

Sities of geological interest for field practices in eastern Cuba's northwest zone

Sitios de interés geológico para prácticas de campo en la zona noroeste del oriente cubano

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Abstract: The research is aimed at highlighting and characterizing significant geological sites for the University of Moa's Geological Engineering field training program. Through a bibliographic review and detailed analysis of geosites such as Cayo Guam River, Farallones de Moa, Los Lirios town, Maguana Beach, and El Yunque of Baracoa, practical geological aspects are identified, offering new educational opportunities. These places hold a wide variety of geological elements, allowing for the application of theoretical knowledge in real situations.

Keywords: geosite, geological heritage, geological trainings

Resumen: La investigación tiene como objetivo destacar y caracterizar sitios geológicos significativos para las prácticas de campo de Ingeniería Geológica en la Universidad de Moa. A través de una revisión bibliográfica y análisis detallado de geositos como el río Cayo Guam, Farallones de Moa, la localidad Los Lirios, playa Maguana y El Yunque de Baracoa, se identifican aspectos geológicos prácticos que ofrecen nuevas oportunidades educativas. Estos lugares presentan una gran variedad

de elementos geológicos que permiten la aplicación de conocimientos teóricos en situaciones reales.

Palabras claves: geositio, patrimonio geológico, prácticas geológicas

Introduction

Field trainings are key for students and professionals' comprehensive education. These activities allow for the application of theoretical geological knowledge and the development of skills and routines specific to fieldwork. Through these experiences, students can elaborate geological maps and describe subsoil sections, contributing to problem-solving (Corbí *et al.*, 2013).

Incorporating geological heritage into scientific teaching has been endorsed by various authors (Brusi *et al.*, 2011; Herrera-Franco *et al.*, 2022; Pareja-Pareja & Martínez-Ibarra, 2023). Within Geological Engineering degree program, field trips stand as the practical work par excellence. The educational opportunities they offer are undeniable: they drive teacher-student relationship optimization, favor the comprehensive development of content, promote growth in science, innovation, and technology, and foster love for nature and ecological awareness (Fernández Ferrer & González García, 2017; Pedrinaci, 2013; Uskola, Seijas & Sanz, 2022; Mousalli-Díaz, 2023).

In the northeastern zone of eastern Cuba, there are geological sites with ideal characteristics for these trainings (Martínez-Corpas, 2017; Dunán Avila *et al.*, 2021; Guanche-Díaz *et al.*, 2024; Ortiz Pérez, Váldez Meriño & Oro Gómez, 2025). Some landmarks are El Yunque de Baracoa for its geomorphological beauty; Cayo Guam River in Moa for its fluvial dynamics; and Farallones polygon due to its mountain range and underground formations (Domínguez-González & Rodríguez-Infante, 2007; Coutin, 2017; Fernández-Rodríguez *et al.*, 2018; Acosta-Abad, 2024). Los Lirios town in El Salvador municipality, Guantánamo province, is also considered relevant due to its weathering and sedimentation processes, as well as Maguana Beach in Baracoa, where coastal dynamics are evident (Ferreira-Gamboa, 2017; García-Carmenaty, 2020; Viltre del Toro, 2023).

This work is aimed at laying the groundwork for future field training research in the Geological Engineering degree program at the University of Moa through the characterization of sites of interest that contribute to professionals' comprehensive education.

Methodology

A bibliographic review of previous works stored in the Geology Department's Geological Fund was conducted, and field practice reports were consulted to understand the state of the art of the proposed topic. Content analysis was implemented to collect and synthesize information. *Léxico Estratigráfico Cubano* (Stratigraphic Lexicon of Cuba) (IGP, 2013) was consulted for the argumentation and interpretation of the sites of geological interest's geology.

The selection of geological sites is based on academic relevance, logistical accessibility, and geological processes diversity. Their proximity to the University of Moa was also considered, which will facilitate their inclusion into field trainings. Distinctive characteristics of each selected geological site were also taken into account.

Results

Characteristics of the geological sites for Geological Engineering field trainings

Cayo Guam River: According to Fernández-Rodríguez *et al.* (2018), Cayo Guam River's hydrographic basin is located in a coastal zone with a predominance of tropical maritime conditions, and is one of the most important surface water reserves in Cuba (Figure 1). It is located near Alejandro de Humboldt National Park and is one of the most plentiful rivers in the region due to abundant rainfall. Intense erosive processes developed there, evidenced by the formation of gullies and landslides. It is characterized by the presence of rocks from the ophiolitic complex (serpentinized peridotites, banded gabbros, chromites, and laterites) and quaternary sediments (sands, gravels, and pebbles in the riverbed).



Figure 1. Cayo Guam River. a) Riverbed. b) Banded gabbros. c) Chromite. (Pérez-García, 2023).

Farallones: Located to southwest of Moa municipality, it belongs to Cuchillas del Toa mountain group. Its geological characteristics make it an ideal site to learn about geology (Orozco, 2007; Njila & Díaz-Martínez, 2016). This massif features high cliff-type elevations which manifest in the region's general landscape. The karst formations present are: poljes, dolines, sinkholes, limestone pavement, resurgences, karst pinnacles, and cave systems. According to Coutin (2017), Farallones de Moa community, is an important exponent for nature tourism due to its landscape's beauty, the presence of Alejandro de Humboldt National Park, and the diversity of its flora and fauna, in addition to presenting a high degree of endemism (Figure 2).



Figure 2. Caves in Farallones de Moa (Wright-Castellanos, 2016).

Geologically, this area is composed of Cretaceous rocks, mainly serpentized peridotites, gabbros, tuffs, and basic-intermediate lavas, and Paleogene rocks such as tuffs from the volcanogenic-sedimentary complex, carbonate-terrigenous sediments like sandstones and limestones (Figure 3). The existing geological formations are Charco Redondo, Sabaneta, San Luis, and the Ophiolite Suite (IGP, 2013).



Figure 3. photographs of documented points in the area.
 a) Green tuffs. b) Sandstones. c) Pink limestones. d) Serpentinite.

Los Lirios: Located in Limonar sector, it belongs to El Salvador municipality in Guantánamo. It features mountain relief characterized by steep slopes and erosive zones. According to García-Carmenaty (2020), exogenous (denudation and accumulation) and endogenous (litho-morphic, volcanic, and tectono-morphic) processes are evidenced in this area. Regarding its lithology, rocks dating from the Upper Oligocene-Lower Miocene (lower part) and the Middle Eocene-Upper Eocene are found. They belong to Yateras Fm, Maquey Fm, and San Luis Fm. (IGP, 2013).

Carbonate rocks formed in deep to medium marine environments, with marked reef development, prevail in this area. The ones standing out are polymictic sandstones, calcareous marls, alternating detrital, biodetrital, and biogenic limestones, terrigenous cement conglomerates stand out (Figure 4).



Figure 4. Documented outcrop points in the area.
 a) Karstified limestones. b) Sandstones. c) Stratified limestones. d) Clays.

Maguana Beach: It is one of the main tourist beaches, located 20 km from Baracoa city. It belongs to Cuchillas del Toa geographic reserve. Its flora and fauna are rich in

abundance and diversity. Geomorphologically, it consists of fine, cream-colored sand, with a medium submarine slope and coarse, dark sediments of fluvial origin. It has a coral reef barrier 180 m from the coast (Figure 5).

It is a place of great geological interest due to its coastal dynamics, influenced by several environmental factors such as waves, ocean currents, and weathering. Volcanic and sedimentary rocks (limestones, sandstones, marls, gabbros, and basalts) can be observed in its surroundings, as they are the result of tectonic and sedimentation processes, dating from the Upper Jurassic to the Lower Cretaceous (Ferreira-Gamboa, 2017).



Figure 5. Maguana Beach (Matos Legrá, 2013).

El Yunque: Located 10 km from Baracoa municipality, Guantánamo province, it constitutes the most famous elevation in this province. It has a height of 560 m above sea level (Figure 6), and consists of a tuffaceous-rocks basement, upon which a large calcareous massif is placed. The summit presents a flat and very rough slope resulting from intense karstification.



Figure 6. Baracoa's Yunque (Najarro Pujol, 2011).

It exposes volcanic and volcano-sedimentary terrains from the underlying Cretaceous of Sierra del Purial Fm and Yateras Fm, and the late Paleogene of Sabaneta Fm. In general terms, tectonic stresses and geological processes (erosion, weathering, serpentinization, karstification, and zeolitization) are evidenced, which have transformed the geomorphology of the area (Figure 7). Lithologically, it is represented by basaltic, andesitic, tuffaceous rocks, and carbonate material (IGP, 2013).



Figure 7. Photographs of geological outcrops registered in the area. a) Gabbros. b) Zeolitized tuffs with a certain degree of oxidation. c) Andesites. d) Zeolitized tuffs.

Discussion

Through field trainings, students can acquire new experiences regarding the geological study of rocks, minerals, processes, and natural phenomena in the outcrops. These activities facilitate teamwork and allow for the development of communication, collaboration, and problem-solving skills. Furthermore, they develop students' observation, mapping, and sampling techniques, which are essential for the professional life of a geological engineer.

The study, analysis, and description of these sites of geological interest complement the theoretical content covered in the subjects: Sedimentology, Stratigraphy, Geomorphology, Geological Mapping, and Geodynamics of Geological Engineering degree program.

Conclusions

Field practices constitute unique opportunities for students to apply their theoretical knowledge in a real-world context.

Eastern Cuba's northwest zone offers to the University of Moa a great variety of sites of geological interest to conduct field trainings.

The analyzed locations: El Yunque, Cayo Guam, Farallones, Los Lirios, and Maguana provide valuable information about regional geology.

Bibliographic references

Acosta Abad, Y. (2023). *Evaluación de la vulnerabilidad de geositios en Baracoa frente a riesgos geológicos y antropogénicos*. (Degree Thesis, University of Moa, Cuba). <http://ninive.ismm.edu.cu/handle/123456789/4198>

Brusi, D., Bach, J., Estrada, M.R., Oms, O., Vicens, E., Obrador, A., Maestro, E., & Biosca, J. (2011). El GEOCAMP: un sitio web y una herramienta de edición para las actividades de campo en Geología. *Enseñanza de las Ciencias de la Tierra*, 19(1), 55-66. <https://www.raco.cat/index.php/ECT/article/view/244379>

Corbí, H., Giannetti, A., Baeza Carratalá, J. F., & Martínez, J. (2013). *Elaboración de itinerarios geológicos como recurso didáctico en Ciencias de la Tierra*. Departamento de Ciencias de la Tierra y del Medio Ambiente. Universidad de Alicante. <https://rua.ua.es/handle/10045/42990>

Coutin R. (2017). *Farallones de Moa: un caso de Estudio del Karst de Montaña en el Extremo Oriental de Cuba*. <https://doi.org/10.13140/RG.2.2.31900.51845>

Domínguez-González, L. & Rodríguez-Infante, A. (2007). Potencial geológico-geomorfológico de la región de Moa para la propuesta del modelo de gestión de sitios de interés patrimonial. *Minería y Geología*, 23(4), 1-22. <http://www.redalyc.org/articulo.oa?id=223515990001>

Dunán Avila, P.L., Valdés-Meriño, L.A., Desdín Paz, L.A., & Caseres Cimet, N. (2021). Evaluación de los geositios en el municipio Imías para la protección y conservación del patrimonio geológico. *Ciencia & Futuro*, 11(3), 1-22.

<https://revista.ismm.edu.cu/index.php/revistacyf/article/view/2090>

Fernández Ferrer, G. & González García, F. (2017). Salidas al campo y desarrollo competencial. *Enseñanzas de Ciencias de la Tierra*, 25(3), 295-301.

<https://dialnet.unirioja.es/servlet/articulo?codigo=7103727>

Fernández-Rodríguez, M., Nfundiko Christian, B., Guardado-Lacaba, R., & Almaguer Carmenate, Y. (2018). Evaluación hidroquímica de las aguas del río Cayo Guam, Moa, Cuba. *Minería y Geología*, 34(3), 268-288.

http://scielo.sld.cu/scielo.php?pid=S1993-80122018000300003&script=sci_arttext&tlng=en

Ferreira Gamboa, J. (2017). *Caracterización de geositos para la protección y conservación del patrimonio geológico del municipio Baracoa*. (Degree Thesis, University of Moa, Cuba). <http://ninive.ismm.edu.cu/handle/123456789/1208>

García Carmenaty, J. (2020). *Caracterización de sitios de interés geológico en el municipio de El Salvador, Guantánamo*. (Degree Thesis, University of Moa, Cuba).

Guanche-Díaz, A., Montesino-Pérez, A., Márquez Orta, I.M. & Hernández Flores, Y. (2024). Proposal for a tourism development plan in the municipality of Baracoa. *Explorador Digital*, 8(2), 6-26. <https://doi.org/10.33262/exploradordigital.v8i2.2945>

Herrera-Franco, G., Carrión-Mero, P., Montalván-Burbano, N., Caicedo-Potosí, J., & Berrezueta, E. (2022). Geoheritage and Geosites: a bibliometric analysis and literature review. *Geosciences*, 12(4), 169.

<https://doi.org/10.3390/geosciences12040169>

Instituto de Geología y Paleontología IGP. (2013). *Léxico estratigráfico de Cuba*. Centro Nacional de Información Geológica. Ministerio de Energía y Minas

<https://www.igp.minen.cu>

Martínez-Corpas, C.R. (2017). Evaluación de los geositos de la zona oeste de Holguín para la protección y conservación del patrimonio geológico. *Ciencia & Futuro*, 7(2), 1-22.

<https://revista.ismm.edu.cu/index.php/revistacyf/article/view/1389>

- Matos Legrá, N.E. (2013). *Opciones turísticas para la comunidad minera de Moa en Baracoa*. (Degree Thesis, Mining and Metallurgical Higher Institute, Moa, Cuba). <http://ninive.ismm.edu.cu/handle/123456789/2782>
- Mousalli-Díaz, V.E. (2023). Guía para salida de campo de geología estructural en ingeniería de petróleos *Revista Docencia Universitaria*, 1-3. <https://doi.org/10.182737revdu.vesp1-2023001>
- Najarro Pujol, L. (2011). Reina de las Antillas: las primeras siete villas fundacionales. una excursión por el tiempo. *Revista Turismo, Desarrollo y Buen Vivir*, (2), 73-101. <https://dialnet.unirioja.es/descarga/articulo/3769621.pdf>
- Njila, T. & Díaz-Martínez, R. (2016). Estudio químico-mineralógico de los perfiles lateríticos ferrosialíticos en los sectores Téneme, Farallones y Cayo Guam en el noreste de Cuba. *Revista Geológica de América Central*, 54, 67-83. <https://doi.org/15517/rgac.v54i0.21149>
- Orozco, G. (2007). *Sobre la presencia de phillipsita y analcima en tobas de la región de Farallones, Moa*. II Convención Cubana de Ciencias de la Tierra. <http://ninive.ismm.edu.cu/handle/123456789/1815>
- Ortiz Pérez, O. L., Váldez Meriño, Y., & Oro Gómez, Y. (6-8 de mayo de 2025). *Tesoros geológicos de Moa, una oportunidad de geoturismo en Holguín*. XII Convención Científica Internacional. Cuba. <http://rein.umcc.cu/handle/123456789/4496>
- Pareja-Pareja, G. & Martínez-Ibarra, E. (2023). Revisión bibliográfica internacional sobre el patrimonio geológico. *Investigaciones Geográficas*, (79), 67-86. <https://doi.org/10.14198/INGEO.22558>
- Pedrinaci, E. (2013). Fundamentos conceptuales en ciencias de la Tierra y competencia científica. *Enseñanza de las Ciencias de la Tierra*, 21(2), 208-214. <https://raco.cat/index.php/ECT/article/view/274153>
- Pérez-García, L.A. (2023). *Memorias de un geólogo: El río Cayo Guam*. <https://peakd.com/hive-10053/@lapgarcia/memorias-de-un-geologo-el-rio-cayo-guam>

Uskola, A., Seijas, N. & Sanz, J. (2022). Revisión de experiencias sobre prácticas científicas en secuencias educativas de geología con trabajo de campo. *Revista Eureka sobre enseñanza y divulgación de las ciencias*, 19(1), 110501-110521. https://doi.org/10.25267/REV_EUREKA_ENSEN_DIVULG_CIENC.2022.V19.I1.1105

Viltre del Toro, R. (2022). *El curso para el desarrollo del geoturismo en el municipio Baracoa*. (Degree Thesis, University of Moa, Cuba). <http://ninive.ismm.edu.cu/handle/123456789/4130>

Wright-Castellanos, D. (2016). *Evaluación de los sitios de interés geológicos más importantes de los municipios Sagua de Tánamo y Moa*. Holguín. (University of Mining and Metallurgical Higher Institute, Moa, Cuba). <http://ninive.ismm.edu.cu/handle/123456789/1385>