Digitization of bibliographic heritage in Mining, Metallurgy, and Geology: an ongoing project at the University of Moa

Digitalización del patrimonio bibliográfico en Minería, Metalurgia y Geología: proyecto en desarrollo de la Universidad de Moa

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Abstract: This paper describes the experience of an ongoing project led by the Scientific-Technical Information Center (CICT in Spanish) of the University of Moa, focused on the digitization of books authored by members of the institution, as well as undergraduate, master´s and doctoral dissertations in the fields of mining, geology, and metallurgy. These documents, currently in paper format, are deteriorating and at risk of disappearance. The project aims to democratize access and preserve these materials. Selection criteria were established with input from specialists in these relevant disciplines, considering factors such as conservation status, heritage and scientific value, and relevance to users. The technical process involved the use of a WIA CanoScan LIDE 90 scanner, saving original files in TIFF format, processing with Adobe Acrobat Pro (64-bit), storing in PDF format, and publishing through Nínive Repository and the online Mining and Geology Journal. As a result, 633 physical documents were converted into digital format, expanding the institutional repository's collection of theses and books. The digitization process has effectively democratized access and dissemination of this unique documentary heritage, with 86% of the digitized documents available as open access, marking a significant step toward institutional digital transformation.

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Keywords: document preservation, data processing, digital preservation, documentary heritage, digital heritage

Resumen: Este trabajo describe la experiencia del proyecto en desarrollo que impulsa el Centro de Información Científico Técnica (CICT) de la Universidad de Moa en la digitalización de libros de autores del centro y los trabajos de diploma, tesis de maestría y tesis de doctorado centrado en las áreas de la minería, geología y metalurgia que se encuentran en soporte papel y están en proceso de deterioro y pérdida, con el objetivo de democratizar el acceso y preservar estos documentos. Para ello se utilizó el criterio de varios especialistas en las distintas materias a digitalizar al establecer los criterios de selección de los documentos, considerando aspectos como el estado de conservación, valor patrimonial y científico de los documentos, así como la relevancia para los usuarios. Se aplicó un proceso técnico con escáner WIA Cano Scan LIDE 90, se guardaron los archivos originales en TIFF, el software especializado Adobe Acrobat Pro (64-bit), el almacenamiento en formato PDF y como plataforma tecnológica el Repositorio Nínive y la Revista Minería y Geología en línea. Fueron resultados del proceso de digitalización la conversión de 633 documentos físicos al formato digital y el incremento de la colección de tesis y libros en el repositorio institucional. El proceso de digitalización documental ha democratizado efectivamente el acceso y la difusión de un patrimonio documental único donde el 86 % de los documentos digitalizados son de acceso abierto, hecho que consolida un paso importante hacia la transformación digital institucional.

Palabras clave: conservación de documentos, procesamiento de datos, patrimonio documental, patrimonio digital, preservación digital

1. Introduction

Documentary heritage constitutes one of the most relevant and considered dimensions within cultural heritage (Romero *et al.,* 2022). With the objective of protecting and promoting its dissemination, the United Nations Educational, Scientific and Cultural Organization (UNESCO) created the "Memory of the World" program in 1992. Since its establishment, this initiative has had the fundamental purpose of protecting the globe's documentary heritage, democratizing its access, and promoting collective awareness on its importance and the need for its conservation (Foster *et al*., 1995). Information is essential for constructing knowledge; in academic centers, it requires the creation of mechanisms for its ordering, classification, and systematization (Vielza *et al.,* 2021).

In this context, the digitization of bibliographic heritage represents an invaluable opportunity for universities. This process not only facilitates the preservation and access to documents of great relevance but also allows multiple users to access the same file simultaneously from any location through electronic devices, integrate it with different applications, drive research, and foster academic collaboration (García y Almarza, 2019; Bodero *et al*., 2022; Castro Leal, 2024; Guadamuz, 2024). Even though digitization implies various challenges (Isoglio & Vigna, 2021; Mero-Santana *et al.,* 2021), an adequate planning and a strategic approach allow institutions to implement projects that benefit the entire university community.

Furthermore, information centers and university libraries have embraced the trend of preserving information in various formats to ensure its long-term preservation. The digitization of documentary sources is an alternative for preserving texts over time. This process not only saves time and physical space but also optimizes fundamental tasks such as information search and retrieval.

In Cuba, the computerization of society process has transformed multiple sectors, including libraries. Documents and resources digitization in these spaces constitutes a corner stone in this strategy, as it enables both the preservation of bibliographic heritage and universal access to information. Cuban libraries are incorporating digital technologies to turn their physical collections into accessible online formats, thus facilitating consultation and use of bibliographic resources. This effort is part of a broader digital transformation, aimed not only at the digitization of materials but also at the improvement of information services and interaction with users through digital platforms.

Access to information and cultural heritage preservation are fundamental for the development of society (Castillo, 2024; Cabrera-Periz *et al*., 2025). Consequently, digitization not only improves access to information but also enhances organizational efficiency, allowing knowledge management to transcend traditional boundaries (European Knowledge, 2024). According to Leyva *et al*. (2023), this initiative enables the incorporation of new roles and services in Cuban university libraries, supporting digital education, collaborative learning, and scientific knowledge dissemination.

Digital transformation in the fields of mining, geology, and metallurgy is a key element to improve access to information. This approach transcends the industry and extends to the academic sphere, where document digitization allows broader access to these resources

through institutional repositories. It enables the creation of precise digital models, which can be used for research, education, and dissemination (Ganchala Chavarría *et al*., 2025). According to Rodríguez *et al*. (2003), collecting, organizing, keeping, and disseminating the generated documentation grants the understanding of the particularities and development of mining, geology, and metallurgy.

The University of Moa, founded in 1976, has consolidated itself as a fundamental pillar in the development of the Cuban Nickel Industry and is nationally recognized as a leading center for education in geological sciences, mining, and metallurgy. This institution develops research, providing practical solutions to the industry, and the scientific results are predominantly found in printed documents, which are unique in Cuba. The scientific production in the specialties of geology, mining, and metallurgy generated at the University of Moa and stored in the Scientific-Technical Information Center (CICT in Spanish) is extensive (Montoya *et al*., 2019; Ortiz Núñez & Escalante Cardoza, 2021); however, due to the age of some of these materials, the municipality's environmental conditions, and storage and conservation limitations, these documents are in process of deterioration and at risk of disappearing.

To face this situation, the CICT has assumed an active role in the digitization of the geological-mining-metallurgical bibliographic heritage generated at the University, as well as in its incorporation into Nínive Institutional Repository. This repository facilitates the storage, preservation, and dissemination of digital resources produced by students, professors, and researchers belonging to the institution.

Consequently, this paper aims at describing the digitization process currently carried out at the University of Moa concerning documentary heritage in the areas of geology, mining, and metallurgy, to preserve these collections and make them available to researchers and the community as a whole.

2. Materials and methods

The digitization process was developed following several key stages that ensured the quality, preservation, and accessibility of the documentary heritage. The main phases are described below (Figure 1).

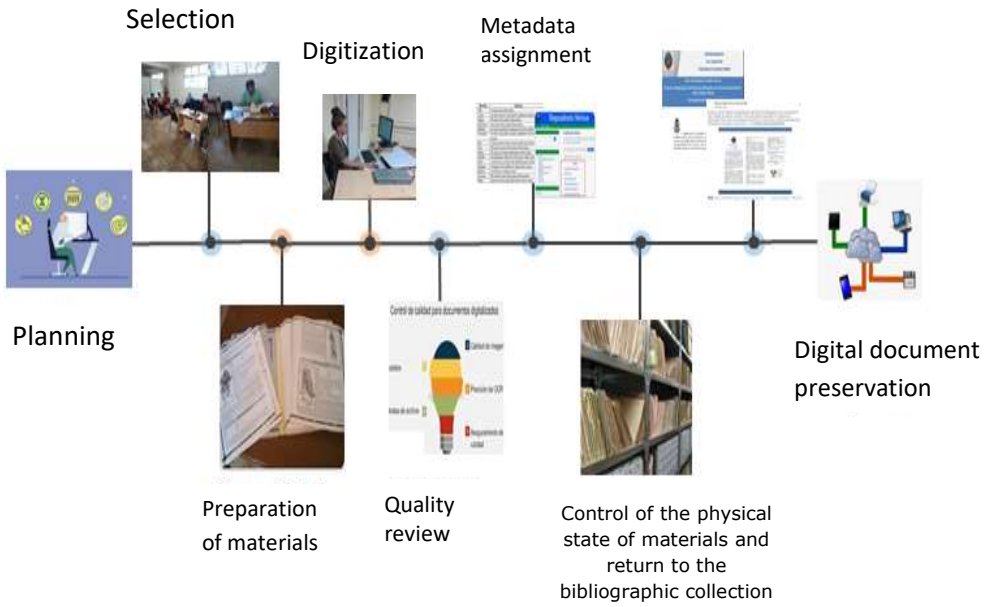

Figure 1. Stages of the digitization process.

2.1. Project Planning

An exhaustive bibliographic and documentary review on digitization in university libraries was conducted to theoretically and methodologically support the design and execution of the project. This search allowed for the identification of best practices, emerging technologies, and successful experiences guiding the preservation and access to documentary heritage in digital format.

To continue with the development of the project, the process objectives were defined, focused on preserving the bibliographic heritage and facilitating its digital access. The expected benefits were established, such as documents conservation in physical format and the optimization of use by the academic community through Nínive Institutional Repository. An analysis of human, material, and financial resources was carried out, along with the preparation of a work schedule. The working team comprised six information management specialists, one library technician, and three specialists in the branches of mining, geology, and metallurgy with extensive experience in those fields and holding a doctoral degree. Two training sessions were held to explain the digitization procedure and the scanner operation.

2.2. Selection of material for digitization

The document selection strategy for digitization considered selective and coherent criteria similar to those established by the National Library of Spain (Biblioteca Nacional de España,

2024). This process was carried out through exhaustive work by specialists in the digitized knowledge branches, who prioritized academic and historically relevant documents, conservation status, and potential use, while also ensuring the preservation of the physical, intellectual, and functional integrity of the document to maintain its value and authenticity over time.

A total of 710 documents were selected for digitization. Among them, there were 49 books by authors from the institution, 459 articles, and 202 different kinds of theses. Until 2025, a total of 633 documents had been digitized, including 45 books, 129 theses, and 459 articles.

2.3. Preparation of materials

A review and conditioning of the most suitable materials for digitization were carried out, based on exclusion criteria such as documents with damaged pages, annotations, missing pages, illegible texts, or elements hindering the scanning process, aiming to ensure the quality of the master file.

2.4. Digitization

The digitization project focuses on public access documents published under the Creative Commons Attribution-NonCommercial 4.0 International License.

To capture and create master files, a WIA Cano Scan LIDE 90 scanner was used at a resolution of 150 DPI. Original files were saved in TIFF format; the specialized Adobe Acrobat Pro (64-bit) software was used; the main preservation storage was in PDF format; and Nínive Repository as well as the online Mining and Geology Journal https://revista.ismm.edu.cu served as the technological platforms. Each generated image is in black and white in accordance with the color of the original document, and has been processed with Optical Character Recognition (OCR) software, ensuring 100% of the textual corpus is fully searchable.

The digitization of large-format documents such as geological maps and plans was carried out through a procedure that initially involved direct photographic capture of the physical documents. These images were obtained in JPG format, which allowed for adequate visual quality and facilitated digital manipulation. Subsequently, these images were converted to

PDF files as it is the preferred standard format for preservation and document management due to its stability and compatibility with other digital archiving systems.

TIFF, JPG, and PDF formats were chosen following technical parameters for access, color depth, and resolution, in accordance with international standards to guarantee the quality and durability of digital files.

2.5. Quality review

The scanning process was carried out by trained personnel, ensuring the correct capture of each document. Quality controls were implemented to verify the legibility, integrity, and fidelity of the digital images. In case of errors or imperfections, the digitization process was repeated.

The digitized document uploading process is similar to the one applied by the National Library of Spain. In this project, Nínive Institutional Repository' server was used. Once the upload is performed, its correct incorporation into the system is verified, paying attention to the following aspects: correct metadata display, correct PDF file display, and updating of the list of documents being uploaded to the technological platform.

2.6. Metadata assignment

The digitized files were processed in Dublin Core bibliographic format and organized with descriptive and specialized metadata to facilitate search and retrieval, including names of deposits, mines, quarries, mining and metallurgy equipment, exploitation methods, industries and institutions, geographical features, among other items of interest to the user community. Likewise, in the case of the geology collection, the Geology Thesaurus (Tesauro de Geología) published by the Spanish National Research Council of the Center for Scientific Information and Documentation of Madrid in 2001, and the Geological Thesaurus (Tesauro Geológico) by the Geological Survey of Cuba from 2013 were used. Finally, they were stored in Nínive Institutional Repository, guaranteeing their preservation and open access.

2.7. Control and return of materials to the bibliographic collection

The integrity of each document was revised, and they were reincorporated into the documentary collection.

2.8. Dissemination and access

Nínive Institutional Repository is a digital service at the University of Moa, based on DSpace freesoftware. It collects, preserves, and distributes digital material related to the learning, teaching, work, or research generated by professionals from this study center (Figure 2). This project includes all digitized documentary collections in the repository for compilation, preservation, and dissemination.

Figure 2. Preview of Nínive Institutional Repository.

Figure 3 shows a digitized thesis accessible at Nínive *R*epository.

Figure 3. Preview of a digitized thesis.

Similarly, informational bulletins are prepared for each department involved in the digitization process, detailing the documents in digital format being incorporated into the institutional repository. Dissemination is carried out through social networks to broaden the

scope of this information and ensure all interested parties are aware of the new available resources.

2.9. Digital document preservation

Backup copies of the information stored in the system were made.

3. Results and discussion

The digitization process implemented at the University of Moa generated progress in the preservation and accessibility of documentary heritage in the areas of geology, mining, and metallurgy. Table 1 presents the main results obtained.

Table 1. Indicators of the Geological-Mining-Metallurgical Documentary Heritage Digitization Project (2025)

Indicators	Data	Significance for the project
Selected documents	710	Volume of collection to be preserved
Articles	459	
Books	49	
Undergraduate theses	202	
Digitized Documents	633	Project progress
Articles	459	
Books	45	
Undergraduate theses	118	
Doctoral theses	11	
Number of digitized pages	10,619	Digitized volume
Documentary period covered by theses	1959/2011	Historical and academic value of selected collection
Documents in open access	617	Commitment to research visibility
Views in January 2026 in Nínive Repository	1279	Demonstrated dissemination
Theses with OCR applied	100 %	Document search
Specialized metadata included	100 %	In-depth indexing
Scanning resolution	150 PPP	Visual quality
Main preservation format	PDF	Accessible collection
Digitization equipment	1	Project progress

An analysis of the data reveals two main achievements: the high digitization rate reached (89%) and the open access rate (86%), which have brought to life a unique heritage collection by providing it with physical protection and visibility. The digital collection in Nínive Repository in the different knowledge areas has grown: mining 252 theses, geology

368 theses, and metallurgy 412 theses. Accessibility has generated a positive impact; the repository's usage data, in January 2026, records 1,217 views for the geology thesis collection, primarily in Cuba, the United States, and Peru, as well as 264 views of books by authors from the geology department; for mining theses, 527 views also in Cuba, the United States, and Peru, as well as 181 views of books by authors from the mining department.

Similarly, metallurgy theses have gained 362 views in Cuba, United States, and Mexico, while books by authors from the metallurgy department have 36 views. These figures validate the incorporation and dissemination of primary information sources, rarely used in the active flow of research, with the potential to encourage their implementation in new research and solutions for the mining industry.

It can be appreciated in Table 1 that the project has prioritized the digitization of undergraduate theses; this is because most of the master's and doctoral theses held by the library were originally created in digital format.

Another achievement is the technical quality of the digitization process which generated, organized and cataloged 622 digital files with descriptive metadata according to the Dublin Core standard. The OCR was 100% achieved, transforming the collection into a database with greater information search and retrieval capabilities. Likewise, the use of specialized metadata (names of deposits, quarries, mines, processes, mining equipment, among others) enriched Nínive Institutional Repository with combined searches, thus turning it into a valuable research tool, accessible through the website https://ninive.ismm.edu.cu/.

The documentary period covered is broad, non-consecutive and selective (1959-2011). It prioritized the criteria used by specialists to identify documents for digitization, thus reflecting a deliberate preservation strategy. On the other hand, the impossibility of digitizing certain documents due to their physical condition, documents with writings, marks, and corrections contributed to the non-consecutiveness by year. This trend concurs with methodological recommendations for material selection in digitization projects, where intellectual relevance as well as the document material conditions and user demand are weighed, consequently ensuring a balance between access, preservation, and responsible use of collections.

The first digitized thesis dates back to 1959, it belongs to the geology collection, and presents a study on oil well drilling—a document that preserves information on the technical

and operational knowledge of oil drilling and establishes a baseline for analyzing technological progress in this activity.

These results demonstrate how the digitization of documentary heritage —understood as "the creation of digital objects on the base of analog physical origins by means of a scanner, camera, or other electronic device" (UNESCO, 2015)—, contributes both to the preservation of valuable materials and to their centralized dissemination through Nínive Institutional Repository and the online Mining and Geology Journal.

The digitization project has driven the expansion of collections available in the repository, increasing this way the possibility of real-time access and visibility to these resources. This represents a significant step towards the institution's digital transformation, as it promotes the implementation of a CRIS (Current Research Information System). It is understood as systems that allow for the comprehensive management of research output— including publications, research data, patents, and other academic products—by centralizing information and facilitating its visibility and analysis (Basanta et al., 2023). In this context, digitization plays a fundamental role in enhancing the management and efficient use of academic information.

However, to consolidate these benefits, it is essential to overcome technical limitations and challenges, including the digitization of complex graphic material such as geological maps and large-format plans, as well as procuring a greater number of scanning resources to speed up the process.

4. Conclusions

The documentary digitization process promoted by the Scientific-Technical Information Center of the University of Moa has effectively democratized access and dissemination of a unique documentary heritage, as evidenced by the 1,279 views, recorded in January 2026, of a collection where 86% of the digitized documents are open access. This is a fact that consolidates a significant step towards institutional digital transformation.

The physical and digital preservation of years of specialized knowledge has been ensured, as 89% of the 710 selected documents, among which several were at risk of disappearance, were safeguarded.

The application of Optical Character Recognition and specialized metadata has transformed the collection from static images into a dynamic database with added value that enhances research in the branches of geology, mining, and metallurgy.

To broaden the project's impact, the main projections involve incorporating another scanning unit and addressing the digitization of complex material such as large-format maps and plans, while evaluating other strategies such as 3D digitization technologies.

The digitization project has not only fulfilled its initial objectives but has also allowed to glimpse the possibility of its continuity over time, since there are relevant documents that could not be incorporated into the process due to certain characteristics they possess. To achieve this, it will be necessary to establish work alliances with the geology department of the University of Moa, which has the technological infrastructure to continue with the project.

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Author's Contribution according to CRediT Taxonomy

Yoneidis Hernández Pérez: Conceptualization/Investigation/Project administration
Niurka de la Vara Garrido: Conceptualization/Writing - Review & Editing
Flor M. Reyes Hernández: Data Curation