PRELIMINARY REPORT #3

Pueblo Viejo-Quixal Seismograph Network

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I. INTRODUCTION

Since the installation of the Pueblo Viejo-Quixal Network, 14 months have elapsed. This report is aiming at reviewing the performance of the network for the period of February 13, 1979 through April 5, 1980 and the results unveiled by distribution of microearthquakes.

II. OPERATION OF THE PUEBLO VIEJO-QUIXAL SEISMOGRAPH NETWORK.

The Pueblo Viejo-Quixal Seismograph Network started its operation on February 13, 1979. Each of 9 stations (six remote stations and one three-component station at the central station) were recorded on individual drum recorders.

On April 28, 1979, the delay-memory-trigger system and a tape recorder were installed. This system significantly improved the precision of epicenter determination (Preliminary Report No. 2).

For the past 14 months, the Pueblo Viejo-Quixal network has registered nearly 2200 earthquakes and revealed some of the important tectonical features. The operation of the network, however, had been marginal for some of the recording periods. Some of the operational procedures need to be reviewed and modified to improve the efficiency of the operation.

The problems we have encountered since the beginning of the seismic monitoring program are as follows:

1. Down time of remote stations.

   Fourteen cases of remote station breakdown were experienced in the past 14 month period as shown in Figure 1. The causes of failure ranged from instrumental malfunctions (mostly those of PA/VCO's and transmitters) to disruption as a result of local banditry. The count of down time also includes those caused by relocation of stations (relocated stations: St. 3 once, St. 7 twice). A combined total of 357 days of signal transmission was lost and an average of 25.5 days of down time has resulted. With careful inspection of the seismic records, it is necessary to identify the problem as it develops and to cure it as soon as possible.

problems described above.

d) The station manager is obliged to log any changes of operational condition and report them to Galveston.

e) The station manager should inspect the data on a daily basis, and if any malfunction is found, he should try to repair it immediately. If he is unable to cure the problem, he should consult with Dr. Matumoto as soon as possible and receive instructions.

f) The station manager also needs to teach the station operator so that he can write all the necessary information correctly. Before shipment of the data, the station manager should inspect the information to see that the description is proper and correct. The description should follow the format prepared by the University of Texas and both the station manager and operator should make themselves thoroughly familiar with this format.

g) The data should be shipped to Galveston every 2 weeks. Upon receipt, the University will make a preliminary examination of the quality of data tapes and return instructions by Telex if any corrective measures should be taken.

III. EPICENTER DETERMINATION

The data covering the period from February 15, 1979 through April 5, 1980 was returned to the Marine Science Institute, University of Texas, for detailed analysis.

During this 14-month period, the Pueblo Viejo-Quixal seismograph network detected approximately 5 events/day (2200 events total), of which 1400 epicenters were located. Table 1 shows the listing of all the events detected by the network.

This section describes the procedure deployed in our epicenter determination. The computer program has several restrictions on its capability to determine the epicenters, and one has to be aware of these limitations when utilizing the results for more detailed analysis.

1. Dependency on the Crustal Model

A computer program for epicenter determination, GUEPC 1, has been developed for the Pueblo-Chixoy seismograph network. This program, similar to other eipcenter programs, requires an assumed crustal model to calculate an epicenter, and the resulting foci are, in general, dependent on the assumed crustal model. This dependency of computed epicenter on the crustal model is typically illustrated in Figure 2. In the figure, two different epicenters calculated from different crustal models are shown (for Dominican Republic data). All the events exhibited in this figure are generated from explosions and their shot points are indicated by stars (★) and labeled I through VII. Of the two different symbols for epicenters, open

Table 2A. Crustal Structure used in epicenter determination (MODEL A)

No.	Vp (km/sec)	Vs (km/sec)	Thickness (km)
1	5.10	2.94	8.20
2	6.20	3.58	12.90
3	6.60	3.81	22.30
4	7.90	4.57	16.60
5	8.15	4.71	

Table 2B. Modified Crustal Structure used in epicenter determination (MODEL B)

No.	Vp (km/sec)	Vs (km/sec)	Thickness (km)
1	4.00	2.24	3.20
2	5.70	3.20	5.00
3	6.20	3.58	12.90
4	6.60	3.81	22.30
5	7.90	4.57	16.60
6	8.15	4.71	- -

2. Dependency on the Distribution of Stations

The precision of the epicenter determination is also affected by the distribution of the stations. For instance, if the stations are distributed on a straight line, we are unable to determine an accurate epicenter. Practically, if two of the stations located at opposite sides (such as stations 4 and 6 or 5 and 7) fail to function simultaneously, the rest of the stations are distributed approximately on a straight line and the epicenter determined from these data is not by any means trustworthy. There is a rather complicated pattern of error distribution according to the distribution of the stations (Flinn, 1965). Initially, the location of the remote stations for the Pueblo Viejo-Quixal network was selected so that requirements of optimum distribution were fulfilled. If some of the stations fail to operate, however, the error distribution alters from the original pattern and special care must be taken to evaluate the precision of the epicenter determination.

Flinn, E. A. "Confidence Regions and Error Determinations for Seismic Event Location", Rev. of Geophysics, 3: (1965), 157.

3. Distant Earthquakes

If an earthquake occurs at greater distance, compared with the size of the network, the epicenter determination usually bears a large error. This is similar to tri-angulating a distant object from a short base line. Similar conditions emerge for deep-focus earthquakes if the spread of the network is not sufficiently large as compared to the depth of the events. In addition, predominance of a low-frequency component characterizes that the onset of the first arrival of a distant earthquake will be gradual and indistinguishable. In most of the cases, the readings of the first arrivals are far less accurate for distant earthquakes than those from near-by earthquakes which is characterized by a high-frequency component.

4. Other Factors Affecting the Precision of Epicenter Determination

When an earthquake occurs, the strain energy accumulated in the earth is rapidly converted to kinetic energy and released as seismic waves. The radiation of kinetic energy, however, is not uniform in all directions. Because of this directive nature, there is a direction for which a P-wave is almost invisible yet an S-wave is very strong, and vice versa. If a station is located along this nodal line for a P-wave, there is a tendency to misinterpret the S-wave as the first arrival, and the resulting epicenter determination is erroneous.

5. Restriction Within the Computer Program

Within the epicenter program (GUEPC I), the following procedure is adopted: The program computes the coordinate of the source (x_o, y_o and z_o) and the origin time (t_o). If only 4 readings are available, the program calculates all four parameters but no error estimate is available. For more than 5 readings, the least-square fitting method is adopted. In this process, a different weighing factor is assigned for the readings of P-waves and those of S-waves. In this program, S-wave is assigned only 1/3 of the weight because the timing precision for S-wave reading is far less than those of P-waves.

If only 3 readings are available, or if a negative depth is obtained during the iteration process, the depth is automatically assigned at 5 km and fixed at this value thereafter.

If the source coördinate is diverging on each iteration step, and reached to the point for which the eigen value function is overflow, the iteration process is discontinued and calculated coordinates (longitude, latitude) are set to zero.

In conclusion, the precision of the epicenter determination is affected by various factors described above. Therefore, the results of epicenter determination should be carefully weighed before applying to further analysis and rejection of less accurate determination is necessary to prevent incorrect conclusion. It is suggested that any earthquake within the following categories should be considered to have a large error.

a. The standard deviation of the eigen-value function (in Table 1,s) is greated than 0.5 or the standard deviation for the coordinate (DX, DY, DZ) is sufficiently large.

b. The source coordinate has diverged during the iteration process (Longitude and Latitude are equated to zero for these events).

c. The quality factor (IQ) is equal to or greater than 4 except for the explosion events (IQ is assigned as 7).

d. Depth information is not reliable for the events fixed at 5 km.

IV. DISTRIBUTION OF EARTHQUAKES; February 13, 1979 - April 5, 1980.

1. Regional Distribution

Distribution of earthquakes that occur during the period from February 13, 1979 through April 5, 1980, are illustrated in Figure 3A. Earthquakes with depth 0 - 20 km were chosen. Also, as described in section III, the earthquakes with less accurately determined epicenters were rejected from this figure. Heavy lines in Figure 3A show the regional fault systems and light lines illustrate contact between two different geological elements (after Bonis _et al._, 1970).

> S. Bonis, O. H. Bohnenberger, and G. Dengo. _Mapa Geologico de la Republiça de Guatemala_, 1970.

The features we can observe in this figure can be summarized as follows:

a) Well-defined activity distributed along the Chixoy-Polochic fault. The distribution extends from 30 km east to 35 km west of station 1 with a nearly east-west trend. Along this extension, two dense clusters are observed. One of the heaviest concentrations of the events is distributed near the Pueblo Chixoy-Quixal project area. Within this cluster, there are possibly two weakly defined trends: One with north-south orientation, and one with north-south orientattion can be recognized. The nature of this distribution will be discussed in section IV-3.

b) Another cluster along the Chixoy-Polochic fault system is located approximately 10 to 15 km west of station 1. Weakly defined north-south orientation can be observed.