Mineral Systems in a Plate Tectonic Context

R. Dietmar Müller[1]
[1]The University Of Sydney, Sydney, Australia

Understanding how different ore deposits depend on plate tectonic processes is critical for better understanding a range of mineral systems. The recent development of global plate models with continuously evolving plate boundaries now allows us to implement spatio-temporal “deep time” mineral exploration, leading to the generation of new ideas and improved predictive exploration models. These models include continental paleo-crustal thickness estimates, oceanic crustal age-area distribution, seafloor spreading rates, sediment thickness, and water and carbon contents of oceanic sediments, altered ocean crust and mantle lithosphere. Custom-tailored python software libraries including pyGPlates and GPlately are used to visualise and analyse mineral deposits and other geological data in the context of reconstructed continents, ocean basins and plate boundary evolution. Machine learning is applied to train mineral prospectivity models to learn how particular types of deposits depend on plate tectonic evolution and tectonic plate properties, particularly those of subducting slabs that partially devolatilise while descending in the mantle, fertilising the upper mantle. For Cretaceous to Cenozoic copper porphyry deposits, our analysis shows that the top five important features for deposit formation are Cordilleran crustal thickness, the total carbon density of the subducting slab, the seafloor spreading rate, and the distance to the trench edge. However, we also find distinct regional differences. Where passive margins have experienced subduction initiation and a conversion to active margins, ocean crust with unusually thick sediments is subducted, making this the most important feature. Where subducting ocean crust is relatively sediment starved, as along North America, other parameters like crustal thickness, convergence rate and seafloor age are more important. Our models also reveal a clear influence of subduction proximity and processes on a range of sediment-hosted craton-edge deposits since the Paleo-Proterozoic. These new approaches are powered by AuScope NCRIS open-source software and open-access data infrastructures such as EarthBank.