

# Information background of 11<sup>th</sup> to 15<sup>th</sup> centuries earthquakes located by the current catalogues in Vrancea (Romania)

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## Abstract

Earthquake catalogues for Romania supply for 11<sup>th</sup>-15<sup>th</sup> century earthquakes located in the region of Vrancea records that consist of a complete set of parameters, including magnitude and depth. Scope of this paper is to verify the reliability and consistency of these parameters with the informative background as explicitly referenced by the catalogues. After retrieving the original sources they mention, the set of data appeared to be related almost exclusively to the Russian plain and too poor to be at the very origin of the parameter assessment. Data for 19<sup>th</sup>-20<sup>th</sup> century earthquakes, such as instrumental locations and CMT solutions, added to the understanding of the macroseismic response of the Russian plain to Vrancea earthquakes. On the one hand, the investigation and analysis of historical earthquake records for the fourteen events listed by the catalogues in the 11<sup>th</sup>-15<sup>th</sup> centuries has shown that for three earthquakes (1022, 1038, 1258) no primary sources could be traced, that three more earthquakes (1091, 1170 and 1328) are attested only by scarcely reliable records and had to be classified as doubtful, and one (1473) is simply a duplication of the 1471 event. On the other hand, the availability of data on recent earthquakes that may be compared to historical ones in terms of macroseismic effects allowed the authors to agree with the previous catalogue compilers' solution with regards to both magnitude and depth of the past earthquakes for which do exist reliable primary historical records.

*Keywords: Vrancea earthquakes; 11<sup>th</sup>-15<sup>th</sup> century earthquakes; intermediate-depth earthquakes; macroseismic effects in the Russian plain*

## 1. Introduction

This paper investigates a set of 11<sup>th</sup>-15<sup>th</sup> century earthquakes that the current parametric earthquake catalogues locate in the Vrancea region, Romania. These earthquakes were listed for the first time by the parametric catalogue for the

Balkan region (Shebalin et al., 1974), and were located by using a unique pair of geographical co-ordinates: Lat 45.700 N, Lon 26.600 E (Table 1 and Fig. 1). The records of these earthquakes have another parameter in common: all were assigned an average depth of 150 km. (Table 1). Starting from this simple observation, the goal of this investigation was two-fold: i) to go back to the data available to the catalogue compilers for the time-window 1000-1500, and ii) to discuss their reliability and significance with respect to the parameters adopted by the current catalogues. The starting point of our study was the analysis of relationships among parametric catalogues reporting earthquakes in the time-window and spatial area of our interest (section 2). Having checked that the background was not such as to allow us to plainly accept as reliable the catalogue compilers' parameterization (section 3), an investigation of the primary sources was performed and the earthquake records for eleven earthquakes were reinterpreted (section 4). At this stage, the information background of the parameters for the 11<sup>th</sup>-15<sup>th</sup> century earthquakes was not considered enough to account for the solutions adopted by the catalogues, and a comparison with well documented earthquakes of the 19<sup>th</sup>-20<sup>th</sup> centuries was made (section 5). The amount and different kinds of data available, other than simply the macroseismic ones for the previous centuries, such as the instrumental locations and CMT solutions, has given ground to assess in general the authors' agreement with solution adopted by the previous catalogue compilers for the 11<sup>th</sup>-15<sup>th</sup> century earthquakes (section 6). At the same time, not all the fourteen earthquakes could be confirmed as such: for three earthquakes (1022, 1038, 1258) no primary sources could be traced, three more earthquakes (1091, 1170 and 1328) are attested only by scarcely reliable records and had to be classified as doubtful, and one (1473) is simply a duplication of the 1471 event.

## **2. Parametric catalogues and the 11<sup>th</sup>-15<sup>th</sup> century earthquakes located in Vrancea (Romania)**

The catalogues selected are those that clearly mention the origin of their information, because this was an essential requirement in the perspective of checking upon their informative background. The list of catalogues from which the records in Table 1 were taken should not be considered as a complete list of

the catalogues in which the earthquakes located in Vrancea in the time-window 1000-1500 might have been included. The relationships among the catalogues, that is, what are the sources of information they refer to with respect to each earthquake, are shown in Table 1. In the following, each catalogue is shortly introduced, from the earliest to the most recent one.

#### **Shebalin et al., 1974**

This catalogue was built upon a series of regional earthquake listings specifically intended to cover all the Balkans in the framework of a UNDP/UNESCO project. Consequently, it relies almost exclusively on ad hoc unpublished catalogues. For what the area in study is concerned, it locates the 29 August 1471 earthquake in Vrancea and defines it as intermediate-depth (“i” in the depth column). This is the first parametric catalogue in which a historical Vrancean earthquake had been defined as intermediate-depth. The only other event this catalogue locates in a nearby area is the 29 August 1473 earthquake, and is not coded as intermediate.

#### **Kondorskaya & Shebalin, 1977**

The “New catalog of strong earthquakes in the U.S.S.R. from ancient times up to 1975” by N.V. Kondorskaya and N.V. Shebalin was first issued in 1977 in Russian. A second edition, in English with corrections for misprints and errors, was published in the USA (Kondorskaya and Shebalin, 1982). Among the catalogues considered in this paper, this is the only one in which the compilers made explicit the link between the macroseismic observations they had in their hands (by including references, number of intensity data points and in some cases radii of isoseismals) and the earthquake parameters they derived. All the adopted solutions carry the associated uncertainties, and any doubtful solution is expressed by putting the parameter between parentheses. The ten earthquakes listed as pertaining to the Vrancea region in the time-window 1000-1500 (Table 1) were all given an average depth of 150 km.

#### **Purcaru, 1979**

This work contains a table listing the earthquakes important for Vrancea in relation with the general purpose of the paper, and this means seven earthquakes in the time-window 1000-1500. There are no explicit references for each record of the catalogue, but a comprehensive list of studies is supplied. The earthquakes are

not located according to a couple of coordinates, but all of them are considered to originate in the rectangle comprised between latitudes 45.3-46.1 N and longitudes 26-27 E (Table 1 and Fig. 1) and with a depth between 50 and 170 km. For all the earthquakes both epicentral intensities and magnitudes are estimated.

### **Constantinescu & Marza, 1980**

The catalogue by Constantinescu & Marza (1980) gives a set of parameters including origin time, coordinates, epicentral intensity and magnitude; all these parameters are given an accuracy code as well. All records carry a single reference. It contains thirteen earthquakes in the time-window 1000-1500 (Table 1), all located exactly in the same geographical point but with an estimated depth of 150 km for nine of them, only. It appears, at this stage, to be the richest catalogue for the area.

### **Oncescu et al., 1999**

In the introduction to the paper (Oncescu et al., 1999) describing the catalogue for Romania, the authors clearly stated that “The new catalogue does not contain reinterpretations of historical earthquakes, as we adopted the earthquake parameters given by Constantinescu and Marza (1980).” The fourteen records for the time-window 1000-1500 listed in Table 1 are taken from the most recent release of the same catalogue, as available on the website (<http://www.infp.ro/>) of the National Institute for Earth Physics-NIEP (Bucharest, Romania). All are located in Vrancea and have an estimated depth of 150 km., except for the 1471 earthquake (110 km) (Table 1).

The records in Table 1, in which the parameters for all the earthquakes have been listed for an immediate comparison, show that out of fourteen earthquakes:

- i) the 1471 earthquake was located in Vrancea and defined as “intermediate” for the first time by Shebalin et al., 1974;
- ii) nine were parameterized as “Vrancea deep” for the first time by Kondorskaya and Shebalin, 1977;
- iii) three were recognized as earthquakes originated in Vrancea for the first time by Constantinescu & Marza, 1980;

iv) the 1473 earthquake was located in Vrancea with a depth of 150 km by Oncescu et al., 1999 for the first time; Shebalin et al. (1974) did not consider it an intermediate event and located it differently (Table 1), while two earlier catalogues (Kondorskaya and Shebalin, 1977; Purcaru, 1979) had already declared that it was to be considered exactly the same earthquake as the 1471 one.

### **3. The informative background**

The following step in the investigation was the systematic check of the references explicitly cited by the catalogues. This was aimed at identifying what kind of material they are pointing at (and especially if there was a systematic referencing among parametric catalogues) and what information they supply with respect to the earthquakes in study. The analysis of the references of the parametric catalogues has shown that:

- i) most catalogues make reference to previous ones, and simply repeat their parameters
- ii) these catalogues mention just a few earthquake studies supplying macroseismic information on these earthquakes.

All the material referenced by the catalogues is listed in Table 1. The four items that authors consider the most important contributions in terms of earthquake records are shortly described in the following.

#### **Mushketov and Orlov, 1893**

The “Earthquake catalogue of the Russian Empire” by I. Mushketov and V. Orlov (1893) is the first descriptive and comprehensive list of earthquakes to be published about Russia and surrounding areas for the period 596 BC-1887. Each record is referenced, and the material ranges from the transcription of primary sources to texts copied without any further qualification from previously published earthquake compilations, such as (Perrey 1843; Mallet 1853-1855; Abich 1882). For the area and time-window of interest, Mushketov and Orlov (1893) systematically relied upon the critical edition of medieval chronicles that had started to be published in 1850 in the series “Complete Collection of Russian

Chronicles” (*Polnoye Sobraniye Russkikh Letopisey-PSRL* 1850-1920, 30 vols.) by the Russian Imperial Archeographic Commission.

### **Réthy, 1952**

In his “Earthquakes of the Carpathian Basin”, Antal Réthy (1952) presented the results of the imposing work he had done to retrieve and interpret records on earthquakes from 455 to 1918 in the former territory of the Hungarian Kingdom, the political influence of which extended as far as Moldavia in the 13<sup>th</sup>-14<sup>th</sup> centuries. Réthy’s final list of references includes 460 different items, and among them quite a number of primary sources. As in the case of Mushketov and Orlov (1893), he supplied the original texts for each earthquake.

### **Florinesco, 1958**

Aurelian Florinesco (1958) considered in his “Descriptive catalogue” the earthquakes felt on the territory of Romania only. This seismological compilation does not contain any list of references. In a few cases, the descriptions of events are accompanied by short quotations in italic, which make a vague reference to the sources Florinesco might have used.

### **Evseyev, 1961**

The “Earthquakes of Ukraine” by S.V. Evseyev (1961) is a seismological compilation on earthquakes felt in Ukraine. The earthquakes are listed chronologically and for each of them there is a short textual description, followed by the references. For the time-window 1000-1500 Evseyev mostly referred to (Mushketov and Orlov 1893), and sometimes directly to the Russian chronicles.

This survey of the catalogues’ references allowed us to have a comprehensive scenario of the sources of information effectively known and used to derive the supporting data for the parameters’ estimate. It is now clear that none of the compilers of the catalogues published between 1974 and 1999 had ever gone back to the primary sources, even in the case such sources were known to the seismological compilations referenced by the catalogues themselves.

All the gathered information guided the following step of the investigation towards a direct recognition of the most important medieval Russian, Hungarian and Moldavian chronicles. The authors of the early historical accounts of the

Eurasian plains overlap in their interest in reporting the events, as they were sharing a common destiny of invasion from the steppe people first and the Mongol invasion of 1241 then (Sedlar, 1994). For what concerns the time-window covered by each of the three sets of chronicles, the order in which they are mentioned above is not casual. The early pan-Russian chronicles (*Povest' Vremennykh Let*, literally “The Tale of Bygone Years”) go back in their accounts as far as the 9<sup>th</sup> century. However, the original manuscripts did not survive, and the earliest redaction today existing is dated 1377 (*Lavrentevskiy* chronicle, Kloss ed., 1997). The Hungarian chronicles concern the area included in the then powerful monarchy of Hungary, whose suzerainty extended as far as Moldavia still at the end of 14<sup>th</sup> century. Information on the Carpathian mountain area is sometimes included in accounts centered on the rest of the territory. The small principality of Moldavia began his life as an independent state in the 1350ies, but experienced a life of struggle against the aggressive and powerful neighbours, represented by Polish, Hungarian and Turkish. This unstable situation was everyday life of Moldavia between 1390 ca and 1512, when it became a vassal state of the Ottoman Empire. The dependence from other dominations influenced the production and especially the survival of autochthonous sources on the Moldavian municipalities, so that chronicles start to be available from late 14<sup>th</sup> century on.

It was not among the goals of the investigation this paper accounts for to carry out a systematic search into primary sources on the Vrancea region from 1000 to 1500. Thus, a special attention was given to the early Russian chronicles, because of their time-coverage encompassing the whole period under investigation, and because they were referred to by Mushketov and Orlov (1893) and Evseyev (1961). They used the Russian chronicles as published in the Complete Collection of Russian Chronicles (1850-1920), and for this reason some information concerning the origin and characteristics of this Collection is presented in Annex 1.

Finally, it is worth to put emphasis on the fact that, differently from previous studies, this research not only did resort to primary records in the original context of the chronicles, but also had the possibility to inquire into their reliability by accessing to their latest published reprints or editions. Their introductions always contain valuable information on when and in which places

the chronicles were written, information painstakingly collected in decades of philological and historiographical research in the very complex subject of early pan-Russian chronicles.

The earthquake records collected are included in the accounts of each and all the earthquakes listed in Table 1, presented in the following section.

## **4. The earthquake records**

The earthquake records retrieved and their interpretation are presented in English translation, which was made with the intent to maintain the simple, and sometimes crude, medieval Russian or Romanian of the originals. Annex 1 supplies the interested reader with the version in modern Russian.

The dating style of the Russian chronicles is the same officially in use in 11<sup>th</sup>-15<sup>th</sup> centuries in the Eastern Orthodox countries, i.e., the style of the “Byzantine Era”. Further details on this topic are given in Annex 1. The year as in the texts is reported and its translation into the Julian calendar is given between parentheses. The dates of the earthquakes at the beginning of each description are the result of our re-interpretation of all the elements supplied by the original sources. This was due to correct some previous misinterpretations. For instance, in the introduction to their catalogue, Kondorskaya and Shebalin (1977) stated that they had uniformly converted all the dates from the Julian to the Gregorian calendar, including the years ante-1582 when the Gregorian reform of the calendar was enforced in some Western European countries. The authors of this paper do not agree with this general conversion, because one cannot properly speak of “Gregorian dates” prior to 1582 and decided to restore the complete date as originally given in the sources.

This section deals with eleven earthquakes out of the fourteen appearing in Table 1. The 12 May 1022, and the 7 February 1258, earthquakes are listed as fakes by Alexandre (1990), while the 15 August 1038, is reported by Réthly (1952) on the basis of later sources only.

These earthquakes were since the beginning included in the search for primary, coeval and reliable sources on earthquakes located by parametric catalogues in Vrancea. The fact that we were not able to find any evidence of these events in the studied documentation made us wary about the reliability of



the records available to the catalogue compilers. For this reason, we consider them very doubtful and will not further discuss them in our analysis.

## **1091**

At the end of the account of the year 1091 the chronicler says:

“In the same year [6599/1091] there was a sign from the sun, as it was going to die, and very little of it remained, like the moon, at hour two of the day in the month of May, day 21. In the same year Vsevolod was hunting close to Vyshegorod, just cast a net when a horrible snake fell from heavens frightening all the people. At the same time the earth struck and many felt. The same year a pilgrim came to Rostov, and soon after died” (*Lavrentevskiy* chronicle, Kloss ed., 1997).

The place mentioned is *Vyshegorod*. There are four places called Vysh(e)gorod in Ukraine and Russia, but only one of them existed at the time of the earthquake. It was an important fortress (*gorod*) 16 km ca from Kiev along the Dnepr River, mentioned for the first time in the early Russian chronicles in 946. During the Mongol invasion in 1240 it was burnt (together with Kiev) and never recovered. In 1523 it is mentioned in the chronicles as a poor and small village.

Mushketov and Orlov (1893) simply reported the scarce information on the 1091 event, and in doing the same Evseyev (1961) added a question: “Probable fall of meteorite?”

This is a very doubtful case, and the information is not enough to assess a macroseismic intensity degree. We estimate it as a Felt with a question mark (Table 2).

## **5 February 1107**

The effects of this earthquake are described in different Russian chronicles.

“In the year 6615 [1107]. Knyaginya Volodimerya died, May 7. And the same year before that the earth shook, February 5, before daybreak in the night. In the same year came Bonyak, and old Sharukan” (*Voskresenskaya* chronicle, Kloss ed., 2001).

“In the year 6615 [1107]. Earth shook on February 5 day. The same year fight Bonyak, and old Sharukan and many other dukes, and stand near Lubna; brothers joined Svyatopolk, and Volodimer, and Oleg, Svyatoslav and Mstislav, Vyacheslav and Yaropolk, went at Polovtsy to Lubna, and at 6 in the day cross Sula and attacked” (*Nikonian chronicle*, Kloss ed., 1997).

The “Chronicle of Novgorod” in the English translation by Michell (in Shakhmatov, 1914) has this remark as the only record for the year 6615/1107:

“6615 [1107]. The earth trembled February 5.”

The *Povest' Vremennykh Let* (The Tale of Bygone Years) in the collated edition by Ostrowski (2004) reports:

“In the year 6615, indiction, moon cycle 4 years, and sun cycle 8 years [1107]. In the same year died Volodimirya, month May in day 7. The same month fought Bonyak, and took horses near Pereyaslavl. The same year came Bonyak and old Sharukan and many other dukes stood near Lubna. Svyatopolk, and Volodimer, and Oleg, Svyatoslav and Mstislav, Vyacheslav and Yaropolk, went at Polovtsy to Lubna, and 6 in the day crossed Sula and attacked them. [...] And on February 5 (month in 15) earth trembled before daybreak”.

Even in a case like this, with four chronicles agreeing on the date and the context of the event, it remains difficult to certainly associate the information on the 5 February earthquake with a specific place. An additional search made us found the same information in the *Ipatevskaya* chronicle (Kloss ed., 1998), from which both *Voskresenskaya* and *Nikonian* chronicles were derived. Since the *Ipatevskaya* chronicle was written in Kiev and was based on the Kiev Code of the year 1200, we assumed that the record has to be linked with Kiev. Most of the records for the previous year (6614/1106) and 6615/1107 are about the war with the Polovtsy, the nomadic tribes occupying the lands between the Dnepr River and Azov and Black seas. Though the Polovtsy never reached Novgorod, they regularly attacked the southern Russian lands such as Kiev.

All the above considerations, and the fact that the same interpretation was given by Mushketov and Orlov (1893) and Evseyev (1961), allowed us to interpret the records in association with Kiev. Because of the absence of any details in the description the effects were estimated as Felt (Table 2).

## 1122

The following is the complete account for the year 1122 in the *Lavrentevskiy* chronicle (Kloss ed., 1997).

“In the year 6630 [1122]. There was a sign in the sun in month March in day 10; and in the moon there was a sign in the same month, day 24. In the same year died princess Mstislavlya, of month January in day 18. The same year died Bishop Gyurgev Danilo, of month September in day 9. The same year came the metropolitan named Nikita from Tsesar’grad [Constantinople] to Santa Sofia; and Amfilofiy Bishop of Vladimir died; and earth shook [a little]. The same year came Yakhove Volodarya, brother of Vasilkov.” (*Lavrentevskiy* chronicle, Kloss ed., 1997).

The chronicle does not name explicitly the place where the earth trembled. In fact, the record originated from Kiev, and can be found in the *Ipatevskaya* chronicle (Kloss ed., 1998), as in the case of the 1107 earthquake. The record can be related to the southern Russian lands, most probably to Kiev itself, as was done by Mushketov and Orlov (1893) and Evseyev (1961). The absence of any details in the description allowed us to classify the effects as Felt (Table 2).

## 1 August 1126

The complete account for the year 1126 in the *Nikonian* chronicle says:

“In the year 6634 [1126]. Metropolitan of Kiev and all Russia Nikita put Father Superior Mark from Saint Ioan as Bishop in Pereslavl’, month October in 4 day. Metropolitan Nikita died. The same year died Nikita metropolitan of Kiev and all Russia, in month March in 9. The same year died princess of Volodimer Manamakh, month June in 11 day. The same year earth trembled in month August in 1 day, 8 in the night. The same year Miroslav Goryatinich was appointed “posadnik” [mayor] in Novgorod” (*Nikonian* chronicle, Kloss ed., 1997).

“Posadnik” is a Slavic word to indicate the mayor of some East Slavic towns, and especially of Novgorod and Pskov. The origin can be drawn back to the princes of Kiev, who used to name a “posadnik” to rule on their behalf.

All the events described by the chronicle for the year 1126, except the last explicitly related to Novgorod, are relevant to southern Russia (Pereyaslavl’, Kiev). Both Mushketov and Orlov (1893), and Evseyev (1961) associated the

information on the earthquake with Kiev, and we concluded the same. The absence of any details in the description allowed us to classify the effects as Felt (Table 2).

### **1170**

According to the *Nikonian* chronicle (Kloss ed., 1997):

“In the year 6678 [1170]. Was a frightful sign in heavens, in sun, in moon, and in stars. The same year earth trembled. The same year was a great terrible and frightful thunder, and many people were killed. The same year Grand Duke Andrey, Yurev son of Dolgorukiy, grand son of Vladimer Manomakh started collecting armies against Grand Duke of Kiev Mstislav Izyaslavovich, joining with many dukes in one council and one agreement; duke of Murom from Murom, duke of Smolensk from Smolensk, Roman, son of Rostislavl’, grand-son of Mstislavl’, grand-grand-son of Vladimer Manomakh.”

Since this record has no confirmation in the earlier accounts at the origin of the *Nikonian* chronicle, it should be considered as very doubtful. Both Mushketov and Orlov (1893), and Evseyev (1961) associated the information on the earthquake with Kiev. The record on this earthquake is so poor in details that it allowed us to classify it only as debatable Felt (Table 2, marked with “?”).

### **12 March 1196**

The account for the year 6704/1196 in the *Voskresenskaya* chronicle reports the earthquake in connection with the latest news on the political allegiances and contrasts in the lands near Kiev:

“The same winter during Great Lent Yaroslav Vsevolodovich with his brothers dukes of Chernigov broke his oath and kissing of the cross, on which he agreed with Rurik and kissed the cross with him, not to wage a war, there will be ambassadors of Vsevolod and Davyd, didn’t await for that, sent his son to Vitebsk on his son-in-law Davyd; Rurik that time was not in Kiev, but he went to Vruchiy, dismissed all his retinue, having trust on kissing the cross, and Olegovich did not arrive Vitebsk started war Smolensk volost. Learning that Davyd Olgovichev sent his son Mstislav Romanovich, and Rostislav Volodimericha with his regiment, and young duke his son-in-law Gleb Ryazanskiy, and Smolenians with them. They were near, and that time on

Tuesday second week of Lent, exactly during liturgy, earth trembled all over Kiev land; in Kiev itself masonry and wooden churches shook and all the people could not stand on their feet from fear, and afraid fell face down. And those regiments the same day in Chernigovsk and Smolensk started fighting; Olgovichs arriving first, put the regiments in order and stayed in snow, as it was a big snow. Mstislav and his retinue having went out from forest and having seen regiments, without putting the troops in order but attacked violently the Olgov's regiment, and trampled down his banners and killed son of Davyd." (*Voskresenskaya* chronicle, Kloss ed., 2001).

The date 13 February as in the catalogue by Kondorskaya & Shebalin (1977) was corrected. In 6704 (March dating) Easter was on the 21<sup>st</sup> of April. Counting back from Easter, "Tuesday of the second week of the Great Lent" corresponds to Tuesday 12 March 1196.

The information on this earthquake is confirmed by *Ipatevskaya* chronicle (Kloss ed., 1998), so that both date and localization are straightforward. The earthquake was widely felt, all over the land of Kiev. It was frightening but no damage is reported either to masonry or to wooden constructions. Relying upon this observation, we can assess at Kiev intensity between 5 and 6 EMS98 (Table 2).

### **3 May 1230**

Unlike all previous earthquakes, for this one a relatively good set of data is available. The section of the *Nikonian* chronicle reporting the earthquake is known in two versions, one based on the *Troitskiy spisok* (*Troitskiy* handwritten copy), and the other on the *Golitsinskiy* copy. Here follows the translation of the version given by the *Golitsinskiy* copy of the *Nikonian* chronicle, which appears to be the most complete:

"On earth trembling. Month May in day 3, during liturgy when honoring the Gospel, in the church of *Santa Madre* in Vladimir earth trembled, and churches, and refectory, and icons hanging on walls, and church-chandeliers with candles and lamps oscillated, people were confused, as everybody had vertigo, and they asked each other what it was, and understood not what was it. This happened in many churches and rich houses, and in other cities was it. In Kiev town it was stronger shaking; in the Pechersky monastery the masonry church of

*Santa Madre* cracked in four; this saw metropolitan Kiril, duke Vladimir, and boyars and many people who came: because it was holy day of father Feodosiy. Also masonry refectory was shaken, with the meal and beverage already in and this was spoiled by falling stones; but itself was not destroyed as well as its top. In Pereslavl the church of Saint Mark cracked in two, three beams with roof fell, and icons oscillated, and church-chandelier with candles and lamps; happened this in one day and one time all over the lands during liturgy. The same month day 10 ...” (*Nikonian chronicle*, Kloss ed., 1997).

The text from the first chronicle of Novgorod, elder redaction (*izvod*) is reported in the edition by Shakhmatov (1914) with the English translation by Michell:

“The earth quaked on a Friday in the fifth week of Easter during dinner, and some had already dined. And this, brethren, was not for good, but for evil; God shows as his signs, that we repent us of our sins. What great mortality God brought on us that spring! And yet seeing this we understood not our ruin; but were more prone to evil. The same year, on May 14, St. Sidor Day on Tuesday, in the middle of the morning the sun grew dark and became like a moon of the fifth night; and it filled out again and we godless ones were glad. On the 19<sup>th</sup> of the same month on [the day of] Veche of the 318 Holy Fathers, Vladyka Spiridon came to Novgorod, appointed by the Metropolitan Kiril; he was appointed priest in Quinquagesima week, and Vladyka after Holy Week on Veche [Day].”

The author of the *Golitsinskiy* copy described damaging effects in Kiev and Pereyaslavl’. According to this record an intensity of 5-6 EMS98 was assigned.

The church of *Santa Madre* mentioned in the description was in Vladimir-na-Klyaz’me, capital of the Vladimir-Suzdal’ principedom, which used to be called Vladimir. This is the result of an ad hoc check, since for instance Shebalin et al. (1977) in their map (Fig. 2) associated the “Vladimir” mentioned in the chronicle with Vladimir-Volynskiy. At Vladimir the intensity was assessed as 4 EMS98.

The *Troitskiy* copy of the chronicle gives less details on the effects, but adds to the list of the affected places the lands of Rostov and Suzdal’. According to the local chronicle, in Novgorod the earthquake was just felt. Felt was assessed in Rostov and Suzdal’ as well (Table 2).

## 1328

The record on this earthquake is supplied by the *Nikonian* chronicle:

“In the year 6836 [1328] [...] The same year earth trembled in Novgorod [...] The same year burnt Yurev Nemetskiy all, and their churches, and palaces went to pieces, and Nemets died 2000 and 500 and 30, and Russians four people.” (*Nikonian* chronicle, Kloss ed., 1997).

What makes this record doubtful is that the Chronicle of Novgorod has the same text on the severe fire in Yurev of the Nemtsy in 1328, but does not mention any earthquake in the accounts for the years 1326-1329. From a further check, it appears that for these years the *Nikonian* chronicle relied on *Rogozhskiy letopisets* (*Rogozhskiy* chronicler, Kloss ed., 2000), who in his turn took the information from the *Tverskoy sbornik* (*Tverskoy* collection, Kloss ed., 2000). This record might be considered less reliable than the others because i) the *Tverskoy sbornik* chronicle was compiled in Tver', not far from Novgorod, but in fact it pertained to another principedom, and ii) the earthquake is not mentioned or did not survive in the extant copies of the chronicles of Novgorod.

For unclear reasons Mushketov and Orlov (1893) put this event in 1327. Following the *Nikonian* chronicle, we dated the earthquake 1328 and assigned Felt at Novgorod (Table 2)

## 1 October 1446

For this earthquake Mushketov and Orlov (1893) referred to *Tsarstvenniy letopisets* (*Tsarstvenniy* chronicler), which according to Shchapov (2003) is an 18<sup>th</sup> century compilation. The original description of this earthquake comes from a coeval source, *Moskovskiy letopisniy svod kontsa XV veka* (Moskva annual code of the end of the 15<sup>th</sup> century, Kloss ed., 2004):

“In the same autumn [1446], on the 1st day of October when the Grand Duke was set free in Kurmysh, at 6 in the night, Moskva shook, the Kremlin and all the town also and the churches shook. People who were sleeping, not all of them felt it, but many who felt it, they were in grief and afraid for their lives. In the morning with tears they told all this to the people, who were not awoken by it”.

Date and affected place are clearly stated. The intensity assessment for Moskva is 3-4 EMS98 (Table 2), as it takes into account that not all the people woke up because of the earthquake, but those who did were frightened by it.

### **29 August 1471 [29 August 1473]**

The primary source for this earthquake is a Moldavian chronicle as it was recompiled by Grigore Ureche, a descendant of an old Moldavian noble family. His “Chronicle of Moldavia up to duke Aron Voda” (Ureche, 17<sup>th</sup> century) written between 1642 and 1647, covers the time-period from 1359, when Moldavia got its independence, up to end of the government by Aron Voda (1591-1595). The original chronicle did not survive, and the 20<sup>th</sup> century edition contains addenda belonging to some copyists: Simeon Daskala (1660-1670), monk Misail (1670-1680) and Aksinte (1712).

The account on the year 6979 [1471] starts from 7 March with the description of the conflict between the two dukes Radu and Ștefan. Then it continues saying that:

“In the same year [6979/1471] August 29, when the “gospodar” [the Moldavian king, then Ștefan the Great] was having dinner, a big earthquake happened in the whole country.” (Ureche, 17<sup>th</sup> century).

This is the whole account on the earthquake; then the chronicle continues with information on the Ottoman pillages in the country.

Purcaru (1979) relied upon a biography of the same king Ștefan the Great (Sadoveanu, 1957) to state that the 1471 and 1473 earthquakes in Shebalin et al. (1974), were in fact to be considered as one. Looking at the set of seismological compilations used by the catalogues (Table 1), it appears that the date 1473 was derived by the Hungarian sources, through Réthly (1952). The two references quoted by Réthly are Bielz (1862-1863) and Koch (1880). Both of them did not quote their sources and simply summarised the effects in Brasov (Kronstadt) as severe damage. Effects in the environment (“mountains shook and rivers dried”) are reported also. Later Florinesco (1958) mentioned the two events, taking the 1471 one from “Moldavian chronicles” and the 1473 from Réthly (1952), though in mentioning the latter Florinesco wrote that “Probablement c’est le meme que celui cite par Bieltz et Koch-1473 aout 29”.



In all, the information about Moldavia is very poor, and there is no description of effects permitting us to evaluate whether the earthquake was so strong as to cause any damage. The wording “widely felt” seems to correspond better to what is reported and to the fact that no other information is available from the coeval sources. The exact location cannot be derived from the available record, and a further check is needed to trust the very late sources used by Réthly. In our opinion, the correct date should be recognized as the one given by the coeval chronicle, that is 29 August 1471. As a consequence, only a generic Felt was assigned to Moldavia (Table 2).

## **5. Comparison with 19<sup>th</sup>-20<sup>th</sup> centuries earthquake data**

At this stage, a comparison was performed with the effects reported in the Russian plain on the occasion of earthquakes located in the Vrancean source zone in the 19<sup>th</sup> and 20<sup>th</sup> century, either on the basis of good quality and well distributed information as in the case of the [14 October Old Style] 26 October 1802 earthquake, or because there are instrumental locations available, as for the 10 November 1940 and 4 March 1977 earthquakes.

### **26 October 1802**

A comprehensive report on the 26 October 1802 earthquake was produced by Tatevossian and Mokrushina (1998). Here are reported the descriptions of effects in the same places mentioned for the historical earthquake (Kiev, Moskva) plus in some others. The places are mentioned (Fig. 3) according to the increasing distance from the Vrancea region.

*Kiev* (600 km).

“XVII. Earthquake felt in Kiev and surroundings. 1802, November 5 corresponding member Bounzh from Kiev informs in the letter to the Academy that in last October 14 at 1.30 p.m. when there was an absolutely clean sky and quiet weather in Kiev was felt an earthquake approaching from south-west. Six shocks were felt during 3 minutes; they were so strong that not only the house of Mr. Bounzh, built on masonry foundation and his masonry pharmacy strongly shook, but also a high bell tower near his home was shook. Bells started to ring by

themselves.” (Nova Acta Academiae Scientiarum Imperialis Petropolitanae (1802); the original text is in French).

Kaluga, Likhvin, Kozelsk, Peremyshl, Tula, Belev (ca. 1000 km).

“November 10, 1802, the academician Severgin delivered to the Assembly a letter of the Consul in Belev, with information on the same earthquake, which on October 14, 2 p.m. was felt in Kaluga, Likhvin, Kozelsk, Peremyshl, Tula and Belev. This phenomenon occurred, like in Kiev, when there was an absolutely clear weather. The direction was from south to north along the left bank of Oka River, and was very weak on its right bank. The duration was ca. 5 min, without jerks or damage. In Kaluga and Kozelsk church bells started to ring.” (Nova Acta Academiae Scientiarum Imperialis Petropolitanae (1802); the original text is in French).

Tambov region (1100 km).

“In 1802 under the governor Koshelev in Tambov region occurred an event, which has to be mentioned. In Lipetskiy and Lebedyanskiy districts on October 14 there was an earthquake. In Lebedyanskiy district it was observed in the villages: Izbishchi, Zamartin’e, and Kalikino. As it is reported to the prosecutor of Tambov, all *izba*(s) [wooden country houses] oscillated during a couple of minutes. In Lipetskiy district, the earthquake was felt at the villages of Mordovka and Yablonovets. A landlord of Mordovka, lieutenant Kolobov recorded: October 14 at 2 p.m. me and my guests lieutenants Ulanov, Palibin and second lieutenant Somov, sat for dinner. Suddenly the table oscillated and all of us run out supposing that the roof was falling. Earthquake was ca. 5 min. Near the landlord house was *izba*, in which cradles were hanged from cellar; and all of them started to oscillate. In coach-house people cut cabbage and suddenly washtub jumped. Though the earthquake was long, nothing happened to houses and people.” (Dubasov 1884, based on the evidence by eyewitnesses).

Smolensk (1100 km).

“1802 October 14 at the end of the second our p.m. in Smolensk was felt a weak earthquake, mostly on the banks of Dnepr River; the bridge across the Dnepr shook noticeably but without damage. This earthquake was felt all over Smolensk region, mostly by inhabitants of villages on river banks.” (Murzakevich 1804).

Moskva (1400 km).

“October 14 at the end of the second hour p.m. we felt a light earthquake, which continued 20 sec and was composed by two shocks or movements. It moved from east to west and in some parts of the city was stronger: for example (as evidenced) in Truba, Rozhdestvenka, and behind Yauza. In some places it was not noticed. It did not cause any damage, except that in the vault wall (in Gorodskoy district) cracks occurred; in other places was noted a hole in the ground ca. *arshin* [0.7m ca] in circumference. The shocks were felt stronger in tall buildings; almost everywhere oscillated chandeliers, in some tables and chairs moved. Many people did not trust themselves and decided that they had vertigo. Workers on Spasskaya Tower felt the walls trembling. People who were walking along the streets or were riding, felt nothing, and most of the inhabitants only the next day learnt there had been an earthquake in Moscow.” (N.M. Karamzin was an eyewitness and author of the observations published in Vestnik Evropy (1802).

Using this information Tatevossian and Mokrushina (1998) assigned the following intensities (MSK64):

- Kiev 5, similar to the one (5-6) assessed in this paper for the earthquakes in 1196 and 1230;

- Moscow 4, similar to the one (3-4) assessed in this paper for the 1446 earthquake.

### **10 November 1940 and 4 March 1977**

Similar effects in the Russian plain were observed in the instrumental period, on the occasion of the 10 November 1940 and the 4 March 1977 earthquakes, instrumentally located in the Vrancean earthquake-source zone.

Figure 4a shows the distribution of reports in Moscow on felt effects, while Figure 4b shows the isoseismal map for the 10 November 1940 earthquake. The earthquake was felt practically all over Moscow; intensity 4 (MSK64) was assigned to it. In Kiev, the intensity was assessed as 5 (Drumya and Shebalin 1985).

Figures 5a and 5b present two different versions of the isoseismal map for the 4 March 1977 earthquake, according to which intensity 3 (Drumya and Shebalin 1985) and 4 (Anan'in 1980) were assigned to Moscow, respectively.

Drumya and Shebalin (1985) assigned intensity 5 to Kiev. To show the content of the available reports on macroseismic effects in Moscow, some excerpts from Drumya and Shebalin (1985) are reported in the following:

“Standard lamp oscillated; table and chairs moved (ca. 10 cm) together with a person sitting on the chair.

On the 5<sup>th</sup> floor plates and dishes clinked, lamp oscillate.

On the 6<sup>th</sup> floor a vase turned over and dropped.

On the 9<sup>th</sup> floor: “I was frightened, ran out and outside also felt ground movement.

On the 2<sup>nd</sup> floor some people had a short vertigo; furniture moved.”

## **6. Discussion and conclusions**

Information on the studied earthquakes is summarized in Table 2 and in Figure 6. Retrieving and re-reading the original data as supplied by the primary sources reveal that only in one case (1471) there is a report from an area at 100-200 km from Vrancea. In the other cases the distances are grouped at 600 km ca. (Kiev, Vyshegorod, Pereyaslavl') and at 1400-1600 km (Moskva, Vladimir, Rostov, Suzdal', Novgorod) from Vrancea. From these cases only once, in 1230, effects at more than one place are reported. In most cases the information is so poor that it was possible to assess a “Felt” only.

From what was described above in terms of available earthquake records, it is clear that it is not possible to identify seismic events as being of Vrancean origin directly from the spatial distribution of the datapoints, perhaps except for the 1230. It means that there should be a background hypothesis, not explicitly given by the catalogue compilers (we mostly refer to Kondorskaya and Shebalin, 1977), which was combined together with the original data to derive the earthquake parameters. The hypothesis, which could be supported by the comparison between the data and parameters given in the catalogues, is the following: there are no local earthquake sources in the Russian plain, thus any shaking in this territory is produced by an earthquake in the intermediate-depth source zone in Vrancea. Without such an assumption it would not be possible to identify a seismic event having its source in the Vrancea region having record on macroseismic effects in Moskva only.

But do we really need any background hypothesis to identify deep Vrancean earthquakes? Certainly, the best would be to have in our hands the descriptions of macroseismic effects at places in the epicentral area (to have a robust set of data to locate the epicentre) and in the far-field (to constrain depth). This is, for example, the case of 1802 earthquake. On the other hand, in the period 1000-1500 one has to deal mostly with very poorly reported earthquakes. It might be added that this situation has much in common with problems related to the location of off-shore earthquakes, for which macroseismic information from epicentral area is not available in principle. Though some formalized approaches, e.g. Bakun and Wentworth (1997), deal with such cases, no one of them is able to give a reliable result in cases when a single intensity datapoint is available. In this situation, the catalogue compilers resort to expert judgment based on explicit or hidden assumptions. The latter is the case of the Vrancea earthquakes location, the background assumption for which was not explicitly made and fully explained. If we consider this “forgotten” assumption as a sound, black box, then the results of this study is that by using the original information as supplied by the coeval sources we made this box transparent. Rejecting the assumption used by Kondorskaya and Shebalin (1977), several moderate magnitude earthquakes in the Russian plain would be located close to Kiev, Moskva and further to the northeast (e.g. Vladimir), with no reliable seismotectonic and observational background. It has to be mentioned that neither regular, nor special seismological observations with a dense network have ever recorded a locally-originated earthquake in the Moskva region.

The similarities between the assessment of intensities in Kiev and in Moscow on the occasion of the 11<sup>th</sup> to 15<sup>th</sup> centuries earthquakes on the one hand and of the 19<sup>th</sup> to 20<sup>th</sup> centuries ones on the other hand, seems to be a kind of identifier of large Vrancean earthquakes: but how large are they? In fact, there are only three earthquakes in Vrancea for which direct measurements of moment magnitude ( $M_w$ ) are available, and which were felt in Moscow and Kiev; they are in the range of  $M_w$  6.9-7.5 (all moment magnitude values are Harvard University data) (Fig. 7). The one in 1977 was discussed above; the earthquake on 30 August 1986 was felt with intensity 3 in Moscow (Kondorskaya et al. 1989); and the one on 30 May 1990 was just felt (Drumya et al. 1996); the one on the following day with a smaller magnitude ( $M_w=6.3$ ) was not felt. CMT depth solutions differ

essentially from one earthquake to the other. Both earthquakes in 1986 and 1990 are intermediate-depth, but the source of the first is at 133 km and of the second at 74 km. This means that seismic waves traveled to Kiev and Moskva along different paths, and this might be the reason why sometimes the relationships between the intensities in Kiev and Moscow might appear to be incoherent. This might partly depend on the accuracy and reliability of the intensity assessments also. Taking into account the striking similarity of these three CMT solutions, which reflect the stability of large-earthquake mechanisms in Vrancea, we can conclude that the magnitudes of the historical earthquakes of 1230 and 1802 were in the range  $M_w=7.2-7.5$ .

Retrieving the original information from coeval sources and comparing the effects with those of later historical but well-documented, as well as instrumentally recorded Vrancean earthquakes, has allowed us to state that the macroseismic effects in the far-field demonstrate the validity of the assumption made by Kondorskaya and Shebalin (1977). To this set of data, different kinds of data for 19<sup>th</sup> to 20<sup>th</sup> centuries, such as instrumental locations and CMT solutions, added to the understanding of the macroseismic response of the Russian plain to Vrancea earthquakes.

On the one hand, the investigation and analysis of historical earthquake records for the fourteen events listed by the catalogues in the 11<sup>th</sup>-15<sup>th</sup> centuries has shown that one event (1471) is a duplication of date (the correct one being 1473), three earthquakes were found not to be supported by any primary source (12 May 1022, 15 August 1038 and 7 February 1258), and three earthquakes (1091, 1170 and 1328) turned out to be attested by not completely reliable records.

On the other hand, the availability of data on recent earthquakes that may be compared to historical ones in terms of macroseismic effects allowed the authors to agree with the previous catalogue compilers' solution with regards to both magnitude and depth of the past earthquakes for which do exist reliable primary historical records.

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## Figure Legend

**Fig. 1** Geographical setting. The map shows the point with Lat 45.700 N, Lon 26.600 E (black dot), where the earthquakes of the Vrancea region are located by the current parametric catalogues, and the location area (rectangle) by Purcaru (1979) (see text and Table 1). Places cited in the text are also shown

**Fig. 2** Isoseismal map for the 3 May 1230 earthquake. This map is unpublished and was compiled by Drumya et al. for the Atlas (Shebalin et al. 1977)

**Fig.3** Intensity datapoints for the 1802 earthquake from Tatevossian and Mokrushina (1998). Place names are given as they were originally reported. The rectangle has the same meaning as in Fig. 1 (location area of Vrancean earthquakes according to Purcaru, 1979)

**Fig. 4** Vrancean earthquake on 10 November 1940: a) distribution of reports on felt effects within Moskva city limits collected in 1940 according to (Medvedev 1948); isoseismal map according to (Drumya and Shebalin 1985). Intensity 4 (MSK64) is assigned to Moskva and 5 to Kiev (both are underlined). The cross indicates the instrumental epicenter

**Fig.5** Isoseismal maps of the Vrancean earthquake of 4 March 1977: a) according to (Drumya and Shebalin 1985), intensity 3 in Moskva and 5 in Kiev; b) according to (Anan' in 1980) intensity 4 in Moskva. The cross indicates the instrumental epicenter

**Fig.6** Places and dates for which this paper supplies macroseismic observations. Intensities are given in Table 2. The rectangle has the same meaning as in Fig. 1 (location area of Vrancean earthquakes according to Purcaru, 1979). A question mark evidences the doubtful cases

**Fig.7** Moment magnitudes and CMT solutions (according to Global CMT catalog) of earthquakes felt in Moskva and Kiev. Grey circles are epicenters of earthquakes within the map frames with  $M \geq 4.5$  since 1964 according to (ISC catalogue). The rectangle shows location area of Vrancean earthquakes according to (Purcaru, 1979). The 4 March 1977 (see text and Figs 5a-b also), 30 August 1986 and 30 May 1990 earthquakes are the large events in Vrancea for which there are direct  $M_w$  measurements. Earthquakes with a smaller  $M_w$  were not felt in Moskva

## Table Title

**Table 1** Earthquakes located in the Vrancea region (11<sup>th</sup> to 15<sup>th</sup> cent) according to parametric earthquake catalogues

**Table 2** Summary of earthquake records

## Annex 1. Notes on early Russian chronicles and excerpts

Russian Chronicles are called *letopis'*, which literally means “annual records”. The original versions of the chronicles survived in several *spisok* (handwritten copy) of 14<sup>th</sup>-18<sup>th</sup> centuries. According to the place of compilation or the place of main interest these copies are subdivided into *razryad* (literally: class, category, rank, or sort), as for example, “initial Kiev”, “Novgorod”, “Pskov”, and so on. Copies pertaining to the same *razryad* (class) have significant differences in style, in what events they report and how they have been interpreted. These characteristics define their *izvod* (redaction). For example, one chronicle can be classified as the “Chronicle of initial Suzdal *izvod*” (Lavrentevskiy *spisok* and similar). The survival of these Chronicles in several copies, in which linguists and historians can identify the differences, led to the widely accepted opinion, that all extant Russian Chronicles are later compilations, the original sources of which did not survive. This opinion is also supported by the fact that earliest known Russian Chronicle is dated to 1377, though the first record in it dates back to 852.

Here follow a few remarks on the Russuna chronicles upon which this paper relies. The relationships among Russian chronicles are given according to (Shchapov, 2003).

*Lavrentevskiy Chronicle*. The Chronicle is dated to 1377, and it was copied from an earlier set of sources by the monk Lavrentiy. This gathering work was ordered by Dmitriy Konstantinovich *velikiy knyaz* (Grand Duke) of Suzdal' – Nizhniy Novgorod principedom. It includes *Povest' Vremennykh Let (PVL)*, which is the earliest known part of Russian Chronicles (852-1116), to which sections were added, extending it up to 1305. There are some gaps in the Chronicle, and namely for the years 898-922, 1263-1283, and 1288-1294. At the beginning, the

*Lavrentevskiy* Chronicle describes the events in Kievskaya Rus'; later, during the 12<sup>th</sup> century it is mostly concentrated on events at Vladimir, while starting from the 13<sup>th</sup> century it includes a wealth of information on the Rostov principedom. The place where monk Lavrentiy wrote the chronicle is not known for sure, either in Vladimir or in Nizhniy Novgorod, in the Pecherskiy Monastery. This chronicle was published in 1846 in the first volume of the *PSRL* by the Archeographic Commission. In this edition some gaps were filled using the *Radzivilovskiy* and *Troitskiy* chronicles, which are similar to the *Lavrentevskiy*.

*Chronicles of Novgorod*. There are two redactions (*izvod*) of the first Novgorod Chronicle, the elder and the younger. The elder redaction exists only in one copy, the Synod *spisok*, which is kept in the archive of Synod. The beginning of the chronicle is lost; it started with records of events of 1016. The Synod copy is in two parts: the earliest, up to 1234, was compiled in the second half of the 13<sup>th</sup> century; the most recent includes the period 1234-1330, ending with the year when it was copied. After 1330 different handwritings added news on 1331-1333, 1337, 1345 and 1352. These later additions are related to Yurev Monastery in Novgorod.

The younger redaction of first Novgorod Chronicle exists in several copies. How this text took the form it has now in *PSRL* and in other editions is a rather complicated story, studied and related by Shakhmatov (1914). Its core formed in the first quarter of the 15<sup>th</sup> century, and it extends to 1439 or 1441. It is possible, that from the beginning up to 1015 this copy includes the lost part of elder redaction.

Except for the first Novgorod chronicle in two redactions, there are also the chronicles known as Novgorod II, III, IV, *Sofiyskaya letopis'*, and *Supral'skaya letopis'*. All of them mostly report on local events, or events affecting the state of Novgorod. Pan-Russian events were rarely reported in these later Novgorod chronicles and appeared more or less randomly.

*Voskresenskaya Chronicle*. It is a pan-Russian Chronicle of the 16<sup>th</sup> century, which reflects the interests of Grand Dukes of the principedom of Moskva. Thirteen copies are known, and the one belonging to the Voskresensk Monastery in New Jerusalem (near Moskva) gave the name to the Chronicle. It is based on

the Moskva code of 1479 as known in a copy made in 1526 and the Tikhonov copy of the Rostov code (1489-1503).

*Nikonian Chronicle*. The core of this chronicle is dated to the 16<sup>th</sup> century, and is named after the patriarch Nikon who owned one of the copies. The main part of this chronicle was compiled in 1539-1542. The Nikonian chronicle is a huge compilation based on several sources, from chronicles of places close to Novgorod, Voskresensk, Iosaf (since 1446), to chronological tables, and special accounts of important historical events, and to today-lost local chronicles and oral-tradition stories. The compilers of the Nikonian Chronicle did an extensive editorial work, assembling and rearranging the historical material in their hands in such a form to prove the leading role of the Moskva dukes and the Church in the making of the Russian state. Later on it became the official chronicle recognized by both the ecclesiastic and the civil authorities.

The most extensive publication of the Russian Chronicles is the 30-volume collection made by the Archeographic Commission in 1850-1920. There are some facsimile reprints, the latest of which started being published in 1997 by the Institute of Russian History (*IRH*) of the Russian Academy of Sciences.

Some chronicles have been translated into English, such as the Novgorod chronicle in the edition by A.A. Shakmatov (1914). Recently, D. Ostrowski (2004) compiled an interlinear collation (10 lines maximum) of the *Povest' Vremennykh Let* (i.e. the earlier part of *PSRL* up to 1116). In an extensive introduction in both Ukrainian and English he says: “*The present interlinear collation includes the five main manuscript witnesses to the PVL, three published versions of the PVL, the corresponding passages from the published version of the Novgorod I Chronicle, and the corresponding passages from the Trinity Chronicle. It also includes a paradosis, that is, a proposed best reading*”--V. 1, p. xix.”

For this investigation, the 1091 and 1107 records were checked in the edition by Ostrowsky (2004), while the records of earthquakes in the time-window 1122-1446 have been checked against the edition supplied by the *IRH* reprints. The only record falling out of the time-span presented in described above chronicles is the one related to the 1471/1473 event.

A remark on the calendar in use in the Russian chronicles is needed to make explicit how the dates of the earthquakes are given in this paper. From the 11<sup>th</sup> to the 15<sup>th</sup> century in the Eastern Orthodox countries, and Russia among them, the calendar of the “Byzantine Era” was officially in use. It established the beginning of the world in the year 5508 B.C., so that the 1 A.D. corresponded to 5509. From 11<sup>th</sup> up to mid of 15<sup>th</sup> century the beginning of the year was set on the 1<sup>st</sup> of March. This dating is referred in the Russian historical documents as the “March-dating”. Starting from mid 15<sup>th</sup> century the beginning of the year was set on the 1<sup>st</sup> of September (“ultra-March dating”). The Byzantine calendar was abolished on 1<sup>st</sup> January 1700, when the Julian calendar was adopted. This means that in converting the dates to the Julian calendar (in use in Russia until 1917) when dealing with events occurred between March and December (when the “March-dating” was in use) or September and December (for the “ultra-March dating”) one year has to be subtracted. With respect to the use in the chronicles described above, the “ultra-March dating” was introduced in the Nikonian chronicle, which means that its compilers made the conversion between the two dating styles as given by the previous chronicles. This was not always done accurately, and created some problems of correct dating.

For the sake of completeness, the excerpts from the chronicles given in the paper in English translation are here supplied in modern Russian, for the readers who might be interested.

### **On the 1091 earthquake**

В се же лето бысть знамень в солнци, яко погыбнути ему, и мало ся его оста, акы месяц бысть, в час 2 дне, месяца мая 21 день. В се же лето Всеволоду ловы деюще зверинья за Вышегородом, заматавшим тенета и кличаном кликнувшим, спаде превелик змии от небесе, и ужасошася вси людье. В се же время земля стукну, яко мнози слышаша. В се же лето волхв явися Ростове, иже вскоре погыбе.

*Lavrentevskiy chronicle, Kloss ed., 1997.*

### **On the 5 February 1107 earthquake**

В лето 6615. Преставися княгиня Володимеря, мая 7. А в том же лете преже того потрясея земля, в февраля 5, пред зарею в ноци. Того же лета прииде Боняк и Шарукан старый.

*Voskresenskaya chronicle*, Kloss ed., 2001.

В лето 6615. Потрясеся земля февраля в 5 день. Того же лета воева Боняк и Шарукан старый и инии князи мнози, и сташа около Лубна; братия же собрашася Святополк, и Володимир и Олег, Святослав и Мстислав, Вячеслав и Ярополк, идоша на Половци к Лубну и в 6 час дне перебреша через Сулу, и кликнуша на них.

*Nikonian chronicle*, Kloss ed., 1997.

В лето 6615, индикта, круг луны 4 лето, а солнечнаго круга 8 лето. В се же лето преставися Володимирия, месяца мая в 7 день. Того же месяца воева Боняк и зая коне у Переяслявля. Том же лете прииде Боняк и Шарукан старый и инии князи мнози, и сташа около Лубна. Святополк же и Володимир, и Олег, Святослав, Мстислав, Вячеслав, Ярополк, идоша на Половци к Лубну, в 6 час дне, бродишася чрес Сулу и кликоша на не. [...] А месяца февраля 5 (в 15) трясе земля пред зорями.

*Ostrowski (2004)*

### **On the 1122 earthquake**

В лето 6630. Бысть знаменье в солнци, в месяца марта в 10 день; и в луне бысть знаменье, того же месяца в 24 день. В се же лето преставися княгыня Мстиславля, месяца генваря в 18 день. В то же лето преставися епископ Гюргевский Данило, месяца септября в 9 день. В то же лето приде митрополит из Цесаряграда в святую Софью именем Никита; и Амфилофий преставися епископ Володимерьский; и земля потрясеся мало. В то же лето яша Яхове Володаря, Василкова брата.

*Lavrentevskiy chronicle*, Kloss ed., 1997.

### **On the 1 August 1126 earthquake**

В лето 6634. Постави Никита митрополит Киевский и всеа Руси игумена Марка от святого Иона епископом Переславлю, месяца октября в 4 день. Успе митрополит Никита. Того же лета преставися Никита митрополит Киевский всеа Руси, месяца марта в 9. Того же лета преставися княгини Володимеря Манамаха, месяца июня в 11 день. Того же лета потрясеся земля, месяца августа в 1 день, во 8 час нощи. Того лета в Новгороде даша посадничество Мирославу Горятиничу.

*Nikonian chronicle, Kloss ed., 1997.*

### **On the 1170 earthquake**

В лето 6678. Быша знамена страшна на небеси, и в солнце, и в луне и в звездах. Того же лета потрясся земля. Того же лета быша громове велицы зело и страшны, и множество человек избиша. Того же лета начаша рать совокупляти на великого князя Киевскаго Мстислава Изяславовича князь велики Андрей, Юрьев сын Долгорукаго, внук Владимира Маномаха, соединися со многими князи в един совет и в единомыслие; Муромстии князи из Мурома, Смоленстии князи из Смоленска, Роман, сын Ростиславль, внук Мстиславль, правнук Владимира Маномаха.

*Nikonian chronicle, Kloss ed., 1997.*

### **On the 12 March 1196 earthquake**

Тое же зимы, в великое говение, Ярослав Всеволодович с братею своею со князя Черниговскими переступив рядь и крестное целование, на чем бяше умолвил с Рюриком и крест целовал с ним, яко не воеватися по ряду, дондеже будут послы Всеволожи и Давыдова, не дождав того Ярослав посла сыновце свою к Витебску на зятя своего на Давыда; Рюрик же не бе в то время в Киеве, но шел бе во Вручий, распустив братью всю, има веры крестному целованию, а Олеговичи не дошед до Витебска начаша воевати Смоленскую волость. Слышав же Давыд Олговичев, и посла Мстислав Романовича сыновца своего, и Ростислава Володимерича с полком своим, и Глеба Рязанского княжича, зятя своего, и Смоляне с ними. Уже бо им близ себе сущим, и в то время, во вторник 2 недели поста, в самую обедню, потрясся земля по всей земле Киевской; в Киеве же церкви каменные и деревянные колебахуся, и вси людие от страха не можаху стояти, но падающие ниц трепещуще от страха. А полци ти того же дни в Черниговстии и Смоленстии начаху сретатися; Олговичи же прежде устерегше, изнарядивше полкы своя, и отоптавшися в снегу стаха, бе бо снег велик. Мстислав же и дружина его выйдоша из леса и узревше полкы, и не успевше полков изрядити, но вборзе пойдоша на них и сразишася со Ольговым полком, и стяги его потопташа и сына его Давыда секоша.

*Voskresenskaya chronicle, Kloss ed., 2001.*



### **On the 3 May 1230, earthquake**

Месяца маия в 3, во время святыя литургия, егда чтут святое евангелие в церкви святыя Богородица в Володимери потрясся земля, и церкви, и трапеза, и иконы, подвизашася по стенам, и паникадила со свещами и светилна поколебашася, людие же изумешася, и мнхутся яко глава обошла кождо их, и тако друг другу сказоваху еже бысть им, и недоумевахуся что есть сие. Бысть же се во многих церквах и в домах господских, и во иных градах бысть сие. В Киеве же граде боле того наипче бысть потрясение: в монастыри Печерском церкви святая Богородица каменная на 4 части разступися; ту сущу митрополиту Кирилу, и князю Володимеру, и бояром и множеству людей сшедшуся: праздник бо бе том дне отца Феодосия. Потрясе же и трапезницею каменою, уже принесену бывшу в ню корму и питью, и все то потре камене свержу падаа; вся же трапезница не паде, ни верх ея. В Переславли же Русском церкви святого Михаила разседся на двое, паде же и перевод трех комар и с кровлею, и потре иконы, и паникадила со свечами и светилна; бысть же то единого дне и единого часа по всей земли во время литургия. Того же месяца 10 ...

*Nikonian chronicle* (Kloss ed., 1997).

### **On the 1328 earthquake**

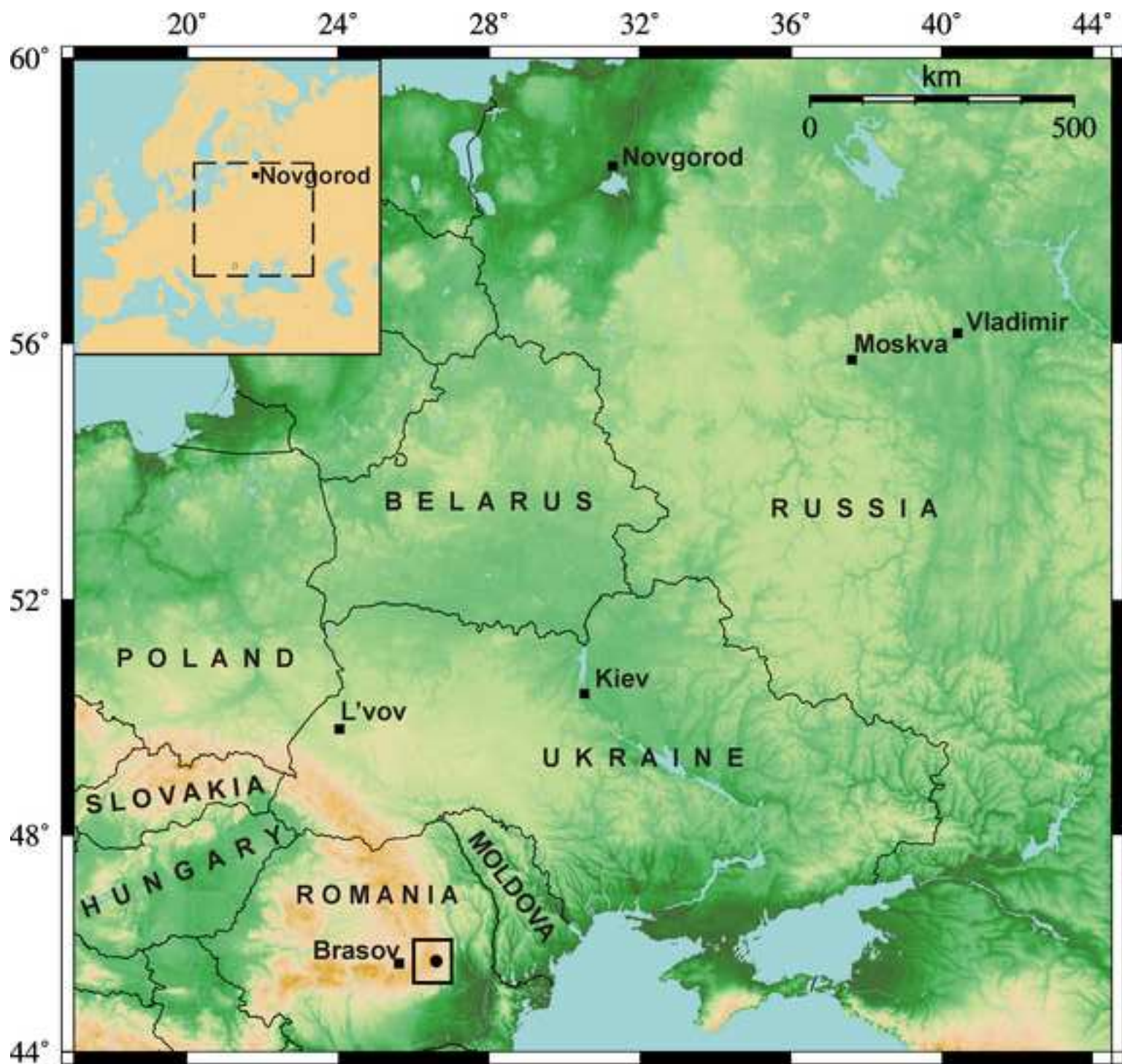
В лето 6836. [...] Того же лета потрясся земля в Новеграде ... Того же лета погоре граде Юрьев Немецкий весь, и божницы их, сиречь церкви их, и полаты их разсыпашася, и Немец згоре 2000 и 500 и 30, а Руси четыре человеки.

*Nikonian chronicle*, Kloss ed., 1997.

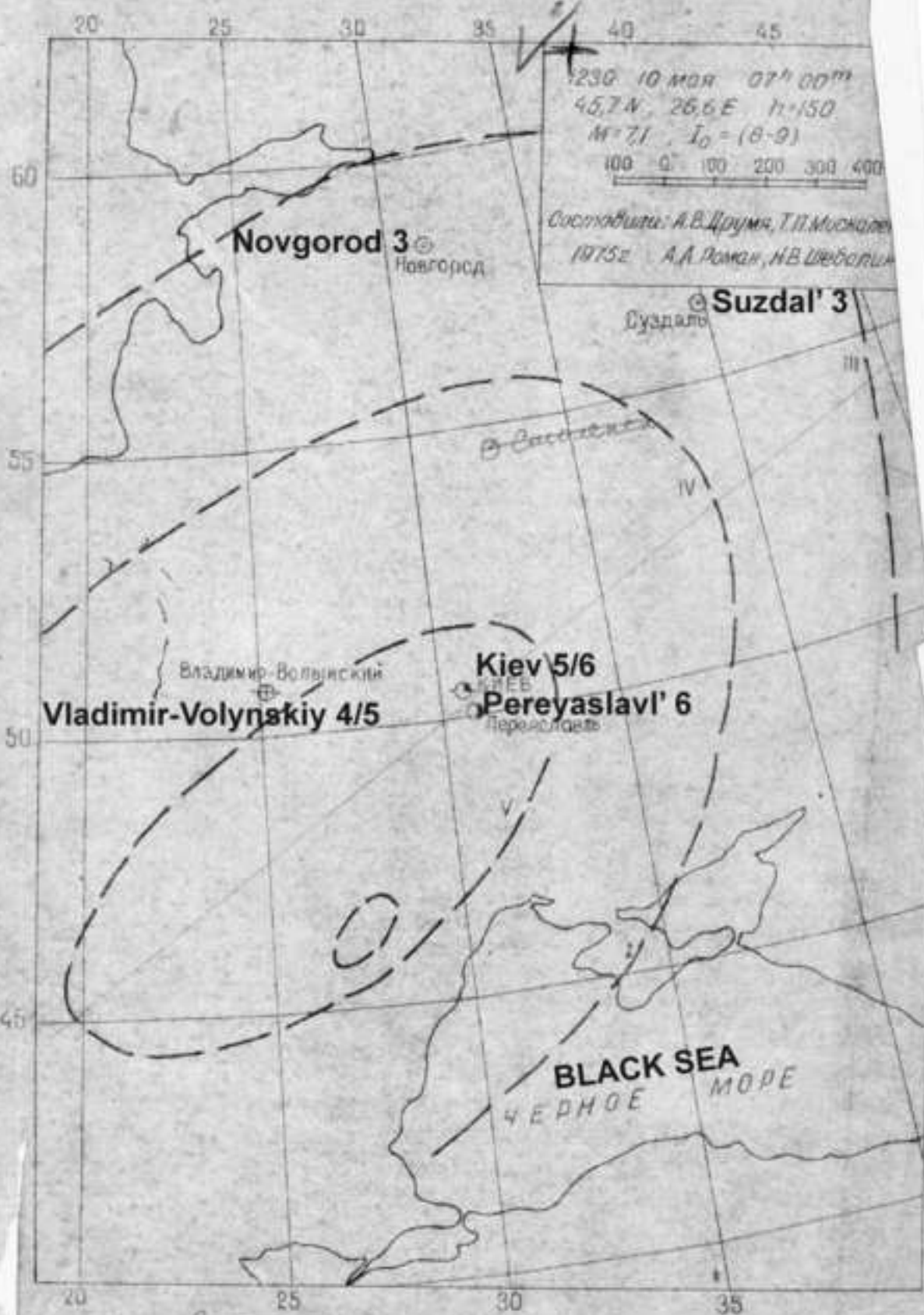
### **On the 1 October 1446 earthquake**

А тое же осени октября 1, в кои день отпущен князь великы с Курмышя, в 6 часов ноци тоа потрясся град Москва, кремль и посад весь, и храмы поколебашася. Людям же спящим в то время и не слышаша вси, мнози же не спяще и слышавше то во мнози скорби беша, и живота отчаявшеся, на утри же со многими слезами не слышащим сия исповедаху.

*Moskovskiy letopisniy svod kontsa XV veka* (Moskva annual code of the end of the 15<sup>th</sup> century) (Kloss ed., 2004).



3



1230 10 мая 07<sup>h</sup> 00<sup>m</sup>  
 45,7N, 26,6E h=150  
 M=71, I<sub>0</sub>=(8-9)  
 100 0 100 200 300 400

Составители: А.В.Друмя, Т.П.Миснаков  
 1975г. А.А.Роман, Н.В.Шевбаля

*Составитель: [unclear]*

20° 24° 28° 32° 36° 40°

56°

52°

48°

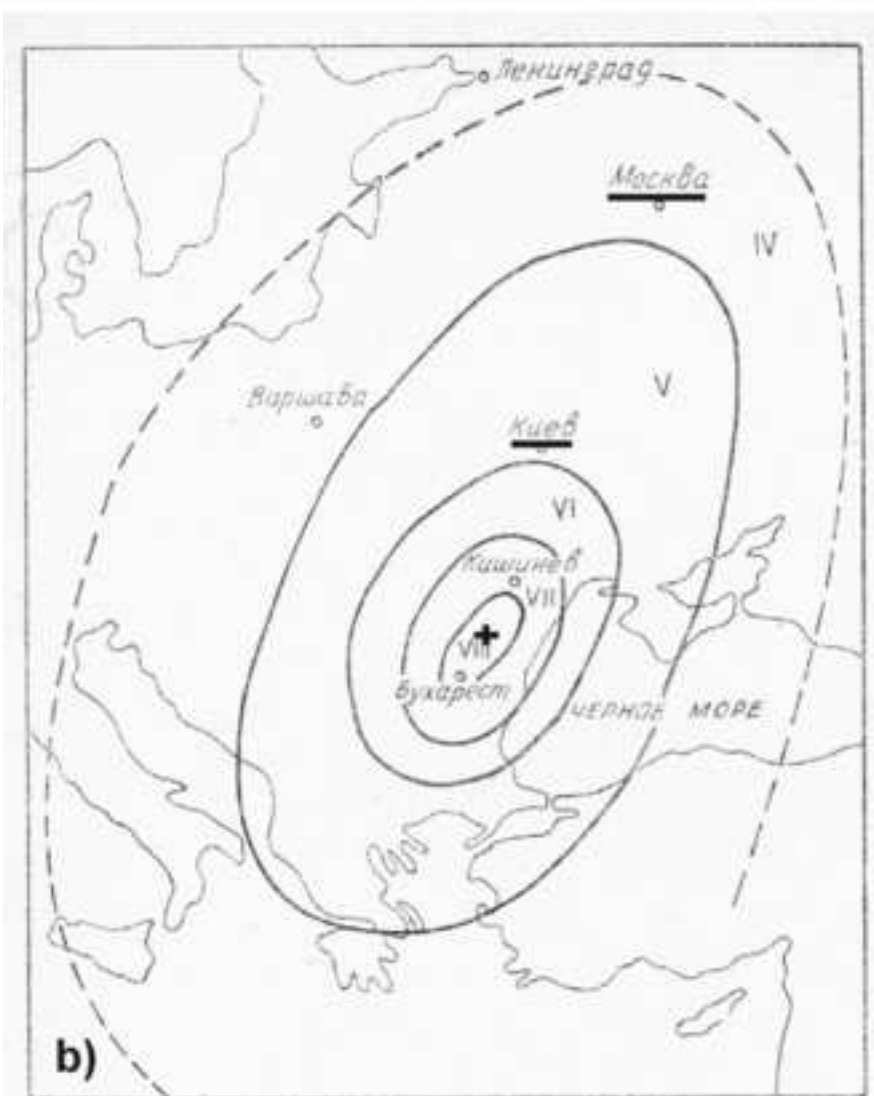
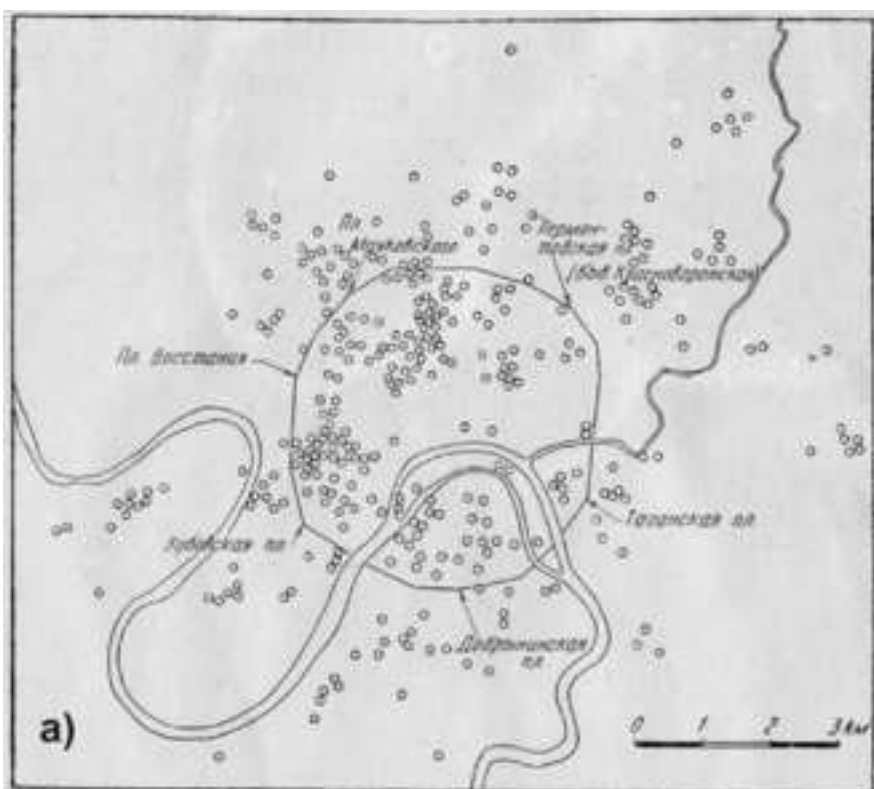
44°

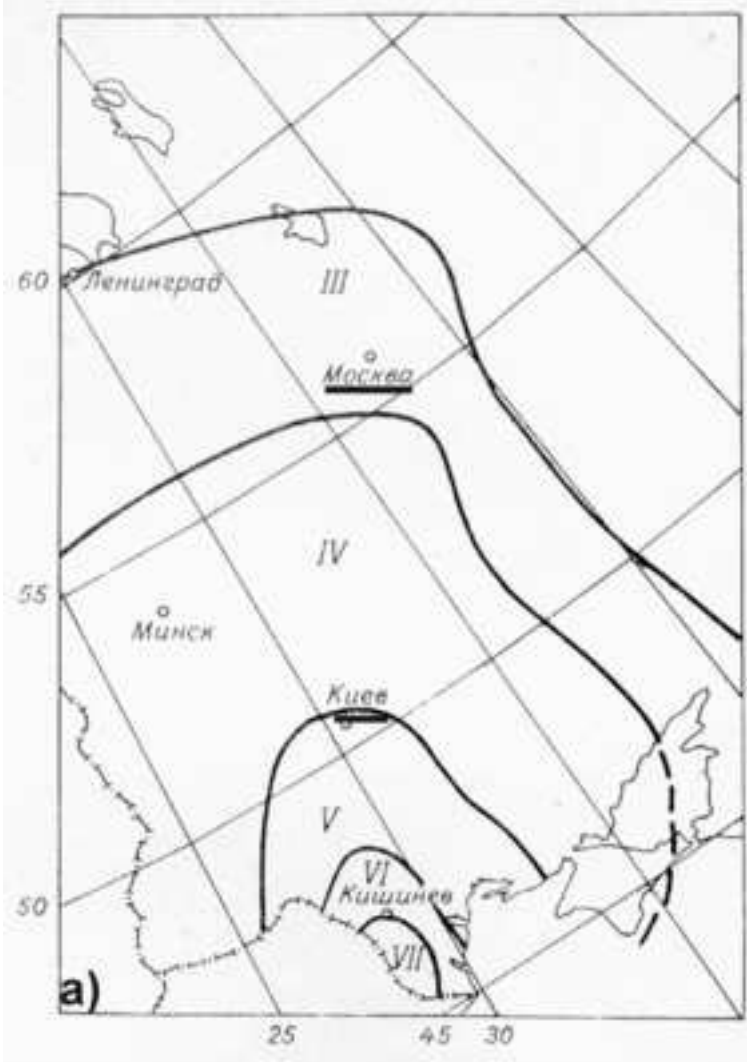
40°

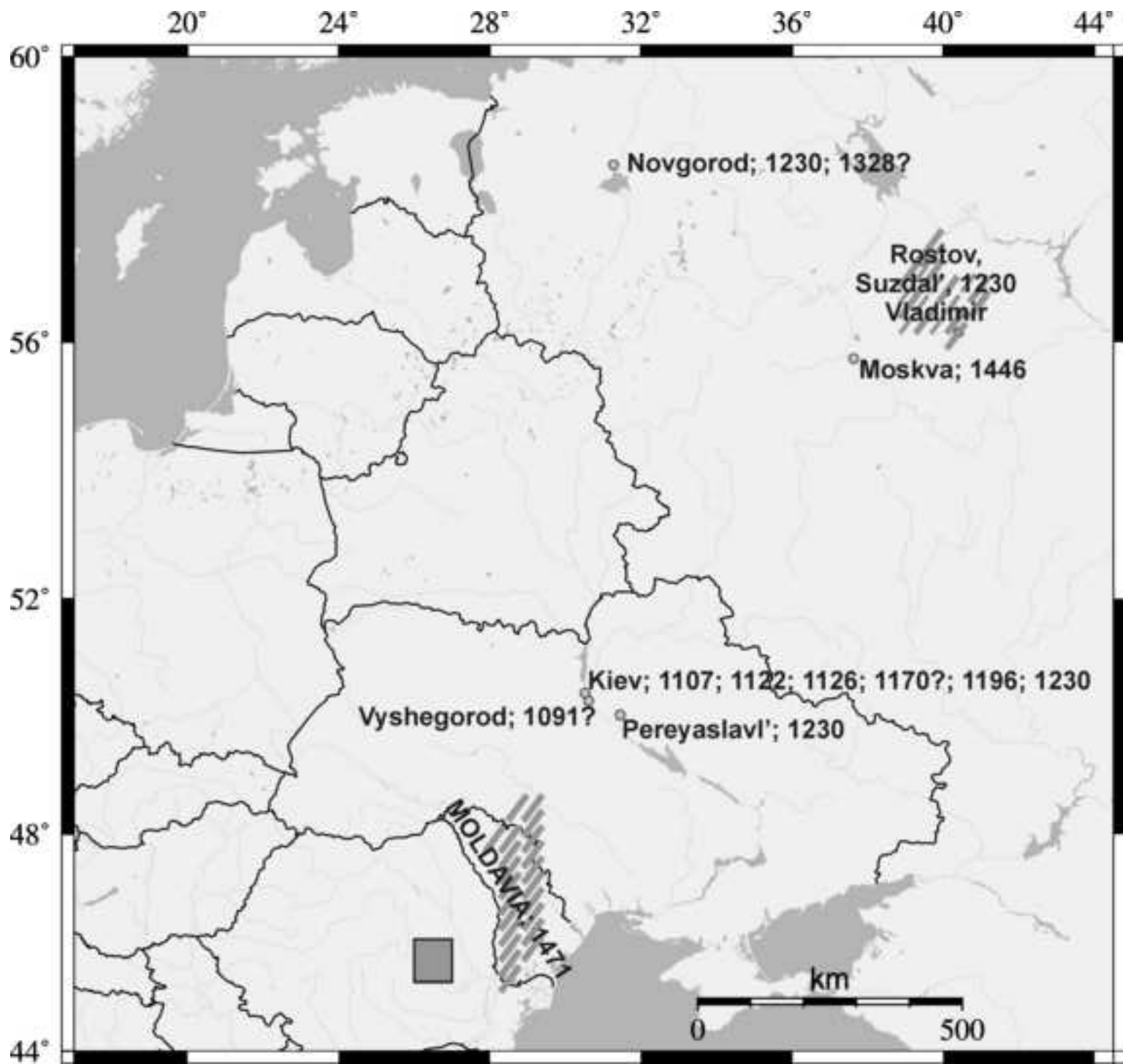


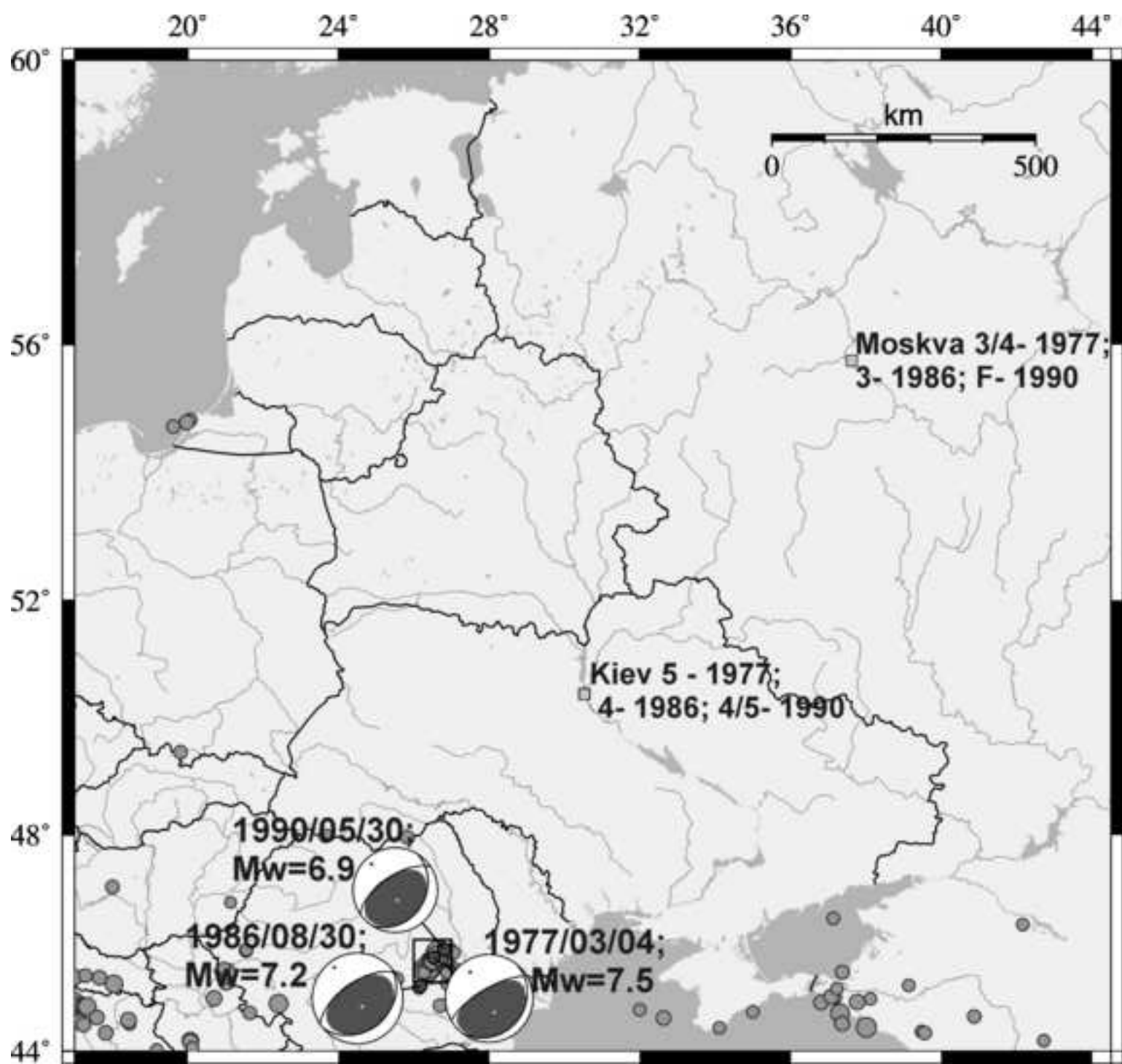
km

0 500











Tab. 1 - Earthquakes located in the Vrancea region (11° to 15° cent) according to the parametric earthquake catalogues

N°	Year	Mo	Da	Ho	Ax	Io	Lat N	Lon E	M	H	Parametric catalogue	Reference/s as cited by the catalogue (see Tab.2)
1	1022	05	12			7	45.700	26.600	6.5	150	Oncescu, 1999	Constantinescu & Marza, 1980
1	1022	05	12	00		7	45.700	26.600	6.2		Constantinescu & Marza, 1980	Florinesco, 1958
2	1038	08	15			8-9	45.700	26.600	7.3	150	Oncescu, 1999	Constantinescu & Marza, 1980
2	1038	08	15			8-9	45.700	26.600	7.0		Constantinescu & Marza, 1980	Florinesco, 1958
3	1091					8	45.700	26.600	7.1	150	Oncescu, 1999	Constantinescu & Marza, 1980
3	1091					7	45.700	26.600	6.2	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
3	1091				Vrancea deep	7	45.700	26.600	6.2	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893
4	1107	02	12	03		8	45.700	26.600	7.1	150	Oncescu, 1999	Constantinescu & Marza, 1980
4	1107	02	12	03		8	45.700	26.600	6.8	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
4	1107	02	5 (12)		Vrancea-Carp	8 ca			6.75		Purcaru, 1979	
4	1107	02	12	03	Vrancea deep	7	45.700	26.600	6.9	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893; Evseyev, 1961
5	1122	10				6-7	45.700	26.600	6.2	150	Oncescu, 1999	Constantinescu & Marza, 1980
5	1122	10				6-7	45.700	26.600	5.9	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
5	1122	10			Vrancea deep	6-7	45.700	26.600	5.9	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893; Evseyev, 1961
6	1126	08	08			8	45.700	26.600	7.1	150	Oncescu, 1999	Constantinescu & Marza, 1980
6	1126	08	08			8	45.700	26.600	6.8	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
6	1126	08	01		Vrancea-Carp	8 ca			6.75		Purcaru, 1979	
6	1126	08	08		Vrancea deep	7	45.700	26.600	6.2	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893; Evseyev, 1961
7	1170	04	01			8-9	45.700	26.600	7.3	150	Oncescu, 1999	Constantinescu & Marza, 1980
7	1170	04	01			8-9	45.700	26.600	7.3	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
7	1170	04	01		Vrancea-Carp	8-9			6.75-7.25		Purcaru, 1979	
7	1170	04	01		Vrancea deep	8	45.700	26.600	7.3	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893; Laska, 1902; Karnik et al., 1957; Evseyev, 1961
8	1196	02	13	07		9	45.700	26.600	7.5	150	Oncescu, 1999	Constantinescu & Marza, 1980
8	1196	02	13	07		9	45.700	26.600	7.3	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
8	1196	02	13		Vrancea-Carp	9 ca			7.25 ca		Purcaru, 1979	
8	1196	02	13	07	Vrancea deep	8	45.700	26.600	7.0	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893; Laska, 1902; Evseyev, 1961
9	1230	05	10	07		8-9	45.700	26.600	7.3	150	Oncescu, 1999	Constantinescu & Marza, 1980
9	1230	05	10	07		8-9	45.700	26.600	7.1	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
9	1230	05	3 (10)		Vrancea-Carp	8+			7 ca		Purcaru, 1979	
9	1230	05	10	07	Vrancea deep	8-9	45.700	26.600	7.1	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893; Laska, 1905; Karnik et al., 1957; Evseyev, 1961; Petrescu & Radu, 1961; Constant. & En., 1963
10	1258	02	07	13		8	45.700	26.600	7.1	150	Oncescu, 1999	Constantinescu & Marza, 1980
10	1258	02	07	13		8	45.700	26.600			Constantinescu & Marza, 1980	Anastasius, 1961
10	1258	02	07		Vrancea-Carp	8			6.75		Purcaru, 1979	
11	1327					8	45.700	26.600	7.3	150	Oncescu, 1999	Constantinescu & Marza, 1980
11	1327					8	45.700	26.600	7.0	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
11	1327				Vrancea deep	8	45.700	26.600	7.0	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893
12	1446	10	10			8-9	45.700	26.600	7.5	150	Oncescu, 1999	Constantinescu & Marza, 1980
12	1446	10	10			8-9	45.700	26.600	7.3	150	Constantinescu & Marza, 1980	Kondorskaya & Shebalin, 1977
12	1446	10	10		Vrancea deep	8-9	45.700	26.600	7.3	(150)	Kondorskaya & Shebalin, 1977	Mushketov & Orlov, 1893
13	1471	08	29	10		9	45.700	26.600	7.5	110	Oncescu, 1999	Constantinescu & Marza, 1980
13	1471	08	29	10		9	45.700	26.600	7.3		Constantinescu & Marza, 1980	Shebalin et al., 1974
13	1471	08	29		Vrancea-Carp	9			7.25		Purcaru, 1979	
13	1471	08	29	08	Vrancea deep	8-9	45.700	26.600	7.1	(150)	Kondorskaya & Shebalin, 1977	Rethly, 1952; Florinesco, 1958; Evseyev, 1961; Petrescu & Radu, 1961; Iosif & Radu, 1962; Drumya et al., 1964; Constantin. & En., 1963; Petrescu & Radu, 1963; Shebalin et al., 1974
13	1471	08	29	10		8	45.700	26.600		i	Shebalin et al., 1974	Radu, 1971
14	1473	08	29			8-9	45.700	26.600	7.3	150	Oncescu, 1999	(Constantinescu & Marza, 1980)*
14	1473	08	29			*	*	*	*		Kondorskaya & Shebalin, 1977	
14	1473	08	29			*	*	*	*		Purcaru, 1979	Sadoveanu, 1957
14	1473	08	29			8?	45.600	25.400			Shebalin et al., 1974	Montandon, 1953; Rethly, 1961

**Table 2. Summary of earthquake records**

<b>date (* if different from Tab. 1)</b>	<b>place</b>	<b>place as identified</b>	<b>primary source/s or coeval chronicles</b>	<b>Is (EMS98)</b>	<b>remarks</b>
1091	Vyshegorod	Vyshegorod	Lavrentevskaya	F?	very doubtful but not excluded
5 Feb 1107 *	Not given explicitly	Kiev	Voskresenskaya, Nikonian, Novgorod Chronicle, Ipatevskaya	F	place identified from the context
1122 *	Not given explicitly	Kiev	Lavrentevskaya, Ipatevskaya	F	place identified from the context
1 Aug 1126 *	Not given explicitly	Kiev	Nikonian, Lavrentevskaya	F	place identified from the context
1170 *	Not given explicitly	Kiev	Nikonian	F?	very doubtful; place identified from the context
12 Mar 1196 *	Kiev	Kiev	Voskresenskaya, Ipatevskaya	5-6	
3 May 1230 *	Kiev	Kiev	Nikonian (Golitsinskiy copy)	5-6	
	Pereslavl'	Pereyaslavl'	Nikonian (Golitsinskiy copy)	5-6	
	Vladimir land Vladimir	Vladimir	Nikonian (Troitskiy copy) Nikonian (Golitsinskiy copy) Lavrentevskaya	4	
	Novgorod	Novgorod	Novgorod Chronicle	F	
	Rostov land	Rostov	Nikonian (Troitskiy copy)	F	
	Suzdal' land	Suzdal'	Nikonian (Troitskiy copy)	F	
1328 *	Novgorod	Novgorod	Nikonian Rogzhskiy letopisets, Tverskoy sbornik	F	doubtful
1 Oct 1446 *	Moscow	Moscow	Moskovskiy letopisniy svod kontsa XV veka	3-4	
29 Aug 1471	Moldavia	Moldavia	Ureche (Moldavian chronicle)	F	no other places mentioned
29 Aug 1473			--		fake, duplication of 1471