Analysis and visualization of vanadium mineral diversity and distribution

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ABSTRACT

We employ large mineralogical data resources to investigate the diversity and spatial distribution of vanadium minerals. Data for 219 approved species (http://http://rruff.info/ima, as of April 15, 2016), representing 5437 mineral species-locality pairs (http://http://mindat.org and other sources, as of April 15, 2016), facilitate statistical evaluation and network analysis of these vanadium minerals. V minerals form a sparse, moderately centralized and transitive network, and they cluster into at least seven groups, each of which indicates distinct paragenetic process. In addition, we construct the V mineral-locality bipartite network to reveal mineral diversity at each locality. It shows that only a few V minerals occur at more than three localities, while most minerals occur at one or two localities, conforming to a Large Number of Rare Events (LNRE) distribution. We apply the LNRE model to predict that at least 307 ± 30 (1σ) vanadium minerals exist in Earth's crust today, indicating that at least 88 species have yet to be discovered—a minimum estimate because it assumes that new minerals will be found only using the same methods as in the past. Numerous additional vanadium minerals likely await discovery using micro-analytical methods. By applying LNRE models to subsets of V minerals, we speculate that most new vanadium minerals are to be discovered in sedimentary or hydrothermal non-U-V ore deposits other than igneous or metamorphic rocks/ore deposits.

Keywords: Vanadium, network analysis, statistical mineralogy, LNRE frequency distribution