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Evidence for earthquake damage on St. Michael church in Cluj-Napoca, Romania

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Abstract: A preliminary archaeoseismological study carried out on St. Michael church in Cluj-Napoca, Romania, revealed various deformations which can be attributed to earthquakes. There are both in-plane and out-of-plane deformations, including dropped keystones, shifted masonry, folded walls, etc. Probably the earthquake of 1763, recorded in historical documents, is responsible for at least part of the damage. The archeo-intensity scale assign at least I = VII for dropped keystones, and I = IX for displaced masonry. These values for the Gothic church in Cluj well exceed the postulated 475-year recurrence intensity I = VI for the region.

Keywords: archaeoseismology, Transylvania, Gothic architecture, seismic hazard

1. Introduction

Instrumental earthquake data are available for less than hundred years in Romania and elsewhere. To recognize earthquakes of longer recurrence periods than 100 years, we have have to refer to historical documents (historical seismology): these provides otherwise unavailable data on the date and time, location, and intensity of earthquakes ranging back to several centuries, posibly even for a few millennia (Guidoboni and Ebel 2009). The study of damaged ancient buildings (archaeo-seismology: Stiros and Jones 1996; Galadini et al. 2006) mostly provides evidence on location, intensity, and strong-motion direction of earthquakes, ranging back in time as for millennia, as far as the first man-made construction is to be found at any given location. Geological evidence for surface and subsurface ruptures (paleoseismology: McCalpin 1996) provides date and displacement mechanism for prehistorical earthquakes.

A preliminary archaeoseismological study carried out on the Medieval St. Michael church in Cluj-Napoca, Romania (Fig. 1), revealed various deformations which can be attributed to earthquakes. The damage is briefly described, intensity values are assigned, and conclusions on seismic hazard in Transylvania are drawn.

2. Results

Damage attributable to earthquakes is identified based on the information in well-documented publications, e.g. the works of Korjenkov & Mazor (2003), Marco (2008), and Kázmér (2015, with references).

In-plane deformations (parallel with the church wall) are shifted masonry: there are (1) damaged and dropped keystones of Gothic windows (Fig. 2); (2) gaps up to 20 cm width between adjacent blocks (Fig. 3); (3) vertical fractures separating stone block into two parts (Fig. 4), etc. Out-of-plane deformations (at an angle with the wall) are (4) rotated masonry blocks in the sanctuary wall (Fig. 3), (5), and the folded wall of the nave (Fig. 5). All displacements are near the top of 17 metres high the church wall, in close proximity to the roof.

Fig. 1 - St. Michael church in the main square of Cluj-Napoca. Built in the late Middle Ages, the naves are Gothic. The tower is a 19th century replacement of the original tower destroyed by the 1763 earthquake. Photo Kázmér, #1049.

3. Discussion and conclusions

The late Gothic church was built during the 14-15th century. Trace of changes in the building plan and repeated restoration campaigns demand a detailed assessment of construction history, not yet fuilly available today. Historical documents testify on repated fires and at least one damaging earthquake.

The church history monograph of Sas (2009) mentions the 1763 earthquake, which damaged the Medieval tower beyond repair. The Réthly (1952) and Zsiros (2000) earthquake catalogues do not mention this event.

The Rodriguez-Pascua et al. (2013) archeo-intensity scale assign at least I = VII for dropped keystones, and I = IX for displaced masonry. These values for the Gothic church in Cluj well exceed the postulated 475-year recurrence intensity I = VI for the region (Leydecker et al., 2008).

Further, systematic studies are needed all over Romania to use the under-utilized seismic archive of ancient buildings and their damage.

Fig 2 -.Dropped stones of the tipped arch of a Gothic window. One block on the left and three blocks on the right dropped downwards by a few centimetres during in-plane shaking of the building. White blocks are newly inserted stones to fill up empty space between shifted blocks (two upper rows) and irreparably broken blocks surrounding the window. Photo #1074

Fig 3 - Repaired traces of in-plane shift of adjacent masonry blocks (white fillings) above the Gothic window. A block adjacent to the supporting pilaster to the right has been rotated clockwise relative to the plane of the wall: its right edge is several centimetres towards the viewer. Photo #1127

Fig. 4 - Broken ashlar in the middle of the picture window lintel broken twice. Repaired traces of stone blocks shifted in-plane. Wall of the southern aisle, window into a staircase. Photo #1139

Fig. 5 - Southern wall of the apse: the upper portion above the window suffered an out-of-plane displacement. The part on the left moved towards the viewer by more than 10 centimetres. It is not a construction error: it is due to intensive shaking, perpendicular to the plane of the wall. Photo #1151

4. Conclusions

St. Michael church at Cluj-Napoca, Transylvania, Romania, has been damaged by major earthquakes since its construction in the late Middle Ages. Features, mostly around the topmost part of the surrounding walls are explicit at windows. In-plane shifted blocks, out-of-plane rotated blocks, dropped stones of window arches, broken ashlars, broken lintels and the folded wall of the apse are hard evidence for shaking caused by an earthquake. The 1763 earthquake (not listed in catalogues) is known to damage the tower beyond repair. Possibly the wall damage can be dated to this event. Assumed intensity is at least IX, exceeding the postulated 475-year recurring intensity I = VI for the region. Systematic archaeoseismological studies are necessary to reduce the incompleteness of the historical earthquake catalogue of Romania.

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