

Isotopic and gases analyses to characterize a uranium waste rock pile

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The process of accessing the ore body in conventional uranium mining involves the generation of large quantities of material that does not contain the target mineral, which are either piled on the surface or dumped in previously excavated slopes. Factors such as high material heterogeneity, segregation in the pile caused by the waste rock dumping procedure, presence of preferential flow paths and low saturation level of the material in the pile may influence the generation of acid rock drainage (ARD). ARD is widely recognized as causing serious environmental hazards and it is a main concern in mining regulations and guidelines.

Site characterization is a major step in the remediation and reclamation of uranium mining facilities. Data on site characteristics form the basis for environmental assessments, risk analyses, decommissioning plans, reclamation and monitoring programs. The characterization of the waste rock pile at a uranium mine in Caldas/MG – Brazil include, among other parameters, isotopic analysis of water and gases. The waste rock dump (21° 56'33.84"S; 46° 29'33.84"W) was built upon the course of the Consulta creek (Figure 1), has a volume of about 12.7x10⁶m³, an area of 56 ha and was distributed in five platforms (Fernandes and Scalvi, 2002).

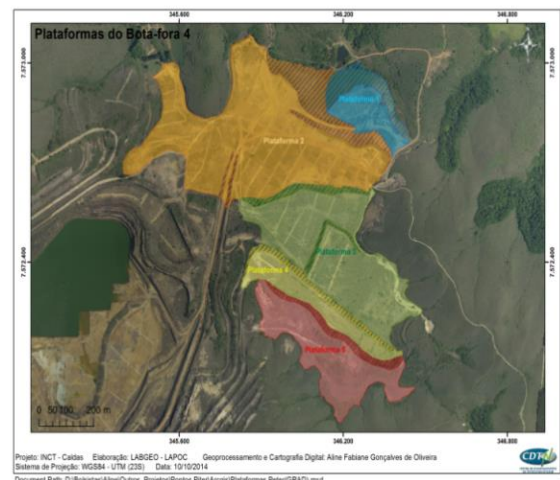


Figure 1. The waste rock pile at uranium mine at Caldas/MG, showing its five platforms in different colors.

The internal configuration of the pile evolves over time due to physical and chemical weathering under the prevalent climatic conditions. This internal structure governs the hydrogeological behavior of the man-made earth structure. Knowing how gases and water behave within unconsolidated masses is mandatory when sustainable solutions are being developed for large-scale mining operations, where huge quantities of waste rock, with no economic value, are generated.

Isotopic Analysis of water

The stable isotopes of water ^2H (or D) and ^{18}O are very useful in providing information on hydrological processes, including groundwater-surface water interactions. Water samples for isotopic analysis were collected at 75 sampling stations in the vicinity of the waste rock, including samples from rain waters, streams, rivers and lakes, as well as watersheds nearby, wells and piezometers. The isotopic composition of rainwater, notwithstanding the limited amount of samples, has allowed the preliminary definition of a local meteoric water line LWL – by computing the linear relationship between the stable isotope deficits $\delta^{18}\text{O}$ and $\delta^2\text{H}$ (Figure 2). Samples that have lower deuterium excess values correspond to the evaporation water line – EWL, $\delta\text{D}\text{‰} = 5,83 \delta^{18}\text{O}\text{‰} - 3,24$. These samples are characterized by intense evaporation such as lakes and tailing ponds. The results reflects a similarity of the isotopic identity between the groundwater and those waters that flow from the bottom of the waste rock dump. Groundwater can be assumed as the major contributor of water inside the waste rock dump, during the dry season.

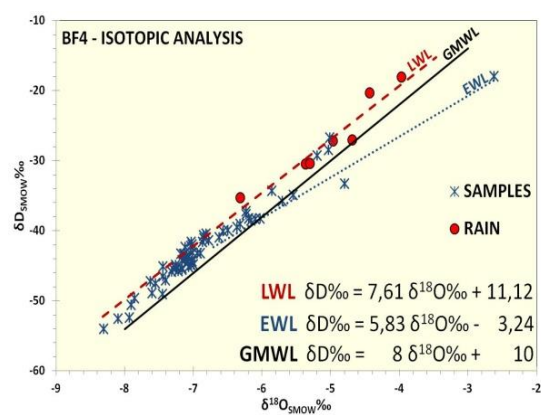


Figure 2. Plot of δD and $\delta^{18}\text{O}$ in water samples at the pile, regarding to the local water line – LWL, evaporation water line – EWL and the global meteoric water line – GMWL.

Gas analysis

Waste rock piles are a three-phase system where airflow is crucial for the dynamics of the geochemical processes (Abreu, 2013). The

References

Abreu, C. B., Influência da fase gasosa como ferramenta auxiliar no diagnóstico do potencial de geração de drenagem ácida de rocha, PhD. Thesis, UFMG, 2013;

geochemistry reaction of sulphide oxidation is favored by the contact of the material with oxygen, whereas large volumes of water are not required for their occurrence. It was carried out a geochemical characterization of a waste rock pile, based on the distribution and concentration of gases within it, from the atmosphere and other gases produced in the sulphide oxidation process. Gas samples from the uranium waste rock pile were collected at 40cm depth and temperature measurements were taken at same depth. Concentrations of O_2 , N_2 , CO_2 , H_2 and Air were measured ex-situ via mass spectrometry. Gas analysis allowed identifying regions along the pile that are most susceptible to generate acid rock drainage, as shown in the Figure 3, for the O_2 measurements. The western region of the heap, adjacent to the mine pit, preferably oxidizes and generates acid effluent while the eastern region does not. The study of the gases flow through the pile was supported by the studies of the solid and aqueous phases of the system. The methodology was proved to be efficient and economically viable for the characterization of sites generating acid mine drainage. In addition, it can support decisions on the decommissioning process of waste rock piles and rehabilitation of areas degraded by mining activities.

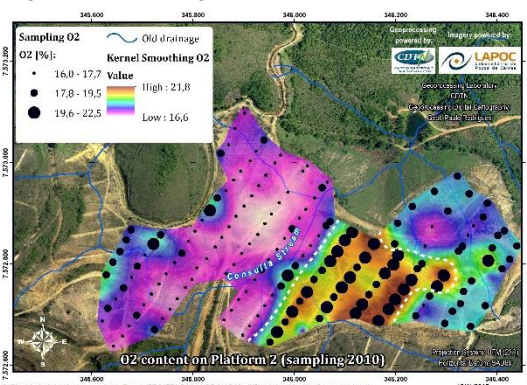


Figure 3. Oxygen concentration profile in waste rock pile; the white line delimits regions where ARD may occur.

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