E. 公開セミナー配布資料

Natinal Program of Prediction of Volcanic Eruption

1973: Recommendation to the Prime Minister and related ministers from the Geodetic Council(chairman: Prof. T. Nagata)

bachground: frequent explosive eruptions of Sakurajima

1974: The program was started in 1974 as 5 years plan

1) Reinforcement of Volcano Monitoring and Research
(Ministry of Transportation)
Japan Meteorological Agency (JMA)
Maritime Safety Agency
(Ministry of International Trade and Industry)
Geological Survey Institute
(Ministry of Construction)
Geographical Suevey Institute
(Science and Technology Agency)
National Research Institute for Earth Science and Disaster Prevention
(Ministry of Education, Science and culture)
National Universities:
Hokkaido University, Tohoku University, University of Tokyo
Tokyo Institute of Technology, Nagoya University
Kyoto University, Kyushu University

2) Coodinating Committee for Volcanic Eruption Prediction
(secretariat in JMA)
JMA has duty to issue volcanic information

1st phase : 1974-1978/ Usu eruption(1977-82)
2nd phase : 1979-1983/ Miyakejima eruption (1983)
3rd phase : 1984-1988/ Izu-Oshima eruption (1986-87)
Tokachidake eruption (1987-88)
4th phase : 1989-1993/ Submarine eruption at Izu(1989)
Unzendake eruption(1991-)
5th phase : 1994-1998/
Aso, Sakurajima and Suwanosejima have erupted through the period.

1991- Land Agency and Local Governments staeted to publish Volcanic Hazard Maps.

Collaborative Monitoring and Study at Mt. Unzen

A) Joint Observation Team of National Universities

Host Observatory:

Shimabara Earthquake and Volcano Observatory, Kyushu Univ.

1. Seismic and Infrasonic Observation
   Kyushu, Hokkaido, Tohoku, Tokyo, & Kyoto Universities
2. Tilt Monitoring
   Kyushu, Tohoku, Tokyo & Kyoto Universities
3. Geodetic Survey (EDM, Leveling, GPS)
   Kyoto, Hokkaido, Tokyo, Nagoya & Kyushu Universities
4. Gravimetric Survey
   Tohoku, Hokkaido, Tokyo, Kyoto, Kyushu & Kagoshima Universities
5. Geomagnetic and Geoelectric Observation
   Kyoto & Tokyo Universities
6. COSPEC (SO_2 Flux)
   Tokyo Institute of Technology
7. Geochemical Observation of Gases and Water
   Tokyo Institute of Technology & University of Tokyo
8. Observation of Dome Growth , Geological and Petrological Study
   Kyushu, Tokyo and many other Universities
9. Infrared Observation of Dome
   Kyushu University

B) Japan Meteorological Agency

1. Seismic and Infrasonic Observation
2. Monitoring of Activity
3. Geomagnetic Observation

C) Geographical Survey Institute

1. Geodetic Observation (Levelling, GPS)
2. Topographic Analysis

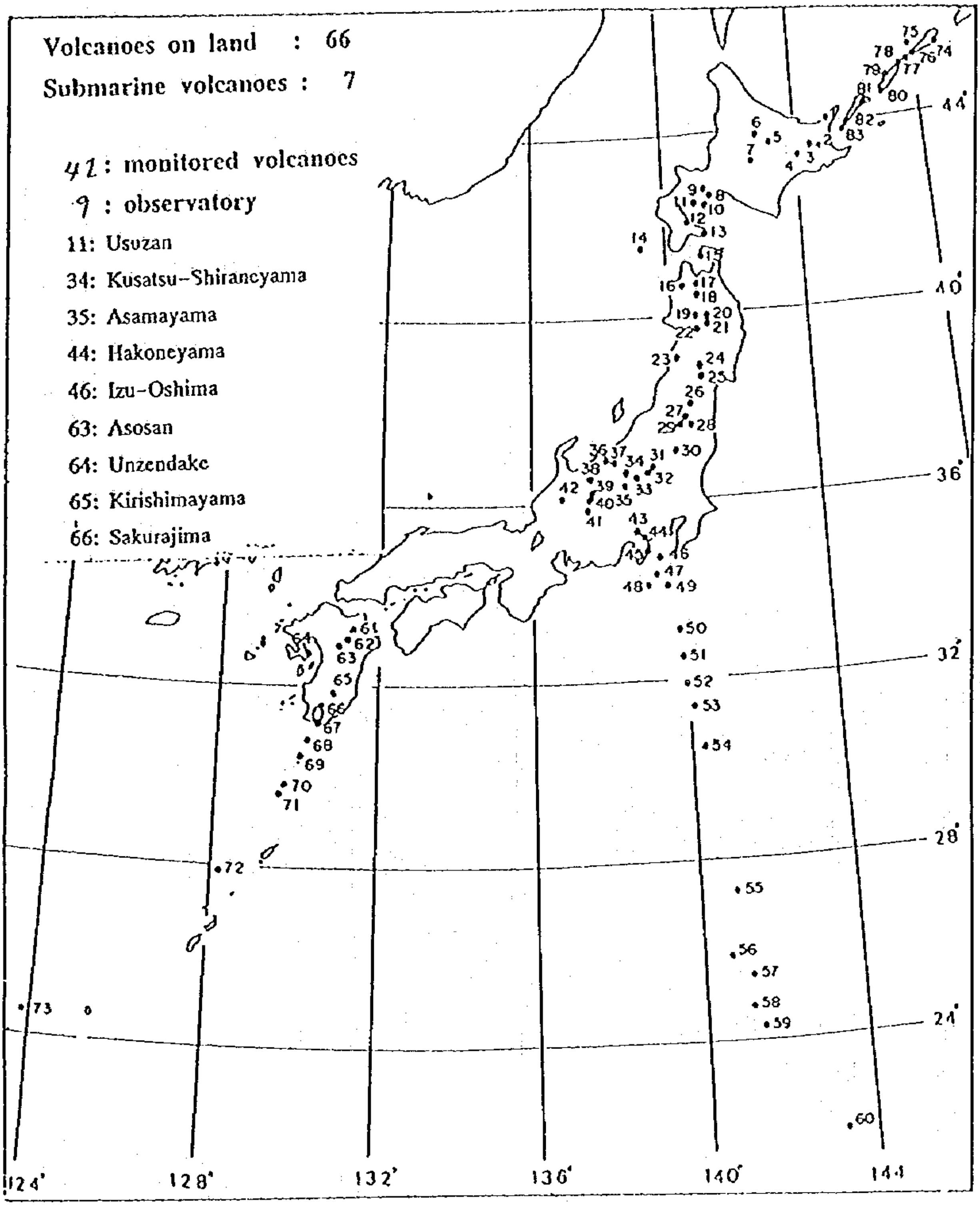
D) Geological Survey of Japan

1. Topographic Analysis and EDM
2. Geological and Petrological study

E) National Research Institute for Earth Science and Disaster Prevention

1. Areal Infrared Survey

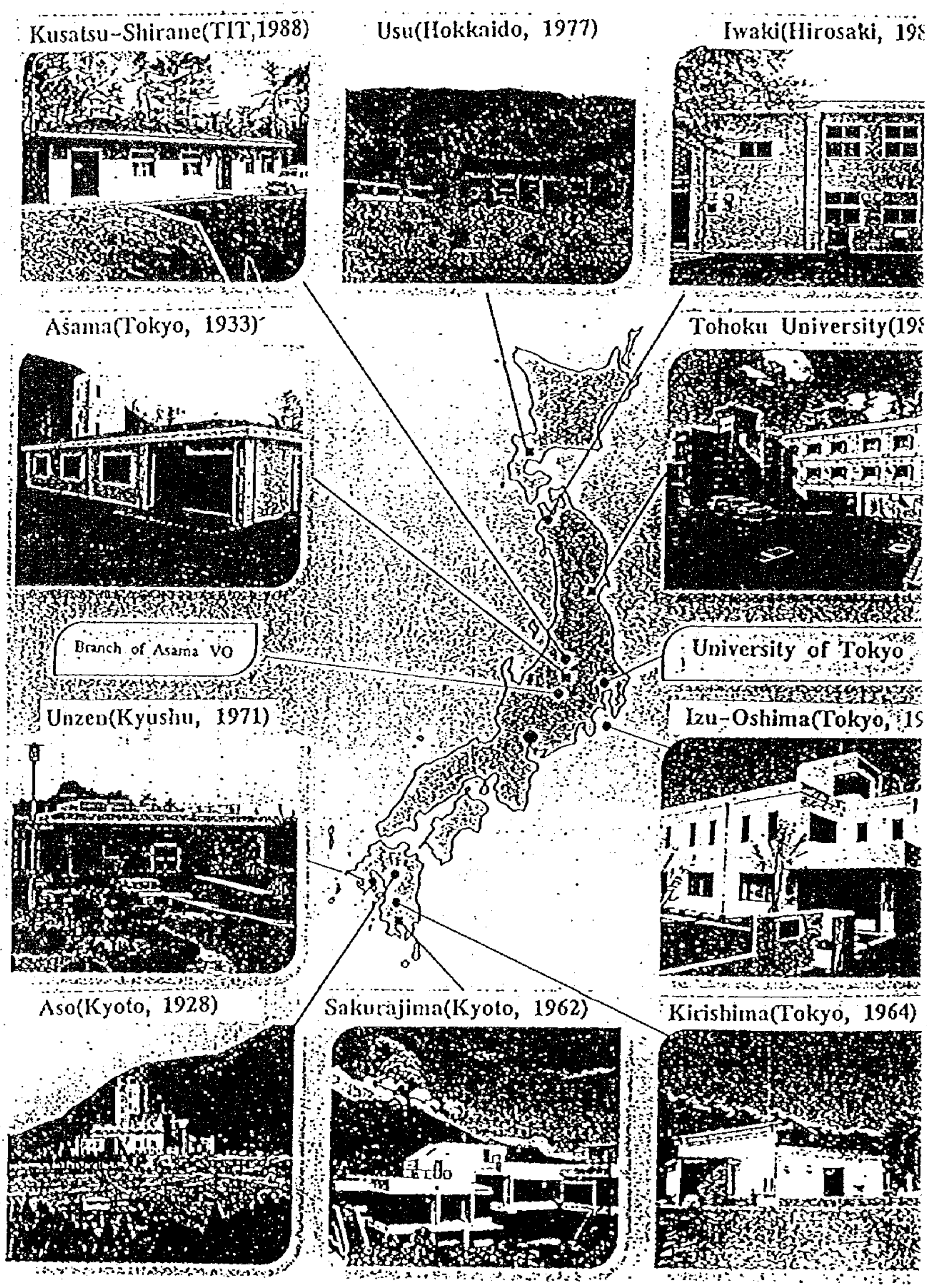
Professor K. Kamo (Kyoto University) stayed at Unzen from June to July of 1992 as the Acting President of the Coordinating Committee for Volcanic Eruption Predictio to establish the Collaborative Observation Team.

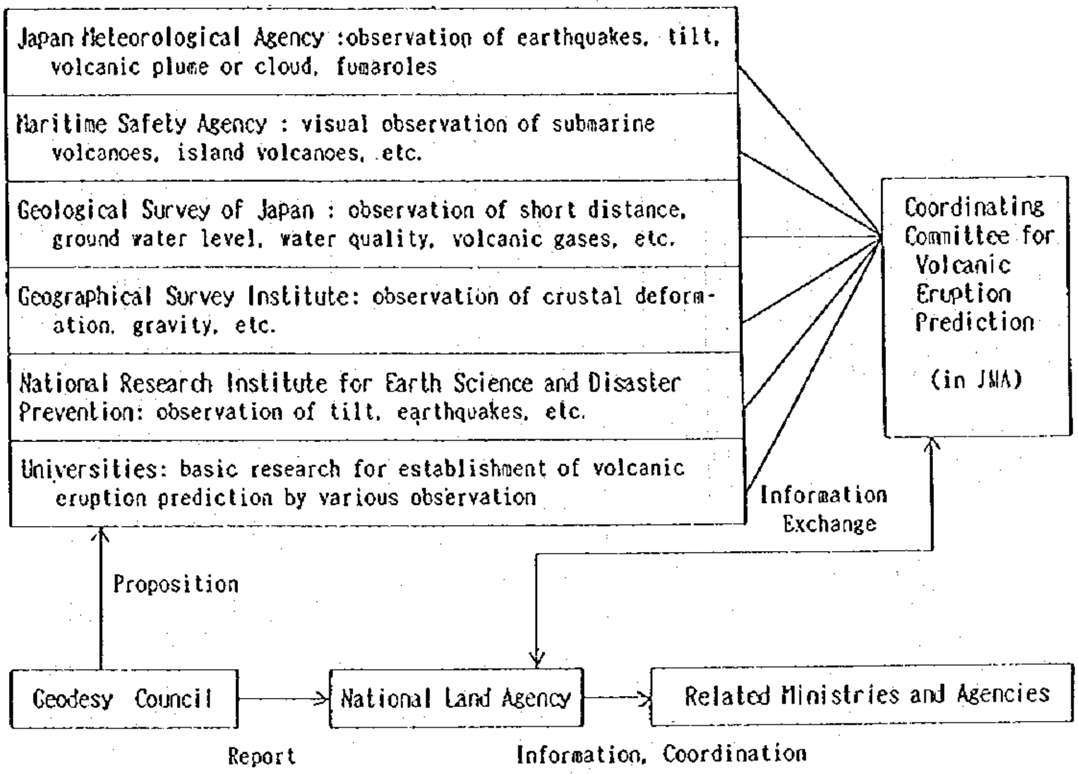


Active Volcanoes in Japan

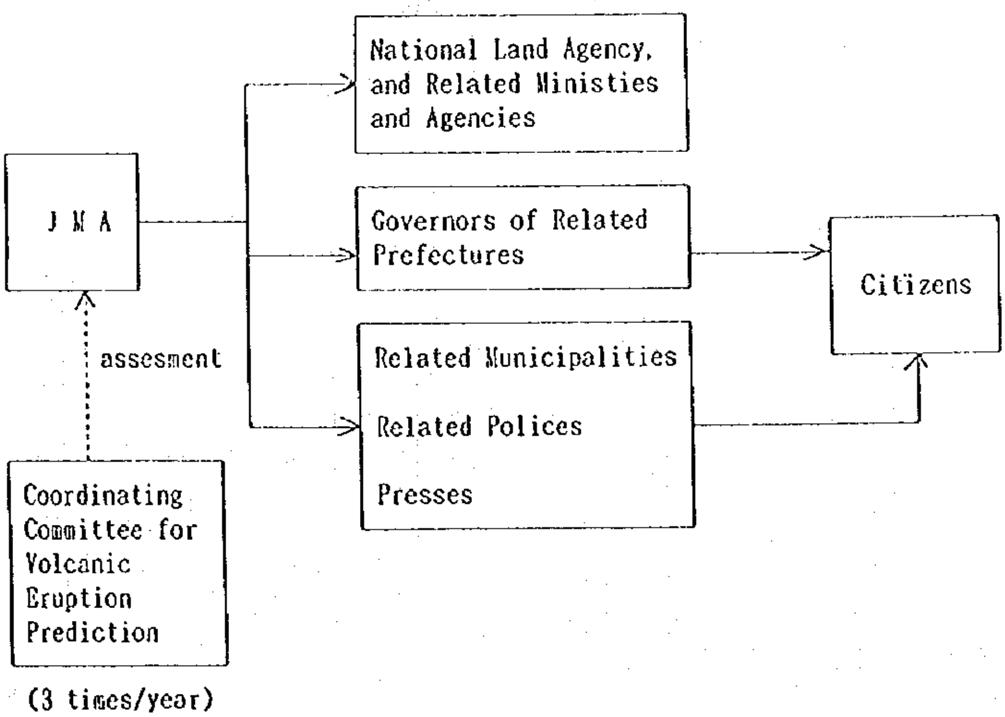
JMA : 21 UNIV : 30 NRIESDP : 9 Local Gov : 2

Volcano Observatories & Research Centers of Universities





FLOW OF VOLCANIC INFORMATION



Outline of Volcanic Activity of Mt. Unzen

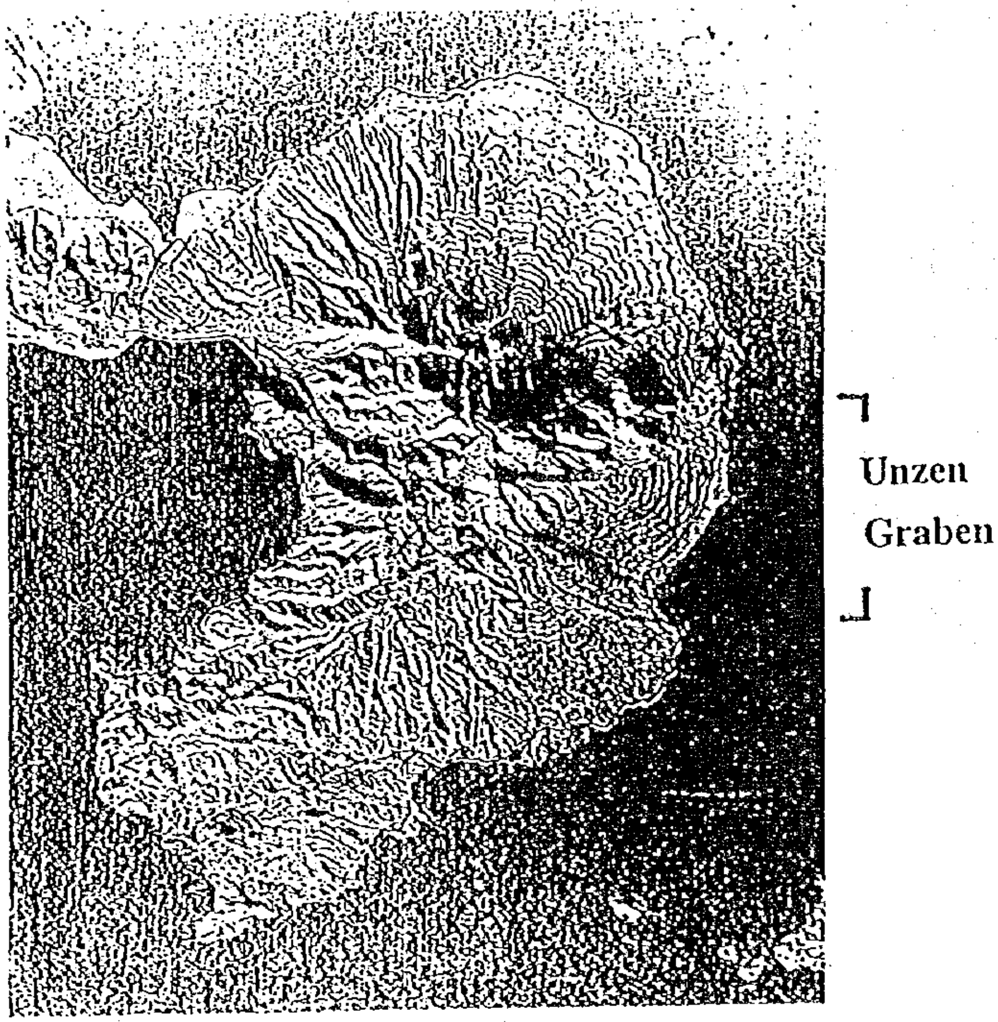
1663: Eruption & Lava flow (5×10^{6} m^3): about 30 killed by mudflow.

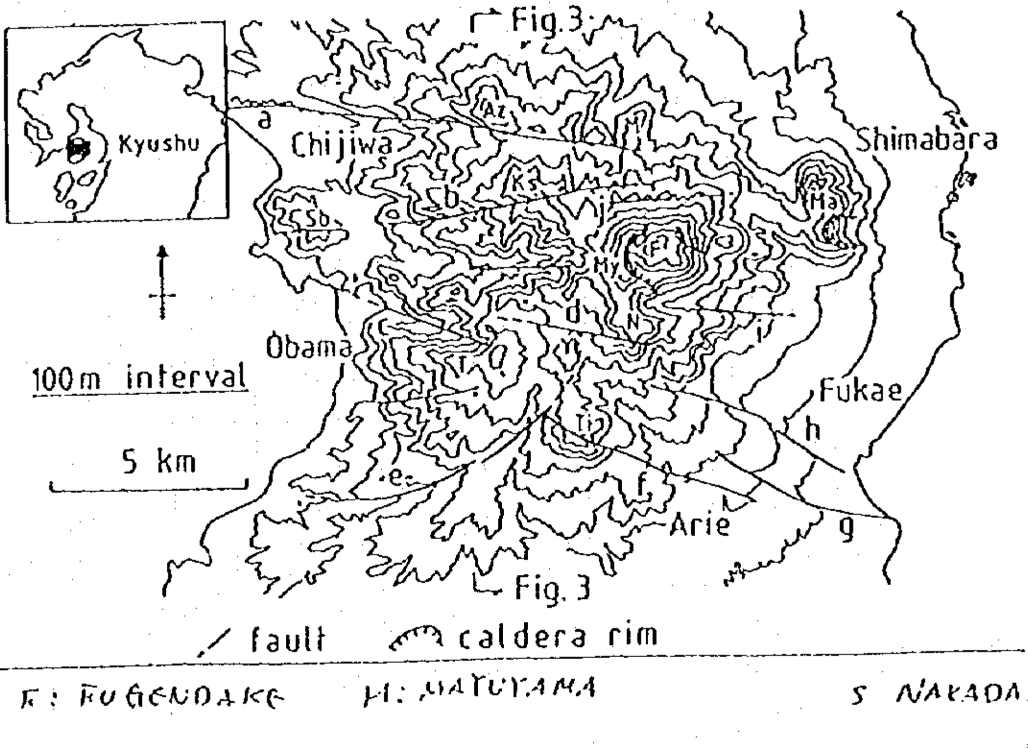
1792: Eruption. Lava flow (2×10^{7} m^3), and Collapse of
Mayuyama Dome(3.4×10^{8} m^3): about 15,000 killed by the dome
collapse & tsunamis.

1922: Shimabara Earthquake (M=6.9): 27 died.
Earthquake swarms had been repeated with the time interval of
a few years until the latest eruption.

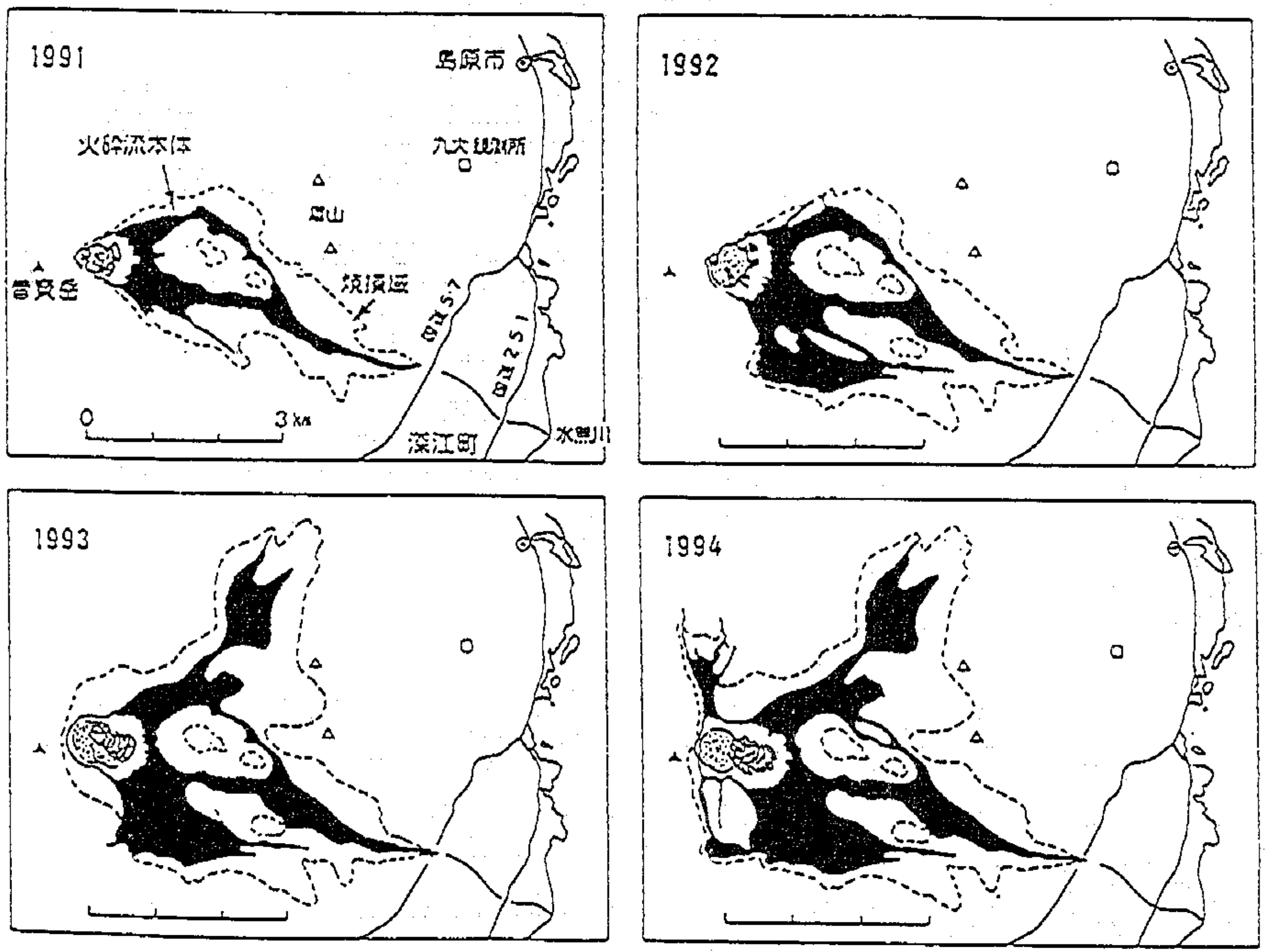
1959:(JMA started seismic observation)
1971:(Kyushu University established Shimabara Volcano Observatory)
1986:(Regular Joint Observation of Active Volcano by national
universities)

1990: July- ; Volcanic tremors were observed
Nov.17; Pheatic eruption occurred
(Joint Observatin by national universities started)
1991: May 10: Earthquake swarm at the summit
(Abnormal and rapid changes were observed by tilt and
geomagnetic observation, and EDM)
May 19-20; Lava dome appeared
24: the first pyroclastic flows
Jun. 3: Larger pyroclastic flows (extent:4km):43 killed.
8 and 11: Explosive eruptions
1992: Nov.-Dec: Activity was declined.
1993: Feb.; Activity was resumed.
1994: Sep-; Extrusion of lava decreased gradually.
1995: Feb.; Dome growth almost stopped, and the frequency of pyroclastic
flows deceased (Total volume of extruded lava: 2×10^{8} m^3).



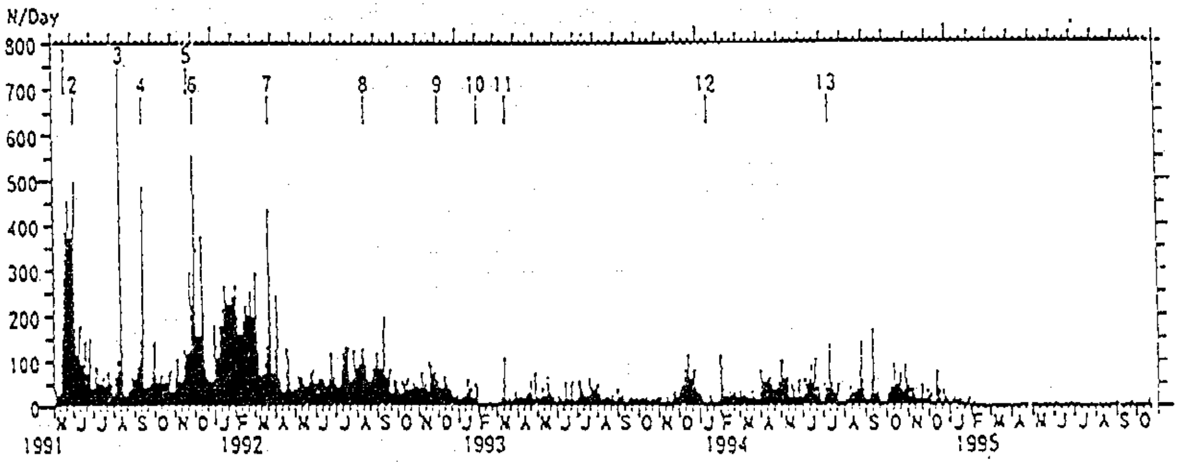


F: FUGENDAKE M: MAYUYAMA S NAKADA

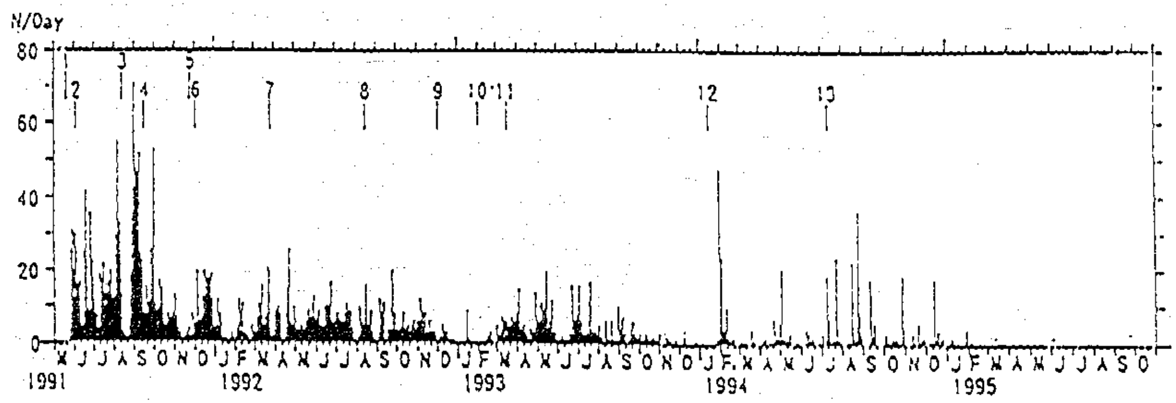


Distribution of pyroclastic flow deposit and the sead area

KYUSHU UNIV (1995)

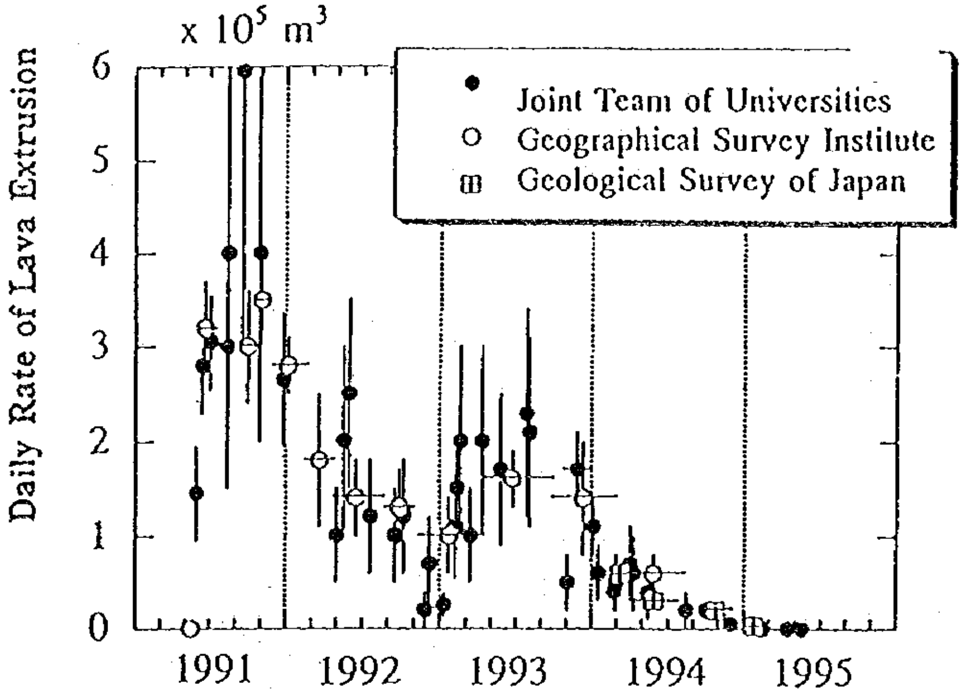


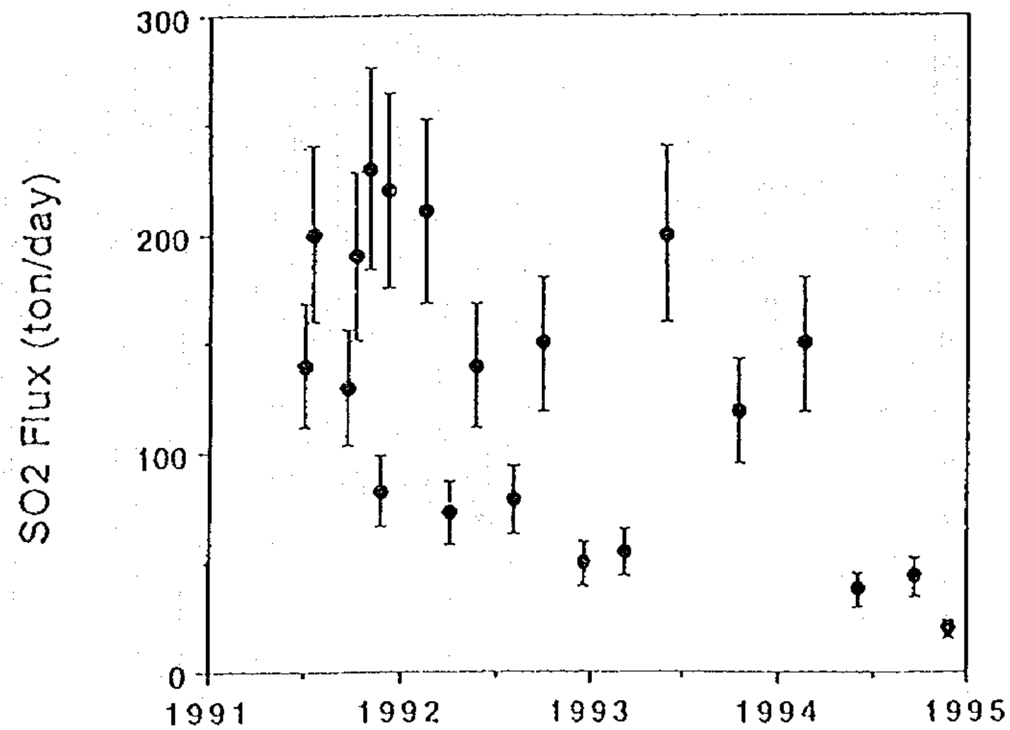
Daily frequency of earthquakes at Unzen Volcano



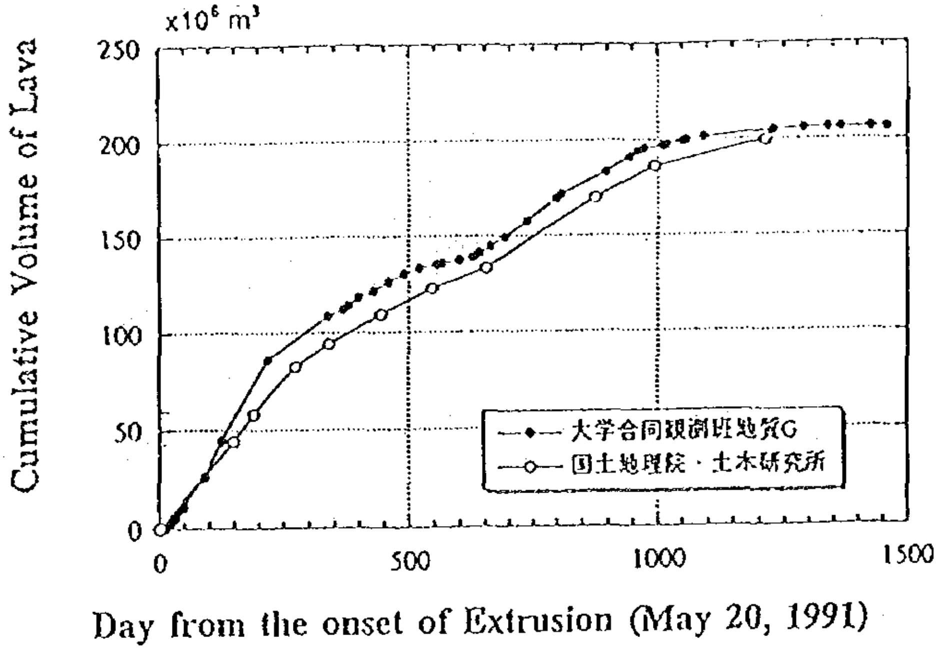
Daily frequency of pyroclastic flows at Unzen Volcano

Kyusu University

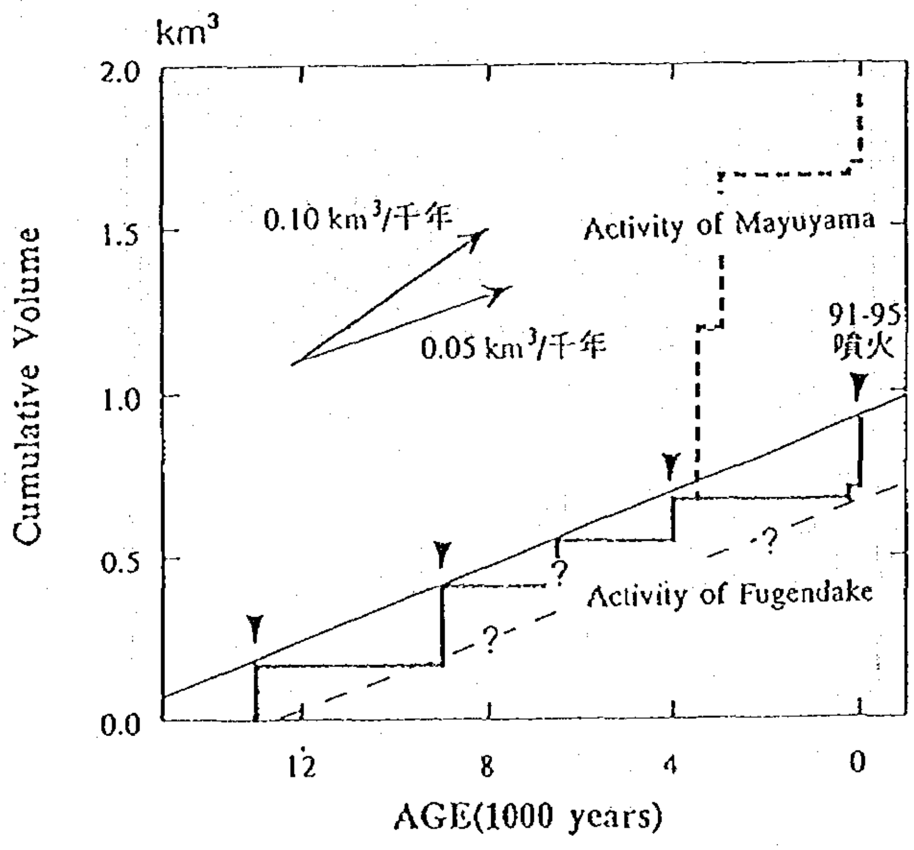




Tokyo Institute of Technology

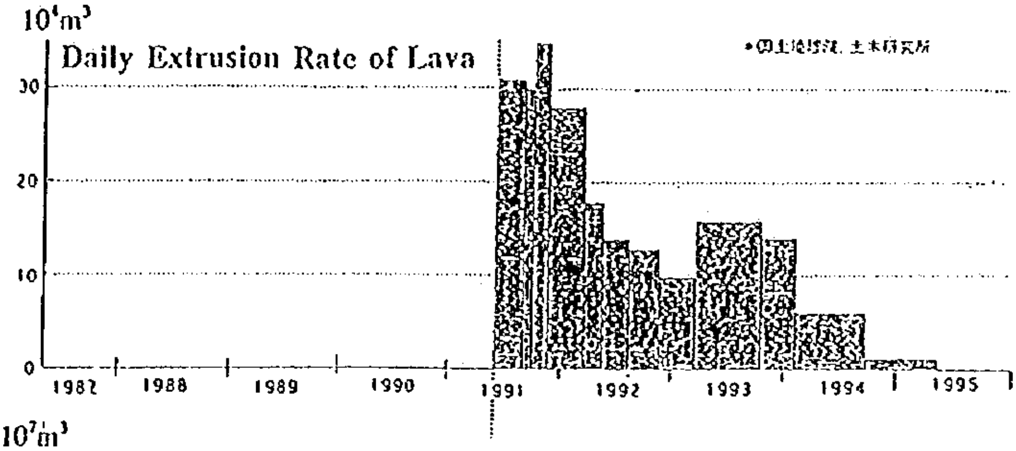


Cumulative Volume of Lava around Fugendake cone of Mt. Unzen

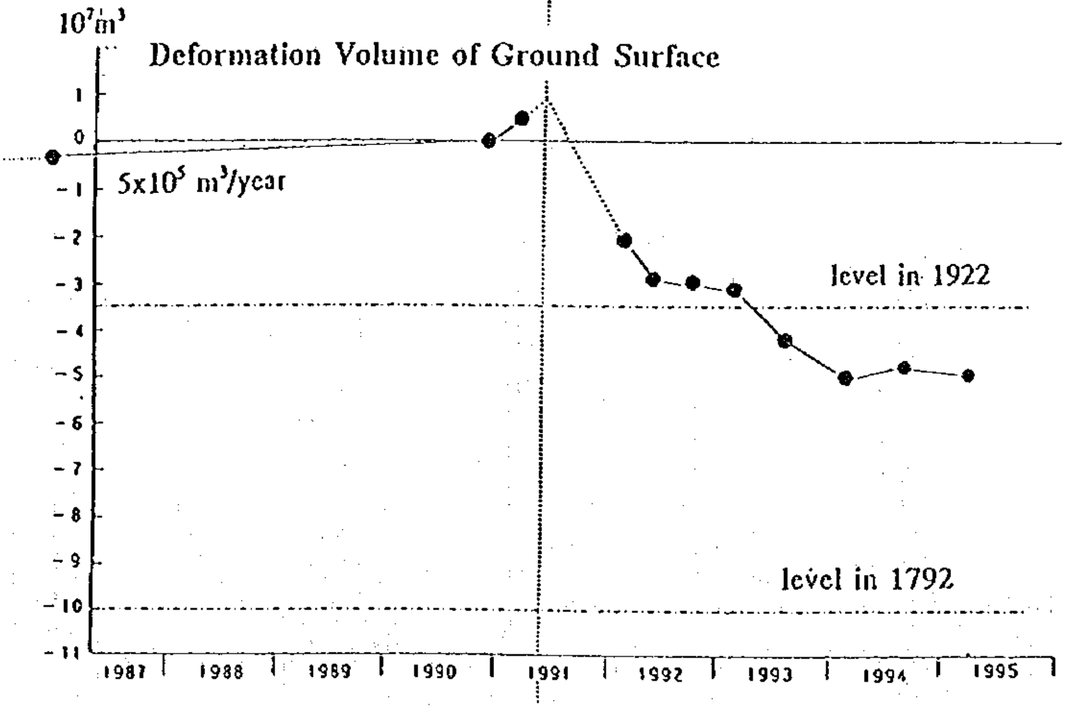


Method of Dating: C^{14}, FT, etc.

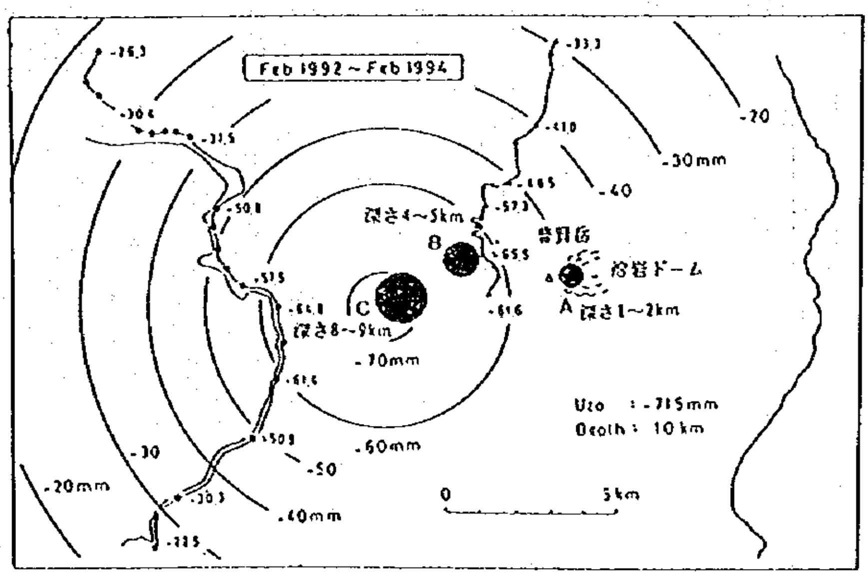
NAKADA, 1991



$10^4 m^3$
Daily Extrusion Rate of Lava
30
20
10
0
1987
1988
1989
1990
1991
1992
1993
1994
1995



$10^7 m^3$
Deformation Volume of Ground Surface
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
$5x10^5 m^3/year$
level in 1922
level in 1792
1987
1988
1989
1990
1991
1992
1993
1994
1995



Feb 1992 ~ Feb 1994
-20
-30mm
-40
深さ4~5km
B
普賢岳
溶岩ドーム
A
深さ1~2km
C
深さ8~9km
-70mm
-60mm
-50
-30
-20mm
-40mm
Uzo : -715mm
Depth : 10 km
0
5km

KYOTO UNIV

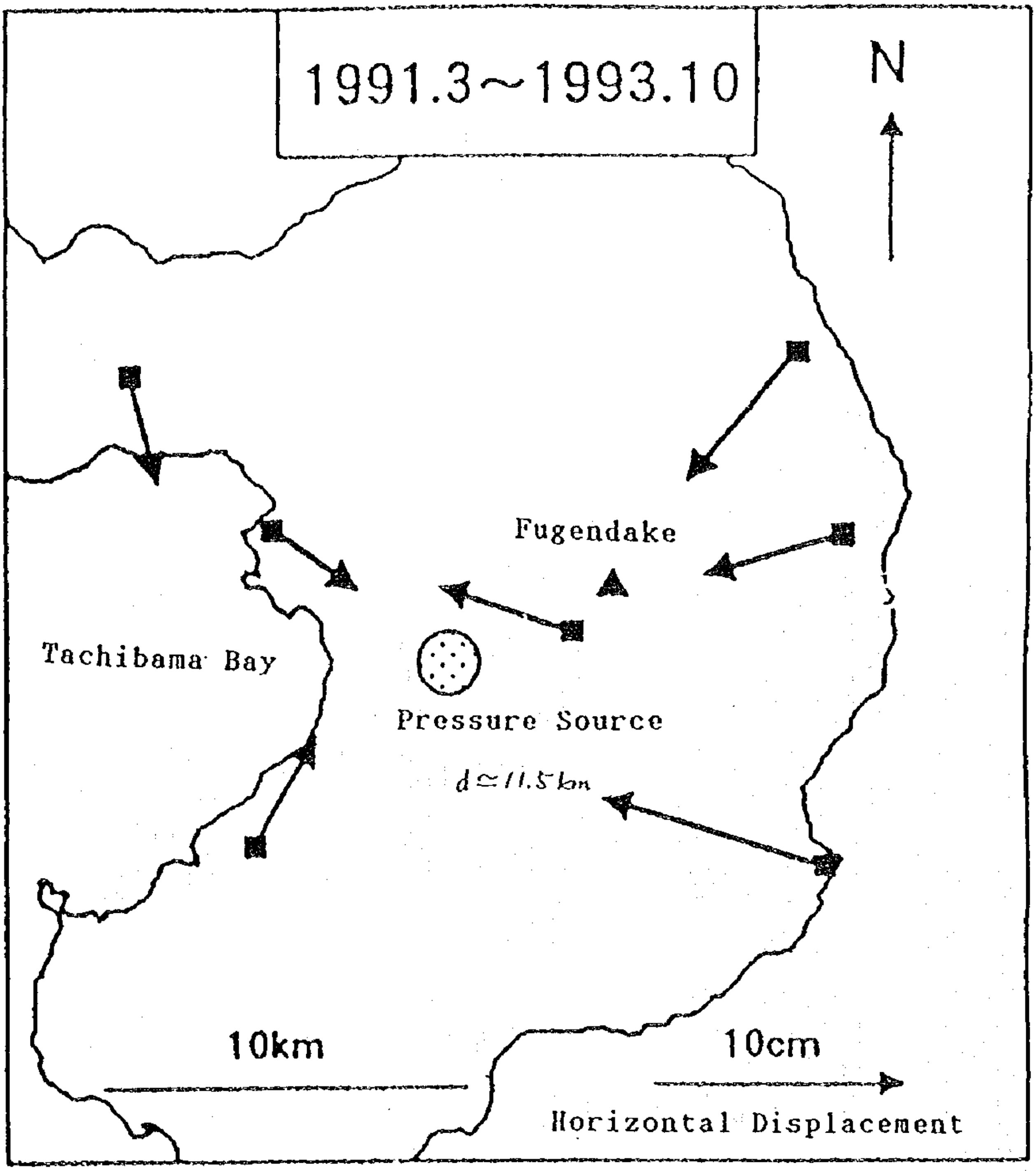
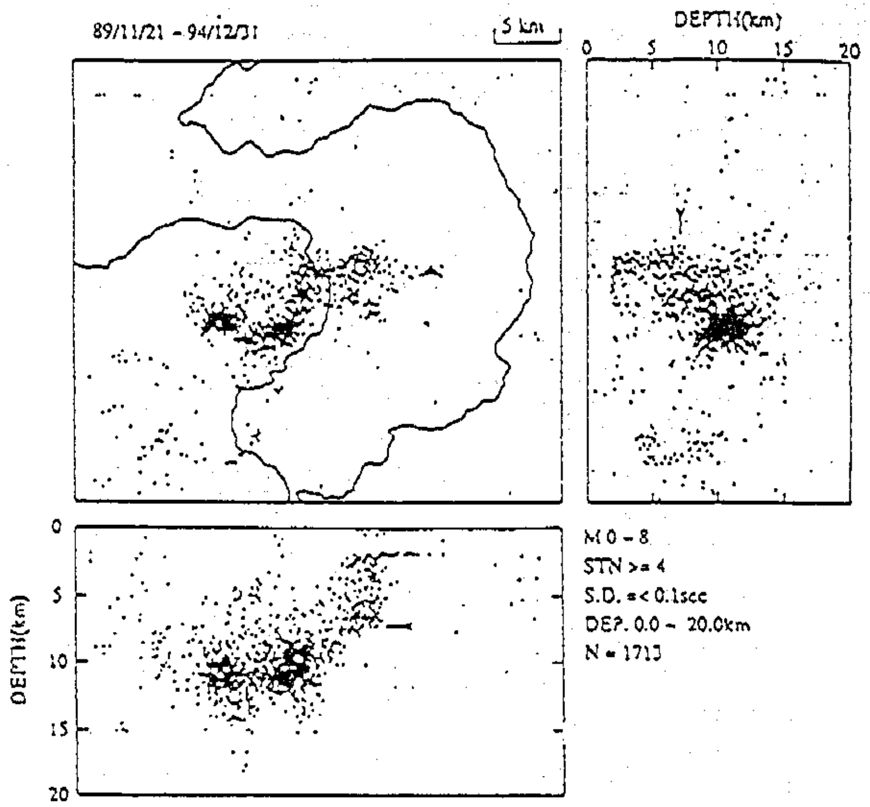
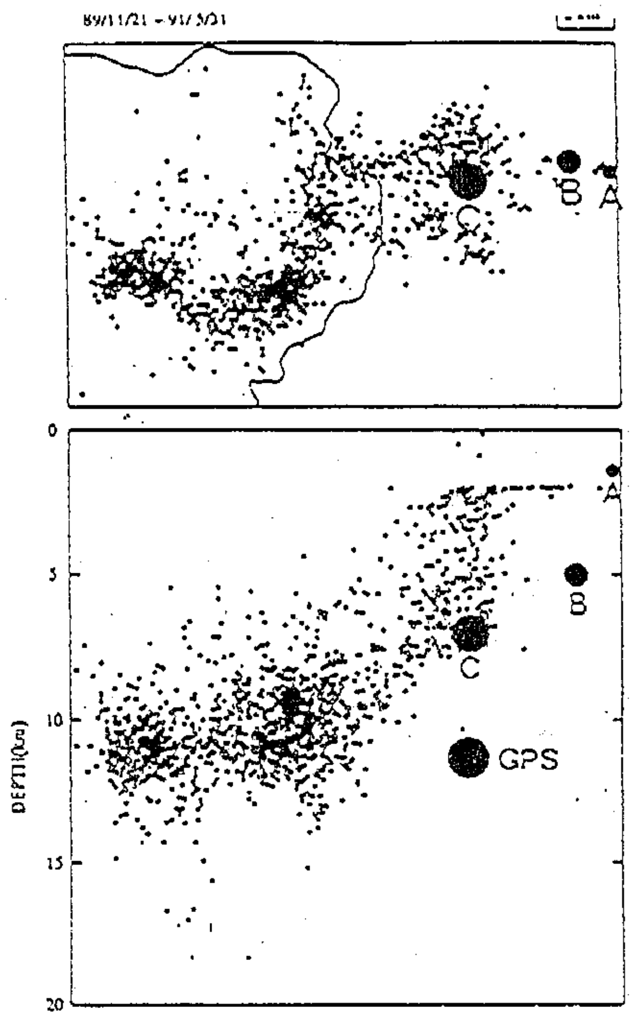


Fig. 2 Horizontal Displacement Around Mt. Unzen Observed by GPS

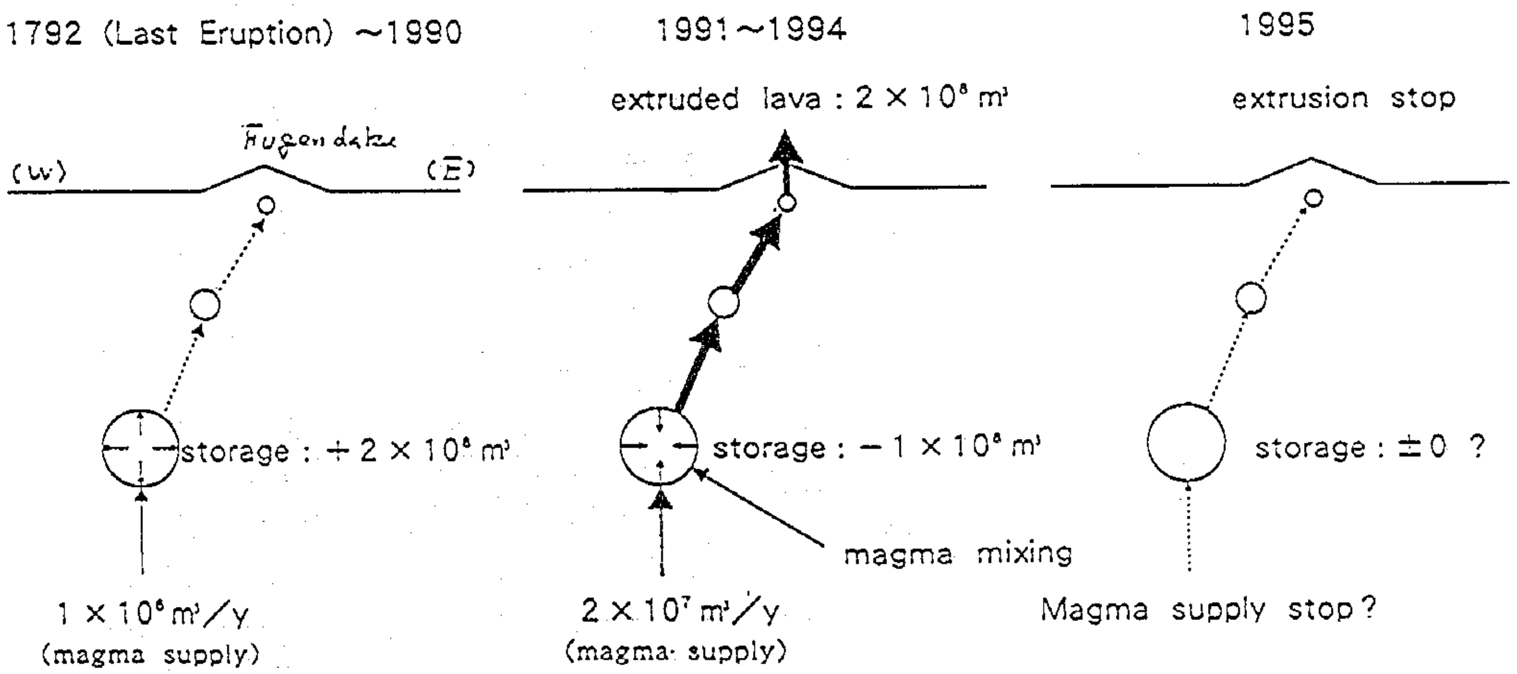
NISHI (1994)



Hypocentral distribution of earthquakes



Location of pressur: sources which induced the ground deformation



MAGMA SUPPLY SYSTEM inferred from Ground-deformation Study at UNZEN VOLCANO

Magma Transport System and Mid-Term Eruption Prediction of Izu-Oshima Volcano

Hidefumi Watanabe (Earthq. Res. Inst., Univ. Tokyo)

A basaltic stratovolcano, Izu-Oshima, located 100 km SSW of Tokyo, erupted from the summit crater and successively from flank fissures in November 1986. Total amount of products was about 80 million tons, roughly equal to that in the last major eruptions in 1950-51. Etensive observation before, during and after the eruption has revealed the physical nature of magma transport system at Izu-Oshima volcano.

Long-term precursors to the 1986 eruption are clearly divided into magma accumulation and ascent stages. Precursors on the seismicity, ground deformation and geomagnetic field at Izu-Oshima volcano are consistently explained by assuming a magma reservoir at a depth of 8-10 km beneath the summit caldera. The accumulation of magma continued for more than 10 years at a constant rate of several million cubic meters per year until 1980, causing an increasing seismic activity around the Oshima island, an inflation of the whole island and an anomalous decrease in the geomagnetic total intensity due to piezomagnetic effects. Since 1981, however, a small deflation and the low seismicity were observed at the caldera region until beginning of the eruption, while very remarkable short-term precursors were detected around the summit crater; e.g. shallow volcanic tremors, variations in the geomagnetic field and the electrical resistivity beneath the crater. All of these data suggested that basalt magma had started to ascend around 1980 through the conduit and reached the surface six years later in 1986. The gradual ascent of low viscosity basalt magma through the conduit might produce no remarkable seismic activity and ground deformation around the summit crater.

A consideration for volume balance of magma into and out of the magma reservoir gives an averaged magma ascent velocity and conduit diameter as 1.2 km/y and 70 m, respectively. An analysis of microgravity variations associsted with the drain back of magma one year after the 1986 eruption also suggests that the upper part of the summit conduit is an open system at least to a depth of 2km, and its diameter is about 80 m.

Since 1987, immediately after the eruption, the constant inflation of the whole island started again, suggesting the continuous magma supply to the reservoir from depths. The rate of inflation is twice as large as that before the eruption. There occurred no earthquake in the source region of the inflation. Tomographic studies on the subterranean structure of the volcano based on delayed arrivals and diffracted waves of local and teleseismic earthquakes, also deleneated a low velocity zone and a melt batch at the same location beneath the caldera as that of the inflation source. All of these independent observational data indicate the exsistence of the magma reservoir at 8-10 km depths beneath the caldera. The magma transport system of Izu-Oshima volcano is characterized by a continuous magma supply and an well-developed conduit connecting the magma reservoir and the summit crater. Basaltic volcanoes that have repeated eruptions every several tens of years might be fed continuously from depths, as illustrated at Izu-Oshima volcano.

There is a possibility of realizing not only the short-term but also mid-term prediction of eruption at Izu-Oshima volcano, by monitoring the ground deformation of the whole island and anomalous variations in the geomagnetic field, erectrical resistivity and gravity around the summit crater.

マグマの供給システム
Magma Transport System

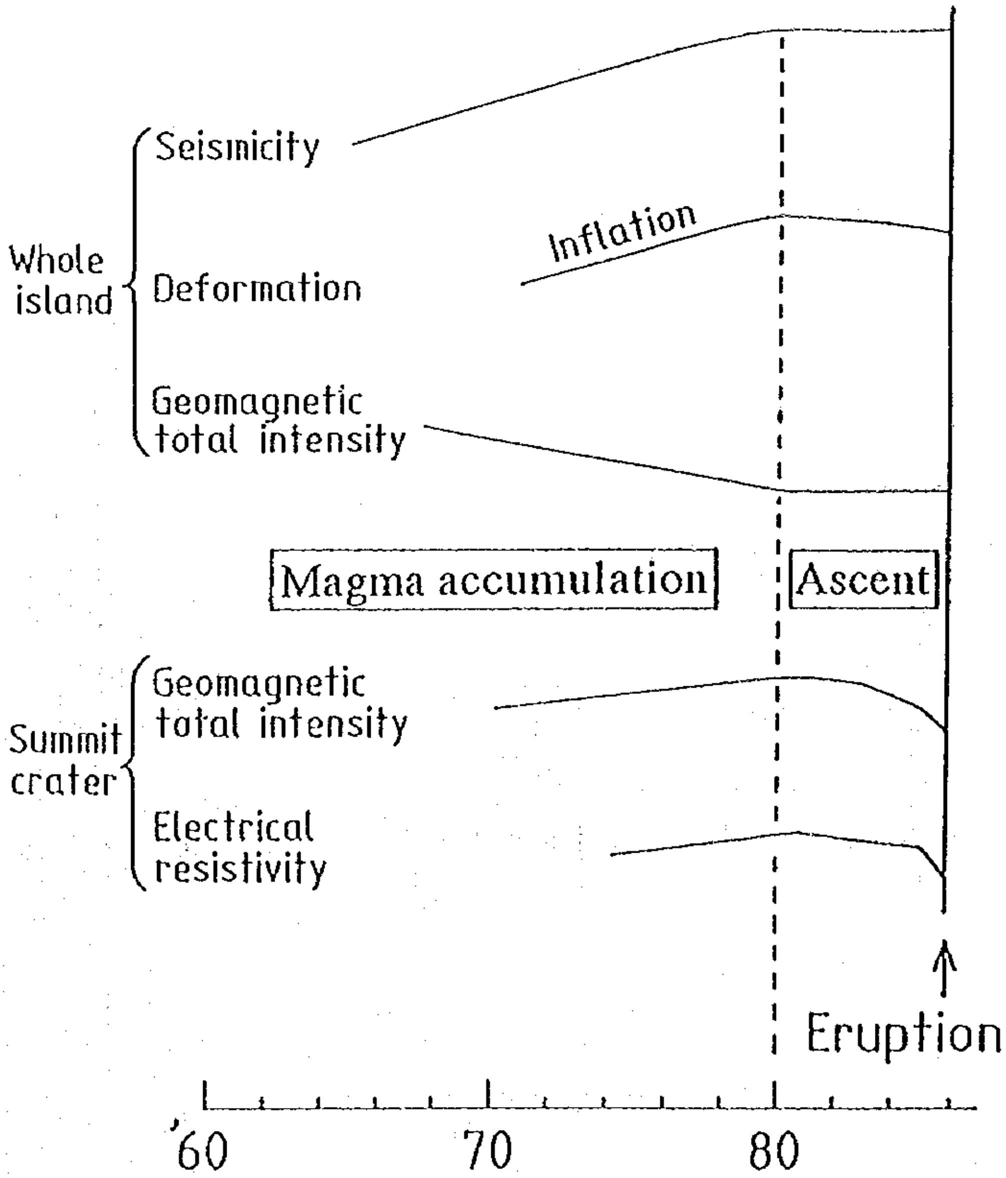
1986年噴火の前兆過程を総合すると，伊豆大島火山の地下では1970年以前からマグマの蓄積が進行し，1980年ころに山頂火口へ向けて上昇し始めたと推察される．

噴火の後も大島全体の膨張が続いている．膨張中心の位置は大島中央部の地下約 8～10 kmで，その領域では地震が起こっていない．この付近にマグマ溜まりが存在し，絶えず深部からマグマが供給され蓄積しているらしい．地下構造の探査結果もマグマ溜まりの存在を示唆している．

Precursors to the 1986 eruption suggested that the accumulation of magma had continued for more than 10 years until 1980, and then the basalt magma had started to ascend through the conduit and reached the surface in 1986.

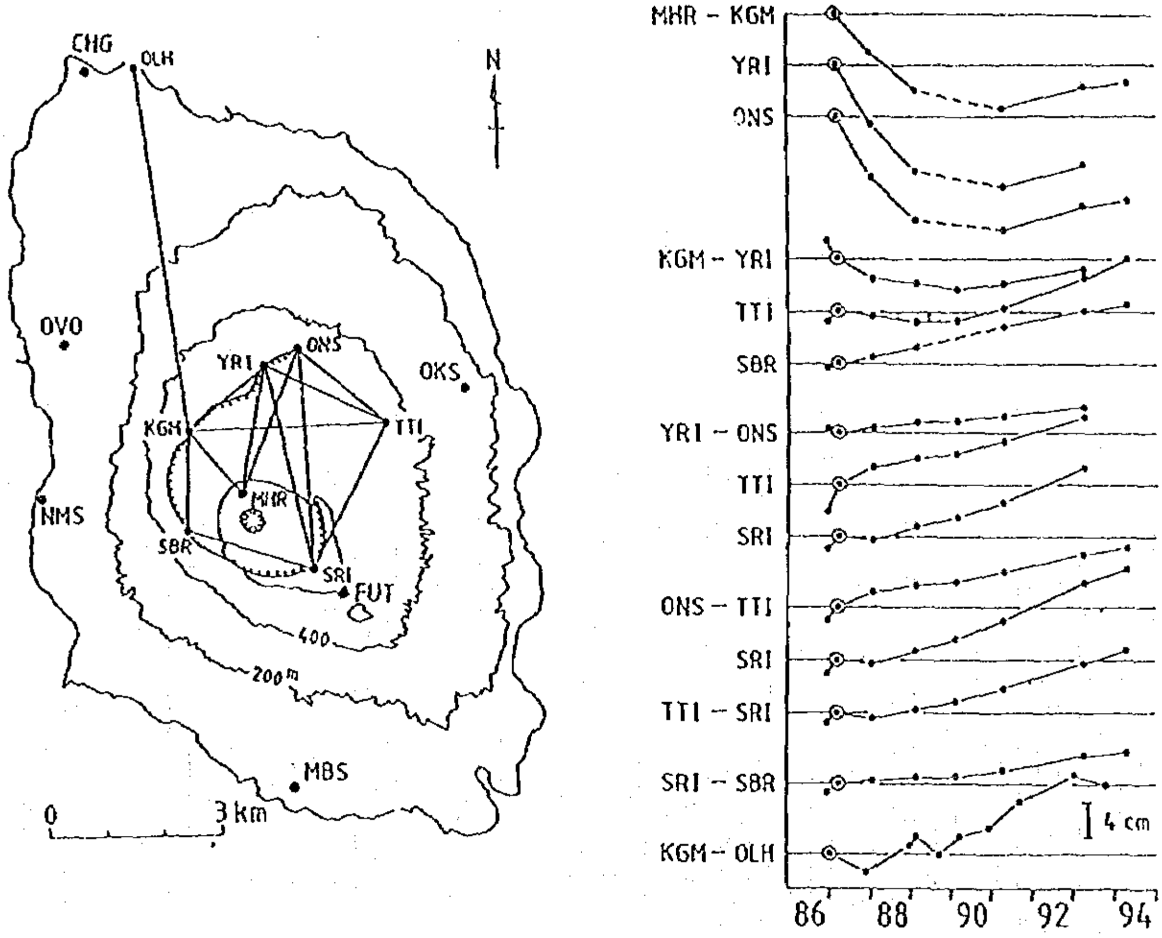
After the eruption, the constant inflation of the island started again, suggesting the continuous magma supply to the reservoir from depths. There occurred no earthquakes in the source region of the inflation. Tomographic studies on the subterranean structure of the volcano also deleneated a low velocity zone and a melt batch at the same location beneath the caldera as that of the inflation source.

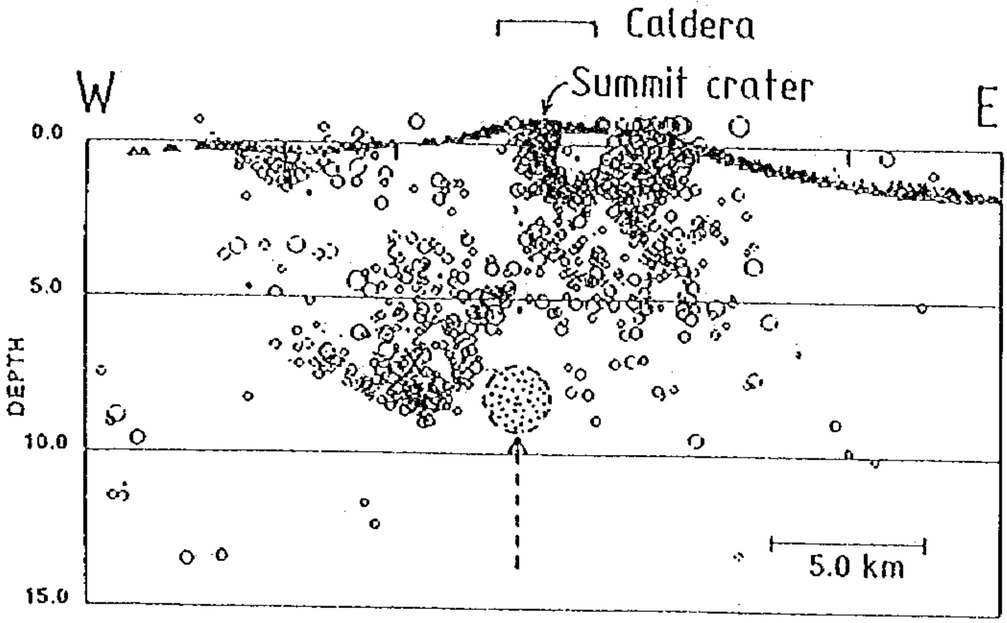
Precursors to the 1986 Eruption



Distribution of bench marks for EDM and GPS measurements on Izu-Oshima and changes in baseline lengths after the 1986 eruption.

伊豆大島の辺長基線網と1986年噴火後の辺長変化





A vertical cross section of the hypocenter distribution of earthquakes across the caldera of Izu-Oshima volcano. Note an earthquake-free zone beneath the caldera as indicated by a shaded circle.

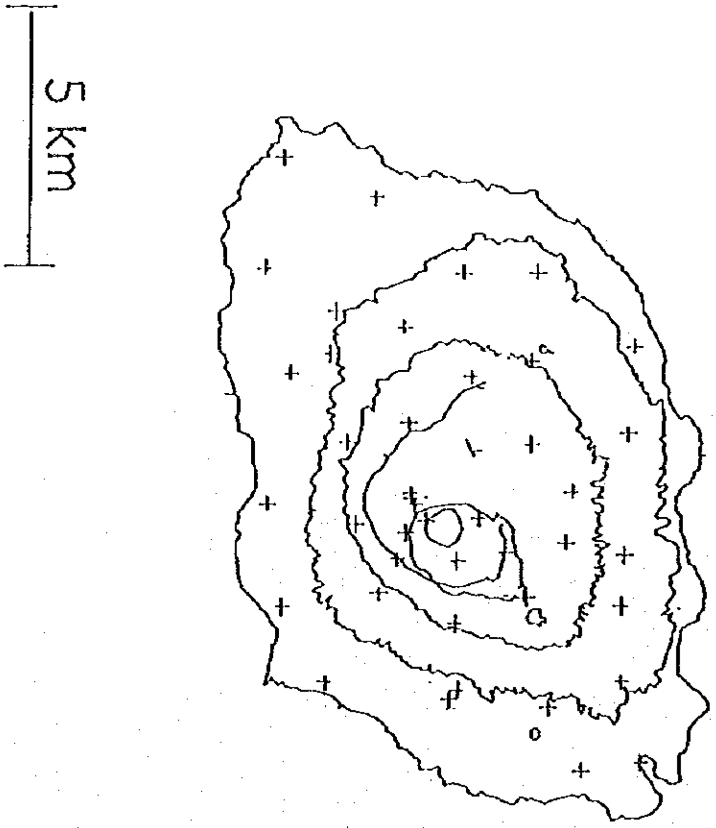
伊豆大島周辺に発生した地震の震源分布（カルデラを通る東西断面図）．カルデラの地下5kmよりも深い領域では地震がおこっていない．

伊豆大島火山の地下構造

Subterranean Structure of Izu-Oshima Volcano

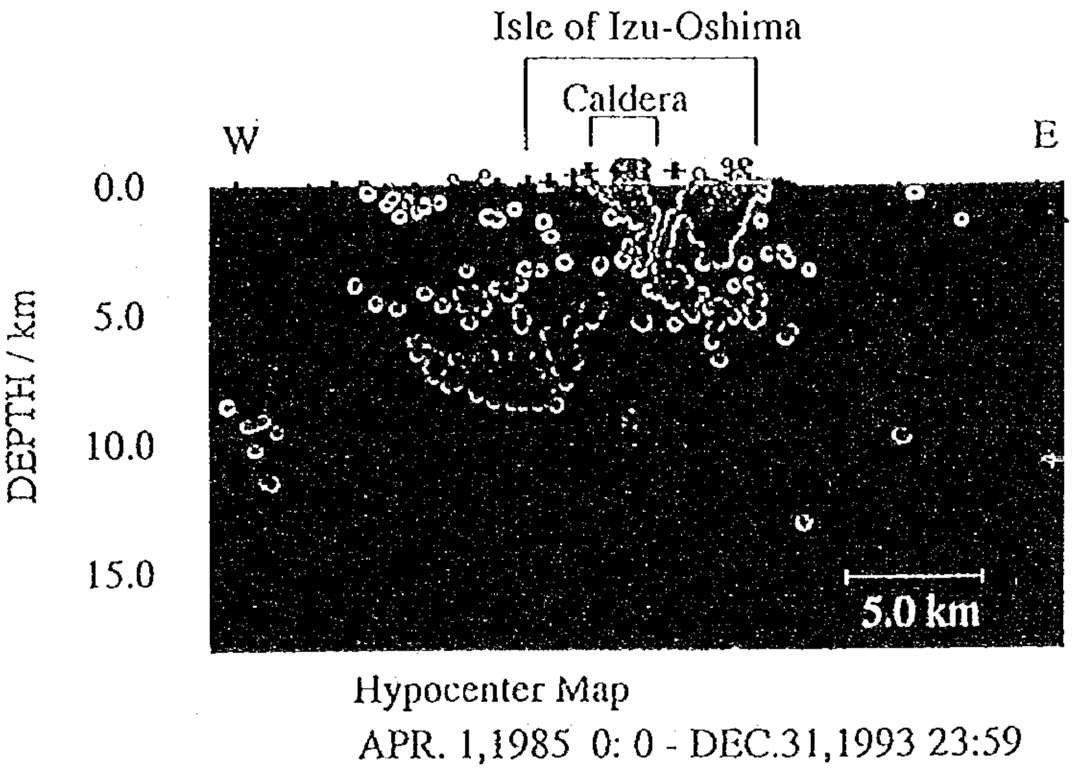
地震波の走時異常を用いたトモグラフィーによって，大島火山の地下 6 km 以深に低速度領域が見い出されている．また，散乱波トモグラフィーによって深さ8 ～10km 付近に強い散乱体が見つかった．その散乱強度はマグマ以外では説明できない

Tomographic studies on the subterranean structure of Izu-Oshima volcano, based on P and S wave arrivals of local earthquakes, revealed a low velocity zone at depths deeper than 6km. Diffraction tomography based on teleseismic waves also deleneated a melt batch at a depth range of 8~10km beneath the volcano.



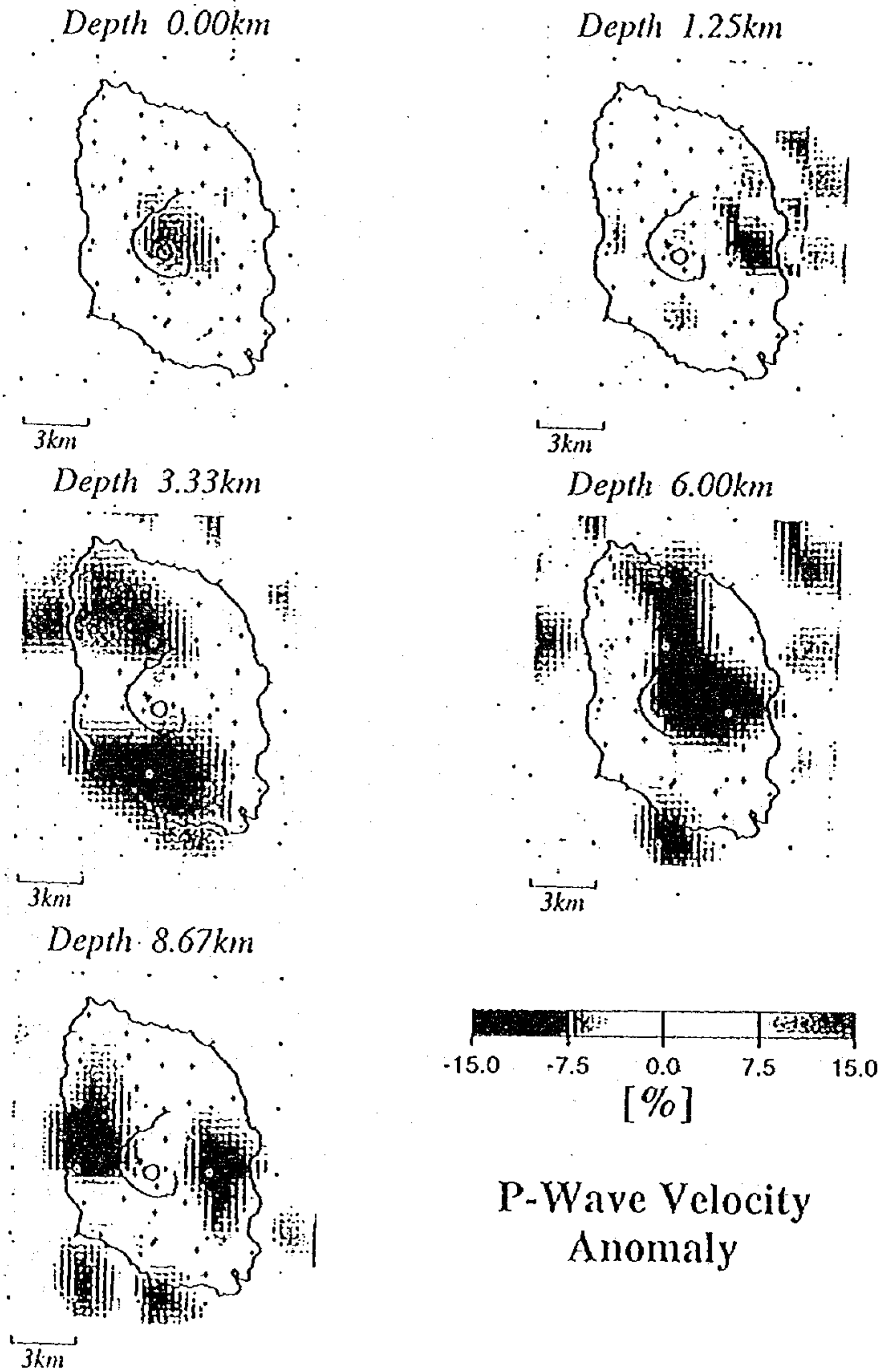
伊豆大島の地震観測網

Seismic network on Izu-Oshima



散乱波トモグラフィーにより得られた散乱強度分布のカルデラ中央部を通る東西断面図（三ケ田，1994）
深さ8~10km付近の強い散乱はメルトの存在を示している.

Vertical cross section of scattering intensities in the EW direction across the caldera (Mikada, 1994). Strong scatterers at depths of 8~10km beneath the central part of the volcano indicate the existence of a melt batch.



P-Wave Velocity Anomaly

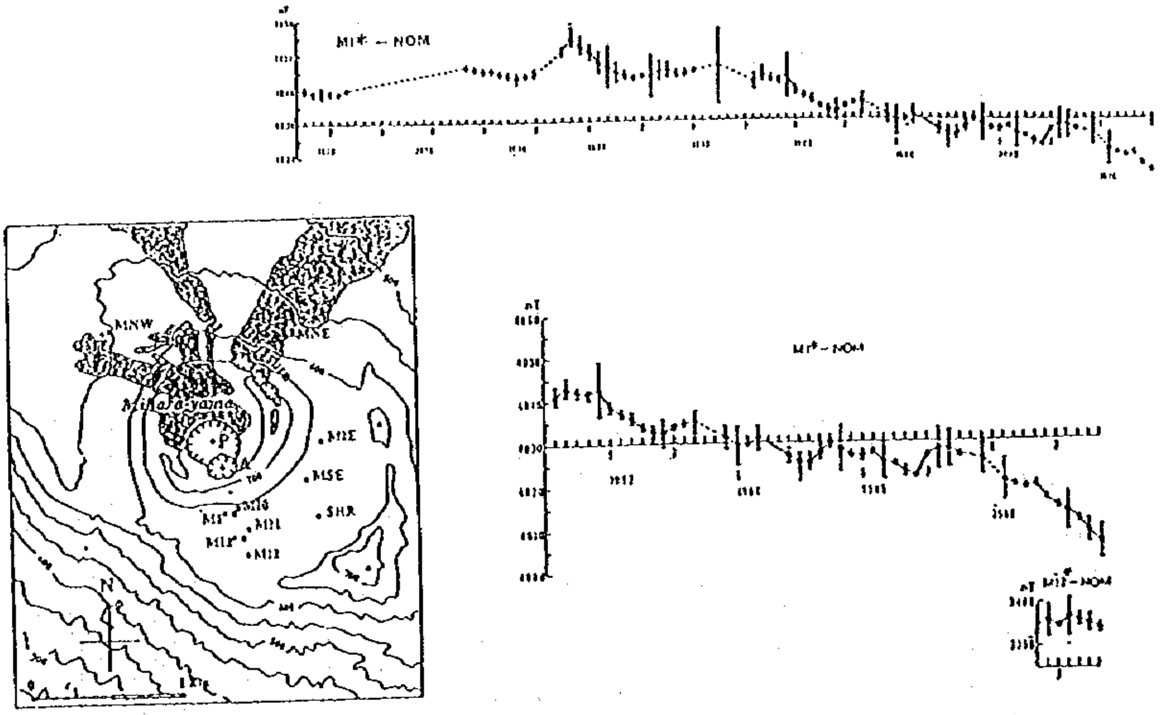
山頂火道内のマグマの移動
Magma Movement in the Summit Conduit

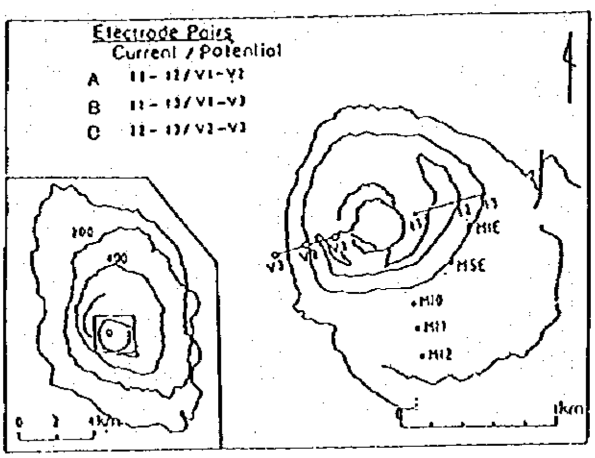
1986年噴火の数ヵ月前から，山頂火口周辺では地磁気や地下電気抵抗の異常な変化が観測された．噴火後には，マグマの下降に伴う重力の異常な減少も観測された．これらの観測データに基づき，火道内でのマグマの昇降を定量的に把握することができる．

Since several months before the beginning of the 1986 eruption, very remarkable short-term precursors were detected around the summit crater; shallow volcanic tremors, anomalous variations in the geomagnetic field and the electrical resistivity beneath the crater. After the 1986 eruption, we also observed an anomalous decrease in gravity due to the drain back of magma from the upper part of coduit to depths.

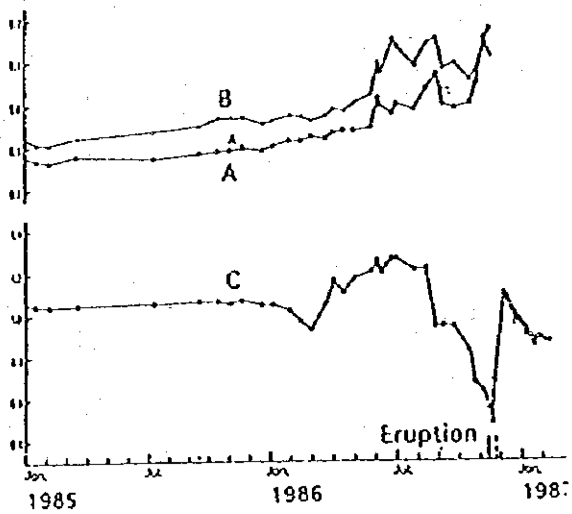
Now the quantitative detection of magma movement in the summit conduit can be made based on anomalous variations in the geomagnetic field, electrical resistivity and gravity around the summit crater.

Time variations in the geomagnetic total intensities
at the southern foot of Mihara-yama.
三原山南麓での全磁力変化



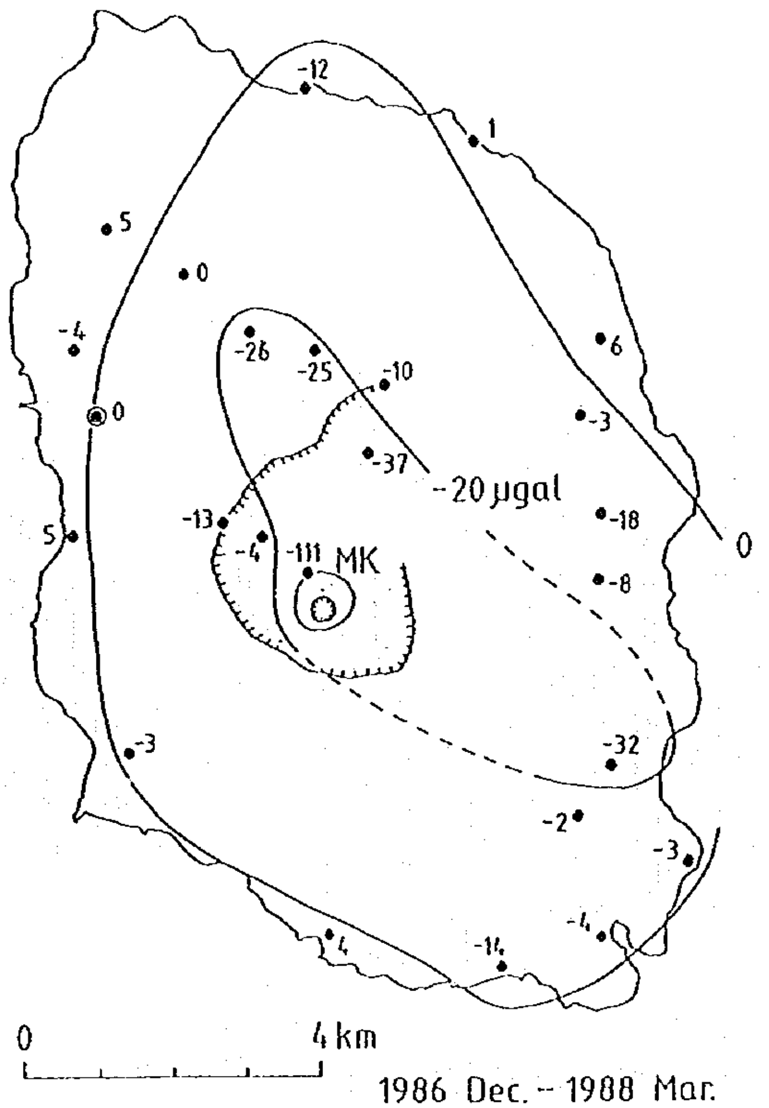


Electrode arrangements of
bipole-bipole measurements
across the summit crater.
電極配置

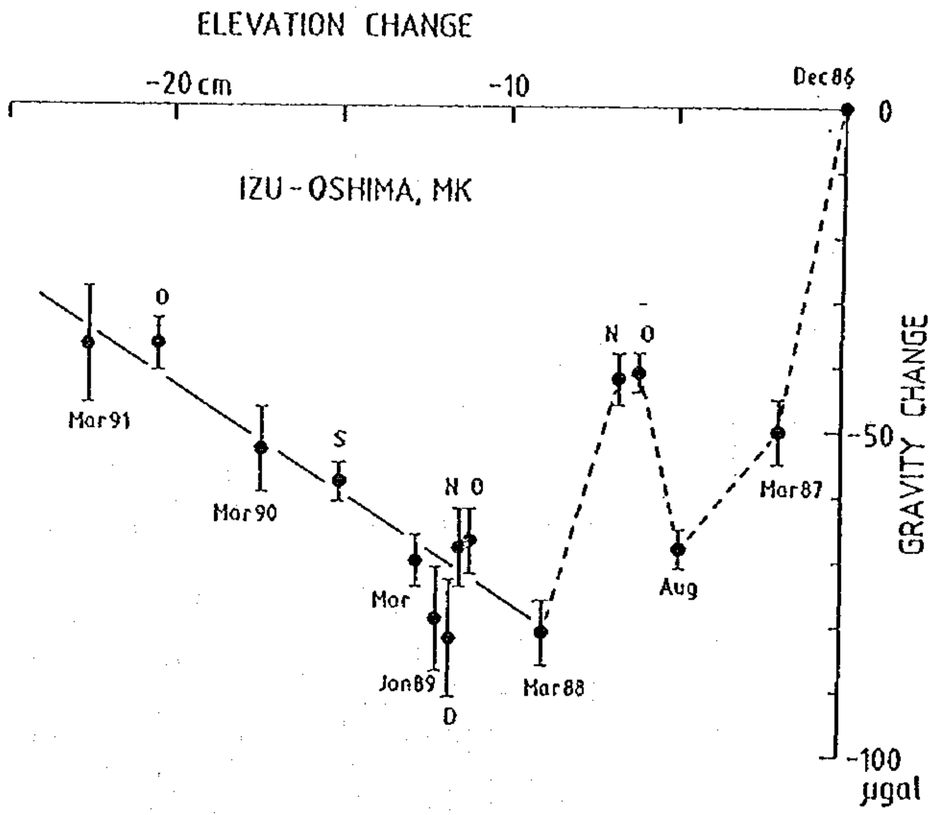


Variations in the apparent resistivity
beneath the summit crater.
三原山火口地下の見かけ比抵抗変化

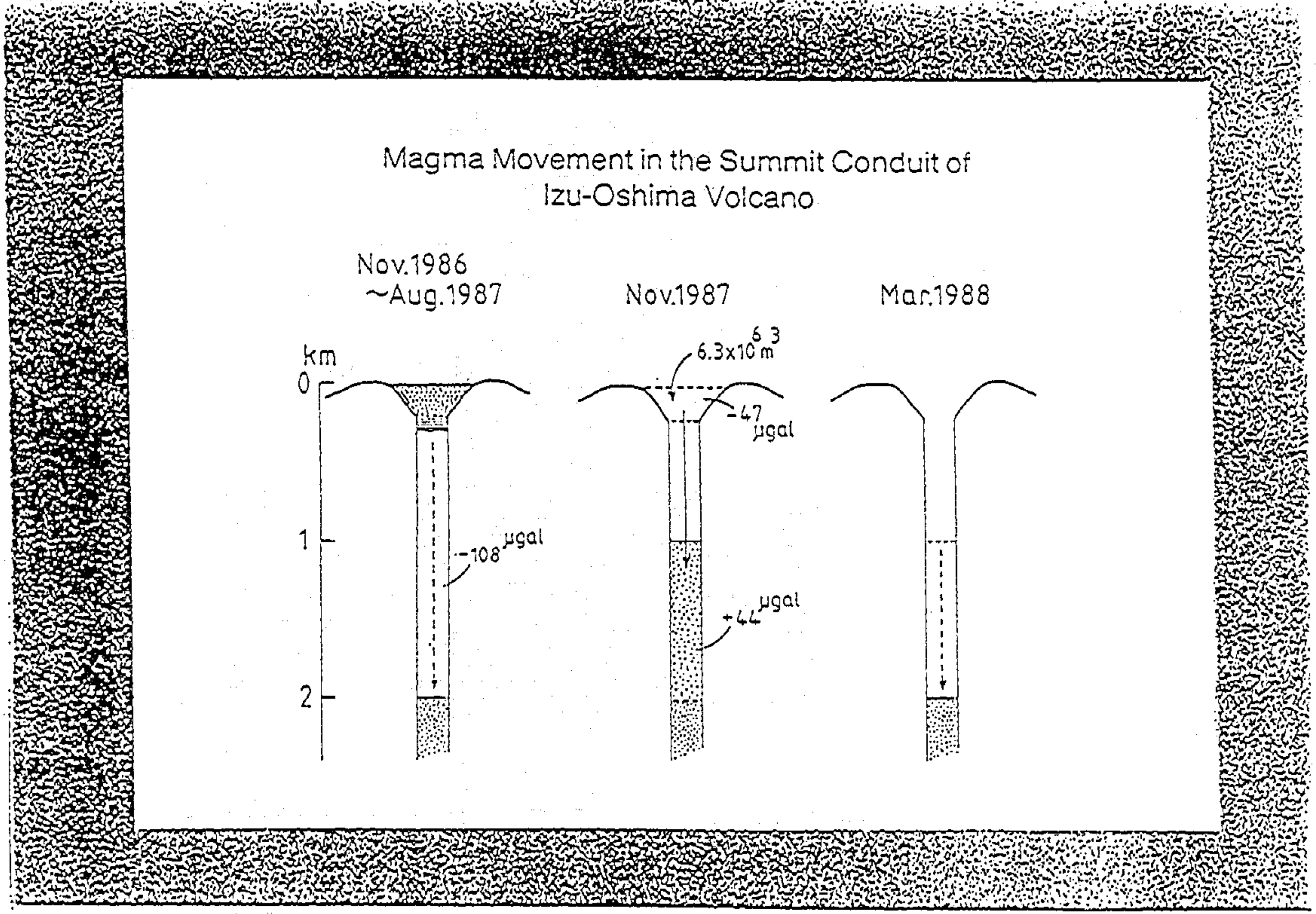
GRAVITY CHANGE

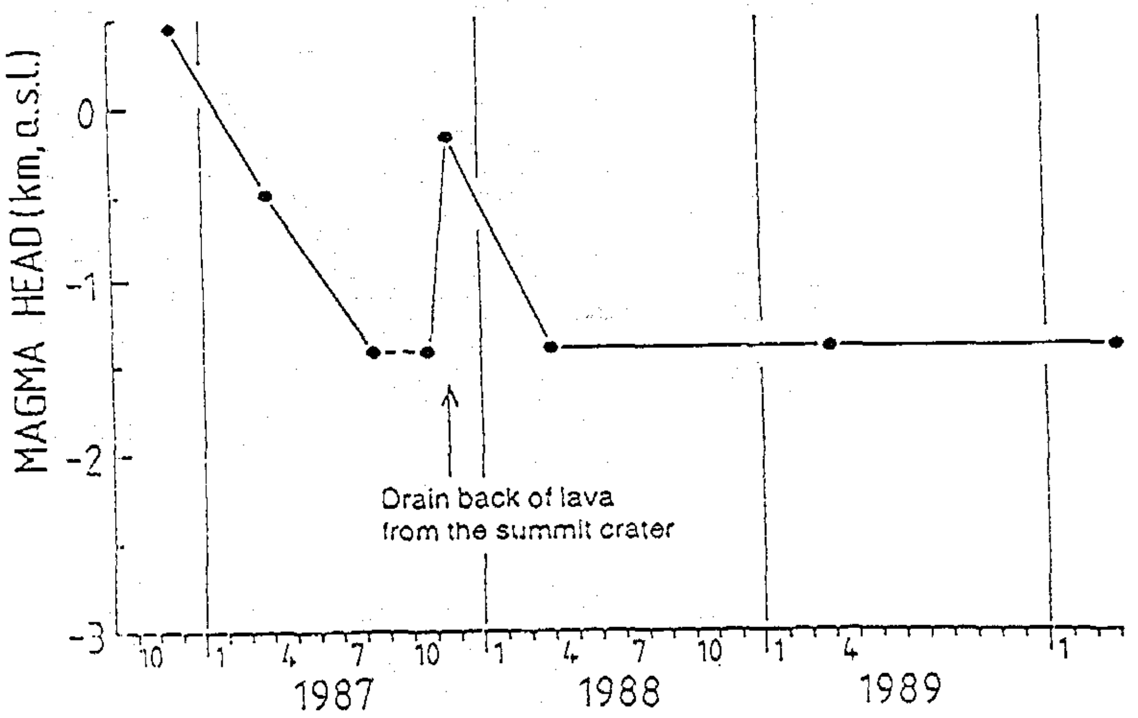


Gravity change on Izu-Oshima island after the November 1986 eruption. A significant gravity decrease was observed at the summit (MK) of the central cone Mihara-yama.



Gravity and elevation changes at the summit (MK) of Mihara-yama. An unusual gravity decrease after the November 1986 eruption (from Dec. 1986 to Mar. 1988) was caused by the drain back of magma from the upper part of the summit conduit to depth.


Magma Movement in the Summit Conduit of
Izu-Oshima Volcano
Nov.1986
~Aug.1987
Nov.1987
Mar.1988
km
0
1
2
-108 μgal
6.3x10^6 m^3
-47 μgal
+44 μgal



Gravimetric estimation of the head of magma in the summit conduit.

On a Hazardless World

Masayuki Watanabe
Specialist in Geologic
Hazard Prevention

The last decade of the 20th century has been designated as an International Decade for Natural Disaster Reduction (IDNDR).

It is intended to give every community an opportunity to establish and participate in a global framework for disaster reduction.

This must be a great initiative and we, scientists and engineers, are expected and requested to promote activities in line with the resolution of the United Nations.

A question might, however, be how can we respond to global needs and expectations and how do we identify our responsibilities ?

It was found only some time ago that the supplies most necessary for survival of a man neck-deep in flood water or clinging to the roof of his isolated house, though not washed away, are fresh drinking water and snakebite serum.

This second item is important because a snake cannot live underwater and may happen to evacuate to the same place as the man.

A man soaked in water or clinging to an object that sticks out of the water, waiting for it to subside, may die of cold. Or if he drinks floodwater out of thirst, he may die of dehydration due to dysentery. In developing countries, as many people die of dysentric dehydration after a flood as are drowned in the flood itself. Many others lose their fight against poisonous snakes after their successful evacuation. Tens, and sometimes hundreds of thousands of people have been killed by storm surges in Bangladesh, situated in the recess of the Bengal bay.

Flooding is no new phenomenon. Rather, it is a phenomenon that has been repeated from time immemorial. Why, then, can a flood which causes habitual mass-death be taken for granted ?

disaster. Why, then, in Latin America,where 93% of land is under the control of rich people,who represent 7% of the population,can poor people be the main cause of the large-scale destruction of natural environments and the floods and drought which have been increasing rapidly ?

Natural disasters consist mostly of the repetition of what happened in the past. Hence, the effort to accomplish disaster prevention by learning a lesson; namely, "turning evil into good." Our predecessors strove hard to achieve this end, thereby enhancing the reliability of remedial measures, cutting costs and conducting education by adding new techniques to lessons already learned.

Japan, as well as the USA, is one of the few countries in which experts specializing in disaster prevention and preparedness are respected and engineering that concerns natural disasters make business. Public works and an excellent system for rehabilitation cover the entire territory, protect its communities and have raised the living standards of the local people. Japan, which is always faced with the threat of typhoons, but has reduced the number of deaths due to typhoon disasters from a one-time high of more than 5,000 to virtually zero, is an ideal example in disaster prevention planning and preparedness. It is therefore important for our experiences to be effectively utilized in disaster-prone developing countries.

Any system or technology cannot however be useful without considering the social background of the society that produces and uses it. Disaster prevention facilities, unlike jewels, are not valuable in themselves, but have value in their functions and in their constantly maintained high standards.

Why is it difficult for developing countries to understand this fact and put it into practice ? Without comprehending this idea, no structural measure is effective.

Disaster-prone areas are generally limited and thus it is not exaggerating to say that similar disasters usually take place repeatedly in the same area. Rather, damage tends to increase as similar disasters occur repeatedly.

Disasters are often the inevitable consequences of human acts though they originate as natural phenomena. In the magnitude of damage caused, the earthquake and the cyclone are major phenomena and, though no human impact is at work in the generation and development of these phenomena, population increases in affected areas add to the danger of disasters.

Great change exists in the realization of a meteorological observation network and a training system for its personnel as the result of cooperation by WMO (World Meteorological Organization), UNESCO (United Nations Education, Scientific and Cultural Organization) and local structures under the aegis of the United Nations (ESCAP (Economicand Social Commission for Asia and the Pacific,) for example). This system makes effective use of artificial satellites and a communications network accurately assesses tropical cyclones from their generation to their disappearance, precisely transmitting forecast data to countries located in their paths. The system also always undertakes technical cooperation for meteorological and hydrological observation practice and organizes necessary training.

Yet in spite of that, disasters seem unlikely to decrease.

From the aforementioned realities of disasters, one can first clearly see that a disaster occurs where there are serious shortcomings in society and that the problem is by no means easy to overcome.

World population, which is now 4.7 billion, will, in the estimates of the United Nations, increase to 6.1 billion by the end of this century and to 8.2 billion in 2025, and levelling off at 10 billion in 2025. However, it is the details of the increase that count. The urban population in developing countries will be in the proportion of one out of every two persons at the end of this century. Urbanization that isunrelated to industrialization not only requires immediate social investment but will surely involve such a problems as environmental imapct, food, security and, eventually, the inevitable outcome of population aging in the midst of poverty. In order to solve these problems, vast social expenses are obviously required.

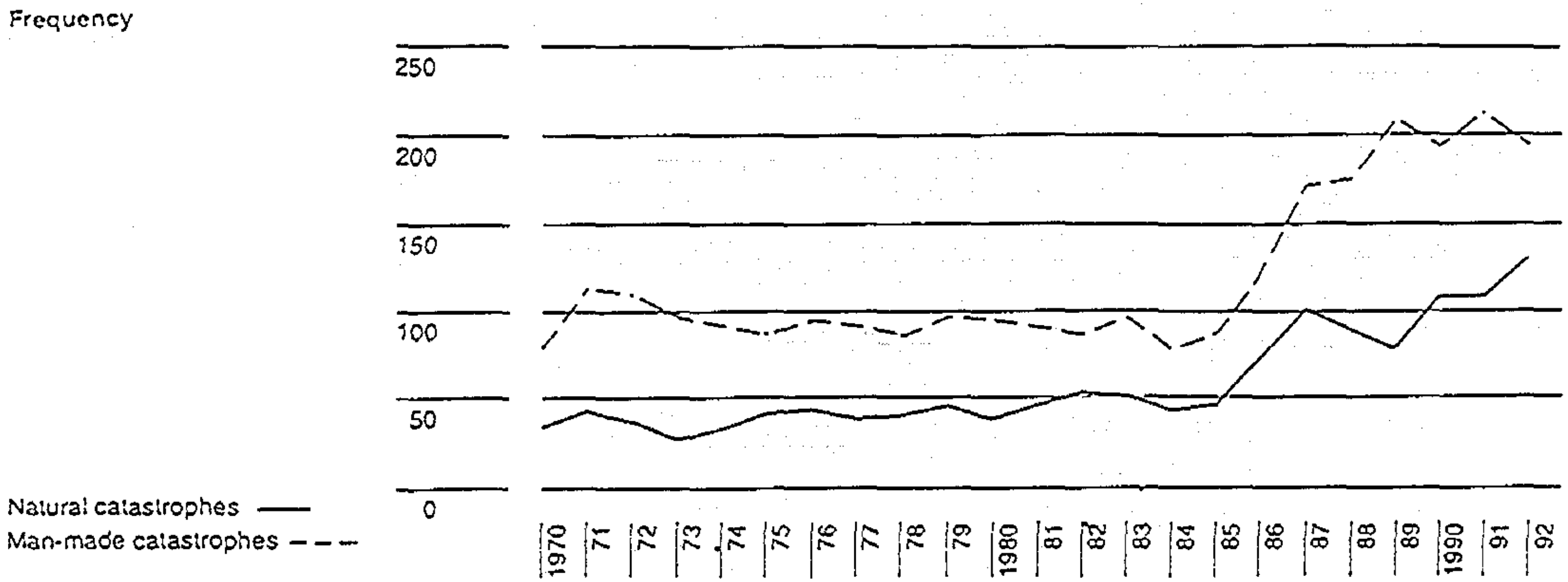
That these problems cannot be effectively coped with by conventional methods which stress the transfer of capital to developing countries through the start of operation of businesss from developed nations or the provision of large infrastructures is clear from the increasing number of foreign economic refugees and illegal" workers coming in quest of job opportunities.

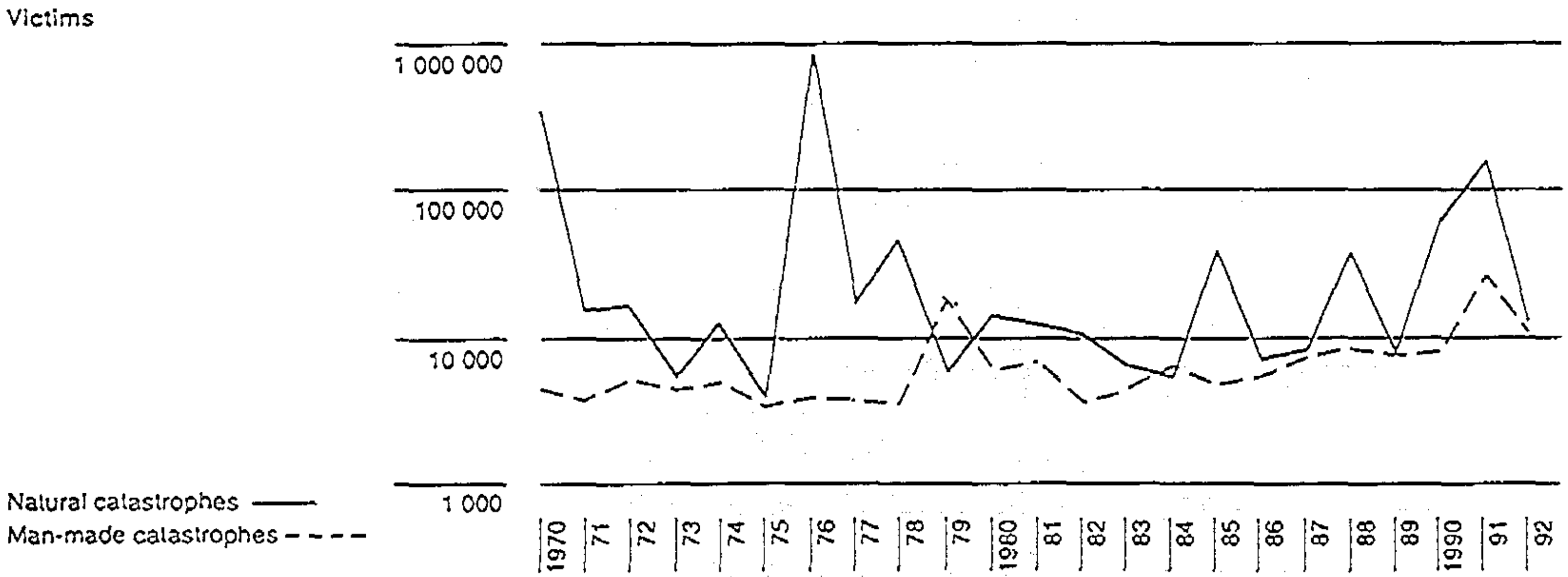
In nearly all developing countries suffering from disasters, the present industrialization alone can hardly help solve their problems and they still remain unproductive agricultural nations. In view of this reality, their disaster prevention programmes should be basically designed for the independence and self-sustenanceof farming hamlets in a catchment basin as an init, rather than being based on such conceptions as are applied to industrialized nations, and should function only in an auxiliary manner to support the inhabitants' own programmes acquired locally.

Any programme lacking this point of view will only share the fate of the birth control programme once attempted to cope with population increases.

References

1) The Swedish Red Cross: Prevention Better than Cure, 1984
2) Jun Nishikawa: Population Growth, Iwanami Booklet No.22, Iwanami Publishing





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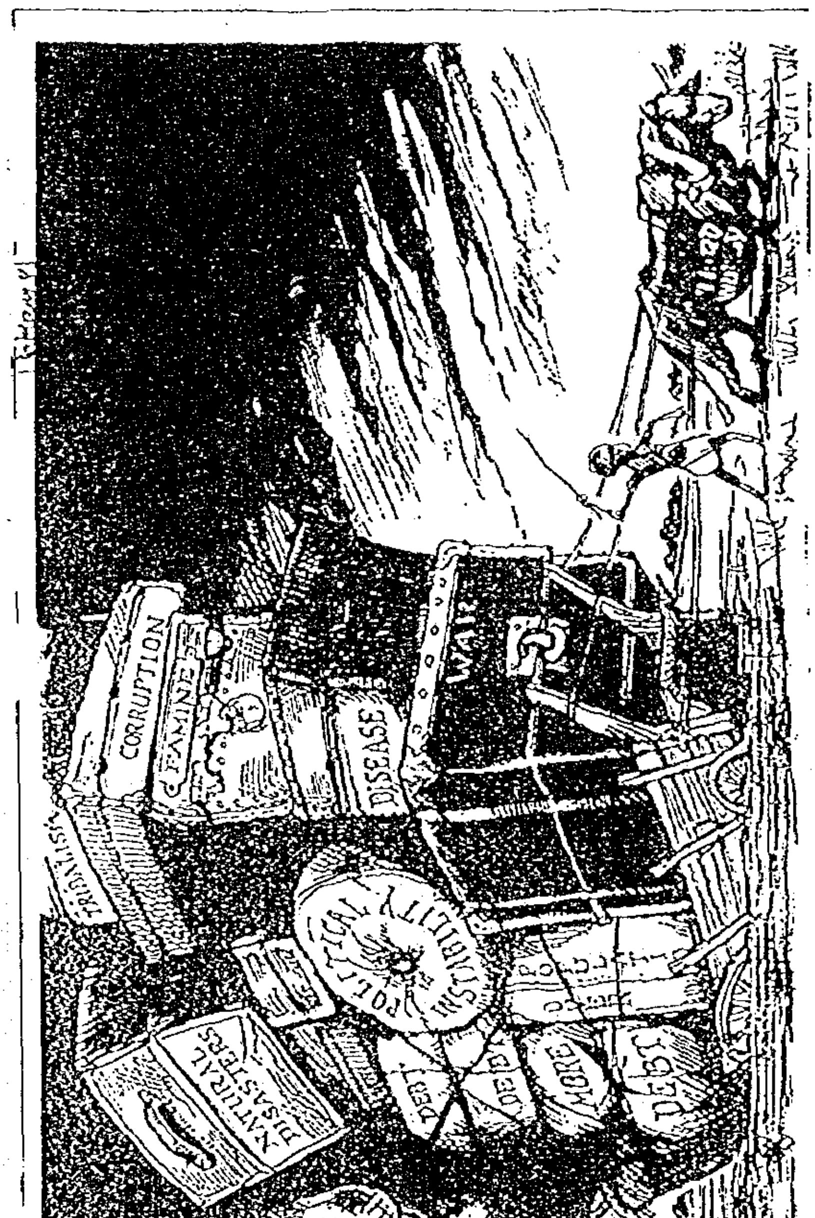
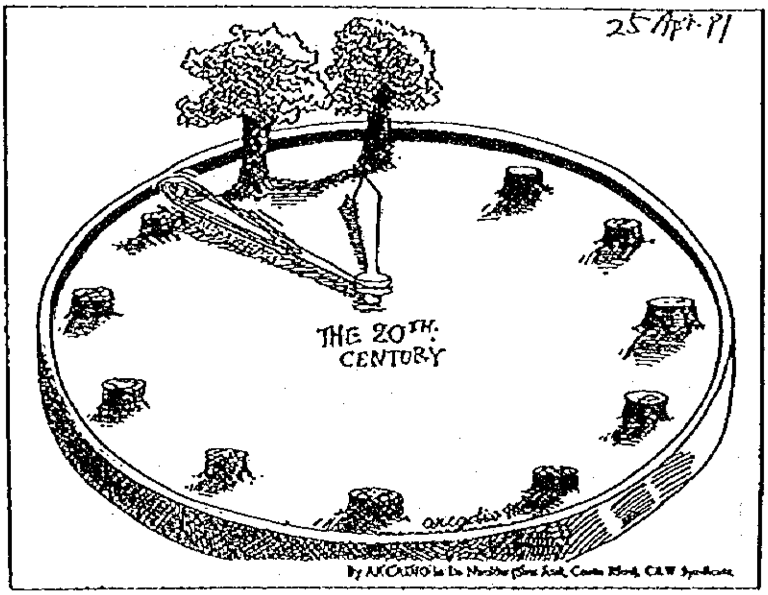

CORRUPTION
FAMINE
DISEASE
WAR
POLITICAL INSTABILITY
NATURAL DISASTERS
DEBT
DEBT
MORE DEBT
DEBT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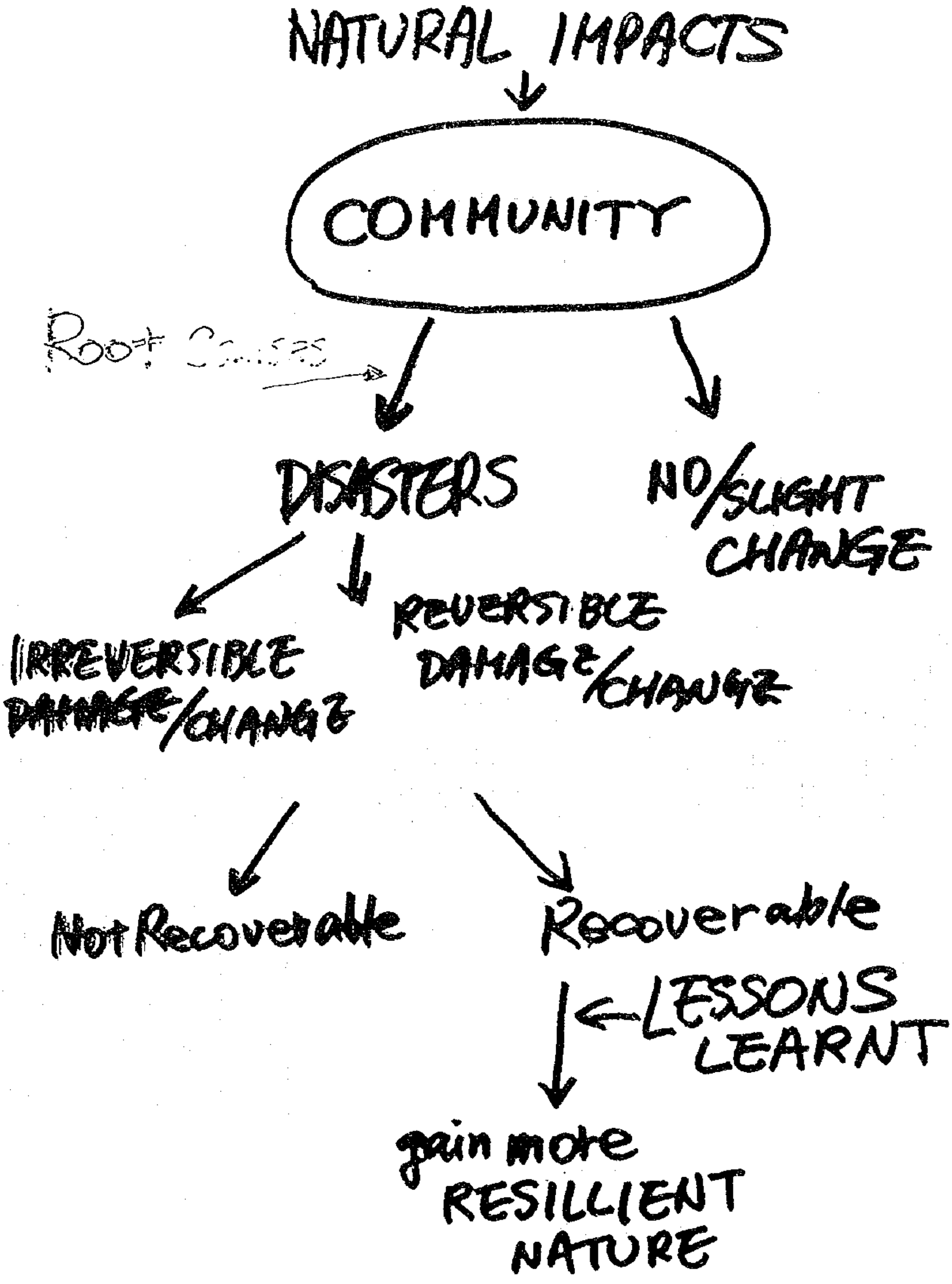
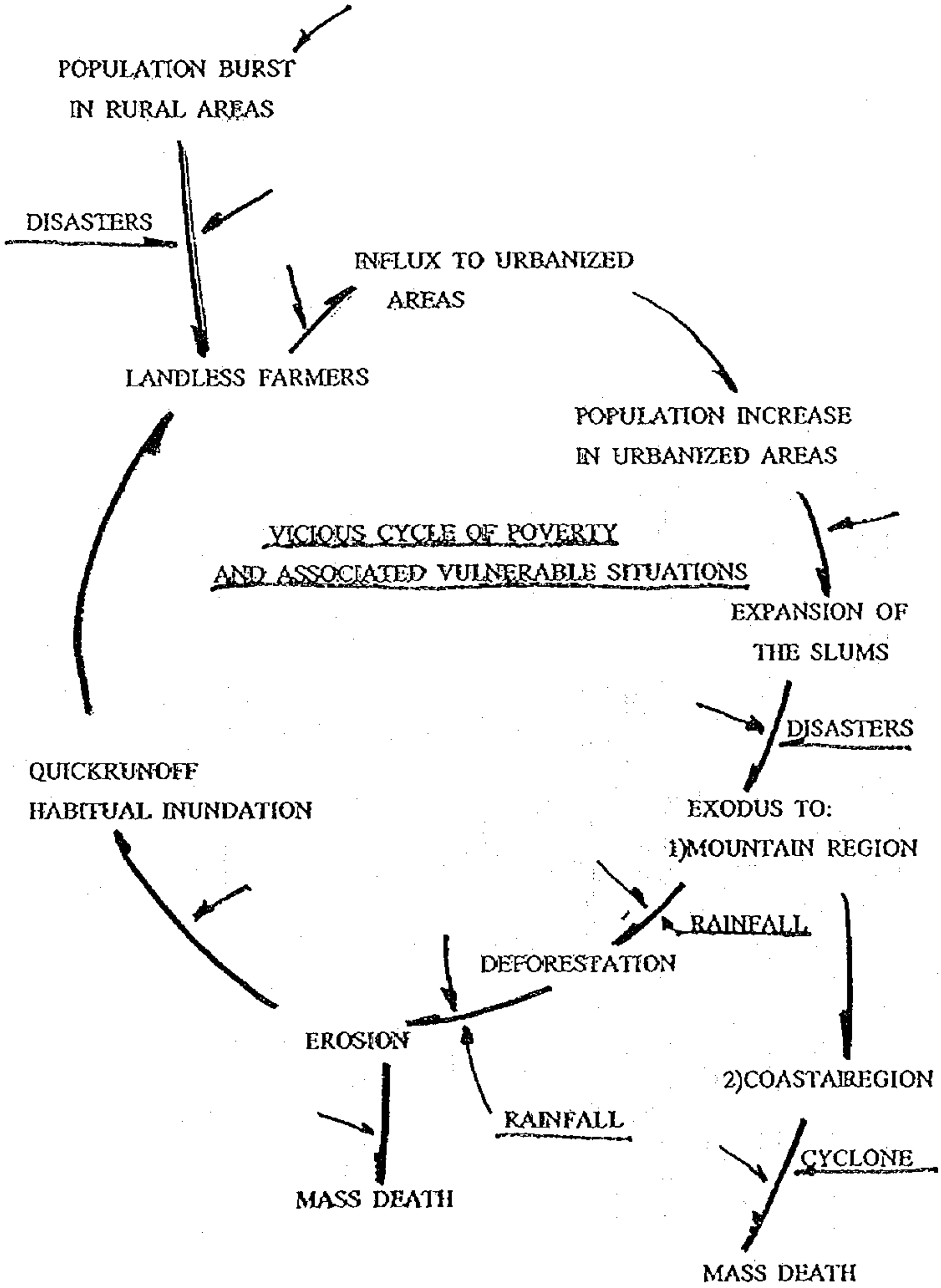
THE 20TH CENTURY


NATURAL IMPACTS
COMMUNITY
Root Causes
DISASTERS
NO/SLIGHT CHANGE
IRREVERSIBLE DAMAGE/CHANGE
REVERSIBLE DAMAGE/CHANGE
Not Recoverable
Recoverable
LESSONS LEARNT
gain more RESILLIENT NATURE


POPULATION BURST
IN RURAL AREAS
DISASTERS
INFLUX TO URBANIZED
AREAS
LANDLESS FARMERS
POPULATION INCREASE
IN URBANIZED AREAS
VICIOUS CYCLE OF POVERTY
AND ASSOCIATED VULNERABLE SITUATIONS
EXPANSION OF
THE SLUMS
DISASTERS
QUICKRUNOFF
HABITUAL INUNDATION
EXODUS TO:
1)MOUNTAIN REGION
RAINFALL
DEFORESTATION
EROSION
2)COASTALREGION
RAINFALL
CYCLONE
MASS DEATH
MASS DEATH

RECENT DEVELOPMENTS IN THE APPROACH TO MUDFLOW DISASTER PREVENTION

Masayuki WATANABE

Summary

Every structural measure against mudflows is required to be resistant to impact force of mudflows. Recent study revealed however that a structure designed taking advantage of dehydration effect required no component against impact force. An artificial lobe formed by the strucuture is proved to be effective in diverting subsequent mudflows and regulating fan formation process.

Evacuation is an essential method to avoid loss of lives. Simulation by means of either hydraulic model or numeric model was proved to be relaible and applicable to actual cases.

Structural measures against mudflows

(1) Dehydration of a flow

Past disasters clearly show that structural measures which are commonly used for river improvement work on an alluvial plain cannot be employed as measures against mudflows. Remarkable changes in channel course, longitudinal profile and sediment concentration, togetherwith the destructive impact forceof a flow, endanger almost all the engineering structures on alluvial cones and fans.

Disasters due to mudflows are characterized, first, by complete destruction due to impact force; secondly, by the magnitude of topographic changes and damage due to sedimentation; thirdly, by the extreme difficulty of evacuation upon the occurence of the flow. It is almost impossible, and not always advantageous, to prevent mudflows from initiating.

From the engineering point of view, it is therefore feasible to take the following two measures:

- to remove large-sized material as much as possible;
- to make the sediment concentration as low as possible.

The lower the sediment concentration is, the easier and more feasible it is to control the flow by means of ordinary river control works.

Kinetic energy carried by large-sized particles can be decreased by the use of sabo dams which create some reaches with gentle bed slope in their reservoirs. Kinetic energy can also be decreased by dehydration: a horizontal screen set up on the channel bed has been proved to be effective for dehydration. The design elements of the screen-type debris flow breaker are given based on the hydraulic tests and field observation.

(2) Fan segment shift

Disasters due to mudflows are characterized by the wide spread of the materials with wide variety of particle size. The damaged area may increase depending on the location of the intersection point that shifts to and fro indefinitely, in accordance with the runoff and its sediment concentration. The key to success is to make the sediment concentration lower by making the most effective use of sand pockets. The size of the sand pockets may depend on the mode of the sediment movement, magnitude and frequency of sediment discharge, the location of the pocket and the condition of human use of the fan. The sand pocket as shown in Figure 1 is ideal if enough area is available.

From the geomorphological point of view damaged areas are regarded as those where the fan segment is being formed, while disaster-prone area are those which will be affected once the formation elsewhere is completed.

The land that compares with the damaged area or with the area extended to the extent of five-to.10-fold at the minimum is desirable as a fan segment.

The sandpocket is enclosed in an embankment made of the materials available on the site, so that the height of the embankment is limited, rather low, and the life of the sand pocket is not long.

New land should be secured for the next fan, and the flow will be guided to the new fan segment as soon as the one currently used is filled, as shown in Figure 2. This operation would be continued as long as sediment transportation continues.

The inner part of the sand pocket is too disadvantageous and dangerous to be used for cultivation and housing but the one already filled-in can be used for cultivation. In this way, every corner of the alluvial fan currently under the threat of debris flows and lahars could be used efficiently without any fear of disasters if the sand pocket is shifted in a certain systematic order as shown in Figure 2

The fan-segment shift method is an ideal measure for artificial fan formation process control, and is feasible as a preventive measure against mudflows.

(3) Some technical points on the fan-segment shift method

Ordinary river training works such as embankment, groin, ground sill and gate can be used for diversion at the inlet of the sand pocket if the flow contains less and finer sediment.

But, in order to divert debris flows and lahars, ordinary river training works are of no use, while solid structures such as dams and guide walls are not really feasible, considering the cost for initial construction and maintenance.

The measures for diversion should be tough enough to resist the huge impact of debris flows and stable enough to cope with the large fluctuation of the river bed downstream. The best way to avoid the collapse of the facility for diversion is to make the best use of the mechanism of debris-lobe formation, and dehydration method by means of screen-type debris breaker can be employed as the artificial debris-lobe formation measure.

A screen-type debris breaker set up upstream, closer to the inlet creates artificial debris lobes which can guide the direction of following flows, asshown in Figure 3. The screen-type debris breaker should be shifted in accordance with the shift of fan segment. The iron bars can, of course, be used again and again.

Simulation of mudflows

Figure 4 (a) and (b) show the results of the simulation by hydraulic model test and numeric model respectively on the case of the Hachiemon alluvial cone in Japan. It is observed that each of the results represents the real events fairly well.

Figure 5 (a) and (b) show the affected area in the case of Mt.Tokachi mudflow disaster in 1925 and in time sequence computed by the numeric model respectively. It apparently represents the real event in 1925. Simulation by either hydraulic model test or computer-aided numeric model can thus be powerful tools for hazard area delineation, planning of structural measures, identification of evacuation spots and early warning.

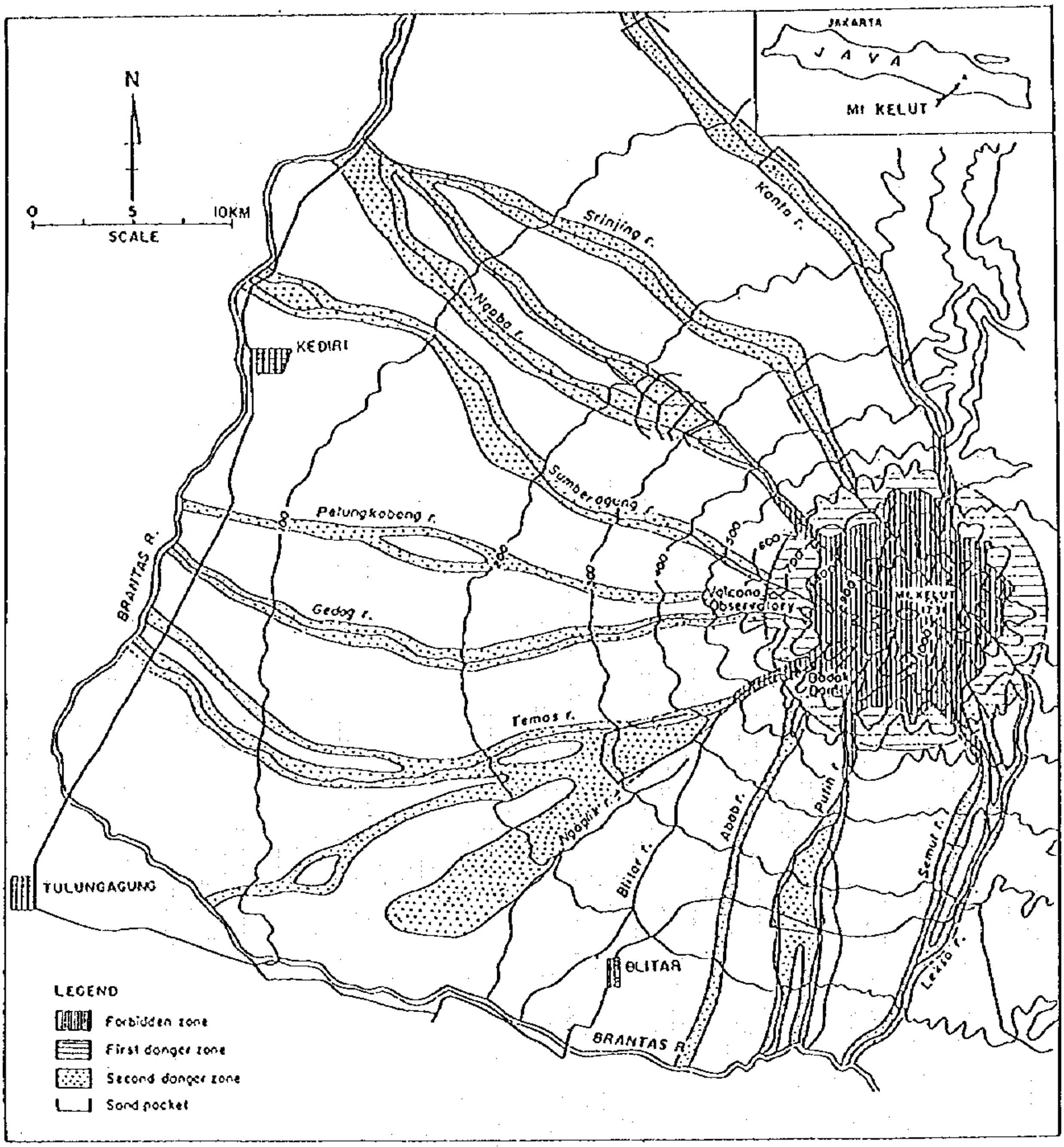


Fig. 1 Mt. Kelut hazard map

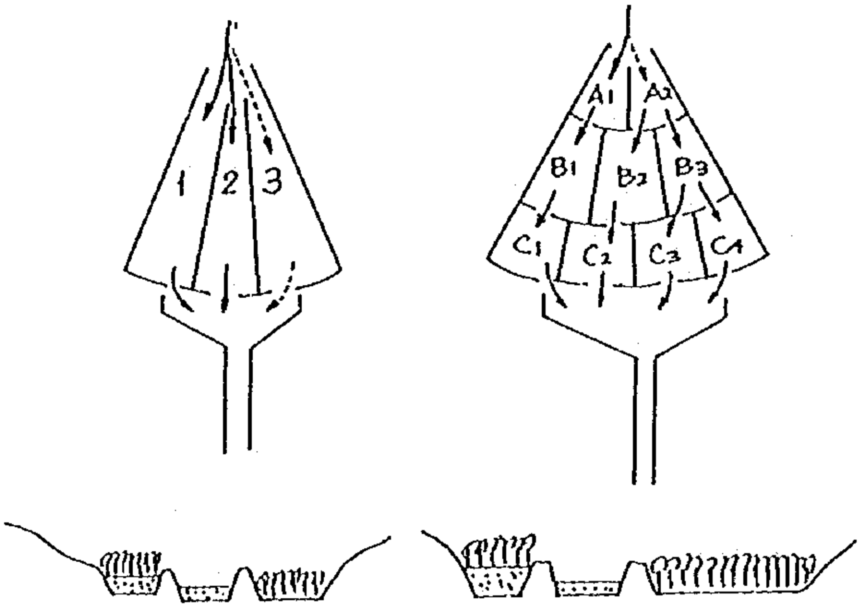


FIGURE 2 *Concept of the fan-segment shift as a measure for fan formation control*

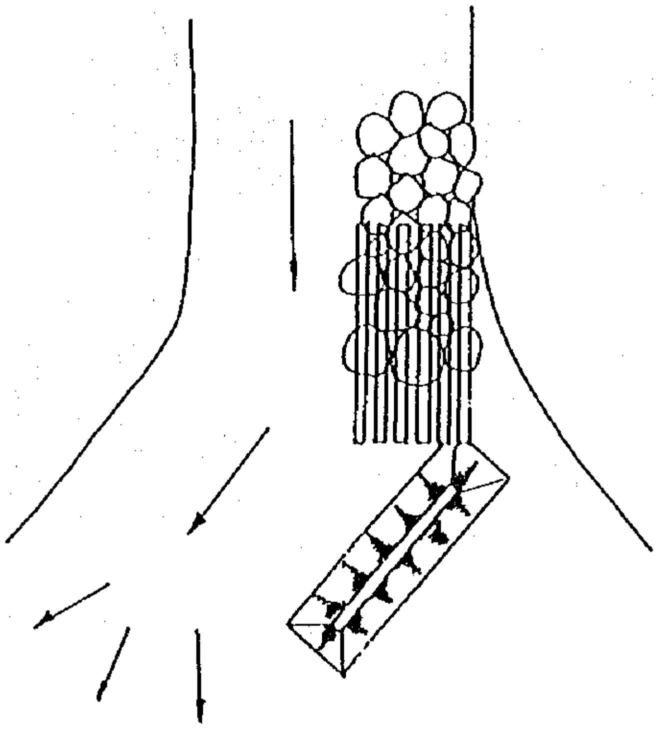


FIGURE 3 *Diversion of debris flow taking advantage of the dehydrate effect of a screen debris flow breaker set at the fan head*

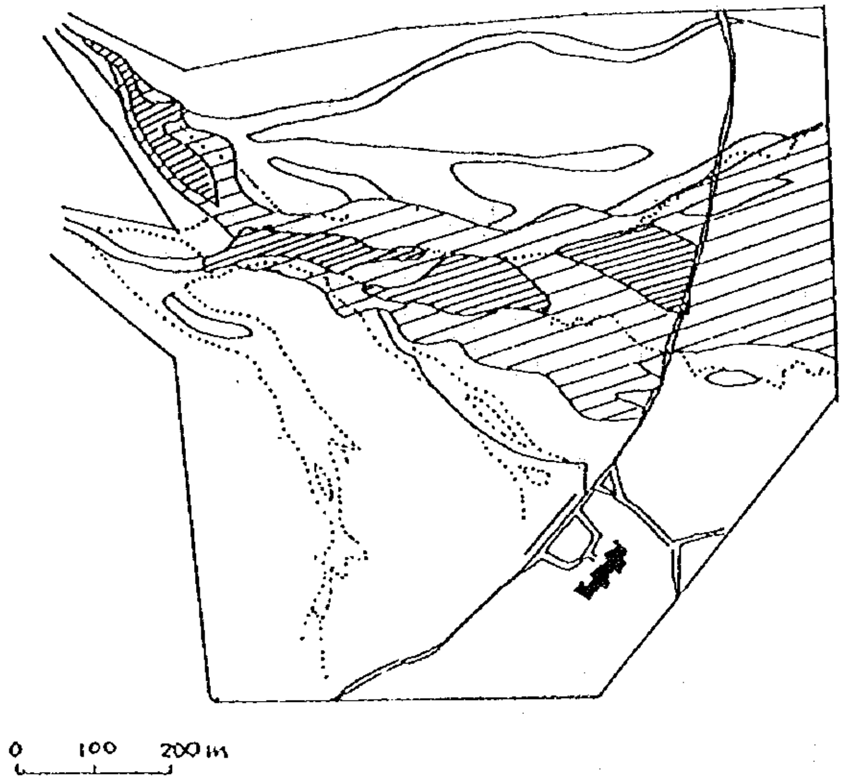


FIGURE 4(a) *Debris Flow Stricken Area . . . comparison between the actual situation and hydraulic model test.* [hatched box] *, sedimentation more than 1 m;* [diagonal lines box] *, sedimentation less than 1 m;* [blank box] *, surface flow;* [dashed box] *, actual hazard area*

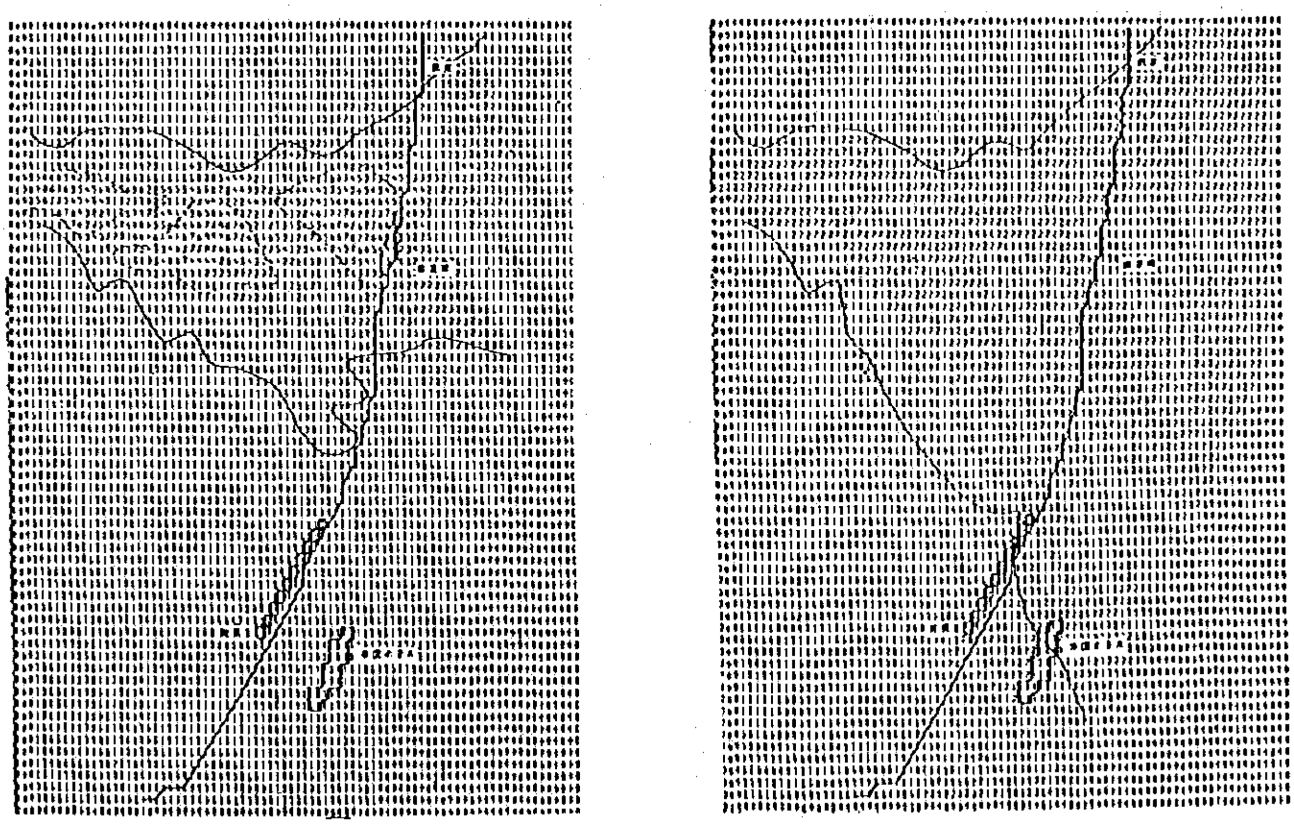
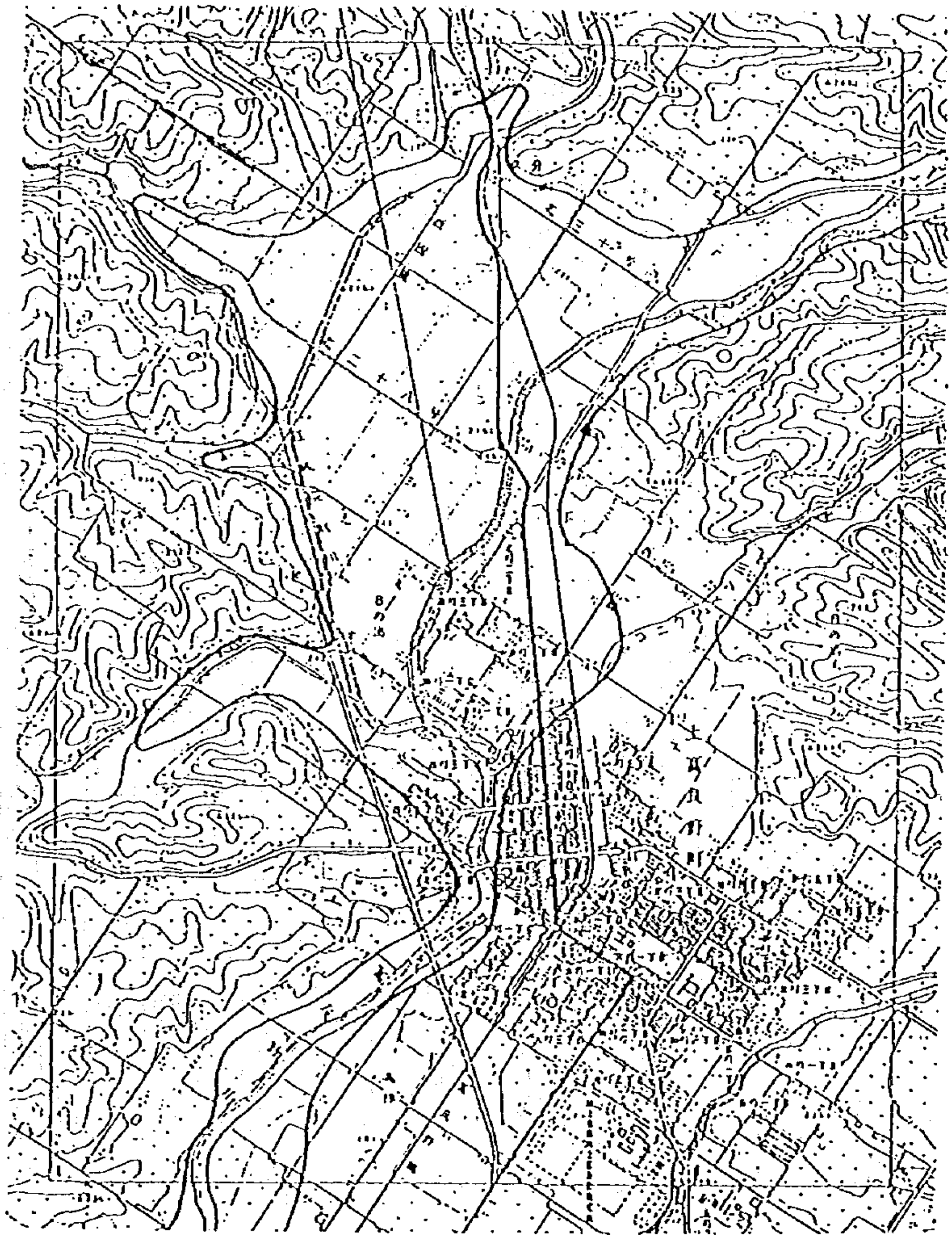


FIGURE 4(b) *(i) Sedimentation area obtained by computer simulation; (ii) flooded area obtained by computer simulation*



FIGURES(a) *Mudflow stricken area, 1925, Furano river, Japan*

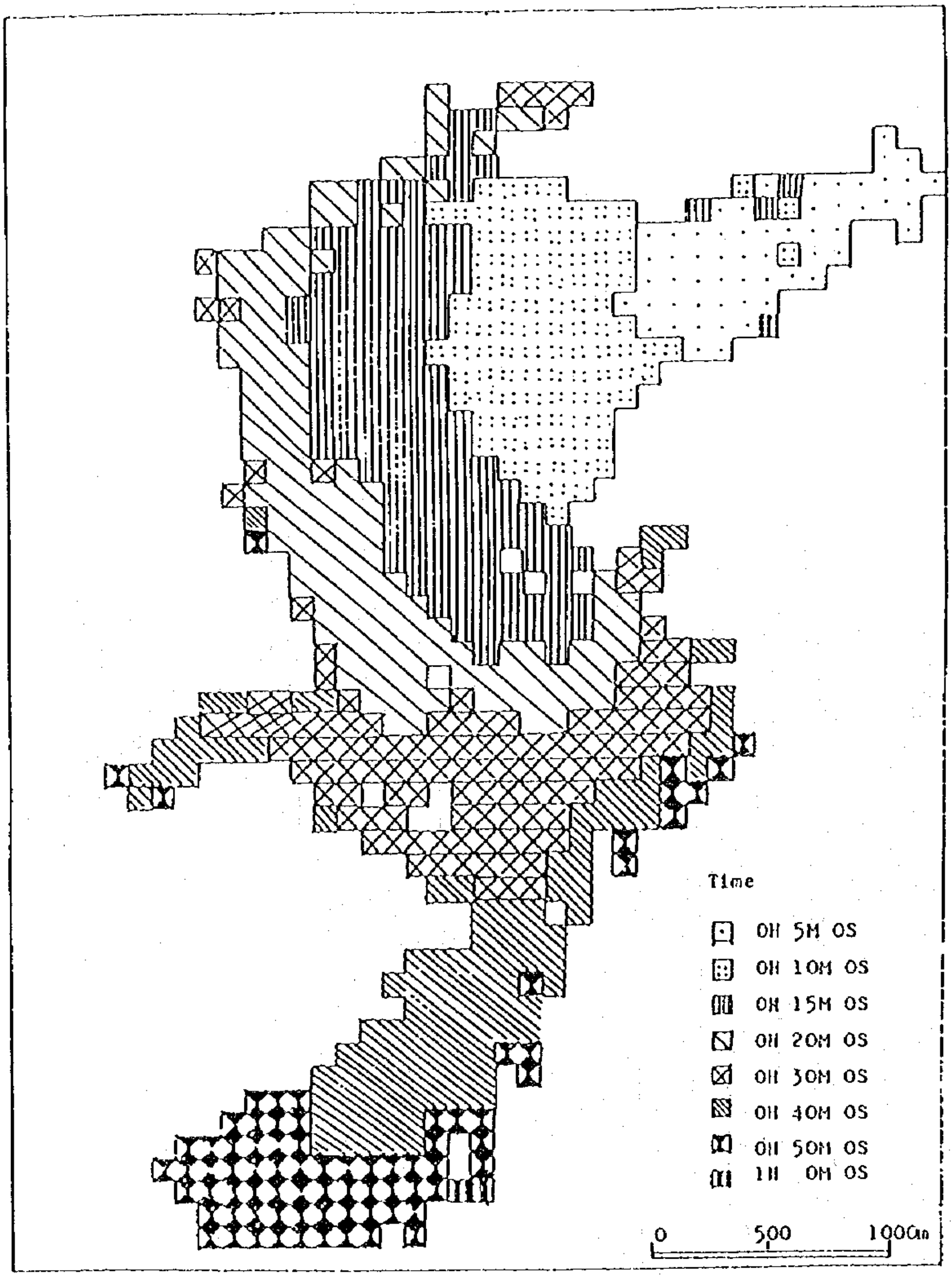


FIGURE 5(b) *Mudflow stricken area obtained by computer simulation*

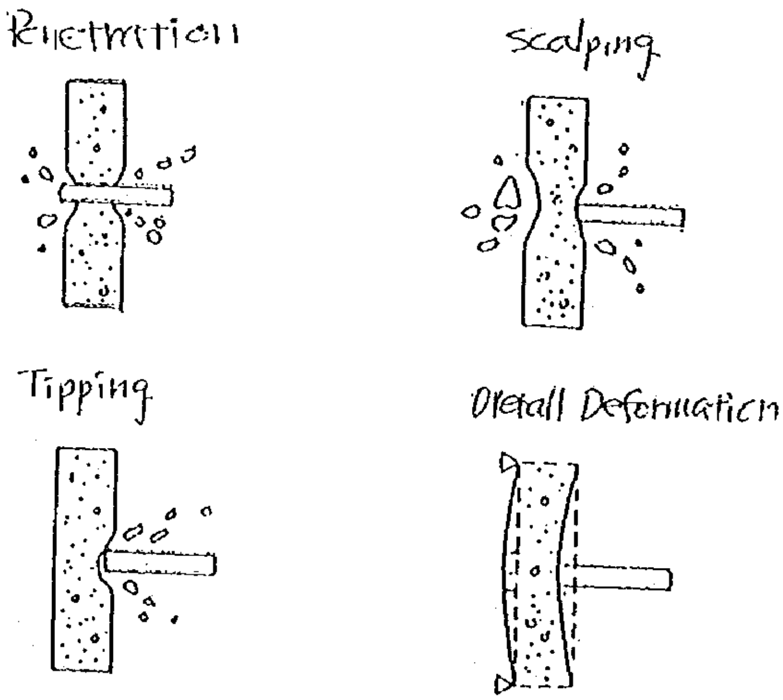


Fig - 1

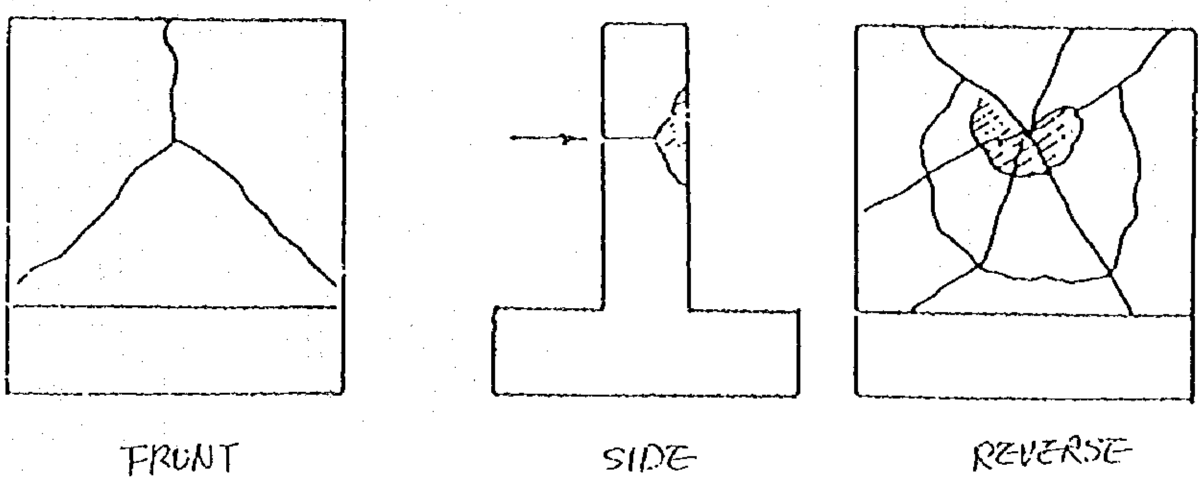
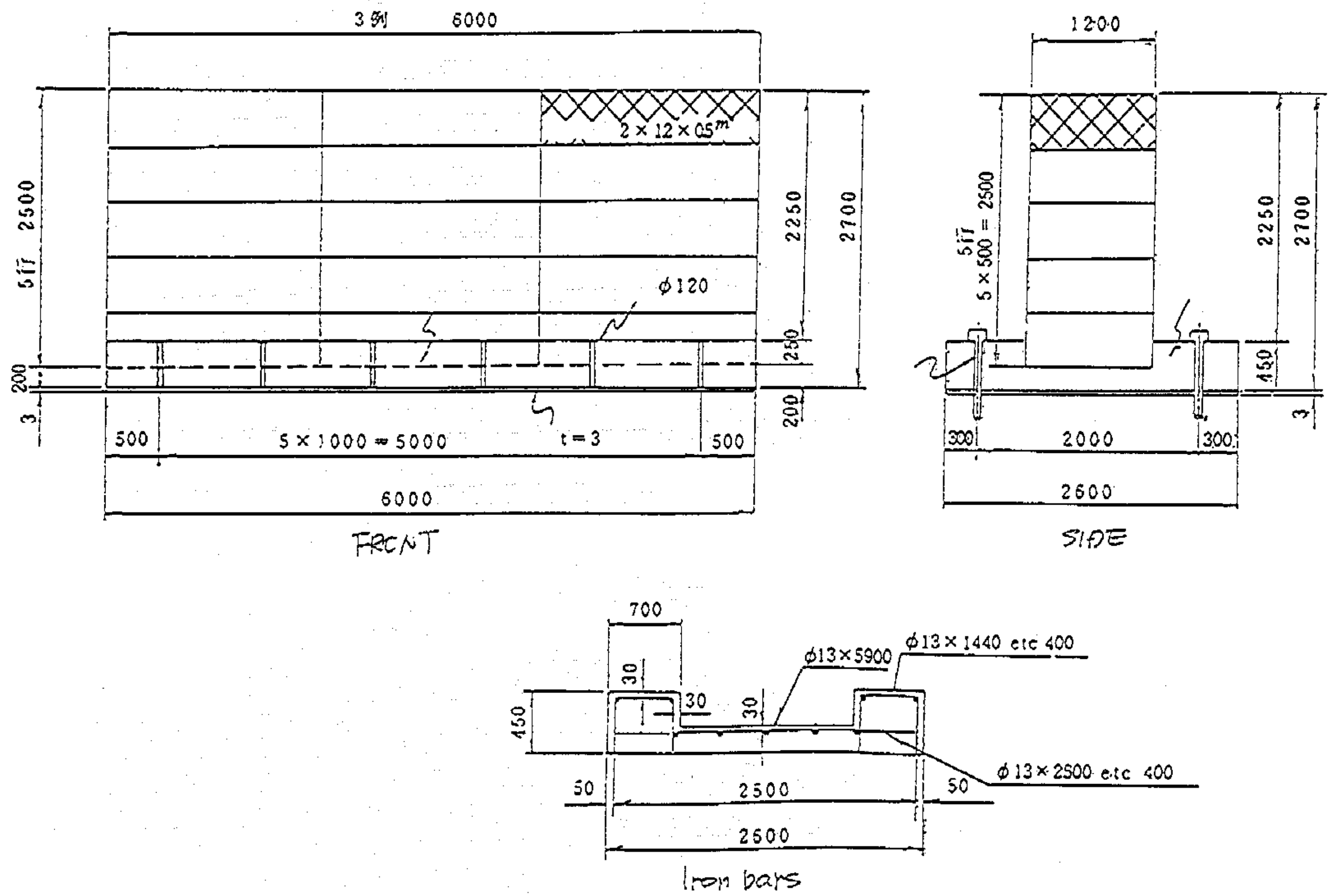


Fig.-2 Various Mode of Destruction



size of the test piece (S = 1 : 30)

Fig – 3

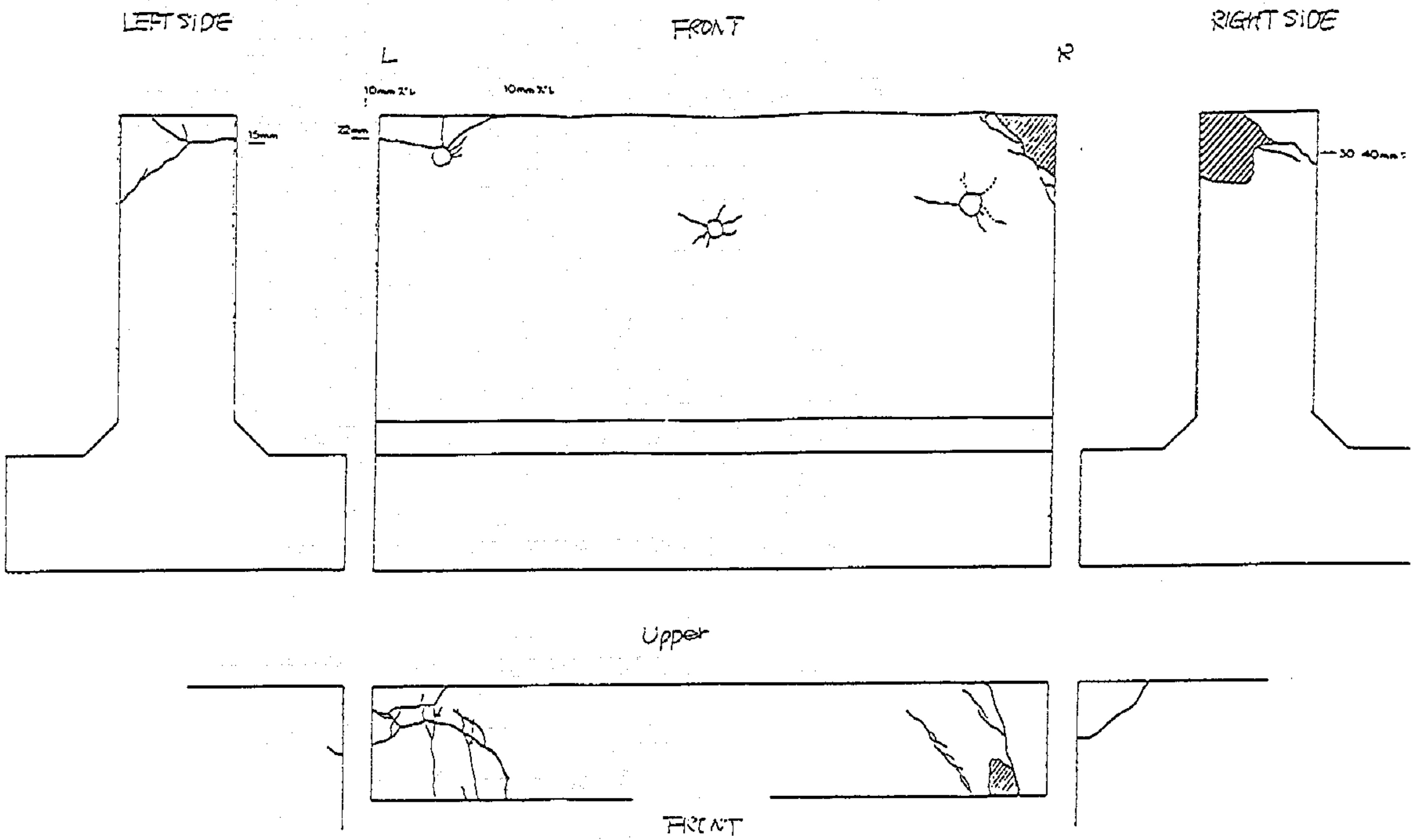


Fig-5 DESTRUCTION AT THE CORNER
TYPE 2 case No. I-5~I-7

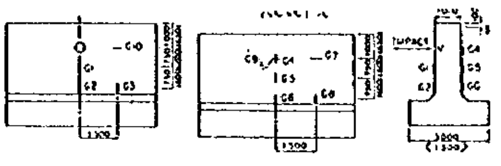


図-1 Location of ( ) sizes of the type 1 sensors

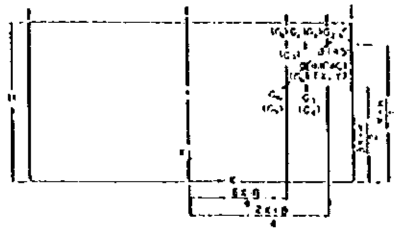


図-5 Location of (ロ) Reverse side sensors

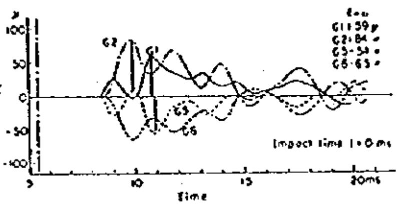


図-3 Time-strain (Case 1-1)

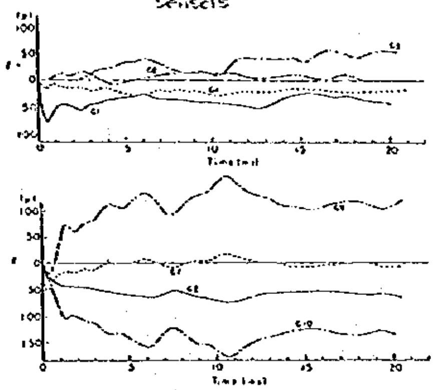


図-6 Time-Strain (Case 1-6)

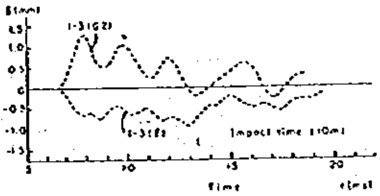


図-4 Time-displacement 1-1

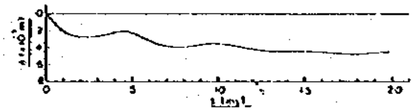


図-7 Time-Displacement 1-6

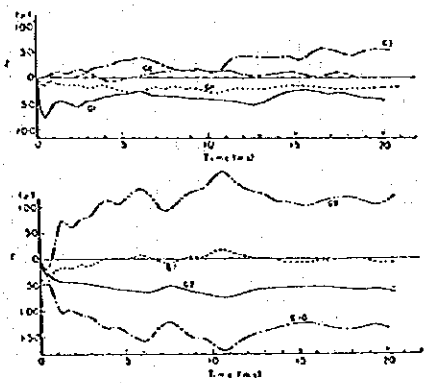


図-6 Time-Strain (Case 1-6)

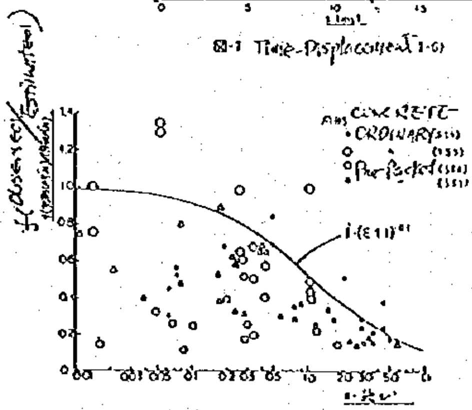


図-5 Value observed/estimated

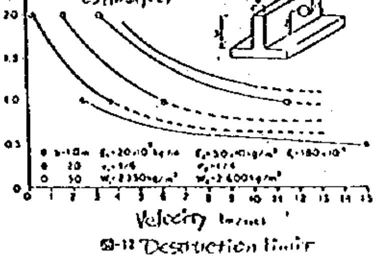


図-12 Destruction limit

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