DIGITAL MAPPING AS A TOOL FOR ASSESSING THE CONSERVATION STATE OF THE ROMANESQUE PORTALS OF THE CATHEDRAL OF OUR LADY IN TOURNAI, BELGIUM

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Abstract

In the framework of the conservation of the Cathedral of Our Lady in Tournai (Belgium), the Royal Institute for Cultural Heritage (KIK-IRPA, Brussels) was called upon in 2012 to carry out a preliminary study of two Romanesque portals called the *Mantile* and *Capitole* portals. The aim of this study was to understand the deterioration mechanisms of the stone and to propose a conservation strategy. Both portals are constructed from the local black Tournai stone, with the exception of the 19th century restoration in Belgian bluestone. Due to the strongly deteriorated state and the large size of the portals, a detailed visual inspection survey of each stone block was necessary to obtain an overview of the actual state of conservation and to develop an adapted conservation strategy. The deterioration patterns were digitally mapped with the Metigo *MAP* software (fokus GmbH), using rectified photographs as a template. These mappings present a visual clarification of the location, extent and degree of the different deterioration patterns. They also enable us to evaluate and compare the deterioration patterns of both portals and can be linked to the results of the laboratory analyses.

Keywords: Tournai stone, deterioration mapping, Tournai cathedral, Romanesque portals, Metigo *MAP*, delamination, black crust

1. Introduction

Construction of the Cathedral of Our Lady in Tournai (Belgium) started in the first half of the 12th century. The nave and transept date back to the Romanesque period and are topped with five towers, all predating the Gothic choir. Its important artistic and historical value was recognised by UNESCO in 2000 with their acknowledgement of the Cathedral as a World Heritage Site. Despite successive architectural changes to the Romanesque construction, two original side portals dating from around 1125 (Deléhouzée 2013) have been spared: the *Mantile* and *Capitole* portals, located respectively at the northeast and southwest side of the nave. In spite of their strongly deteriorated state, these finely sculpted portals in Tournai limestone are unique examples of Romanesque monumental sculpture in Western Europe (Fig. 1). Both portals consist of multiple round arches embodied in a trefoil arch with a drip moulding. The arches are supported by jambs and jamb columns. Each

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block is decorated with a Romanesque sculpted relief and the entire surface was probably polychromed (for further details see De Roy J. *et al.*, in press).

In 1999, a new restoration campaign of the Cathedral was considered crucial. In this framework, a preliminary study of the Romanesque side portals was commissioned to the KIK-IRPA in 2012. The aim was to understand the deterioration mechanisms of the black Tournai stone in an urban environment and to work out a conservation strategy for these portals.

Fig. 1: Mantile portal Mantile portal (left), picture dating from 1899 © KIK-IRPA, Brussels, B3188. Capitole portal (centre) © KIK-IRPA, Brussels, A126815. Relief of inner arch of Mantile portal (upper-right) © KIK-IRPA, Brussels, X049701. Relief of trefoil arch of Capitole portal (bottom-right) © KIK-IRPA, Brussels, X057496.

2. Characterization of the stone

Both the architecture and the sculptures of the *Mantile* and *Capitole* portals were executed in black Tournai stone, a local "black marble" (sedimentary limestone that allows for fine polishing) also known as Noir de Tournai, which was widely used in the Low Countries from the 11th to the 15th century (Groessens 2008). Tournai stone is a local stone exploited on the right bank of the Scheldt river near the city of Tournai. Geologically, the black Tournai stone is a compact, fine-grained, silicified and clay-bearing limestone from the Lower Carboniferous (Tournaisian) age (Camerman 1944; Hennebert and Doremus 1997). The stone can be described as a bioclastic wackestone according to Dunham's classification (Dunham 1962) and as a biomicrite according to Folk's classification (Folk 1965).

Petrographic analysis of loose samples from the portals revealed that the silicified matrix of the stone mainly consists of calcite, sometimes with grains of dolomite. While the compact stone core has coarser bioclasts (≤ 250 µm) than the outer edges (≤ 100 µm), careful examination reveals a more prominent presence of small clay laminae in the outer edges which are almost absent in the stone core. The clay laminae form a laminated structure on the outer edges of the stone. As further research revealed, this distribution of clay minerals in the stone, in combination with extrinsic factors, is the most important reason for the deteriorated state of the portals (for further details see Fontaine *et al.*, 2015).

3. Material history

Already in the mid-18th century the ruinous state of the portals was mentioned (Van Den Noortgaete, 1995) and in the second quarter of the 19th century it was argued that there would soon be nothing left of the original sculptures (Scaff, 1971). This poor condition led to the restoration of the two Romanesque portals by architect Bruyenne between 1848 and 1871. The restoration mainly consisted of replacing strongly degraded stone volumes by Belgian bluestone or Petit Granit. The fact that the *Capitole* portal contains far more replaced stone volumes than the *Mantile* portal suggests that the former was much more deteriorated in the 19th century. Since the replacement stone is still in good condition, it was not included in this preliminary study.

Despite this restoration, the poor condition of the remaining original Tournai stone was still mentioned throughout the 20th century (Van Den Noortgaete, 1995). Photographs from different archives confirm this ruinous state, but a detailed inventory of the condition has never been made.

A precious source of information for evaluating the progression of the degradation are the photographs from 1943 made by the KIK-IRPA in the context of a major inventory campaign during the Second World War. Comparison with the current state of conservation leads to conclude that the general condition of the portals did not undergo major changes. Large lacunae did not expand and the current deterioration patterns were already present.

4. Digital mappings

To obtain an overview of the state of conservation two kind of mappings were carried out by visual inspection from scaffoldings:

- Detailed mappings of each different deterioration pattern of each single block of Tournai stone: 78 blocks for the *Mantile* portal and 57 for the *Capitole* portal (Fig. 2)
- General mappings for each portal with the main deterioration patterns, the positioning of the stone blocks, the readability of the sculpted reliefs and an inventory of the 19th-century restoration

Rectified, accurate photographs on true scale were used as templates for these mappings, carried out using the Metigo *MAP* software by Fokus GmbH. The true scale gave us the opportunity to document each deterioration pattern in detail but also to calculate very precisely the damage of each deterioration pattern. Nevertheless it has to be taken into account that it concerns reliefs mapped in two dimensions and thus sculptural undercuts are not included. The mappings of the portals are a combination of line- and area-mappings. The mapping terminology and colour scheme of the weathering phenomena was based on the classification of the ICOMOS-ISCS *Illustrated glossary on stone deterioration patterns* (ICOMOS-ISCS, 2008).

The following deterioration patterns were observed on both portals: detachment/delamination, cracks, black crusts in various thicknesses, soiling, biological colonization, blistering and efflorescence.

For quantitatively important deterioration patterns, namely black crusts and delamination, sub-categories were made to indicate the degree of the deterioration.

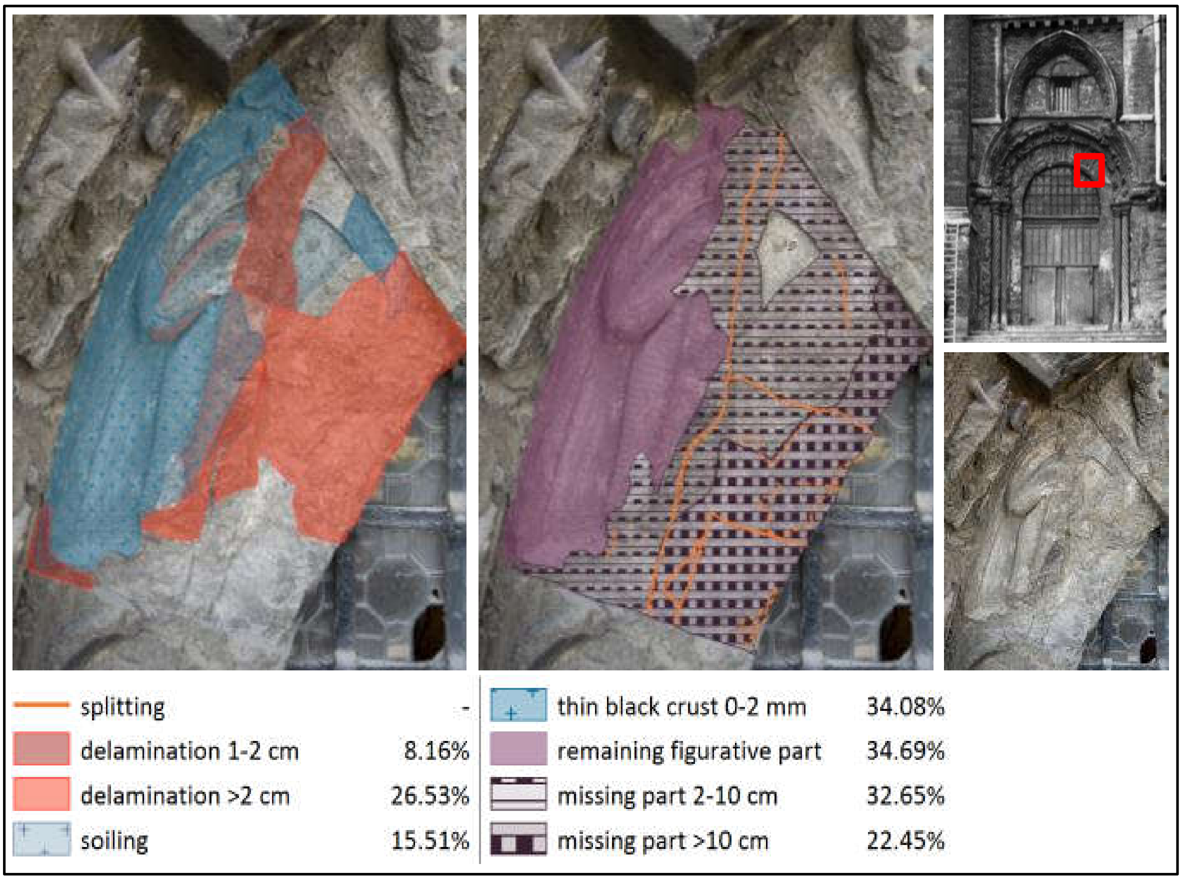

Fig. 2: Detailed mapping of block BC2 (Bandeau Cintré 2) of the Mantile portal.© KIK-IRPA, Brussels.

The mapping of the bedding planes of the Tournai stone proves that the construction of both portals is similar. Although the positioning of each block was not random (Fig. 3), the bedding planes were not taken into account during the construction of the portals. The blocks were positioned in three different directions, namely natural-bedded, edge-bedded and face-bedded. The latter blocks suffer from material loss due to their weaker and fragmented schist-like outer edge positioned parallel to the surface. This loss continues to a few centimeters depth, making a lot of sculpted reliefs hardly readable or even leading to their total loss.

From the identical positioning of the stone blocks in both portals we can derive that the lower part of the *Capitole* portal was very likely face-bedded. This would explain why that part would have suffered substantial material loss and was replaced with Belgian bluestone in the 19th century.

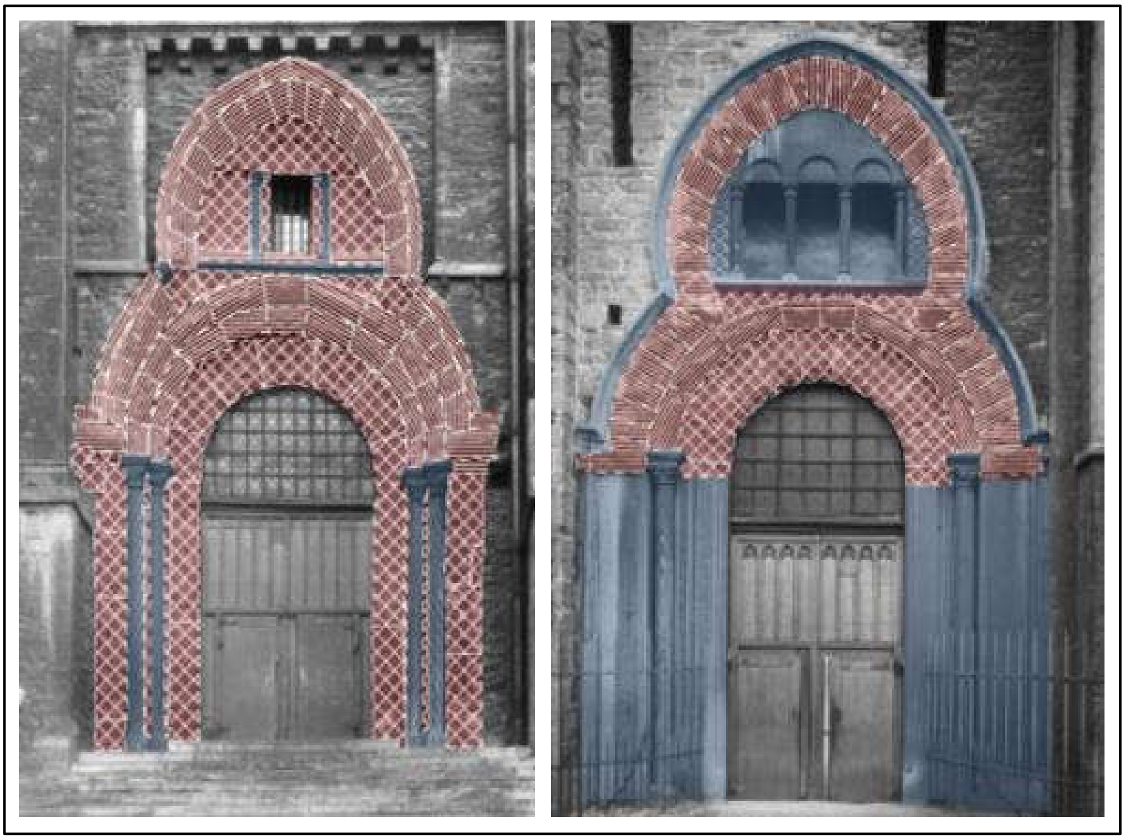

Fig. 3: Mapping of the bedding planes of the original stone blocks in the Mantile (left) and Capitole portal (right). Hatchings underlines the bedding planes, while crosshatching is used for face-bedded blocks. Blue-coloured zones correspond to the 19th century restoration with Belgian bluestone ©KIK-IRPA, Brussels.

5. Results

From the detailed mappings an overview can be deducted of the different degradation phenomena and their distribution on the portals (Fig. 4). Detachment is a common phenomenon of the original Tournai stone and was found on 51% of the original surface of the *Mantile* portal and on 39% of the *Capitole* portal. Black crusts were omnipresent as well: on 62% of the *Mantile* portal and on 79% of the *Capitole* portal. These phenomena are divided in different subcategories according to their degree of degradation. Other deterioration patterns such as biological colonisation, blistering and efflorescence were less common and will thus have less impact on the conservation treatment.

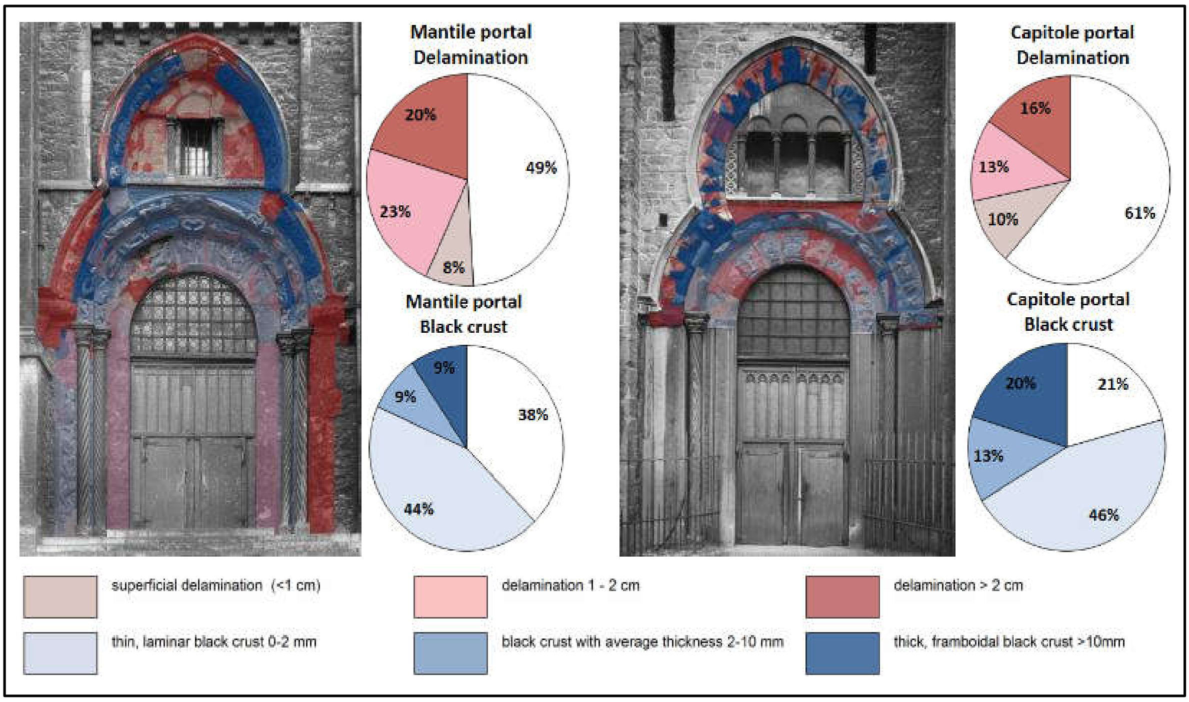

Fig. 4: Mappings and diagrams of the delamination and black crusts on the Mantile (left) and Capitole portal (right) © KIK-IRPA, Brussels.

A general mapping describing the state of the sculpted surface comprises four different categories: first of all sculptures with an original surface in good condition, secondly stone blocks with an original surface that is hardly readable, thirdly original stone surfaces that have completely disappeared and lastly 19th-century replacements (Fig. 5).

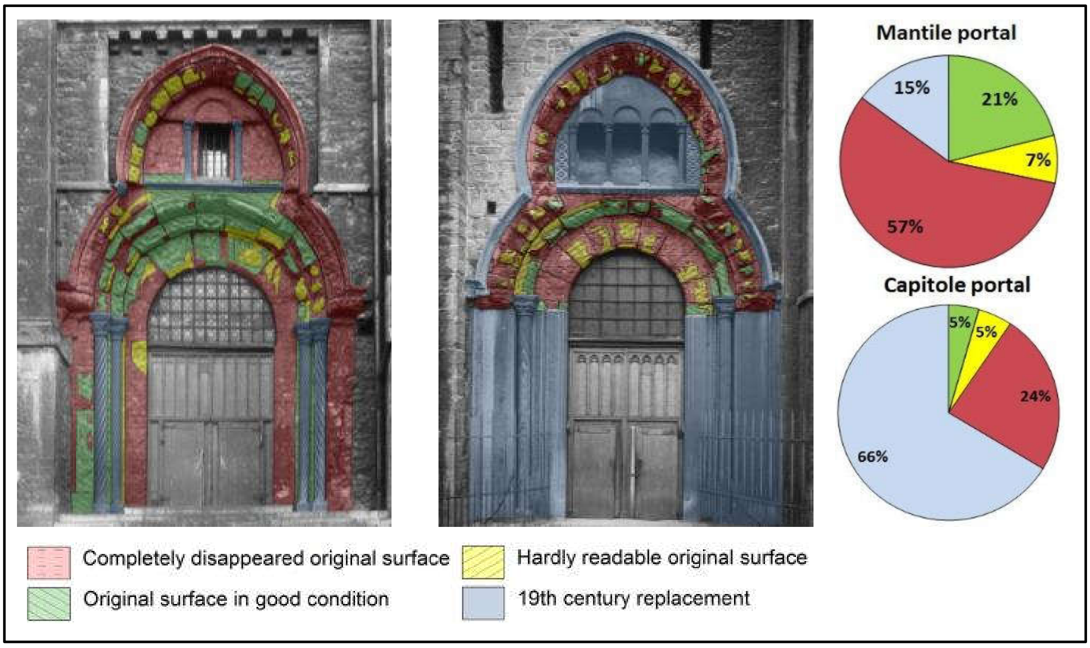

Fig. 5: General mapping and diagrams of the state of conservation of the sculpted surface. Mantile portal (left) and Capitole portal (right) © KIK-IRPA, Brussels.

Unfortunately hardly 5% of the finely detailed Romanesque sculptures remains for the *Capitole* portal and 21% for the *Mantile* portal. In total 66% of the *Capitole* portal and 15% of the *Mantile* portal was replaced by Belgian bluestone in the 19th century, leaving only around a third of the original stone of the *Capitole* portal while the *Mantile* portal still contains 85% of its original stone volumes.

From the mappings it became furthermore clear that orientation of a portal has an influence on its conservation state. Due to its southwest orientation, corresponding to the direction of prevailing winds and ample exposure to the sun, the *Capitole* portal is more deteriorated than the *Mantile* portal, as we can read out of the mappings.

Stone volumes in the deeper parts of the archivolts of both portals are better protected from meteorological phenomena such as rain and direct sunlight and are thus better preserved. These sheltered areas, however, contain more black crusts.

6. Practical use of the mappings for the conservation treatment.

The detailed mappings were used as a guideline for further scientific research in order to understand the mechanisms of the deterioration. Furthermore they were used to select representative locations for sampling and allow an informed choice of on site test-areas for micro-drilling resistance, ultrasonic pulse velocity and water absorption measurements (for further details see Fontaine L. *et al.*, 2015).

The results of these measurements in combination with additional scientific research and the data from the mappings revealed that the specific degradation of the Tournai stone is caused by intrinsic as well as extrinsic factors. These were studied by the monuments and monumental decoration lab of the KIK-IRPA. The presence of numerous clay laminae in the schist-like outer edges of each stone block constitutes an intrinsic factor for the degradation of the stone. This schist-like 'crust' makes the stone unsuitable for use as a building stone and must ideally be removed before use in an outdoor context. The core of these blocks is, however, in good condition. The cracks in the outer edges follow the bedding plane of the stone block. This leads to a high amount of material loss by detachment when the blocks are face-bedded.

Furthermore also extrinsic factors such as climatic conditions (temperature, humidity, precipitation) and a malfunctioning of the rainwater drainage system are significant for the degradation of the portals. Hydric dilatation is the main driving force of this degradation but hygric and thermic dilatation also play an important role (for further details see Fontaine L. *et al.*, 2015).

The principal aim of the study of the two Romanesque portals was to develop a conservation treatment based on a representative test area. The area chosen for this pilot conservation had to include all the different deterioration phenomena. A representative area was selected on the basis of the mappings. Furthermore the main focus of the conservation, namely the stabilization of the detachment, could be deduced from the mappings. With this in mind, an injection mortar was designed and tested in the lab. During the pilot conservation all the different steps of the treatment were executed onsite, starting with injecting an ethyl silicate-based mortar and followed by the removal of the soiling and the black crusts. The latter was carried out with compresses in combination with micro-abrasion for the crusts with a thickness of more than 2 mm and by a mechanical elimination followed by a soft micro-abrasion cleaning for the thinner films (for further details see De

Roy J. *et al.*, in press). During the removal of the crusts thicker than 2 mm, additional injections turned out to be necessary due to the thicker transition zone of the outer stone layer with very limited cohesion (Fontaine L. *et al.*, 2015). This is in contrast with the thin film-like crusts where the underlying stone support appears in relatively good condition.

The mappings were also used to estimate the cost and time required for the future conservation project as all the deterioration patterns had been linked to a specific conservation method.

7. Conclusion

The digital mappings proved to be extremely useful for this complex case of the *Mantile* and *Capital* portals in Tournai stone. Apart from the general mappings, a total of 135 blocks of stone were individually mapped on site using the Metigo *MAP* software. These information confirmed the need for a conservation treatment, revealing that most attention should be paid to stabilizing the delamination. This deterioration pattern is caused by a combination of both intrinsic and extrinsic factors and led to a study of suitable conservation methods. The different orientation of both portals is clearly visible in the state of conservation. Besides a conservation treatment, preventive measures should be taken into account. The digital mappings can be reused and completed as at the time of our inspection some cracks and losses were still covered by thick black crusts. We conclude that such digital mappings are also the perfect tool for monitoring the condition of the portals in the future.

Aknowledgments

This research is part of the preliminary study of the Romanesque side portals, commissioned in 2012 by the Walloon cultural heritage agency (DGO4/Département du Patrimoine), the Province of Hainaut and the City of Tournai. The study has been carried out in collaboration with the monuments and monumental decoration lab of the Royal Institute for Cultural Heritage (KIK-IRPA, Brussels). The authors would like to thank the following colleagues at the KIK-IRPA for their contribution to the preliminary study: R. Hendrickx, C. De Clercq and H. De Clercq.

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