CONTRIBUTION TO THE INVESTIGATION
OF SMALL INTERMEDIATE-DEPTH EARTHQUAKES
IN THE VRANCEA REGION

CORNELIUS RADU

Geophysical Research Centre, Acad. of RSR, Bucarest*

VLADIMIR TOBYAS

Geophysical Institute, Czechosl. Acad. Sci., Prague**

The principal instrument equipment of the seismic stations of the Roumanian Academy, placed nearest to the earthquake region of Vrancea (45°3' - 46° N, 25°9' - 27°6' E), was until 1965 formed by mechanical horizontal seismographs with a magnification of 40 (in Campulung, Foscani and Bacau), or 140 to 180 (in Iasi and Bucarest) [1]. The dynamic range of these instruments enables seismograms of intermediate-depth earthquakes to be evaluated from the weakest shocks with a magnitude of $M = 2.5 - 2.7$, up to intermediate strong ones with a magnitude of $M = 5 - 5.5$. The upper limit of the magnitude corresponds to the maximum recordable amplitudes at which the record still remains continuous and the instrument is still in operation. The lower limit corresponds to the minimum detected signal, which is determined by the quality of the record on smoked paper and by the level of the disturbing seismic noise. In optimum cases, for purpose of evaluation, the seismograms can be magnified optically up to 10 times.

The total number of intermediate depth earthquakes, exceeding the upper limit of the magnitude $M = 5.5$, was about 5 percent of all the earthquakes in the Vrancea region, recorded by the network of Roumanian seismic stations during 1937 - 1963 [2]. For purposes of their investigation, at least records of more remote stations are available. No data has so far been published about earthquakes with a magnitude $M < 2.5$. The nearest seismic station with sensitive short-period seismographs is in Rakhov (USSR) at epicentral distances of 2.5° to 3.1°, which records intermediate-depth earthquakes with a magnitude of $M \geq 3.5$ [3] from the Vrancea region at maximum magnification of 30,000. The number of weakest earthquakes recorded by Roumanian seismic stations is considerably lower than the extrapolated values of the occurrence frequency curves for shocks of intermediate strength. From observations covering 1954 - 1963 a dependence was derived of the mean number of earthquakes of the $K = 11 - 13$ energetic class, $\bar{N}$, on $K$ in the form $\log \bar{N} = 5.46 - 0.45K$ [4]. The earthquake magnitude interval $M = 0.66K - 3.20 \pm 0.33$ corresponds to the energetic class $K$. For $K = 10$ the number of earthquakes observed is still 75 percent, but for $K = 9$, including the lower limit of recorded shocks, only 7 percent of the extrapolated number. It may be assumed that this considerable difference is also due to the decrease of the threshold sensitivity of seismographs resulting from the solid friction of the recording stylus. For the predominant periods of seismic waves in the initial phase of the earthquake in the Vrancea region, the values of the threshold amplitudes at the seismic stations considered, considering simplifying assumptions regarding the character of friction and a stationary harmonic motion [5], are in hundredths of millimeters. They are, therefore, of the same order as the minimum trace amplitudes which can be evaluated on the seismogram, considering the optical magnification of the record.

*) Address: Str. Cuțitul de Argint 5, București.

**) Address: Boční II, Praha 4 - Spofilov.
The first stage of the research into weak earthquakes was aimed at equipping the seismic stations with more sensitive short-period seismographs. On the basis of short-termed measurements of the level of seismic noise in 1962 at selected stations in Campulung, Focsani and Iasi [6], these stations were gradually equipped with vertical electromagnetic seismographs with galvanometric recording in 1964 and 1965. At the stations in Campulung and Focsani, Hiller seismographs, and in Iasi a VEGIK seismometer with an OSB-VI oscillograph were installed. From the graphs of maximum amplitudes of the vertical component of short-period noise, observed under various conditions of disturbance (on work days, during the night, with traffic on nearby roads, etc.), the total maximum amplitudes of noise were derived as their envelope curves. From the condition that the peak-to-peak amplitudes of disturbances in the seismogram should not exceed 1 mm, the corresponding allowable magnifications of the seismograph for the individual stations (Fig. 1) were computed. The maximum magnification of the seismographs at all stations was adjusted to approximately the same value. The shape of the amplitude characteristics was not specially adjusted to suit the local conditions of seismic noise, and the recommended response characteristics of both types of seismographs were used. Their basic constants are given in Tab. 1.

A detailed analysis of the noise level on seismograms from 10 randomly selected days shows that at the Iasi station, where the magnification exceeds the partially allowable magnification, the prescribed level of disturbance on the seismogram was exceeded exceptionally over a period amounting to 5 percent of the total recording time. At the Campulung and Focsani stations larger disturbances occur for short intervals very seldom (at Focsani at night at double sensitivity). In agreement with the curves of allowable magnification it is possible to increase the sensitivity at these stations without adjustment of the amplitude characteristic. From this point of view the most convenient situation exists at Campulung, where the periods of the first onsets of seismic waves are outside the range of periods of the maximum of seismic noise.

Fig. 1. Mean magnification (thick curves), allowable magnification (thin curves) and the period range of the first onset of seismic waves for the Campulung (1), Focsani (2) and Iasi (3) stations.