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Geophysical anomalies and quartz deformation of the Warburton West structure, central Australia

A.Y. Glikson [a,*], A.J. Meixner [e], B. Radke [c], I.T. Uysal [b], E. Saygin [d], J. Vickers [f], T.P. Mernagh [e]

[a] Planetary Science Institute, Australian National University, Canberra, Australia
[b] Queensland Geothermal Energy Centre of Excellence, University of Queensland, Australia
[c] Eungella, Braidwood New South Wales, Australia
[d] Research School of Earth Science, Australian National University, Australia
[e] Geoscience Australia, Canberra, Australia
[f] Research School of Earth Science, Canberra, Australia

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ABSTRACT

This paper reports geophysical anomalies and intra-crystalline quartz lamellae in drill cores from the Warburton West Basin overlapping the border of South Australia and the Northern Territory. The pre-Upper Carboniferous ~450 × 300 km-large Warburton Basin, north-eastern South Australia, is marked by distinct eastern and western magnetic, gravity and low-velocity seismic tomography anomalies. Quartz grains from arenite core samples contain intra-crystalline lamellae in carbonate–quartz veins and in clastic grains, similar to those reported earlier from arenites, volcanic rocks and granites from the Warburton East Basin. Universal Stage measurements of quartz lamellae in both sub-basins define Miller–Bravais indices of {10–12} and {10–13}. In-situ quartz lamellae occur only in pre-Late Carboniferous rocks whereas lamellae-bearing clastic quartz grains occur in both pre-Late Carboniferous and post-Late Carboniferous rocks — the latter likely redeposited from the pre-Late Carboniferous basement. Quartz lamellae in clastic quartz grains are mostly curved and bent either due to tectonic deformation or to re-deformation of impact-generated planar features during crustal rebound or/and post-impact tectonic deformation. Seismic tomography low-velocity anomalies in both Warburton West Basin and Warburton East Basin suggest fracturing of the crust to depths of more than 20 km. Geophysical modelling of the Cooper Basin, which overlies the eastern Warburton East Basin, suggests existence of a body of high-density (~2.9–3.0 gr/cm^3) and high magnetic susceptibility (SI ~ 0.012–0.037) at a depth of ~6–10 km at the centre of the anomalies. In the Warburton West Basin a large magnetic body of SI = 0.030 is modelled below ~10 km, with a large positive gravity anomaly offset to the north of the magnetic anomaly. In both the Warburton East and Warburton West the deep crustal fracturing suggested by the low velocity seismic tomography complicates interpretations of the gravity data. Universal Stage measurements of quartz lamellae suggest presence of both planar deformation features of shock metamorphic derivation and deformed planar lamella. The latter may be attributed either to re-deformation of impact-generated lamella, impact rebound deformation or/and post impact tectonic deformation. The magnetic anomalies in the Warburton East and West sub-basins are interpreted in terms of (1) presence of deep seated central mafic bodies; (2) deep crustal fracturing and (3) removal of Devonian and Carboniferous strata associated with rebound of a central uplift consequent on large asteroid impact. Further tests of the Warburton structures require deep crustal seismic transects.

1. Introduction

The discovery of large impact structures, including Vredefort (South Africa; 298 km; 2023 ± 4 Ma) (Dietz, 1961; Kamo et al., 1996; Therriault et al., 1997), Sudbury (Ontario; 250 km; 1850 ± 3 Ma) (Dietz, 1964), Chicxulub (Mexico; 170 km; 64.98 ± 0.05 Ma; Hildebrand et al., 1991), Manicouagan (Quebec; 214 ± 1 Ma; 85 km; Dressler, 1990), Woodleigh (Western Australia; 120 km; 360 Ma; Glikson et al., 2005; Mory et al., 2000; Uysal et al., 2005), Popigai (Siberia; 90 km, 35.7 ± 0.2 Ma; Masaitis, 1998); Chesapeake Bay (offshore Virginia; 85 km; 35.5 ± 0.3 Ma; Poag et al., 2004), and Morokweng (South Africa; 70 km; 145.0 ± 0.8 Ma; Hart et al., 2002) (for further details refer to the Earth Impact Database, 2001; Glikson, 2013) underpins the significance of large asteroid impacts in the history of Earth. The development of geophysical exploration and drilling techniques uncovered a number of large buried impact structures identified by circular gravity and magnetic and seismic tomography anomalies and confirmed by shock metamorphic features. In Australia such discoveries include

* Corresponding author at: Planetary Science Institute, Australian National University, Canberra, A.C.T., Australia. Postal address: P.O. Box 3698, Weston, A.C.T. 2611, Australia.
E-mail address: Andrew.glikson@anu.edu.au (A.Y. Glikson).

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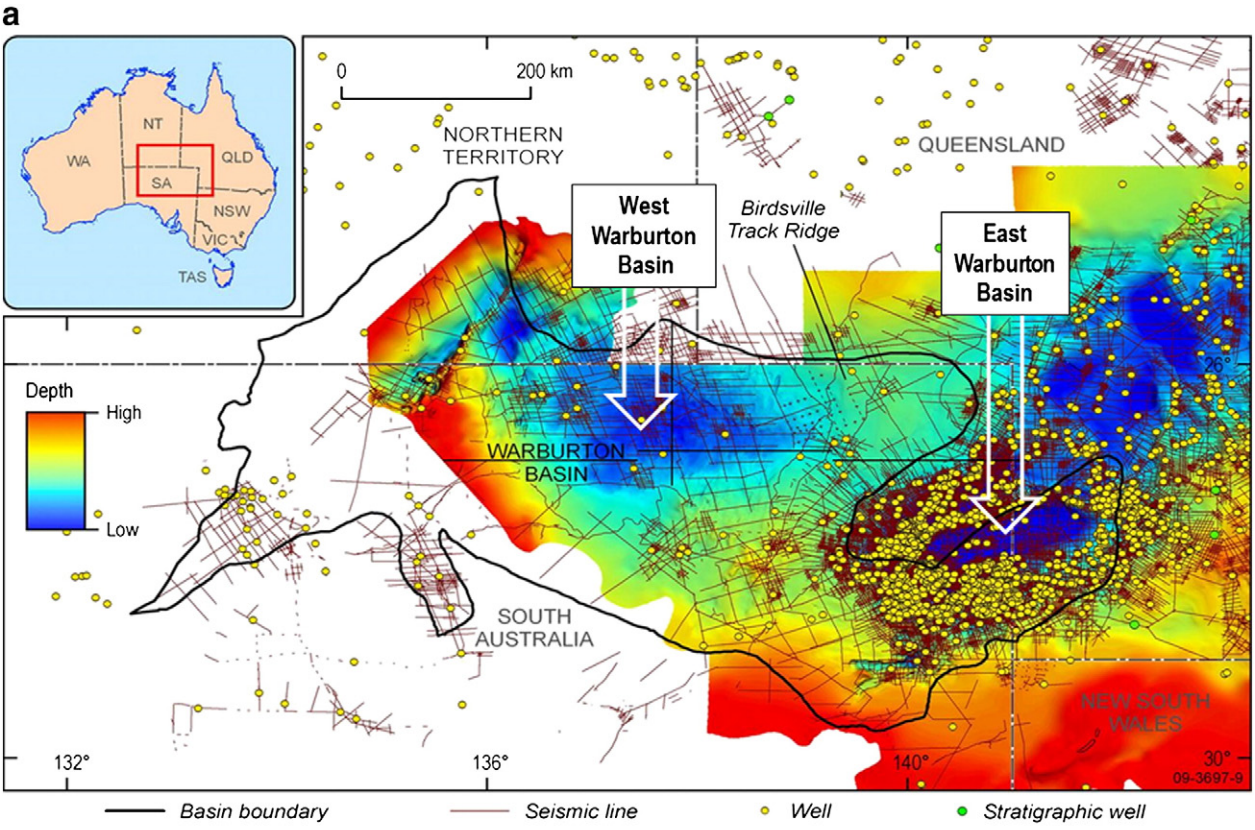
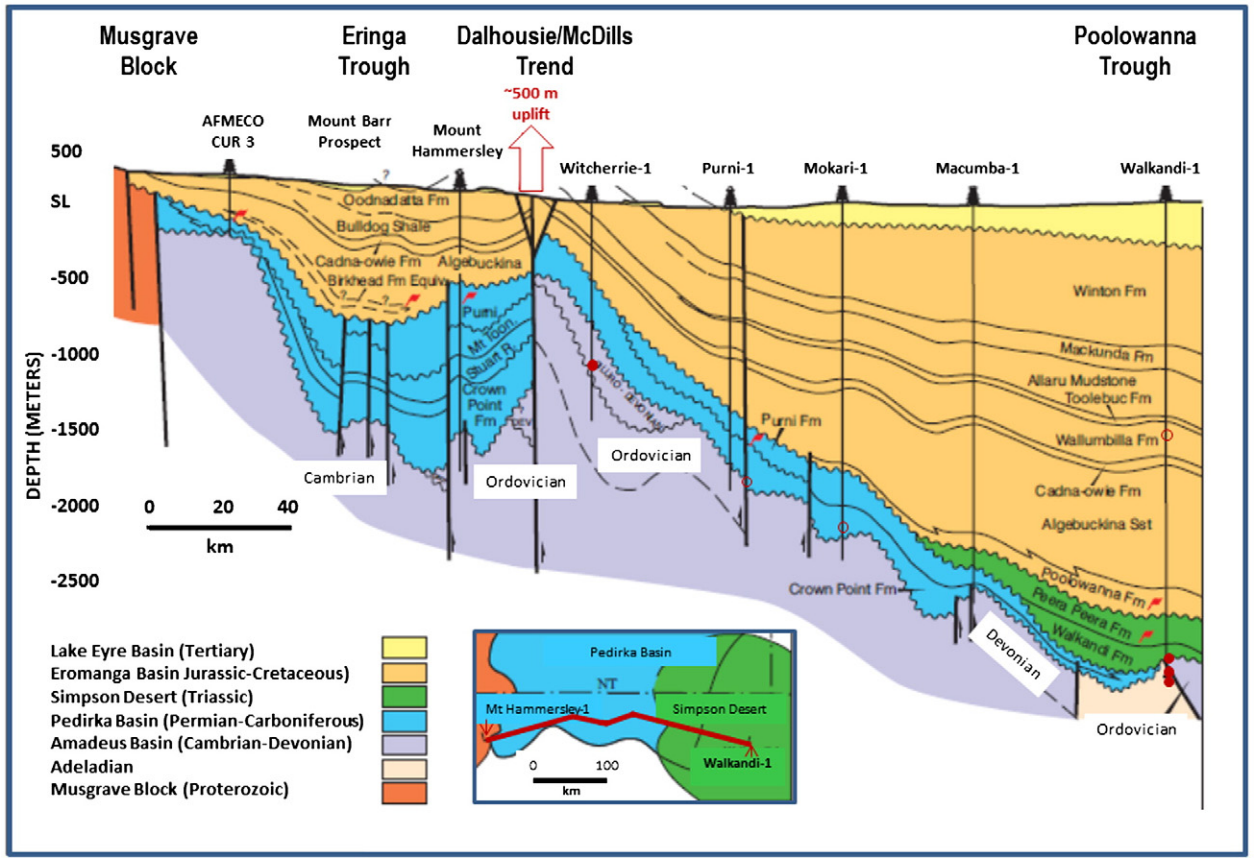

a
NT
WA
SA
QLD
NSW
VIC
TAS
0
200 km
NORTHERN TERRITORY
QUEENSLAND
West Warburton Basin
Birdsville Track Ridge
East Warburton Basin
Depth
High
Low
WARBURTON BASIN
SOUTH AUSTRALIA
NEW SOUTH WALES
26°
30°
132°
136°
140°
09-3697-9
Basin boundary
Seismic line
Well
Stratigraphic well


b
Musgrave Block
Eringa Trough
Dalhousie/McDills Trend
Poolowanna Trough
~500 m uplift
AFMECO CUR 3
Mount Barr Prospect
Mount Hammersley
Witcherrie-1
Purni-1
Mokari-1
Macumba-1
Walkandi-1
500
SL
-500
-1000
-1500
-2000
-2500
DEPTH (METERS)
0 20 40
km
Oodnadatta Fm
Bulldog Shale
Cadna-owie Fm
Birkhead Fm Equiv
Algebuckina
Purni
Mt Toondi
Stuart R
Crown Point Fm
Cambrian
Ordovician
Ordovician
Winton Fm
Mackunda Fm
Allaru Mudstone
Toolebuc Fm
Wallumbilla Fm
Cadna-owie Fm
Algebuckina Sst
Purni Fm
Crown Point Fm
Poolowanna Fm
Peera Peera Fm
Walkandi Fm
Devonian
Ordovician
Lake Eyre Basin (Tertiary)
Eromanga Basin Jurassic-Cretaceous)
Simpson Desert (Triassic)
Pedirka Basin (Permian-Carboniferous)
Amadeus Basin (Cambrian-Devonian)
Adeladian
Musgrave Block (Proterozoic)
Pedirka Basin
NT
Mt Hammersley-1
Simpson Desert
Walkandi-1
0 100
km