

7. The Urup Earthquake and Associated Tsunami of 1963.*

By Serguei L. SOLOV'EV,

Sakhalin Complex Scientific Research Institute.

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On October 13, 1963 at 5h 18m Greenwich Mean Time a strong earthquake originated at the bottom of the Pacific near Urup Island. The quake was felt on all the Kurile Islands. Tsunami waves arose and spread far to the south and to the east from the source. On Urup Island the height of the maximum flood wave was equal to 4~5 meters.

The earthquake was preceded by a sufficiently strong foreshock on October 12. The intensity of this foreshock on the shore was one degree smaller than that of the principal shock. After the Urup earthquake many aftershocks occurred. The strongest of them, which took place on October 20, also generated a tsunami the maximum registered flood being equal to 10~15 meters.

The main parameters of these shocks instrumentally determined at the Sakhalin Complex Institute are given in Table 1.

Table 1. Main parameters of the Urup earthquakes.

Date, October	Time of origin, GMT			Epicenter		Depth Km.	M
	h	m	s	N	E		
12	11	27	00	44.6	149.1	50	6 ³ / ₄ -7
13	05	17	57	44.6	149.5	60	8-8 ¹ / ₄
20	00	53	11	44.6	150.5	20-30	7 ¹ / ₄ -7 ¹ / ₂

Isoseismal scheme for the main earthquake and distribution of epicenters of its aftershocks are shown in the Fig. 1. The region of aftershocks can be represented by two ellipses: the main Urup and auxiliary Simushir ones. There are some doubts about attributing shocks from the auxiliary ellipse to the aftershocks of the Urup earthquake because at the middle of 1963 two earthquakes with magnitude about 7 occurred within this ellipse and also generated some aftershocks. However, Fig. 2

* Communicated by R. Takahasi.

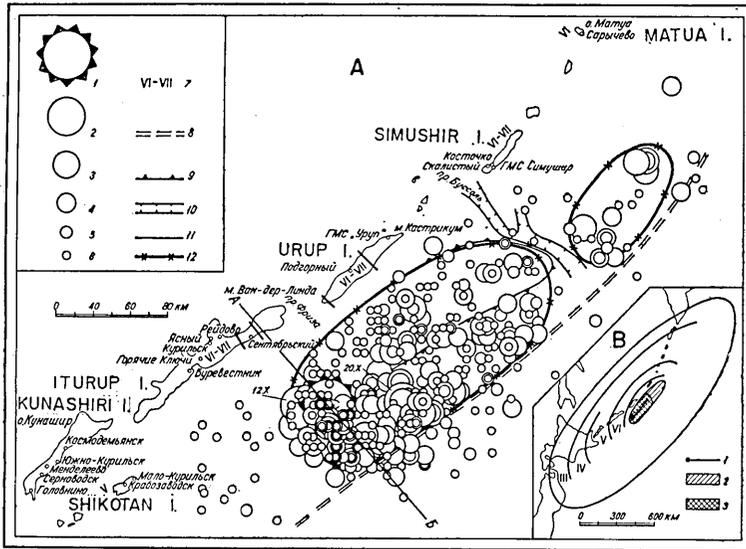


Fig. 1. Map of the Urup earthquake of October 13, 1963.

A-epicentral region

- 1-epicenter of the principal earthquake;
- 2-epicenters of earthquakes of October 12 and 20;
- 3-6-epicenters of aftershocks with magnitude:
 - 3- $M=6-6^{3/4}$; 4- $M=5-5^{3/4}$; 5- $M=4-4^{3/4}$; 6- $M<4$;
- 7-intensity of the principal earthquake according to 12-degrees scale;
- 8-axis of the deep-water Kurile-Kamchatka trench;
- 9-foot of the Vityaz' range;
- 10-transverse graben of the Boussole strait;
- 11-same transverse faults on the islands of the Big Kurile ridge;
- 12-region of aftershocks.

All epicenters are determined at the Sakhalin Complex Scientific Institute.

B-scheme of isoseisms

- 1-epicenter and master fault;
- 2, 3-seismic source: 2-main part, 3-auxiliary part.

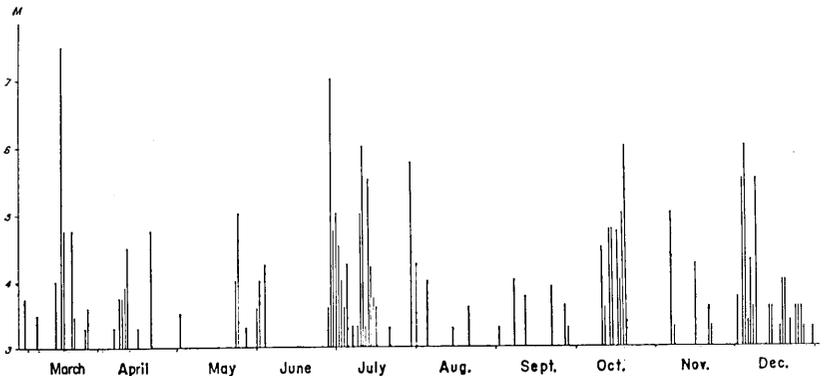


Fig. 2. Occurrence of earthquakes in 1963 to the south-east of Simushir Island.

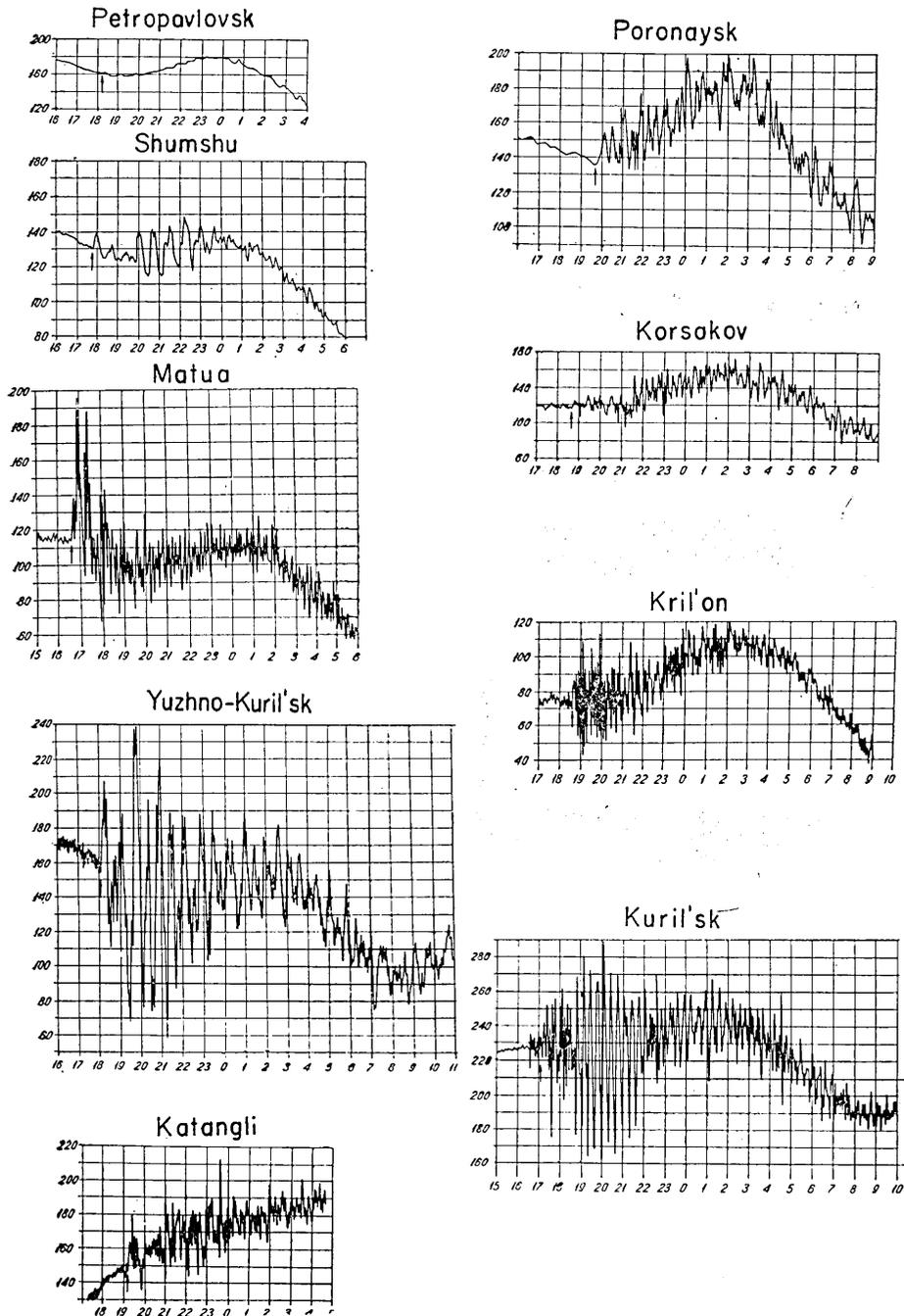


Fig. 3. Tsunami of October 13 as recorded at different stations: Arrows indicate the assumed beginning of tsunami. Horizontal axis is Sakhalin degree time, vertical: ocean level in cm.

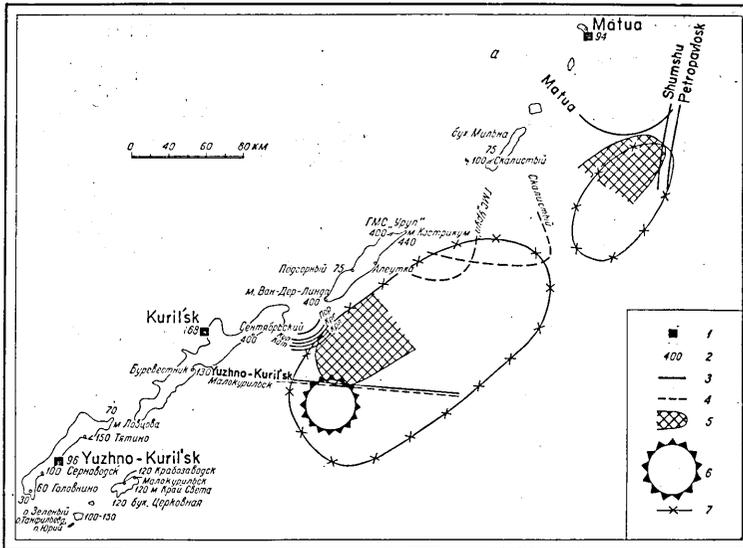


Fig. 4. Source of the tsunami of October 13.

1-mareographs; 2-maximum height of flood in cm;
3-isochrones of tsunami propagation to different points;

Abbreviations as follows:

Пор-Poronaysk; *Кур*-Kuril'sk; *Крс*-Korsakov;
Кат-Katangli; *Крл*-Kril'on;

4-doubtful isochrones; 5-assumed source of the tsunami;
6-epicenter of the earthquake; 7-region of aftershocks.

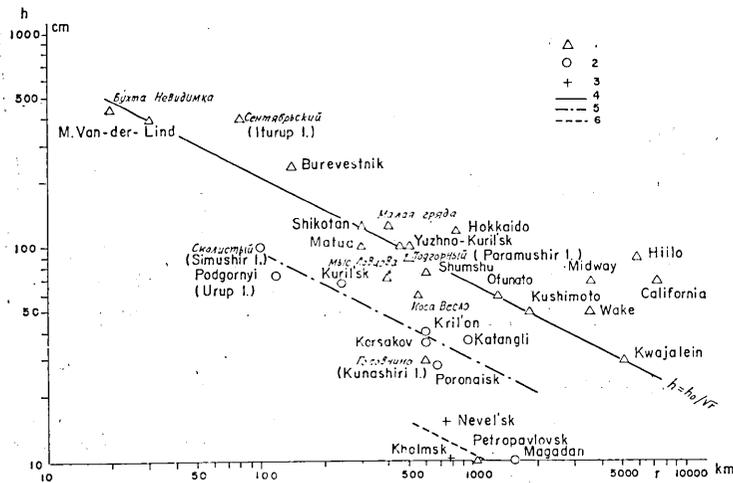


Fig. 5. Attenuation of flood with distance.

1~3-points situated on the coasts of (1) the Pacific, (2) the sea of Okhotsk, (3) the Japan sea;

4~6-relation $h=h_0/\sqrt{r}$ for (4) direct wave, (5) diffracted wave, (6) twice diffracted wave.

Amplitudes of tsunami at Burevestnik and Petropavlovsk are reduced to the mouth of bays according to tables by Ikonnikova.

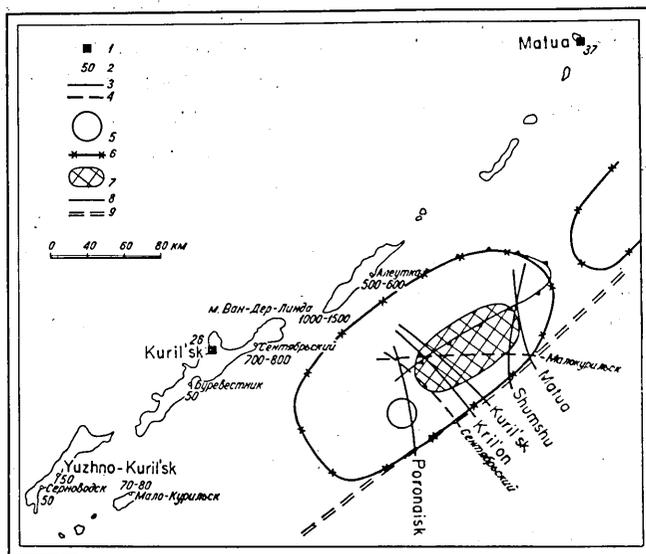


Fig. 6. Map of the tsunami of October 20.

1-mareographs; 2-maximum height of flood in cm. 3-isochrones of tsunami propagation to different points; 4-uncertain isochrones; 5-epicenter of the shock of October 20; 6-region of aftershocks of the principal earthquake; 7-assumed source of the tsunami of October 20; 8-foot of the Vityaz' range; 9-axis of the deep-water Kurile-Kamchatka trench.

affirms the justification of including the Simushir oval to the region of aftershocks of the Urup earthquake. So the total length of this region approaches 500 km.

In Fig. 3 the records of tsunami made at some Soviet stations are reproduced. The source of tsunami determined on the basis of these data is shown in Fig. 4¹⁾. The longitudinal axis of the source coincides with the longitudinal axis of the aftershocks domain. Both these lines as well as the inner isoseisms from Fig. 1 apparently indicate the location and length of the seismic source.

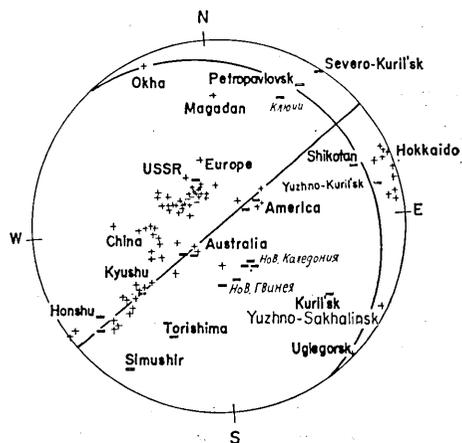


Fig. 7. Mechanism of the focus for the earthquake of October 13 as inferred from P-wave signs.

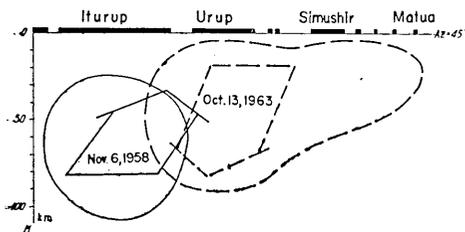


Fig. 8. Longitudinal vertical section of the foci of two earthquakes November 6, 1958 and October 13, 1963. Seismic source of 1958 and the relative movement of its "continental" wing according to V.N. Averyanova are shown by continuous lines. The same values for the source of 1963 are shown by broken lines.

with K. Iida's relation³⁾ between magnitudes of earthquakes and tsunamis. But near the source, at the southern extremity of Urup Island, the height of the flood was unexpectedly great and exceeded 10 meters. This phenomenon could perhaps be explained by a possible mighty underwater fall.

An attempt was undertaken to find the mechanism of the source for the three earthquakes described on the basis of the signs for P-waves (Fig. 7). Lack of necessary data however prohibits making final conclusions but it seems that in all three cases up and down movements have occurred along vertical faults. On October 13 the "oceanic" wing was perhaps more active and was shifted upwards (Fig. 8).

These conclusions somewhat disagree with peculiarities of tsunami source so that additional investigations of movements at foci of the Urup earthquakes are necessary.

Fig. 5²⁾ illustrates the attenuation of the tsunami amplitude with distance which can be approximated by cylindrical divergence. Waves diffracted into the sea of Okhotsk were 2.5 times weaker than the direct ones. Maximum radiation was directed to the center of the Pacific.

Some data about the tsunami of October 20 and its source are shown in Fig. 6. At large distances this tsunami was 2.5 times weaker than the sea wave of October 13. This fact is in good agreement

1) S.A. FEDOTOV, V.N. AVER'YANOVA, A.M. BAGDASAROVA, I.P. KUZIN and R.Z. TARAKANOV, "Some Results of Detailed Investigation of Seismicity of the South Kurile Islands," *Izvestiya Akademii Nauk SSSR, Ser. Geofizicheskaya*, 5 (1961), 633 (in Russian).

(2) Z.N. IKONNIKOVA, "Tsunamis in the Far East," *Trudy Dal'nevostochnogo Nauchno-Issledovatel'skogo Hidro-meteorologicheskogo Instituta. Vypusk 12* (1961), 3, (in Russian).

3) K. Iida, "Magnitude and Energy of Earthquakes Accompanied by Tsunami and Tsunami Energy," *J. Earth Sci., Nagoya Univ.*, 6 (1958), 101.

7. 1963 年の Urup 地震とそれに伴った津波について

ソ連邦 Sakhalin 総合科学研究所 Serguei L. SOLOV'EV

1963 年 10 月 13 日 5 時 18 分 (GMT), Urup 島東方沖に発生した強震は Kurile 列島全部に感じ、津波を伴った。Urup 島における津波の最高波高は 4~5 m であつた。

10 月 12 日にかなり強い前震があつたが、本震後も多くの余震が起り、その中で最大なものは 10 月 20 日に起きた余震で、局地的に波高 10~15 m の津波を発生した。以上の地震について、Sakhalin 総合科学研究所の観測結果から余震域、浪源域および津波の波高分布などを図示した。
