BULLETIN OF THE EARTHQUAKE
RESEARCH INSTITUTE
Vol. 55 (1980), pp. 885-893

36. A Possible Correlation between the 1980 East off Izu Peninsula Earthquake and Mantle Earthquakes beneath the Sagami Bay.

By Ken'ichiro YAMASHINA,

Earthquake Research Institute.

(Received October 31, 1980)

Abstract

The present paper proposes a possible correlation between recent shallow and mantle earthquakes in the Izu region, Central Japan, as follows. (1) The 1980 East off Izu Peninsula earthquake and recent major shallow earthquakes ($M \geqq 5.0$) in the Izu region were all preceded by mantle earthquakes (about 110-160 km in depth) within two months (especially the period 15-60 days prior to the former) in the Sagami Bay, Izu-Oshima and Izu Peninsula areas. Such a phenomenon will occur accidentally with about 1% probability, or about 0.3% for those beneath the northern Sagami Bay. (2) When a mantle earthquake (especially about 110-160 km in depth) occurs in the Sagami Bay, Izu-Oshima and Izu Peninsula areas, or especially under the northern Sagami Bay, with magnitude larger than about 3.0-3.5, it may be a precursor to a subsequent shallow earthquake ($M \geqq 5.0$) in the Izu region within two months with probability of about 30% or 40%. (3) A similar correlation may also exist between the major shallow earthquakes and mantle earthquakes (about 110-160 km in depth) which occurred under the northern Sagami Bay 110-150 days prior to the former. The probability that such a phenomenon will occur accidentally is about 1%. The present results, however, are not conclusive because of the lack of sufficient data, and further studies on future earthquakes will be needed.

1. Introduction

The East off Izu Peninsula earthquake (June 29, 1980) and recent major shallow earthquakes in the Izu region were preceded by mantle earthquakes at intermediate depths. The present paper discusses a pos-

sible correlation between them.

MOGI (1972, 1973) proposed a correlation between shallow and deep (or intermediate) earthquakes along the subducting lithosphere. For example, the great Sanriku earthquake in 1933 was preceded by three large deep earthquakes beneath the Japan Sea during 1931-1932. The Tokachi-oki earthquake in 1952 was preceded by six deep earthquakes beneath the Hokkaido-Sakhalin areas during 1950-1951. A statistical study by UTSU (1975) also presented a correlation between shallow and intermediate earthquakes in the Kanto and Hida regions.

MOGI (1972, 1973) and UTSU (1975) were interested in mechanical correlations between seismic regions which belong to the same segment of the subducting plate. The present paper, however, is concerned with earthquakes which are quite different in tectonic setting. Shallow earthquakes in the Izu region occur within the crust of the Philippine Sea plate. In contrast to this, mantle earthquakes discussed in the present paper are caused by the Pacific plate underthrusting the Japanese Islands from the Japan trench.

2. Data

The earthquake catalog compiled by the Japan Meteorological Agency (or JMA ; monthly) is used in the following discussion. During the last

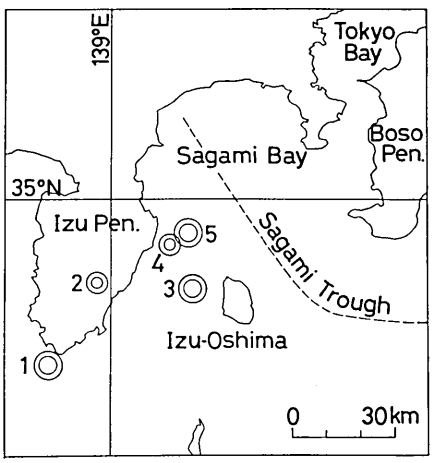

Fig. 1. Epicenters of five major shallow earthquakes which occurred recently in the Izu region; [1] Izu-Hanto-oki (1974, M=6.9), [2] Eastern Izu Pen. (1976, M=5.4), [3] Near Izu-Oshima (1978, M=7.0), [4] Northeastern Izu Pen. (1978, M=5.4), and [5] East off Izu Pen. (1980, M=6.7).

6.5 years (January, 1974—June, 1980), there were five shallow earthquakes which occurred in the Izu region with magnitude larger than 5.0. They are the 1974 Izu-Hanto-oki (M=6.9), 1976 Eastern Izu Pen. (M=5.4), 1978 Near Izu-Oshima (M=7.0), 1978 Northeastern Izu Pen. (M=5.4), and 1980 East off Izu Pen. (M=6.7) earthquakes (see Fig. 1). In addition to these, one more sequence with M≧5.0 occurred in the central part in the Izu Peninsula (M=5.1, 5.8 and 5.4) just after the 1978 Near Izu-Oshima earthquake. This sequence, however, is discussed together with the Near Izu-Oshima earthquake, since the former was aftershock-like activity

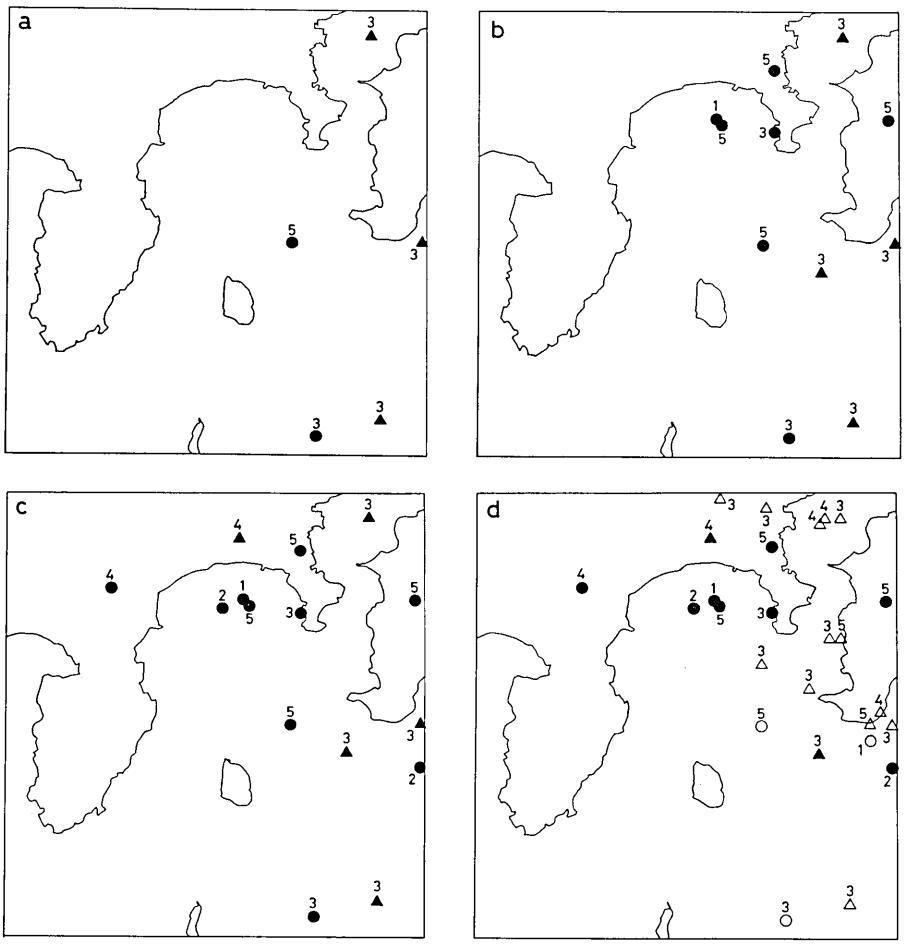

Fig. 2. Composite epicentral distribution of mantle earthquakes which preceded the five major shallow earthquakes in Fig. 1 within [a] 15 days, [b] 30 days, [c] 60 days, and [d] 100 days. Numerals represent the number of a subsequent major shock. Circles and triangles represent depth≧90 km and 90 km>depth >30 km, respectively. In Fig. 2d, solid circles and triangles are those which occurred 15-60 days before the major shallow earthquakes.

of the latter in a broad sense.

Figs. 2a, b, c and d represent the epicenters of mantle earthquakes prior to the five major shocks within 15, 30, 60 and 100 days, respectively. The figure shows that all of the five major shocks were really preceded by mantle earthquakes within two months (especially 15-60 days before the former). The depths of these mantle earthquakes were mostly over 90 km.

Such an observation would have no significance if mantle earthquakes occurred every one or two months. In Fig. 3, all epicenters of mantle earthquakes (depth $\geqq$90 km) are shown for the period from January, 1974 through June, 1980. In this period, there were 23 mantle earthquakes (90-160 km in depth) in the Sagami Bay, Izu-Oshima and Izu Peninsula areas; i.e. the area enclosed by thick lines (138°40′E, 139°40′E, 34°20′N and 35°20′N) in Fig. 3 (Region A). Here, the westernmost event beneath the Suruga Bay (west of the Izu Peninsula) was excluded, since it was isolated in location and depth (190 km) from the others. The total duration of 60-day periods following these mantle earthquakes (including one which occurred in November, 1973) attains about 42% of the whole period (Fig. 4). The probability that all of the five major earthquakes occurred accidentally during this 42% period is about 1.4% (once out of 70 times). This suggests that there may be some corre-

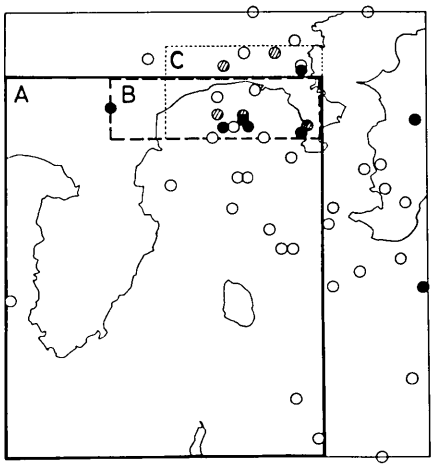

Fig. 3. Epicentral distribution of all mantle earthquakes with depth$\geqq$90 km during January, 1974—June, 1980. Solid and hatched circles represent those which occurred 15-60 days and 110-150 days before the major shallow earthquakes. The events in regions A, B and C which are enclosed by solid, broken, and dotted lines, respectively, are discussed in the text.

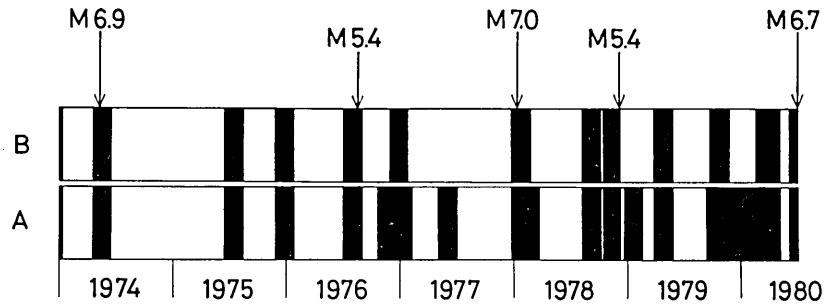

Fig. 4. Correlation between mantle earthquakes (depth≧90 km) and the major shallow earthquakes (M≧5.0) in the Izu region. Shaded areas represent 60-day periods after the mantle earthquakes which occurred in regions A and B, respectively, in Fig. 3.

lation between major shallow earthquakes and mantle earthquakes.

Among the 23 mantle earthquakes in the Sagami Bay, Izu-Oshima and Izu Peninsula areas, 7 shocks were followed by major shallow earthquakes (M≧5.0) in the Izu region within two months. If we assume a hypothetical rule "when a mantle earthquake (about 90–160 km in depth) occurs beneath the Sagami Bay, Izu-Ohima and Izu Peninsula areas, a major shallow earthquake may occur within two months", it results in successful prediction with probability about 30%.

Figs. 2 and 3 show that mantle earthquakes which preceded the major shallow earthquakes concentrated under the northern Sagami Bay. Accordingly, a similar calculation is carried out for mantle earthquakes in the area enclosed by broken lines (139°00′E, 139°40′E, 35°10′N and 35°20′N) in Fig. 3 (Region B). Thirteen mantle earthquakes (depth ≧90 km) occurred in this area. The total duration of 60-day periods following these shocks (again including one which occurred in November, 1973) accounts for about 30% of the whole period (Fig. 4). If the five major shallow earthquakes occurred randomly in time, the probability that all of them occurred during this 30% period is only about 0.26% (once out of 400 times). A hypothetical rule "when a mantle earthquake (about 90–160 km in depth) occurs under the northern Sagami Bay, a major shallow earthquake may occur within two months", was true for 5 out of 13 cases (about 40%). The depths of these five shocks ranged 110–160 km.

Fig. 5 suggests that magnitudes of the major shallow earthquakes are 2.0–3.0 larger than those of the preceding mantle earthquakes under the northern Sagami Bay. Because of the lack of sufficient data, however, confirmation of such a relation is left for further studies. Here, two triangles represent magnitudes obtained by the data of the network

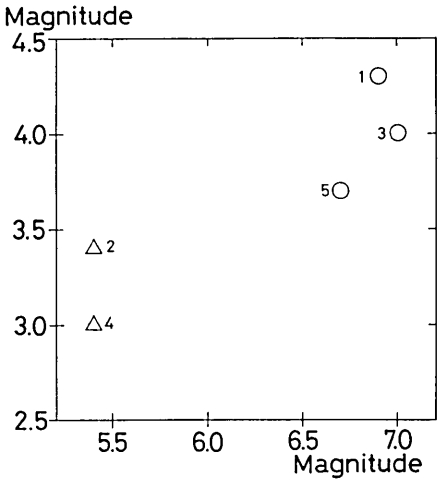

Fig. 5. Magnitudes of the major shallow earthquakes in the Izu region (horizontal axis) versus those of preceding mantle earthquakes (vertical axis) which occurred in region B in Fig. 3. Triangles represent that magnitudes of mantle earthquakes were estimated using data obtained by the Kanto network of the Earthquake Research Institute. Numerals are the number of the major shallow earthquakes (Fig. 1).

of the Earthquake Research Institute, since they were not determined by JMA.

Up to the present, we have discussed mantle earthquakes which occurred less than 100 days (especially 15-60 days) before the major shallow earthquakes. Another correlation may also exist between the major shallow earthquakes and mantle earthquakes about 110-150 days prior to the former. In fact, four out of five major shallow earthquakes (except the Izu-Hanto-oki) were preceded by the latter, which occurred beneath the Sagami Bay, or to be exact, in a rectangular area enclosed by dotted lines (139°10′E, 139°40′E, 35°10′N, and 35°25′N) in Fig. 3 (region C). In this case, the probability that such a phenomenon will occur accidentally is about 1.1%.

The threshold magnitude of mantle earthquakes compiled by JMA is considered to be about 3.0-3.5 in these areas. Earthquakes with smaller magnitudes do occur more frequently, of course. Further study may also be needed to determine whether a similar correlation is applicable for shallow and mantle earthquakes with smaller magnitudes.

3. Discussion and Conclusions

The earhquake catalog compiled by JMA suggests following empirical rules. (1) The 1980 East off Izu Peninsula earthquake and recent major shallow earthquakes ($M \geqq 5.0$) in the Izu region were all preceded by mantle earthquakes (about 110–160 km in depth) within two months (especially the period 15–60 days prior to the former) in the Sagami Bay, Izu-Oshima and Izu Peninsula areas. Such a phenomenon will occur accidentally with about 1% probability (or about 0.3% for those beneath the northern Sagami Bay). (2) When a mantle earthquake (especially about 110–160 km in depth) occurs in the Sagami Bay, Izu-Oshima, and Izu Peninsula areas, or especially under the northern Sagami Bay, with magnitude larger than about 3.0–3.5, it may be a precursor to a subsequent shallow earthquake ($M \geqq 5.0$) in the Izu region within two months with probability of about 30% or 40%. (3) A similar correlation may also exist between the major shallow earthquakes and mantle earthquakes (about 110–160 km in depth) which occurred beneath the northern Sagami Bay 110–150 days prior to the former. The probability that such a phenomenon will occur accidentally is about 1%.

The physical basis of the present correlation, if it exists at all, between shallow and mantle earthquakes is unclear. Both of the seismic activities are associated with different plate motions with each other. The former occur in the shallow part of the Philippine Sea plate, and the latter around the interface of or within the Pacific plate subducting beneath the Japanese Islands. Consequently, explanations by MOGI (1972, 1973) and UTSU (1975), who discussed a correlation between earthquakes which occurred in the shallower and deeper parts of the same segment of a subducting plate, can not be applied in the present case.

A possible factor of triggering earthquakes by previous coseismic stress and strain changes (e. g. YAMASHINA, 1978) is also difficult to apply to the present case. The magnitudes of the mantle earthquakes which preceded the major shallow earthquakes were only about 3–4. Hypocentral distances between them exceeded 100 km. Therefore only quite a small fluctuation in stress and strain was expected in the hypocentral region of the major shallow earthquakes. In fact, no observable crustal deformation caused coseismically by those mantle earthquakes was reported.

One possible explanation would be given in connection with dehydration or magmatic activity. The depths of mantle earthquakes which preceded the major shallow earthquakes ranged about 110–160 km along the Wadati-Benioff zone. These depths, roughly speaking, correspond to

the volcanic front on the surface (e. g. SUGIMURA, 1960; SUGIMURA and UYEDA, 1973). Although it is unclear whether primitive magma originates at these depths, earthquakes there may correlate with the magmatic activity above in some way; e. g. dehydration. Transfer of water, magmatic products or magma itself to a shallower level, or change in mechanical state remotely caused by them may play a certain role to induce subsequent shallow earthquakes.

The present discussion has not yet been conclusive because of the lack of sufficient data and an adequate physical basis. It is, however, quite an interesting phenomenon and may contribute to arc tectonics and earthquake prediction, if the correlation is confirmed by future earthquakes.

Acknowledgements

The author is grateful to Dr. Paul Somerville, Professors Kazuaki Nakamura and Kunihiko Shimazaki, and Mr. Ichiro Kayano for their many critical comments and helpful suggestions.

References

MOGI, K., 1972, Relation between great shallow earthquakes and deep earthquakes. *J. Seismol. Soc. Japan*, 25, 263-264 (in Japanese).

MOGI, K., 1973, Relationship between shallow and deep seismicity in the western Pacific region. *Tectonophysics*, 17, 1-22.

SUGIMURA, A., 1960, Zonal arrangement of some geophysical and petrological features in Japan and its environs. *J. Fac. Sci., Univ. Tokyo, Sect. 2*, 12, 133-153.

SUGIMURA, A. and S. UYEDA, 1973, *Island Arcs: Japan and Its Environs*, 247 pp., Elsevier, Amsterdam.

UTSU, T., 1975, Correlation between shallow earthquakes in Kwanto region and intermediate earthquakes in Hida region, central Japan. *J. Seismol. Soc. Japan*, 28, 303-311 (in Japanese with English abstract).

YAMASHINA, K., 1978, Induced earthquakes in the Izu Peninsula by the Izu-Hanto-oki earthquake of 1974, Japan. *Tectonophysics*, 51, 139-154.

---

36. 1980年伊豆半島東方沖地震と相模湾のマントル地震の相関について

地震研究所　山科健一郎

伊豆地域の最近の浅い大きな地震とマントル地震との相関を調べた結果，次のようなことがわかった．(1) 1980年伊豆半島東方沖地震や最近の浅い大きな地震 (M≧5.0) は，いずれも2カ月前以内 (特に15-60日前) に，相模湾，伊豆大島，伊豆半島地域のマントル地震 (深さ 110-160 km) を伴っていた．このような現象が偶然起こる確率は約 1%，相模湾北部付近だけに注目すると約0.3% であ

る．(2) 相模湾，伊豆大島，伊豆半島地域，特に相模湾北部付近で，マグニチュード約3.0-3.5以上のマントル地震（特に深さ 110-160 km）が起きた時は，2カ月以内に伊豆地域で浅い地震($M \geqq 5.0$)が起こる可能性がある．その確率はそれぞれ約 30%，40% である．(3) 同様な相関が，浅い大きな地震と 110-150 日前の相模湾北部付近のマントル地震（深さ約 110-160 km）の間にもあるかもしれない．偶然そうなる確率は約1% である．しかしこれらの結果は，データ不足のためはっきり結論づけることはできない．今後の同地域の地震活動を見守る必要がある．