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Predicting global porphyry copper prospectivity using positive-unlabelled machine learning

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The majority of the world's known copper reserves is contained in porphyry copper deposits. These deposits are understood to form along subduction zones within the magmatic arc, though the exact contributions to this process of different factors within the subducting and overriding plates are not entirely certain, hampering efforts to develop large-scale prospectivity models for this deposit type. Previous efforts to tackle this problem through the use of data-driven machine learning methods have shown promise, but have been hindered by the relative paucity of fully labelled data required for training classification models. Here we present a suite of models trained using a semi-supervised positive-unlabelled (PU) algorithm, allowing the classifier to be created from data of which only a small subset of one class is labelled: in this context, known porphyry copper deposit locations. These models can be used to create time-dependent prospectivity maps representing the probability of a deposit forming at a given place and time, while model inspection can provide deeper insight into the processes behind the genesis of these deposits, at both a global and regional scale. Furthermore, deep-time erosion rate estimates extracted from global landscape evolution models are used to explore the uplift and erosion histories of known porphyry copper deposits in order to better understand the potential for these deposits to survive to the present day. These two factors of deposit formation and preservation are combined into a powerful prospectivity model, with the potential to facilitate the identification of possible new prospective zones along the world's subduction zones through time and help minimise the environmental and financial costs of mineral exploration.