. × indicates a false second pulse. M in Fig. 2c indicates a minute pluse. However, the clock circuit was deranged in this case, and there are only 8-s pulses recorded between the 2-min pulses. In the explosion seismic experiments, we would like to keep the time accuracy within 0.01 s. A high precision quartz oscillator was adopted in the clock circuit and time calibrations were carried out more than two times before and after an explosion. But when such an electrostatic noise deranged the clock signals as shown in Fig. 2, the observed signal became useless even if it had a clear onset. In order to record signals of high quality, protection against the electrostatic noise must be taken into consideration not only in seismic observations but also in other field-operations using electric circuits.

4. Observations by Buried Seismometers

In this preliminary experiment, to examine the noise-depth relation in the ice sheet, three buried seismometers were set at depths of 3, 5 and 10 m at two observation points in addition to a seismometer on the surface. Figures 3, 4 and 5 show the resultant observed noises at different depths under the wind velocities of 5.5, 10 and 22 m/s, respectively. a, b, c and d in these figures show the noise signals at depths of 0, 3, 5 and 10 m, respectively. An electric-circuit noise in the amplifier of the recorder for the seismometer buried at a 10 m depth is so large that noises at the depth of 10 m were omitted in Figs. 3 and 4. In Fig. 5, the noise at the 10 m depth is shown, because it becomes larger than the electric circuit noise. Amplitudes were measured on the reproduced signals and the scales (in mV) are shown in the left part of each signal. In these figures, the noise-depth relation could not be found. The investigated depth range might be too shallow to reduce the noise.

5. Conclusion

In seismic explosion experiments in Antarctica, observations under a wind velocity of less than 15 m/s or so are recommended. To increase the probability of success in the experiments it is desirable to use buried seismometers and to pay attention to electrostatic noise. The signal cable from a seismometer to a recording box should be as short as possible and stretch it parallel to the direction of the wind to avoid induced noise current. To reduce the noise caused by wind, the buried seismometers must be set fairly deep. In our experiment, it took several hours to dig a hole 10 m deep, so it would be beyond the power of man to dig such a deep hole at many observation points along a profile. A boring machine for the exclusive use is necessary to be developed. The effective depth to reduce the noise caused at a surface, however, is not known. If experiments must be executed under severe weather conditions, such as in winter, the seismometer buried at a proper depth is inevitable.

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