

A Topographic diagnosis of Producciones Mineras Palmarito de Cauto quarry

Diagnóstico topográfico de la cantera Producciones Mineras Palmarito de Cauto

Reinier Fajardo Trujillo fajardoreinier4@gmail.com ⁽¹⁾

Luis Alberto Ramírez Meléndez irmelendez@ismm.edu.cu ⁽²⁾

Walkis Herrera Blanco wherrera@ismm.edu.cu ⁽²⁾

Alberto Raidel Vásquez González agvazquez950303@gmail.com ⁽¹⁾

⁽¹⁾ Producciones Mineras Palmarito de Cauto Company, Mella, Cuba

⁽²⁾ University of Moa, Moa, Cuba

Abstract: A topographic diagnosis was conducted at Palmarito de Cauto quarry aimed at improving mining operations' control and execution, given the critical role of topography for resource control and accounting in quarries. With this purpose, AutoCAD Civil 3D software was employed, and current regulations from the National Office of Mineral Resources (ONRM, in Spanish Acronym) were reviewed. Both positive and negative outcomes were obtained from the evaluated parameters. Measures to mitigate identified existing difficulties were proposed.

Key words: construction material, mining topography, zeolites

Resumen: Se realizó un diagnóstico topográfico en la cantera Producciones Mineras Palmarito de Cauto para perfeccionar el control y la ejecución de los trabajos mineros que se realizan, debido a la importancia que tiene la topografía para el control y contabilización de los recursos en las canteras. Para ello se utilizó el *software* informático Auto CAD civil 3D y se recopilaron los documentos y normas vigentes de la Oficina Nacional de Recursos Minerales (ONRM). De los parámetros evaluados se obtuvieron resultados positivos y negativos. Al detectar los problemas existentes se propusieron medidas para minimizar las dificultades detectadas.

Palabra claves: material de la construcción, topografía minera, zeolitas

Introduction

Accurate knowledge of terrain topography is essential to ensuring operations efficiency and security (Castro Moreira & Vélez-Glices, 2017; Ospina, 2021; González *et al.*, 2022; Jaramillo, 2023; Ramallo, 2023). Topographic diagnosis enables risk areas identification, available material volumes quantification, optimal extraction planning, and environmental impacts minimization.

Palmarito de Cauto quarry, located in Mella municipality, is of great significance for the socio-economic development of Santiago de Cuba province due to its raw material extraction volume, making it a key aggregates production and commercialization site. It has a mechanical processing plant enabling the obtention of construction materials such as gravel, granite, sand, and stone powder, as well as industrial products like several types of talc.

Zeolites extracted from this quarry possess multiple benefits, hence they have been studied by several authors to determine their properties for diverse applications (Céspedes-Ortiz *et al.*, 2011; Céspedes-Ortiz, Rodríguez-Iznaga & Petranovskii, 2011; Rodríguez *et al.*, 2014; Córdova-Rodríguez *et al.*, 2020; Bohorquez-Escobar *et al.*, 2020; Zvereva *et al.*, 2022; Franco *et al.*, 2024).

However, the quarry lacks periodic topographic updating and has experienced management problems resulting from topographic and cartographic work. These issues have caused limitations that affect the control and execution of mining activities. Therefore, this study is aimed at carrying out a topographic diagnosis to enhance execution and control of mining activities at Producciones Mineras Palmarito de Cauto quarry.

The information generated will optimize material extraction planning, identify risk zones requiring attention, and establish appropriate control measures. This will promote not only project profitability but also workers safety and environmental protection.

Materials and Methods

Geographic Characterization

The study area is lies 10 km northeast of Mella municipality, in Santiago de Cuba province, and 2 km southwest of Palmarito de Cauto settlement. It covers approximately 1.7 hectares within the concession area (12 h). It appears on cartographic sheet 5076-IV at a 1:50,000 scale of Santiago de Cuba.

Study Area Geological Characteristics

Lithologically, this formation consists of very pure, microcrystalline, compact, hard limestones, free of terrigenous material, in a reddish-brown color and whitish-yellow calcareous marls.

Tectonically, the deposit presents no significant complications. The main cracking observed at the surface is generally directed North. There is also parallel cracking covered with clayey-ferrous material, which sometimes widens and culminates in caverns.

The deposit's complexity lies in the variability of its thickness, which is moderately variable, with the greatest values towards the south and southeast, and the smallest thicknesses towards the northwest. Important considerations include the useful mineral thickness, which may vary due to internal cave-shaped karst and surface karst development limiting mineral reserves exploitation from the surface.

AutoCAD Civil 3D was used for the quarry representation (Belete-Fuentes, Maceo & Batisa, 2021; Stefanus, Rifai & Nasrun, 2022). This software combines an extensive range of spatial data processing tools with access to an unprecedented variety of data formats. It performs a great number of tasks related to civil engineering, topography, and drafting. The software's dynamic, style-based objects simplify object creation.

The study was carried out under the current standards from the National Office of Mineral Resources (ONRM in Spanish acronym), the National Standardization Office, and the National Hydrography and Geodesy Office, including:

- NR-FA-01-01 (2001): it establishes general principles for storage, transport, care, and verification of hydrography and geodesy measurement instruments.
- Decree Law 183 (1998): for calibration of measuring instruments according to the specific process or services where they are required.
- ISO 10012 (2003): for the requirements and management of measurement processes controls.
- NC 13-15 (1987): for the establishment, design, and dimensions of monuments used in state geodetic networks and special works.

Inspection to Producciones Mineras Palmarito de Cauto Company

Each quarry area was examined to assess its technical state, the condition of topographic monuments, measurement instruments, and the cartographic information, as well as standards compliance. After identifying existing problems, actions aimed at mitigating them were proposed.

Inspection Point No. 1

- Equipment and Instruments Storage, Transport, Care, and Verification:

The construction materials company Palmarito de Cauto lacks an internal topographic office for these tasks, hence, accredited companies with necessary equipment must be hired.

Measurement instruments are stored in the Geominera Oriente Company optical room in Santiago de Cuba, meeting all required standards. Tripods are in good condition and meet standards too.

Geominera Oriente's measurement instruments hold verification and calibration certificates issued by Geocuba's meteorological laboratory No. 57.

However, the quarry's major shortcomings are insufficient workforce to meet the standards, deficit of instruments in the company, lack of appropriate materials for this kind of work, and the absence of a topographic office.

It is recommended to evaluate the storage, transport, care, and verification of equipment and instruments.

Inspection Point No. 2

- Status Verification of the Quarry's Topographic Monuments

Monument construction did not comply with Cuban standard NC 13-15 (1987) concerning monument type based on work nature and terrain conditions. It is proposed to restore the geodetic base with new monuments. This involves a densification project to determine coordinates values which must be adjusted and referenced to the National Geodetic System.

Inspection Point No. 3

-Verification of Monuments Number and their Compliance with the Territorial Extension Standard

The study area covers 8.1 hectares with 5 existing monuments, meeting the requirements for this territorial extension.

Inspection Point No. 4

- Evaluation of the Cartographic Update Frequency in the quarry

Cartographic updates occur every six months. It is performed by the provincial project company which counts on an internal topography office. Accuracy in relation to coordinates, considering mining details of the deposit mineral conception, was verified. It is recommended to continue employing the same company that has executed previous plans updates.

Inspection Point No. 5

- Processed Material Accounting

Volume calculations are performed monthly and, every six months, the stored aggregate volume in stockpiles is quantified. The rest of the daily extracted material is accounted for by truck load. The company uses its own equipment for monthly accounting and hires third parties for semi-annual measurements. The hired company works on the base of surface comparisons or digital terrain models obtained from direct surveys with total stations.

In the quarry's procedure, all extracted volumes are recorded every month, positively impacting final product accounting.

Inspection Point No. 6

- Compliance with Topographic Work Norms in the quarry

In construction material quarries, certain topographic tasks are required for each work cycle. Table 1 summarizes which ones are met:

Tabla 1. Operations performed at Palmarito de Cauto quarry

Topographic Operations	Complied	Not Complied
Work faces surveying after each work cycle		X
Surveying of roads		X
Volume calculation for blasts		X
Cartographic updates every 6 months	X	
Calculation of volumes of processed material	X	
Updating of the trench after each cycle		X

To mitigate most of cartographic update problems, a Geographic Information System (GIS) is proposed to store all plans from previous years throughout 2023 and allow updating of work faces and trenches every cycle.

Contracting a company with suitable equipment for working faces surveying after each cycle is recommended. Points should be measured both at the edge and toe of the slope, incorporating results into the GIS for the quarry work faces updates.

Mining roads' annual topographic updates are suggested to track progress. Regarding blast volume calculations, it is suggested to take into account the ore swell factor for greater accuracy in the volume of broken ore.

Inspection Point No. 7

- Quarry Technical Condition Assessment According to ONRM Inspection Models

In accordance with the National Office of Mineral Resources' inspection models for aggregates extraction, topographic updates for reserve control are done by the end of each year. Meanwhile, trench advances should be controlled periodically after every blast, however, in Palmarito de Cauto quarry such controls are not performed due to lack of qualified personnel and authorized updating equipment.

In the technical status of the quarry, points corresponding to its topography are reflected, which are shown in Table 2.

Table 2. Palmarito de Cauto quarry technical status

Parameter	Assessment
Bench Height	Bench height varies from 10 to 13 to 15 m, being within allowed standards. According to the project, benches are 15 m-high, having a high fragmentation level due to blasting.
Slope Angle	The project specifies 80° for slope angles. According to geological compass measurements, this parameter ranges between 70° and 85°, being within permissible limits
Berm Width	According to the extraction project, berms should be 4 m-wide, however the fact is that their current width is too narrow, varying between 1 and 3 m.

These technical parameters must comply with the extraction project standards as they affect the quarry proper operation and condition for each work cycle.

Inspection Point No. 8

- Quarry´s Cartographic Information Review

The quarry holds multiple cartographic updates. Although these are stored under satisfactory conditions, digitizing them is recommended for their preservation and mining progress verification. The development of a Geographic Information System (GIS), integrating cartographic and topographic updates, is an essential tool to manage mining work at the quarry.

The outcomes of this study contribute to implementing national topographic regulations dictated by the National Office of Mineral Resources (ONRM in Spanish acronym) and the Hydrography and Geodesy National Office (ONHG in Spanish acronym) in the quarry.

Conclusions

A topographic diagnosis of Palmarito de Cauto quarry, in Santiago de Cuba province, was designed, identifying strengths and weaknesses.

Eight corrective measures were proposed to improve mining work execution and control in Palmarito de Cauto quarry.

Bibliographic References

Belete-Fuentes, O., Maceo A., & Batista, Y. (2021). Determinación de la red óptima de levantamiento topográfico con estación total para el cálculo de volumen. *Revista de Topografía AZIMUT*, 12(1), 8-17.
<https://revistas.udistrital.edu.co/index.php/azimut/article/view/13091>

Bohorquez-Escobarm C.B., Guillén Gordín, R.J. & Imbert-González J. (2020). Determinación de la adsorción y desorción de pares zeolita-metanol en un ciclo de enfriamiento. *Ingeniería Mecánica*, 23(3).
<http://scielo.sld.cu/scielo.php?pid=S1815-59442020000300005&script=sc>

Castro Moreira, J.C. & Vélez-Glices, M.A. (2017). La importancia de la topografía en las ingenierías y arquitectura. *Polo del conocimiento*, 2(7), 1071-1081. <http://polodelconocimiento.com/ojs/index.php/es/article/view/331>

Céspedes-Ortiz, M.C., Rodríguez-Iznaga, I., Petranovskii, V., Rizo-Beyra, R. & Aguilera- Domínguez, L. (2011). Zeolitas naturales de diferentes yacimientos cubanos: composición y estabilidad química y térmica. *Revista Cubana de Química*, XXIII(1), 80-88. <http://www.redalyc.org/articulo.oa?id=443543722011>

Céspedes-Ortiz, M.C., Rodríguez-Iznaga, I. & Petranovskii, V. (2011). Sistemas catiónicos binarios de cobre-cinc en mordemita y clinoptilolita. *Revista Cubana de Química*, XXIII(3), 52-60. <http://www.redalyc.org/articulo.oa?id=443543724007>

Córdova-Rodríguez, V., Rodríguez-Iznaga, I., Garcell-Puyàns, L., Petranovskii, V. & Rodríguez-Heredia, D. (2020). Estudio comprensivo sobre la remoción de iones cromatos a diferente basicidad con zeolita tipo mordenita natural. *Revista Cubana de Química*, 32(2), 494-510.

Decreto Ley 183. (1998). *De la Metrología*. Ciudad de la Habana. <http://www.inimet.cubaindustria.cu/L183.pdf>

Franco, A.M., García, E.R., Medina, R.L. & Ramírez, A.C. (2024). Properties and applications of natural zeolites. *Brazilian Journal of Development*, 10(1), 1713-1799. <https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/article/view/66577>

González, L. E., Pardo, F. R., Céspedes, E.R., Murrell, A. C., Pérez, Y.R. & Santacruz, S.N. (2022). Polígono patrón para el desarrollo de la topografía en la gestión de proyectos. Caso de estudio Universidad de Holguín. *Dominio de las Ciencias*, 8(3), 666-681. <http://dominiodelasciencias.com/ojs/index.php/es/article/view/2833>

Jaramillo, R. N. (2023). Memorias del Primer Congreso Internacional de Topografía y Geodesia 2023. *Conectividad*, 4(2), 115-125. <http://revista.ister.edu.ec/ojs/index.php/ISTER/article/view/104>

Norma Ramal NR FA 01-01. (2001). *Hidrografía y Geodesia. Instrumentos de Medición*. <https://es.scribd.com/document/503899118/Norma-Ramal-1-2001onhq>

- Oficina Nacional de Normalización. (1987). *NC 13-15. Geodesia y cartografía. Monumentos geodésicos. Diseños y dimensiones*. Ciudad de La Habana. <http://www.otn.vcl.cu/wp-content/uploads/2019/01/Normas-vigentes-dic-2018.pdf>
- Organización Internacional de Normalización. ISO 10012. (2003). *Sistemas de gestión de las mediciones. Requisitos para los procesos de medición y los equipos de medición*. <https://www.iso.org/standard/26033.html>
- Ospina, E.J. (2021). Levantamientos topográficos mediante el uso de drones. *Ingeniería: Ciencia, tecnología e innovación*, 8(2), 100-113. <https://revistas.uss.edu.pe/index.php/ING/article/view/1912>
- Ramallo, E. D. & Ostapoff, A. J. (2023). La obtención de información topográfica de un terreno en base a datos de libre acceso y software de código abierto. *Tecyt*, (9), 16-22. <https://revistas.unc.edu.ar/index.php/tecyt/article/view/42488>
- Rodríguez, V. C., Chávez, R. A., Ferro, D. T. & Heredia, H. R. (2014). Impactos del empleo de la zeolita natural de Palmarito de Cauto para descontaminar residuales de fibrocemento. *Revista Científica Interdisciplinaria Investigación y Saberes*, 3(3), 32-38. http://revistasdigitales.utelvt.edu.ec/revista/index.php/investigacion_y_saberes/article/view/73
- Stefanus, S., Rifai, A.I. y Nasrun, N. (2022). Implementación de Autocad® Civil 3D para el diseño de alineación horizontal de las carreteras Indramayu-Jatibarang. *Ciudadano: Journal Ilmiah Multidisiplin Indonesia*, 2, 739-747. <https://www.journal.das-institute.com/index.php/citizen-journal/article/view/187>
- Zvereva, I. A., Shelyapina, M.G., Chislov, M., Novakowski, V., Malygina, E., Rodríguez Iznaga, I. & Petranovskii, V. (2022). A comparative analysis of natural zeolites from various Cuban and Mexican deposits: Structure composition, thermal properties and hierarchical porosity. *Journal of Thermal Analysis and Calorimetry*, 147, 1-13. <https://link.springer.com/article/10.1007/s10973-021-10947-4>