Erzbergwerk Rammelsberg (Goslar, Germany): Development of a 3-D model-based database as a tool for documentation, research, and conservation of a complex UNESCO World Heritage Site.

Sebastian HOYER, Technische Universität Braunschweig, Germany

Antonia ZÖLLNER, Technische Universität Braunschweig, Germany

Ulrich KNUFINKE, Lower Saxony State Office for Monument Preservation, Germany

Yahya GHASSOUN, Lower Saxony State Office for Monument Preservation, Germany

Abstract

The surface facilities of the Rammelsberg ore mine with more than 50 surface buildings are part of the UNESCO World Heritage Site "Erzbergwerk Rammelsberg, Altstadt Goslar und Oberharzer Wasserwirtschaft" as evidence of ore extraction dating back to the early Middle Ages. Although the mine has not been in operation since 1988 and has been listed as a World Heritage Site for 30 years, parts of the historic mine workings and the ore processing facilities above ground are open to visitors as museums. Like all sites of industrial and especially of montane heritage, the facilities are structurally complex, and their permanent preservation poses great challenges for operators and monument conservation due to their size, construction, and materiality.

Against this background, the montane industrial complex is being recorded, analyzed and presented in a digital model for the "digital conservation" of the status quo in an interdisciplinary research project (geodesy, history of building construction, preservation of monuments) of the „Niedersächsisches Landesamt für Denkmalpflege (NLD)" and the „Technische Universität Braunschweig", which has been running since 2020. The project entitled "Die obertägigen Bauwerke des Rammelsberges in Goslar: Vom montanindustriellen Komplex zum Welterbe der UNESO. Erfassung und Modellierung von komplexen Baudenkmalen" is funded by the funding line of the „Niedersächsisches Ministerium für Wissenschaft und Kultur (MWK)" PRO*Niedersachsen. It is associated with the „Schwerpunktprogramm 2255 - Kulturerbe Konstruktion"[1] of the Deutsche Forschungsgemeinschaft (DFG) and cooperates in terms of content, for example, with the project „Denkmalschutz 3D: Deals 3D", funded by the German government (Bundesministerium für Wissenschaft und Forschung – BMBF) as part of the civil security research program. A close cooperation with the operatior of the World Heritage Site, Weltkulturerbe Erzbergwerk Rammelsberg Goslar GmbH helps to use the results of the project in the practice of preservation and maintenance. The main focus of the project is on the surface facilities of the mine and therefore its content forms a compatible extension to the research project "Altbergbau 3D" funded by the (BMBF), in which parts of the complex underground mine areas were

---

[1] See DFG Schwerpunktprogramm 2255 „Kulturerbe Konstruktion; "https://kulturerbe-konstruktion.de/

documented using photogrammetric methods (Bauerochse et al, 2021). Within the project, a georeferenced 3-D database is being developed using the example of the surface facilities of the Rammelsberg ore mine and its surrounding landscape. It documents the historical development and the current state of the facility. A main aspect of the research is the development of a comprehensive classification for structuring and ordering the heterogeneous aboveground monument inventory[2] and assigning it to a specially developed classification, in the sense of an unambiguous assignment on the comprehensive scale from building to detail. In this context, questions of spatial theory concerning the ascertainability and representability of functional areas of free ground plans or the determination of landscape morphologies (e.g. spoil heaps) are also discussed and for the first time brought to a consistent structuring. The recording, classification, georeferencing, and enrichment with archival material in the developed exemplary database scheme serve the research of the World Heritage Site, its monitoring, and its monumental building maintenance. Despite the World Heritage status since 1992, there is no final overview of the documents collected over the years of operation as well as archival records, which are very scattered, existing in different archives. The project aims at finding and sifting these archival documents and, on their basis, reconstructing and visualizing the building development phases of the last 1000 years.

In the first phase, the entire plant was surveyed by both terrestrial laser scanning and UAV photogrammetric flight (Fig. 1). For the ore processing plant built into a mountainside in the 1930s, which is directly connected to the underground facilities, the complete, detailed scan of the interior spaces was also linked to HDR panoramic photos, which provide the intuitive orientation representation for georeferencing (Fig. 2). In a second phase, based on this, a classification principle was developed following established room book schemes as well as DIN EN ISO 12006-2[3] and GEFMA 924[4], and the prototype of a georeferenced database was created using PostgreSQL, which on the one hand, systematically captures the complex spatial and material structure of the facility, and on the other hand, allows a manageable representation of the captured point cloud and current photos. The large point cloud resulting from the first phase has been visualized using Potree (an open-source WebGL-based point cloud renderer for large point clouds) and linked exchangeably with the database. In the ongoing third phase, the relevant spatial and material elements are identified and enriched with corresponding information (construction period and changes, material, construction, relevance for the monument value, potentially: preservation cycles, planning, etc.). Also deposited are historical

---

[2] Erhaltung des kulturellen Erbes - Allgemeine Begriffe; Dreisprachige Fassung EN 15898:2019; DIN EN ISO 12006-2:2020-07

[3] Hochbau - Organisation des Austausches von Informationen über die Durchführung von Hoch- und Tiefbauten - Teil 2: Struktur für die Klassifizierung (ISO 12006-2:2015); Deutsche Fassung EN ISO 12006-2:2020

[4] Datenmodell für das FM - Teil 1: Katalog der Bauwerkstypen; Teil 2: Katalog der Facilities; Teil 3: Katalog der LzPh., Haupt- und Teilprozesse, Services; Teil 5: Katalog der Risiken und Gefährdungen; Teil 6: Katalog der Dokumentenarten; Teil 7: Katalog der Rollen; Teil 8: Katalog der Qualifikationen und Befähigungen, Ausgabedatum 2017-09

sources such as construction drawings, photographs, or other documents of particular importance for evaluation and preservation (Fig. 3).

The aboveground facilities of the Rammelsberg are the occasion for the development of a general methodology for recording and implementation in a georeferenced database. The article discusses the possibilities developed with it for the research, mediation, and preservation of a complex montane industrial world heritage.

Fig. 1. Dense 3D Point cloud of Rammelsberg from UAV images., Landesamt für Geoinformation und Landesvermessung Niedersachsen, 2021

Fig. 2. Panoramic view of the interior of the ore processing plant, Niedersächsisches Landesamt für Denkmalpflege, 2021
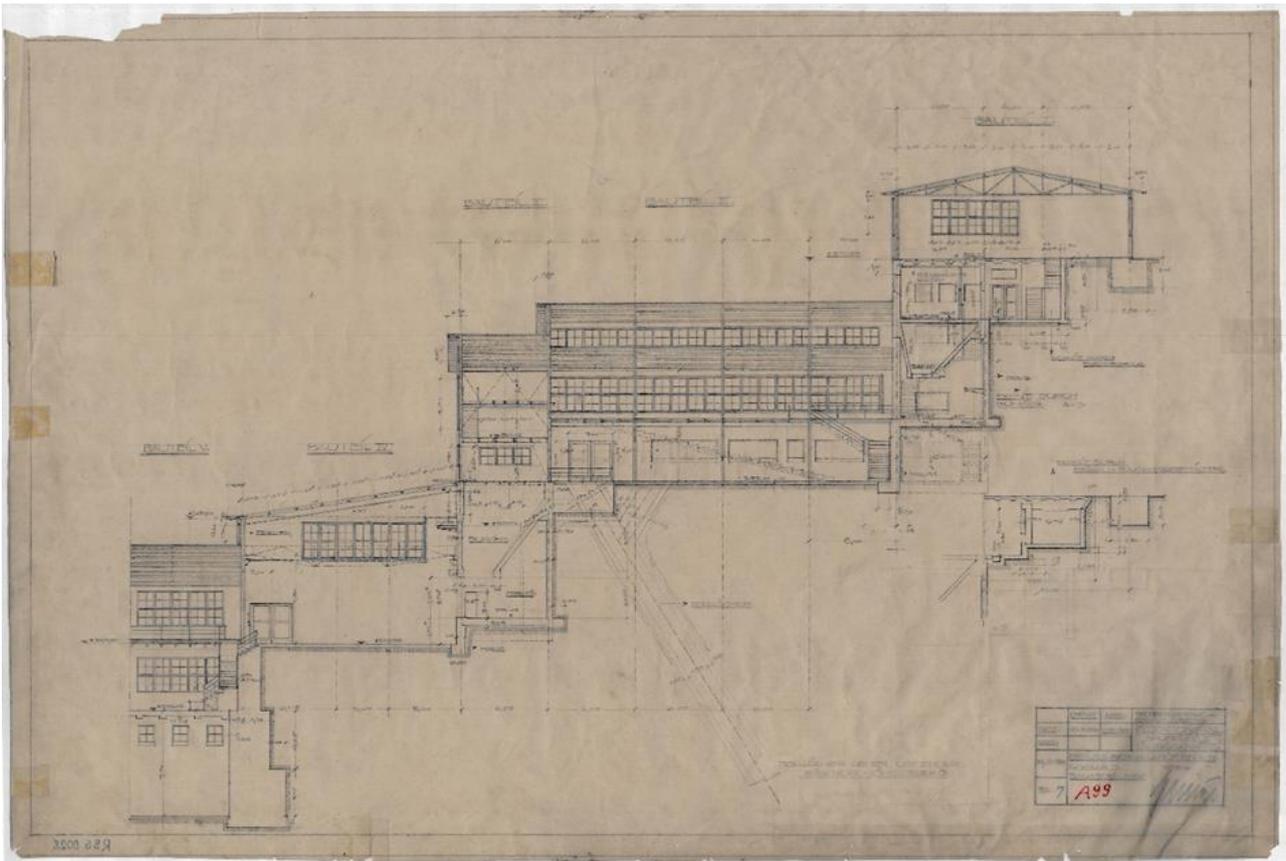
Fig.3. Section of the ore processing plant, longitudinal section of the flotation plant, WERBG archive, RBG 00028, 1936

Funding

Author Contributions

Conceptualization: Dr. Christina Krafczyk, PD Dr.-Ing. Ulrich Knufinke, NLD, Prof. Dr. Klaus Thiele, Dr. Sebastian Hoyer, TU Braunschweig
Project Administration: Niedersächsisches Landesamt für Denkmalpflege, TU Braunschweig
Supervision: Christina Krafczyk, Klaus Thiele
Writing – original draft: Sebastian Hoyer, Ulrich Knufinke, Yahya Ghassoun, Antonia Zöllner

References

Bauerochse, A. Ghassoun, Y. Hoyer, S. Knufinke, U. Nüchter, A. Platen, V. Zöllner, A. (2021). Dokumentation der Erzaufbereitung am Rammelsberg : Synergien bei der 3D-Erfassung und der Erforschung des UNESCO Weltkulturerbes; In: Denkmalpflege : Berichte zur Denkmalpflege in Niedersachsen, Heft 3 2021, S. 63-68

Olaf Gisbertz, O u. Sebastian Hoyer, S. (2021). »Masse statt Klasse?« - Neue Methoden der Baudokumentation von jungen Baubeständen; In: Berichte der Koldewey Gesellschaft 50; Hrg. Dietmar Kurapkat und Katja Piesker, Thelem Universitätsverlag- und Buchhandlung, Dresden.

Antonia Zöllner (als Antonia Suthoff): Das Erzbergwerk Rammelsberg - Entwicklung eines Leitfadens zur präventiven Konservierung, Masterarbeit, TU Braunschweig, 2019.