THE TASHKENT EARTHQUAKE OF APRIL 26, 1966, AND ITS AFTERSHOCKS

GEOPHYSICS

1967

SovietRxiv

Fig. 1. Isoseists of the Tashkent earthquake and epicenters of aftershocks. 1 –zones of different intensities, 2 –seismic stations, 3 –epicenters of the main shock and aftershocks

Figure 1: Fig. 1. Isoseists of the Tashkent earthquake and epicenters of aftershocks. 1 –zones of different intensities, 2 –seismic stations, 3 –epicenters of the main shock and aftershocks

Abstract

Full Text

UDC 550.340

GEOPHYSICS

V. I. ULOMOV, A. I. ZAKHAROVA, N. V. ULOMOVA

THE TASHKENT EARTHQUAKE OF APRIL 26, 1966, AND ITS AFTERSHOCKS

(Presented by Academician M. A. Sadovskii on February 16, 1967)

As a result of a survey carried out by staff members of the Institute of Seismology of the Academy of Sciences of the Uzbek SSR and the Institute of Earthquake-Resistant Construction and Seismology of the Academy of Sciences of the Tajik SSR ([1]), a map of isoseists of the Tashkent earthquake of April 26, 1966, was compiled (Fig. 1). The intensity of the shocks reached 8 points. Strong oscillations lasted 8-10 sec., accompanied by a powerful underground rumble. The zone of maximum shaking is elongated from the north-

Fig. 1. Isoseists of the Tashkent earthquake and epicenters of aftershocks. *1* –zones of different intensities, *2* –seismic stations, *3* –epicenters of the main shock and aftershocks

west to the southeast and occupies an area of about 10 km^2 in the central part of the city.

The configuration of the 8-point isoseist is probably determined by the character of the displacement of the rocks in the focal zone. The elongation of the isoseists of lower intensities in the northeastern direction is explained by unfavorable ground conditions and the strike of buried basement structures. A similar elongation of isoseists is also observed far beyond

within Tashkent, which is generally characteristic of the Tashkent region. The minimum ground shaking in the city was observed on the pebble deposits of the Chirchik River that are favorable in a seismic respect (the southeastern part of the city territory).

At the Central Seismic Station "Tashkent," at the moment of the main shock, instruments of the following types were operating:

1. A three-component installation consisting of SVK and SGK seismic receivers and GK-UP-M galvanometers. The frequency response is flat in the period interval $0.3 \div 9.0$ sec. Magnification 1000, recording speed 60 mm/min.
2. A three-component installation consisting of VEGIK vibrographs and an H001 electrographic oscillograph with visible recording. The frequency response is flat in the period interval $0.05 \div 1.5$ sec. Magnification about 2000. Recording speed 240 mm/min. The sweep was in standby mode, with a memory of about 10 sec.
3. A three-component installation consisting of SK-Sh-M seismic receivers and an H002 oscillograph with thermal visible recording. The frequency response is flat in the period interval $0.05 \div 3.0$ sec. The magnification was different on all channels: from 300 to 3000; recording speed 120 mm/min.
4. A three-component installation of SMR-2 seismographs with mechanical recording. The frequency response is flat in the interval $0.3 \div 5.0$ sec. Magnification of the order of 7.
5. An SBM intensity seismometer.

Somewhat later the station equipment was supplemented by an automatic earthquake-recording installation UAR, AIS seismometers, ISO-2 + S-5-S accelerographs, and tiltmeters of the system of A. E. Ostrovskii.

On the day following the earthquake, directly in the epicenter, with the aim of determining the depth of occurrence of the foci of aftershocks, a mobile seismic station mounted on a GAZ-51 truck began operating. Recording was carried out by horizontal VEGIK seismic receivers and GB-IV galvanometers over a wide range of magnifications.

In addition, in the epicentral zone, the Institute of Physics of the Earth of the USSR Academy of Sciences and the Institute of Geophysics of the Academy of Sciences of the Armenian SSR installed the ESS epicentral seismic station and, at four sites on different soils, ISO-2 + S-5-S and AIS instruments. Aftershocks were also recorded at four sites in the city by seismometric equipment consisting of VEGIK vibrographs and OSB-VI-M oscillographs.

These stations, which had been operating at the time of the earthquake in standby mode, were switched in the second half of May to a continuous-recording mode.

On the recommendation of E. F. Savarenskii, in May–June another 7 stations were opened, of which 3 were opened by the Comprehensive Seismological Expedition of the Institute of Physics of the Earth of the USSR Academy of Sciences and 4 mobile stations by the Institute of Geology and Geophysics of the Academy of Sciences of the Uzbek SSR. (The location of the seismic stations is shown in

Fig. 1.) In July–August another 13 stations of the “Zemlya” type of the Institute “VNIIGeofizika” began operating. The main task of this group was the study of the deep structure of the Tashkent region.

The main shock of the Tashkent earthquake was recorded by all seismic stations of Central Asia, the nearest of which, “Tashkent,” was located at a distance of 2–3 km (the difference in arrival times of the transverse and longitudinal waves at the station was 2 sec). This made it possible to determine with high accuracy (±2 km) the coordinates of the earthquake focus: $\varphi = 41°19'.5$ N; $\lambda = 69°17'$ E; $H = 8$ km; origin time according to Greenwich: 23 hr 22 min 50 sec; earthquake magnitude $M = 5^1/_4 \div 5^1/_2$, which corresponds to $K = 13.5$ (M and K were found from (2)).

Immediately after the main earthquake there followed numerous weak repeated shocks—aftershocks, most of which were felt in the form of thunderous peals and sounds resembling powerful artillery salvos. In the first days the shocks followed one another every 2–3 min. Then these intervals increased, and the sound phenomena weakened somewhat. The presence of a large number of aftershocks of considerable strength is the most characteristic feature of the Tashkent earthquake (Table 1).

Table 1

Date	Greenwich time (hr, min)	Magnitude M	Energy class K	Depth H, km, instrumental	Depth H, km, by M, I_0	Intensity at the epicenter
1966						
7 V	21-10	3.9	11	6	4–6	6–7
9 V	17-27	3.5	10–11	7	5–7	5–6
9 V	18-45	4.4	12	7–8	5–7	7
9 V	18-50	4.1	11	6–7	7–9	6
24 V	07-49	3.7	11	5	2–4	7
4 VI	21-11	3.7	11	3	2–4	7
29 VI	09-00	3.6	10–11	2–3	2–3	7
4 VII	14-22	4.0	11	3	3–5	7
1967						
24 III	07–04	3.7	10–11	3	3–4	6–7

It is evident from Table 1 that the relatively high intensity of the aftershocks is explained by the small depth of occurrence of their foci. The focal depth was determined both from instrumental data from 3–9 stations and by the formula of N. V. Shebalin (3): $I_0 = 1.5M - 3.5\lg h + 3$, with good agreement of the results. The construction of dependences of the Benioff-graph type (4) for the periods between strong aftershocks made it possible to reveal the character of accumulation and release of elastic stresses and, on this basis, to predict the most

Fig. 2. Mechanism of deformation of rocks during the main earthquake and its repeated shocks (diagram).

Figure 2: Fig. 2. Mechanism of deformation of rocks during the main earthquake and its repeated shocks (diagram).

probable time of occurrence of strong shocks after 9 V 1966. These predictions were justified in 3 of 4 cases (seven-point shocks on 24 V, 5 VI, and 4 VII 1966).

By the end of 1966, more than 700 perceptible aftershocks with $K \geqslant 6$, recorded by the "Tashkent" station, had occurred. To determine the coordinates of their foci, the dynamic features of the records, the travel times of longitudinal and transverse waves, their differences, azimuths, and emergence angles of the seismic radiation from the arrivals of longitudinal and transverse waves were used in the broadest possible way. All constructions were carried out taking into account the features of the velocity section previously obtained on the basis of analysis of recordings of seismic waves caused by powerful industrial explosions and of seismic-prospecting data.

The coordinates of the aftershock epicenters were determined with an accuracy of $\pm 0.5 \div 1.0$ km. The epicentral zone of the aftershocks is elongated in a northwestern direction and occupies an area of about 10 km^2 (Fig. 1). Study of the focal mechanism of the Tashkent earthquake by the method of A. V. Vvedenskaya (5) showed that both possible rupture surfaces in the focus have northwestern strike. Along the more probable of them (according to geological data of A. G. Khvalovsky and N. B. Wolfson), the northeastern wing of the rupture was uplifted. The "opening" along the rupture occurred in a direction from northwest to southeast, approaching the roof of the Paleozoic basement, which lies within the city at a depth of 2.0–2.5 km.

Analysis of the wave pattern and of the distribution of aftershock hypocenters with depth makes it possible to present the phenomenon of repeated shocks as the result of relaxation of elastic stresses that arose at the moment of the earthquake in the over-focal zone (Fig. 2). The foci of the aftershocks are characterized by a slow "surfacing" from depths of 7–8 km to depths of the order of 2–3 km. It should be noted that, according to repeated leveling data obtained on the territory of Tashkent and its environs during the period of the aftershocks (A. P. Raizman), the epicentral zone of the aftershocks is characterized by a large (about 55 mm) local uplift. The results of secondary lev-

leveling of the city territory showed that the uplift of the earth' s surface was not simultaneous, but gradual. This confirms our ideas about the gradual relaxation of elastic stresses associated with the destruction of the over-focal region.

Fig. 2. Mechanism of deformation of rocks during the main earthquake and its repeated shocks (diagram). **1** –Mesozoic sediments, **2** –Paleozoic basement, **3** –zones of tectonic disturbances, **4** –hypocentral regions of the main earthquake and its aftershocks, **5** –Central Seismic Station "Tashkent," **6** –character of

rock displacements in the earthquake foci, **7** –conventional boundaries of rocks and the character of their shear displacement, **8** –uplift of the earth' s surface according to geodetic data.

As a result of a preliminary study of data from the network of Central Asian stations and the seismic stations of the Institute of Seismology of the Academy of Sciences of the Uzbek SSR located in Tashkent, the following were determined:

1. The coordinates of the foci of the main shock and 150 aftershocks of the Tashkent earthquake and their energy characteristics.

2. The mechanism of the earthquake focus.

3. The distribution of the seismic effect of the earthquake on the surface.

Institute of Seismology
Academy of Sciences of the Uzbek SSR

Received
10 II 1967

CITED LITERATURE

1. L. A. Kogan, L. K. Lozovich et al., *Architecture and Construction of Uzbekistan*, No. 10 (1966).

2. *Instructions on the Procedure for Carrying Out and Processing Observations*, Inst. Phys. Earth, Academy of Sciences of the USSR, 1966.

3. N. V. Shebalin, *Collection, Earthquakes in the USSR*, Vol. 5, Publishing House of the Academy of Sciences of the USSR, 1961.

4. G. Benioff, in: *Weak Earthquakes*, IL, 1961.

5. A. V. Vvedenskaya, *Izv. AN SSSR, ser. geofiz.*, No. 4 (1960).

Note: Figure translations are in progress. See original paper for figures.