Progress towards the further subdivision of Neoproterozoic time

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Subdivision of Precambrian time based on globally recognisable geological events began with the banging in of the basal Ediacaran golden spike in South Australia earlier this year. The Nuccaleena Formation, hosting the golden spike, is a thin (<5 metre) dolostone unit that drapes glaciogenic deposits of the Elatina Formation laid down during the Marinoan phase of Neoproterozoic glaciation. It is the only GSSP that does not rely on biostratigraphy for its placement, and could act as a benchmark for future Precambrian subdivision. The choice of this level presumes that Nuccaleena-type "cap carbonates" can be correlated globally using their characteristic lithology and isotope stratigraphy.

Although reports exist of carbonate units above Neoproterozoic diamictites at other levels, the central tenet of one unique "cap carbonate" event is consistent with existing biostratigraphic, geochronological and isotopic information. Firm age constraints based on U-Pb zircon dating of tuffs have been reported from Namibia and China, and indicate that the Ediacaran Period began around 632 Ma, which is consistent with more ambiguous age constraints from other locations, including Australia, Oman and Burkina Faso.

These new age constraints have immediate implications for the further subdivision of the Ediacaran Period and definition of the immediately underlying "Cryogenian". Most importantly, glaciogenic strata that lack typical cap carbonate facies were clearly deposited both before and after this circa 635 Ma Marinoan event at 730 Ma (Sturtian) and 580 Ma (Gaskiers). It is not known whether these others were single events or of the areal extent and magnitude of the "Snowball Earth" Marinoan glacial episode but they will likely form important marker horizons for global stratigraphic correlation.

Acritarch biostratigraphy holds great promise for subdividing the Ediacaran period (cf. K. Grey's abstract). A characteristic, large spiny acritarch assemblage first appears in South China just above the basal Ediacaran cap dolostone there, while similar microfloral assemblages are known from post-630 Ma, but pre-550 Ma strata elsewhere in the world. Ediacaran-type soft-bodied fossils may also be of use as these, e.g. Charniodiscus, are known only from post-580 Ma strata in Newfoundland, Namibia, China and Australia, making that approximate level a favourite for subdividing the quite long (90 My) Ediacaran period. However, Precambrian biostratigraphy is still in its infancy. Given the ambitious time-frame set by the ICS, imminent subdivision of the Neoproterozoic cannot realistically be based on biostratigraphy.

Defining the base of the "Cryogenian" Period represents a thorny problem. Absolute age constraints on the oldest of the Neoproterozoic ice ages are relatively poor, while the correlation of mid-Neoproterozoic glacial deposits is uncertain at best. Biostratigraphic information from Sturtian - Marinoan strata is rare and often stratigraphically ambiguous, so isotope stratigraphy will likely play a decisive role. 730 Ma - 640 Ma carbonates in Australia, Canada and Namibia exhibit unusually elevated $\delta^{13}C$ values, up to >10‰. Such high $\delta^{13}C$ values are central to existing correlation schemes, and with $^{87}Sr/^{86}Sr$ isotopes, are used to identify Cryogenian-equivalent strata in Mongolia, Scotland, Greenland, Svalbard, China, Brazil and USA.

The "Tonian" "period", the first named interval of the Neoproterozoic, seems to lack any evidence for glaciation. This long (>250 Ma) chunk of Precambrian time is remarkable for its large drowned cratons covered in stromatolites, abundant molar-tooth structure and a characteristic assemblage of large organic-walled fossils, such as Chuaria and Tawuia. This interval appears to be typified by moderately, but not

uniquely positive 13C values, while 87Sr/86Sr values remained below 0.7065 with minimal variation. Despite the potential of acritarchs such as Trachyhystrichosphaera for biostratigraphy, there does not yet seem to be sufficient distinction between Neoproterozoic and Mesoproterozoic strata to allow for any biostratigraphic base to the Neoproterozoic.

One important aspect for the future will undoubtedly involve the study of Neoproterozoic glacial deposits worldwide. If the widely presumed hypothesis that these deposits are globally synchronous turns out to be correct, then this knowledge, along with improved geochronological constraints, will be crucial in establishing correlatable horizons that integrate sequence-, isotope, litho-, magneto- and bio-stratigraphy. This is a major goal of a recently established IGCP 512 project “Neoproterozoic Ice Ages”, and of the Ediacaran Subcommission.