Geophysics

Determination of Earthquake Magnitude by Digital Data

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ABSTRACT. By means of coda waves and broad band digital data a nomogram is constructed in order to calculate magnitudes of Caucasian earthquakes. It enables us to have a uniform catalogue of earthquakes from 1955 up to now. *© 2008 Bull. Georg. Natl. Acad. Sci.*

Key words: *coda wave, nomogram, envelope, broad band, uniform catalogue.*

Energetic characteristics are being determined for Caucasian earthquakes from 1955. Namely, energetic class K and magnitudes (by means of body, surface and coda waves) were determined. Analog seismograph records were used. In the eighties of the 20th century more than 40 seismic stations operated in Georgia; these stations were equipped with short period (SKM-3 type) and long and medium period (SD-SKD type) analog seismographs. Due to economic and political events that took place in the nineties in Georgia seismic stations gradually ceased functioning; from 2003 seismic stations of Georgia are being equipped with digital seismographs and now we have 15 digital seismic stations. Six seismic stations are calibrated (i.e. it is possible to determine dynamic characteristics of earthquakes). In Tbilisi and Oni broad band seismographs are functioning.

At present on the basis of digital data local magnitude Ml is determined by shear waves. It is desirable that the earthquake catalogue be uniform (i.e. to specify earthquakes using the same energetic characteristic). We have decided to determine magnitude on the basis of digital data using coda waves, because for Caucasian earthquakes magnitudes determined by coda waves and surface waves are equal within the limits of error [1]. For the Caucasian earthquakes two nomograms exist which are obtained by using coda waves: one nomogram for short period records, the other – for long and medium period records [1, 2]. Thus it is possible to determine magnitudes from digital data using nomograms for corresponding frequency band. And then we can compile a nomogram for computing magnitude, using coda waves for broad band digital data.

For this purpose 19 earthquakes of the Caucasus and Turkey were selected (Table). Their local and moment magnitudes varied within 1.5-5.8, epicentral distances ranged between 10 – 380 km. Digital records obtained at Mtatsminda, Oni, Delisi, Akhalkalaki and Gori were used. In order to determine earthquake magnitudes by coda waves, digital records were filtered approximately in the frequency band that was similar to frequency characteristics of analog seismographs with short period (1.0 - 2.5 Hz) and medium and long period (0.07 – 2.5 Hz). Magnitudes were determined (where it was possible) by nomograms for equipment with short period, as well as for medium and long periods. It is known that for the Caucasian earthquakes coda waves arrive approximately at a time which is 2-3 times more than the travel time of a transverse wave (time is measured from the origin time) of origin [1] and that's why an earthquake record should be long enough (coda window) for measurement of corresponding amplitudes. The method of measurement of coda amplitudes is considered in [2]. Afterwards, for the same earthquakes maximum amplitudes of coda were measured for broad band records of Mtatsminda and Oni and coda envelope in 50-2000 sec time interval was obtained. In order to draw a nomogram we determined the correlation between measured coda amplitudes A_{100}

Table

Data & Time		Longitude, degrees	Latitude, degrees	Magnitude	Coda Magnitude
12.03.2005	07-36-10.5	39.42	40.90	Mb=5.4 Mw=5.6	5.5
06.06.2005	07-41-28.5	39.22	41.08	Mw=5.6	5.6
06.10.2005	17-57-28.3	42.72	42.03	ML=4.7 Mw=4.2	4.3
06.02.2006	04-08-00.1	42.64	43.52	Mb=5.0 Mw=4.8	4.8
06.02.2006	09-43-24.3	42.62	43.59	Mb=4.3	4.2
01.04.2004	06-35-40.6	41.19	43.70	ML=2.6	2.3
17.04.2006	05-13-32.4	42.4	45.33	Ms=4.0	4.1
21.02.2007	11-05-27	38.33	39.27	Mb=5.7 Mw=5.7	5.7
09.07.2007	09-33-27.7	41.11	43.86	ML=4.3	4.0
18.07.2007	19-16-39.6	42.45	43.72	ML=3.9	3.5
24.07.2007	18-16-46.7	41.33	43.86	ML=2.1	1.8
24 .07.2007	19-31-23.2	41.32	43.70	ML=4.4 Mw=4.4	4.2
24.07.2007	21-16-38.2	41.36	43.80	ML=1.5	1.2
24.07.2007	20-24-50.2	41.24	43.74	ML=2.5	2.1
25.07.2007	05-25-53.4	41.27	43.76	ML=1.6	1.2
14.08.2007	22-21-05.5	41.52	43.83	ML=3.8	3.4
25.08.2007	22-05-48	39.28	41.17	Mw=5.1	5.1
04.09.2007	22-12.50.0	41.12	43.85	ML=3.7	3.4
05.09.2007	00-11-32.2	39.28	41.17	Mw=5.1	5.1

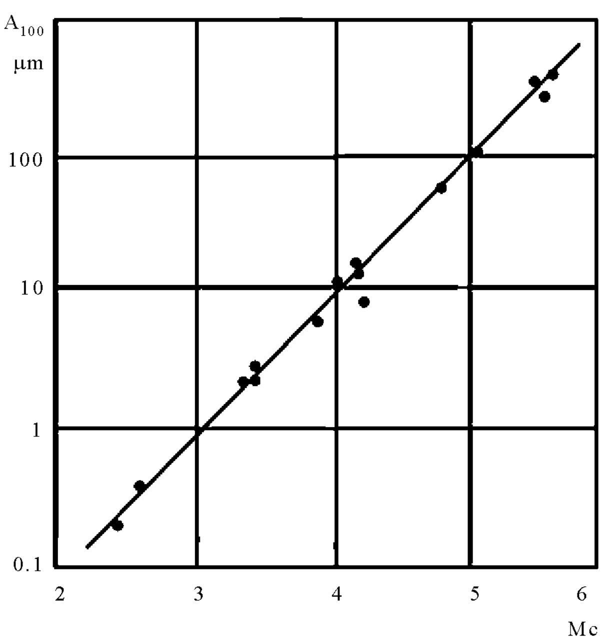

Fig. 1. Correlation between coda magnitude Mc and A100.

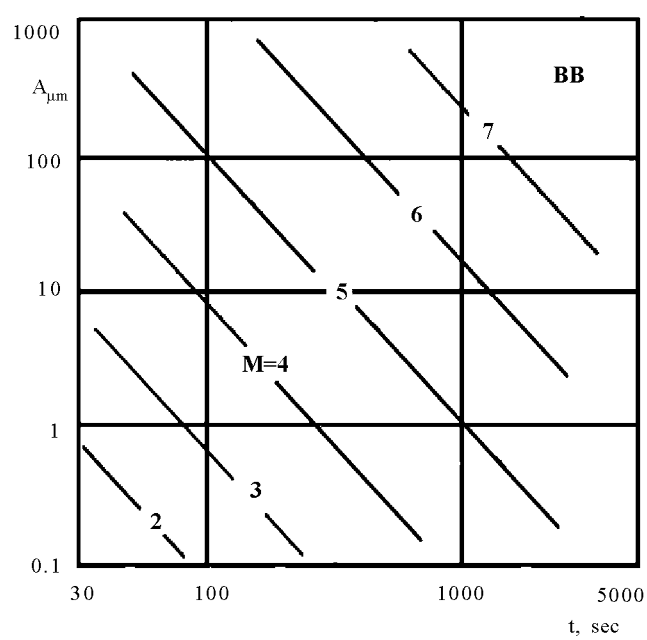

Fig. 2. Nomogram for defined coda magnitude using broad band digital data.

at fixed (t = 100 sec) time and calculated (by us) coda magnitudes (Fig.1). Correlation between Mc (magnitude, determined by coda waves) and A_{100} is approximated by the straight line:

$$\lg A_{100} = -3.1 + Mc\ ,$$

with the help of this relationship and coda envelope we obtained the nomogram by which magnitude can be defined using broad band (BB) digital data of Mtatsminda and Oni (Fig.2). Also we computed the correction of "Oni" station with respect to "Mtatsminda" station:

$$\delta = \frac{\sum A_{mta}/A_{oni}}{n} = 1.15$$

where n is the number of earthquakes. It means that before the obtained nomogram is used for Oni records, measured amplitudes of coda should be multiplied by station correction.

The obtained nomogram will enable us to compute coda magnitude by broad band digital data of Oni and Mtatsminda; the use of this nomogram is more advisable for M ≥ 3.0 earthquakes, and for earthquakes with smaller magnitude the nomogram for short period (SKM) records is appropriate [1]. This nomogram needs no correction for epicentral distance because in a certain frequency band the form of coda envelope does not depend on the epicentral distance, azimuth of station, depth of the earthquake, and so the magnitude defined by only one station (after making a correction for corresponding station) coincides with the magnitude defined by several seismic stations [1]. Thus, the obtained nomogram will enable us to compile a uniform catalogue for Caucasian earthquakes from 1955 to the present day, which is very important for a number of seismological tasks.

გეოფიზიკა

მიწისძვრის მაგნიტუდის განსაზღვრა ციფრული მონაცემებით

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მაგნიტუდის გამოთვლა კავკასიის მიწისძვრებისათვის წარმოებს 1955 წლიდან. მაგნიტუდები ისაზღვრებოდა ზედაპირული ტალღების საშუალებით, 1980-იანი წლებიდან კი, აგრეთვე, - მოცულობითი სიგრძივი ტალღებიდან. სეისმური ქსელის ციფრული სეისმოგრაფებით აღჭურვის შემდგომ ხდება ლოკალური მაგნიტუდის გამოთვლა განივი ტალღების საშუალებით. სტატიის ავტორთა მიზანია მიწისძვრების დახასიათება ერთგვაროვანი ენერგეტიკული მაჩვენებლებით, იმისდა მიუხედავად, თუ რომელი ტიპის სეისმოგრაფით იქნება იგი ჩაწერილი (ანალოგური თუ ციფრული). ამისათვის გამოიყენეს კოდა ტალღები და ააგეს ნომოგრამა კავკასიის მიწისძვრის მაგნიტუდის გამოსათვლელად კოდა ტალღებისა და ფართო დიაპაზონის მქონე ციფრული მონაცემების საშუალებით. იგი საშუალებას იძლევა, ვიქონიოთ მიწისძვრების ერთგვაროვანი კატალოგი 1955 წლიდან დღემდე, რაც მეტად მნიშვნელოვანია სეისმოლოგიის ბევრი ამოცანის გადასაწყვეტად.

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