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Spatial distribution of environmental risk associated to a uranium abandoned mine (Central Portugal)

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The abandoned uranium mine of Canto do Lagar is located at Arcozelo da Serra, central Portugal. The mine was exploited in an open pit and produced about 12430Kg of uranium oxide (U3O8), between 1987 and 1988.
The dominant geological unit is the porphyritic coarse-grained two-mica granite, with biotite>muscovite. The uranium deposit consists of two gaps crushing, parallel to the coarse-grained porphyritic granite, with average direction N30°E, silicified, sericitized and reddish jasperized, with a width of approximately 10 meters. These gaps are accompanied by two thin veins of white quartz, 70º-80º WNW, ferruginous and jasperized with chalcedony, red jasper and opal. These veins are about 6 meters away from each other. They contain secondary U-phosphates phases such as autunite and torbernite. Rejected materials (1000000ton) were deposited on two dumps and a lake was formed in the open pit.
To assess the environmental risk of the abandoned uranium mine of Canto do Lagar, were collected and analysed 70 samples on stream sediments, soils and mine tailings materials. The relation between samples composition were tested using the Principal Components Analysis (PCA) (multivariate analysis) and spatial distribution using Kriging Indicator.
The spatial distribution of stream sediments shows that the probability of expression for principal component 1 (explaining Y, Zr, Nb, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Hf, Th and U contents), decreases along SE-NW direction. This component is explained by the samples located inside mine influence. The probability of expression for principal component 2 (explaining Be, Na, Al, Si, P, K, Ca, Ti, Mn, Fe, Co, Ni, Cu, As, Rb, Sr, Mo, Cs, Ba, Tl and Bi contents), increases to middle stream line. This component is explained by the samples located outside mine influence.
The spatial distribution of soils, shows that the probability of expression for principal component 1 (explaining Mg, P, Ca, Ge, Sr, Y, Zr, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, W, Th and U contents) decreases along SE direction and increases along NE and SW directions. The probability of expression for principal component 2 (explaining pH, K, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr and Pb contents), decreases from central points (inside mine influence) to peripheral points (outside mine influence) and gradually increases along N and SW directions. The spatial distribution of tailing materials did not allowed a consistent spatial distribution.
In general, the stream sediments are classified as unpolluted and not polluted or moderately polluted, according to geoaccumulation M¨ller index with exception of local samples, located inside mine influence.
The soils cannot be used for public, private or residential uses according to the Canadian soil legislation. However, almost samples can be used for commercial or industrial occupation. According to the target values and intervention values for soils remediation, these soils need intervention. Tailing materials samples are much polluted in thorium (Th) and uranium (U) and they cannot be used for public, private or residential uses.