

## LARGE AND MODERATE HISTORICAL EARTHQUAKES OF 15<sup>TH</sup> AND 16<sup>TH</sup> CENTURIES IN ROMANIA RECONSIDERED

M. ROGOZEA, M. RADULIAN, GH.MARMUREANU, N. MANDRESCU, D. PAULESCU

National Institute for Earth Physics, P.O.Box MG-2, RO-077125 Bucharest-Magurele, Romania,  
E-mail: mrogozea@infp.ro, Email: mircea@infp.ro

Received June 11, 2012

*Abstract.* The purpose of this paper is to find historically-based arguments to validate or rectify the earthquake parameters as existing now in the catalogues. Systematic search for the original information collected from annals of time, reviews, notes on old religious writings, newspapers, etc. was carried out. In parallel, all the information available in the catalogues of earthquakes in the Carpathian region was considered. The historical data are critically analyzed and, on the basis of our investigation. Also, we tried to compensate for the uneven geographical distribution: clearly more systematic and rich documentation comes from Brasov (Transylvania) area as compared with other provinces, such as Wallachia and Moldova. Basically, only the events mentioned in at least two independent documentary sources were included in the revised catalogue. A significant fraction of the total catalogued events was proved to be improperly parameterized in the previous catalogues.

*Key words:* historical earthquakes, Vrancea.

### 1. INTRODUCTION

Romania is considered as an earthquake-prone area with moderate seismicity. The main seismic activity is concentrated at intermediate depths (60–170 km), beneath Vrancea region (Fig. 1). A few events with magnitude above 7 are recorded each century in this particular source. Besides the Vrancea earthquakes, the seismicity is located in the crust mostly along the Carpathians. Commonly, the crustal events are moderate (below  $M_w = 5.5$ ) with a few exceptions in the Shabla zone (north-eastern Bulgaria, close to the Black Sea shore) and Făgăraș-Câmpulung zone [36], where  $M_w = 7.1$  and  $M_w = 6.5$  events, respectively, were recorded.

The purpose of this paper is to reevaluate the historical events occurred in the 15<sup>th</sup> and 16<sup>th</sup> centuries in Romania and the surrounding areas by collecting all the available information referring to these events (catalogues, monographs, books, other specific documents).

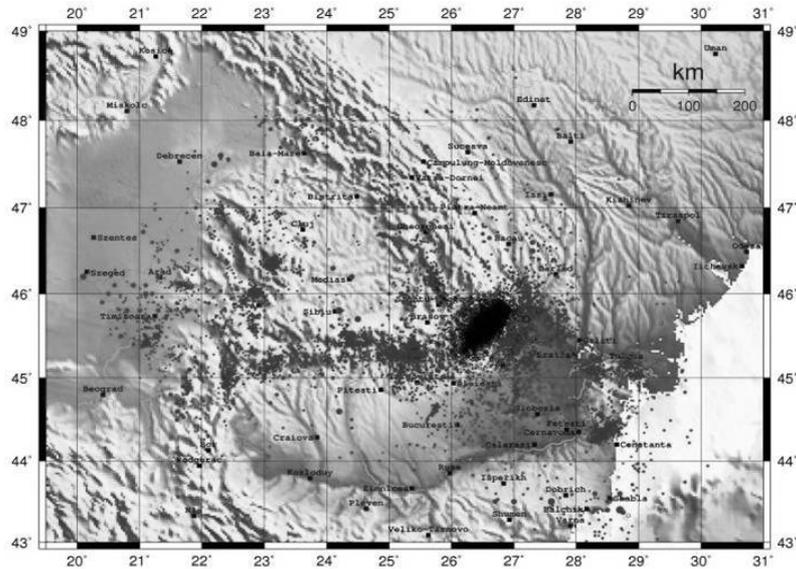


Fig. 1 – Epicenters of the earthquakes occurred on the Romanian territory between 984 and 2011, with events at normal depth (less than 60 km, gray dots), as well as at intermediate depth (60–180 km, black dots) (after ROMPLUS catalogue- <http://www.infp.ro/catalog-seismic>).

## 2. DOCUMENTATION

The historical information was extracted from: chronicles (Neculce, Costin), catalogues of earthquakes in the Carpathian region, drafted in the XIX<sup>th</sup> century and XX<sup>th</sup> century [5, 7, 9, 14, 16, 17, 21, 26, 28, 30, 35, 37, 38, 39], annals of time, reviews, notes on old religious writings, newspapers, etc. Notes on earthquakes and their effects are found in the work of other historians and literates such as: N. Iorga, C. Giurăscu, N. Stoienescu, I. Bianu, V. Căndea, I. Bârlea, A. Lepădatu, Burlacu, C. Capros, T. Pamfilie, P. Cernovodeanu, etc. The information ranges from close to zero (the only specification that the earthquake occurred, without any detail on its effects in a particular place) to sufficiently reach (including macroseismic information in different places) for reliable mapping.

Clearly the information is focused on damage at monumental buildings (churches, palaces, castles, monasteries, mosques, towers, etc.) at the expense of information on damage on ordinary houses. These historical monuments were particularly made from thick stone walls (which had mostly buttresses), while the peasant houses were of wood or adobe (unconventional materials). It is obvious that, at the same level of movement of soil, monuments and common houses react differently and as a result some data filtering is required in order to avoid underestimation or overestimation of intensity values in some areas.

### 3. DATA ANALYSIS

For the XV<sup>th</sup> century the collected information indicates the producing of six earthquakes with impact in Romania (Table 1).

The first event, occurred in 1411, is mentioned in Turdeanu's paper [42]: "In 6919 (1411), during Mircea Voda and his son Mihail Voda on February 23, a big earthquake happened, at the 6<sup>th</sup> hour of night that produced the collapse of many houses". The above paragraph is the English translation of a Slavic manuscript, found in the library of Holy Synod of Moscow. Given the precise details about the event ("big earthquake"), date (23 February, at six o'clock in the night) and the specification of the ruler of the country that time (Mircea Voda and his son Mihail), Turdeanu [42] assumed that the manuscript was issued in 1411 in Wallachia.

Despite the fact that the earthquake was classified as a large one, Turdeanu [42], drew attention (p. 62) on the lack of any proof of significant repairs at any monastery or church existing that time. The disaster passed without leaving a trace in the memory of posterity, except the mentioned manuscript. Nevertheless, Cernovodeanu and Binder [6] reported on this event as one leading to many buildings collapse, but without mentioning any other source (apparently, they relied on the same Slavic source, as Turdeanu [42]). Because this earthquake was not included in any known database, and in this moment we have only one linked source, we assume that it was a local event described in an exaggerated manner by the contemporary witness.

The next earthquake occurred in 1443 in the Pannonian Plain according to Stefanescu [39] and was felt in Hungary, Bohemia, Silesia, Poland and Transylvania. Stefanescu [39] took the information from sources like: *Annales Silesiae* p. 157; Martini Cromer, *De rebus Poloniae* p. 328; Pistorius Nidamus: *Rerum Polonicarum*, t. II. p. 213 and 713; Bonfinius: *Rerum Hungaricarum*, Dec III, Lib. VI. p. 456 and 465. On the basis of information from Dlugosius (Polish chronicler), Callimachus (1519) and Aeneas Piccolomini Szlvius (Pope Pius II), (see Fuchsio Lupinum, p.33), Cernovodeanu and Binder [6] placed the epicenter in the Tatra (Zvolen) region. The reports of damage show that the St. Ladislau Cathedral in Oradea was destroyed and possibly the Citadel of Angevins in Timisoara was destroyed, too.

In his notes, Rethly [37] mentioned that the earthquake caused damage mostly in Hungary, where the "castles and houses were overturned and the mounts shook". Major effects were reported in Poland as well: some of the citadel towers in Zabrdowicz collapsed, the roof of the St. Thomas Monastery collapsed also, the roof of the St. Catherina Monastery in Krakow and the roof of St. Augustine Church in Casimiria fell down.

According to Florinesco [9], the earthquake was strongly felt in Central Europe causing damage in Poland, Hungary and Bohemia. It was felt also in

Transylvania, where the author names a few general destructions to cities, citadels, houses, without specifying the particular location or the source.

A variety of information suggest that the seismic waves were felt everywhere in the northern part of the Balkan Peninsula (Laska [19]). Popescu [30] admits that this earthquake, which was strongly felt in Poland and Hungary, it should have been felt in Bucovina as well, but he has no attestation in favor of this supposition.

Few Romanian studies mentioned the earthquake effects on our country. Thus, Iliesu [15] notes: "In this year, 1443, it was in Timisoara a strong earthquake so powerful that demolished a part of the Royal Palace, a part of the citadels fortification and many other buildings". Similarly, Trâpcea [41]: "Iancu de Hunedoara used the circumstance that an earthquake damaged in 1443 the castle to rebuild it and strengthen it with a moat" and Hategan [13]: "On 5<sup>th</sup> July 1443 a powerful earthquake destroyed, in same places down to the ground, the fortification walls and many houses in the town. Iancu de Hunedoara started working: brought stones from Varsetul place, sand from Lipova and wood from the forests around Timisoara. He demolished the damaged walls and recuperated the materials. The Angevin Castle was down to ground, too... for foundation oak pillars were used, but somewhat better manufactured that those angevini and without the intermediate layer of stone... as concerns the fortification... the military Italian architects applied the technique of stone walls ..."

The analysis of Prochazkova and Karnik [32] and also the recent studies of Labak [20] and Grunthal and Wohlstrom [12] located the earthquake epicenter in Slovakia and estimated the magnitude at 6.0, and epicentral intensity at VIII. The tracing of isoseismals indicated values below V for the western part of Romania. It is difficult to associate the effects in Timisoara, as they are described by Hategan [13] and Iliesu [15], with the event produced in Slovakia. Unfortunately, both Hateganu [13] and Iliesu [15] did not mention the source they used and, although the related details are interesting, we cannot have a real measure of reliability of this information.

The epicenter of August 4, 1444 event was localized in Szegeed Hungary, near the frontier with Romania, in the following catalogues: Shebalin [38], Constantinescu and Marza [7], Zsiros *et al.* [46], Oncescu *et al.*, [26]. Shebalin *et al.* [38] quoted Rethly [37] like source, (and Rethly [37], quoted in his turn, Teleki (1852), Reizner (1884-1900) and Bielz [5]).

We could not find any historical source on this event and therefore from the existent information in catalogues it is impossible to indicate how credible is the catalogue parameterization (Lat. 46.20<sup>0</sup>N, Lon. 20.10<sup>0</sup>E, maximum intensity VII–VIII). More than that, the summary description of the effects from Constantinescu and Marza [7]: "destructive and widely felt from Bohemia to Balkans" suggests a possible confusion between events which took place between 1433 and 1444.

In their analysis of the 1446 earthquake, Tatevossian and Albin [40] came to a contemporary source in which the effects felt in Moscow are described. They started from Musketov and Orlov [23] who refer to the "Tsarstvenniy chronicler"

which, after Shchapov (2003), represents a compilation of different chronicles in 18 century. The original description of the earthquake is from a contemporary source, Muscovites Chronicle written in the late of XV-th century (Kloss ed., 2004): “In autumn 1446, in the first day of October, at 6 at night, when the Grande Duke was released from Kurmysh, Moscow, and Kremlin, all towns were shaken. Not all people which are asleep were awakened by this earthquake, but those who felt it, were afraid for their lives. In the next morning, they told with tears in their eyes what behaved those who were awaked by the shake”.

Based on this information, Tatevossian and Albini [40] estimated the intensity III-IV (EMS 98 scale) at Moscow, because the earthquake did not wake up all the population of the city. Because our investigation did not provide other information about this event, the hypocenter placed in the Vrancea region is based on the hypothesis that there are no other earthquakes, apart from Vrancea, to be felt in Moscow. Source parameterization (lat 45.7<sup>0</sup>N, lon.26.6<sup>0</sup>E, depth 150 km, maximum intensity VIII-IX, magnitude 7.3) from Kondorskaya and Sheliban [17], taken from Constantinescu and Marza [7] and Oncescu *et al.* [26] catalogues, requires also a typical behavior of Vrancea earthquake, with slow attenuation of the waves which propagates to the north-east.

The 1471 earthquake is the most important and best documented earthquake produced in XV<sup>th</sup> century, with effects in Romania, as well as abroad. As reported in the “Moldavian-German chronic”, “Chronicle from Putna” and other contemporaneous sources from Moldova, “in the same year (6979 = 1471), month of August, day 29, a terrible earthquake happened” and even “all over the word, when the ruler (Stefan the Great) was sitting at lunch” (Grigore Ureche, “Chronical of Moldavia”, 1965, p.71). The specification of time (the ruler took the lunch) shows that the “Bistrita Chronicle” (“Anonymous Chronicle”) which made this specification was written at the royal court in Suceava, during the reign of Stefan the Great. On the other side, it proves that that the notes related to the earthquake and its time of occurrence are made by an eyewitness or by a person knowing directly the things that happen at the royal court (Ursu, [45]; Giurascu, [10]).

In the annals of the Melk Monastery (Austria), it is mentioned that in August 29, 1473, at 11 o'clock, “It was such a big earthquake that almost all houses and chimneys collapsed and even a part of the town walls fell down (in Brasov). Many people thought that is the end of the World”. Strong earthquakes were recorded for five days in all Transylvania, Wallachia, Moldavia and Szeklerland, that made the mountains and hills to move. This earthquake was felt in “seven provinces from east” (Pertz, [29]).

Another source [44] provides more information about the effects of 1471 earthquake. In the chapter: “The earthquake chronicle from Barsa Country (XV-XX centuries)”, from the paper “From chronicles and charters. Contribution to the Transylvania history” (Nussbacher, [24]), the mentioned document is reproduced, in modern translation and commented by the author. Since the paper mentions other affected lands, we present further some extracts: ... “In St. John the Baptizer

day (August 29), between 10 and 11, a big earthquake was in Brasov, that shaken all buildings, hills and valleys”. “In the parochial Church, the arch key above the altar, wearing the Hungarian emblem felt. The tower of this church was inclined as if it were ready to collapse. Much of the city walls collapsed, many towers cracked and the roofs fell down. People escaped from their tables on the street like fools and many of them died. Also, on the city hill (perhaps Tampa), from the peak of the hill, towards the city, two big rocks dislocated and rolled down to the valley. Many partition walls of the houses were cracked, and in the villages many walls collapsed”. Further it is shown that “at the same time, an earthquake happened in Moldavia, felt from Cetatea Alba (Nistru), to Caffa (in Crimea) and the city of the voivode (Radu the Handsome) of Wallachia totally collapsed”. Such effects have been reported for other Vrancea strong earthquakes, in the Carpathian foothills and Bucharest. So they say that an entire village in Moldavia – with people, buildings, animals and all the others – would have been drowned (the information, probably refers to a massive landslide and was not verified so far). Further they had shown that until September 1, 1471 there were five aftershocks without noticeable effects. As noted before, in the Annals of Melk monastery is mentioned another event in August 29, 1473 instead of August 29, 1471. Ștefănescu [39], p. 12 considers the date of the earthquake (1471) as certain, and Purcaru [33] states that the two earthquakes refer to a single event. Summarizing all available data, Tatevossian and Albini [40] conclude that the 1473 event is a false duplicate of the one in 1471. We accept this conclusion and suppose that the error in dating the exact year was passed on through the Hungarian’s compilations from nineteenth century, at Rethly [37] and Montandon [22]. Rethly [37], at his turn, mentions two references: Bielz [5] and Koch [18]. This error is taken among others by Florinesco [9] and further spreads to other authors. Thus, the current form of the Romplus catalogue (Oncescu *et al.* [26]) contains both events: in 1471 and 1473 (this two appeared also in the Shebalin *et al.* catalogue [38]). Previous studies indicate a magnitude between 6.9 and 7.5 and a maximum intensity around VIII–IX.

In terms of macroseismic effects, the information covers both regional scale, in the cities (Brasov, Suceava, Targoviste) and global (the earthquake was felt on extended territories, including Russia and Republic of Moldova). This earthquake was felt as far as in Cetatea Alba on the Nistru river, in Moldova and Caffa, in Crimea (Cernovodeanu and Binder [6]). In Wallachia, the earthquake led to the ruin of Princely Palace and caused cracks in the soil through which water with sulfur and mud was brought to the surface, with nasty-smelling fumes.

In Transylvania significant effects were reported in Brasov “so great earthquake that all buildings, mountains and valleys were shaken”. According to the Melk Monastery Chronicle, almost all the houses, chimneys and a large part of the city walls were destroyed. Movements with the same intensity were registered in Turda, Bistrita, Salaj and throughout the all Szeklerland (Cernovodeanu and Binder [6]).

The first event mentioned in XVI<sup>th</sup> century is a devastating earthquake produced on September 10, 1509 in the Marmara Sea. Ambraseys [3] described in detail this event. An estimation of the casualties amounted to 13000 people, as mentioned in a letter to the Doge of Venice by the voivode of Transylvania (Sanudo, 1879–1902).

In his chronicle, Radu Popescu, refers to a destructive earthquake produced in Constantinople in 7016 (1507–1508), during the reign of Mihnea Voda cel Rau (1508–1510): "... In these times it has been a great earthquake. In Tarigrad windows, churches and houses fell and many people were killed" (Cernovodeanu and Binder [6]).

The earthquake is also mentioned by Florinesco [9], but with a wrong date (September 14, 1509): "powerful ground earthquake in Constantinople (Turkey) strongly felt to the south of the Transylvanian Basin (Barsa)". Cernovodeanu and Binder [6] included this event in the chronological list of Romanian earthquakes (p. 229), but using the wrong dating took from Florinesco [9]. As a result of this earthquake, Balkan Peninsula and Brasov were strongly damaged.

1512 earthquake is reported by Grecescu and Simonescu [11]. The authors found two independent sources that allude to a phenomenon which seems to indicate a possible earthquake in 1512 in the Wallachia. It was felt in Targoviste and Dealu Monastery. The first report is from the "Cantacuzin Chronicle" and states that "the roof of Radu Voda's tomb cracked..." (The history of Wallachia 1290–1690, The Cantacuzinesc Annals by Grecescu and Simonescu, p. 27, [11]. The second narration belongs to Radu Popescu who wrote that "there has been a lightning and the stone on Radu Voda's tomb broke as could be seen until today..." (Cernovodeanu and Binder [6]). We may have to deal with a local earthquake, but the information is too vague and insufficient to consider such an event. There are no other references about this earthquake.

Another earthquake occurred on November 24, 1516 (St. Catherine's day), at the first hour after lunch. This is a well documented Vrancea earthquake, for which there are several independent contemporary sources. The earthquake caused damage in Brasov and was felt in Suceava. The event is mentioned in "The Chronicle of Moldavia" by Grigore Ureche, p. 143, [43], who wrote that "... in the same month, there was a great earthquake, in a Monday", without giving other details.

A similar information appears in "The History of Wallachia rulers" by Radu Popescu (p. 35), with a notable difference about the year: "a great earthquake happened in 7025 (1517), in the month when Bogdan Voda of Moldova died". The earthquake caused significant damage in Brasov, as mentioned by Atanasiu [1] and Cernovodeanu and Binder [6], both based on the story of Romer (1916). Several houses and much of the surrounding wall of the city were destroyed. The same information can be found at Nussbacher [24] and Dudaş [8]. Florinesco [9] mentions the date and time of the earthquake (13:00) and that it caused damage in Brasov (several houses destroyed).

The data found by Rethly [37] from Romer (1916), Quellen IV (1903), Koch [18], Bielz [5] and Jeitteles [16], speaks as well about the damage caused by this earthquake in Brasov.

Another earthquake occurred on February 6, 1517 which was strongly felt in Transylvania especially in Rupea (Florinesco, [9]). The likely epicenter coordinates are also specified by Florinesco [9]:  $46^{\circ}03'$  N and  $25^{\circ}14'$  E, without any indication on what basis they were established.

Rethly [37], after Bielz [5], talks about an earthquake, which took place in 1517 on St. Dorothea's day, in the vicinity of Rupea.

The 1521 earthquake occurred in Belgrade and Semlin region, according to von Hoff [14]. Certainly Stefănescu [39], p. 11, takes the information from von Hoff [14]. Florinesco [9] notes that several strong earthquakes were reported for three days in Belgrade and Semlin regions. These movements were felt quite strongly in Banat as well (fractures in the walls).

A source from Brasov states that in 1521 in "Wallachia, Transylvania and Fagaras a strong earthquake was felt" (ref.: Hurmuzaki, XV, 1, p. 251–252. No. CDLVI., Cernovodeanu and Binder [6], p. 212. The same source is also reported in Nussbacher [24]): "A major earthquake happened in 1521 in the Wallachia that was also felt in Fagaras, Transylvania and Brasov" (Hurmuzaki, XV, 1, no. 456, p. 251–252).

Referring to the earthquake effects on Brasov city, Armbruster [4] notes that "it was during the reign of Istvan Bator, when the church bells in town beat themselves" (p. 405). We point out that Bator Istvan was prince of Transylvania between 1571 and 1575, and so it may actually make reference to the effects of the 1571 earthquake.

Opriş [26] says that "after a strong earthquake in 1521, Brasov needs to be repaired" (source: Pascu, Voievodatul, II, p. 171).

Analyzing all available data about the seismic activity during 1521, by the effects felt in Romania, we believe that, apart from an earthquake in Serbia, we can speak of a possible seismic sequence in the Fagaras-Cămpulung area, known as a seismogenic zone. Thus we can make a connection between the macroseismic effects in Banat with those reported in Fagaras, Curtea de Arges and Transylvania. However, it is difficult to draw any conclusion as the existing information is too vague.

The earthquake from St. Elizabeth's night (November 19, 1523) was analyzed systematically by Radu and Toro [34]. They adopted the following parameters for this event: date: November 19, 1523 (night), epicenter:  $46^{\circ}20'$  N,  $24^{\circ}40'$  E (Medias), depth – 10 km the magnitude – 4.7 and maximum intensity – 7.

The two authors consider that for the previous event dated June 9, 1523 the month is recorded wrong (June instead of November) and that in fact we are dealing with a single event. The information is based on compilations from XIX-th century (Hain, 1854; Laczco, 1858, Hutter, 1862; Bielz, [5]; Koch, [18]), taken by Rethly [37] and Florinesco [9]), Radu and Toro [34].

The Chronic of Hutter states that on November 19, 1523 at Medias “was such a high trembling that the Council House towers fell.” The choir vault and support pillar located on the south part of the altar at the Evangelical Church in Sebes collapsed. In those days many old people have died in Ardeal and in Sibiu 20 houses have collapsed (Cernovodeanu and Binder [6], p. 211.

At Brasov a great earthquake was felt in the same year (Temple Coronenis). In Sighisoara a great earthquake happened on the day of Saint Catherine (Cronik der Makt-Nachbarshaft) (Radu and Toro [34], p. 1070.

The columnist Ostermayer wrote about the 1531 earthquake that was felt in Brasov and “five days in a row was attended by a comet” (Cernovodeanu and Binder [6], p. 211, Ref. Quellen VIII, p. 248). Nussbächer [24] takes the information from Quellen IV (p. 7, 12, 155, 500) and states that during that period “two large earthquakes were in Brasov”. The earthquake is also remembered by Florinesco [9] which gives some strong indication of the effects felt in Brasov, where the Black Church was damaged. It is possible that Florinesco [9] may be exaggerated because of a wrong translation. The correct translation, according to Toro, would be: “This earthquake is remembered by an inscription in a large church [Black Church].”

The earthquake is included in the catalogue of Shebalin *et al.* [38] with the following parameters: 45.6°N latitude, 25.3°E longitude, 20 km depth, 5.0 magnitude and VI as maximum intensity. However it is not included in the Romplus catalogue.

For the 1543 earthquake, Rethly [37] mentions some documents from the XIX-th century (Bielz, [5]; Jetteles, [16]; Chronica oder Sammlung und neuer Nachrichten von den merckwügdigten Erdbeben etc. von M.I.A.W. – Wien, 1764; Quellen (IV), p. 53, 78, Nussbächer (p. 20), [24], that states that an earthquake happened in 1543 in Transylvania. The event is also mentioned by Bielz [5], that talks about a terrible earthquake in Sibiu and Transylvania. Probably based on the information from Rethly [37], Florinesco [9] speaks of a devastating earthquake that took place during 1543 in Transylvania and in particular in Barsa Country. It is difficult to decide the source of this event: Vrancea intermediate-depth event (as in Romplus catalogue), or shallow event with the epicenter in Transylvania (as in the catalogue of Shebalin *et al.* [38]). Two essential elements remain to be clarified: the date and the hypocenter, Vrancea or Transylvania/Fagaras-Campulung. The information is not precise and therefore this event can be confused with the one in July 19, 1545.

According to Ostermayer, on July 19, 1545, during a religious service in Black Church, “it was such a strong earthquake that everyone has left the Church” (Cernovodeanu and Binder [6], p.212, Ref. Nussbächer p. 21, [24], Quellen IV, p. 506). However, according to Rethly [37] it is a false event, probably due to the confusion with the big event of November 19, 1523 (p. 32).

Florinesco [9] speaks of a strong earthquake occurred in Barsa region that was felt all over Transylvania. Without specifying any source, it reminds the different damages in Brasov, meaning fractures in the walls of the houses and even their collapse. Wounded or dead people were also reported. Unfortunately the information provided by Florinesco [9] about the damages is not reliable and can be considered only with great reserve.

The only information about the October 26, 1550 earthquake comes from [37] who quotes Bielz [5] and Quellen chronic collection. The earthquake was felt in Sibiu and Brasov. The observer from Brasov did not report any effect of the earthquake. He only said that a comet was seen on the same day. He also specified the time: 2 a.m. and the lasting time: a quarter of an hour.

In his book “The Memory of Romanian old books, Old notes”, Dudaş [8] speaks of a strong earthquake on the Sunday preceding the Sunday of All Saints, in southern Transylvania that held a quarter of an hour.

Another ambiguous event is the one from August 21, 1552. Due to the lack of information we can not specify exactly where it was in Transylvania or in Vrancea. This event appears as a deep one only in Kondorskaia and Shebalin [17] and in Romplus catalogue (Oncescu *et al.* [26]). Bielz [5] talks about a big earthquake in Brasov. Rethly [37], inspired by Jeitteles [16], also recalls this event. However the information is vague, just remembers that it was an earthquake in Brasov. Florinesco [9] talks also about this earthquake, as being in Transylvania and strongly felt in Brasov.

Another problem is related to the July 18, 1556 earthquake, as it appears only in Shebalin *et al.* [38] catalogue, where is located in Transylvania (felt in Brasov). The information comes from Rethly [37] and Florinesco [9]. Nussbächer ([24], p. 22), taking the information from Quellen IV, p. 518, states that there were “two earthquakes”.

The November 20, 1558 event was reported by Rethly (1952). The author, inspired by Jeitteles [16], reminds of an earthquake that was felt in Brasov on 20<sup>th</sup> November (November 10, Old Style, as wrote on a church inscription). Bielz, [5] also remembers of an earth movement, which took place on 20<sup>th</sup> November.

Florinesco [9] says that there has been an earthquake in the south part of Transylvania. In Brasov a church was fractured. The event is also noted by Nussbächer [24], p. 22, (Quellen IV, p. 12, 155).

Jeitteles [16] recalls of an earthquake on August 17, 1569 in Transylvania. According to Rethly [37] this event was felt in Brasov. The author mentions the time when the event occurred – morning between 6 and 7. The night before, a jolt of land occurred between 12 and 1 o'clock at night. The earthquake was either a crustal one, placed in Fagaras-Câmpulung area, in Romplus catalogue, or a subcrustal one in Vrancea, after Radu (1979), Constantinescu and Mârza (1980)

catalogues. Nussbächer [24] mentions an event on August 15, 1569, after Quellen, IV, p. 82 and another one on August 17, 1570 (Quellen, IV p. 10).

A greater earthquake was produced on April 10, 1571 morning at 8, followed by a series of small movements of the Earth until 14 May, according to Bielz [5]. Nussbächer [24], p. 22, also recalls this earthquake (Quellen, IV p. 492). Atanasiu (1969) speaks of four earthquakes between April 10 and May 19, 1571 in Brasov. The information, taken from Romer, is however controversial. Shebalin *et al.* [38] says that we are dealing with an error of transcription and therefore is identical with the earthquake on May 10, 1571. However, we do not exclude the possibility of a seismic sequence in Fagaras-Câmpulung, for example.

May 10, 1571 event appears only in Romplus. Jeitteles [16] reminds us of a series of three earthquakes on May 10, 14 and 19, the latter being the strongest. Nussbacher [24] remembers three small earthquakes on April 10 and May 14, followed by a "very strong" one ("violentissimus") on May 19, at 18 o'clock (Quellen, IV, p. 10 and 155). The next earthquake is recorded on July 11, 1572 (Quellen, IV, p. 493). About damage or injuries we have no information. According to Constantinescu and Mârza [7], Black Church in Brasov was affected.

The April 1, 1578 event is certified by Purcaru (1979) and Romplus catalogue as being in Vrancea. No other information on this event is available. Atanasiu (1991), Rethly [37] and Florinesco [9], proved the existence of an earthquake on April 30, 1590. Florinesco [9] said that two shakes were felt in Barsa. Nevertheless, Popescu [30] does not mention about it. The exact date of the earthquake is not known, as in Shebalin [38] and Bielz [5] appears on 5/28/1590, while in Rethly [37] on 04/28/1590. Nussbächer [24], p. 23, states that on 04/28/1590, at 11 o'clock was an earthquake happened (Quellen, IV, p. 42, 53, 157). Jeitteles [16] remembers only that it was an earthquake in Transylvania, without specifying the date. Rethly [37] inspired by Bielz [5] says: "On April 28, 1590, on the eve of Easter at 11 at noon was a trembling."

The date and time when the October 20, 1590 event occurred are uncertain as there are differences in the chroniclers. Ostermayer states that there was "a great earthquake in Brasov, so that the bells began to ring and the Black Church first choir vault was broken and many houses collapsed." Radu Popescu, recalling the death of Stephen Bathory, King of Poland that died on December 26, 1586, probably refers to the same earthquake from August 10, 1590 when says that "there have been such a big earthquake in Hungarian Country (Transylvania) that in Brasov bells ringed themselves and many houses were destroyed" (Cernovodeanu and Binder, [6], p. 212).

As Mathias Miles relates in the "Sibenburgischer Wurg-Engel" chronic (1770), on August 11, 1590 a "powerful and frightening earthquake" occurred. It was felt so strongly in Brasov that the bells rang, many houses and walls collapsed

and the vault of the church shrine cracked from top to bottom (Nussbacher [24]). For the earthquakes that occurred from 1598 till 1601, we encounter in the chronic the expressions, “terrible”, “frightening” and “great”, but without evidence of damage caused.

Miles chronicler talks about the April 21, 1595 event. The author states that: the December 1, 1594, April 22 and December 8, 1595 earthquakes were felt not only in Transylvania, but also in two other Romanian lands, in Turkey and Greece. The Ottomans, according to the testimony of Jesuit Alfonso Carillo (from Sigismund Barthory’s court), have interpreted this phenomenon as “bringing evil” and as a coincidence in 1595 they suffered the most painful defeat from the Romanians under Mihai Viteazul. A charter of Prince Alexander Voda, from April 13, 1626, alludes at one of these three earthquakes when reminds us that Molomocul monastery from Gherghita “was torn down and the entire wall fell down; it was a great earthquake in the days of Voivode Mihai Viteazul” (Cernovodeanu and Binder [6], p. 212; columnist Miles, DRH, B., vol XXI, p. 78–79, doc. 45). At Nussbacher [24], p. 24, a large earthquake in Barsa region is mentioned on April 22, 1595 (Quellen IV, p. 54, V, p. 278, 375).

We found data about this earthquake at Florinesco [9] who states only that “a great earthquake shook the Balkan Peninsula, Southern Transylvania and Romanian Principalities.” Rethly [37] – Koch [18] speak of a strong earthquake on April 21 in Barsa, and on another one on April 22 around noon, at 12. The April 21 earthquake was felt in Transylvania, the two Wallachian Principalities, Greece and Turkey. Jeitteles [16] also remembers the two shakes in Transylvania.

According to some sources, April 16, 1596 event may be identical with the one from April 21, 1595. After Montandon [22], an earthquake was recorded at the same date in Novgorod. In the USSR catalogue (1978) a Vrancea earthquake ( $45.7^{\circ}$  N,  $26.6^{\circ}$  E,  $h = 150$  km) is identified on April 16, 1596 with magnitude, 6 and epicenter intensity, VI–VII.

Bielz [5] stated that on November 22, 1598 morning, between 3 and 4, two movements of the Earth were felt. Rethly [37] also speaks about the earthquake mentioning the date, November 22 (27<sup>th</sup> Sunday after Trinity), time (morning between 3 and 4), the presence of two movements and that it was felt in Barsa.

Florinesco [9] speaks of a devastating earthquake in Transylvania, especially in Barsa region. Two strong shocks, one after another, with the epicenter probably at Bretcou ( $46.3 - 26.18$  – near Miercurea Ciuc) were felt. The event occurred on November 21, around 3–4 according to Nussbacher [24], p. 24, (Quellen, V, p. 376).

The December 28, 1598 event was in Vrancea and had the magnitude  $M_w = 5.7$  (Romplius). The only information we have for this event is from Rethly [37], indicating that there had been two major movements of the Earth.

Rethly [37] states that on March 4, 1599 a terrible earthquake happened that shook the entire Transylvania. Florinesco [9] mentions also this devastating earthquake in Transylvania.

Rethly [37] reports an earthquake on the morning of May 23, 1599, without giving us further information. It may be the Prejmer earthquake mentioned by Nussbächer [24], p. 24, but on May 20 (Quellen, V, p. 433).

May 29, 1599 earthquake was produced in Vrancea and had  $M_w = 5.9$ , as stated in Romplus. According to Florinesco [9], the earthquake was produced at the Carpathians (Vrancea) Arc bend and was felt especially in Brasov and Barsa. The information we found is from Nussbächer [24], p. 25, but on May 23 at 3 a.m., (Quellen, V, p. 376).

In Shebalin's catalogue [38] an earthquake appears on November 11, 1599, probably on the basis of information from Rethly [37] and Florinesco [9].

#### 4. CONCLUSION

The aim of this paper was to analyze the earthquakes in our country or in neighboring areas with effects on our territory, from XV<sup>th</sup> and XVI<sup>th</sup> centuries. We took into account only the events that were included in at least one documentary source or in a catalogue.

The documentation is clearly more systematic for Brasov, compared to other areas in our country, such as Wallachia and Moldova.

The first event, in chronological order (February 23, 1411) is not included in any of the consulted catalogues. Although the event is specified with enough precision in a Slavic manuscript, the existence of a single source of information determined us not to include it for now in the official catalogue of Romanian earthquakes (ROMPLUS). Further investigations are necessary to identify at least one other independent source for this earthquake. This would be extremely important as we have to clarify two problems: (1) acknowledge of the Slavic manuscript (date, size), and (2) if it is a deep Vrancea earthquake or a local surface one.

One of the analyzed events (June 5, 1443) was produced outside Romania border and therefore it is not included in the ROMPLUS catalogue. Note however that significant macroseismic effects associated with this earthquake were reported in the western part of Romania, in Oradea and Timisoara. Such effects are practically not possible if the magnitude (6.0) and location (Slovakia) resulted from investigations of Labak (1996) and Grünthal and Wohlstrom (2007) are correct. In order to put in agreement these investigations with the multitude of conflicting historical data, we do not exclude the possibility of a parallel local earthquake in the western part of our territory (or at a relatively small time interval).

The event from August 4, 1444 has the epicenter placed in Hungary, in Szeged, at a relatively short distance from the Romanian border. Until now we have no serious information for this earthquake. Therefore we have to take over as such the source parameters, as they appear for the first time in Shebalin *et al.* [38] catalogue, based on descriptions of Hungarian compilation from the 19<sup>th</sup> century used by Rethly [37].

The event produced on August 29, 1473 according to different catalogues is considered false and as such we propose its elimination from the ROMPLUS catalogue [26].

Two earthquakes are not included in ROMPLUS catalogue [26] (those produced in 1411 and 1443). The 1411 event is a potential earthquake as it is not listed in any of the existing catalogues with an original and sufficiently precise historical source. Until we confirm this information with other independent sources, we cannot make changes to the official catalogue. It remains an open question for future investigations. Whereas the second earthquake, it was registered outside Romania. It could be eventually considered for the analysis of macroseismic data recorded in other affected areas.

After investigating all available documents, we conclude that two major Vrancea earthquakes were generated during 15<sup>th</sup> century, one in 1446, and the other in 1471. Although the macroseismic data are disparate and often vague or exaggerated, we believe they are sufficient to classify these events among major Vrancea earthquakes ( $M_w > 7$ ). Still remains a question mark for the event in 1446, whereas in this case we have a single source of reliable information on how the earthquake was felt in Moscow. The association of this information with the existence of a typical Vrancea intermediate-depth earthquake (100–150 km deep) is based on the fact that, so far, we do not know another seismic source that could cause similar effects in Moscow area. The presence of reliable information for other distant points would eliminate these questions marks (as the simultaneous identification of macroseismic effects on long distances can be attributed only to a Vrancea event).

The earthquake in 1521 situated in Belgrade and Semlin seems to have been felt quite strongly in southeastern Romania. On the other hand, there are indications that a sequence of earthquakes would be produced in Fagaras-Câmpulung, a seismogenic zone well known in our country. The existing information is not sufficient to include these alleged events in the reviewed seismic catalogues.

A false earthquake is the one in June 9, 1523, statement that is in line with the assumption of Radu and Toro [34]. The sources mostly used are Rethly [37] and Florinseco (1958). For a large amount of data (earthquakes of 1517, 1556, 158, 1569, 1571, 1578, November 22, 1598, December 28, 1598, 4 March 1599, May 20, 1599, May 29, 1599), we did not find source information to confirm the existing information in catalogues.

## ANNEX

*Table 1*  
XV–XVI-centuries earthquakes that were identified in existing catalogues or were certified by historical documents

Date	Time	Zone	Reference	Source	Notes
23/02/1411	6th hour of the night	Vrancea	[6], [42]	MS. Many contemporary	Slavic houses collapsed in Romanian Country (probably Targoviste).
05/06/1443		Pannonian Plain	[3], [6], [9], [37], [31], [39]	Dlugosius (1703), Callimachus (1519)	several buildings collapsed. Felt in Hungary, Bohemia, Silesia, Poland, Transylvania.
04/08/1444		Banat	Catalogue	Without sources	
10/10/1446		Vrancea	[23], [40]	Russian chronicles	The effects were felt in Moscow according to Russian Chronicles (III – V).
29/08/1471	10:00	Vrancea	[1], [6], [9], [25], [29], [31], [39], [40], [44]	[43], Moldovan-German Chronicle, Chronicle of Putna; Chronicle from Bistrita, witnesses	Information about aftershocks.
29/08/1473		Vrancea		[29]	Duplicate of 1471 event.
24/11/1516	the first hour after lunch Vrancea	Vrancea	Römer (1916), [1], [3], [4], [24], [6], [8], [9], [26], [37]	[5], [14], [16], [18], [43],	Felt in Suceava, caused significant damage in Brasov.
09/06/1523			[6], [9], [25], [34], [37]	Hutter's chronicle	Felt in Transylvania.
<b>1543</b>		Vrancea	[9], [25], [26], [37], [38]	[5], [16] 1860; Chronica oder Sammlung und neuer Nachrichten von den merckwügdigten Erdbeben	The information was of very poor quality; could be confused with July 19, 1545 event.

Table 1 (continued)

19/07/1545		Barsa region	[6], [9], [25], [37]		It was well felt in Brasov (People ran out of the Black Church), throughout Transylvania.
21/08/1552			[9], [17], [26], [37]	[5], [16]	Due to the scarce information we can not specify exactly where it was in Transylvania or in the Vrancea area.
18/06/1556			[9], [24], [25], [37], [38]		There were “two earthquakes”.
10/04/1571	At 8 o'clock in the morning		[1], [25], [37], [38]	[5]	Shebalin <i>et al.</i> [38] says that we are dealing with an error of transcription and therefore is identical to the earthquake of May 10, 1571. He does not exclude the possibility of seismic sequences in Fagaras-Câmpulung, for example.
01/04/1578		Vrancea	[33]		Is very doubtful.
21/04/1595		Vrancea	[6], [9], [22], [25], [37]	Miles (1770) [16], [18] Quellen IV (1903)	The effects are reported in Transylvania and Barsa. Also felt in Turkey and Greece.
16/04/1596		Vrancea	Evseev, 1961		It may be duplicate of the April 21, 1595.
04/03/1599			[9], [37]		We have very little information, so we cannot say exactly where it happened. It was felt only in Transylvania.
23/05/1599			[25], [37]		It was felt in Brasov.

## REFERENCES

1. I. Atanasiu, *Earthquakes of Romania* (in Romanian), Edit. Academiei Române, București, 1961.
2. S. Airinei, *Lithospheric microplates on the Romanian territory reflected by regional gravity anomalies* (in Romanian), St. Cerc. Geol., Geogr., Geofiz., **15**, pp. 19–30 (1977).
3. N. Ambraseys, *Earthquakes in the Mediterranean and Middle East: A Multidisciplinary Study of Seismicity up to 1900*, Cambridge, UK, Cambridge University Press, 2009, p. 968.
4. A. Armbruster, Dacoromano-Saxonica, *Cronicari români despre sași: Români în cronică săsească*, Editura Științifică și Enciclopedică, București, 1980.
5. E. A. Bielz, *Beitrag zur Geschichte merkwürdiger Naturbegebenheiten in Siebenbürgen. Verhandlungen und Mittheilungen des siebenbürgischen Vereines für Naturwissenschaften zu Hermannstadt*, VII, VIII, XIV, XXXI, XXXII, Nagyszeben, 1862–1863.
6. P. Cernovodeanu, P. Binder, *Cavalerii Apocalipsului. Calamitățile naturale din trecutul României (până la 1800)*, 1993.
7. L. Constantinescu, V. Mârza, *A computer-compiled and Computer-oriented Catalogue of Romania's Earthquakes During a Millenium (AD 984–1979)*, Rev. Roum. Geol., Geophys., Geogr., Ser Geophys., **24**, pp.171–191 (1980).
8. F. Dudaș, *Insemnări pe bătrâne cărți de cult*, 1992.
9. A. Florinesco, *Catalogue des tremblements de terre ressentis sul le territoire de la R.P.R.*, Le résumé français, Académie de la R.P.R., Comité national de la Géodesie et Géophysique pour l'A.G.I., București, 1958.
10. C. C. Giurăscu, *Târguri sau orașe și cetăți moldovene din secolul al X-lea până la mijlocul sec. XVI-lea*, Edit. Academiei Române, București, 1967.
11. C. Grecescu and D. Simonescu, *The history of Wallachia 1290–1690, The Cantacuzinesc Annals*, Edit. Academiei Române, București, 1960, p. 27
12. G. Grunthal and R. Wohlstrom, *A Unified Database of Large European Earthquakes*, Eos, **88**, 6, 2007.
13. I. Hațegan, *Cronologia Banatului. II/2.Vilayetul de Timisoara. Repere cronologice, selecție de texte și date*, Edit. Banatul și Artpress, Timișoara, 2005.
14. K.E.A. Hoff, *Verzeichnis der Erdbeben seit 1821. Annalen der Physik und Chemi. XXIX. 1833. /b v. Hoff K.E.A, Chronik der Erdbeben und vulkanischer Ausbrüche, Geschichte der durch Ueberlieferung nachgewiesen natürlichen Veränderungen der Erdoberfläche. Gotha, 1840.*
15. N. Ilieșu, *Timișoara, o monografie istorică*, Edit. Gh. Mateiu, Timișoara, 1943.
16. H.Jeitteles, *The most remarkable starting points, that is, epicentres of earthquakes in Hungary and Transylvania* (map attached), Nature Science Bulletin., I, Pest, 1860.
17. N.V. Kondorskaya, and N.V. Shebalin, (eds.), *1982 New Catalogue of strong earthquakes in the USSR from Ancient Times through 1975*, 2nd edition, Boulder (Colorado), (1st edition, 1977, Moscow, in Russian).
18. A. Koch, *Description of earthquakes in Transylvania (1443–1880)*, Gazette of the Kolozsvar Association of Medical and Natural Sciences, 1880, pp. 108–112.
19. W. Laska, *Die Erdbeben Polens, Mittheil*, Erdbeben Commission K. Akad. Wissensch, Wien, NF, 8, 1902, pp.1–36.
20. Labak P., *Reinterpretacia Zematrasenia 5.6.1443 na srednom Slovensku*, Kalab Z. (ed.), *Data Analysis in Seismology and Engineering Geophysics*, Academy of Sciences of the Czech Republic, Institute of Geonics, Proceedings, Vol. I, pp. 83–93 1996.
21. R. Mallet and J.W. Mallet, *The earthquake catalogue of the British Association*, Londra, 1858.
22. F. Montandon, *Les tremblements de terre destructeurs en Europe*, Genève, 1953.
23. I.V. Mushketov, and A.P. Orlov, *Katalog zemletryaseniy Rossiyskoi Imperii* (Catalogue of earthquakes of Russian Empire), Notes of Russian Geographic Soc., 26, St. Peterburg, 1893.
24. G. Nussbächer, *Din cronică și hrisoave. Contribuții la istoria Transilvaniei. Din cronică cutremurelor în Țara Bârsei (secolele XV–XX)*, Edit. Kriterion, 1987. pp. 54–58; pp. 231–233.

25. G. Nussbächer, *Caietele Coroanei. Contribuție la istoria Brașovului. Caietul 4*, Edit. Aldus, Brașov, 2005.
26. M. C. Oncescu, V. Mârza, M. Rizescu, M. Popa, *The Romanian earthquake catalogue between 1984–1997*, in: Wenzel F., Lungu D., Novak O. (eds.), *Vrancea earthquakes: tectonics hazard and risk mitigation*, Kluwer Academic Publishers, Dordrecht, 1999, pp. 43–49.
27. I. Opreș, *Efectele cutremurelor asupra monumentelor istorice din România*, Acta Musei Napocensis, XXI, 1984.
28. A. Perrey, *Mémoire sur les tremblements de terre dans le bassin du Danube*, Annales des Sciences Phys. et Natur., Lyon, 1846.
29. G. H. Pertz, *Monumenta Germaniae Historica Scriptorum*, Tomus IX (Annales Mellicenses), Hannover, 1851, p. 522.
30. I. G. Popescu, *Cutremurele de pământ din Dobrogea*, Extras din revista „Analele Dobrogei”, 1938.
31. I. G. Popescu, *Cutremurele de pământ din Bucovina*, Cernăuți, 1939.
32. C. Radu and E. Toro, *The strong historical earthquakes in Transylvania (Romania): November 19, 1523 and October 3, 1880*, Annali di geofisica, XXXIX, 5, 1996.
33. D. Prochazkova, and V. Karnik (eds.), *Atlas of Isoseismal Maps. Central and Eastern Europe*, Geophysical Institute of the Czechoslovak Academy of Science, Prague, 1978.
34. G. Purcaru, *The Vrancea, Romania, earthquake of March 4, 1977 – a quite successful prediction*, Phys. Earth. Inter., 18, 1979.
35. C. Radu and I. Cornea, *Cercetări seismologice asupra cutremurului din 4 martie 1977*, 1979.
36. M. Radulian, M.N. Mandrescu, G.F. Panza, E. Popescu, A. Utale, *Characterization of Seismogenic zones of Romania*, Pure Appl. Geophys., 157, pp. 57–77 (2000).
37. A. Réthly, *A Kárpátmedencék földrendései (455–1918)*, Budapest, 1952.
38. N.V. Shebalin, V. Karnik, and D. Hadzievski, *Catalogue of earthquakes of the Balkan region. I, UNDP-UNESCO Survey of the seismicity of the Balkan region*, Skopje, 600, 1974.
39. G. Ștefănescu, *Cutremurele de pământ în România în timp de 1391 de ani, de la anul 455 până la 1874*, Extras din Analele Academiei Române, Seria II, XXIV, 1901.
40. R. Tatevossian, and P. Albin, *Information background of 11<sup>th</sup> to 15<sup>th</sup> century earthquakes located by the current catalogues in Vrancea (Romania)*, Natural Hazards, published online 19 September 2009, DOI 10.1007/s11069-009-9448-2 (30 pp.), 2009.
41. T. N. Trâpcea, *Despre cetăți medievale din Banat. Studii de Istoria Banatului*, Univ. Timișoara, 1969, pp. 23–83.
42. E. Turdeanu, *Un manuscris religios din timpul lui Mircea cel Batrân*, Ființa românească, Paris. 7, pp. 57–68, apud. P. Ș. Năsturel. *Notices bibliographiques*, Cyrillo-methodianum, Thessalonique, II (1972–1973), 1968, pp. 198–199.
43. G. Ureche, *Letopiseșul Țării Moldovei, ediție critică de P.P. Panaitescu*, Edit. de Stat pentru Literatură și Artă, București.
44. \*\*\*Urkundenbuch, VI, no. 3901, 1958, pp. 516–517
45. I. Ursu, *Ștefan cel Mare*, București, 1925, pp. 420–424.
46. T. Zsiros, P. Mónus, L. Tóth, *Hungarian earthquake catalogue (456 – 1986)*, Geodetic and Geophysical Research Institute, Hungarian Academy of Sciences, Budapest, 1988.