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## A classification and predictive model of the complex REE mineral system

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We model the intermittent, non-linear interactions and feedback loops of the complex rare earth elements (REE) mineral system applying the self-organized criticality concept. Our semantic knowledge model (REE\_MinSys ontology) represents dynamic primary and secondary processes that occur over a wide range of spatial and temporal scales and produce the emergent REE deposits and their geometry, tonnage, and grade. These include the scale-invariant, out-of-equilibrium geodynamic and magmatic processes that lead to the formation of orthomagmatic (carbonatite, alkaline igneous rocks) and syn- and post-magmatic hydrothermal REE deposits. The ontology also represents the redistribution of the REE from these primary ores by metamorphic fluids and/or post-depositional surface and supergene processes in sedimentary basins, fluvial channels, coast areas, and/or regolith around or above them. The ontology applies concepts of the complex systems theory to represent the spatial and spatio-temporal elements of the REE mineral system such as source, driver, threshold barriers, trigger, avalanche, conduit, relaxation, critical point attractor, and self-organization for the alkaline igneous, Iron oxide (subcategory of IOCG), hydrothermal, marine placers, alluvial placers (including paleo-placers), phosphorite, laterite, and ion-adsorption clays REE deposits. The ontology is instantiated with diverse data drawn from globally-distributed types of well-studied small to giant REE deposits to build the REE\_MinSys knowledge base. Users can query the data in the knowledge base to extract explicit and inferred facts in each type of REE deposit, for example by asking: "Which rare earth elements are in REE phosphate deposits?"; "Which rare earth elements are largely explored in REE placer deposits?" Data from the knowledge base will be divided into training and testing sets after they are preprocessed and trends and data patterns are identified through data analytical procedures. The training and test datasets will be used to build models applying machine learning algorithms to predict potential REE deposits of different kinds in unexposed or covered areas.