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Revisiting Svenskby, Southeastern Finland: Communications Regarding Low-Magnitude Earthquakes in 1751–1752

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Abstract: This investigation examines the contemporary documentation of a sequence of low-magnitude earthquakes at the fringes of the Kingdom of Sweden, today Southeastern Finland, in 1751–1752. A total of 11 pages of original correspondence sent from the target village of Svenskby to the Swedish capital Stockholm are reviewed. Newspaper accounts from Sweden and Russia are included in the analysis, and a timeline of the reporting is constructed. A newly created catalog shows over 30 distinct events between the end of October and December 1751 (Julian calendar). The assignment of macroseismic intensity to the earthquakes is hampered by loud acoustic effects that accompany and/or constitute the observations. Maximum intensities are assessed at IV–V (European Macroseismic Scale 1998), and maximum macroseismic magnitudes in the range of M_M1.9–2.4, and were probably observed at short epicentral distances close to the ground surface. Comparisons to macroseismic data related to instrumentally recorded earthquakes in the region support the notion of low magnitudes. The data from 1751 provide an analog to modern macroseismic observations from geothermal stimulation experiments. Such experiments have acted as a spur for considering seismic risk from low-magnitude earthquakes whose consequences have seldom previously been a matter for concern.

Keywords: historical seismology; macroseismology; macroseismic intensity; earthquake sequence; earthquake sound; Vyborg rapakivi granite batholith; Southeastern Finland

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1. Introduction

Non-instrumental seismology investigates the consequences of past earthquakes, and significantly lengthens the availability of earthquake records that can be used to estimate earthquake parameters. The evidence can be, for instance, traces left in the natural or built environment by large, shallow earthquakes, investigated from paleoseismological and archeoseismological perspectives, respectively, or macroseismological investigations of written documentary materials testifying to various earthquake effects (e.g., [1–4]). The wealth of information about considerable earthquakes that becomes available has a direct bearing on notions of long-term seismic hazard.

With the help of macroseismology, it is also possible to investigate the transient effects of non-damaging, low-magnitude earthquakes. Small earthquakes do not contribute to seismic hazard as such, but can be relevant locally; they are more than curiosities for seismicity assessments of low-seismicity regions where they dominate the available earthquake databases. They may help to identify areas of anomalous local response (amplification or attenuation). They require significant extrapolation up to the magnitudes at which damaging ground shaking might occur. The *b* value of the empirical Gutenberg–Richter magnitude–frequency equation [5] is used to extend the observed magnitude ranges to non-observed ranges and becomes distorted by superfluous events among the actual low-magnitude earthquake data.

Textual accounts depicting the effects of ground shaking may fail to distinguish low-magnitude seismic events from those of non-seismic origin. For example, both a small earthquake and a cryoseism (ice quake) can be described as a sudden jerk of the ground, accompanied by an audible boom. A clear seasonal variation in the frequency of events with a peak in the winter months is evidenced in the historical national and regional catalogs in Northern Europe [6,7], but no similar dependence is observed for earthquakes recorded instrumentally. What are likely frost effects in cold weather and rapid temperature changes may have been erroneously taken for earthquakes, and small earthquakes in the summer have been interpreted as thunder or passed unnoticed by people working outdoors. In the absence of seismograms, individual cases often remain unresolved, especially if the account is devoid of detail, and no background information is available.

This investigation focuses on a sequence of low-magnitude earthquakes at the fringes of the Kingdom of Sweden, now Southeastern Finland. It began in October 1751, and written communication about the events continued until the following spring. Given the skewed seasonal variation of pre-instrumental earthquake data in Northern Europe, frost effects could be suggested as the origin of the sequence. However, similar protracted, low-magnitude earthquake sequences have since been observed in the region, both in the pre-instrumental [8,9] and instrumental [10–12] eras (instrumental monitoring of local seismic events in the country began in the latter half of the 1950s), and also in the summer. Due to this similarity, the 1751 sequence is customarily taken to be of seismic origin (e.g., [6]). All the sequences occurred within the Vyborg rapakivi granite batholith (VRGB; Figure 1), which is composed of lighter material than the surrounding bedrock and is also significantly younger, 1.6–1.3 Ga old, from Proterozoic time [13]. Whether the earthquake sequences had the potential to evolve into higher-magnitude events is an essential question for the analysis of the seismic hazard of the Loviisa nuclear power plant, situated at a distance of approximately 28 km from the 1751 sequence.

At the time of the earthquakes, the region of interest crossed the state border between the Kingdom of Sweden and the Empire of Russia, as demarcated in the peace treaty of 1743 (Figure 1). A river divided the municipality of Pyttis (Pyhtää in Finnish; the Swedish name is used here) in two parts, and the western part of Sweden came to be known as Swedish Pyttis (Ruotsinpyhtää in Finnish). Focus is on the village of Svenskby, located in Swedish Pyttis. Macroseismic data collection and analysis of earthquakes occurring in the proximity of borders warrants special attention (e.g., [14,15]). In the Precambrian, crystalline bedrock of the Fennoscandian Shield, earthquakes with a local magnitude of M_L above 4 are infrequent, and the respective areas of perceptibility typically extend across more than one country. Such earthquakes have also occurred in the eastern part of the Fennoscandian Shield [16]. Other previous investigations targeting the vicinity of the border have focused on a large historical earthquake felt in several countries in Fennoscandia [17], and on smaller events for which no cross-border data were found [18]. The seismicity record is relatively short; for example, the data available for 1626 are too sparse to resolve epicenter(s) and magnitude(s) unambiguously, so different earthquake scenarios were formulated instead [19].

Moreover, the position of the border has been altered several times throughout the centuries, which complicates the assessment of data completeness. Whether the spatial clustering of earthquake sequences in the westernmost part of the VRGB is a dominant seismicity feature, or results from data incompleteness alone, or a combination of both these reasons, is an open question. Ultimately, scrutinizing the flows of communication and data accumulation and collection procedures can give useful insight into data completeness, which must be considered in a sound assessment of long-term seismicity rates.

This investigation examines the contemporary documentation of the 1751 earthquake sequence. Previous literature consists of a three-page summary published in the Proceedings of the Royal Swedish Academy of Sciences [20]. The present work reviews the original correspondence and correspondents, constructing a timeline of the correspondence. Newspaper accounts from Sweden and Russia are included in the analysis. A newly created catalog of the 1751 sequence is presented. These reports are compared to macroseismic questionnaire data from instrumentally recorded low-magnitude earthquakes in the VRGB.

Finally, this investigation attempts a macroseismic intensity and magnitude assessment, and discusses the unusually ample reporting on this earthquake sequence.

Figure 1. The target region. The lower part shows the area denote by the gray dot in the upper part in more detail. The gray color stands for the Vyborg rapakivi granite batholith. Blue circles show earthquake epicenters between 1610 and 2012. The yellow dot shows the village of Svenskby and the red triangle the seismic station VJF deployed in 2003. The dashed line shows the border at the time of the earthquake sequence, and the continuous lines show current national borders.

2. Contemporary Correspondence and Newspapers

The total population of Swedish Pyttis was 1331 inhabitants in 1749 [21], and consisted of both Finnish-speaking and Swedish-speaking residents. Swedish Pyttis was a rural municipality, but a hub of postal services with a large post office, where letters and other postal matters from the whole western Europe were postmarked and checked before they were handed over to the Russian side of the border [22]. The target locality is the village of Svenskby (literally Swedish village; Ruotsinkylä in Finnish), located approximately 13 km north of the border checkpoint with the post office (Figure 2a). It consisted of 22 farms. The presence of a Swedish military regiment gave it a special characteristic.

(**a**) (**b**)

Figure 2. Views of the target area: (**a**) remains of the post office located by the border checkpoint between Sweden and Russia. Photo: Thomas Ermala on 28 August 2019; (**b**) Pyttis church from the latter half of the 1400s was situated in the Russian territory after the peace treaty of 1743. Photo: C. W. Stenbäck in 1932. Source: Picture collections of the Finnish Heritage Agency.

The main documentation that has survived to the present day and testifies to the earthquake sequence consists of three letters written in the village of Svenskby, Pyttis, and the town of Degerby (today Lovi(i)sa) in 1751–1752 and sent to the Royal Swedish Academy of Sciences in Stockholm [23]. The transcribed letters are available in the Supplementary Materials both in the original Swedish and as English translations.

The first correspondent, Carl (sometimes written as Karl) Östberg (1716–1775), vice pastor of the Pyttis parish, dated his letter on 22 November 1751. After the peace treaty of 1743, the Pyttis church (Figure 2b) became part of the Russian administration east of the border. A modest wooden building was then hastily erected in Swedish Pyttis to replace the loss of the church. Often, the two local languages resulted in twice the number of religious services officiated [24]. Carl Johan von Holthusen (1715–1791), who dated his letter on 1 March 1752, was Captain of the Royal Swedish Regiment of Jönköping, stationed in the border area. The reports by Östberg and von Holthusen were read at the meetings of the Royal Swedish Academy of Sciences on 18 January and 4 April 1752, respectively [25,26]. The third correspondent acted on the initiative of the Academy. Archiater Evald Ribe (1701–8 October 1752), a member of the Academy, requested that David Starck (1710–1778), vicar of Degerby, visit Svenskby and confirm that the observations of underground tremors and roar had been reported truthfully. Ribe's request was dated on 30 January 1752, but has not survived to the present day. David Starck dated his report on 30 March 1752. His visit to the village of Svenskby in February or March 1752 can be regarded as the first documented macroseismic field trip in the VRGB.

Figure 3 gives the timeline of the communications as well as newspaper accounts. The Swedish newspaper Stockholms Post-Tidningar published an account of the phenomena in the village of Svenskby on 30 December 1751 and 5 March 1752 [27,28]. The former account resembles parts of the report by Carl Östberg. However, it mentions an event on 30 October 1751 not found in any of the three reports. The latter account is most likely based on the report by Carl Johan von Holthusen and does not provide any additional information about the earthquakes.

The oldest German-language newspaper in Russia, St. Petersburgische Zeitung ('St. Petersburger Newspaper') published an account of the earthquakes on 7 February 1752 [29]. From 1728, the newspaper was translated into Russian under the name Санкт-Петербургские Ведомости ('St. Petersburger Gazette') [30]; therefore, an identical account can be found in the Russian-language version on the same day, though the dates follow the Russian calendar [31]. The newspaper accounts published in St. Petersburg repeat and shorten the account in the Swedish newspaper on 30 December 1751 (see Table S1 in the Supplementary Materials).

Date	Svenskby of Swedish Pyttis	Stockholm	Degerby	St. Petersburg
12 Nov 1751	First earthquake account is sent to Stockholms Post-Tidningar			
22 Nov 1751	Carl Östberg concludes his earthquake account			
30 Dec 1751		First account from Pyttis is published in Stockholms Post-Tidningar		
18 Jan 1752		Account by Carl Östberg is read at the Academy meeting		
30 Jan 1752	Second earthquake account is sent to Stockholms Post-Tidningar	Academy member Evald Ribe writes to David Starck		
7 Feb 1752 (*)	(David Starck's visit in February or March)		(David Starck leaves for Svenskby in February or March)	Earthquake account from Svenskby is published in St. Petersburgische Zeitung and Санкт-Петербургские Ведомости (*
1 Mar 1752	Carl Johan von Holthusen concludes his earthquake account			
5 Mar 1752		Second earthquake account is published in Stockholms Post-Tidningar		
30 Mar 1752			David Starck concludes his earthquake account	
4 Apr 1752		Account by Carl Johan von Holthusen is read at the Academy meeting		

Figure 3. Timeline of the reporting investigated. The dates are according to Julian calendar except for (*) which follows the Russian calendar.

3. Analysis of the Communications

Carl Östberg referred to the phenomena most often with the Swedish word "smäll" which translates into "bang", or "thud", but he also used the word "shaking" when describing the strongest effects: " . . . shaking in the house as if the wall had been hit by a sturdy stock". Carl Johan von Holthusen used the word earthquake in addition to thunder, but frequently referred to the shocks as "knall" a kind of bang. David Starck, meanwhile, used the words "bang" and "earthquake". Comparisons to gunshots also appear in the reports, and the reporters expressed some concern about the loudness of the sounds affecting witnesses' ears. The weather was reportedly mild during the phenomena.

The reports agree in that the earthquakes were observed within a confined area. Östberg estimated that the bangs were heard within a distance of 500 steps, while the account in the Swedish newspaper on 30 December 1751 is more explicit and reports that the shaking was strongest within a distance of 500 steps but also noticeable over a distance of a quarter of a (Swedish) mile, approximately 2.5 km. Von Holthusen mentioned that the phenomena were not noticeable above a distance of half a mile, approximately 5 km. According to David Starck, the phenomena were also observed in another village located approximately 3 km southwest of Svenskby. No original reports are known from east of the border.

3.1. Considerations of Intensity Assignment

Macroseismic intensity compacts the variety of ground-shaking effects experienced in a given place into a single integer value: the larger the numeral, the more severe the effects. A macroseismic scale ranks the effects characteristic of each level; for example, rattling windowpanes are associated with intensity IV on the 12-level European Macroseismic Scale (EMS-98) used here [32]. Each level subsumes all the levels beneath it in the hierarchy. The success of assigning intensity to a given place depends on the similarity between what is reported and what is expected to be reported according to the scale; how well the data fit the scale can be referred to as the certainty of intensity assignment [33]. An example of a discrepancy between an observation and a macroseismic scale is the direction of movement of the propagating seismic wave. The formulations by Carl Östberg reveal the subjectivity of such remarks: " ... he who stood facing the east thought the shock occurred a few steps away towards the west, while he who stood more westwards thought the shock occurred even further away in front of him". This insight would have been helpful when macroseismic questionnaires were designed in the late 1800s, including questions that concerned the ground movement direction [34].

Another discrepancy is posed by the many sensations of acoustic effects that accompany observations of ground shaking. The earthquake effects summarized by macroseismic intensity are expected to follow ground shaking alone, so discerning them from audible observations becomes critical for small earthquakes. For example, local residents may be awakened or frightened by an abrupt underground roar rather than a tremor [35]. Instrumental data have shown that earthquakes in the VRGB occur within the uppermost 2 km of the crust [10], which provides a reasonable explanation for the acoustic effects and consequent observations by local residents. Similar observations have been reported in Southeastern France, where swarm events occur close to the ground surface [36]. By contrast, in West Bohemia and Vogtland in Central Europe, the focal depths of prolific earthquake swarms have been determined to be between 6.5 and 11 km, or even somewhat deeper clusters [37]. Acoustic observations related to low-magnitude earthquakes have been reported elsewhere, in different tectonic environments [38,39].

The information about the earthquake sequence is summarized as a new catalog in Table 1. When estimating macroseismic intensities, the acoustic effects have been disregarded. For example, "farm animals (even outdoors) may be frightened" is a classification factor of intensity VI on the EMS-98 but, for example, von Holthusen primarily described various sounds that made horses and other creatures neigh and bellow on 5 November. A few persons losing their balance is also a classification factor of intensity VI, but it is considered to be an extreme effect, because the overall effects on houses and objects appear to have been less strong, and no damage was reported. The objects that fell or were shifted were light or precariously supported, such as firewood standing upright. On the other hand, the effects were not weak: there were clear sensations of the house and ground lifting up, and effects on movable property. Stove dampers and windowpanes rattling suggest intensity IV. The maximum intensity level is estimated at IV–V (EMS-98) due to insufficient descriptions for selecting either IV or V. The intensities express a cumulative effect, since it is not possible to separate the effects of individual events that occurred in rapid succession.

Over 30 distinct shocks can be discerned according to the reports. However, there is some uncertainty about the dates and whether, for example, the date von Holthusen reported as 5 November and Östberg as 6 November may in fact refer to the same day.

3.2. Magnitude Estimations

The sparsity of earthquake data makes it difficult to establish intensity prediction equations for the Fennoscandian Shield, and even more so to construct one specifically for the VRGB to investigate whether attenuation properties there are different from those of the surrounding bedrock. No recent equations exist. Equation (1) for macroseismic magnitude, M_M, was based on 76 earthquakes in Fennoscandia in 1960–1979 [40]. It reads:

$$M_M = 0.38\ (\pm\ 0.25) + 1.14\ (\pm\ 0.18)\cdot \log R_F + 0.23\ (\pm\ 0.07)\cdot I_{max} \qquad (1)$$

where R_F is the radius of perceptibility in km, and I_{max} the maximum intensity. It is valid for intensities $3 \leq I \leq 6–7$ given on the Medvedev–Sponheuer–Kárník or Modified Mercalli Intensity scales; however, they are similar to the EMS-98 [41]. Equation (1) was calibrated with the Uppsala local magnitude, M_L(UPP). For a better comparison to the present local magnitude scale used in Finland, 0.2–0.3 magnitudes should be subtracted from the obtained values [42]. The distances reported above are taken to be more like diameters. For a maximum intensity IV–V (4.5), with the subtraction (0.25), the maximum macroseismic magnitude becomes $M_M 1.70 \pm 0.65$ and $M_M 2.05 \pm 0.70$ for a radius of perceptibility of 3 km and 6 km, respectively. The uncertainty is impractically large, so comparisons to modern macroseismic data from the VRGB are made in an attempt to restrict it.

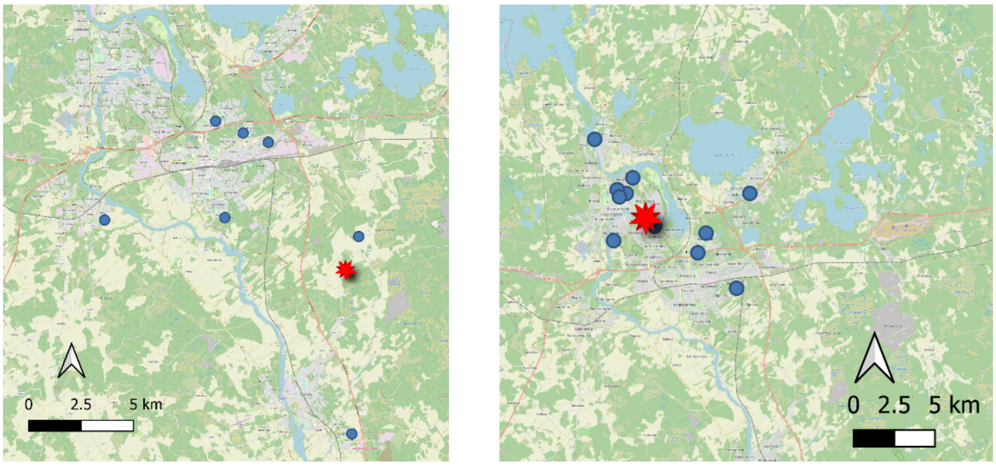
Table 1. A descriptive catalog of the reported events. The contents by default follow Carl Johan von Holthusen's testimony. CÖ refers to the report by Carl Östberg, DS to that of David Starck, PT to the newspaper Stockholms Post-Tidningar on 30 December 1751.

Date & Time *	Effects	Effects (CÖ)	Remarks
In the night between 27 to 28 October 1751 CÖ: Around 10 p.m. of 27 October	houses and ground shook, strong roar, people were awakened	houses with windowpanes and stove dampers shook, as if a big stock was hit on the wall, light objects fell from a rod to the floor, a person outdoors fell to the ground	2 strong events, followed by weaker ones CÖ: the first shock was followed by 4 others in the night
30 October 10 p.m.	–	PT: a lesser shock than 3 days earlier	1 shock
5 November nighttime	sounds alarmed animals, shocks uplifted houses and ground	–	Began with sounds, followed by 2 shocks
CÖ: 6 November soon after 9 p.m.	–	roar, a person outdoors was pushed upward	3 shocks
CÖ: nighttime between 9 and 10 November	–	hens at a farmer's began to fly around	2 shocks
17 November until 7 a.m. following morning	windowpanes and stove dampers rattled, hanging objects were shifted, splinter wood fell	a farmer and many solders heard the sounds	14 shocks
11 December 8 p.m.	the ground was felt to rise	–	1 shock
14 December 6:30 a.m.	the firewood standing upright in a furnace shell fell, stove dampers rattled, outdoors women and children were frightened	–	1 bang
25 December soon after 3 p.m.	DS: the first event was the strongest, stove dampers shook in the houses	–	4 strong bangs

* Julian calendar.

Similar small earthquakes have occurred in modern times. The contents of the macroseismic questionnaire refer to the night between 9 and 10 May 2003 as follows: "There were 3–4 strong 'bangs' within an hour and about ten lesser ones, the first one shook the bed, and rattled the windowpanes and frightened me and my dog a lot". The Finnish national seismic network recorded ten earthquakes in Anjalankoski in the VRGB between 21:18:40.50 on 9 May and 05:24:07.40 on 10 May (UTC, local time +3 h). A total of 16 events were recorded in May, and an additional two in October. The instrumental magnitudes were estimated to be in the range of $M_L 1.6–2.1$. Waveform modeling of depth-sensitive phases indicated focal depths in the uppermost 2 km [10]. The closest seismograph stations, VJF and PVF, were located at a respective distance of 50 km and 61 km from Anjalankoski, so many minute earthquakes were not recorded at all.

The rapid succession of the earthquakes complicates the feasibility of connecting them to individual macroseismic reports with possibly uncertain timing, but selections can be attempted. Figure 4a shows the locations of reports timed at either 00:18 or 00:20 local time on 10 May, all possibly related to the first earthquake with a magnitude estimated at M_L1.8 and whose epicentral distances vary between 1.7 and 11.6 km. There is only one nearby report 1.7 km away (the one cited above) due to the distribution of habitation, but a blaring roar compared to an explosion were observed even 7 km away.



(**a**) (**b**)

Figure 4. Locations of macroseismic reports related to the earthquake in: (**a**) Anjalankoski on 10 May 2003 at 00:18 local time, M_L1.8; (**b**) Kouvola on 27 February 2012 at 06:04 local time, M_L1.3. The red stars show the epicenters and the blue dots the origins of the macroseismic reports.

Figure 4b shows the locations of 11 macroseismic reports for the M_L1.3 earthquake in Kouvola in the VRGB on 27 February 2012 at 06:04 local time. The epicentral distances vary between 775 m and 7 km. Most respondents were awake and not moving, and described the occurrence as a strong roar that attenuated away, and as weaker than some previous events. One respondent awoke due to the event, and it was not experienced as frightening. Only the observations made on the first (ground) floor are shown in Figure 4.

There are no modern counterparts of macroseismic reports for earthquakes with an M_L above 2 in the VRGB, but the magnitude uncertainty can be restricted from below. Figure 4 shows that the sounds could have been observed from distances of several kilometers, but some of the extreme effects, such as the feeling that the ground was lifting up, and also the loudness of the sounds, may be explained by short epicentral distances and shallow focal depths that caused stronger effects than expected from a low magnitude alone. It is possible that the acoustic effects extended to the eastern side of the border, although this has not been reported.

Table 2 summarizes the parameters estimated for the largest events of the sequences. Location in the village of Svenskby at (26.46 E, 60.61 N), and its immediate vicinity is reasonable. The intensity is assessed as being IV (EMS-98) in the absence of effects on objects and houses, and at IV–V when such descriptions are available. The corresponding magnitudes from Equation (1) are M_L1.9 and 2.1, respectively. It is judged on the basis of the comparisons to modern examples that the maximum values in 1751 were not below 1.9, but may have been above 2.1. It is estimated that the maximum magnitudes may have been in the range of M_L1.9–2.4.

Table 2. Parameter estimates for the largest shocks on each date.

Date and Time *	Intensity (EMS-98)	Magnitude (M_L)	Remark
27–28 October 1751 nighttime	IV–V	2.1	2 events
30 October 10 p.m.	IV	1.9	1 event
5 November ** nighttime	IV	1.9	2 events
9–10 November	IV	1.9	2 events
17–18 November	IV–V	2.1	(14 events) ***
11 December 8 p.m.	IV	1.9	1 event
14 December 6:30 a.m.	IV–V	2.1	1 event
25 December 1751 soon after 3 p.m.	IV	1.9	1 event

* Julian calendar. ** There may have been a separate sequence on 6 November 1751. *** It was not possible to separate the number of strong events.

4. Discussion

The preserved original correspondence, 11 pages in total, is lavish by local standards. Earthquake entries from the 1700s in the national database are typically attested to by a solitary source, such as a concise newspaper account. Newspapers are valuable sources of historical earthquake information, particularly in the case of earthquakes for which no formal investigation into the consequences was launched (e.g., [43]). The reason for reporting on small earthquakes is to inform contemporaries of something out of the ordinary in a low-seismicity region and that no damage was sustained [44]. The price of paper was a factor that restricted the growth of the press in the past: the length of an average newspaper was four pages in Sweden in the 1700s [45]. The technological advance of wood pulp in the 1870s permitted an increase in the size and number of newspaper titles.

Information about historical earthquakes is today gathered from many documentary sources, and is inherently incomplete. The 1751 sequence is the only occurrence known for the VRGB in the entire century. One reason behind the attention it received was most likely the prolonged duration, which increased the sensitivity of the population [36]. However, the literacy rates of the local residents were extremely low at the time [46]. The first reporter, Carl Östberg, was a member of the clergy, who were the most learned and literate at the time and often contributed to the reporting of various natural phenomena [46]. By contrast, the presence of the military regiment in the area, including literate captain Carl Johan von Holthusen, was unusual. The time of peace made it possible for Captain von Holthusen to pay attention to natural phenomena; many tumultuous years of war had strongly affected the target area in the first half of the 1700s [47]. The incentive of the Royal Swedish Academy of Sciences led to an additional earthquake account by vicar David Starck. The Academy was established in 1739, but the appearance of the correspondence (relating to the earthquake sequence) relatively shortly afterwards may have occurred by chance, and is not alone a convincing argument for the frequency of earthquakes in the area.

Carl Östberg left Pyttis in 1755 to take up the post of vicar elsewhere in the country [48], whereas David Starck continued working as the vicar of Degerfors until his death in 1778. He wrote a description of the nearby municipalities, including Pyttis, dated on 10 May 1761. It was published in two Swedish newspaper accounts the following year [49,50], and much later as a book chapter [24]. In addition to mentioning the Pyttis earthquake sequence, recollecting in particular the events around Christmas, on 1 November 1755, Starck described exceptional water movements in the river dividing Pyttis, and correctly attributed them to the Lisbon earthquake [24,50]. The presence of an identified earthquake reporter in the area could mean an increased likelihood for the absence of other earthquake reports following from an absence of earthquakes, rather than an absence of reporting. In essence, however, people's behavior is key; that earthquakes could have been reported does not mean that they were [51]. The appearance of the investigated documentation was exceptional, and higher magnitudes must be considered to be thresholds of complete reporting.

In modern times, enhanced geothermal systems (EGSs) have acted as a spur for considering seismic risk from low-magnitude earthquakes whose consequences have seldom previously been a matter for concern. EGSs can induce earthquakes, and because it is economically more beneficial to operate them within urban areas, the earthquakes are more likely to pose problems. A geothermal stimulation experiment of a ~6-km-deep well in the Finnish capital region during the summer of 2018 induced earthquakes with magnitudes up to M_L1.8 [52]. The local residents often observed these earthquakes, because they disrupted nighttime sleep and caused discomfort [53]. The observations were at the threshold of human perception, which resulted in a variety of sensations. This was seen in the macroseismic questionnaires as a difficulty of characterizing the sensation. The questionnaire offered the options, either heard or felt, or both, which were favored differently by different respondents. In the village of Svenskby in 1751, the events were almost certainly shallow, as suggested by the instrumental records, but David Starck also reported that the observations given by a local resident were either felt or heard. The macroseismic data from historical low-magnitude earthquake sequences provide analogs to modern ones, since they are less affected by changes in the built environment than higher-magnitude, damaging earthquakes.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/geosciences12090338/s1, Table S1: Reports regarding the earthquake sequence in present Southeastern Finland in 1751–1752.

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