MASTER

ANNUAL REPORT

OPERATION OF A TELEMETERED SEISMIC NETWORK
ON THE ALASKA PENINSULA

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INTRODUCTION

In June 1973, the Geophysical Institute of the University of Alaska began a cooperative program with Lamont-Doherty Geological Observatory of Columbia University (LDGO) to study the seismotectonics of the eastern Aleutian-Alaska Peninsula arc structure. The Geophysical Institute's part of the program called primarily for the installation and operation of a large-aperture seismic network on the Alaska Peninsula and the southern offshore area between the Semidi Islands and the western coast of Kodiak Island.

After a period of buildup that was plagued with technical and logistic difficulties, we are now operating a very reliable twelve-station, short-period seismic network in the area (Figure 1 and Figure 2). The network overlaps with one operated under contract with the National Oceanographic and Atmospheric Administration (NOAA) on Kodiak Island and the lower Cook Inlet areas. That contract provides the major logistic support for the maintenance of the system described here and provides for a large part of routine data reduction and analysis. Data are routinely disseminated (in the form of a quarterly earthquake bulletin) and upon special request provided to LDGO.

OPERATION AND MAINTENANCE OF THE ALASKA PENINSULA SEISMIC NETWORK

There have been practically no changes in station layout or design during the past years, and the system has continued to operate reliably during the report period. There are still signal fadeouts during severe weather conditions on some of our VHF circuits, but procurement of

new test equipment for field calibration of VHF components hopefully will reduce further these signal losses.

The major technical activity is now associated with the decision to convert the present system which is a mixture of Geophysical Institute VHF links and leased commercial communication circuits into one which will operate without the commercial lines. The new system under development will use several recording centers throughout the state. In the Alaska Peninsula one recording center will be set up in King Salmon (KSL) to receive all signals from the network via the VHF links only. However, actual recording will not be continuous but will be in a mode employing a seismic event detector. A microprocessor will scan all incoming data, buffer it and start the recording medium, a tape recorder, only in the case of a seismic event. Thus only "useful information" is to be recorded. This scheme will allow elimination of expensive commercial circuits and also permit abandonment of the present film recorders which are notoriously difficult and expensive to maintain in a field site environment. Tape recording of events has the additional advantage of allowing automatic data processing or a more rapid manual processing, thus also requiring less manpower than the present film reading.

The event detection system is presently in the debugging state in the seismology laboratory. We expect to have the first system deployed in the field during this summer. There will, of course, be a time period during which the old and the new system will have to be operated in parallel, but we hope to be able to drop all commercial lines and the film recorder system by the end of next contract period.

DATA PROCESSING AND ANALYSIS OF SEISMICITY

Hypocenter data derived from the network are continuously compiled into an earthquake catalog of the area and monthly and quarterly epicenter maps are being prepared. Figure 3 shows as an example the seismicity during the first half of 1978.

The major portion of the seismicity of the area is associated with a Benioff zone, which is now beginning to be well delineated in the area. This can be seen from a comparison of Figures 4 and 5 which show the projection of events into a vertical plane approximately perpendicular to the line of volcanoes on the Alaska Peninsula. The data set for the two figures is from February 1976 through December 1977 and from February 1976 through June 1978, respectively. Only the best located events (RMS travel time residual of less than one second and relative errors in the horizontal and vertical direction of less than ten km) have been used for these cross sections. The epicenter map (Figure 3) shows also a cluster of activity in the area off the southwest coast of Kodiak Island. This activity is associated with a magnitude $M_B = 5.8$ earthquake that occurred on April 12, 1978, there. This area has been a rather active one for at least the past 30 years (see Figures 6 through 8). Hypocenter locations shown for the period between 1954 and 1963 are based upon the hypocenter relocations in that area by Tobin and Sykes (1966). Magnitude determinations during this period are largely lacking, but it is estimated that the threshold magnitude for these events is about $M_B = 4.5$. For later periods, only events of magnitude $M_B \geq 5$ are shown in Figures 7 and 8. Many of these events seem to reflect the plate subduction process, i.e., they represent thrusts on shallowly

dipping fault planes. The focal mechanism of the April 12, 1978, event is inferred from the aftershock distribution which does not show the usual sharp linear trends frequently associated with strike-slip faulting or thrust motion on a steeply dipping plane, but rather a broad zone expected from a shallowly dipping thrust zone (Figure 9). Fault plane solutions for the larger events associated with post-1964 events in this area, determined by Stauder and Bollinger (1966), also indicate that these events represent shallow thrusts with the relative motion and the dip direction of the fault plane consistent with the underthrusting of the Pacific plate (Figure 10). The uniformity of solutions obtained by Stauder and Bollinger in this area is remarkable.

First motion studies of the April 12, 1978, event from Alaska seismic stations do not permit a fault plane solution because of the unfavorable azimuthal distribution of stations relative to the epicenter, but the first motion distribution for the main event and the larger aftershocks are compatible and highly suggestive of a shallowly dipping thrust as the mechanism for these events, too (Figure 9).

The dense clusters of shallow seismicity on the Alaska Peninsula seen in Figure 3 are in the area of the two maars (the result of the initial perforation of the earth's crust by the volatiles of a rising magma front) that were formed in early April 1977. This activity is composed of several swarms, the most intense of which occurred in July 1978. We are presently investigating the relation of this swarm activity with the tectonics of the area.

Data from the network also are presently used for generating fault plane solutions in the Benioff zone in order to investigate the state of stress therein.

We have begun to use data from the network to invert travel time data into a seismic velocity structure of the area using the Hedgehog method developed by Knoppoff and Keilis Borok.

CONCLUSION

The Alaska Peninsula seismic network has for the past year continued to provide short-period seismic data from a portion of the Aleutian-Alaska arc structure, data that are proving valuable for the study of the seismotectonics of the area. An understanding of the seismotectonics is important for assessing the potential of the area as a region of geothermal energy sources and the assessment of the seismic risk in an area likely to contain extensive fossil energy sources.

REFERENCES

Stauder, William, and Bollinger, G. A., The S wave project for focal mechanism studies: The Alaska earthquake sequence of 1964; report prepared for Air Force Cambridge Research Laboratories, 1966.

Tobin, Don G., and Sykes, L. R., Relationship of hypocenters of earthquakes to the geology of Alaska, J. Geophys. Res., 71, 1659-1667, 1966.

Figure 1. Seismic station networks, Alaska Peninsula, Kodiak Island and lower Cook Inlet area.

Figure 2. Technical layout of and typical data flow from seismic station.

Figure 3. Epicenter map of Alaska Peninsula and Kodiak Island, January through June 1978. Letter code indicates depth range of event (A = 0-25 km, B = 26-50 km, etc.). Size of letter is proportional to magnitude, the size used for the geographic coordinates corresponding to magnitude $M = 2.0$.

Figure 4. Benioff zone in the Alaska Peninsula-Kodiak Island area, based upon data through 1977.

Figure 5. Benioff zone in the Alaska Peninsula-Kodiak Island area, based upon data through September 1978.

Figure 6. Epicenters of earthquakes ($M_B \geq 4.5$) in Kodiak-Alaska Peninsula area 1954-1963, after Tobin and Sykes (1966). Symbols as in Figure 3.

Figure 7. Epicenters of earthquakes ($M_B \geq 4.5$) in Kodiak-Alaska Peninsula area 1964. Symbols as in Figure 3.

Figure 8. Epicenters of earthquakes ($M_B \geq 4.5$) in Kodiak-Alaska Peninsula area 1965-1975. Symbols as in Figure 3.

Figure 9. Epicenters of April 12, 1978, earthquake off Kodiak and aftershocks. Symbols as in Figure 3. Stereographic projection of first motions from University of Alaska short-period network upon the lower focal hemisphere for main shock and two aftershocks. Open circles represent compression, triangles represent dilatation.

Figure 10. Fault plane diagrams (stereographic projection) of earthquakes associated with the 1964 Alaskan earthquake in the Kodiak Island region. Shaded areas represent rarefaction quadrants; arrows represent direction of P (pressure) axis. From Stauder and Bollinger (1966).