HYDROTHERMAL ORGANIC AGGREGATES ASSOCIATED WITH THE HIGH-NI GRADES OF THE CERRO MATOSO LATERITE DEPOSIT, MONTELÍBANO, COLOMBIA

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ABSTRACT

Mineralogical and geochemical analyses (EDS, ICP-MS, XRD) of black mudstones locally overlying the peridotites of Cerro Matoso at Pit-1 link these sediments with deep-sea hydrothermal systems. In this unit, rounded particles were identified that would correspond with organic aggregates commonly found in reducing environments related to hydrothermal vent systems. These aggregates are formed by methane-producing microorganism (methanogens) metabolism that sustains such extreme environments mediated by anaerobic methane-consuming cell consortia. The organic aggregates register Ni content up to 8 wt%. For this fossilized methanogen-AOM (Anaerobic Oxidation of Methane) consortium we propose an ultramafic contribution, followed by a hydrothermal enrichment of Black/White-Smoker type and a supplementary contribution of bio-mineralized Ni of the organics within the sediments during the formation of the Ni-bearing deposit. The sediments configured an atypical lateritic profile at the Pit-1 where Ni-concentrations reached up to 8 wt%, in contrast to the southern Pit-2 where the peridotites developed a typical lateritic profile with nickel concentrations not exceeding 4 wt%. During the Cretaceous and Cenozoic, the ultramafic rocks and associated deep-sea hydrothermal-related sediments were accreted to the South American continent. They were recently exhumed allowing supergene Ni-enrichment forming the laterite deposit known today with its locally extraordinary high Ni contents. Together with the organics, authigenic phyllosilicates and Fe-(oxy) hydroxides are the main ‘‘ore minerals” that contributed to add the lateritic Ni-enrichment after supergene leaching processes due to weathering of the Cerro Matoso peridotites.

INTRODUCTION

The only economically mineable nickel deposit known so far in Colombia is located 100 km southeast of Monteria in the Department of Córdoba. The mining complex of Cerro Matoso has an annual production of approximately 41.1kt of ferronickel, 32 Mt total reserves with a pondered average of 1.2 wt% Ni and thus a static life of 10 years (South32, 2019), although the measured + indicated + inferred laterite resources sum 312 Mt @ 0.9% Ni, + stockpiles of 43 Mt @ 1.2 wt% Ni. In this Australian South32-owned complex, the nickel ore is mined, molten, and processed to produce, in one of the largest lateritic nickel mines worldwide, an alloy of iron and nickel of high purity and low carbon content, for exportation to the international markets, mainly Asia. Recently, the company South32 began extraction of laterites from the Queresas and Porvenir hills, located 30 km north of Cerro Matoso deposit in the Planeta Rica peridotites. The only available report so far for the Planeta Rica deposit is from the United Nations, published in 1975. This report calculated Ni reserves of 5.2 Mt on a dry basis. Berger et al. (2011) resumed that laterites contain about 70 percent of world nickel resources that have been mined for more than 100 years, and account for about 40 percent of world nickel production.

Using XRD, BSE-EDX and SEM analyses Castrillón (2019), described petrographic and mineralogical characteristics of mudstones overlying the Cerro Matoso peridotites in the Pit-1, remarking that this new Fe-Ni-ore unit corresponds to deep marine sediments that can be separated in two units, identified as black mudstone facies I and facies II. The facies I is composed of berthierine + greenalite (55 vol%), siderite (38 vol%), and goethite (7 vol%) while the facies II includes greenalite (10 to 40 vol%), siderite (30-70 vol%), chromite (< 3 vol%), and magnetite (14 vol%). These rocks represent sediments which may be ancient analogues of the modern metalliferous sediments and oxy-hydroxides in spreading ridge areas with volcanic activity.

The formation of deep-sea Fe-rich sediments that overlie oceanic crust has been well documented in the Pacific Ocean. According to Hein et al. (1997) and Kuhn et al. (1998), these deposits consist of of Fe-Mn oxyhydroxides and clay minerals that are efficient scavengers for trace elements such as Ni, Co, Cu and Rare Earth Elements (REE). Metalliferous sediments derived from a complex mixture of a vent plume fall-out, sulfide mound debris, and biogenic sedimentation processes (Boström and Peterson, 1969; Metz et al., 1988; German et al., 1993; Mills et al., 1993), which are dominated by polymetallic sulfide crystallization and Fe oxidation and by precipitation of plumes when hot reduced hydrothermal fluids are mixed with cold-oxygenated deep-sea water (Feely et al., 1987).

Marine currents disperse the fine-grained particulates derived from hydrothermal venting until they eventually settle out to form metal-enriched sediments beneath the overlying plume (Baker et al., 1985). Plume vent particles from deep-sea sediments may be related to organic processes that according to Toner et al. (2009) participated in the Fe cycling in deep-sea hydrothermal plumes. Additionally, they are related to the high nickel grades in the laterite deposit of Cerro Matoso, specifically at Pit-1, with Ni grades exceeding 8-9 wt% where black Fe-rich mudstones overlie the peridotites. Although little is known about the processes or dynamics of the plume environment, some particles have been described as bio-mineralization products (e.g., Konhauser et al., 2002; Kappler et al., 2005; Konhauser and Riding, 2012).

Microorganism consortia participate in the bio-mineralization by (AOM), a process that frequently is coupled to sulfate reduction and usually accompanied by methanogens,