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Data-driven Investigation Reveals Land Exposure Since the Early Archean, using refined data from GEOROC and EarthChem

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The subaerial exposure of the modern continental crust through time remains intensely debated, with estimates of the first exposure ranging from the late Archean to the Neoproterozoic. To constrain when and how much of the continental crust was exposed subaerially during Earth's history, we trained a supervised machine learning model on the compositions of modern subaerial and submerged basalts. The parental training dataset comprises geochemical data from ~10,000 basaltic rocks (43–55 wt.% SiO2, ≤17 wt.% MgO; most younger than 65 Ma) erupted subaerially or subaqueously in various tectonic settings from GEOROC. Then, we applied this well-trained model to a refined worldwide dataset of basaltic compositions (23, 000 basaltic rocks from the EarthChem repository) and calculated the mean proportions of basalts erupted subaerially. The application dataset used herein originally contained missing categories and non-negligible errors, including incorrect age information and misplaced chemical compositions inconsistent with the original publications. Here, our refined age data and associated 2σ errors differ from those in the unrefined dataset, which includes an erroneous age peak at ~3.2 Ga as well as errors reaching ~0.68 Ga compared to maximum errors of ~0.24 Ga in the refined dataset. This is because many samples from the raw dataset were assigned average ages of 3.175 Ga with 2σ errors of 0.675 Ga. About 83% of the refined data have age errors ≤50 Myr, much better than merely ~45% in the raw dataset. The machine learning results suggest that ~20% of the proto-continents were exposed subaerially in the early Archean, which may have driven the synthesis of biopolymers crucial to the origins and evolution of life. The proportion of exposed continental crust increased markedly during two stages between the late Archean and the Paleoproterozoic before reaching present-day levels of exposure no earlier than ~1.8 Ga.