ISSN: 2692-5397
DOI: 10.33552/MCMS.2021.04.000584
Modern Concepts in Material Science
Iris Publishers

Mini Review

Manodisciplines Applied to Understand the Complexity of Mudstones and its Links with the Instability of Slopes: Interrelationships between Endogenous and Exogenous Contributing Factors, Weathering Agents & Dynamics, Next to other Environmental Considerations

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Received Date: September 06, 2021

Published Date: September 23, 2021

Abstract

The Mudstones – in spanish '*lodolitas or fangolitas*', so called in Ibero and Suramérica – are natural materials conformed up of the subclasses silt and clay, or their combinations, which usually also include the sand grain size, fine to very fine; are overconsolidated rocks, from an geotechnical point of view. These sediments can be evaluated both by classical methods and instrumental analysis techniques, revealing unknown and important variables in the genesis of wide and acute processes that compromise the Crust, object of study of modern geodynamics exogenous. While it is true that the problems in clay shales (mudstones) date back many years, it was only from the early 1960's that they were extensively studied [1].

The marine rocks (Paja Formation, Kip: stratigraphic symbol) are specifically addressed: never in a state of equilibrium (apparent, or quasi-static); on the contrary, in addition to their clear 3D anisotropy, they possess great hydrobiogeochemical reactivity and produce geomorphological problems. These contributing factors, inherent or causal – not only internal but external – are of great interest in the studies or slopes and cuts hazard zoning [2-4], direct object of the author's doctoral research for the comprehensive detailed mapping of susceptibility to mass movements (onwards MM) in urban settings [5].

Keywords: Andean mudstones; Materials science and engineering; Landslides; Quantitative geomorphology; Urban geology; Environment & risk

Brief Local Materials Science

The Kip have a sedimentary origin, with a strong siliciclastic contribution (represented by quartz, muscovite and clays), deposited in marine environments of the warm Lower Cretaceous (from shallow basins in the Sea of Tethys, which connected large oceans from E to W), with their particular organic components and non-crystalline phases, which were later lithified. Its micro biolytic contents are high (discrete organic carbon, dispersed and in organo-mineralogical aggregates), millimeter fragments of Phaeophyta abound, occasionally Girogonites of charophytes, and small ammonia associated with a possible 'bloom', together with sulfides (framboidal pyrite is abundant, which defines euxinic conditions), made concordant with the views [6] and papers of

Dr. Silva. Sulphates and some inorganic phosphates, carbonates being scarce (dolomite/ankerite, calcite minor). Several oxides-oxyhydroxides and sodalite, crystoballite; other phyllosilicates, nacrite and pyrophyllite (up to 21%); dickite, illite, gibbsite, halloysite, kaolinite, phlogopite, vermiculite and zeolite as products of weathering [3,7]. Thus, total crystalline phase around 55-69%, while the high biogenic signature is up to TOC>5, sulfur (4.8%) and they are considered non-calcareous rocks (Ca <4.3%).

To obtain all this detailed characterization were used petrography, physicochemical tests (of waters, soils and rocks), added techniques combined to nano disciplines: RXD, RXF, SEM, FTIR+RAMAN Spect., TOC-TS. It is important to contrast the images captured with reflected and incident light microscopy (where the internal details of the allochemicals of brown algae are evident), with the distribution, mixture and composition obtained by SEM, for comprehensive, real and very detailed interpretations.

Other precise data, contents and results of these very fine-sized and overconsolidated terrestrial materials are summarized in Ríos et al. [7], which is also about the discovery of cubic habit Na A Zeolites within this lithobiounit, of samples collected by the present author.

Complex Behavior: From Lithomaterials to Geodynamic Processes

Such solid substances (rocks) of the central-northern part of the Eastern Cordillera of Colombia were folded, lifted, shortened and exhumed, which originate broad outcropping patterns, subject to processes of hydric or fluvial erosion, with hazardous mass movements and torrential events. Then covered by scant soils and abundant colluvial deposits; in addition to seismotectonic, petrological and geomorphological aspects, they seasonally facilitate MM in the typologies of translational landslides, debris flows and soil creep, with some rocks falls and subsidence, due to climatic, hydrological, biological and anthropic conditions.

That is why they matter the endogenous (emphasizing the apparently monotonous geofeatures of texture, structure and composition, with the relationships of these «intrinsic properties», like structural geology, tectonics, hydrogeology, slope, etc.) and exogenous factors (vg land use, vegetation cover, climate, identified and zoned).

De visu they tend to be massive – and it is convenient to call them mudstones – but at the level of millimeters to microns their primary structures stand out: incipient lamination, wavy and non-parallel lenticular, locally flat-parallel, all discontinuous. Primary intragranular, intergranular, intercrystalline porosity was identified, low compared with secondary porosity, associated with structural discontinuities. The thick layers dip smoothly and favorably, but these areas with fracturing systems and joints (irregular and inclined, in several families) create important channels for fluids. All this increases microporosity, caused by oxidation/dissolution, and permeability (storage capacity and flow, respectively): the mobilization of fluids is facilitated (acids, with salts, ions, etc.), becoming aureoles of weakness and more prone to the attack of the rocky massif.

Hydroclasticism (physical weathering) is due to volumetric changes, on a milli and micron scale, in the face of alternating cycles of humidity and drying, according to climatic conditions, climatic variability, biotic activity, affected by altitude and latitude, and micro-scale granulometric heterogeneity, in addition to packing of phyllosilicates and organic matter. This "orchestra of degradation" makes the rock massif friable: it reduces the volume of the faces closest to the surface and increases its reactive area, being a geochemically very efficient phenomenon (it creates more and more specific micro-surfaces). Compared with fresh bedrock, ferric oxides increase due to weathering up to more than 11%. In turn, its uninterrupted degradation is evidenced, quantifiable by nanosciences: progressively generated mold porosities can be measured (from BSE+BSED images) and opening of the lamina sets with MO (that are 'washed',). Similarly, thanks to field inspections, sampling, petrographic analyzes and the use of SEM (microanalysis report, based on EDS and multi-elemental mapping), only in this way could a microlaminated gypsum facies be determined, which produces a significant subsidence to the south of the urban area of Vélez (Santander). Specific, larger and more reactive micro-surfaces are created hydrobiogeochemically.

The potential deformations of the ground (flows, of greater extension and very low kinematic rate) or rupture surfaces (landslides) are shallow. They occur under the vadose zones and facilitated by lithological contacts (stratigraphic discontinuities), before marked changes in the stress-deformation state, microporal hydrostatic over-pressure (recharge and discharge of infiltration waters). The MM are triggered by earthquakes of moderate to strong magnitude, drastic variations in hydroclimatic conditions (storms, intensity and persistence of rains, humidity vs increase in temperature due to high insolation), earth movements and anthropic excavations (urban planning, poorly confined landfills or not stabilized, road cuts, mining work, etc.).

General Summary

The research is related to the meso-centi until micro-nano "Mudstone's World", generated in very high sulfide and ferruginous marine conditions, and the convenient applicability of instrumental analysis techniques combined with classical methods and geomatic tools, to truly know its complexity and interconnections (composition, structure and petrophysical properties come to play a determining role). Such highly dynamic interrelationships have environmental implications, such as increased weathering and susceptibility or propensity to MM, so extensive and reactive, in the mountain ranges that expose such Cretaceous rocks. Other considerations, for instance the use of geomatic tools and up scaling mapping, are not covered here.

They pose serious challenges for territorial planning, environmental management (for example, the preservation of hydrographic basins and restoration of degraded areas) for the sustainable development, stability and integrity of engineering works, causing serious effects on lives and properties, also compromising security, risk reduction, adaptation and resilience to the climate change, in both rural and urban areas of many severely impacted countries around the world, not just in Colombia.

Finally, they are misnamed 'shales', because in addition to their fine granulometry, not all of them are laminated and/or fissile, concept very much in agreement with other authors.

Acknowledgement

The author wishes to sincerely thank the personal contributions of teachers, researchers and various Colombian institutions. To the support of the personnel and availability of the laboratories at the UIS headquarters, in Bucaramanga and Piedecuesta, especially the PTG (the Guatiguará Technology Park).

Conflict of Interest

No conflict of interest.

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