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The earthquake in Churwalden (CH) of September 3, 1295

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Key words: Earthquake, macroseismic, rockslide, Churwalden, Switzerland, 13th century

ABSTRACT

The location of the September 3, 1295 earthquake has so far been assumed to be in the Central Alps. It was assessed at an intensity VIII in the catalogue MECOS 99 in MSK. This event was recently analyzed within the “Revision of the Earthquake Catalog of Switzerland” (ECOS), a project carried out by the Institute of Geophysics at the Swiss Federal Institute of Technology Zurich (ETHZ) from 2000–2002. Additional sources and newly interpreted information regarding observers, copies, place names and dating have now made it possible to more precisely locate the event at Churwalden and analyze its effects in more detail. The assessment of the intensity of VIII having been confirmed, this event is classified as one of the seven strongest quakes of the last millennium known in Switzerland.

ZUSAMMENFASSUNG

Bisher wurde das Erdbeben vom 3. September 1295 in den Zentralalpen lokalisiert und auf eine Intensität von VIII eingeschätzt (MECOS 99). Im Rahmen der “Revision des Schweizerischen Erdbebenkatalogs” (ECOS) am Institut für Geophysik an der ETHZ in den Jahren 2000–2002 wurde es deshalb erneut sorgfältig untersucht. Dank zusätzlicher Quellen und vertiefter Interpretation bezüglich Beobachter, Kopien, Ortsnamen und Datierung war es möglich, das Erdbeben im Gebiet von Churwalden zu lokalisieren und die Auswirkungen präziser zu beschreiben. Die bisherige Intensität VIII des Bebens wurde bestätigt. Damit gehört dieses Erdbeben zu den sieben stärksten bekannten Ereignissen in der Schweiz im letzten Jahrtausend und ist das schwerste im Kanton Graubünden.

1. Introduction

Critically documented historic reports on earthquakes of the pre-instrumental period are important to seismic hazard assessment because parametric earthquake catalogs help us to draw conclusions about possible future earthquakes. On the one hand, annals and chronicles from the Middle Ages mention seismic events fairly often, which is astonishing if one considers the modest number of written documents produced during that era and preserved. On the other hand, the quality of information for accurately assessing of the intensity of a single earthquake is poor.

Until the High Middle Ages observers of earthquakes in Central Europe did nothing but date the event. In a few cases only the intensity was described by a general term, such as for example “strong”. The earthquake of January 3, 1117, occurring in Verona, is the first event that provoked general reports on damage in Central Europe and even a definite reference to damage at Bamberg by Ebbo (Vita Ebboni). From the 14th century on writing about earthquakes increased, mainly as a result of the quake in Friuli in Italy, 1348, earlier mislocated at

Villach in Austria (Hammerl 1992), and the 1356 Basel earthquake (Switzerland).

In early modern times information on seismic events began to be collected more systematically, as is illustrated by Stumpf (1548) or Lycosthenes (1557), and above all, by the many notes in parish records found in the Canton of Zurich referring to an earthquake swarm with few damages in Glarus during the autumn 1650 (Staatsarchiv Zürich). After the Unterwalden earthquake on September 18, 1601 (Schwarz-Zanetti et al. 2003), interest in seismology had increased considerably, which is illustrated by the works of Keckermann (1602), Lavater (1613) and Burgauer (1651). Quite a number of major and smaller earthquake compilations followed and became the basis for assessing frequency and intensity of earthquakes in Switzerland up to the present. The best-known compilation was written by Volger (1857).

Unfortunately, the uncritical use of data often provided false results, since earthquake information frequently copied was often altered and misinterpreted. Alexandre (1990) assessed the proportion of errors in compilations regarding the

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Early and High Middle Ages in Central Europe and Italy at 50% and 75%, what corresponds to the findings in the revision of the MECOS 99 (Fäh et al. 2003). The simultaneous use of the Julian and Gregorian calendars in Switzerland from 1584 up to the 18th century, and occasionally the 19th, led to a considerable number of erroneous or duplicated dates. Wordings such as “prodigious or strong earthquake” (e.g. “ingens” or “magnus”) were sometimes interpreted as referring to a damaging event even if there was no definite indication of damage, for example in Constance in October 1048 or in St. Blasien in March 1127.

Furthermore, earthquake effects were amplified by mistake because medieval annalists added information from earlier reports of divergent provenance without mentioning the origin. For example, the majority of the so-called original observations on the quake of May 12, 1021, occurring in the area comprising Lake Constance and Bavaria, may be traced back to the now lost “*Annales Hildesheimenses (maioris)*.” In this context the humanist Stumpf produced in 1548 the most interesting false interpretation of ancient seismic history by erroneously linking the information about the Bavarian event in 1021 with the rebuilding of the Basel Cathedral. This fake Basel quake 1021, assessed at an epicentral intensity of IX with massive damage, has counted as one of the strongest quakes in Switzerland up to MECOS 99 and was revised during the ECOS project.

Consequently, an historically informed analysis of documentary information regarding observers, location, dating, and course of an event is essential (Alexandre 1990:7). The ECOS group has therefore introduced a scheme to rate the quality of historical information. Qualification ‘A’ stands for eyewitness reports, ‘B’ for partly confirmed or for incomplete sources, ‘C’ for unconfirmed or imprecise sources and copies of lost sources and ‘F’ for errors in sources, compilations and interpretations. Events are considered as confirmed if they are mentioned by at least two or even better by three corresponding eyewitness reports. These may be supplemented by fragmentary contemporary reports or copies of lost sources. This is how historically acceptable minimal statements are produced whereby earthquakes dated to the Early and High Middle Ages lacking descriptions on intensity may be underestimated (Fäh et al. 2003).

Thanks to corresponding information, no doubt remains on the dating of the Churwalden quake of 1295. In determining the epicenter and the effects of the earthquake more precisely, we had to rely on scarce reports by eyewitnesses and contemporaries in Italy, Germany and Austria. Due to missing eyewitness reports from the epicenter a slight uncertainty remains. Our preliminary historical work is followed by a seismological interpretation according to the guidelines of the European Macroseismic Scale 1998 (EMS-98; Grünthal 1998). The scale lists the sole mention of an earthquake as “felt,” subsumes labels like “strong” under intensity V (no damage), ascribes minor damage until such as cracks in walls or chimneys partial collapsing to an intensity of VI, medium-sized damage as large

and extensive cracks in walls to an intensity of VII and heavily damaged as serious failure of walls to an intensity of VIII. Furthermore, we calculated a magnitude based on the intensities derived from historical sources.

2. Sources

Even though the quantity of written documents towards the end of the 13th century in Central Europe was still fairly low, the Churwalden event of September 3, 1295 may be described on the basis of nine contemporary reports and copies. Surprisingly, no indication of this event could be traced in the chronicles of Vitoduranus (1924) in eastern Switzerland or Kuchmeister at St. Gallen (Nyffenegger 1969, 1974) from the first half of the 14th century. As aforementioned eyewitness reports from the epicenter are lacking. However, two contemporary entries in the annals of Osterhofen and Colmar as well as a detailed copy of a source from Constance, in connection with shorter information by eyewitnesses and compilers from Diessen (D), Heilsbronn (D), St. Florian (A), Vienna (A) and Monza (I), make it possible to fix the date approximately and to assess the damage. Italian compilations from Bergamo, Como, Verona and Milan, the quality of which has not been examined, and a contemporary source add further information.

Nevertheless the basis is scarce for a seismological evaluation, wherefore information of archaeological investigations will be associated as an experiment. The result is interesting but ambiguous without concise argument.

– *Annales Osterhovenses* (contemporary around 1284–1313): Churwalden and Diocese of Chur (CH) (Historical quality: A-B; seismological information: Intensity VIII)

“In the same year (1295), on September 4, a monastery of the Praemonstratensian order at Churwalden and fifteen castles in the same area were completely destroyed by an earthquake.”

– *Annales Basileenses et Colmarienses* (contemporary around 1226–1305): Churwalden and Diocese of Chur (CH), fake in the Wallis (CH) (Historical quality: B and F; seismological information: Intensity VIII)

“An earthquake in the Valais has in part destroyed 14 castles, caused the gable cross of the higher church tower to fall off and destroyed a considerable number of sites in different localities in the area. At Chur mountains burst open and rocks split off, several bells chimed, animated by the motion, five castles were completely destroyed and many others got cracks, as did many houses. After this event most annalists report two more quakes within one week.”

– The Chronicle of Constance by Gebhard Dacher (STSG, penned around 1470; and Ruppert, 1891): Constance (D) and Diocese of Chur (CH) (Historical quality: B-C, seismological information: Intensity VI and VIII)

“In the aforementioned year (1295), on the Saturday (3. September) before Maria’s birth (Thursday, 8. September), in the afternoon around 6 p.m. a strong earthquake occurred. People were so impressed that they thought houses were going to collapse. And a stone cross on top of the Barfüsser Church at Constance fell down. Most people were sitting round the table. The metal beakers, wooden beakers, and glasses were moved as by a miracle. It all lasted as long as an unhurriedly spoken Paternoster and an Ave Maria. Just about one hour later there was a weaker earthquake equally having the duration of a Paternoster and an Ave Maria. This happened on the third day, or on the third ninth (none: Roman dating) of the first autumn month (September). Meanwhile, the first quake was so strong that the bells in many places started to chime on their own and many walls broke down. And quite a number (around twenty in all) of strongholds and castles with towers in the diocese of Chur collapsed, and in the Domleschg valley a huge mountain fell down. And on the first Saturday during the night and during the day there were some additional 19 quakes, and then for a couple of days they occurred daily.”

– *Continuatio Vindobonensis* (contemporary around 1267–1302): Vienna (A) (Historical quality: B–F; seismological information: Intensity felt)

1295. “In the same year, around the date of Maria’s birth, September 8, such a gale was registered in Austria, which lifted the church cross off the left tower of St. Stephan, the parish church. In the same year three earthquakes occurred on Saint Ciriacus (August 8, most probably fake dating for “eight days after Saint Augustinus”, September 4).”

– *Notae Diessenses* (contemporary around 1122–1432): Diessen on the Ammersee, near Munich (D) (Historical quality: A–B; seismological information: V)

“A strong earthquake occurred on September 3, 1295.

– *Continuatio Florianensis* (contemporary around 1276–1310): St. Florian, near Linz (A) (Historical quality: A–C; seismological information: Intensity felt)

“1295: In the course of this year earthquakes were felt at different places.”

– *Annales Halesbrunnenses Maiores* (original?): Heilsbronn (D) (Historical quality: B or C; seismological information: Intensity V–VIII)

“In the year of the Lord 1295, on September 4, a strong quake was felt around midday, predominantly in the diocese of Chur, destroying towers and castles, as reported.”

– *Annales Seldentalenses* (copy, perhaps in connection with the *Annales Halesbrunnenses*): Sölden, Oetzal (A), diocese of Chiemsee (A and D) and diocese of Chur (CH) (Historical

quality: C and F; seismological information at Sölden: Intensity felt)

“1295. There was a powerful earthquake around lunchtime that caused many castles in the Diocese of Chiemsee to collapse.” However, it is improbable that also in the area of Sölden and in the Diocese of Chiemsee, i.e. at least one hundred kilometers distant from Churwalden, similar destruction occurred. It must rather be interpreted as a reading mistake by the annalist who had turned the two letters “ur” in “Churiensi” (of Chur) into “im” for “Chimensi” (of Chiemsee).

– Italian source and copies: Monza and Milan, Como, Verona, Bergamo (Historical quality: A and C, seismological information: Intensity felt–VI)

Albini (1994) evaluates the five chronicles with observations about earthquakes mentioned in Baratta (1901), i.e. Corio (1503), Dalla Corte (1596), Calvi (1677), Tatti (1734) and Frisi (1794). The latter is based on an eyewitness report in the obituary of the cathedral of Monza and is dated Saturday, September 3: “On Saturday, September 3, an earthquake occurred on the very day of that year 1295.” (Camassi, undated), whereas Corio, Dalla Corte and Calvi erroneously dated the event to the third Saturday in September, i.e. September 17. As far as Bergamo is concerned, the mentioned “molti danni” cannot be defined any further. In the city of Verona a couple of chimneys collapsed, but the sources of this additional information could not be evaluated any further here.

– Archaeology: Churwalden, Gams and Müstair (CH) (Historical quality: C)

Earthquakes of the intensity of the 1295 quake may also leave archaeologically detectable traces, traces of damage which can not be autonomously identified. Therefore archaeologically traces of destruction are imprecise indications on earthquake and at best they supplement only historical reports. Montandon (1942–43; 78) held that several castles in the Domleschg valley and along the Rhine could show damage. Parts of the monastery Churwalden were investigated archaeologically and proved damages at the end of the 13th century, what corroborate the statement in the *Annales Osterhovenses*. But in most cases examinations of castles in the region are lacking. And the architect Lukas Högl did not find any indications of earthquakes when he was working on a project to conserve the ruined Strasburg castle near Malix, around three kilometers north of Churwalden, or at the castle of Haldenstein near Chur (Högl 2001).

But for the donjon of Gams near Grabs (in the Rhine Valley) time-consuming work, done in 1999–2000 by the “Atelier d’archéologie médiévale, Moudon”, has found probably seismological indications: “Very unusual cracks, 7 to 30 centimeters long running vertically and exclusively across the whole breadth of the north oriented walls. (...) The enormous and

uniform pile of debris found at the beginning of the excavations in the whole precincts of the castle yard proves that the collapse of the walls was caused by one massive event. We assume that this led to the outbreak of a fire in the donjon, which destroyed its wooden structure. An earthquake, which hit the castle directly or which caused the landslides in the surroundings, could be a plausible explanation. (...) Information for dating the castle is gained from its building technique, C-14 dating and finds verifying that the castle was inhabited only in the 13th century. The masonry bond consisting of carefully stacked layers of unworked stones and cobbles presents analogies with the castles of that time. Two C-14 dates of the castle's first layer of use indicate a calibrated time-window from 1215 to 1287" (Gollnick 2001).

Archaeological traces of an earthquake could be expected also in the famous monastery of Münstair (GR), around 70 kilometres from Churwalden. Recently, the early and high medieval buildings in this convent have been thoroughly studied by the Institute of Monument Conservation, ETHZ. The church, the Heiligkreuz-Chapel, the so-called Plantatower, the episcopacy residence and the northerly assembly were all constructed in early medieval times. But the damage found has to be traced back to the time after 1295 in what modifications of building, rotting materials and fires disequibrated the statics (Goll 2003).

3. Summary of the evaluation of sources

3.1. Dating the year: 1295

The year 1295 was remarkable from both a seismological and meteorological point of view. It caused quite a number of preserved reports with observations about natural phenomena. This makes it possible to reliably date the earthquake into the year 1295 (Schwarz-Zanetti 1992). The observers at St. Florian near Linz and Colmar in Alsace mention two or several quakes, respectively, in the course of this year. Two of these can be dated more precisely. Apart from the strong quake in September at Churwalden, there must have been a quake in April in Alsace occurring simultaneously with a flood. The meteorological situation in Grisons during the summer is unknown, but strong precipitation and floods in the north of Italy are documented.

3.2. Month and day: September 3 (or 4)

The Colmar and St. Florian sources make no mention of the month. The remaining sources agree on September. An exception thereto is a source from Vienna that dates the quake to August 8. Presumably, the Latin phrase or acronym "in octava sancti Augustini" was misinterpreted as "August 8" instead of "on the eighth day after St. Augustinus' day" (in octava August 28 means one week later, so September 4). Osterhofen and Heilsbronn date the quake to September 4, whereas Constance, Diessen and Monza maintain the date of September 3.

The date of September 17 mentioned in Italian records was demonstrated by Albini et al. (1994) to be a mistranslation from the Monza source which confused "Saturday, September 3" with the "3rd Saturday in September," thus re-establishing September 3. However, since we are dealing with a main shock followed by several aftershocks, the date of September 3 / 4 1295 fixes the time of the event more reliably, even if September 3 is more probable for the main shock.

3.3. Time of day: In the afternoon

Three sources give approximate indications for the time of day: the Constance source of 1470 by Gebhard Dacher (STSG and Ruppert, 1891) whose indications are based on a lost document by Hans Stetter (?- around 1399), and the sources from Monza and Heilsbronn. Constance explicitly indicates the sixth hour of the afternoon, whereas Monza indicates the 9th hour of the day, i.e. around 3 p.m. By contrast, Heilsbronn fixes the event near "midday." Thus, it may be concluded that the main shock occurred in the course of the afternoon. The short duration of the quake is described by the Constance source with the usual reference to prayers, here the duration of an unhurriedly spoken Paternoster and an Ave Maria, which means around one minute.

3.4. Epicenter: Churwalden, Grisons (CH)

The Praemonstratensian Monastery of Churwalden was founded around 1150 as a subsidiary of Roggenburg, near Ulm (D). We can thus assume that the Osterhofen monastery near Passau (D), of the same religious order, was well informed about what happened at Churwalden. At first sight, however, the Colmar annalist confirmed this evidence only partially, for he mentions major damage at Chur and in the Valais, 150 km away. If, however, Chur had been hit in the same way as the Churwalden monastery, the Praemonstratensian pilgrims' hostel St. Luzi at Chur would certainly have been mentioned in the Osterhofen report. Further indications pointing to a catastrophe of such an extent could have been expected from the Valais and the central part of Switzerland, but nothing was found. For this reason, locating the quake in Chur and in the Valais must rather be ascribed to an error of understanding or of memory by the Colmar annalist. He probably transformed the place name "Curiovallis" for Churwalden into the better known place names "Chur" (Curia urbs, Coria, Curo) and "Wallis" (Valesia, Valais; Graesse 1972). However, according to a note by the historian Jürg Muraro, the precise place name "Curiovallis" is only provable in documents dating from the 16th century, documents at the end of the 13th century contain spellings like "Curwaldt" or "Curwalde" (Graesse 1972; Planta 1939–86).

Naming Churwalden as the epicenter is further supported by information from Constance, where reports mention the diocese of Chur and a rockslide at Tumplez. In the edition by Ruppert (1891) Tumplez is erroneously transcribed as

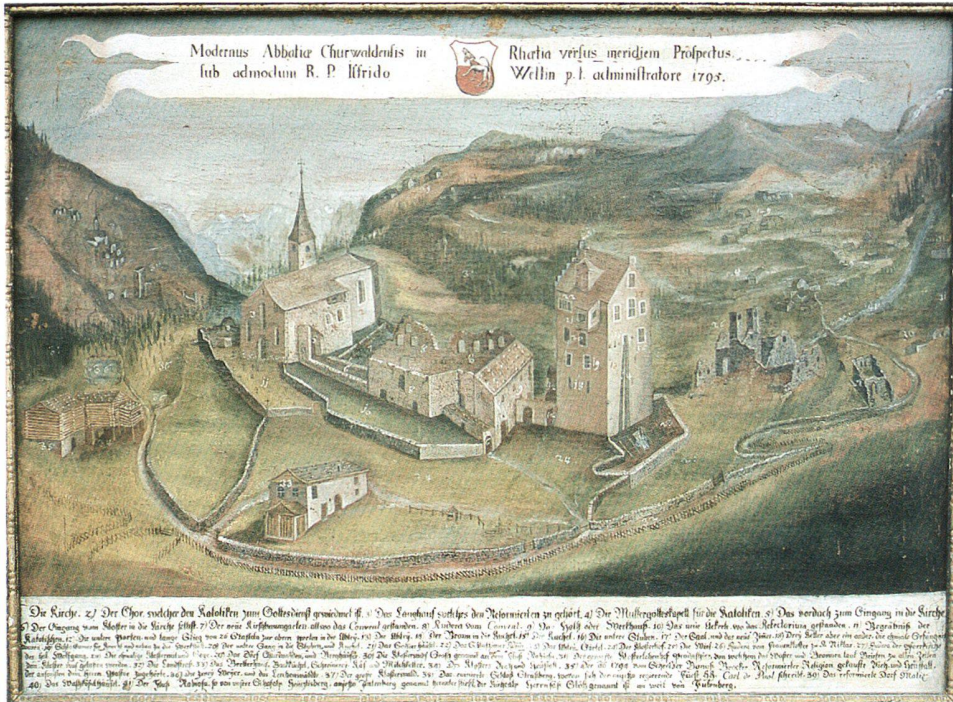


Fig. 1. View of the monastic precincts at Churwalden around 1795. Oil painting by an unknown artist. Roggenburg, vicarage. (Bergmann 1997:8) Caption: (8) Ruins of the convent. (26) Ruins of the convent of St. Niklas. (27) Ruins of the St. Wolfgang parish church.

“Tumpalz” and interpreted as “Tünfalstal,” presumably on the basis of the Fürstenberg Manuscript (LBSTUT). In all probability the Domleschg Valley which runs west of Churwalden is meant. There is a locality called Tomil or Turnegl in Rhaeto-Romanic (Tumliasca or Tumleatga in earlier times; Graesse 1972), a place name most probably derived from the Latin word ‘tumbiculus,’ meaning ‘small hill.’ The Colmar annals in turn mention bursting mountains and splitting rocks in Chur or perhaps in the diocese of Chur, what may correspond to the abovementioned rockslides in the source from Constance.

The annals of Diessen on the Ammersee (D), 40 km northwest of Munich, mention neither the place of observation nor any traceable source, so that we are probably dealing with an original observation from Diessen. However, the annalist of St. Florian near Linz (A) explicitly located the various earthquakes of that year at “different” places. As far as the source from Vienna is concerned, we can say that it has come from farthest east. The five Italian pieces of evidence are based on the original note found in the obituary of Monza Cathedral. The quality of supplemental information from the remaining compilations of Milan, Como, Verona and Bergamo (Albini et al. 1994) could not be further evaluated.

3.5. Main shock and after shocks

All but two, perhaps three, sources imply a single shock. The observer from Constance, however, mentions 19 aftershocks in the course of the following day and further ones in the days

to follow. The annalist from Colmar reports two aftershocks in the course of the following week. The observation made in Vienna by a citizen in the *Continuatio Vindobonenses* speaks about three shocks altogether.

3.6. Damage and effects

Reports on damage were scarce and imprecise, which is typical for that time. The two most prominent sources mention the destruction of the monastery of Churwalden and of five to fifteen castles, which would correspond to an intensity of at least VIII on the EMS-98. If we could fully trust the descriptions “completely deleted the monastery and castles” from the Osterhofen³ and Colmar⁴ sources, the intensity rating would be even higher.

These scarce statements can be compared in a hypothetical sense with results of archaeology and history of arts. So archaeological excavations in Churwalden during 1962–1964 brought to light remains of monastic buildings, which on the basis of beaker tiles were dated to the 12th and 13th centuries (Bergmann 1997). However the circumstances of the destruc-

³ “... per terre motum claustrum ordinis Premonstratensis Churbaldia et quindecim castra in eodem confinio funditus corruerunt.” (Wattenbach, W. 1861: *Annales Osterhovenses*. MGH, SS, 17, p. 538–58.)

⁴ “... petre fissa sunt, plures campane pulsaverunt, quinque castra penitus destructa (destruxit), plura vero fissa sunt et domus multe. Et post hunc duos alios (duo alii) motus una. (Jaffe, P. 1861: *Annales Basileenses et Colmarenses*. MGH, SS 17, p. 183–221.)

Tab. 1. Some important intensity site points

Place	Latitude	longitude	I min.	I max.	Iw	historical quality
CHURWALDEN (CH)	46.79	9.54	7	8	8	A-B
BERGAMO (I)	45.69	9.67	6	8	7	C
GAMS (CH)	47.21	9.44	7	8	7	C
CONSTANCE (D)	47.67	9.18	5	6	6	B-C
VERONA (I)	45.438	10.994	-	-	6	C
ST. FLORIAN (A)	48.14	14.37	4	-	5	C
DIESSEN (D)	47.94	11.10	4	-	5	A
TUMEGL/TOMIL (CH)	46.76	9.45	-	-	felt	C
MONZA (I)	45.59	9.28	-	-	felt	A
VIENNA (A)	48.22	16.38	-	-	felt	B
HEILSBRONN (D)	49.34	10.79	-	-	felt	A-C
COMO (I)	45.81	9.08	-	-	felt	C
VALAIS (CH)	46.26	7.62	-	-	-	F

tion of these buildings are not discussed. According to Bergmann the remains of the monastic buildings probably belongs to the ruins of two churches visible on a picture of the 18th century. The painting by an unknown artist, most probably from Southern Germany, showing the monastic precincts in the year 1795 (Museum of the monastery, Roggenburg, D) supplies an indication which probably can be traced to the 1295 event.

Furthermore, the convent church with the twin towers (number 26 on the picture in Roggenburg) is also represented

in a watercolor by the Zurich cartographer and veduta painter Heinrich Keller around 1820 as well as in an 1821 lithograph based on this watercolor (Bergmann 1997). The phrase contained in the Colmar report “caused the gable cross of the higher church tower to fall” is striking in this connection and may be interpreted in two ways: a) the earthquake lifted the cross “off the higher tower of the church” with reference to the twin towers of the convent, or more logical from a linguistic point of view b) the quake lifted the cross off the tower of the bigger church, hereby referring to the larger church of the monastery.

The two copies of reports from Constance and Verona on damage clarify the extent of the earthquake. In the northwest the area is marked by the cross that had fallen from the Barfüsser Church at Constance and in the south by collapsing chimneys at Verona. Possible earthquake damage to castles, which is mentioned in the sources very generally, has not been suggested archaeologically. But at Gams near Grabs the archaeological survey revealed cracks of 7 to 30 centimeters in the walls from a single massive event at the end of the 13th century, whereby the cause could have been an earthquake or a landslide. Consequently, these findings need to be included in our discussion as hypothesis.

Traces of the earthquake should be found also in Chur, as the example of the cathedral probably shows. The third cathedral in Chur was built in the 12th und 13th century and inaugurated in 1272. An examination of the western cladding during

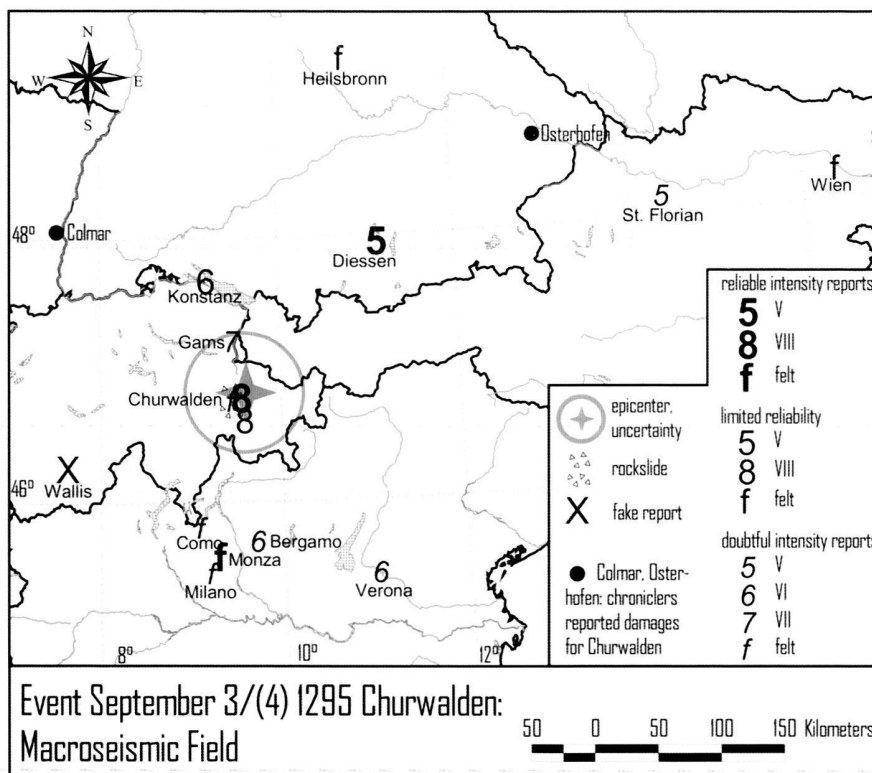


Fig. 2. Intensity distribution (Sitemap): Earthquake, September 3 (4), 1295 at Churwalden, based on Table 1

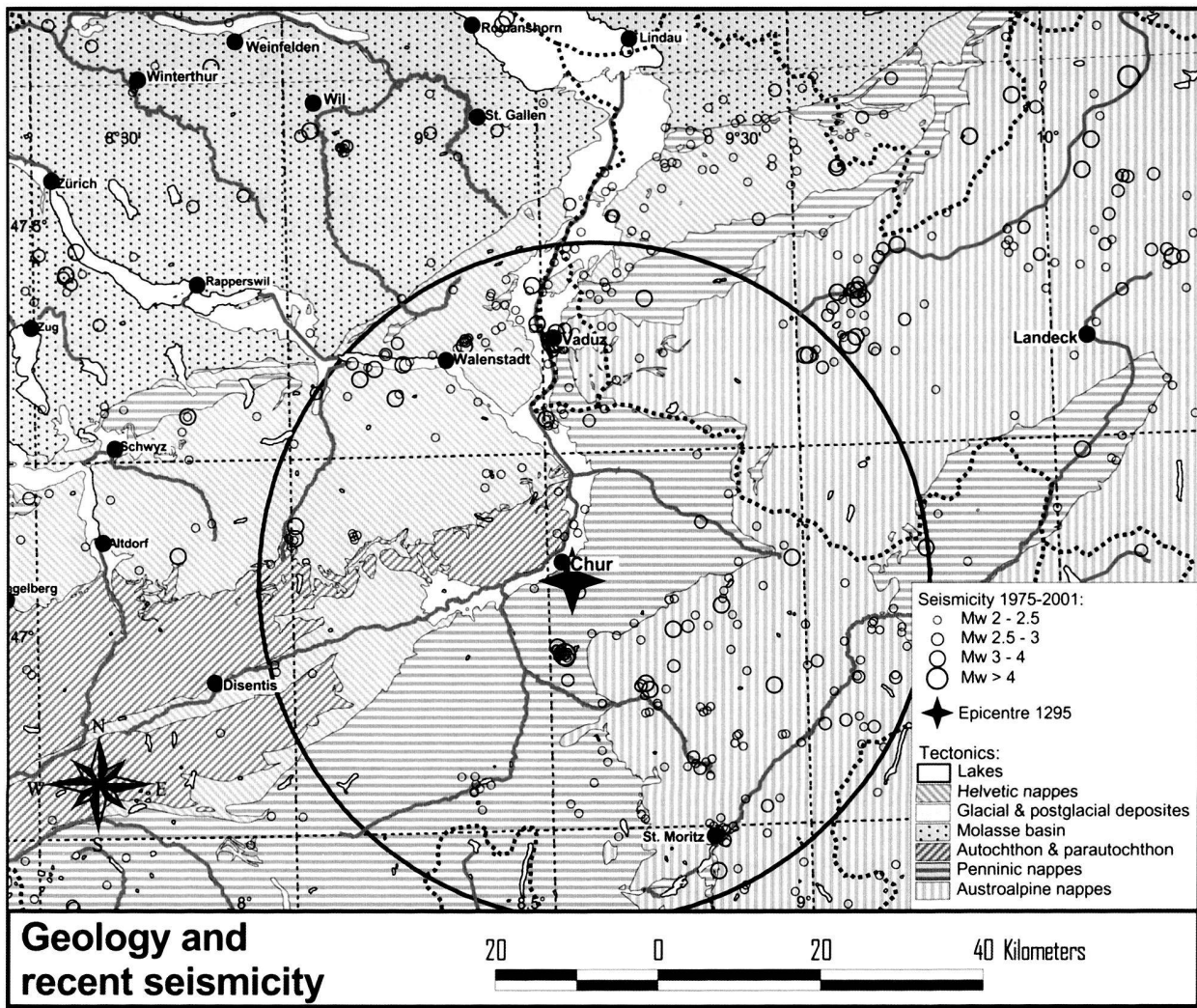


Fig. 3. Geology and recent seismicity in the region of Churwalden

the summer of 2002 indicated strange damage. The masonry over the arch of the big western window is cambered and caved in, an effect which could not be generated by static problems. This deformation might be a sign of ground motion (Högl 2002). In the end the frequently mentioned rockslides can be added to the cases of damage at Churwalden. Most probably one of these rockslides occurred in the nearby Domleschg valley.

3.7. Macroseismic field

The reconstruction of the macroseismic field (Fig. 2) is based on several sources (Tab. 1) of outmost different quality. As mentioned in the introduction the quality of the historical information is characterized by the letters 'A', 'B', 'C' and 'F'. Eyewitness reports or primary sources which describe place, time, observer and the effects, are indicated through the letter

'A'. At least two to three primary sources are the base of a reliable reconstruction, secured by a thoroughly crosschecking. Partially incomplete sources in agreeing with eyewitness reports are qualified by 'B'. And doubtful sources, copies of lost sources and archaeological or geological statements are indicated by 'C'. Likewise important is the identification of fake report, called 'F'.

Table 1 provides estimates of the site intensities in the European Macroseismic Scale (EMS-98). The information for one site (village, town) is seldom well defined, more often it allows a range of interpretation. Considering this spectrum we assigned the minimum (I_{min}) and maximum (I_{max}) possible value, and set the probable intensity value (I_w). For the year of the event, the number of reported sites is considerable. However, the distribution of intensity points is not regular, due to the lack of reports from the Alpine valleys. We can estimate the radii of the isoseismals to about 20 km for intensity VIII,

60 km for intensity VII, and 125 km for intensity VI. The method for the magnitude and intensity calibration is described in Fäh et al. (2003).

4. Discussion

Based on our re-evaluation of historical records, the most likely epicentral intensity (EMS-98) for the 1295 event is VIII. The moment magnitude, M_w , deduced from quantitative analysis of the whole macroseismic field is 6.5. However, due to the uncertainties of the intensity assessments and scarcity of data points, the magnitude error can be as large as 0.5 units. Both the concentrated damage in Churwalden and the distribution of other available macroseismic observations place the epicenter close to Churwalden, GR (46.79N/9.54E, Fig. 2). Given the small number of reliable records, however, the location uncertainty is defined by a 50 km radius around the epicenter.

Comparing the most likely epicentral location deduced for this 1295 event with instrumental seismicity recorded in the recent past (Fig. 3) shows that the location coincides with a region of enhanced activity. In fact, an earthquake of magnitude M_w 4.6 followed by numerous aftershocks occurred on the 20th of November 1991 near Vaz, just 7 km S of Churwalden. Its source was situated at a depth of 6–7 km and its focal mechanism corresponded to slip on a northeastward dipping normal fault striking NW-SE (Marone 1999). Such an extensional mechanism with a NE-SW oriented direction of maximum extension typifies events in the Penninic domain of eastern Switzerland. Further to the north, this extensional regime is replaced mostly by strike-slip events with some thrust events around the Walensee and in the Rhine Valley of St. Gallen (Kastrup et al. 2003). Focal depths in Grisons and St. Gallen south of the Alpine front are restricted to the upper 10–15 km of the crust (Roth et al. 1992; Deichmann et al. 2000). Due to the large extent of the macroseismic field, we expect that the source for the event of 1295 was also located at 5–15 km depth.

The area south of Chur is characterized by the strongest uplift rates of the Alps, together with the Valais area (Geiger et al. 1986; 1993). While the Valais was hit in 1755, 1855 and 1946 by strong earthquakes of magnitude 6 or larger, the area south of Chur has been relatively quiet during the last centuries. Nevertheless, considering the similarity in uplift and the strong earthquake in 1295, this area south of Chur could be the place of a strong earthquake in the future.

In summary, our evaluation of the historical sources has significantly improved many earlier reports of the important earthquake that occurred in 1295 in the region of Grisons. Although the information concerning the exact date includes two days and the epicentral location is not well constrained, available documents allow us to 1) assess the intensity in Churwalden and neighboring localities and 2) estimate the magnitude of this event with more confidence. This result has important consequences for assessing earthquake risk in Grisons. In fact, based on insurance estimates, a contemporary earthquake in the region of Chur, equivalent in strength to the 1295 event

($I_{max} = VIII$), would cause structural damage corresponding to about 800 Million SFr and total losses on the order of 1.5–2.5 Billion SFr (Schaad 1995).

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Abbreviations

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Illustrations:

- Figure 1: View of the monastic precincts at Churwalden around 1795. Oil painting, anonymous, Roggenburg, vicarage (Bergmann, 1997; 8). Copyright by Verlag Anton H. Konrad, Weissenhorn, D, 2002.
- Table 1: Some important intensity site points
- Figure 2: Intensity distribution: Earthquake, September 3 (4), 1295 at Churwalden.
- Figure 3: Geology and recent Seismicity.

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