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EARTH PHYSICS

REEVALUATION OF THE MACROSEISMIC EFFECTS OF THE 23 JANUARY 1838 VRANCEA EARTHQUAKE

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Abstract. The aim of this paper is to analyze the great event that occurred on January 23, 1838 (magnitude M_w = 7.5 in the Romanian catalogue). Valuable information has been collected from original or compiled historical sources, such as chronicles and manuscripts on that time, and related books and reports. The historical data are critically analyzed and, on the basis of our investigation, we showed the degree of significance of the earthquake parameters, as resulted from the effect distribution. The pattern of the intensity data points as reevaluated for this historical earthquake is compared with the pattern of instrumentally recorded major earthquake of March 4, 1977, the two events assumed to be similar as hypocenter location, source parameters and rupture propagation.

Key words: historical earthquakes, Vrancea.

1. INTRODUCTION

The Vrancea seismic region generates each century at least one major earthquake felt over an extended area in Europe. Certainly, it is crucial, for seismic hazard evaluation, to know as much as possible the characteristics of these large events. In the 19th century, two Vrancea major shocks produced extreme damage as reported in different contemporary documents: October 26, 1802 (M_w = 7.9) and January 23, 1838 (M_w = 7.5). The event of 1802 was evaluated as the largest size Vrancea event. At the moment, it is difficult to send out a reliable estimation of the source depth for these events.

The earthquake of January 23, 1838 occurred at around 3 o'clock in the night and, according to the available information, caused damage over more than two thirds of Romania. It was also felt over an extended area in Europe including Ukraine, Poland, Bulgaria, Russia, Turkey (up to Constantinople), the northeast Italy, and Greece. The damage in the epicenter region was widespread and varied from place to place over a great distance.

This event is listed in all the catalogues including Vrancea activity [1, 14, 18, 28, 31, 34]. According to the modern writers the event was assigned with a magnitude of 7.5, [7, 16, 20, 29, 30, 33].

Unfortunately, most of the catalogues compiled for earthquakes that occurred in Romania [30, manuscripts published by 17; Constantinescu and Marza, 1980 and 1995; ROMPLUS catalogue by 20, updated daily on the web site www.infp.ro of the National Institute of Earth Physics, in Magurele], are not providing the procedures followed to estimate the magnitude and depth for historical events.

The main goal of the present paper is to re-evaluate all the historical information related to the major earthquake occurred on January 23, 1838. This kind of approach provides an important and objective tool to parameterize the size and location of the Vrancea historical events. Taking in to account that both magnitude and focal depth control the shape of the intensity distribution, the parameterization of historical damaging events (the set of such events in the case of the Vrancea source is better represented in comparison with the majority of other seismic sources in the world) is obvious for improving seismic hazard assessment.

2. REGIONAL TECTONICS AND SEISMICITY

The Vrancea seismic zone is located in Romania (Fig. 1), in the South-Eastern Carpathians arc bend at the contact between the Eastern European plate to the north and north-east, the Moesian sub-plate to the south and the Intra-Alpine sub-plate to the west.

Vrancea marks the last stage of a subduction /collision process along the Carpathians. Remarkably, this stage is characterized by particularly strong intermediate-depth seismicity. The hypocenters of the earthquakes are concentrated to a small epicenter area of approximately 30×70 km^2. The depth extent of seismicity ranges from 70 to 180 km with only few events above and below. A seismic gap at depths of 40–70 km led to the assumption that the lithospheric slab is presently detached. Up to now the deepest event that has been recorded with reliable depth resolution was localized at a focal depth of 220 km [21]. According to the historical catalogue of Vrancea events, large intermediate-depth shocks with magnitudes $M_w > 6.5$ occur three to five times per century. The most recent large events occurred in 1940 ($M_w = 7.7$), 1977 ($M_w = 7.4$), 1986 ($M_w = 7.1$) and 1990 ($M_w = 6.9$).

For figures exceeding this limit please consult with the editor first. For scanned figures, the depth of colors shall be set at maximum 8 bytes. Usage of colored figures isn't currently encouraged. The rate of the seismic moment release of the intermediate-depth seismicity within this small volume (0.8 × 1019 Nm·yr^{-1}) is comparable to the seismic moment rate for the entire Southern California [36, 67], inducing a high seismic hazard for the region, especially to Bucharest, the capital of Romania.

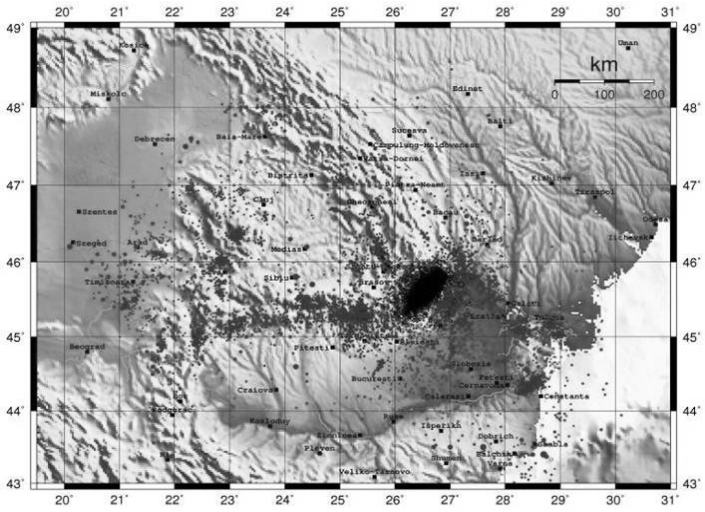

Fig. 1 – Epicentres of the earthquakes occurred on the Romanian territory between 984 and 2011, with events at normal depth (less than 60 km, gray dots), as well as at intermediate depth (60–180 km, black dots) (after ROMPLUS catalogue – http://www.infp.ro/catalog-seismic).

3. DESCRIPTION OF THE 1838 EARTHQUAKE IN CONTEMPORARY SOURCES

Romania at that time was divided into three principalities: Moldavia in the reign of Michael Sturdza (1834–1849), Transylvania under the rule of King Ferdinand V (1835–1848) and Valachya, led by Alexandru D. Ghica.

The most important data for assessing the effects of historical earthquakes are those coming from sources contemporary to the event. Frequently, these data are the most problematic, since many studies, reports or catalogs which mention the event do not specify any information about the sources. Therefore, we had to go back to the contemporary sources, official documents and reports related to earthquake damage, newspapers and comments of foreign travelers, and compilations of historians. Many of these data are available in the archive of the Romanian Academy library. In describing the effects of this earthquake in the extra-Carpathian region, reliable sources are: *Gustav Schűller*'s report (mine adviser of the Grand Duke of Saxony, commissioned by the Governor of Romania to study this phenomenon); "Romania" newspaper – which refers more to the misery caused by this earthquake in Bucharest and its description in Bukovina, made by [25].

Gustav Schűller completed its report after visiting the Slam-Ramnic (Ramnicu Sarat), Buzau, Ialomita and Prahova counties. Note that his mission was deployed immediately after the earthquake. He encountered numerous cracks and

fissures, opened especially in the lower terraces of the rivers Siret, Putna, Milcov, Ramna, Ramnic, etc., most of them parallel to the river course.

In the Ramnicu Sarat county, Gustav Schuller stated: "at the Rogoz piquet, the earth was cracked, the water burst and then ascended to the human waist." In the Lămoteşti, Malurile, Bolboca and Corbu villages, cracks and fractures of the earth were observed. The crack size was proportional to the size of the valley, terrace or floodplain were it formed. Their length reached from a few centimeters to tens or even hundreds of meters, the width from a few centimeters to several tens of centimeters and the depth reached even at four meters as in Băbeni village where cracks destroyed about 16 houses. Sometimes, through these cracks, water mixed with sand burst to the ground surface, especially in the lowlands, while in the upper courses of rivers (in the sub-Carpathian hills), these cracks did not contain any water or sand. The material brought to the surface had either yellow gray color or dark gray one. Some cracks were closed shortly after the earthquake but others have lasted long time after. About the behavior of construction, the author noted that, "all massive and stone masonry buildings have suffered greatly, and some of them, especially churches and other large buildings could not be used. The peasant houses and all wooden buildings, being flexible and adaptable, all were less damaged than the others buildings, but everywhere stoves were cracked and broken. In some places, the earth has bended in waves like the ones when the sea swells, and objects that are on earth, such as houses and trees go up and down, just like a boat rocked by a storm" [32].

The earthquake was strongly felt in Bucharest, lasting about 30 seconds. All the houses were damaged – some less, others more – because of this terrible shock.

The "Romania" newspaper wrote in its issue dated January, 23, 1838: "Mr. Alexandru Dimitrie Ghica, along with much of the nobility and aristocracy of the city and representatives of foreign countries were at theater where a French band represented "Angelo" play. At the first signs of the earthquake, the public panicked, the ladies screamed and fainted, and all crowded to the exit to escape from the theater building, which could knock down upon them [34].

The „Romania" magazine also mentions that, "few walls remained with no cracks in Bucharest". The newspaper also reported on an aftershock produced after a few days, on January 11: "On January, 24, at dawn, at 3 o'clock in the morning, a small earthquake felt in Bucharest, with two small shaking, that moved the earth" [3].

Prof. *Wurzer* [38] stated that "a powerful earthquake crossed, shaking the capital of Bukovina, on January, 23, 1838, in the evening, like the wind that chases away a storm cloud, with a hissing roar that seemed to raise the earth, brought the inhabitants of Czernowitz, in an unspeakable fear and terror". He continued: "It was on January 23 evening, when, as in previous days, a very cold weather kept every family close together and a deep silence reigned in the capital of Bukovina and a deeper one into the air, when suddenly they heard a hissing roar that seemed to have come up from the ground and along with the wind accompanied the storm. At that time, the earth shacked strongly and the buildings began to lurch visibly.

Shortly afterwards, followed a stronger shake and again, a third one, but much weaker. The earthquake lasted only a minute and a half, but even in this short time, caused concern, fear and terror everywhere. However no life was endangered and no house was much damaged. The buildings had only here and there a few cracks and broken windows".

In Transylvania the earthquake was felt more in the south-east. The massive mountain which rises between the Romanian Plain and the Transylvanian Depression were not formidable obstacles in the path of the seismic flow energy released from the outbreak. According to *Rethly* [31] and *Florinesco* [11], the rocks fell down in Harghita mountains area creating this way a new lake (Red Lake). On the other hand, Prof. *Herbich* [13] considered that the deluvial material slipping on Ghilcos and Piatra Rosie mountains occurred after heavy and long-lasting rains that caused sudden melting of snow. This huge amount of water soaked and increased deluviale deposits weight on the slopes, facilitating the separation and sliding of a huge mass of material that has crossed the Bicaz Valley upstream the junction with Suhard river. The water accumulated behind this natural dam formed Red Lake. It seems therefore that the oscillations caused by the earthquake have acted only as a trigger, so that the intensity of seismic shock could be less.

Two motions was felt in Sibiu, on the east-west direction, and several buildings suffered damage. Strong shakings were also felt in Nadas village. The river ice has been broken. Many people were injured. The earthquake was also felt in Cluj, but it was very weak. The earthquake effects have spread far to the west, as recorded by the seismometers in Milan. 39 churches were destroyed or suffered damages in Valcea county, as well as in Romanati District (53 churches), in Mehedinti County – 4 churches and in Olt County – 17 churches.

Severe damages were recorded in: Dambovita, Prahova, Ilfov and Ialomita counties, in Săcele, Buzau, Ramnicu Sarat cities. Major damages were reported in Ramnicu Sarat and Putna villages. In these areas the soil was split over long distances, some cracks having a length of 40 meters and a width of 2 meters. In some villages the water has flooded the houses and basements.

The information on the effects of the earthquake in south-eastern Romania, close to Danube river (Calarasi, Dobrogea) is sparsely.

The 1838 earthquake was strongly felt in the Balkan Peninsula: Turnovo, Trojan, Vratsa, Drianovo, Lukavitsa, in Tsaribrod region and with a lower intensity in Istanbul, Pera and eastern Thrace. The shock was felt in the Skodra lake region, in Albania [2, 18].

4. REVISED MACROSEISMIC DATA

Set out below are fairly literal translation of the most important sources of information about local earthquake effects. As far as the other locations are concerned, we simply offer a strictly faithful summary of available information, to

provide the complete set of intensities, locations and coordinates and to draw a new map of the macroseismic area of the Vrancea earthquake. According to the information found in the mentioned documents, the damages caused by this earthquake are summarized as in Annex 1 (Table 1). A total of 128 intensity data points are resulting from our investigation.

Based on the intensity data values, the representation of the isoseismals is given in the Fig. 2. The geographic distribution of intensity provides useful information on both structural features of the affected region and the focal mechanism of the seismic event source.

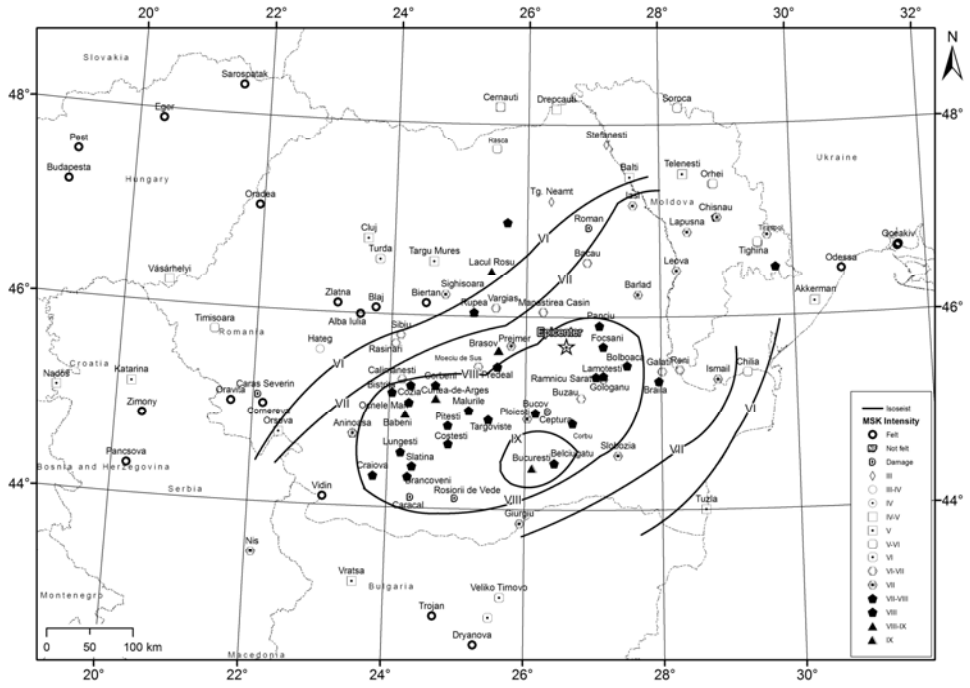

Fig. 2 – The seismic intensity map based on the intensity revised data**.**

The analysis of the resulted intensity pattern shows the NE-SW elongation of the isoseismals, which is typical for Vrancea major shocks. At the same time, an enhancement of effects toward SW is visible, suggesting directivity effects like in the case of 1977 earthquake. The strong attenuation toward NW is also revealed.

Further comparative analysis of the intensity as a function of epicenter distance for the 1838 earthquake, with two major Vrancea earthquake, registered instrumentally and located in the upper part (1977, h = 94 km), the other in the lower part (1940, h = 150 km) of the descending slab is showed in Fig. 3. The analysis was done on four quadrants. The general trend of the distribution is closer to the 1977 event, which asymmetrically ruptured toward SW.

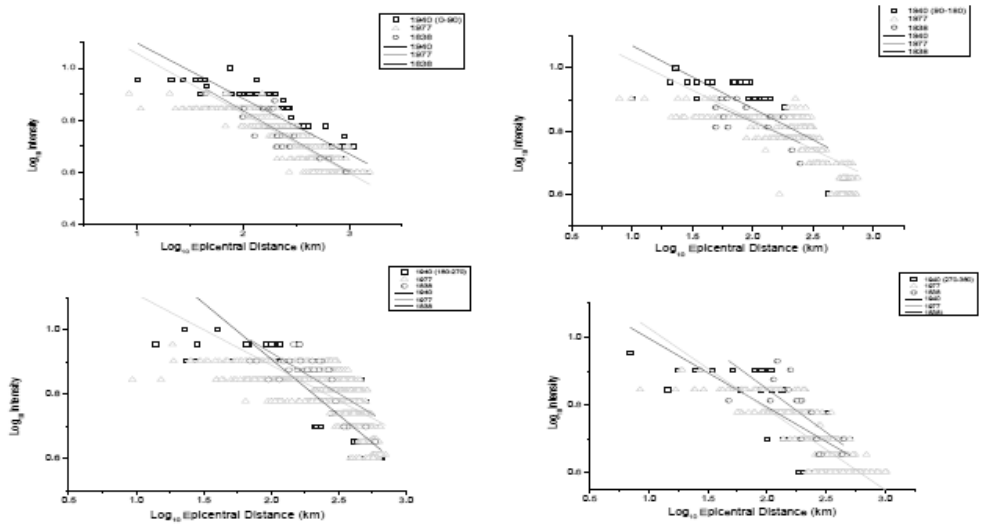

Fig. 3 – The distribution of intensity with epicenter distance from three Vrancea earthquakes plotted separately in four quadrants**.**

5. CONCLUSIONS

A careful and thorough review of all the available documents, studies and reports on the Vrancea earthquake of 1838 is carried out in the present study. In this way, we hope to fill up the gap between the original information and the catalogue compiled parameters, which in most of the cases are presented as they are, without any reasonable justification.

In most available publications the earthquake is dated on January 11, (23 old style) Tuesday to Wednesday, the St. Theodosius day.

The earthquake caused major damage in the Romanian Plain, in localities like Ramnicu Sarat, Buzau, Focsani to the east and Craiova and Slatina to the west and in the southern part of Moldova. Bucharest and its surroundings were particularly affected. Severe damage was reported to the houses and buildings. Thus, 36 houses and 5 churches were completely destroyed and another 50 churches were strongly damaged. 8 people were killed and 14 injured.

In his report, Gustav Schüller noted that almost all massive buildings constructed from stone and churches, in particular, suffered more and „weren't able to be further used". "The peasant houses and all buildings made of wood were less damaged than the others, especially the stoves, which have cracked and have been everywhere ruined". He reported also a lot of morphological effects, especially in the Buzau Valley and Ramnicu Sarat area. The effects consisted in occurrence of cracks in the ground near the river courses, settlements, formation of the craters and pits filled with sand.

The earthquake was also felt quite strongly outside Romania, in Republic of Moldova, Russia, Hungary and Greece [2, 14, 28, 34].

Based on all information gathered and organized in Table 1, the macroseismic intensities were evaluated. The estimation of the effects was carried out using the Medvedev Sponheuer – Karnik (MSK – 1964) scale. The analysis of effect distribution highlights the preferential propagation of seismic energy toward south and south-west, which would be in favor of the hypothesis of a focus located in the upper part of the Vrancea active zone (90-100 km), similarly to the March 4, 1977 earthquake.

Annex 1

Table 1

Intensity data points (MSK scale) for the 1838 earthquake: localities and areas mentioned in historical sources and local effects; D = damage; F = felt

Nr.	**Locality name** (current)	**Locality name** (original)	**Country**	**Lat.** (^{0}N)	**Lon.** (^{0}E)	**Reference**	**I (MSK)**	**Damage**
1	Cetatea Alba	Akkerman	UA	46.13	30.30	[35]	5	Accompanied by two strokes in underground roar from south to north-west, and lasted two minutes.
2	Alba Iulia	Alba Iulia	RO	45.99	23.52	[9]	F	Earth shakening
3	Aninoasa	Aninoasa	RO	44.75	23.48	[5, 6, 22]	7.5	collapsed church
5	Bacau	Bacau	RO	46.570	26.910	[6]	6.5	Strong earthquake
6	Babeni	Babeni	RO	44.97	24.24	[10, 14, 32]	8.5	cracks in the soil that damaged 16 houses.
7	Barlad	Barlad	RO	46.23	27.67	[5, 6, 22]	7	destroyed churches and houses
8	Balti	Balti	MO	47.45	27.55	[35]	5	Minor cracks in the buildings, doors cracked

9	Belciugatu	Belciugatu	RO	44.48	26.43	[32, 35]	8	cracks in the soil
10	Berdichev	Berdichev	MO	49.89	28.60	[35]	F	It was felt
11	Biertan	Biertan	RO	46.13	24.49	[31]	F	It was felt
12	Bistrita	Bistrita	RO	45.19	24.04	[42]	8	Damage on the building of Bistrita monastery
13	Blaj	Blaj	RO	46.06	23.75	[31]	F	It was felt
14	Brancoveni	Brancoveni	RO	44.32	24.30	[23]	8.0	Collapse of Brancoveni Monastery
15	Brasov	Brasov	RO	45.65	25.60	[1, 10, 11, 18, 28, 31, 34, 35]	8.5	Lasted one minute and 30 seconds, walls cracked, chimneys, gables, roofs collapsed with a terrible noise, so that a large number of houses became uninhabitable
16	Bucuresti	Bucuresti	RO	44.43	26.10	[1, 4, 5, 6, 8, 11, 12, 15, 19, 22, 23, 26, 31, 32, 34, 35]	9	Lasted 30 seconds. Reported 73 death, 14 injured, 36 house collapsed. Only few houses have remained without cracks in the walls
17	Budapesta	Budapesta	HU	47.18	19.00	[31]	F	It was observed
18	Bolboaca	Bolboaca	RO	45.50	27.50	[10, 31, 32, 35]	8	Cracks in the soil, the cracks extended under the houses and affected them very much.
19	Bohodarovka	Bohodarovka	UA	49.40	37.08	[35]	F	Lasted about 10 seconds
20	Braila	Braila	RO	45.34	27.97	[35]	7.5	all houses were damaged, some of them were completely destroyed

21	Buzau	Buzău	RO	45.16	26.82	[22, 32, 35]	6.5	Episcopal Complex in Buzau was demolished
22	Bucov	Bucov	RO	45.00	26.15	[35]	7.5	all houses were damaged, some of them were completely destroyed
23	Calimanesti	Calimanesti	RO	46.22	24.18	[31]	6.5	The chandelier felt and cracks in the castle
24	Caracal	Caracal	RO	44.11	24.35	[22]	D	The church was damaged
25	Caras Severin	Caras Severin	RO	45.11	22.07	[9]	D	It was a big earthquake
26	Ceptura	Ceptura	RO	45.02	26.33	[22]	D	The church was damaged
27	Cernauti	Cernauti	UA	48.18	25.56	[25, 35]	5.5	Windows were broken
28	Chilia	Chilia	UA	45.42	29.28	[35]	5.5	Big earthquake; lasted three minutes and a half, causing cracks in some houses
29	Chisnau	Chisnau	MO	47.03	28.88	[35]	7	It was heard a loud bang, followed by an underground hit, then the earth started wobbling, the walls and roofs were vibrating, the doors, windows, and furniture cracked, some things felt.
30	Cluj-Napoca	Cluj-Napoca	RO	46.78	23.60	[1, 31]	5	The houses had cracks
31	Corbeni	Corbeni	RO	45.28	24.67	[32]	7.5	Cracks in the soil
32	Corbu	Corbu	RO	44.89	26.70	[10, 32, 35]	8	Cracks in the soil, the cracks extend under the homes and affected them very much.

33	Cornereva	Cornereva	RO	45.02	22.15	[9]	F	Large earthquake
34	Costesti	Costesti	RO	44.67	24.88	[46]	8	The walls of Bistrita Monastery were affected
35	Cozia	Cozia	RO	45.27	24.31	[47]	7.5	Hermitage of St. Ioan la Piatra was ruined
36	Craiova	Craiova	RO	44.32	23.80	[11, 31, 35]	8.0	All houses were damaged, some of them completely destroyed, more than 100 cracks in the soil, partially filled with water.
37	Curtea-de-Arges	Curtea-de-Arges	RO	45.14	24.68	[15, 26]	8.5	The Episcopal city Curtea de Arges was completely destroyed
38	Drepkautsy	Drepcauti	MO	48.16	26.43	[35]	4.5-5	Some cracks in a church
39	Dryanova	Dryanova	BG	42.59	25.29	[2]	F	It was severe
40	Varzsonyi	Varzsonyi	HU	46.35	17.22	[31]	F	Felt
41	Eupatoria	Eupatoria	UA	45.20	33.36	[31]	F	Felt
42	Focsani	Focsani	RO	45.70	27.15	[32]	8	Large cracks on the banks of the Siret river.
43	Fatezh	Fatezh	RU	52.10	35.87	[35]	NF	Not felt
44	Galati	Galati	RO	45.43	28.02	[5, 22]	6.5	The tower of St. Spiridon church was affected
45	Giurgiu	Giurgiu	RO	43.86	25.97	[35]	7	all houses were damaged, some of them were completely destroyed
46	Gologanu	Gologanu	RO	45.36	27.15	[10, 11, 32, 35]	7	the larger damage and more intensive phenomena occurred in this area

47	Hateg	Hateg	RO	45.61	22.95	[9]	3.5	The earth was shaken
48	Iasi	Iasi	RO	47.16	27.60	[5, 8, 22, 34, 35,	7	Lased two minute and half. Many churches and monasteries suffered damage, the wall cracked or fell down.
49	Istanbul	Constantino-pol	TR	41.01	28.98	[1, 2, 11, 18, 28, 31, 34 35]	F	two shakes were felt severely
50	Ismail	Ismail	MO	45.35	28.84	[10, 31, 35]	7	It lasted three minutes. In all buildings walls were cracked, ovens and chimneys were more or less damaged, and in some houses the walls completely collapsed. Six people received slight injuries from the collapse of their walls and plaster. The Cathedral of the Holy Virgin Protection was severely damaged
51	Jitomir	Jitomir	MO	50.25	28.67	[35]	F	Felt
52	Katarina	Katarina	RS	45.16	20.21	[31]	5	Church damaged
53	Karikiv	Karikiv	UA	50.00	36.23	[35]	F	Lasted 30 seconds; felt; tree curl
54	Kursk	Kursk	RU	51.72	36.18	[35]	4	swinging chandeliers and lamps
55	Kaluga	Kaluga	RU	54.53	36.27	[35]	F	Lasted 10 second
56	Eger	Eger	HU	47.90	20.37	[31]	F	Felt

57	Ekaterinoslav	Dniepropetrovsk	UA	48.46	35. 03	[10, 31]	F	Felt
58	Evpatoria	Evpatoria	UA	45.20	33.36	[35]	F	Felt
59	Kiev	Kiev	UA	50.45	30.52	[28, 31, 35]	F	Felt
60	Lacul Roşu	Lacul Roşu	RO	46.47	25.47	[11, 23, 31]	8.5	The Rosu lake was formed after rocks falling into Bicaz river.
61	Lacul Skodra	Lacul Skodra	AL	42.07	19.53	[2]	F	The shock was perceptible in the region of Skodra lake
62	Lamotesti	Lamotesti	RO	45.39	27.15	[2, 10, 15, 35]	8	Cracks in the soil. The cracks were filled with sand and dark mud.
63	Lapusna	Lapusna	MO	46.88	28.42	[35]	7	Lasted 3 minutes. In the stone church from the village a stone fell from the dome and pierced the wooden floor
64	Leova	Leova	MO	46.48	28.25	[35]	7	earthquake accompanied by a terrible roar; three more blows shook the house foundation, the stoves and chimneys were wrecked, the windows broken, the doors bounced and the walls were cracked. Church bells beat by itself
65	Lukavitsa	Lukavitsa	BG	41.48	24.51	[2]	F	It was severe
66	Lungesti	Lungesti	RO	44.57	24.19	[42]	8.0	The central tower of the Monastery Mamu fell down

67	Manastirea Casin	Manastirea Casin	RO	46.05	26.25	[5]	6.5	Church and additional buildings were affected.
68	Milano	Milano	IT	45.46	9.19	[2, 10, 11, 31]	F	Felt
69	Moeciu de Sus	Moeciu de Sus	RO	45.48	25.30	[9]	6.5	The earth trembled very much
70	Malurile	Malurile	RO	45.02	25.17	[2, 11, 10, 15, 35]	7.5	cracks in the soil
71	Moscova	Moscova	RU	55.27	37.22	[31]	F	Felt
72	Nades	Nadoš	RS	45.05	19.12	[10, 31]	5	It was a very strong earthquake, shaking all the buildings.
73	Nowomoskowsk	Nowomoskowsk	UA	48.57	35.12	[31]	F	Felt
74	Ocnele Mari	Ocnele Mari	RO	45.09	24.29	[35]	7.5	In town, the destructive force was very high; in one church the bell fell down
75	Odessa	Odessa	UA	46.47	30.73	[10, 18, 28, 31]	F	Violent shocks
76	Oceakiv	Oceakiv	UA	46.67	31.59	[35]	F	Felt
77	Oradea	Oradea	RO	47.07	21.93	[9]	F	Felt
78	Orhei	Orhei	MO	47.37	28.83	[35]	5.5	Cracks were at the St. Dumitru Church and in the other buildings
79	Orsova	Orsova	RO	44.73	22.40	[18, 28, 31, 34]	5.0	The shocks were violent.
80	Oravita	Oravita	RO	45.03	21.68	[31]	F	Felt
81	Panciu	Panciu	RO	45.91	27.09	[39, 48]	8	The Brazi monastery was damaged
82	Pancsova	Pancsova	RS	44.31	20.23	[31]	F	Felt
83	Pest	Pest	HU	47.50	19.10	[31]	F	Felt
84	Perekon	Perekon	UA	46.09	33.41	[35]	4.5	Furnace walls were cracked
85	Pitesti	Pitesti	RO	44.86	24.87	[8, 35]	8	several houses collapsed, people were buried under the ruins.

								Tricola and Vierisi Monasteries were also badly damaged.
86	Ploiesti	Ploiesti	RO	44.94	26.03	[35]	7	all houses were damaged, some of them were completely destroyed
87	Predeal	Predeal	RO	45.48	25.58	[9]	8	Houses were damaged, and collapsed
88	Prejmer	Prejmer	RO	45.70	25.78	[10, 11, 31]	7	The tower in the city was demolished
89	Rasinari	Rasinari	RO	45.70	24.07	[11]	6.5	The chimneys and pipes have been destroyed
90	Ramnicu Sarat	Ramnicu Sarat	RO	45.38	27.04	[2, 35]	7.5	almost all houses were damaged
91	Rasca	Rasca	RO	47.74	25.52	[6]	F	Was felt.
92	Reni	Reni	UA	45.45	28.28	[10, 31, 35]	6.5	slight underground noise; houses were more or less damaged
93	Roman	Roman	RO	46.93	26.93	[22]	D	The Precista church was affected
94	Rupea	Rupea	RO	46.04	25.22	[9]	8	Many citadels were damaged, the roof of church was uncovered
95	Rosiorii de Vede	Rosiorii de Vede	RO	44.11	24.99	[22]	D	The church St. Spiridon was shaken
96	Sankt Petersburg	Sankt Petersburg	RU	59.34	30.12	[28, 31]	F	Felt
97	Sarospatak	Sarospatak	HU	48.30	21.57	[31]	F	Felt
98	Sevastopol	Sevastopol	BG	44.51	33.60	[1, 10, 31]	F	Felt
99	Sibiu	Sibiu	RO	45.79	24.14	[1, 9, 10, 28, 31, 34, 35]	6.5	terrible noise which ended with two strong shocks. Several buildings were destroyed, including the Catholic

								Church. Several chimneys were destroyed on the East-West direction.
100	Sighisoara	Sighisoara	RO	46.22	24.79	[11, 31]	7	The vault of a church was demolished
101	Slatina	Slatina	RO	44.43	24.36	[22, 35 , 41]	7.5	The earthquake caused serious damage to Streharet Monastery, and St. Ioan Sculii Church, the three towers of the monastery Clocociov have been destroyed.
102	Slobozia	Slobozia	RO	44.56	27.36	[22, 49]	7	The earthquake damaged the church and bell of the St. Arhangels Mihail and Gavril Monastery
103	Stefanesti	Stefanesti	RO	47.79	27.20	[6]	3	The earth was trembled and held 6 minutes
104	Soroca	Soroca	MO	48.17	28.30	[35]	5.5	Cracks only in some houses, the furniture moved
105	Tagnarog	Tagnarog	MO	47.13	38.55	[35]	4	Slight move of the furniture, chandeliers were dangle.
106	Targoviste	Targoviste	RO	44.93	25.46	[35]	8	Dealu Monastery and Viforata hermitage were almost completely destroyed. Bishop House, seminar, cell, typography had a pathetic picture of

								destruction. Two residents were seriously injured, 6 seminarians received minor injuries.
107	Telenesti	Telenesti	MO	47.48	28.36	[35]	5	Windows broken and cracks in the walls
108	Tighina	Bender	MO	46.77	29.48	[10, 31, 35]	5.5	Felt vibrating the soil, cracks in houses.
109	Timisoara	Timisoara	RO	45.76	21.37	[31, 35]	5.5	The houses were damaged
110	Tiraspol	Tiraspol	MO	46.84	29.63	[10, 31, 35]	7	Houses were more or less damaged.
111	Tg. Neamt	Tg. Neamt	RO	47.20	26.36	[8]	3	The earth was shaken
112	Targu Mures	Vasarhelyt	RO	46.57	24.60	[31]	5	A big shock
113	Tryavna	Tryavna	BG	42.87	25.50	[2]	6	Felt
114	Trojan	Trojan	HU	42.88	24.71	[2, 31]	F	It was severe
115	Turda	Thorda	RO	46.57	23.79	[31, 35]	6	The walls of stone were cracked. Cages with birds fell from the shelves.
116	Tuzla	Tuzla	RO	44.00	28.63	35	5	up to three min. duration, but no damage in the city.
117	Vargias	Vargias	RO	46.09	25.55	[10, 11, 31]	6.5	The vault of the Greek-Catholic church was demolished
118	Vásárhelyi	Vásárhelyi	HU	46.24	20.65	[31]	4.5	A big shock
119	Viena	Viena	AT	48.12	16.22	[35]	F	It was obseved
120	Volchanskiy	Volchanskiy	UA	50.17	36.95	[35]	F	Lasted 10 seconds
121	Veliko Tirnovo	Tirnovo	BG	43.08	25.66	[2, 31]	6	It was severe
122	Varsovia	Varsovia	PO	52.08	21.00	[31]	F	Felt
123	Vidin	Vidin	BG	44.09	23.08	[31]	F	Felt
124	Vratsa	Vratsa	UA	43.21	23.56	[2,31]	5	It was severe
125	Zbaraj	Zbaraj	UA	49.66	25.78	[35]	5	broken windows

126	Zenkov	Zenkov	UA	51.43	27.25	[35]	4.5	Chandeliers were dangle, the doors were swigged
127	Zimony	Zimony	RS	44.84	20.40	[31]	F	Felt
128	Zlatna	Zalathna	RO	46.09	23.18	[31]	F	It was less than in Brasov

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