Deciphering the spatial distribution of surface uplift in a sector of the Andean chain and its implications for supergene ore deposits formation

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A morphometric approach, based on the investigation of the topography and river network features of two hydrographic basins, Utcubamba and Chiriaco, was applied to determine the relationship between the irregular distribution of vertical motions (e.g., surface uplift) and the genesis of supergene Zn deposits located in the Bongará district, in the north-eastern sector of the Peruvian Andes. In the area three mixed supergene-hypogene ore deposits have been recognized: Mina Grande, Cristal and Florida Canyon. The Florida Canyon deposit falls within the Eastern Cordillera, in the Utcubamba Basin, and represents one of the most important Zn-Pb MVT deposits hosted in the carbonate and former evaporite-bearing rocks of the Pucarà Group. The mineralization consists mainly of sulfides and only one-third of the resource is nonsulfides and is hosted in Triassic rocks. The Mina Grande and Cristal deposits fall within the western margin of the Subandean Fold-and- Thrust Belt, in the Chiriaco Basin, and consist mainly of nonsulfide ores with less sulfides hosted in more recent Jurassic rocks. The MVT sulfide mineralizations formed at the same time (70 – 80 Ma) at two different depths of 2,500 - 3,000 m b.s.l. for Florida Canyon and 1,5000 - 2,000 m b.s.l. for Mina Grande - Cristal and currently outcrop approximately at the same altitude of around 2,700 m a.s.l. Since the late Oligocene, when Andean deformation migrated eastward from the Western Cordillera to the present Sub-Andean zone, the rocks of the Pucarà Group were repeatedly uplifted and eroded allowing the exhumation of primary sulfide bodies and the formation of the supergene deposits.

The research has been carried out through the evaluation of the parameters such as elevation, local relief, swath profile, river longitudinal profiles, slope/area analysis to derive the normalized channel steepness index (ksn) and transformed river profiles (χ-long profiles). The spatial distribution of such indexes allowed to derive some consideration about the spatial distribution of vertical motions (e.g., surface uplift). Furthermore, the sharp increase in maximum, mean and minimum elevation moving from the Utcubamba Basin to the Chiriaco Basin, coupled with a jump in the mean Ksn values, suggest that the Chiriaco Basin has experienced either more recent surface uplift or surface uplift at rates higher than the Utcubamba Basin. This trend seems to be confirmed by the uneven erosion that the Florida Canyon and the Mina Grande – Cristal deposits have experienced. In fact, the Utcubamba Basin has been subjected to an uplift protracted in the time, resulting in a rugged local relief and lowering the mean and minimum elevations, which would have removed the Jurassic succession and exposed at the weathering the Triassic-hosted Florida Canyon. In the Chiriaco Basin, the higher surface uplift in terms of time and/or rate has exposed at the weathering the Jurassic-hosted Mina Grande – Cristal deposits allowing the almost complete alteration of primary sulphides.
and the development of non-sulphide mineralization.