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A Test of the Hypothesis That Syn-Collisional Felsic Magmatism Contributes to Continental Crustal Growth Via Deep Learning Modeling and Principal Component Analysis of Big Geochemical Datasets

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The continental crust archives the evolution of the Earth. There is therefore considerable interest over the topic of crustal generation and destruction linked to plate tectonics. Because of the compositional similarity of the bulk continental crust with magmas formed in subduction-related settings, subduction zones are accordingly regarded as the major sites of crustal formation. This describes the widely-accepted island-arc model. However, not only is there subtle compositional difference between the average continental crust and subduction-related magmas, there is no net crustal growth at active subduction zones due to equal or even greater amounts of crustal loss. In this situation, geoscientists proposed the collision-zone model, in which collisional magmas of mantle input that resemble the bulk continental crust in composition and have high preservation potential are interpreted to contribute to new crust generation and hence crustal growth. To test this hypothesis, we applied deep learning (DL) algorithm and principal component analysis (PCA) to big geochemical datasets by examining the existence, distribution, geochemical signatures, and sources of the collisional magmas. DL successfully built a regression model of whole-rock element compositional data and mean zircon $\varepsilon_{Hf}(t)$ data of igneous rocks. This can not only assign values to the missing Hf data, but statistically unveil the potential relations between the compositions (both isotopic and geochemical) and the possible sources of the igneous rocks. The DL and PCA enabled to recognize the mantle-derived, bulk continental crust-like granitoids (MBGs) and define their geochemical and isotopic fingerprints differing noticeably from arc magmas (e.g., Kohistan arc type and Tibetan adakite-like type). Our results show that the MBGs are common in collisional settings as a response to collision, similar with the average continental crust in composition, and possibly sourced from subducted ocean crust, and hence contribute to crustal growth. Our results therefore generally support evident contribution of syn-collisional felsic magmatism to net continental crust growth. However, further refinement of the petrogenesis and estimation of the (relative) volume are critically needed. This will help to strengthen our understanding of crustal evolution.