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Calibrating the Tonian Stratigraphic Record

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Recent improvements in U-Pb zircon and Re-Os radiometric dating and systematic application of these techniques to the Neoproterozoic stratigraphic record have greatly increased the number of ages for this notoriously poorly age-calibrated interval in Earth's history. An outcome of this proliferation of dates has been the validation of the globally synchronous onset and demise of the long-lived early Cryogenian (i.e. Sturtian) glaciation (ca. 7.17–660 Ma). The end of the second Cryogenian (i.e. Marinoan) glaciation is also well dated at ca. 635.5 Ma, providing a robust age for the base of the Ediacaran Period. However, while some sedimentary successions are blessed with multiple ages, others lack direct ages altogether. The sparse biostratigraphy and difficulty in correlating between basins presents challenges to applying the new ages globally. This problem is particularly acute for the Tonian period (1000–720 Ma), for which chemostratigraphy is the only currently viable method for making global correlations. Here we propose a method for establishing a preliminary Tonian time scale that relies on the generation of a reference section onto which available radiometric ages can be mapped via chemostratigraphic correlation. The Akademikerbreen and lower Polarisbreen groups in northeastern Svalbard are used as the reference section due to their excellent preservation, limited unconformities, well established carbon and strontium isotope profiles, and key microfossil occurrences. Furthermore, ages and stratigraphic data indicate that the Akadimkerbreen and Polarisbreen groups were deposited in a thermally subsiding basin, which allows for the generation of a geologically realistic age-depth model rather than using simple linear interpolation between ages. We expand upon this age model for the Tonian period by applying a Monte Carlo simulation to generate confidence intervals on the derived ages. The model can then be used to provide age estimates for key Tonian events, such as the onset and end of the Bitter Springs carbon isotope anomaly and the first appearance of key middle Neoproterozoic fossils. This model can easily be tested and incrementally improved with the acquisition of new radiometric ages.