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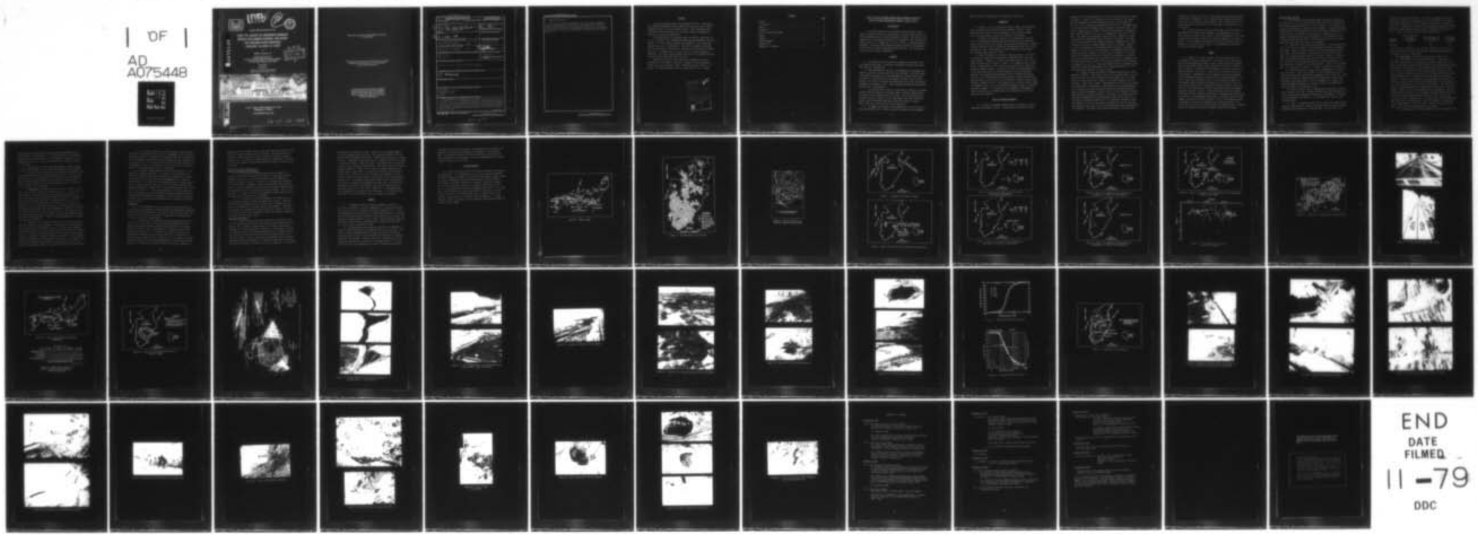

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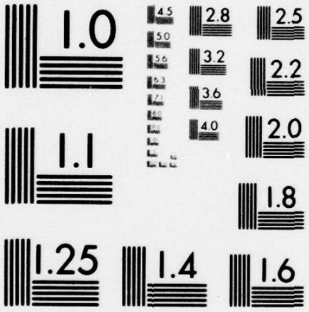

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by

William F. Marcuson III

Geotechnical Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

August 1979

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

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The magnitude 7.0 earthquake near Izu Oshima occurred at 12:24 p.m. on 14 January 1978. The main aftershock occurred on 15 January and had a magnitude of 5.7. These two earthquakes are believed to have caused liquefaction of tailings and two dam failures which resulted in some 80,000 m^3 of tailings flowing down the mountainside and into a stream. These tailings, containing sodium cyanide, contaminated the stream all the way to the Pacific Ocean, a distance of 30 km.

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The tailings dams were approximately 30 m high and were constructed using the upstream construction method. These dams had been previously analyzed pseudostatically using a seismic coefficient of 0.2. This case history clearly indicates that a pseudostatic analysis using routine static soil properties as input is not appropriate if liquefaction is the mode of failure.

Preface

The study reported herein was performed by the U. S. Army Engineer Waterways Experiment Station (WES) as part of the Office, Chief of Engineers (OCE) civil works research effort. This investigation was authorized by OCE under CWIS 31145 work unit entitled "Liquefaction Potential of Dams and Foundations."

The investigation was conducted under the general supervision of Dr. P. F. Hadala, Chief, Earthquake Engineering and Geophysics Division, and Mr. J. P. Sale, Chief, Geotechnical Laboratory. This report was prepared by Dr. W. F. Marcuson III. The visit to Japan was arranged with the assistance of Professor K. Ishihara of the University of Tokyo, and Drs. E. O. Pfrang and H. S. Lew of the U. S. National Bureau of Standards. The Public Works Research Institute of the Japanese Ministry of Construction officially hosted the trip.

During the conduct of this study and the preparation and the publication of this report, COL John L. Cannon, CE, and COL Nelson P. Conover, CE, were Directors of WES. Technical Director was Mr. F. R. Brown. OCE Technical Monitor of this study was Mr. R. R. W. Beene.

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Contents

VISIT TO JAPAN TO OBSERVE DAMAGE WHICH OCCURRED DURING THE NEAR IZU OSHIMA EARTHQUAKES, JANUARY 14 AND 15, 1978

Introduction

1. During the period of 7-21 February 1978 the author visited Japan to study and observe the damage which occurred during the Near Izu Oshima Earthquake which occurred on January 14, 1978. This trip was arranged with the assistance of Professor K. Ishihara of the University of Tokyo and Drs. E. O. Pfrang and H. S. Lew of the U. S. National Bureau of Standards. The Public Works Research Institute (PWRI) of the Ministry of Construction in Japan officially hosted the trip. The itinerary for this trip can be found in Appendix A.

Purpose

2. The purpose of this visit was to examine the failure of two 30-m-high tailings dams. Preliminary information indicated that these dams failed by liquefaction.

3. The advancement of the state of knowledge and earthquake liquefaction analysis requires additional case histories. The most widely used method of analysis, which was developed by Professor Seed and his co-workers at the University of California, is tied to only one case history, the slide at the Lower San Fernando Dam during the San Fernando Earthquake of February 9, 1971. These tailings dam failures may provide another case to investigate.

4. In studying case histories, to gain data to improve or validate design criteria or analyze the primary cause of failure, emphasis must be placed on identifying the mode of failure. This can best be accomplished by on-site inspection of the dam remains and debris materials. Details provide extremely important clues to the cause of failure. Hence, there is a real need for on-site inspection.

5. In summary the purpose of this trip was to visit the sites of these dam failures and to obtain the evidence needed to make judgments

about the mode of failure and soil conditions at the site.

Background

6. Figure 1 is a 1:2,250,000-scale map of Japan. The Izu Peninsula is located about 100 km (65 miles) southwest of Tokyo. About 40 km (30 miles) east of the Izu Peninsula is the Island of Oshima. This is the northernmost island of the chain of Izu Islands.

7. Figure 2 is a geologic map of the Izu Peninsula. The base rock of the peninsula consists primarily of andesitic lavas and pyroclastic rocks of the latest Miocene, Neocene, and Tertiary ages. Younger volcanic rocks and lavas of Pleistocene and Quaternary ages cover these pyroclastic rocks. Unconsolidated alluvium sediments can be found in Neocene small areas along the rivers.

8. The Izu Peninsula is an area of many new faults. New faults are defined as faults which have moved in Quaternary time (last two million years). Figure 3 is a map of the southern half of the Izu Peninsula showing these new faults. Figure 4 is a drawing of the Izu Peninsula. Superimposed on this figure are extensions of the Nankai and the Kanto Oceanic Troughs. A projection of these troughs intersects at a near right angle near the northern portion of the Izu Peninsula. Because of the complex geology exhibited by the troughs and volcanic activity, it is believed that residual stresses of high intensity must exist at depth in the area of the Izu Peninsula. Because of these high-intensity locked-in stresses, earthquakes in this area are fairly common; for example, the epicenter of the Kanto Earthquake of 1923 is located in the Kanto Trough and the epicenter of the Izuhanto-Oki Earthquake of 1974 is located on the Irozaki Fault on the southern tip of the Izu Peninsula (see Figure 3).

Near Izu Oshima Earthquake

9. At 12:24 p.m. Japanese Standard Time, on January 14, 1978, a magnitude 7 earthquake occurred. Its epicenter was located at north

latitude 34°, 38' and longitude 130°, 18' east. This epicenter is shown in Figure 5. Figure 6 is a drawing of the Izu Peninsula. The epicenters of earthquakes occurring between 10:38 p.m. on 13 January and 12:23 p.m. on 14 January are superimposed on this plot. Hindsight tells us that these small earthquakes were foreshocks to the main event. Figure 7 (a similar plot to Figure 6) shows the epicenters of earthquakes which occurred between 12:24 p.m., 14 January, and 11:59 p.m., 14 January. The large circle represents the main shock. Figure 8 is a plot of epicenters of earthquakes which occurred on 15 January. The large circle is an epicenter of the largest aftershock (magnitude 5.7), which occurred at 7:32 a.m. Japanese Standard Time on 15 January. Figure 9 is a plot of epicenters of earthquakes which occurred on 16 January. Figure 10 is a plot of all the epicenters of earthquakes which occurred between 10:38 p.m., January 13, and 11:59 p.m., January 16. The open circles are foreshocks, the solid circles are aftershocks, the double circle is the main shock, which occurred at 12:24 p.m., 14 January, and the solid circle with a cross is the largest aftershock, which occurred on January 15 at 7:32 a.m. From these figures (6-9) it is apparent that the stress release was taking place in a westerly direction, i.e. the epicenters moved from east to west with time.

10. Figure 11 shows the depth of earthquake hypocenters plotted against a longitude. The larger circles are for larger events. Most of these data plot at a depth of around 10 km and almost all of the data fall at a depth below 20 km. Figure 12 is another drawing of the Izu Peninsula - Tokyo area of Japan. Superimposed on this plot are locations of strong motion in instruments. Each location has a corresponding box which indicates the peak accelerations which were measured during the Near Izu Oshima Earthquake. The top line in the box indicates the maximum acceleration in gals (1000 gals = 1 gravity). The middle line represents the maximum vertical acceleration in gals and the lower line represents the maximum acceleration of the east/west component in gals. Unfortunately, the only record which was obtained on the Izu Peninsula was obtained in the town of Ito on the eastern coast about two-thirds up the peninsula. This record had a peak acceleration in the east/west

direction of 100 gals or 1/10 g. These records were generally obtained on SMAC Type B instruments. This instrument has a natural frequency of 10 Hz and is 70 percent critically damped. These records were not obtained during the visit but were to be available to the public later on during 1978.

11. During the main shock the Inatori Fault, shown in Figure 5, was subjected to right lateral movement. The maximum offset on the Inatori Fault was about 18 cm; Figure 13 shows photographs of this 18-cm offset along the Inatori Fault as it crosses a highway in the town of Inatori. Various Japanese engineers and scientists reported horizontal movement of as much as 60 cm; however, no displacements larger than 18 cm were actually observed.

Damage

12. Figure 14 is a map of Japan. The Izu Peninsula has been crosshatched for easy identification. Also shown on this map are numbers indicating Japanese intensity values. These values are Japanese Meteorological Agency (JMA) seismic intensity values and not Modified Mercalli values. In general, the JMA intensity 5 would correspond to a Modified Mercalli VII or VIII. Figure 16 is an enlarged view of the Izu Peninsula. Superimposed on this figure are two horseshoe-shaped curves indicating the areas in which most of the damage occurred. The interior horseshoe represents the area of most extensive damage with less damage occurring around the periphery of the interior curve but within the bounding curve. Estimates of peak acceleration in the interior curve are about 400 gals (4/10 g) and within the overall damaged area about 300 gals (3/10 g). These estimates are based on calculations made from the dimensions and weight of tombstones that did and did not overturn. This earthquake caused about one hundred million dollars damage to property and killed 25 people. Most of this damage occurred to highways as a result of landslides and rockfalls and most of the people were killed in houses located below the landslides and in vehicles which were traveling along these highways during the earthquake.

Tailings dams failures

13. The Mochikoshi Mining Company began operating a gold mine on the west coast of the Izu Peninsula near the town of Tohi in about 1940. The refining company trucked the ore to the interior of the peninsula to refinery located near the damsite shown in Figure 5. During the refining process gold was extracted from the ore, and tailings, contaminated with sodium cyanide, were pumped up the mountain in a pipe about 4 in. in diameter and deposited in the tailings lagoon. They completely filled two areas between 1940 and 1965. In 1965 they started filling an area which they continued to use until the earthquake.

14. Since 1965 the tailings were deposited in a bowl-shaped structure on the top of a mountain. This bowl-shaped structure is formed by three dams. Figure 17 shows a plan view of this bowl-shaped structure. Also shown in this drawing are cross sections of the three as-built dams. For convenience these dams will be called: Dam No. 1, located in the most northerly direction and shown at the top of Figure 17; Dam No. 2, which is the southeasterly dam and is shown below Dam No. 1 on the right side of Figure 17; and finally Dam No. 3, which is the westerly dam. A cross section of Dam No. 3 is shown at the bottom of Figure 17.

15. The base portions of Dams 1 and 2 (embankments to a height of 16 m for Dam No. 1 and 12 m for Dam No. 2) were constructed in 1965. Tailings were deposited behind these embankments until about 1970. After 1970 the tailings were impounded behind 3-m-high dikes. These dikes were added on an annual basis. Had the earthquake not occurred, the refining company had planned to continue to deposit tailings behind these structures for another year or so.

16. About 120 metric tons of tailings were deposited in the reservoir during an 8-hr day. Tailings had been deposited behind Dam No. 1 for a 3-month period immediately preceding the earthquake. At the time of the earthquake about 480,000 cu m of tailings were stored in the tailings lagoon.

17. Prof. K. Ishihara reported that in about 1971, Japan formed a committee headed by Prof. Fukuoka of the University of Tokyo to prepare guidelines and regulations for tailings dams. In about 1973, this

report was issued and distributed. One of the requirements was that a pseudostatic analysis be conducted for all tailings dams. This regulation also required the use of an earthquake coefficient of between 0.15 and 0.25 g. According to officials at the Mochikoshi Refinery, the dams had been pseudostatically analyzed using an earthquake coefficient of 0.2 g. The soil properties used for this analysis were:

Material	Angle of Internal Friction ϕ , deg	Cohesion Intercept C , tsm	Unit Weight γ , tsm
Dam	20	1.2	1.75
Tailings	30	1.2	1.75

Using these soil properties, and a seismic coefficient of 0.2 g, factors of safety of 1.033 and 1.102 had been calculated pseudostatically for dams No. 1 and 2, respectively.

18. Main shock. The main shock occurred on January 14 at 12:24 p.m. As a result the tailings behind the No. 1 Dam liquefied. With this liquefaction and resulting loss of shear strength the small dikes became unstable and thus about 80,000 cu m of contaminated tailings flowed out of the reservoir. These tailings flowed down the mountainside and into a stream and then some 30 km down the stream into the ocean. Figure 17 shows a plan view of the tailings reservoir with dams. The crosshatched zones show where liquefaction and flow took place. Figure 17 also shows cross sections of the dams after the failure had occurred. Figure 18 shows aerial photographs taken of the tailings reservoir and showing the No. 1 Dam after it had failed. The residue left by the tailings flowing down the mountainside can be seen in the photographs. Figure 19 shows the streambed after the earthquake. Note the gray markings on the side of the streambed indicating how high the tailings must have been when they flowed down the river. This is about 1-1/2 m up on this streambed wall. In Figure 20 one can see heavy equipment removing the tailings deposit from the streambed. At this point the tailings deposit is about 2 m thick. Figure 21 shows sand boils that occurred in the tailings during the main shock.

19. Assuming that the tailings weighed 100 pcf (1602 kg/m^3) then

the 80,000 cu m of tailings that flowed down the mountainside had a total weight of 12,800,000 kg. It is estimated that the difference in elevation from the tailings dam to the streambed at the foot of the mountain is about 400 m. Thus the tailings had a potential energy of 5×10^{18} ergs.

20. The conversion of this potential energy to kinetic energy possibly was responsible for the debris flowing such a long distance.

21. About 15 min after the main shock, sand boils occurred in the old tailings deposit areas (those used prior to 1965). This area had had about 1/3 m of fill deposited on the surface of the tailings and grass had been planted and the area is now used for grazing cattle. Figure 22 shows pictures of the tailings material after it had boiled up as a result of the earthquake.

22. Aftershock. The largest aftershock, which occurred on January 15 at 7:32 a.m., registered a magnitude of 5.7. It is believed to have triggered the failing of the second tailings dam; however, an aerial photograph exists, supposedly taken at 10:00 a.m. on January 15, which shows the second dam intact. Mochikoshi Mining Co. officials believe that the second dam failed at around 12:30 to 1:00 p.m. on January 15. At this time about 3000 cu m of liquefied material broke the second dam and flowed down the mountainside. Again (as in the first dam failure) the base or main portion of the No. 2 Dam remained stable. It was the small dikes used for stacking tailings that became unstable and allowed the dam failure. Figure 23 shows photographs of the second dam after it had failed.

23. Figure 24 is a mechanical analysis of the tailings material which was obtained from the Japanese. The material falls generally between 0.01-mm- and 0.1-mm-diameter sizes. According to the Japanese, the specific gravity is 2.6, the liquid limit is 30 percent, the plastic limit is 17 percent, the plasticity index is 13 percent, and the water content is 35 percent. Figure 25 shows the results of a sieve analysis which was conducted on tailings material at the WES. Also shown on this plot are the Atterberg limits that were obtained at WES. Note that there is a discrepancy between the limits obtained in Japan and at WES.

24. In the writer's opinion the sample tested at WES was representative of the material that liquefied. **Atterberg** limits conducted at WES indicate that it is nonplastic. Recognizing that the refinery processes different ore materials and that the materials are spigoted into a tailings lagoon, it is quite possible that the tailings materials are heterogeneous. Thus, it is possible, even likely, that the plasticity index of the tailings ranges from 0 to 15 percent.

25. In Japan, tailings dams fall under the jurisdiction of the Ministry of Industry and Trade. As a result of these failures the Ministry of Industry and Trade has established a committee to formally investigate these failures and to make recommendations in regard to future safety. This committee will undoubtedly make a thorough analysis. Prof. K. Ishihara believes that the dam received strong shaking with a maximum acceleration of about 0.25 g. This shaking may have had a duration of from 10-20 sec. Field investigations are currently under way. These investigations include undisturbed sampling, Standard Penetration Testing, and cone penetration resistance. This work will be conducted by private soil consultants and supervised by the committee investigating the failure.

Discussion

26. If one assumes that the soil properties which are given in the tabulation in paragraph 17 were obtained from consolidated, undrained laboratory triaxial shear tests, then one can speculate that values obtained for the cohesion (1.2 tsm) are largely due to the dilatant behavior of the material during shear.

27. Considering the second dam, which failed approximately 24 hr after the main event and 5 hr after the largest aftershock, one can assume that large pore water pressures were developed in the tailings during the shaking. This is confirmed by the sand boils which were manifest on the surface. It is possible to postulate that after the earthquakes straining occurred along a shear zone. The materials in this shear zone tended to dilate. Because of the high excess pore water pressures existing in the surrounding material, it is possible that the material in the shear zone actually sucked in pore water, leading to a

decrease in shear strength. This in turn would allow the material in the shear zone to again deform with more dilation. This would lead to an increase in water content in the shear zone and a decrease in shear strength. It is the author's opinion that such a hypothesis is possible and that this sequence of events was probably the mode of failure of the second dam.

Highway and railroad damage as a result of rockfalls and landslides

28. If one travels the highway leading from the damsite in a southerly direction to the coast (see Figure 26) many landslides and rockfalls can be seen. As stated previously, the Izu Peninsula is primarily volcanic in origin. The area is very rugged and mountainous. As a result most of the damage resulted from landslides and rockfalls. Where cut and fill operations had been used to construct highways along the mountainside the fill portions occasionally slumped. This is seen in Figure 27. Figures 28 and 29 are photographs showing landslides and rockfalls that occurred along this highway.

29. If one travels the coastal highway up the eastern coast of the Izu Peninsula many rockfalls and landslides are seen. Figure 30 shows aerial photographs of some of these slides. Immediately north of the town of Inatori, the road goes through three tunnels. Landslides carried away the highway which connected the three tunnels. Figure 31 is an aerial view of these landslides. Figure 32 was taken standing at one tunnel looking toward another.

Landslide near Kawazu

30. During the main shock about 100,000 cu m of material slid down the mountainside and buried four houses, killing seven people and one dog. This landslide occurred north of the town of Kawazu and is designated by the word landslide in Figure 26. The killing of the dog is significant because the Japanese generally keep the animals outside. This indicates that the material moved with such speed that the dog could not escape. Figure 33 shows aerial photographs taken of the area immediately after the earthquake. It should be noted that the material slid down one mountain, up the side of the hill adjacent to it, and then

turned and flowed down the valley. Figure 34 is a photograph taken of the scarp remaining after the slide. The surficial deposits were composed of loam and weathered volcanics. Immediately below this is a layer of scoria. Immediately below the scoria is a volcanic tuff which is hard to chip with a shovel. Below this layer of volcanic tuff is a soft layer of plastic clay (visually classified CH). This can be seen in the photographs in Figure 35. There are two schools of thought concerning the failure plane of this slide. One school says that the failure plane is in the scoria. The other school of thought, which appears to be more logical, is that the failure plane is located in the soft clay below the volcanic tuff. This appears more logical because of the large chunks of tuff which slid during the earthquake (see Figure 36). This soft clay was found at the head of the slide and also at the existing surface toward the center of the slide area. Figure 37 is a photograph taken of this material in the center of the slide area. It is believed that this layer of soil was continuous over the entire slide surface.

Summary

31. In summary the Near Izu Oshima Earthquake occurred at 12:24 p.m. on January 14 and had a magnitude of 7. The main aftershock occurred at 7:32 a.m. on January 15 and had a magnitude of 5.7. These two earthquakes are believed to have caused the liquefaction of tailings and two dam failures which resulted in some 80,000 cu m of tailings flowing down the mountainside and into a stream. These tailings, being polluted with sodium cyanide, contaminated the stream all the way down to the Pacific Ocean, a distance of 30 km.

32. The earthquakes caused numerous rockfalls and landslides resulting in about $100 million in damage and the loss of 25 lives. As a result of these earthquakes there are many strong motion records in Japan which can be used to provide information concerning site amplification and soil response. However, there are no strong motion records which were obtained closer than 40 km to the dam failures. It is believed that the record obtained at Ito might be modified and scaled to

approximate the motions at the dam. There appears to be sufficient information to perform a postearthquake investigation of the tailings dams. The Japanese Ministry of Industry and Trade is performing such an investigation and consequently, it is not recommended that the Corps conduct an analysis at this time.

Acknowledgements

33. This trip would not have been possible without the assistance of many people. It is impossible to list all the people who provided assistance during the conduct of this field trip; however, special thanks are due Mr. Nakazawa of the Public Works Research Institute (PWRI), Mr. Iwasaki of the PWRI, Professor K. Ishihari, University of Tokyo, Dr. K. Mori, University of Tokyo, Dr. Tatsuoka, University of Tokyo, Dr. E. O. Pfrang, National Bureau of Standards (NBS), and Dr. H. S. Lew, NBS. Without their help, this report would not be possible. Special thanks are due Dr. B. J. McDonald and COL G. F. Wilson of the U. S. Embassy, Japan, and COL J. T. Miller, District Engineer, U. S. Army Engineer District, Far East, for the assistance they provided during the writer's stay in Japan.

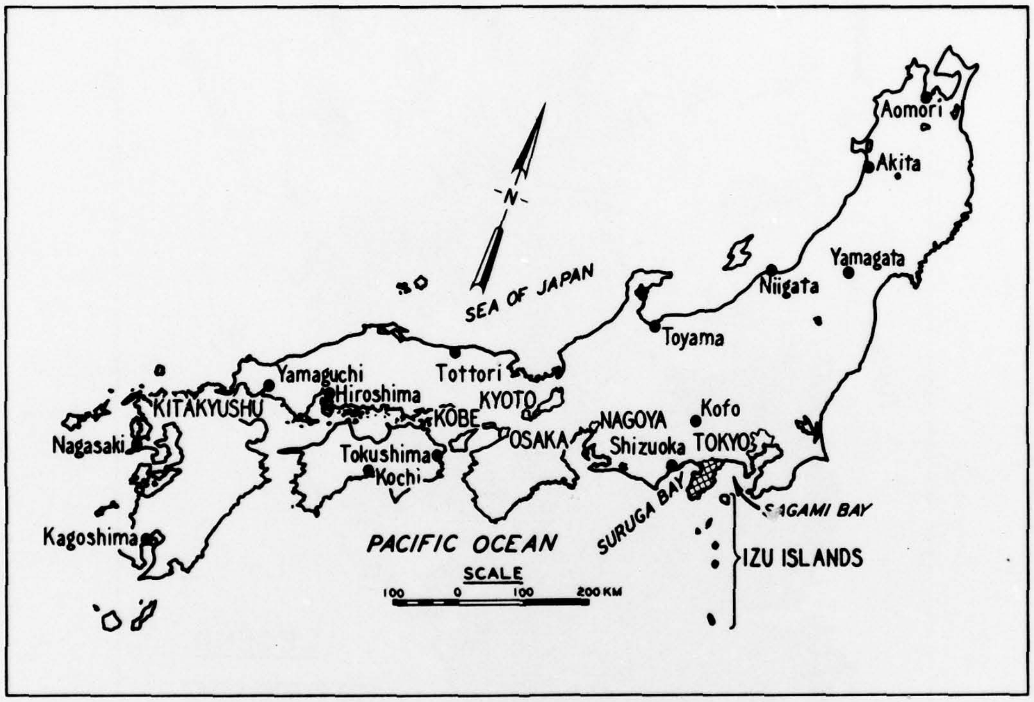


Figure 1. Map of Japan

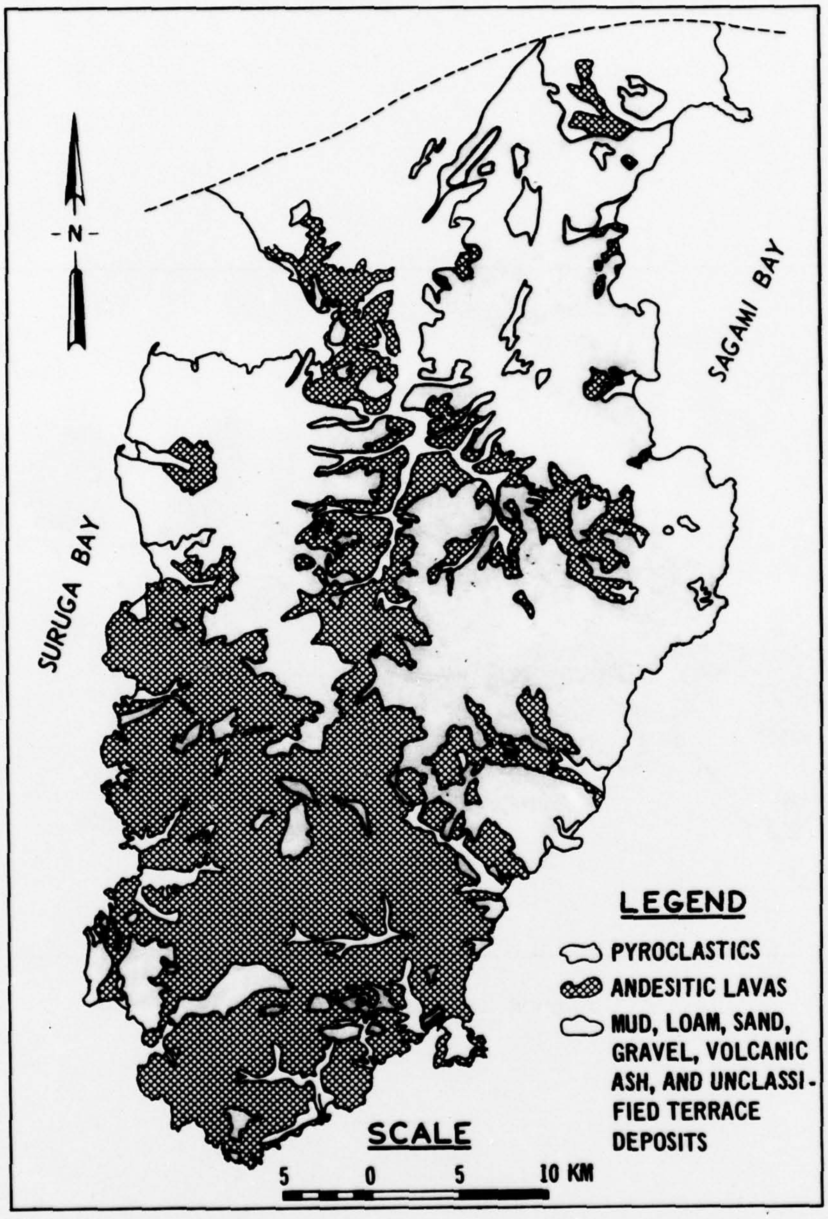
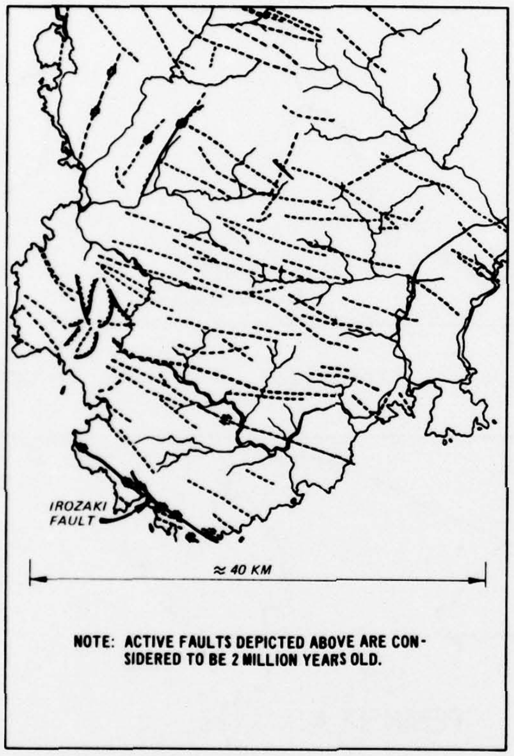


Figure 2. Geologic map of Izu Peninsula



NOTE: ACTIVE FAULTS DEPICTED ABOVE ARE CONSIDERED TO BE 2 MILLION YEARS OLD.

Figure 3. Map of southern Izu Peninsula showing active faults

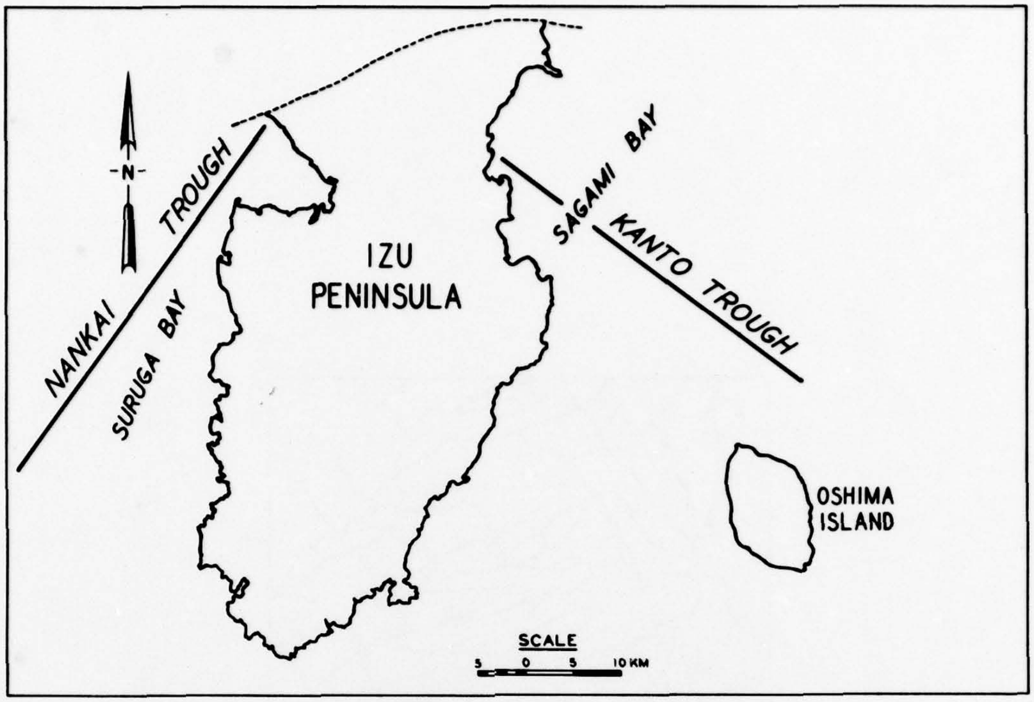


Figure 4. Extensions of oceanic troughs

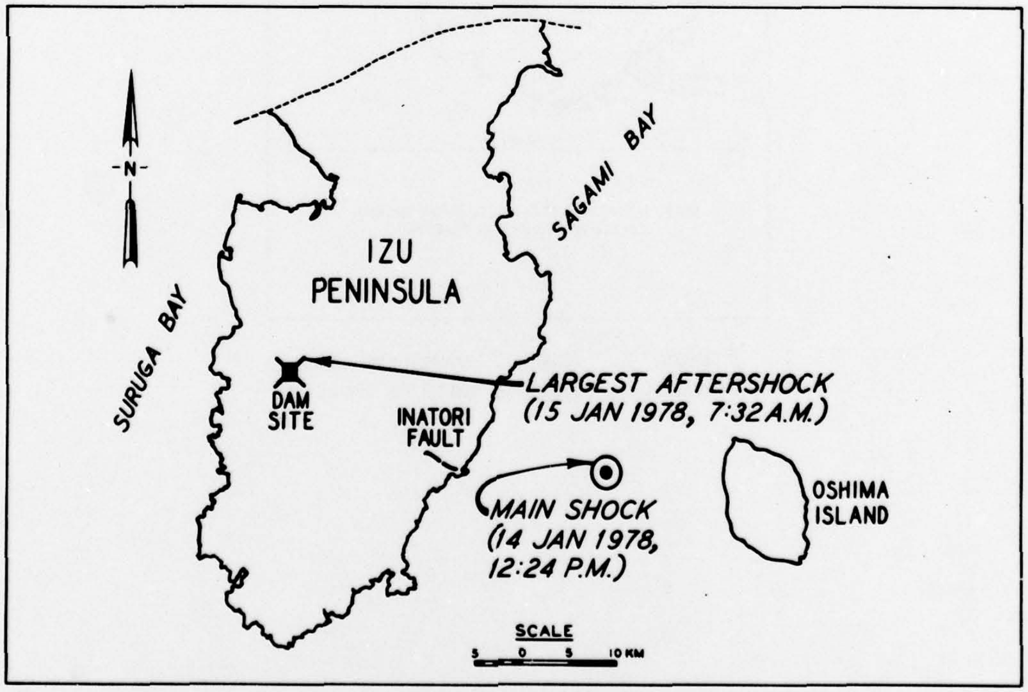


Figure 5. Map of Izu Peninsula with epicenters superimposed

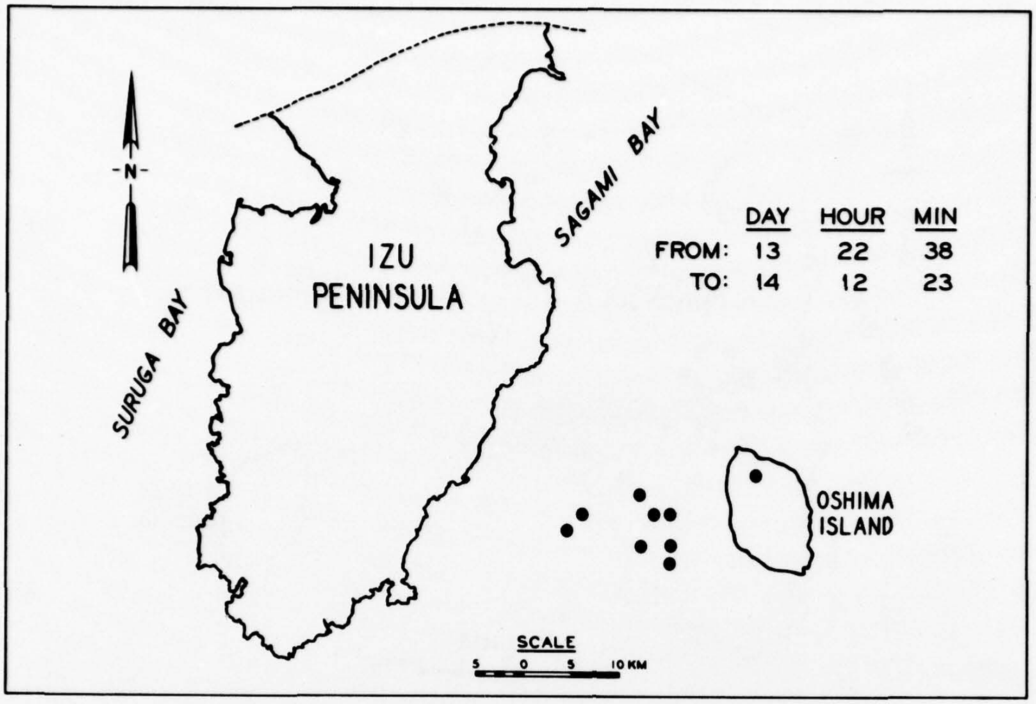


Figure 6. Map of Izu Peninsula with epicenters of foreshocks superimposed

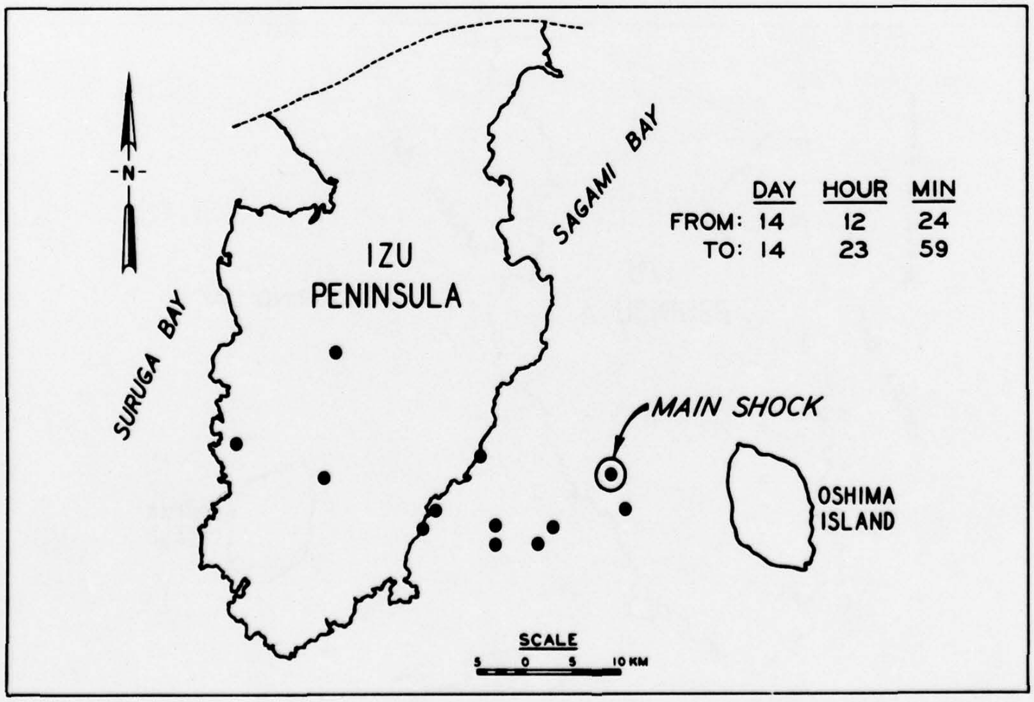


Figure 7. Map of Izu Peninsula with epicenters of earthquakes on January 14 superimposed

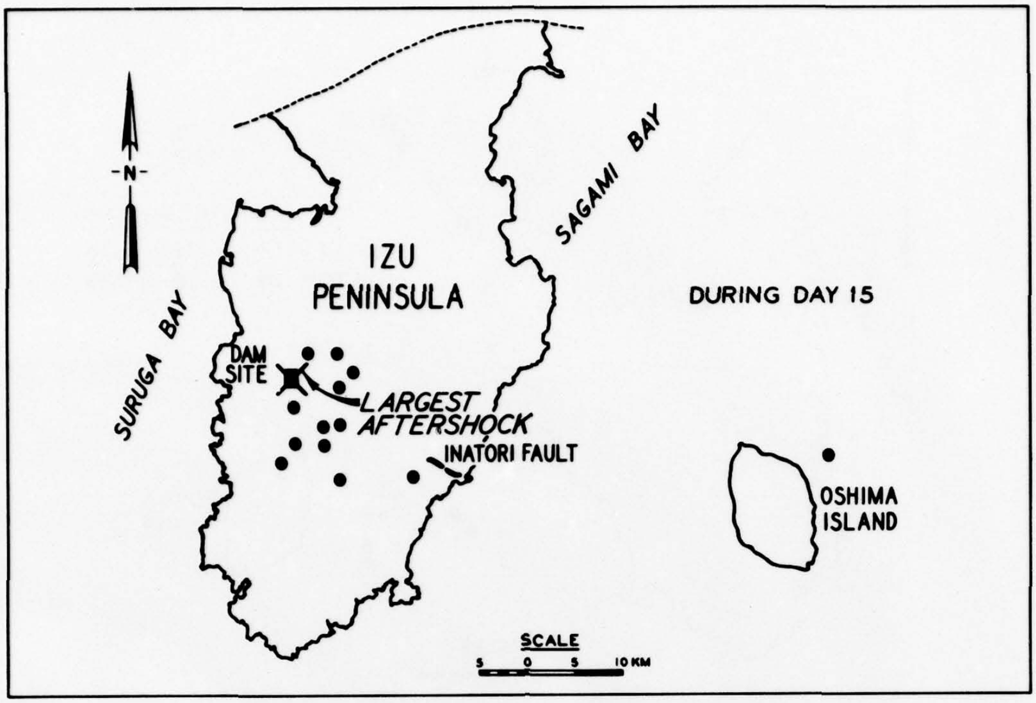


Figure 8. Map of Izu Peninsula with epicenters of earthquakes on January 15 superimposed

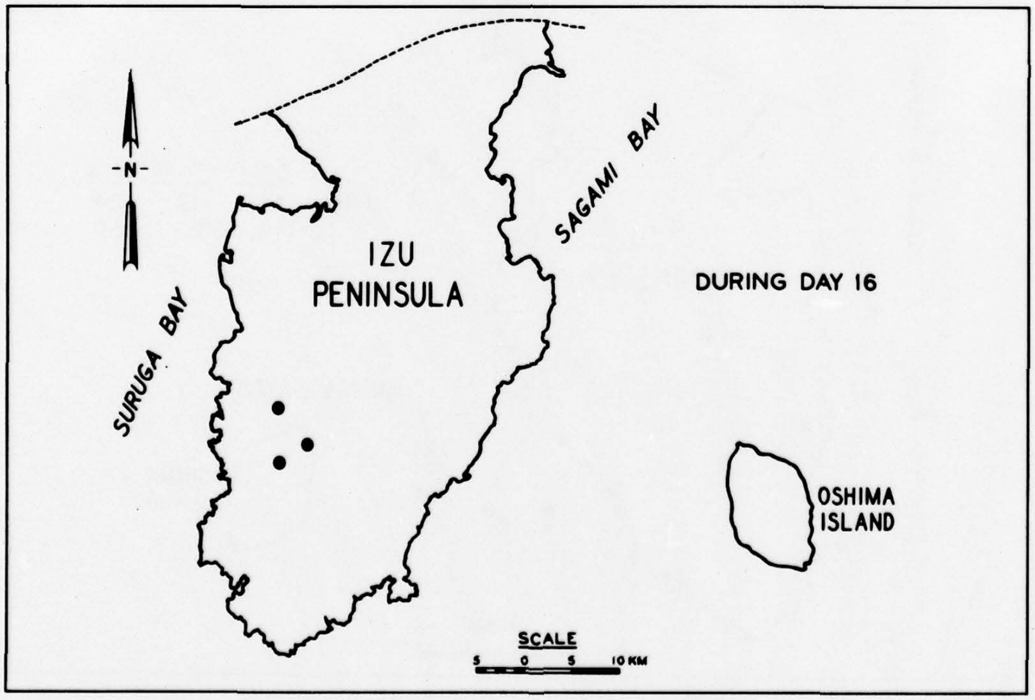


Figure 9. Map of Izu Peninsula with epicenters of earthquakes on January 16 superimposed

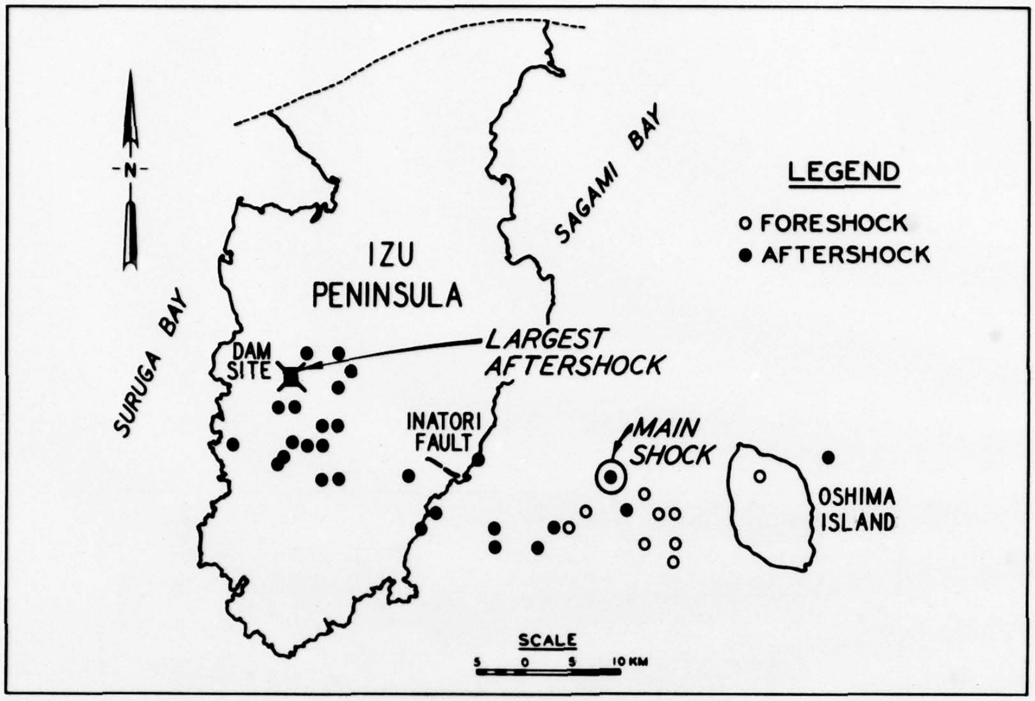


Figure 10. Map of Izu Peninsula with epicenters of all earthquakes January 13-16 shown

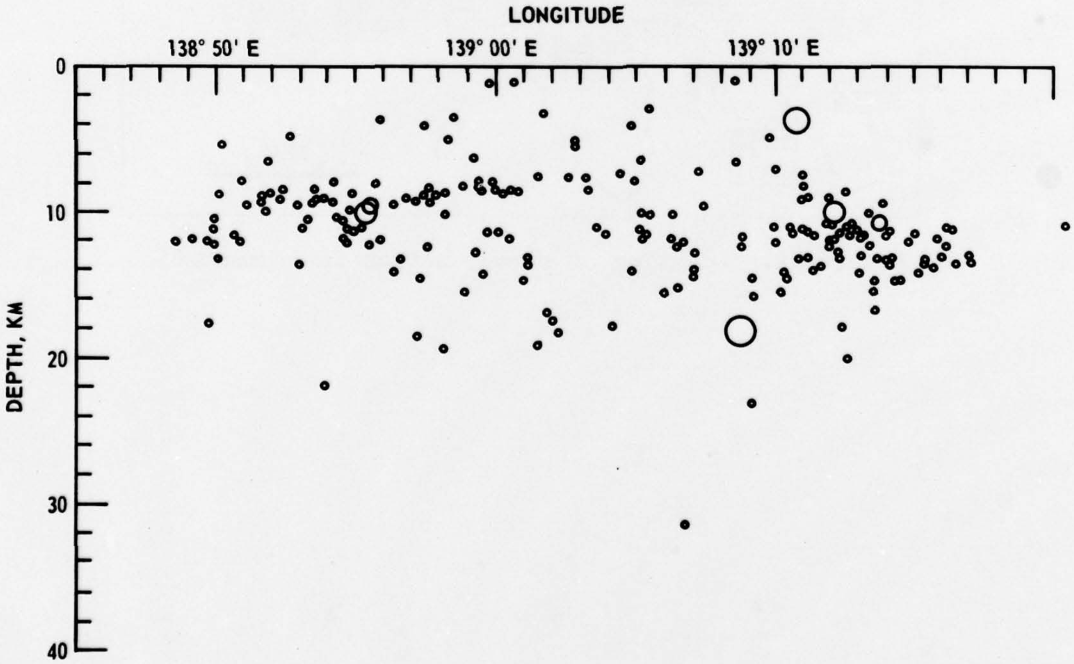


Figure 11. Plot shows focal depth, km
(from Prof. Hakuno)

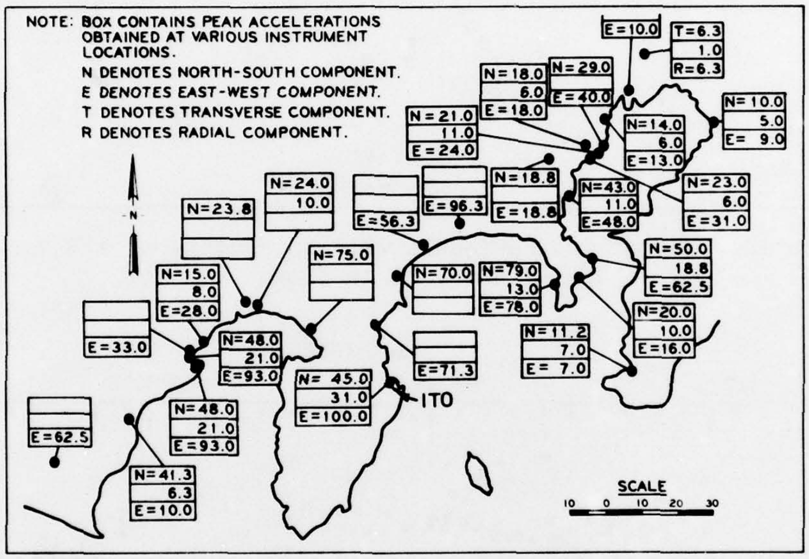
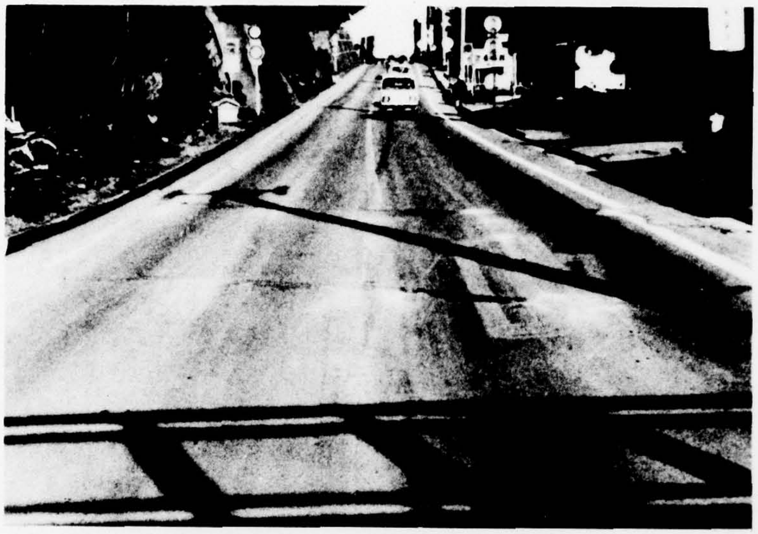


Figure 12. Location of strong motion instrumentation



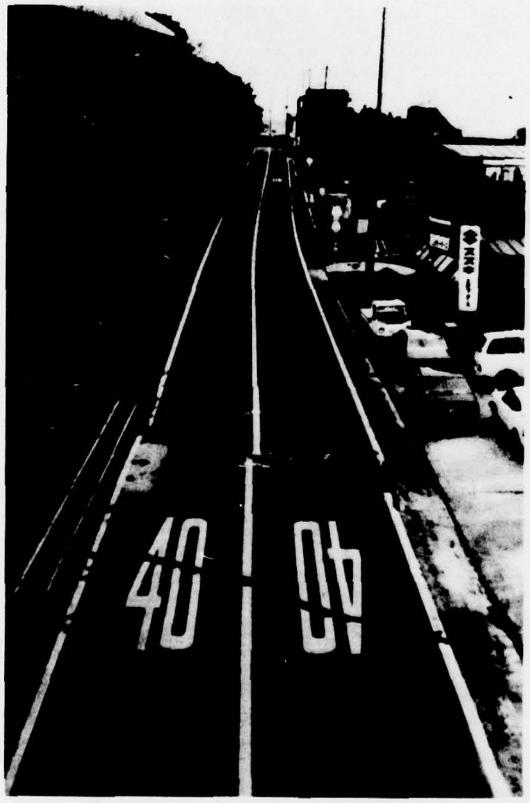


Figure 13. Photos showing Inatori fault offset

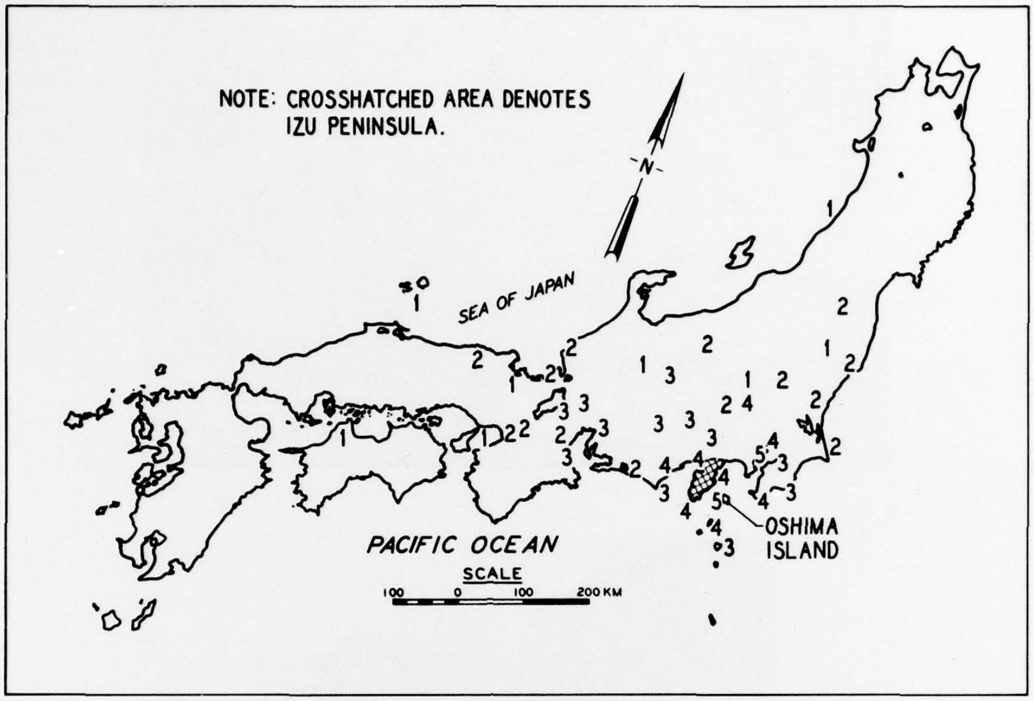
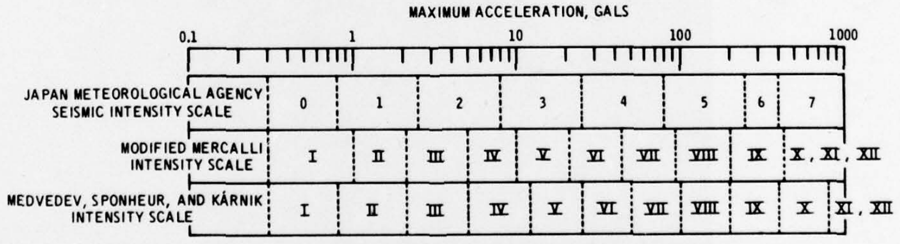


Figure 14. Map of Japan with JMA intensities superimposed



COMPARISON OF VARIOUS SEISMIC INTENSITY SCALES

FROM TOSHIO IWASAKI, 1978

Figure 15. Relationship between the various intensity scales and peak ground acceleration

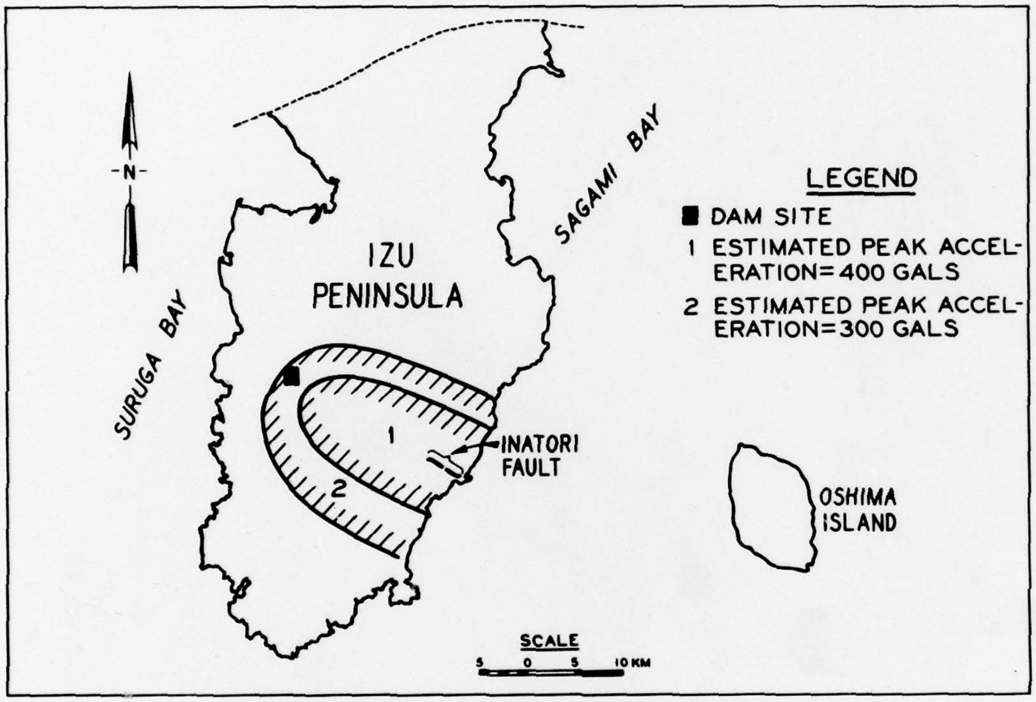


Figure 16. Map of Izu Peninsula showing area of intensive damage

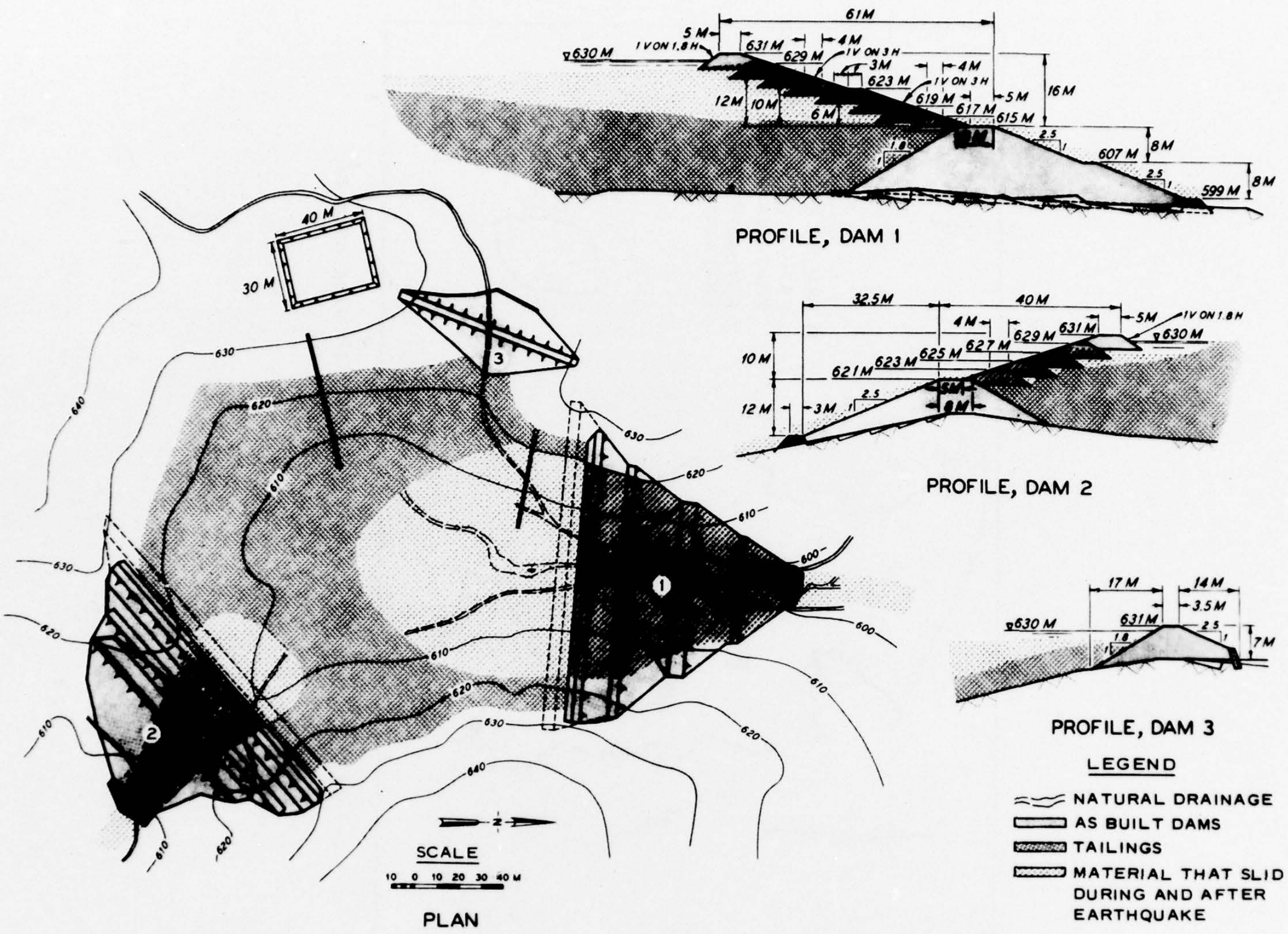


Figure 17. Plan view and cross sections of the tailings dams

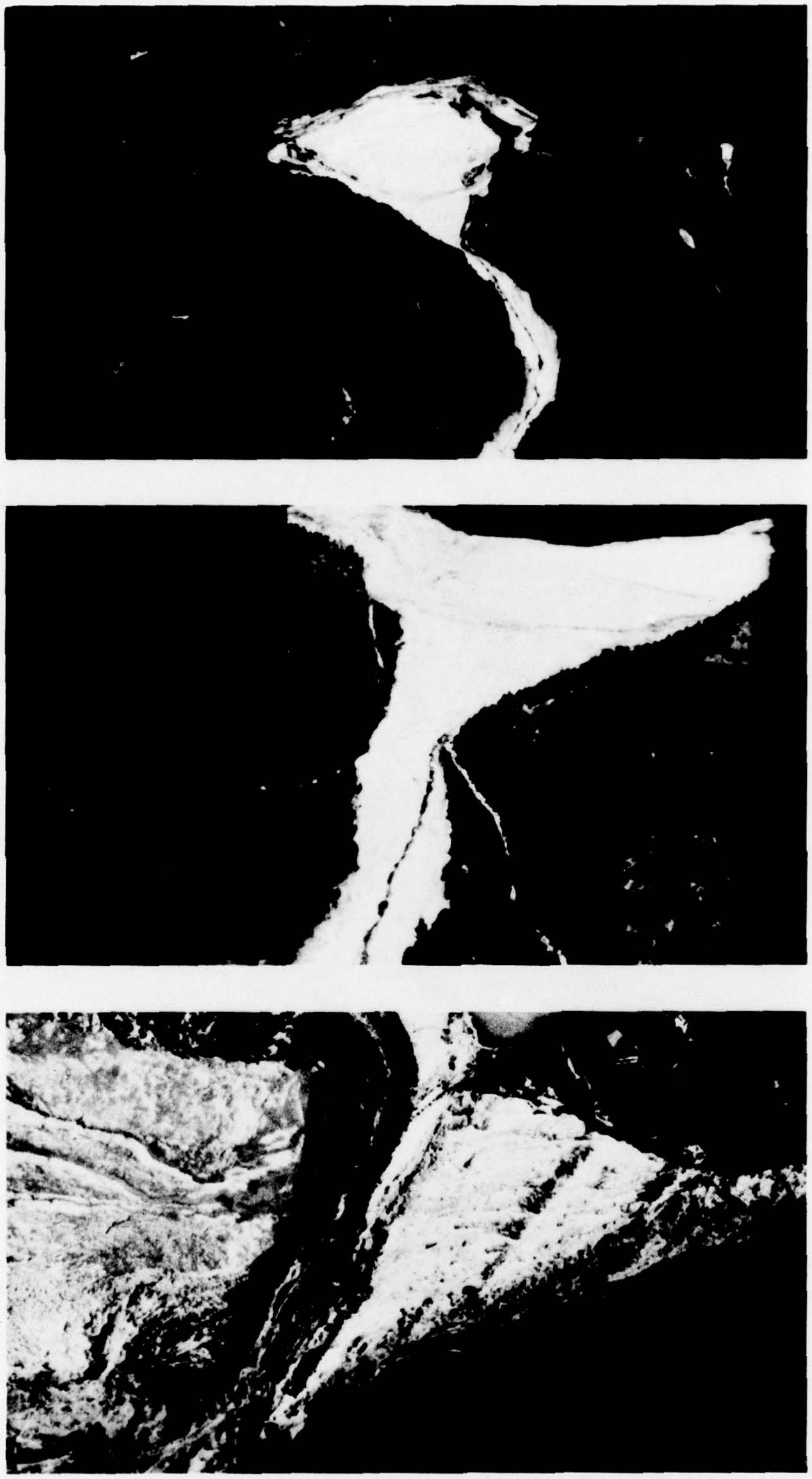


Figure 18. Aerial views of the Mochikoshi Mining Co.'s tailings dam No. 1 after failure

Figure 19. The streambed about 1 km downstream of the tailings dam - after the failure

Figure 20. Equipment cleaning up the streambed

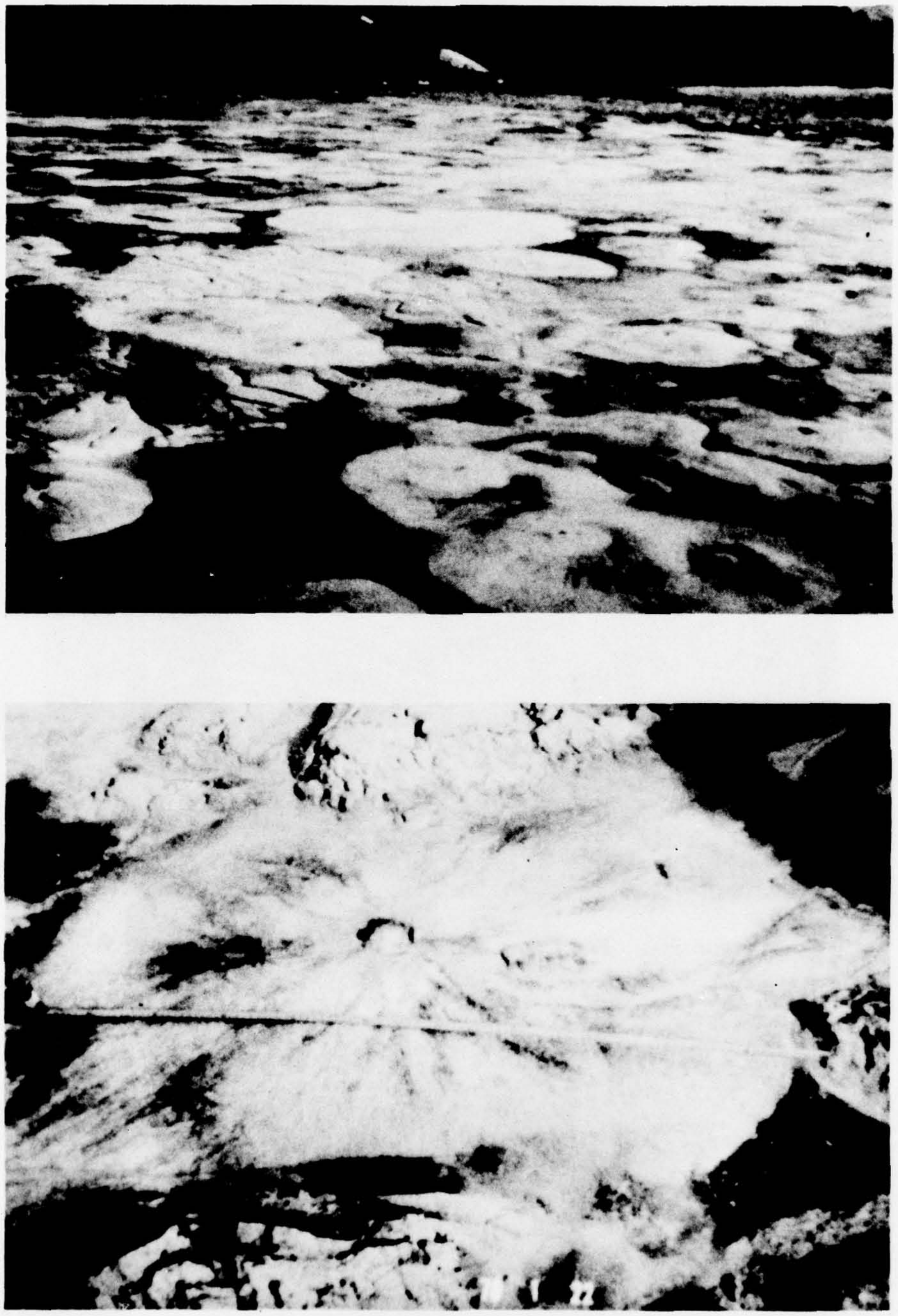


Figure 21. Sand boils in tailing deposit after the earthquake

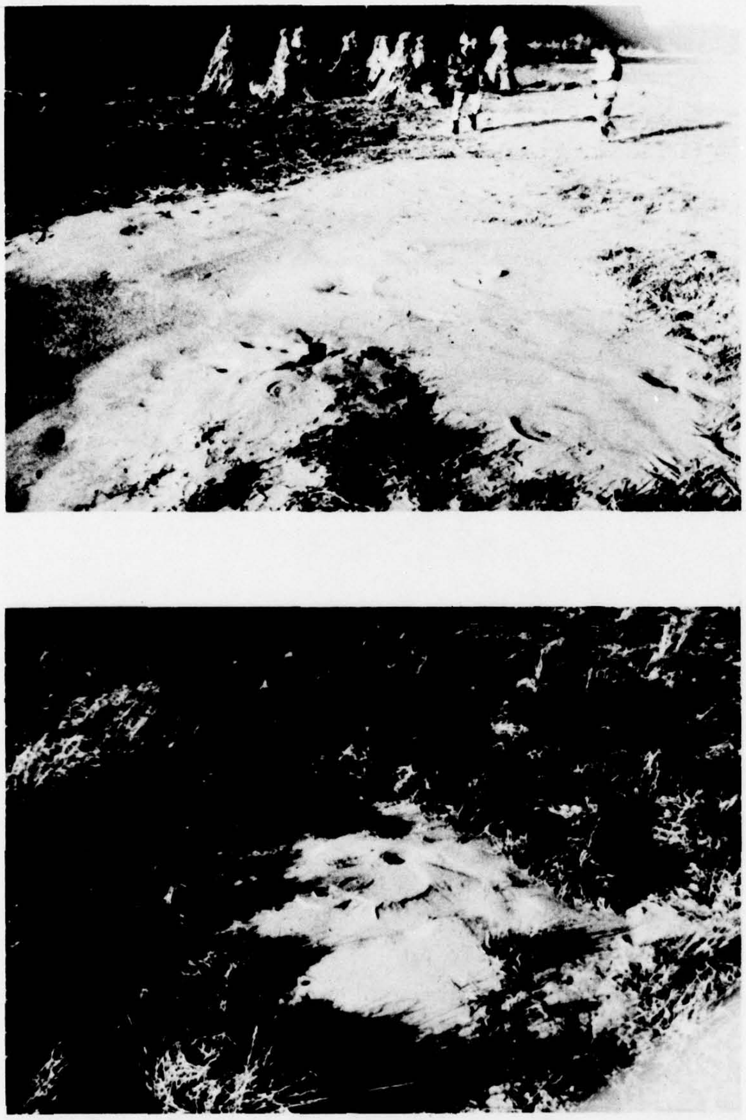


Figure 22. Soil boils in old tailings deposits

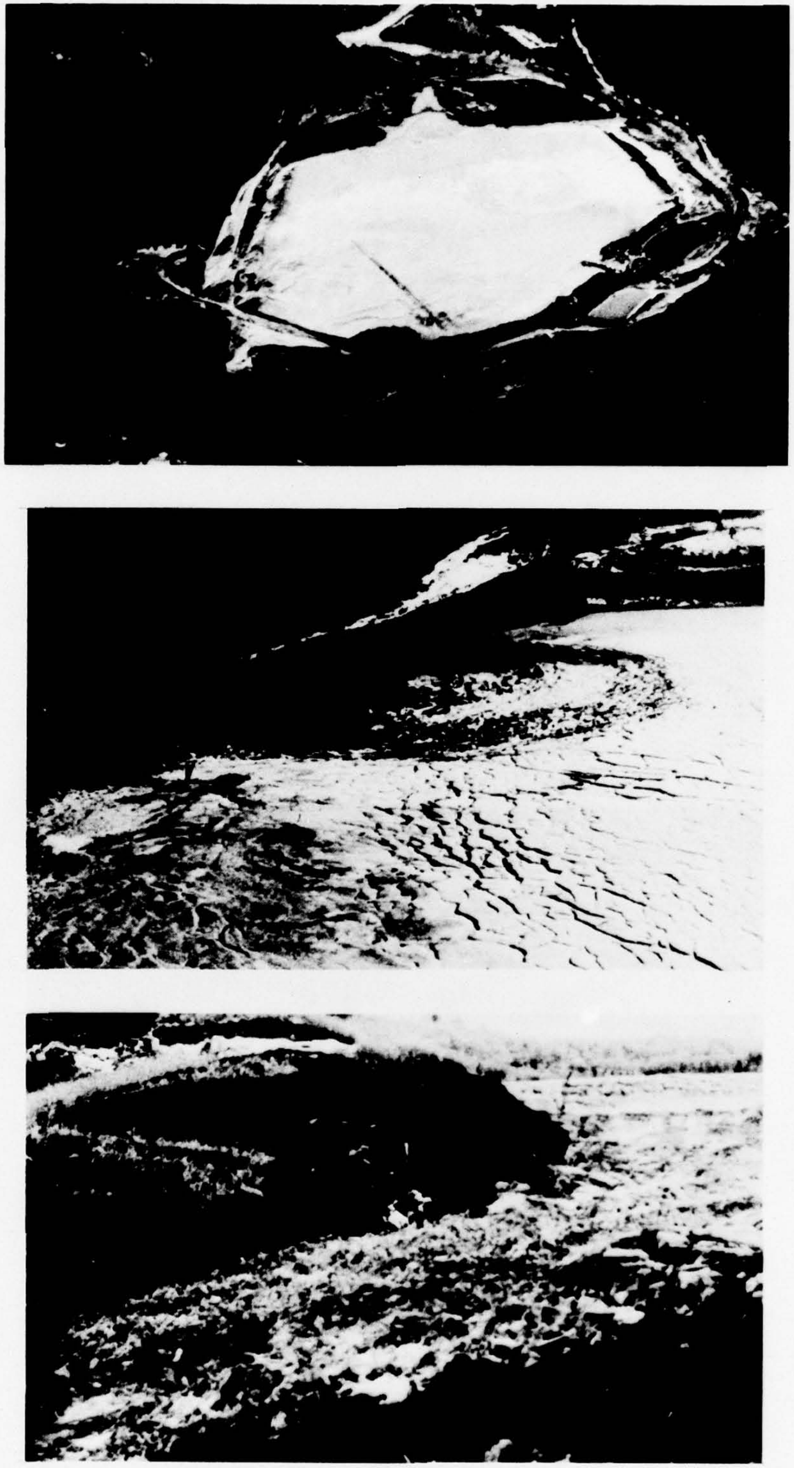


Figure 23. No. 2 tailings dam after failure

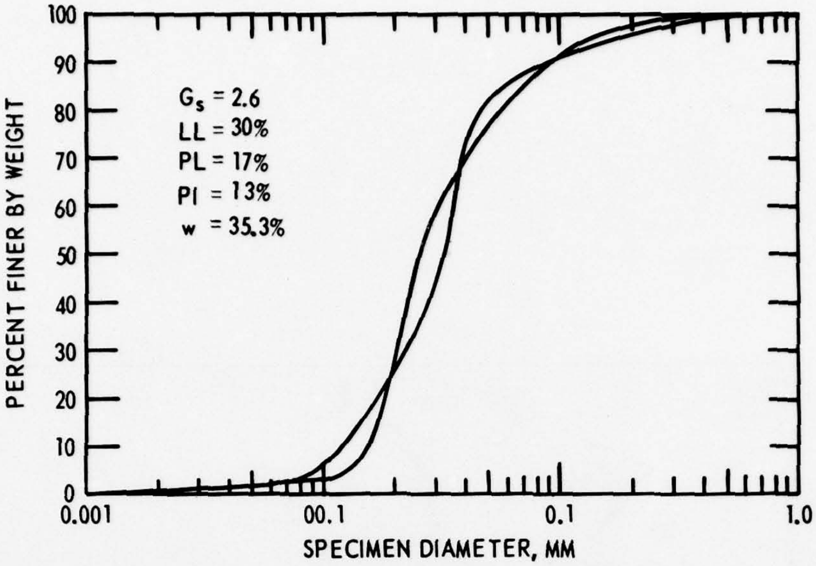


Figure 24. Gradation determined by Japanese

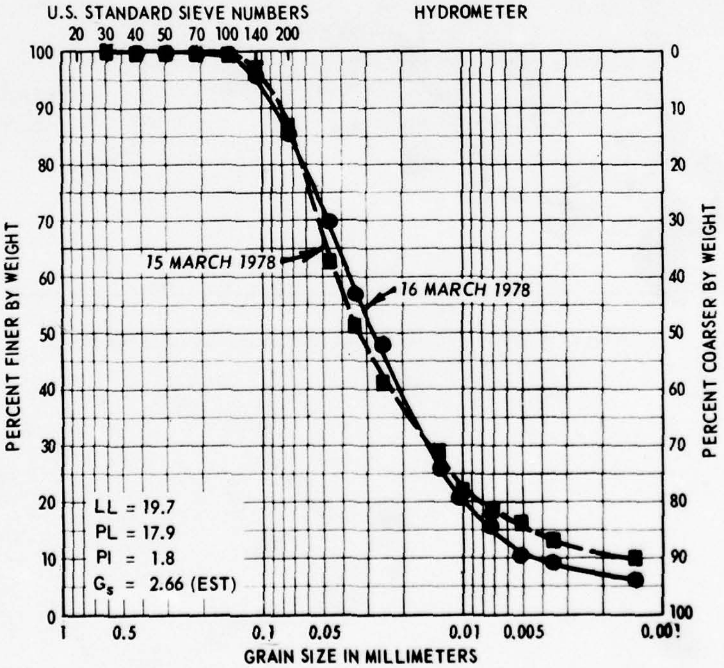


Figure 25. Gradation determined by WES

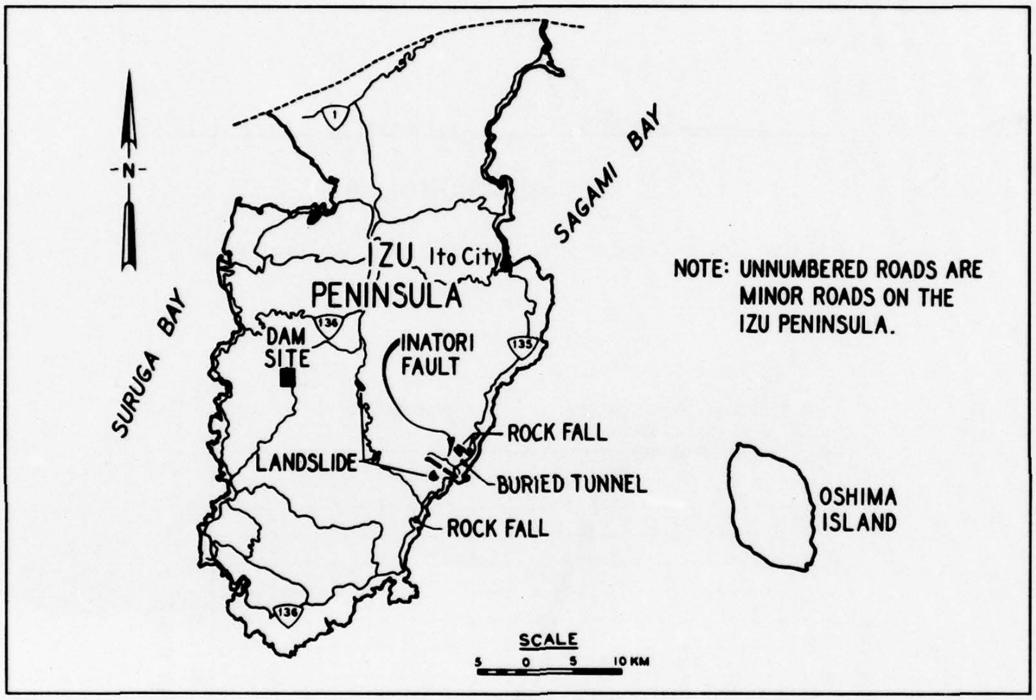


Figure 26. Road map of Izu Peninsula

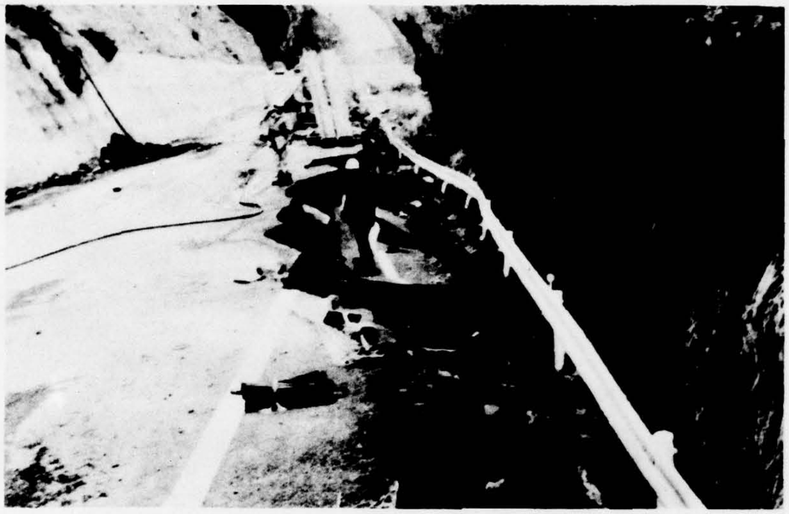


Figure 27. Examples of failures where the highways had been constructed using cut and fill techniques

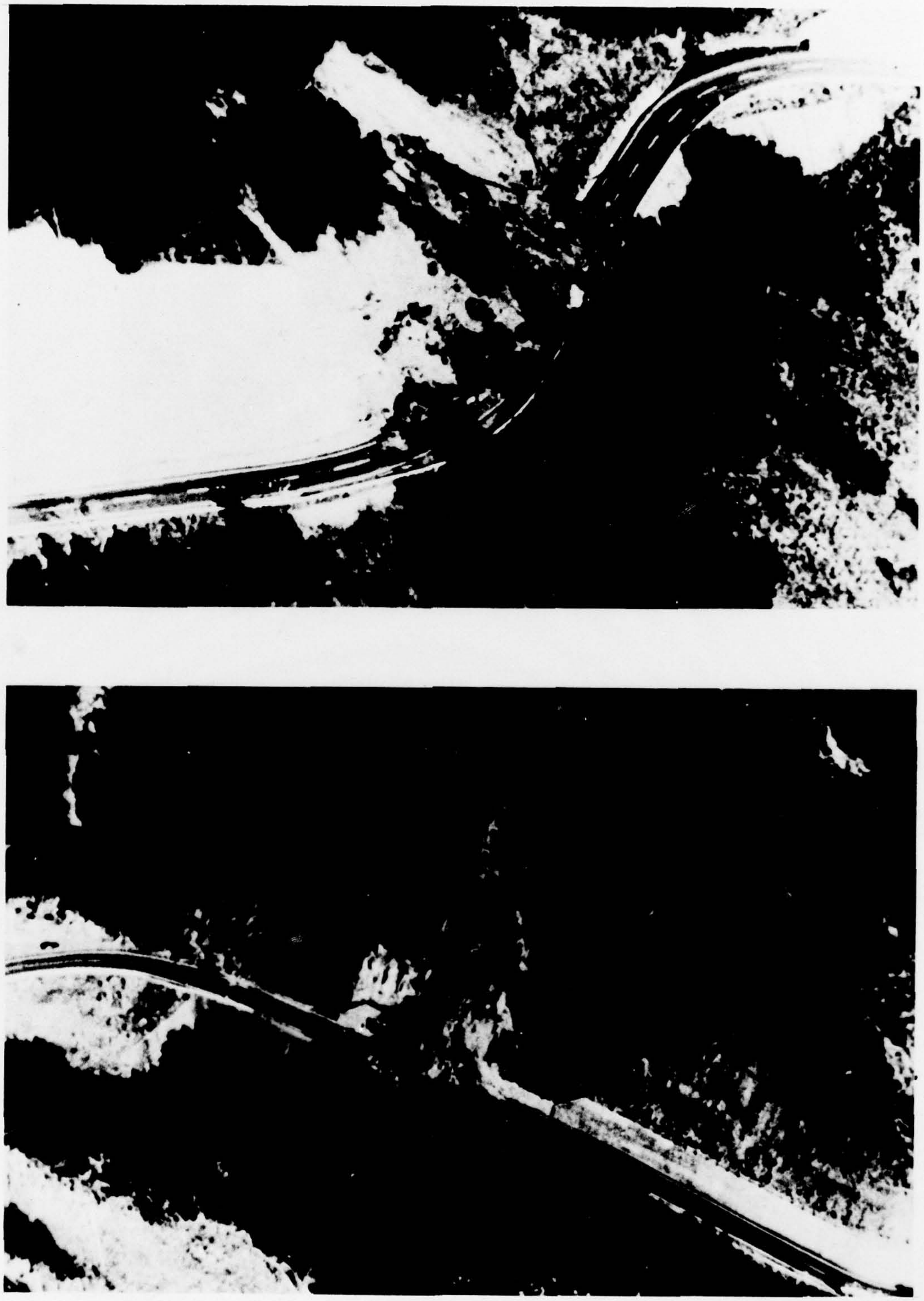


Figure 28. Highway landslides and rockfalls

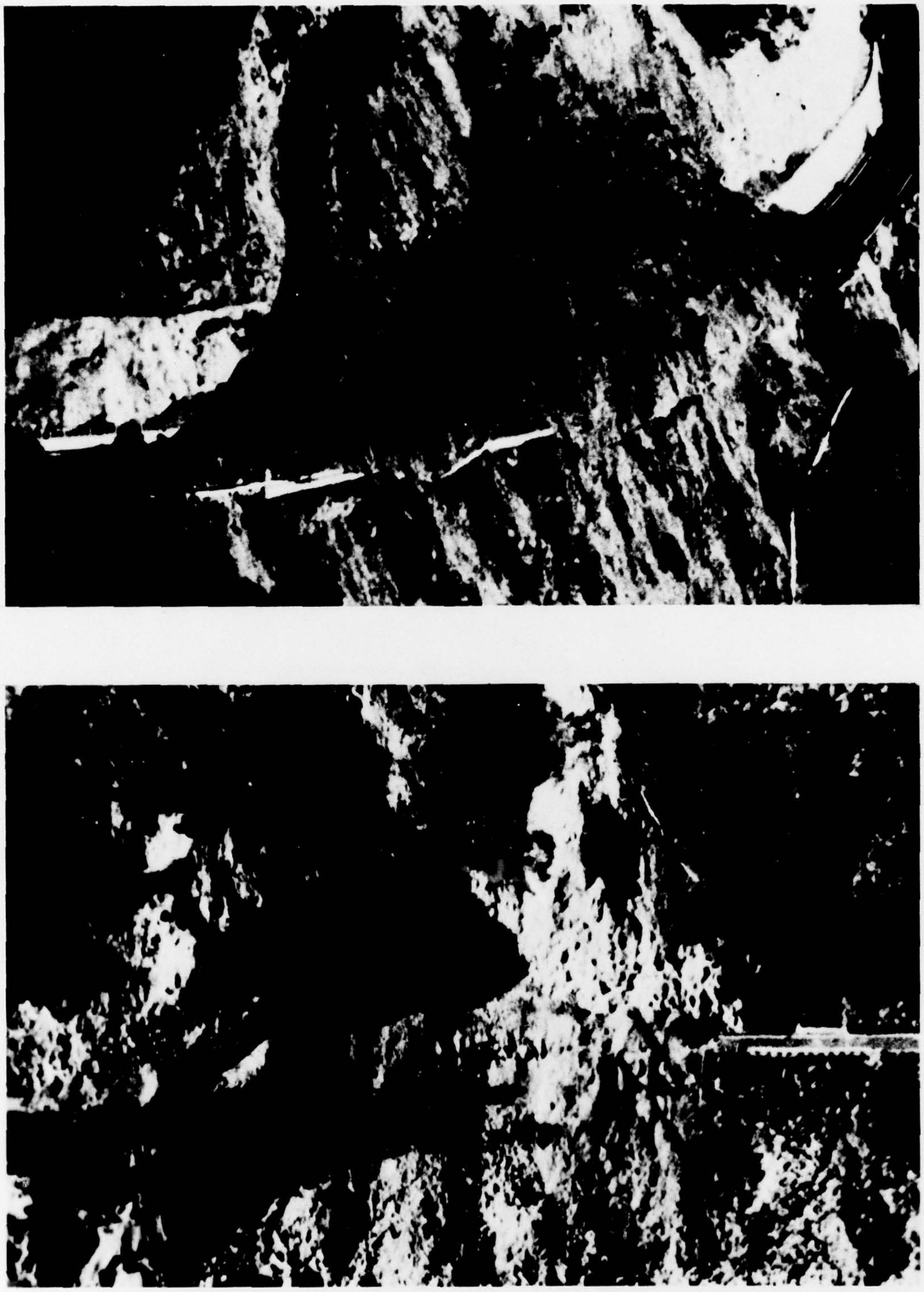


Figure 29. Rockfalls and landslides along the highway

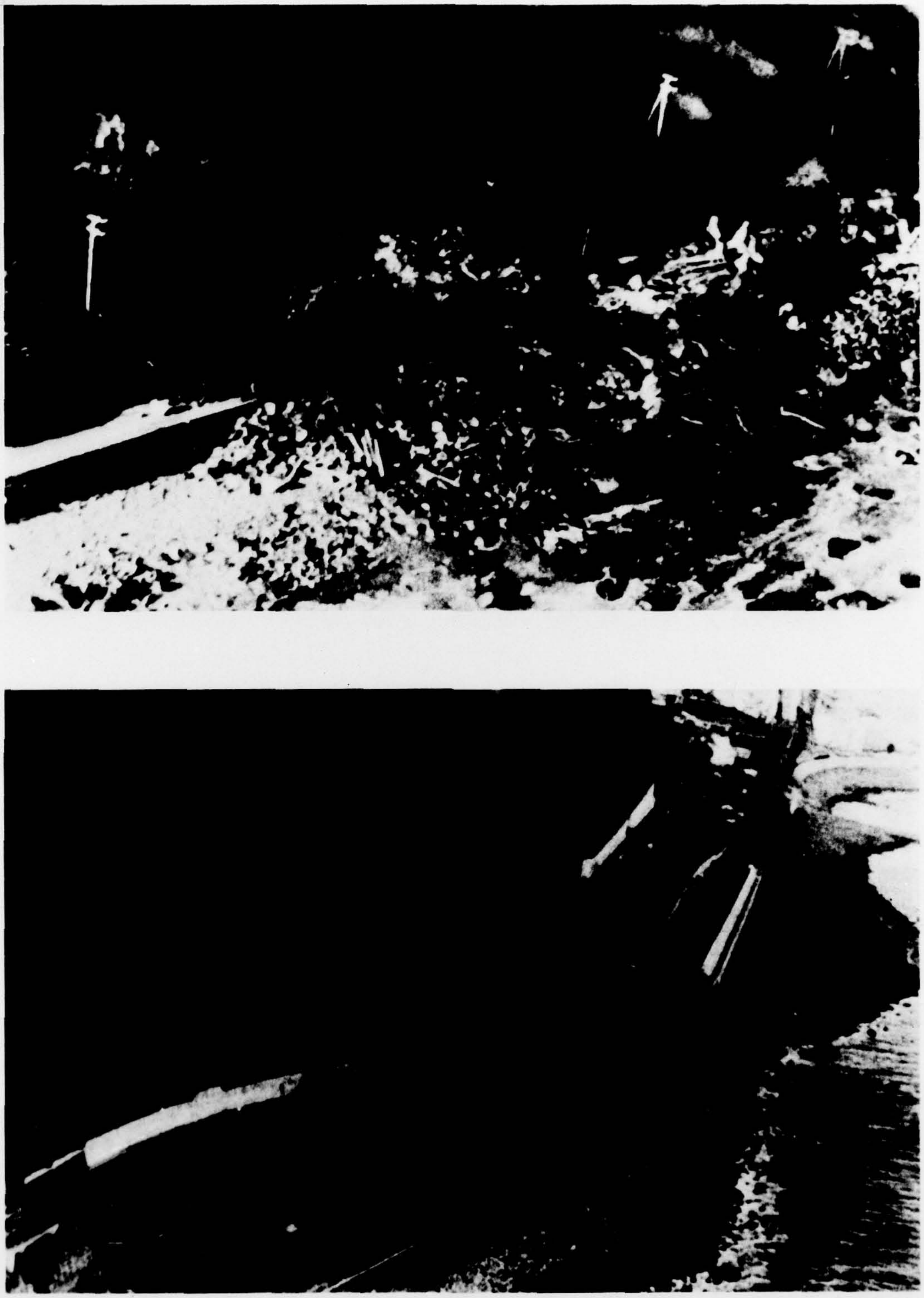


Figure 30. Aerial photos of landslides and rockfalls

Figure 31. Aerial photo of landslides at the tunnel site

Figure 32. View of tunnel after earthquake

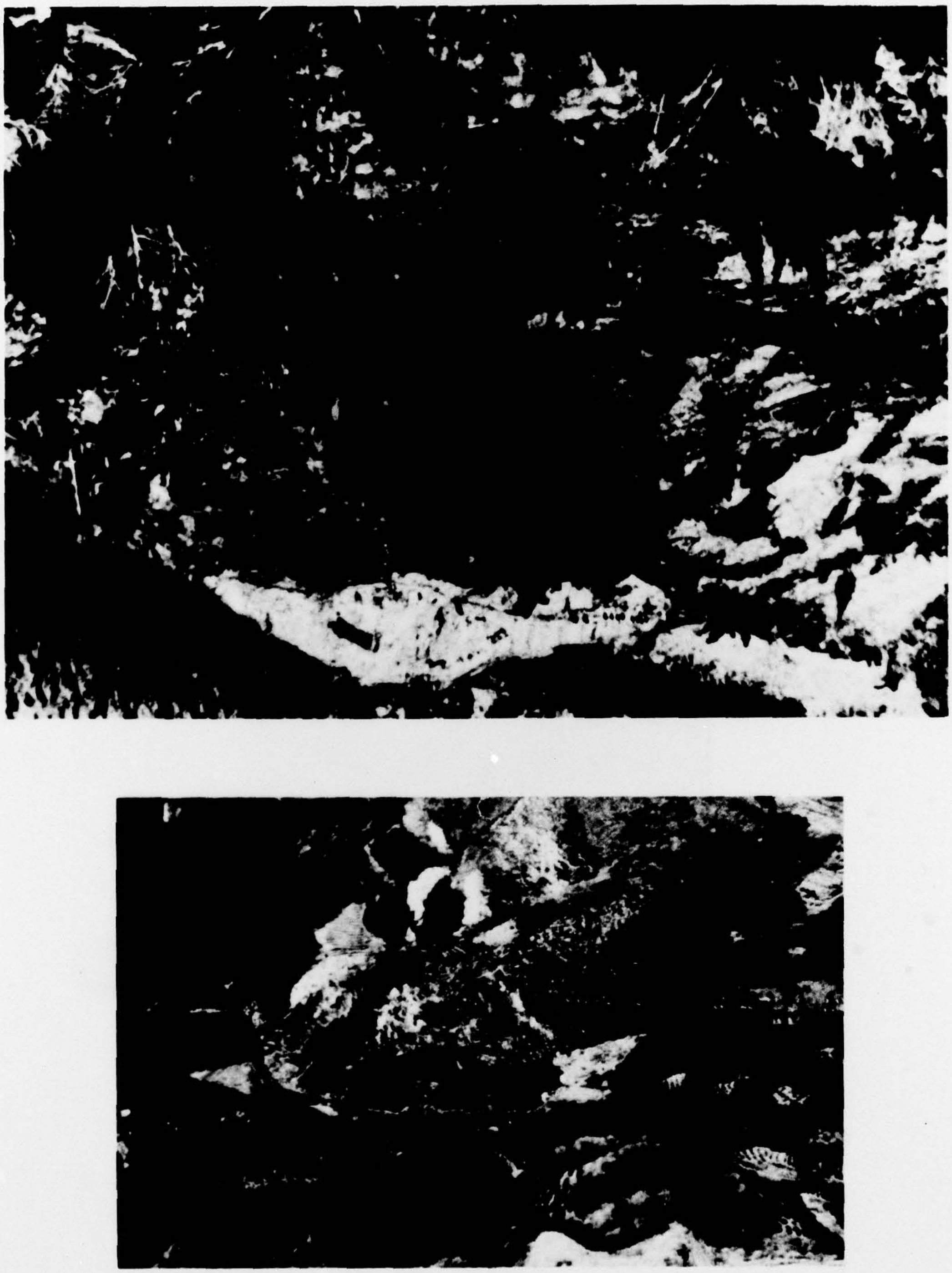


Figure 33. Aerial photo of the Kawazu landslide

Figure 34. View of scarp of landslide

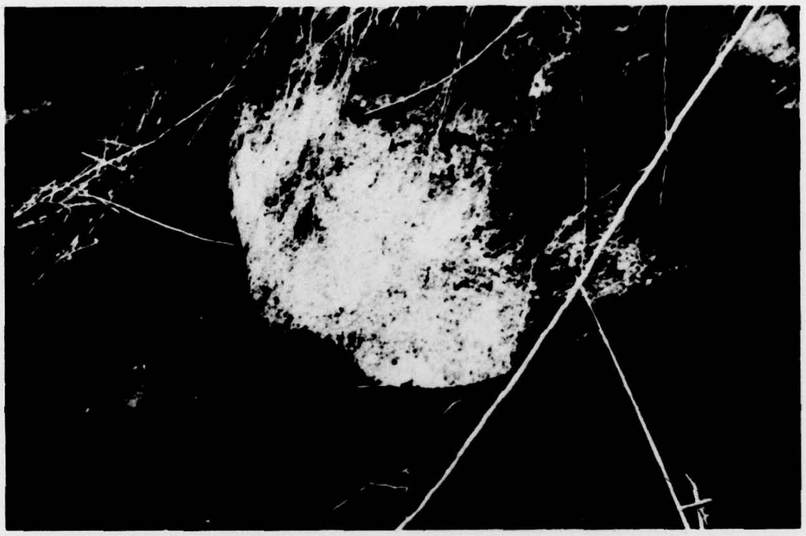


Figure 35. View of postulated zone of weakness

Figure 36. Photos of material of the slide

Figure 37. View of postulated zone of weakness near center of slide area

APPENDIX A: SCHEDULE

February 8, 1978

AM: Public Works Research Institute (PWRI):
Mr. Nakazawa, Director, Public Works Research Institute
Ministry of Construction, Bunkyo-ku, Tokyo, Japan

Mr. Sugahara (PWRI)

Mr. Urano, Planning Section, Public Works Research Institute
Ministry of Construction, Japanese Government,
2-28-32, Honkomagome, Bunkyo-ku, Tokyo, Japan

PM: Chiba Branch of the PWRI:
Dr. Ohashi, Head, Earthquake Disaster Prevention Division
Chiba Branch, Public Works Research Institute, Ministry of
Construction, 4-12-52, Anagawa, Chiba-shi, Chiba-ken, 280

Mr. Iwasaki, Chief, Ground Vibration Section, Earthquake
Disaster Prevention Division, Chiba Branch, Public Works
Research Institute, Ministry of Construction, 4-12-52,
Anagawa, Chiba-shi, Chiba-ken, 280

February 9, 1978

AM: Building Research Institute (BRI):
Mr. Sugimura, Chief Research Engineer, International Institute
of Seismology and Earthquake Engineering, Building Research
Institute, Ministry of Construction, 3-28-8 Hyakunincho,
Shinjuku-ku, Tokyo, Japan

Mr. Kitagawa, Dr. of Engineering Researcher, International
Institute of Seismology and Earthquake Engineering, Building
Research Institute, Ministry of Construction, Japanese Government,
3-28-8 Hyankunin-cho, Shinjuku-ku, Tokyo, Japan

Mr. Kawashima (PWRI)

PM: University of Tokyo:
Earthquake Research Institute (ERI): Professor Hakuno

Associate Prof. Department of Civil Engineering: Professor
Ishihara, Professor of Civil Engineering, Bunkyo-ku,
Tokyo, Japan

February 10, 1978

Izu Peninsula: Mr. Iwasaki (PWRI):
M.S. in Civil Eng., Chief, Ground Vibration Section,
Earthquake Disaster Prevention Division, Public Works
Research Institute, Ministry of Construction, 4-12-52
Anagawa, Chiba-shi, Japan

Mr. Tokida (PWRI)

Dr. Tatsuoka (University of Tokyo)
Assoc. Professor of Civil Engineering
Institute of Industrial Science
University of Tokyo, 22-1, Roppongi 7 Chome, Minato-ku
Tokyo 106, Japan

Mr. Sakabe (Public Works Office-Shizuoka Prefecture)

Mr. N. Takahashi (Mochikoshi Refining Company)

February 11, 1978

Izu Peninsula

February 13, 1978

U. S. Embassy: Dr. Bruce J. McDonald (Office of Naval Research)
COL G. F. Wilson (Army Attache)

February 14, 1978

AM: Port and Harbor Research Institute (P&HRI):
Dr. Hayashi, Dr. Eng, Deputy Director General, Port &
Harbour Research Institute, Ministry of Transport, Japanese
Government, 1-1 3-Chome Nagase, Yokosuka, Japan

Mr. Tsuchida, Chief, Earthquake Resistant Structures Laboratory
Port and Harbour Research Institute, Ministry of Transport
1-1, 3-Chome, Nagase, Yokosuka, 239 Japan

PM: District Engineer, Far East District: COL Miller, CE
Camp Zama, APO 96343

February 15, 1978

United States - Japan Panel on Wind and
Seismic Effects: Dr. Okubo (PWRI)
Director, Planning and Research Administration
Division, Public Works Research Institute,
Ministry of Construction, Japan
Office, 2-28-32 Honkomagome, Bunkyo-ku, Tokyo

Mr. Iwasaki, (PWRI) Chief, Ground Vibration Section
Earthquake Disaster Prevention Division
Public Works Research Institute, Ministry of
Construction, 4-12-52 Anagawa, Chiba-shi, Japan

A meeting was held to review the agenda for the upcoming 10th Joint meeting.

February 16, 1978

Helicopter ride over the Izu Peninsula with COL Miller and Mr. Wes Goecker (CE)

February 17, 1978

Visit to the dam site: Mr. Mori, Ph. D. (University of Tokyo)
Dept. of Civil Engineering
Bunkyo-ku, Tokyo
Residence: 1-4-8 Minami-Azabu, Minato-ku,
Tokyo

February 20, 1978

Attended meeting of the Japanese Society of Civil Engineers
SUBJECT: Near Izu Oshima Earthquake

On 20 February 1978 the writer attended a meeting of the Japanese Society of Civil Engineers. Several members presented lectures on damage to various types of civil engineering structures resulting from the Near Izu Oshima Earthquake. Subjects discussed included, but were not limited to, dams, roads, railroads, bridges, building and power facilities.

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Marcuson, William Frederick
Visit to Japan to observe damage which occurred during the near Izu Oshima earthquakes, January 14 and 15, 1978 / by William F. Marcuson III. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National *Technical Information Service*, 1979.
13, [31], 3 p. : ill. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; GL-79-20)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under CWIS Work Unit 31145.

1. Dam failures. 2. Earthquakes -- Japan. 3. Liquefaction (Soils). 4. Tailings. I. United States. Army. Corps of Engineers. II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; GL-79-20.
TA7.W34m no.GL-79-20