Seismic Shift in Regional Neoproterozoic Correlation, Amadeus Basin, Central Australia

by

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Neoproterozoic outcrop occurs primarily in the northeast corner of the basin and along the northern margin. Detailed work, especially by the NTGS, has produced a detailed understanding of that stratigraphy.
Over the remainder of the basin the Neoproterozoic either lies beneath surficial deposits or outcrops only patchily, with stratigraphic relationships difficult to establish.

Two all-encompassing terms were introduced for these patchy Neoproterozoic outcrops (the ININDIA BEDS and WINNALL BEDS), but historically their application has been somewhat inconsistent.
The ININDIA and WINNALL BEDS
(from outcrop studies)

### Northern Territory Amadeus Basin

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### Western Australia Amadeus Basin

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A SEISMIC SHIFT IN DEFINING THE NEOPROTEROZOIC

Also in 2013, Santos acquired ~1300 km of semi-regional seismic data across the eastern Amadeus Basin, tying several wells and isolated seismic grids.

Do these data assist in extending the Neoproterozoic stratigraphy across the basin?

Let’s look at a couple of the lines that cross the basin, namely *amsan13b-04* and *-08*.
Structure within the Neoproterozoic is dominated by multiple phases of salt tectonics within the Gillen.

Bland seismic zones within the Neoproterozoic are diapirs of Gillen Salt.

The Neoproterozoic section thickens towards the south while the Palaeozoic thickens towards the north.

Basement appears as a broad arch, dipping towards both the north and south (but this is not the Central Ridge).

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Blue horizon = Petermann Ranges (Base Palaeozoic) Unconformity.

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Structure within the Neoproterozoic is dominated by multiple phases of salt tectonics within the Gillen.
Also, there appears to be a severely faulted pre-Neoproterozoic section at the southern end of the line.

Neoproterozoic section displays extreme salt tectonics of the Gillen.

Between the salt diapirs the seismic appears to show units displaying distinctive character that, when tied to wells, can be related to specific stratigraphic intervals.

Also, there appears to be a severely faulted pre-Neoproterozoic section at the southern end of the line.
Evident here are: a faulted basement (possibly related to faulting in the pre-Neoproterozoic section); complex salt tectonics; a significantly folded cover; and a significant angular unconformity. Note that the seismic character of the individual intervals is uniform laterally for significant distances.

Wells drill the highs, thereby missing significant portions of the stratigraphy and suggesting that those portions were perhaps not deposited. However, the seismic reveals numerous mini-basins that contain more complete sections, suggesting that deposition of the entire succession occurred across the basin.
The various stratigraphic units display distinctive, and laterally consistent, seismic signatures. Mini-basin adjacent to Erldunda-1 preserves the complete Neoproterozoic succession. A disconformity separates the Gillen Formation from the Loves Creek Formation. Other disconformities within the Neoproterozoic are evident on other seismic lines. Also, the Julie Dolostone often displays a topography upon the Petermann Ranges Unconformity.
Note the seismic character of the various units is similar to the previous line.
BASE OLYMPIC/PIONEER DISCONFORMITY

The Pioneer Sandstone cuts progressively deeper into the stratigraphy as a low angle disconformity towards the northeast, eventually scouring into the Bitter Springs Group, suggesting the Olympic/Pioneer ice-sheet was located to the northeast of the basin.
Let’s briefly return to the stratigraphy and the terms “Inindia Beds” and “Winnall Beds”.

These terms were retained until AGES2017 when the NTGS recognised that the outcrops of “Inindia Beds” were being identified as facies of the Areyonga, Aralka, Pioneer and Pertatataka formations (such as at Mount Connor) - and they recommended dropping the name.

With that in mind, and in light of the seismic, let’s extend that conclusion with a fresh look at two wells in the west-central portion of the basin - namely BR05DD01 and Wallara-1.
WELL CORRELATIONS

The stratigraphic description in both Wallara-1 (drilled 1990) and Stratigraphic Core Hole BR05DD01 (drilled 2005) attempted to avoid the “Beds” terminology - but resulted in conflicting stratigraphies.

In BR05DD01, lenses of sand occur amid the originally defined Pertatataka Formation that separate grey/black shales from red/brown shales.

In Wallara-1, lenses of fine sand separate dark grey shales from green/grey shales.

Note the dark grey shale unit beneath the sands is ~half the thickness of that in BR05DD01 ~180km to the west.
WELL CORRELATIONS

Such a dark grey shale / sandstone / brown shale succession is typical of the Aralka / Pioneer / Pertatataka succession.

Conclusion: to revisit the formal stratigraphies of these two wells.

The down-cutting of the Base Pioneer towards the east suggests it to be a disconformity - as was evident on the seismic.

It also nullifies the postulate of a diachronous Areyonga glaciation from a Re-Os age obtained from the “Aralka” shale in Wallara-1.
OUTCROP CORRELATIONS

These same Areyonga, Aralka, Olympic/Pioneer, Pertataka units have also been identified from detailed outcrop studies in the Board Ridges of Western Australia, ~200 km further west.

So it has been rightly deemed that the term “Inindia Beds” is no longer required in the stratigraphic table … … and it seems from the adjacent outcrop column that the term “Boord Formation” may soon follow suit.

To conclude, with further detailed field work, greater seismic coverage, more wells, and incorporating new detrital chronologic and chemostratigraphic analyses currently underway (University of Adelaide), these all-encompassing stratigraphic terms are becoming redundant.

(From Haines & Allen 2014)
SOME INTERESTING SEISMIC:
Shelving Margin

Previous seismic shows the southern margin of the basin to be a significant fault boundary. The northern margin is the same.

Seismic shows the eastern margin to be a depositional edge, with the Neoproterozoic wedging-out eastward upon a gently shallowing shelf.

And upon that shelf the seismic shows some interesting features: such as a scour at Base Areyonga level.
The base of the glacial Areyonga scours down into the Bitter Springs Group.  
Trace of scour parallels the eastern margin of the basin.
GZW (Grounding Zone Wedge) form during halts in ice-sheet movement where sediment continues to be delivered from sub-glacial streams.

Typically GZW are ~5-20 km wide, a few tens of kms long and 50-200m thick.
SOME INTERESTING SEISMIC: Glacial Mound & Valley

Approximate trace of Mound and Tunnel Valley

Fluvio-glacial deposits within sub-glacial ice tunnel

3D seismic image of Tunnel Valley, offshore Denmark
SOME INTERESTING SEISMIC:
Grounded Zone Wedge

NNW

Chandler Salt
Base Palaeozoic
Base Areyonga

Lower Gillen
Glacial Mound

SOME INTERESTING SEISMIC:
Grounded Zone Wedge

Advancing
Retreating

Kilometre-wide arcuate hummocky terrain belt
Previous interpretations have limited the Areyonga ice-sheet to the north and northeast of the basin, but clearly a mobile, and northwesterly advancing, ice-sheet was located to the southeast of the basin.
Conclusions

- Some early interpretations of the extent of deposition of several Neoproterozoic stratigraphic units were strongly influenced by the pattern of outcrop, limiting their occurrence to the northeast and northern margin of the basin.

- A broad grid of semi-regional seismic data acquired over the eastern Amadeus Basin, however, reveals numerous salt-induced mini-basins within which the entire Neoproterozoic succession has been preserved, indicating deposition occurred across the entire basin.

- When tied to wells, specific rock intervals correlate to consistent seismic signatures, and sequence of signatures, that can be traced regionally.

- It is suggested that the stratigraphy between and including the Areyonga and Pertatakaka formations in the Wallara-1 well and BR05DD01 stratigraphic hole should be revisited.

- The seismic also reveals a number of unique features that provide new insight to various Neoproterozoic events, such as the location of the Areyonga ice-sheet.
Santos Ltd is thanked for providing access to, and publication of, the seismic data, for assisting with the drafting of figures for the extended abstract, and for sponsoring my attendance at the seminar.