Issues with the Precambrian time scale: Western Australia geology and GSSPs

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To GSSP, or not to GSSP[1]? That is the question regarding division of the Precambrian timescale. Can it be done? Some would argue that without a reliable biostratigraphic record, Phanerozoic timescale concepts cannot be applied to the Precambrian. Are there sufficient, datable Precambrian GSSPs that truly reflect global events? What are the global events? Are they truly global? If GSSPs are impractical, what combination of GEONS, chrono-stratigraphy, orogenic cyclicity, or a combination of all of the above, and possibly more, will need to be applied?

One of the best areas in the world to test the GSSP concept for Precambrian time is Western Australia, where a nearly continuous stratigraphic record is preserved from 3515- 490 Ma. In the Pilbara Craton, the East Pilbara Granite-Greenstone Terrane consists of four unconformity-bound groups (Pilbara Supergroup: PS) deposited from 3515-3426, 3350-3310 Ma, 3270-3235 Ma, and 3235-3000 Ma, the last being undated. Are these depositional (and hiatal) periods reflected on other cratons and what exactly do they represent? Controversy exists, but it has been proposed that the craton records a change in tectonic style from vertical, plume-dominated tectonics to horizontal subduction-accretion tectonics at ca. 3200 Ma [1, 2] and could be used to define the early Archaean-mid Archaean boundary. But does this represent a global change in tectonic style? More importantly, this change is not reflected in a single stratigraphic section, but preserved in disparate tectonic elements separated by major tectonic boundaries.

Following late tectonic clastic sedimentation (2970-2930 Ma De Grey Supergroup) and emplacement of 2890-2830 Ma "post-tectonic" granites, the Pilbara Craton was unconformably overlain by the 2775-2445 Ma Mount Bruce Supergroup of the Hamersley Basin [3]. This comprises three groups: three unconformity-bounded flood basalt units and interbedded sedimentary rocks of the 2775-2630 Ma Fortescue Group; banded iron-formation, shale, dolomite and volcanic rocks of the 2630-2445 Ma Hamersley Group; and undated, unconformably overlying clastic rocks of the <2445 Ma, >2200 Ma Turee Creek Group. The Fortescue and Hamersley Groups record continuous deposition over 330 million years and span the transition to an oxygenated atmosphere.

One could argue that the unconformable base of the Fortescue Group can be used as a GSSP for the start of the Late Archaean, as the 2775 Ma age reflects the beginning of magmatic events on most cratons. However, unconformities are inconsistent with GSSP practice. The onset of BIF deposition in the Hamersley Group, at ca. 2600 Ma (Marra Mamba Iron Formation), is too old, however, to represent the end of the Archaean, as several cratons record events to ca. 2500 Ma. However, a younger period of BIF deposition, from ca. 2500-2450 Ma (Brockman Iron Formation), might be used to this end, as much of this succession is well exposed in outcrop or accessible in drill core.

[1]Global boundary Stratotype Section and Point, also known informally as "golden spikes".

A series of Proterozoic basins unconformably overlie the Pilbara and Yilgarn Craton including the c. 2200 Ma Yerrida Basin, the c. 1900 Bryah-Padbury Basins, the 1840 Ma Earaheedy Basin, the 1650-1070 Ma Bangemall Basin, and the 840-490 Ma Officer Basin. Imprecise dating leaves it unclear as to whether these basins contain continuous sections through major global events, or, if so, where GSSPs may be placed. Although new techniques [4] may help refine the ages of depositional events, it probably will not aid the current project. My personal view is that the GSSP concept will not work for the Precambrian and that a division based on geochronology of global tectonic events, in combination with lithostratigraphy, will be most appropriate.

References:

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[2] Smithies et al., 2005. Earth & Planetary Science Letters 231, 221-237.
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[4] McNaughton et al., 1999. Science 285, 78-80.