# INNOVATIVE TECHNOLOGIES FOR THE EXTRACTION OF NICKEL, COBALT AND MANGANESE FROM LATERITE CRUSTS

By

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## ABSTRACT

ERM Sustainability Mining Services team (formerly CSA Global) has worked on innovative technologies for extracting nickel, cobalt and manganese from laterite mineralisation since 2018. This work commenced on Kazakh Ni-Co-cobalt laterite deposits with Ni grades from 0.3–1.3% (average 0.7% Ni) and cobalt grades around 300–500 ppm. In these deposits, Ni-Co mineralisation is comprised mostly of high-magnesium silicates, commonly nontronite, with minor amounts of Ni-Co in limonite.

Modern processing of Ni-Co ores generally involves either pyrometallurgical or hydrometallurgical methods. Hydrometallurgical methods, including AAL, HPAL and heap leaching, are the most common. However, these conventional approaches have not been economic for the Ni-Co laterite deposits in the Urals and Kazakhstan due to the prevalence of Ni-silicate mineralisation and overall low grades.

The successful development of *in situ* recovery technology for extracting copper and gold from regolith/weathering crusts was identified as a potential opportunity to extract Ni-Co from the Ni-Co enriched regolith in the Urals and Kazakhstan. Initial laboratory and pilot investigations – using sulfuric acid as the lixiviant – were completed on the Tochilnogorskoe, Kungurskoye and Rogozhinskoe deposits in the Urals. However, it was quickly recognised that sulfurous acid is a superior lixiviant for Ni-Co laterite deposits. This approach was successfully demonstrated in pilot tests on the Ekibastuz-Shiderty deposit in 2017.

CSA Global prepared the first formal Scoping Study on the use of ISR at Ekibastuz-Shiderty using the Clean TeQ process to treat Ni-Co pregnant solutions using a combination of IX, SX and neutralisation of pregnant solutions.

Subsequently, Kaznickel completed extensive ISR tests, over the course of 2021-2022, at the Gornostay Project using sulfuric acid as the lixiviant. This extended pilot test work resolved numerous issues in operating the test polygon and achieved a stable leaching regime. Kazniclel also developed an improved IX technology for processing pregnant solutions.

At the same time, the research by the authors identified potential improvements for the extraction of Ni-Co from low-grade Ni-Co laterite deposits in Kazakhstan based on:

- Selective sorption of Ni on Lewatit TP-220 resin, followed by removal of iron from the resin using soft acid solutions, and desorption of Ni by 7-10% ammonium hydroxide, producing an eluate of Ni ammine complexes such as $Ni(NH_3)_4(OH)_2$, $Ni(NH_3)_6(OH)_2$ etc. These complexes are easily dissociated to produce $Ni(OH)_2$, with ammonia recycled to the IX process.
- Improved heap leaching outcomes using enhanced agglomeration approaches that are more manageable than ISR. Poor permeability is the main issue with the heap leaching of clay-rich materials typical of regolith deposits. A polymeric additive that is stable with aggressive acid leaching was identified for improved agglomeration and permeability. The dynamics of heap leaching using this approach are much better than those of ISR.

Processing using sulfurous acid was found to be favourable for the leaching of manganese from weathering crusts by both ISR and heap leaching. Mn grades in pregnant solutions were 50–60 g/L. $MnO_2$ was produced directly from these solutions by electrowinning. However, Mn oxide mineralisation is often associated with elevated calcium, leading to gypsum permeability blockages (colmatation). In these cases, hydrochloric acid is better lixiviant than sulfurous acid, with Mn precipitated as the hydroxide. Recovery of the HCl by sulfuric acid improves the economics of this approach.

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