AEGC2019
Data to Discovery
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Incorporating the AIG, ASEG, PESA, and WABS

Geophysical expression of the Meyers Crater, a new meteorite impact crater discovered in the Coolgardie Goldfield of Western Australia

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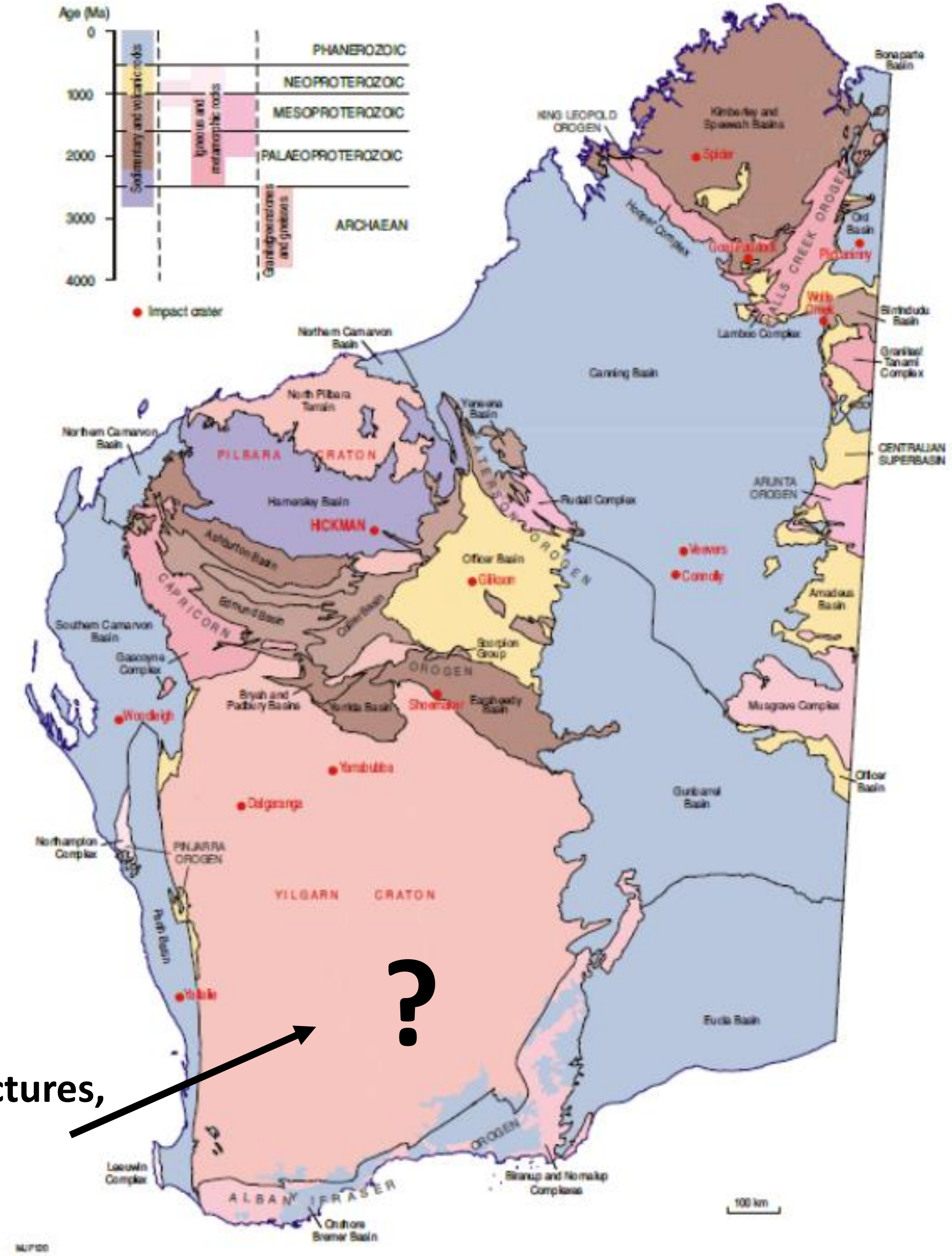
Resource Potentials

Originally submitted for "Geotourism"



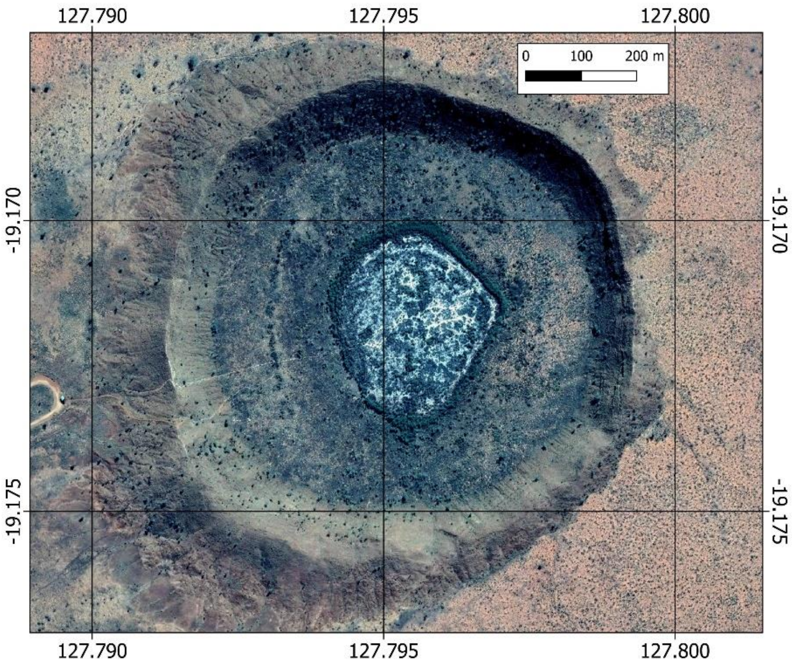
In a goldfield, so Mineral Case Study – check ✔

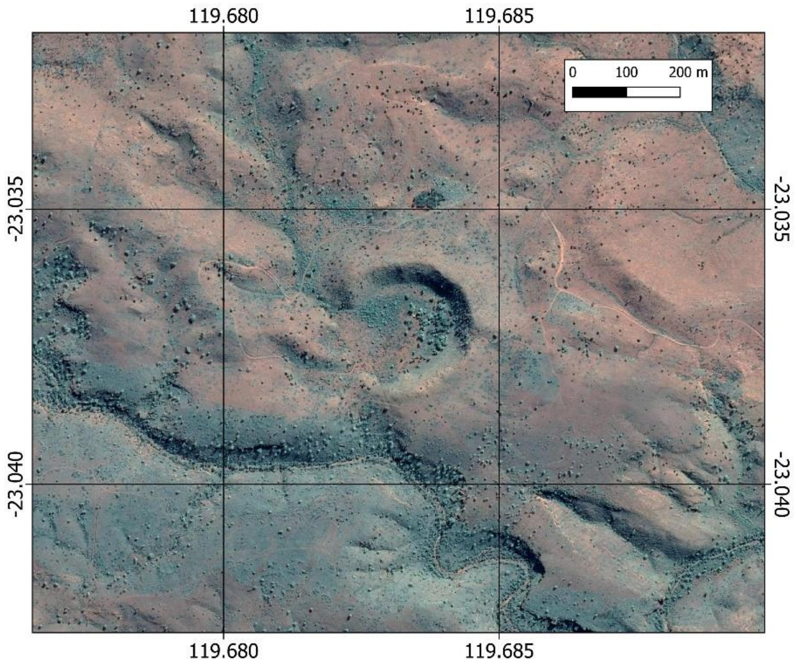
Geophysics-Cross-Disciplinary – yes, for sure!

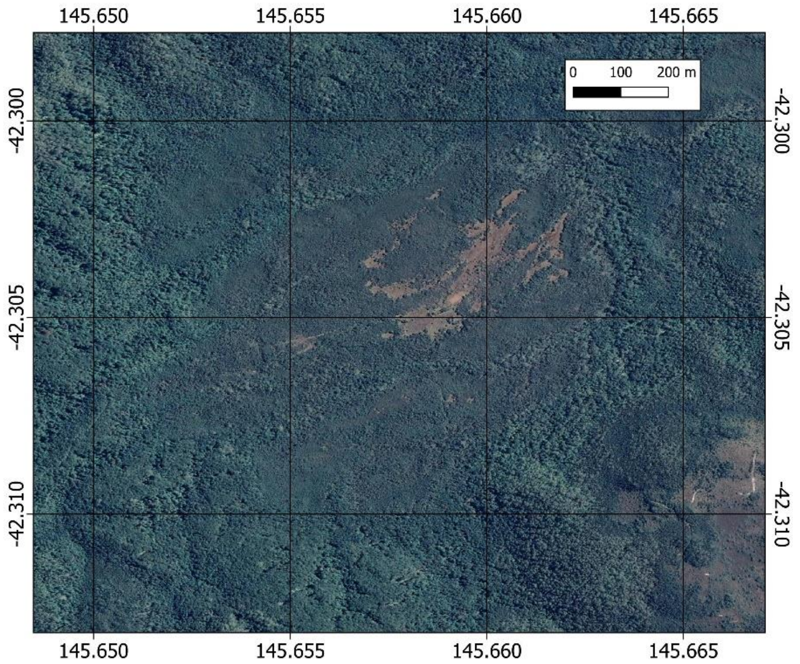
Large area in GSWA map with no impact craters or structures, geophysics plays a key role in discovery

Pleistocene “simple” impact craters in Australia

Obvious ⟷ Subtle







Wolfe Creek, WA
Diameter: 880m
Depth: 150m
Asteroid: 20-50m and 50kt
Age: <300Ka
Discovery: 1947 Vacuum Oil Co
Method: fly over
Gravity anomaly: -3mGal
Impact: 5.7GPa

Hickman, WA
Hickman: 260m
Depth: 65m
Asteroid: 10-15m and ?kt
Age: 10-100Ka, 50Ka?
Discovery: 2007 Arthur Hickman
Method: Google Earth
Gravity anomaly: ?
Impact: ?

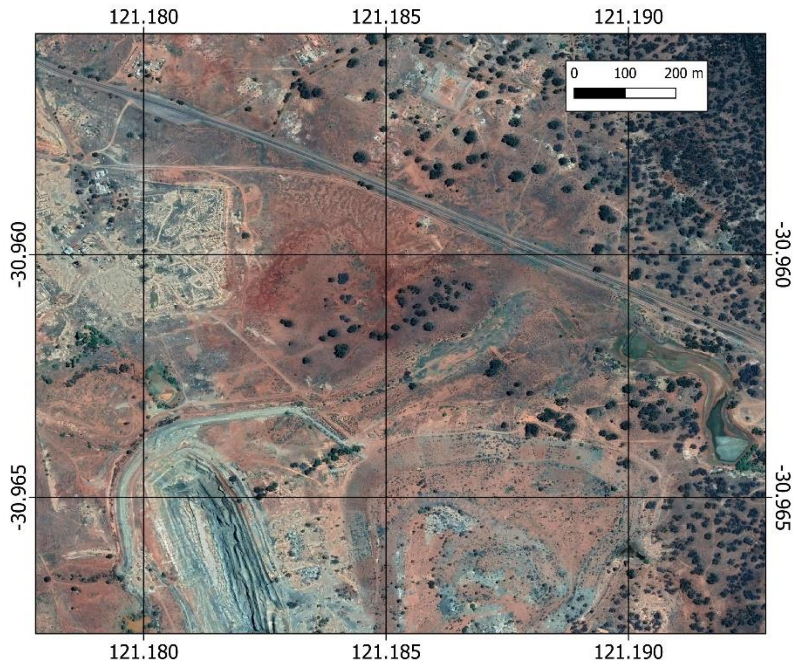
Darwin, TAS
Diameter: 1,200m
Depth: 160m
Asteroid: 50m and 50kt?
Age: 800Ka
Discovery: 1972 RJ Ford
Method: mapping
Gravity anomaly: -3.5mGal
Impact: 5GPa

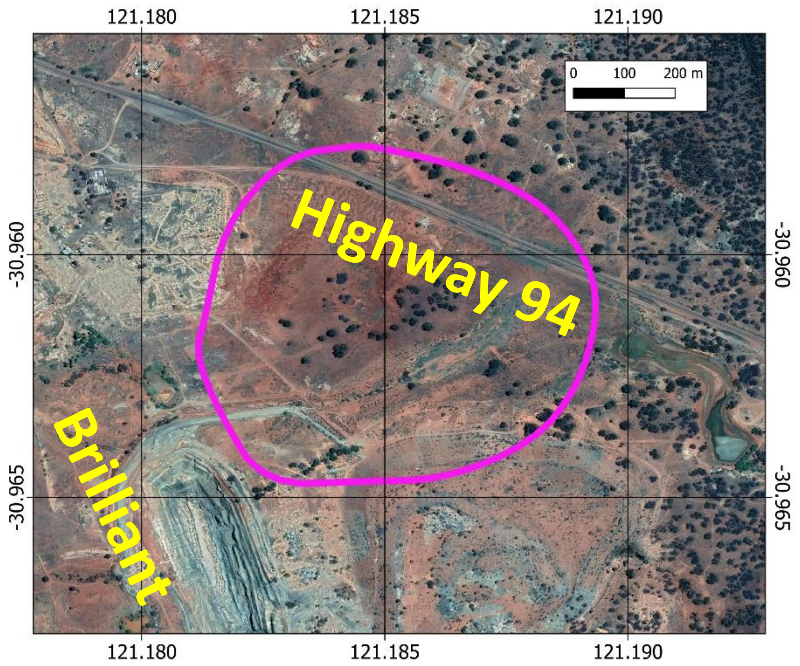
No surface expression of crater – geophysics and drilling!

Resource Potentials

Blind!

<u>Meyers, WA (unconfirmed)</u>
Diameter: 800m
Depth: 140m
Asteroid: 40m?
Age: Pleistocene to Miocene?
Discovery: 2017 JB Meyers and others
Method: gravity and passive seismic
Gravity anomaly: -5mGal
Impact: 4GPa?



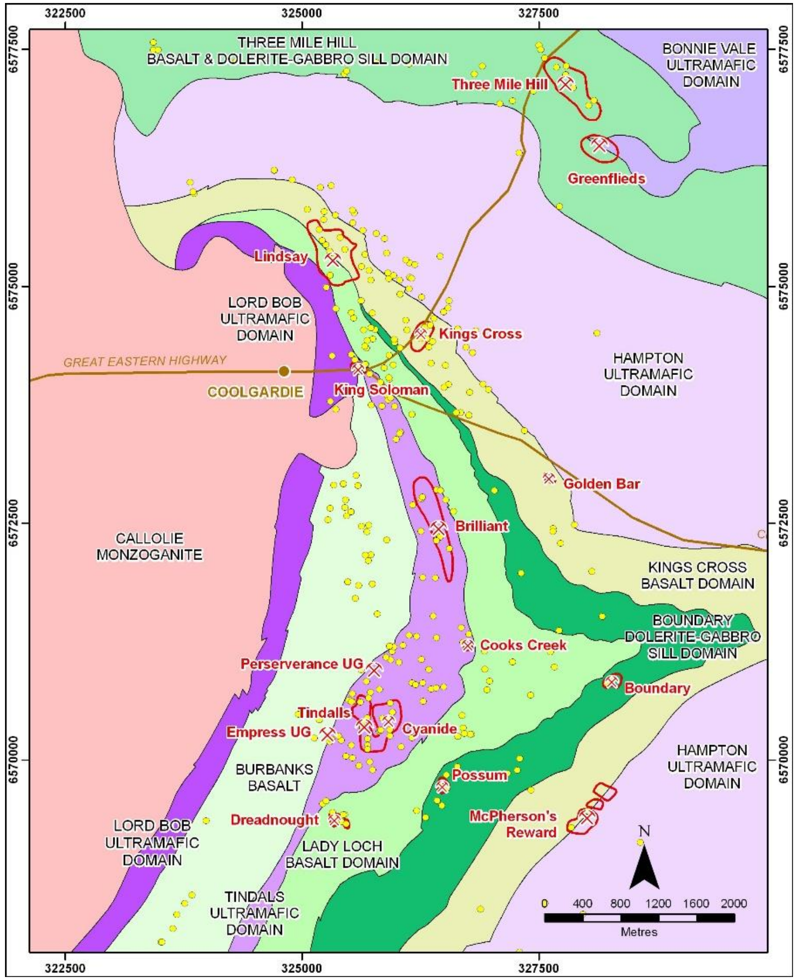


Within Coolgardie Goldfield, exploration and mining since 1892, Coolgardie-Esperance National Highway 94 crosses NE side, Brilliant Gold Mine on W side, crater overlooked until now!

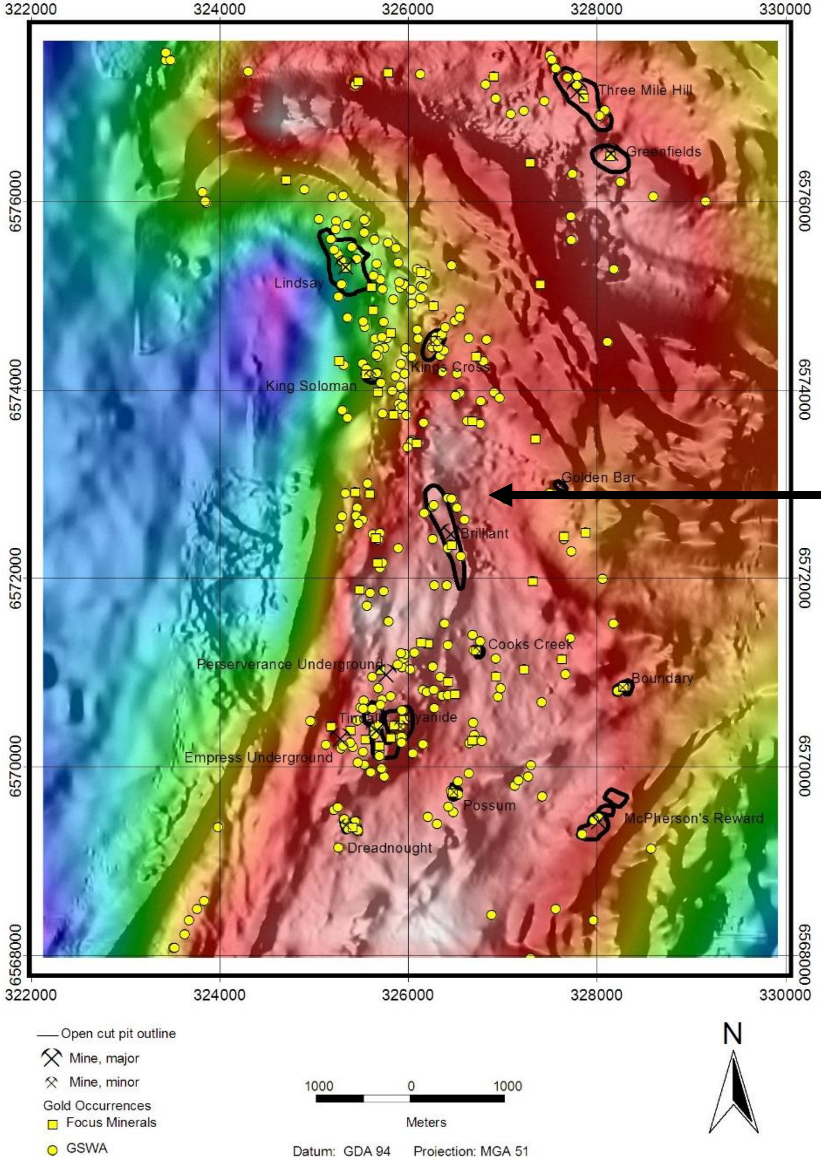
“Hole” in 2017 high resolution gravity survey and gold gap….

Resource Potentials

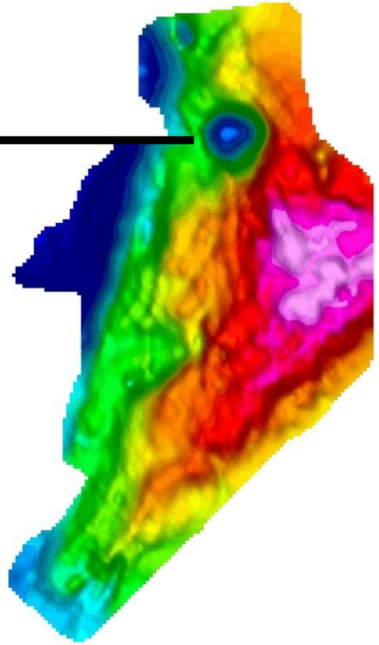
Interpreted Archaean greenstone-granite geological domains (Meyers and Wood, 2010)



GSWA 1VD gravity over magnetics



Merged detailed gravity 2010 and 2017

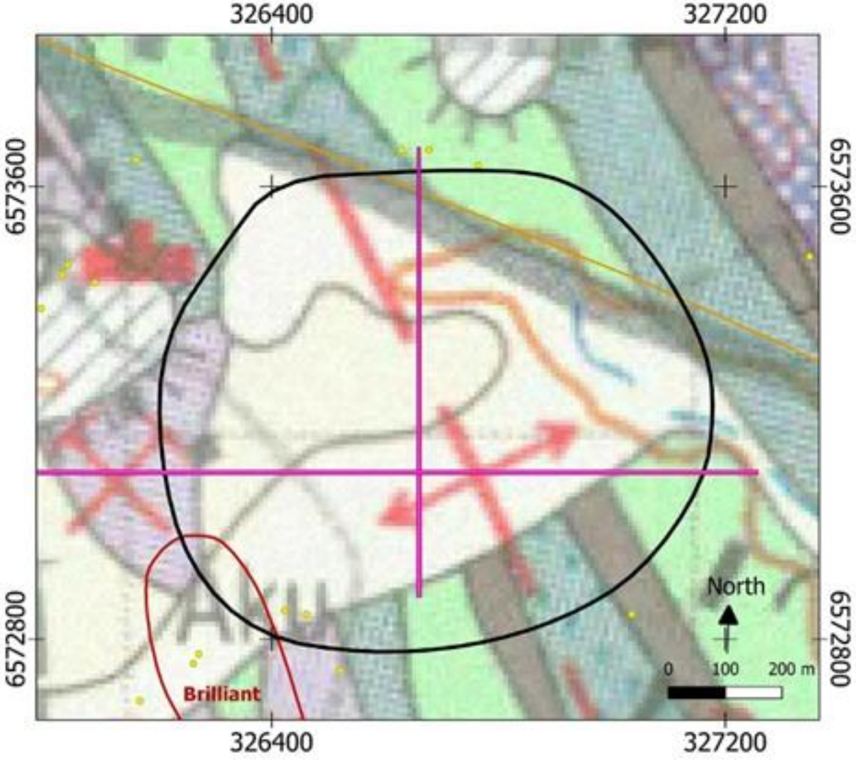


2005 VTEM survey, thin claypan? Crater – haha!!!

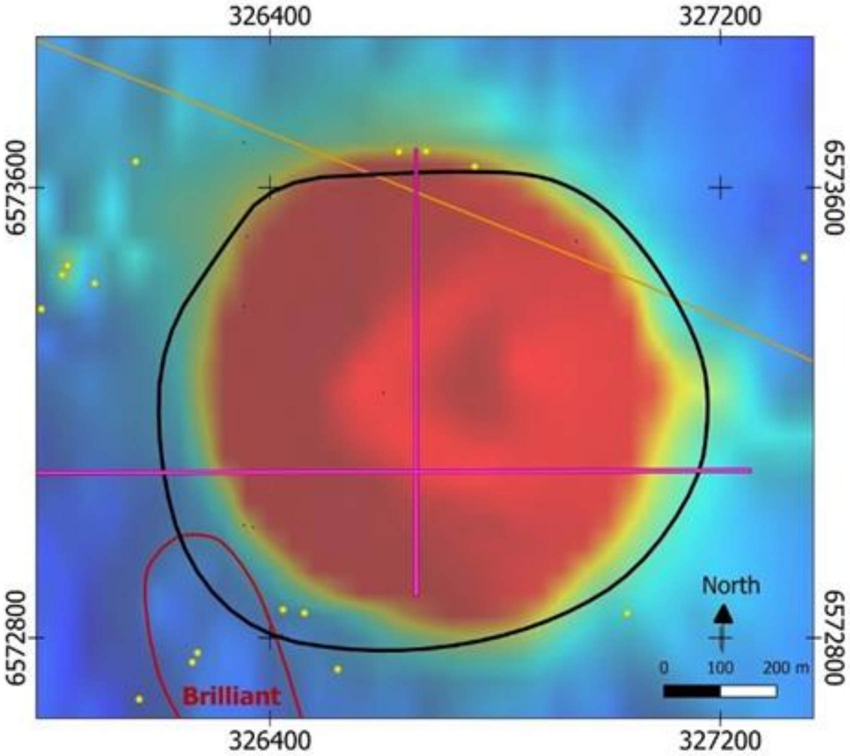
Resource Potentials

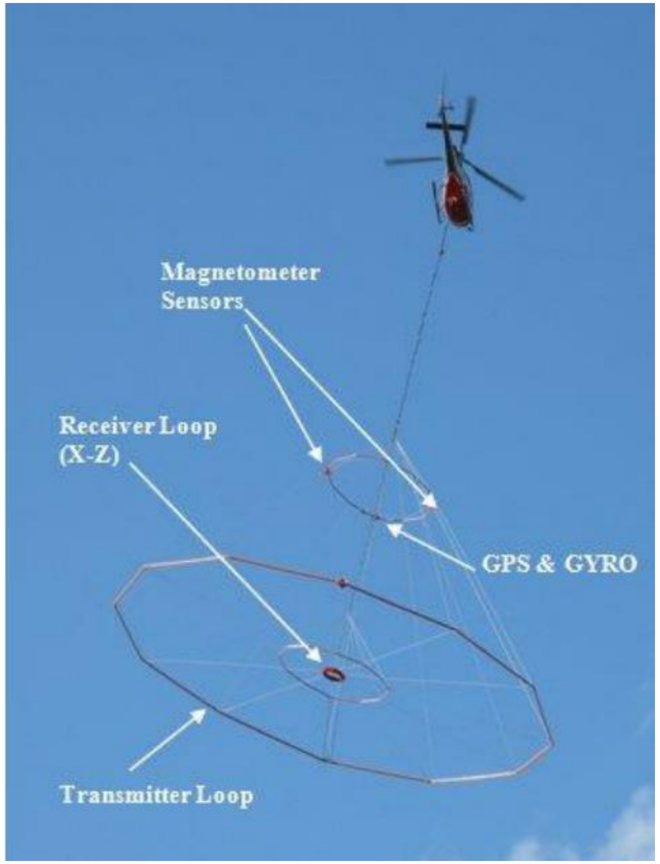
Very conductive and circular disk shaped anomaly 800m wide in VTEM helicopter EM survey (cannot detect base of conductive layer), transported cover in mapping, sparse drilling indicates thicker cover, all initially suggesting a typical eroded zone filled with Cainozoic clays (claypan) and hypersaline groundwater.

GSWA 1:100,000 scale geology (Hunter and Swager, 1988)



VTEM Z receiver dB/dt channel 26 (100m E-W line spacing)



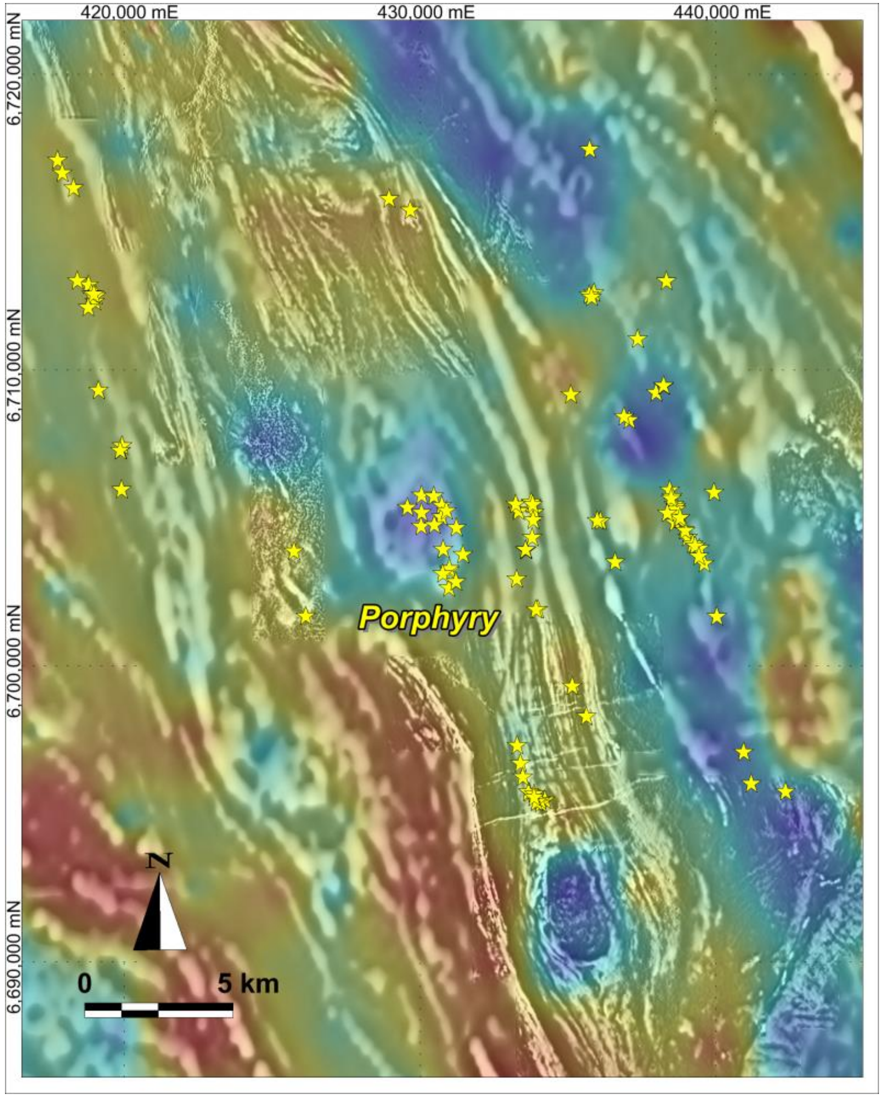


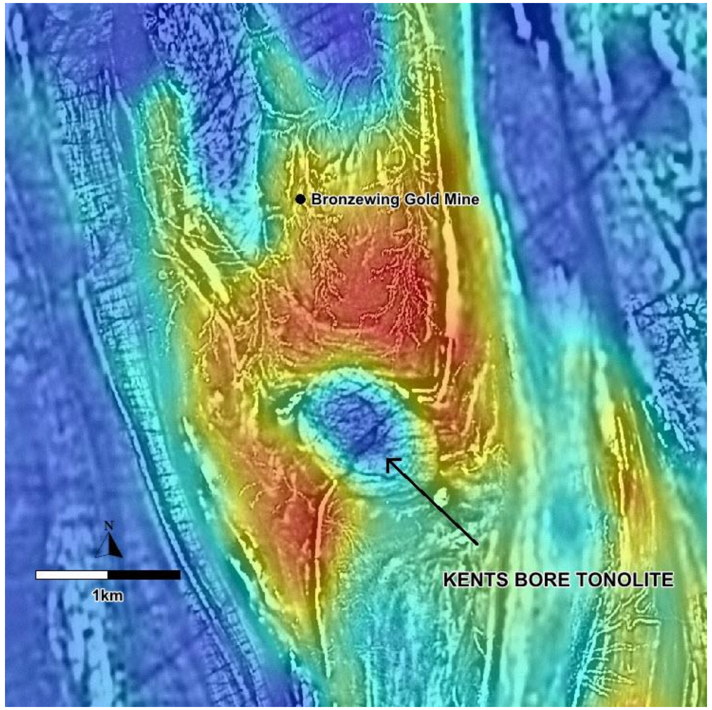
VTEM HEM survey system

Not an internal granite to the greenstone belt

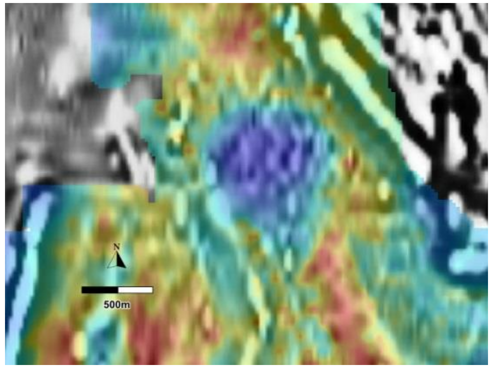
Resource Potentials

- **Images of gravity draped over magnetics**
- **Magnetic anomaly pattern does not indicate an intrusion**





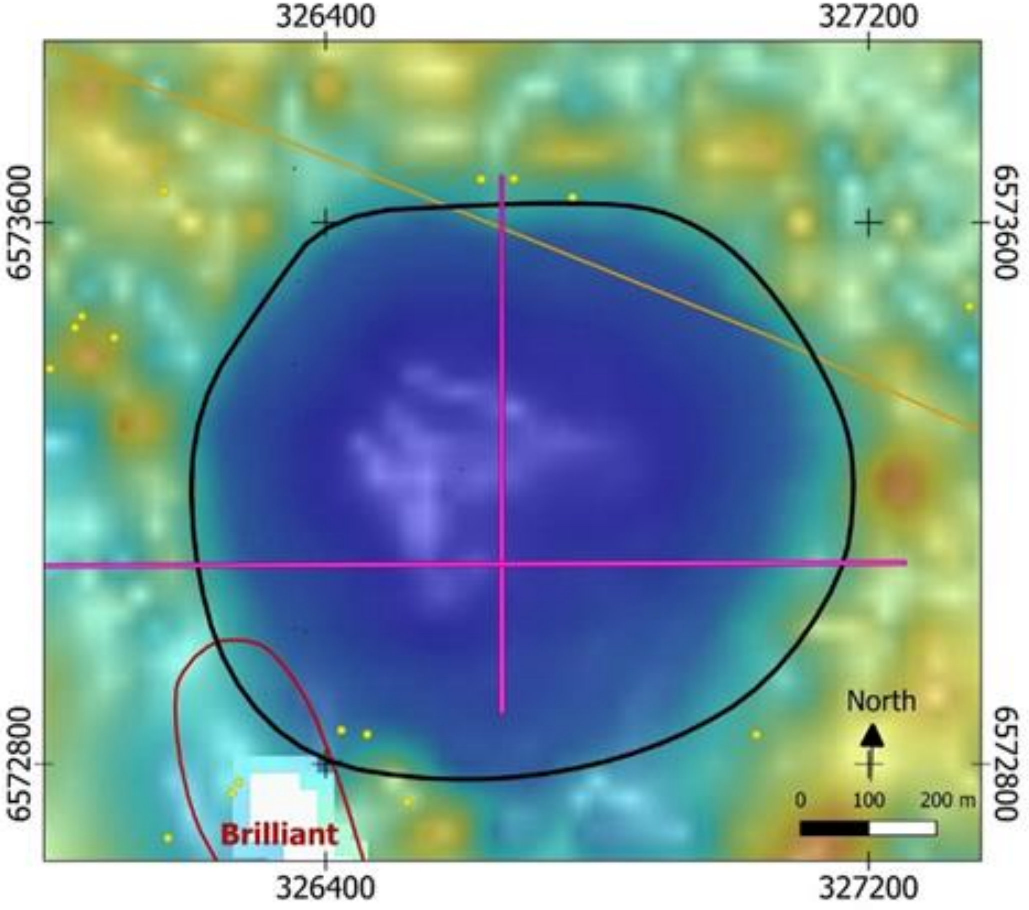
Crater – not granitic intrusive stock



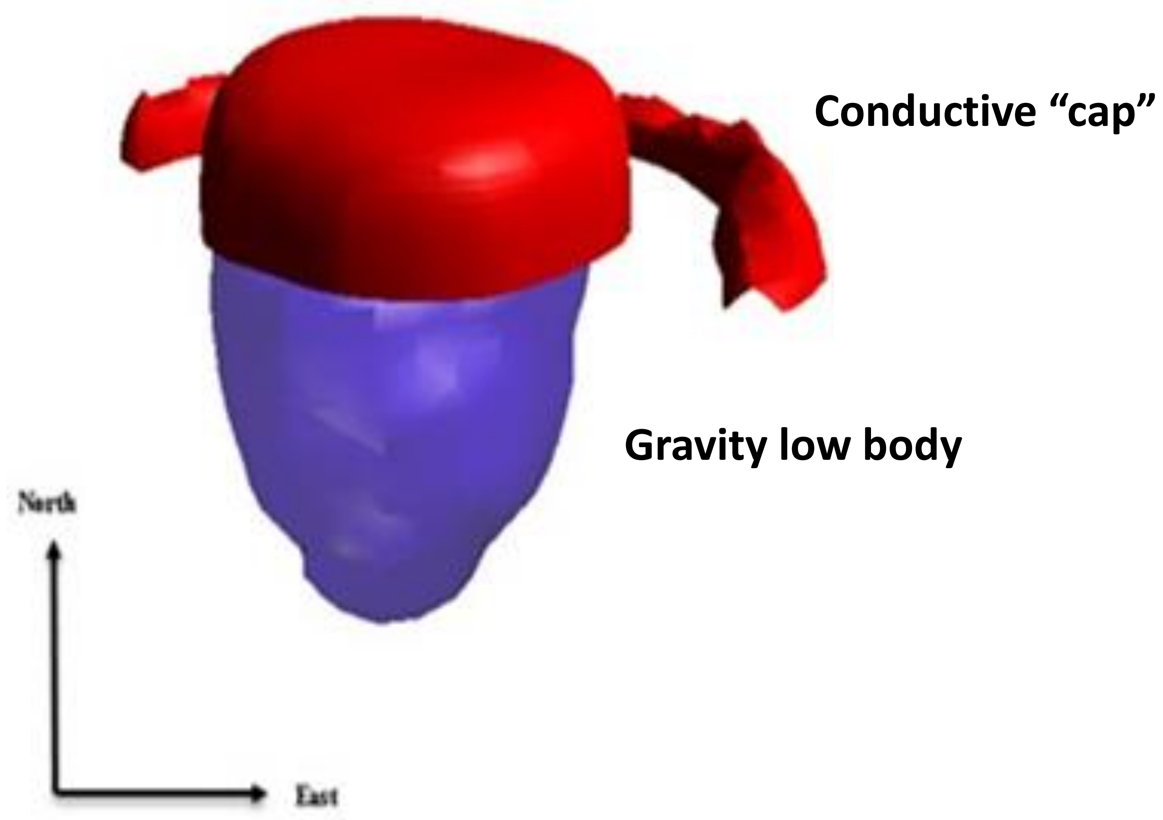
2017 gravity and VTEM models

Resource Potentials

2017 gravity 100m E-W lines x 50m stations
-5 mGal, very strong!
(half vertical derivative image)



VTEM CDI inversion of conductive clay cap for diameter constrained 3D gravity inversion of “fang" or cone shaped low density zone

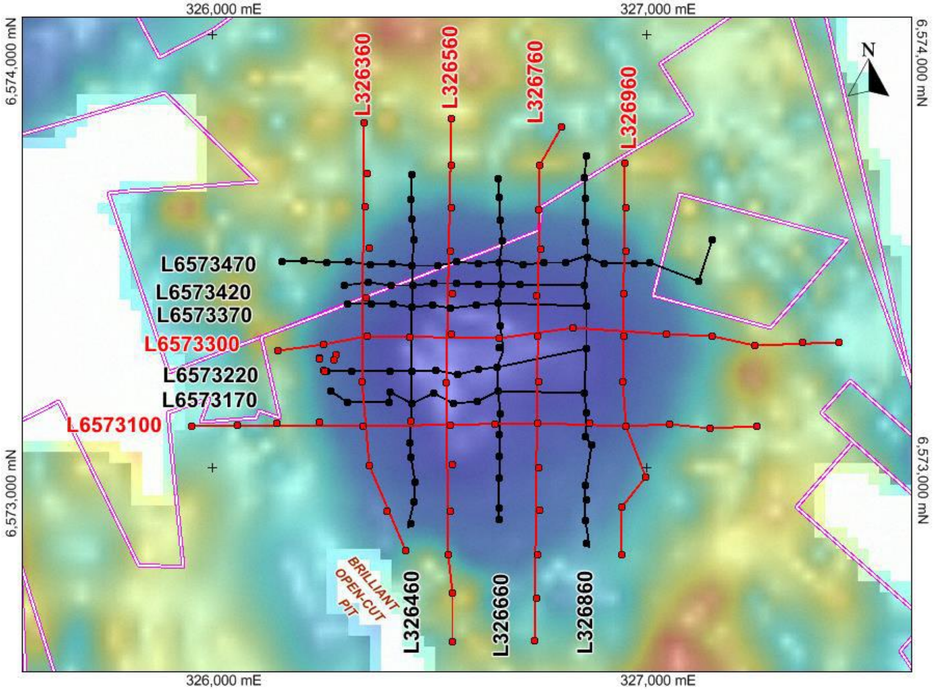


Crater morphology confirmed by passive seismic

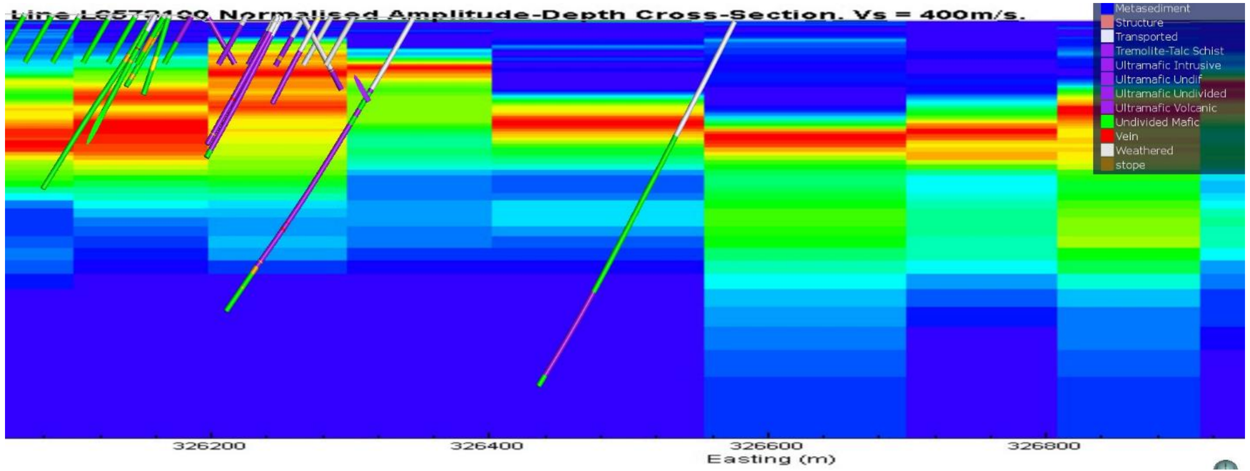
Resource Potentials

- **Passive seismic HVSR method using 8 Tromino seismometers, 2017 and 2018**
- **Average Vs 400m/s of crater fill deposits over higher velocity acoustic bedrock for depth conversion constrained by drilling**
- **Drilling for gold along west side of crater structure confirmed geometry and impact rocks**

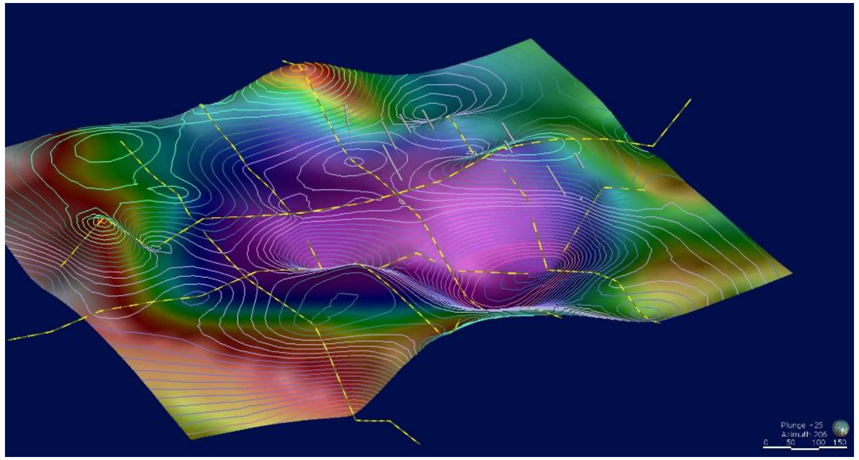
Passive seismic stations over gravity image



Drilling and HVSR cross section (no VE)

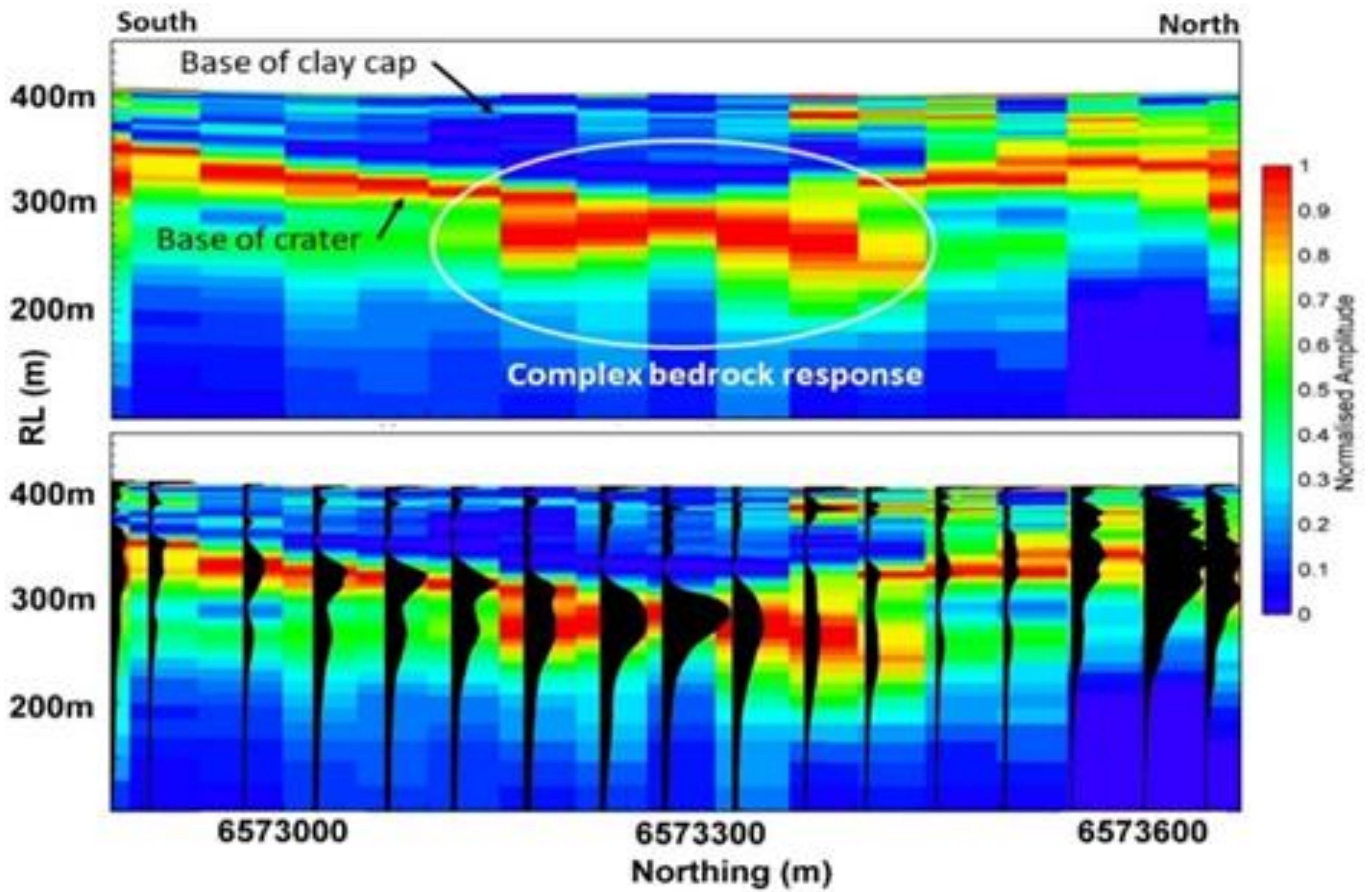


Gravity colour over passive seismic depth



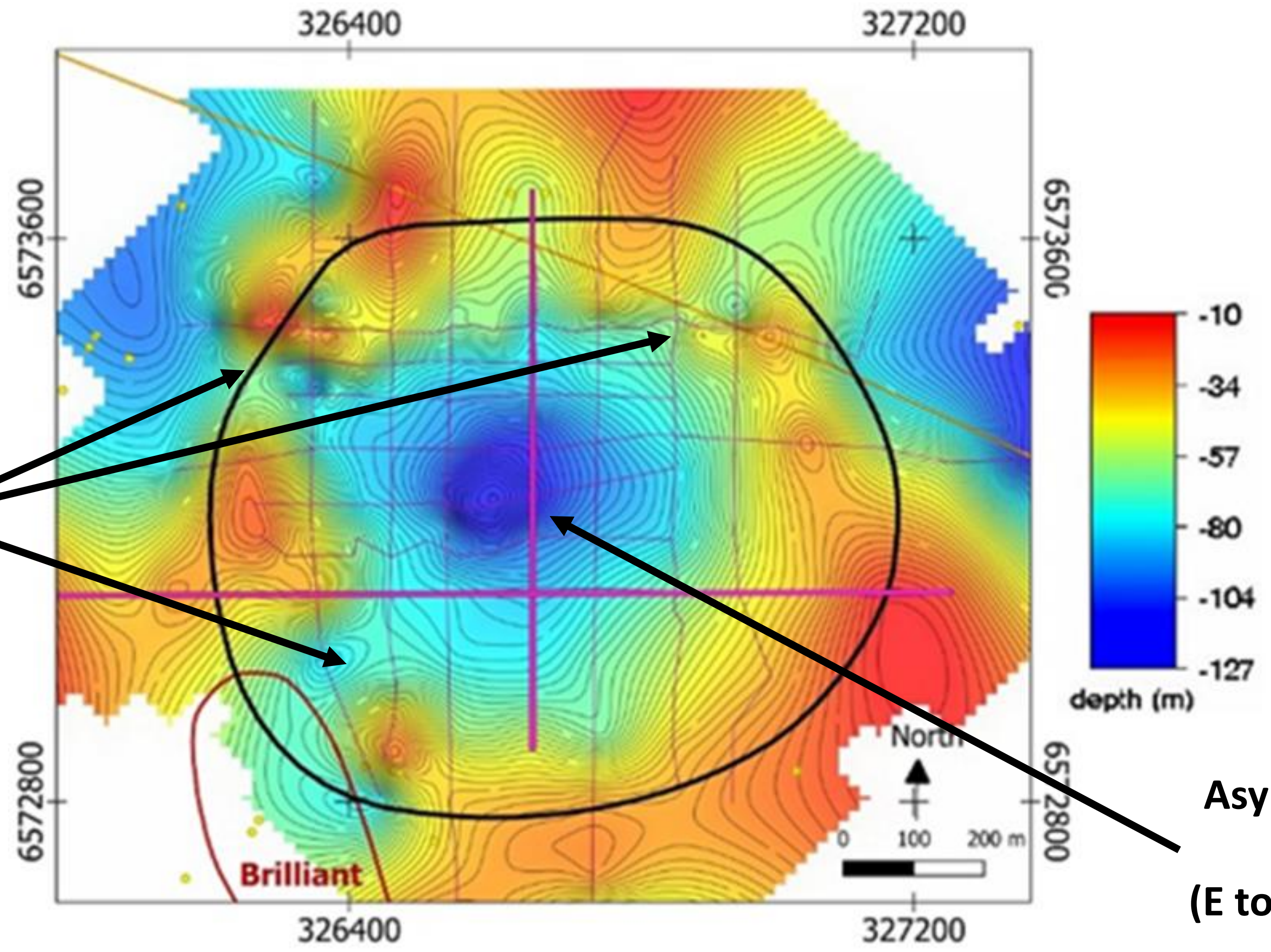
Acoustic bedrock (greenstone breccia) overlain by peat and clay

Resource Potentials



Bowl shaped crater with sedimentary fill to 120m or more

Resource Potentials

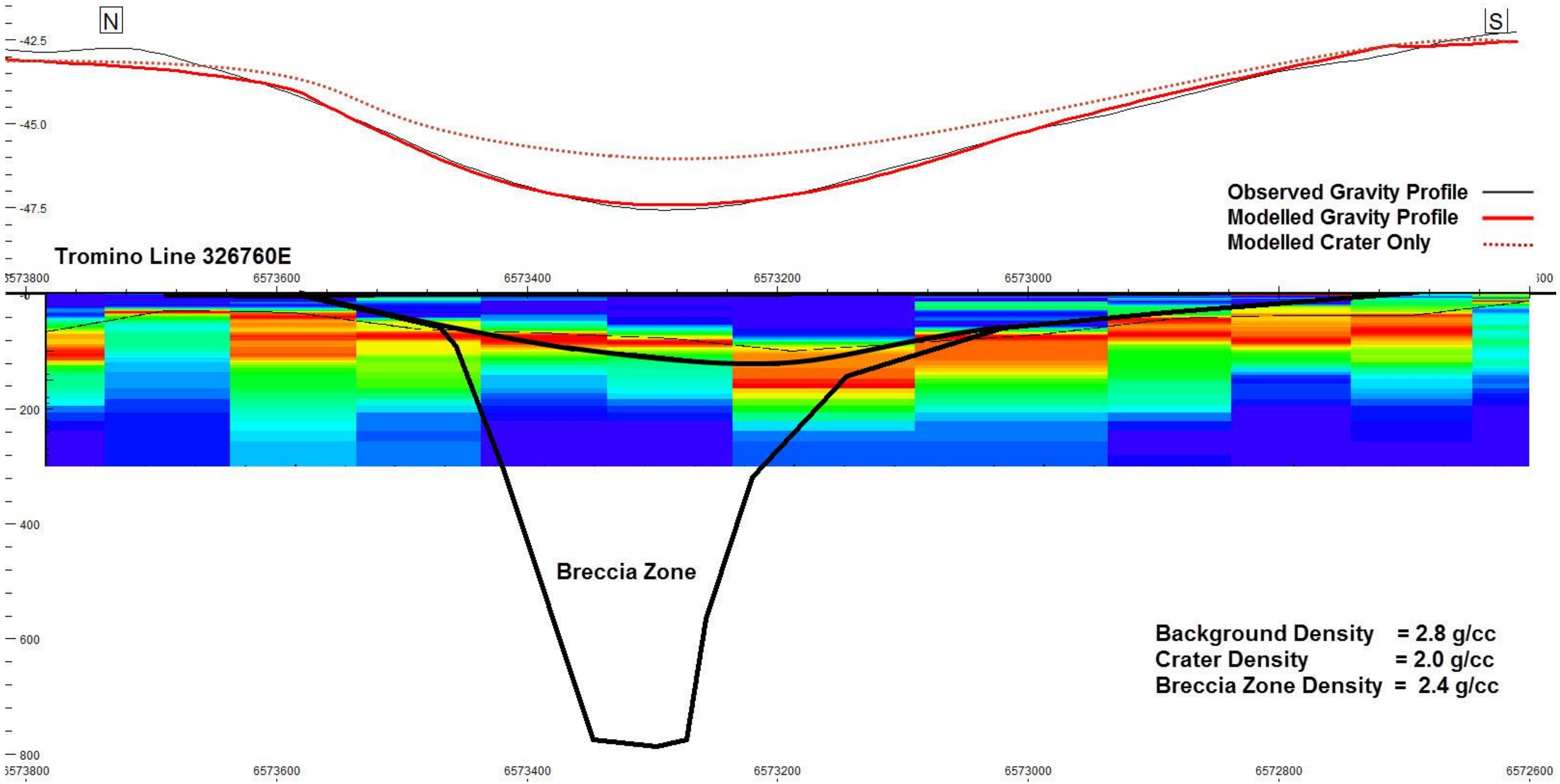


Raised rim eroded and breached (thousands of years or more)
Original diameter likely wider (1,000m?)

Asymmetric steep W side
(E to W trajectory?)

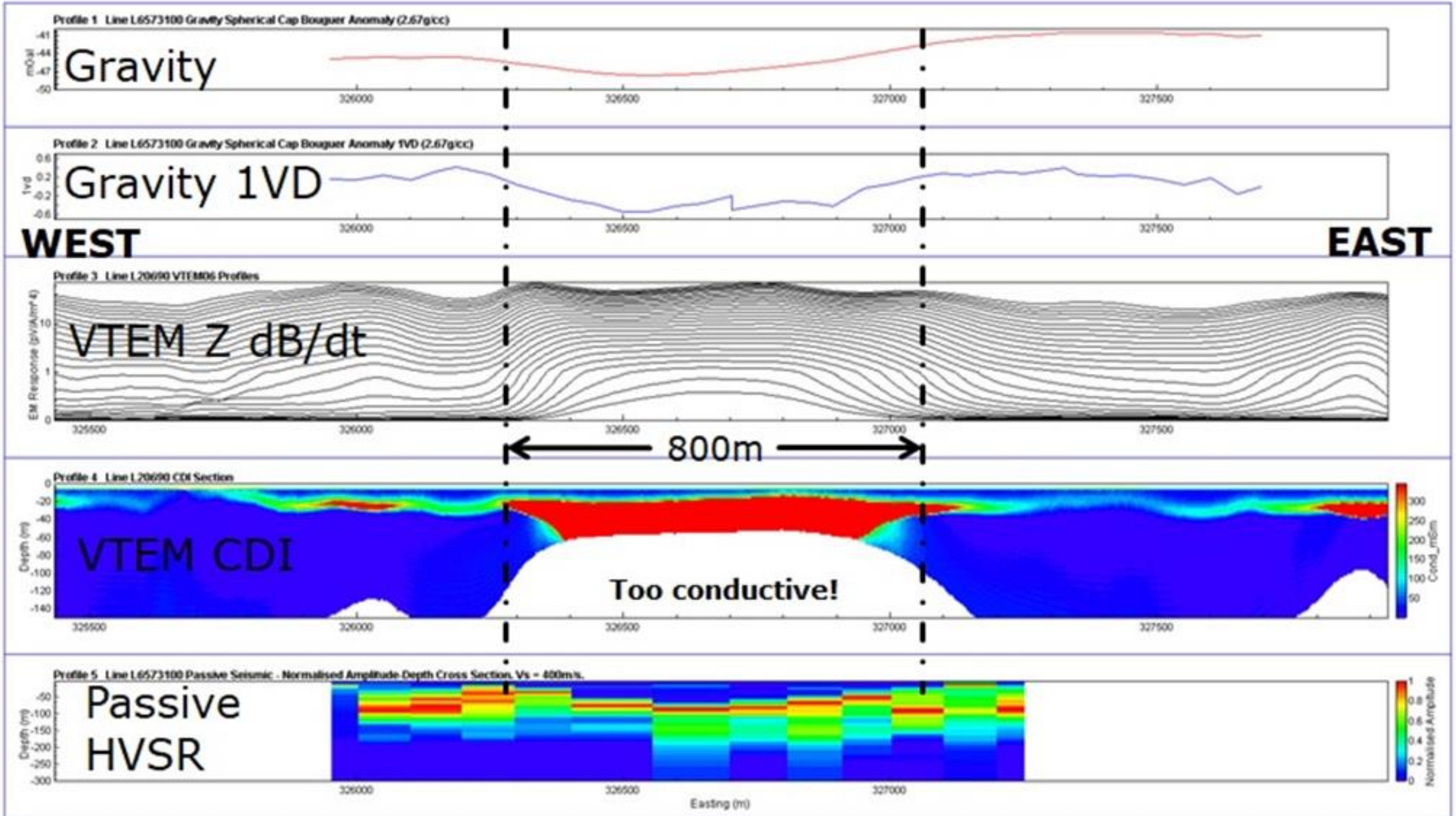
2.5D gravity modelling required a deep low density root below crater

Resource Potentials



Complimentary geophysical data sets

Resource Potentials

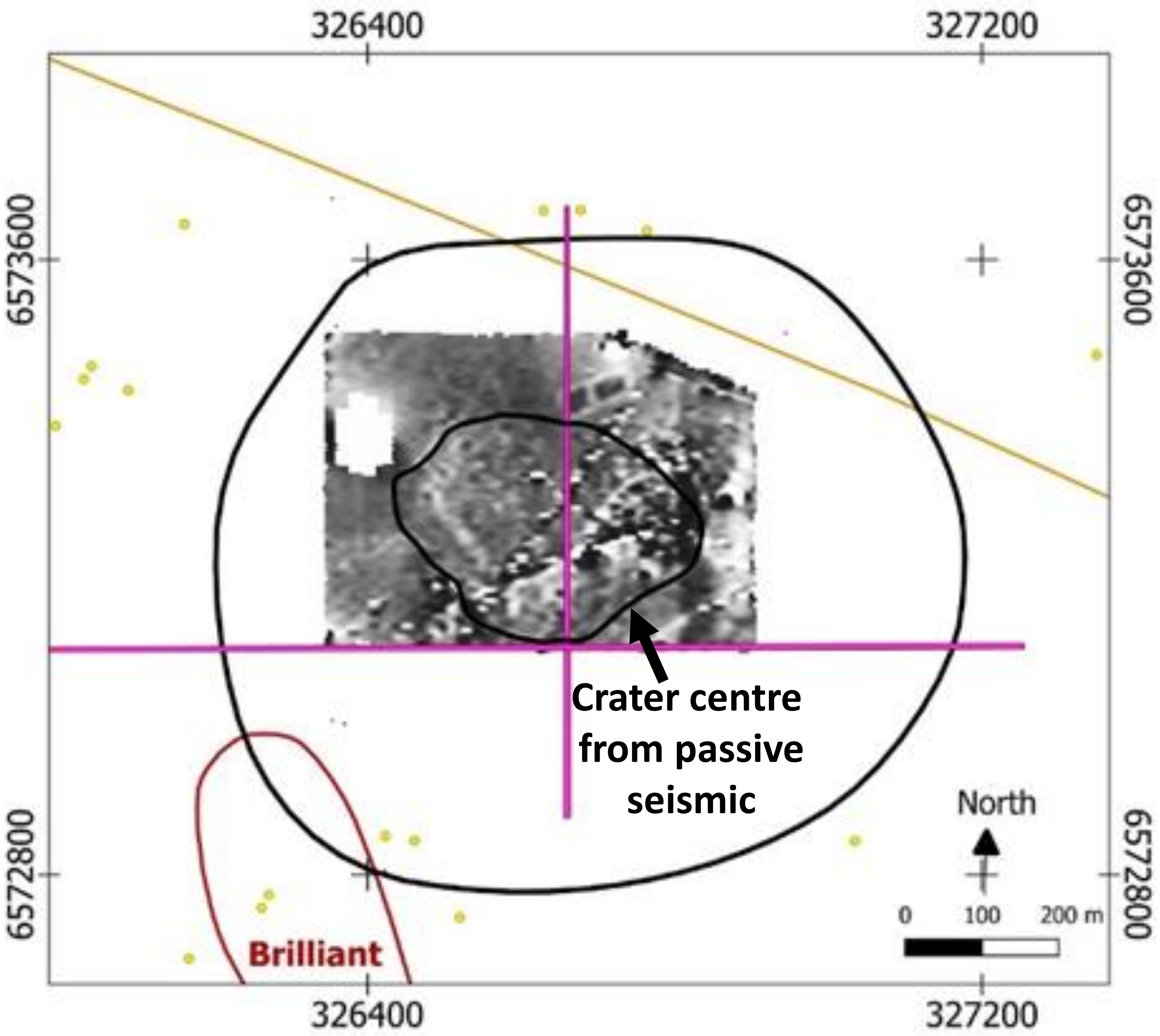


High resolution ground magnetics, 10m N-S line spacing

Resource Potentials

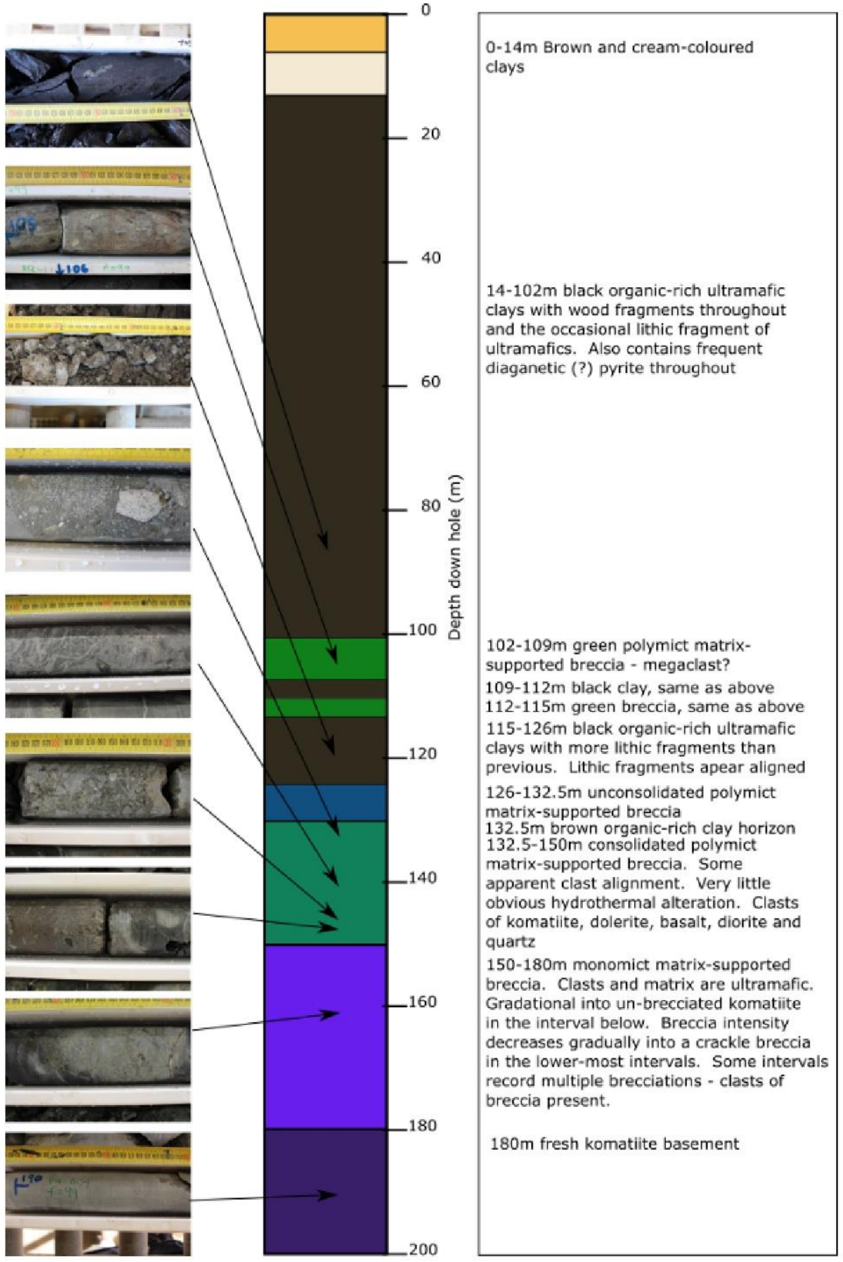
- **Test to see if large meteorite fragments exist, like Canyon Diablo meteorites at Barringer Crater**
- **No strong magnetic anomalies from meteorite fragments, but possible magnetic zone from vapourised asteroid/meteorite material in NW part of inner deep zone of crater floor**

High pass filtered



RC and diamond drilling

Example hole TND17052: W dipping toward Brilliant gold bearing diorite porphyry in high-Mg basalt to ultramafic volcanic host, 14m clay cap, 120m of peat with breccia bedrock slump blocks, weathered and fresh polymict breccia with suevite zones, monomict breccia, then normal bedrock



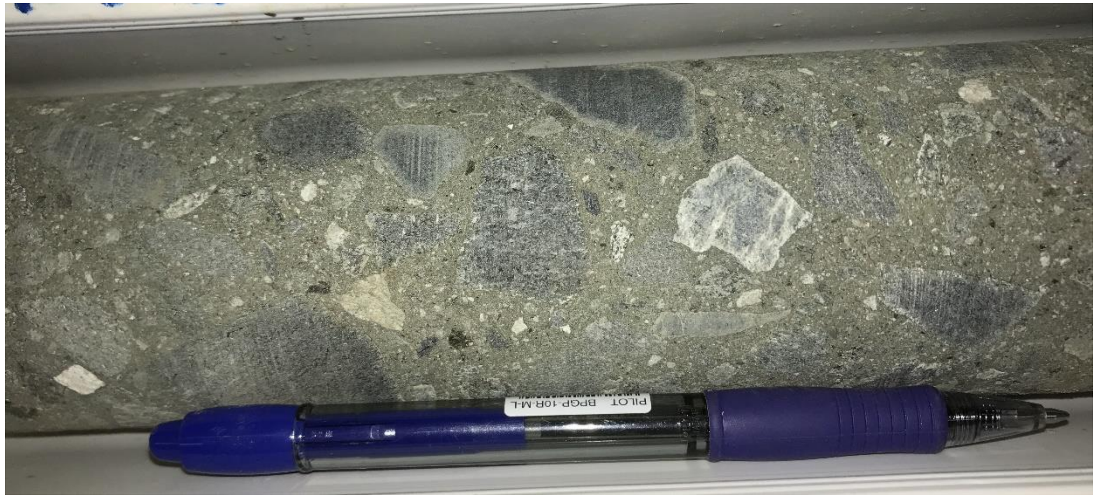
Thick accumulation of peat and wood fragments under clay cap

- **Preserved accumulation of peat and wood, flat to slumped**
- **Anoxic, framboidal pyrite**
- **Saline and conductive water**
- **Clay cap acted as a seal**

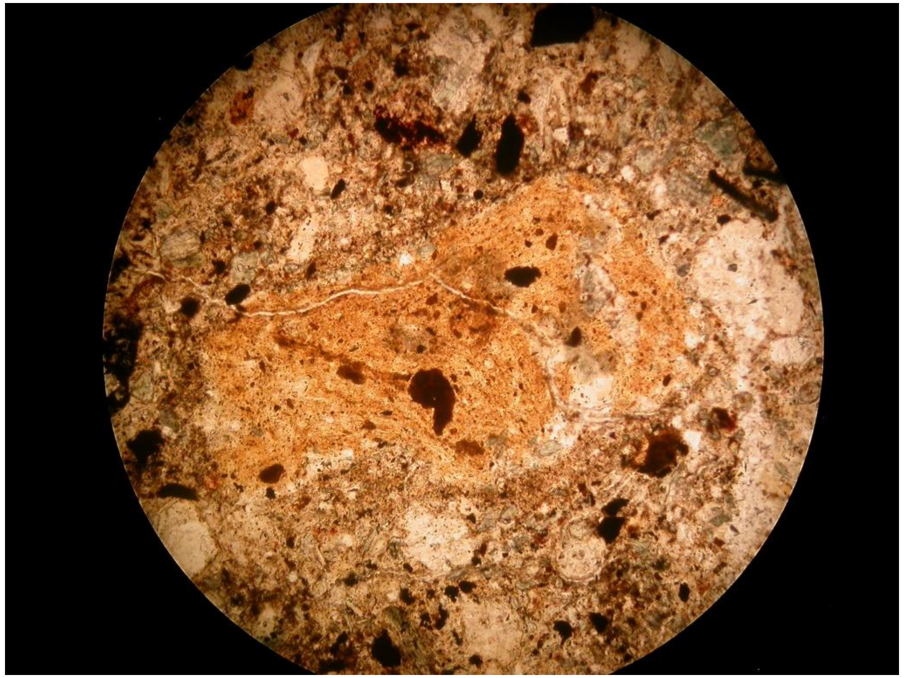
Polymict breccia, angular clasts from below and surrounds

Resource Potentials

Silica after glass – "suevite breccia"



Ejecta layer – tuff like suevite breccia with siderite-goethite replacing plant material, and abundant fine sulphide fragments



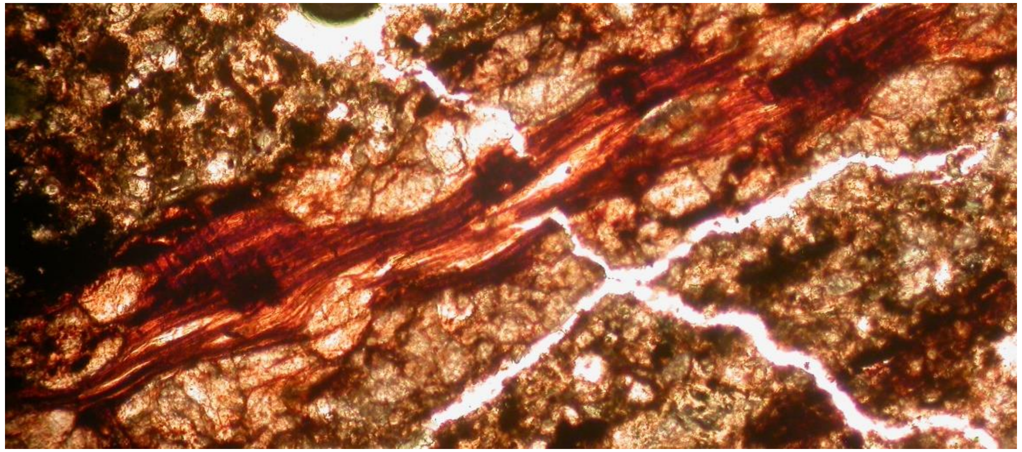
- **No planar deformation structures (PDFs) in quartz, yet…**
- **Opaques are clasts of goethite, leucoxene and sulphide (pyrite after pyrrhotite)**

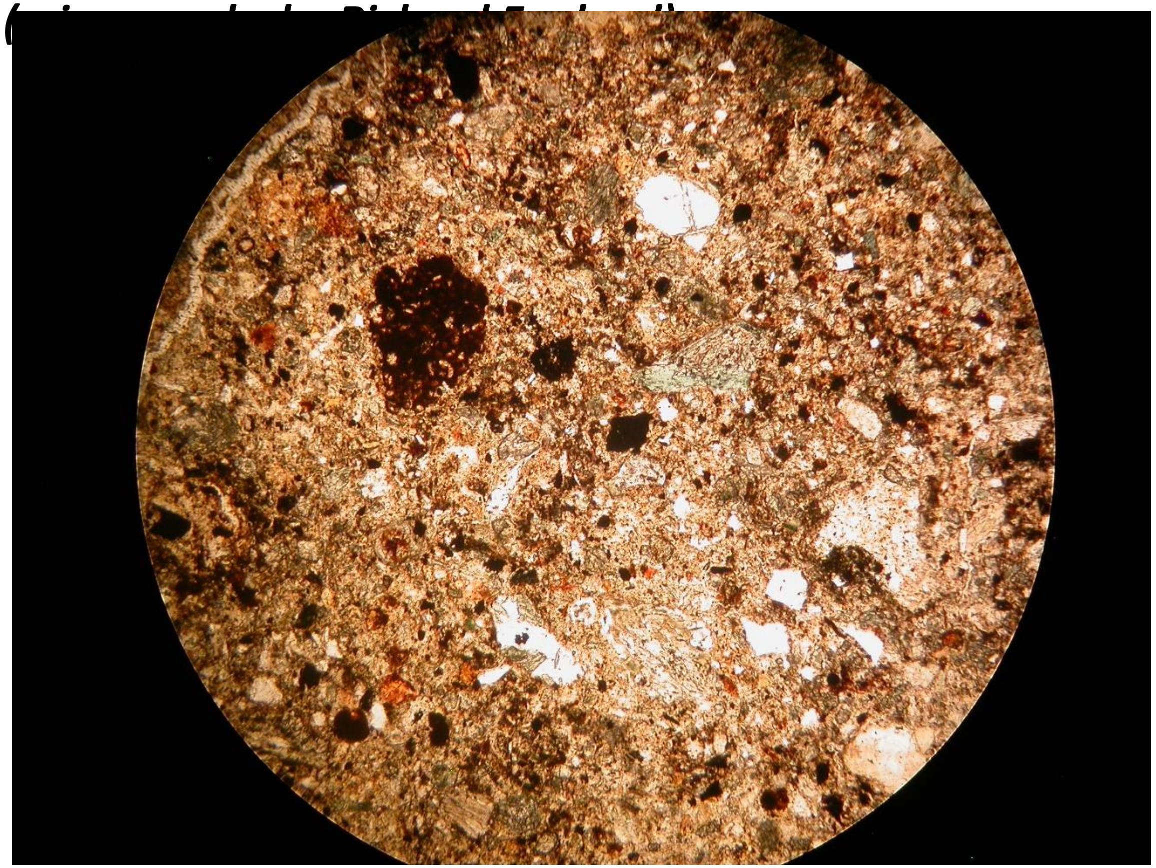
(micrograph by Richard England)

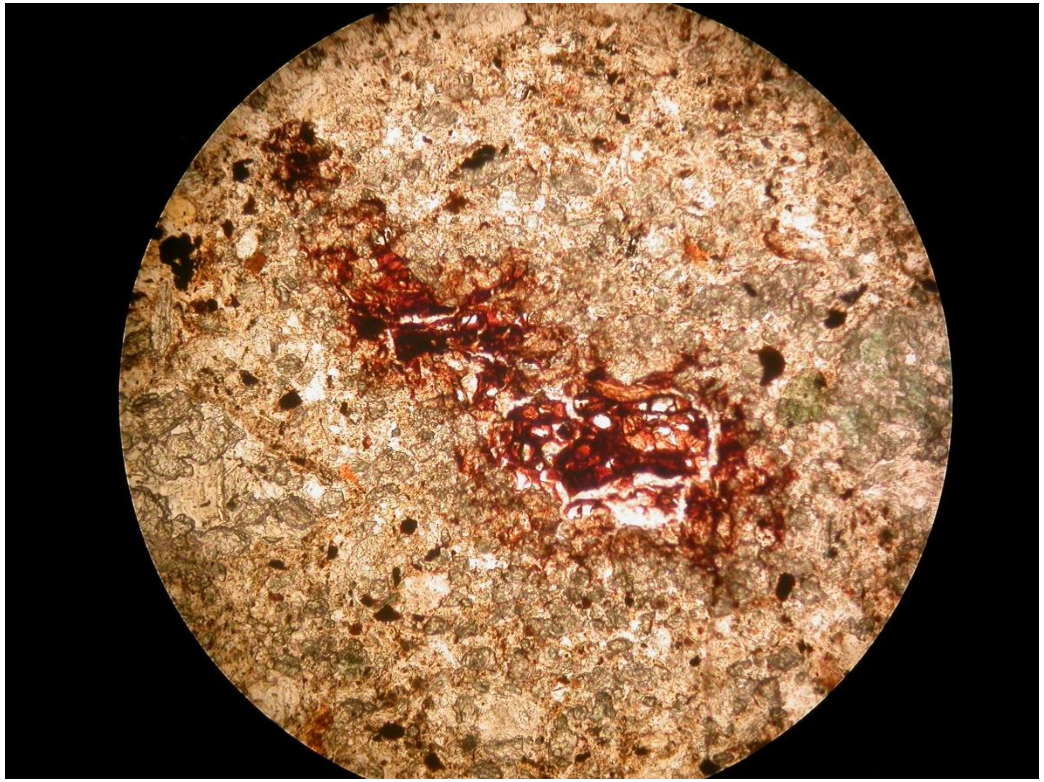
Ejecta layer – tuff like suevite breccia with siderite-goethite replaced plant material and abundant fine sulphide fragments

Resource Potentials

- **Angular to rounded and unsorted clasts, including broken quartz, but no PDFs yet**
- ***Matrix supported mineralised plant fragments, likely pre-impact vegetation forming part of basal polymict suevite breccia***







Monomict breccia and breccia dykes below ejecta layer

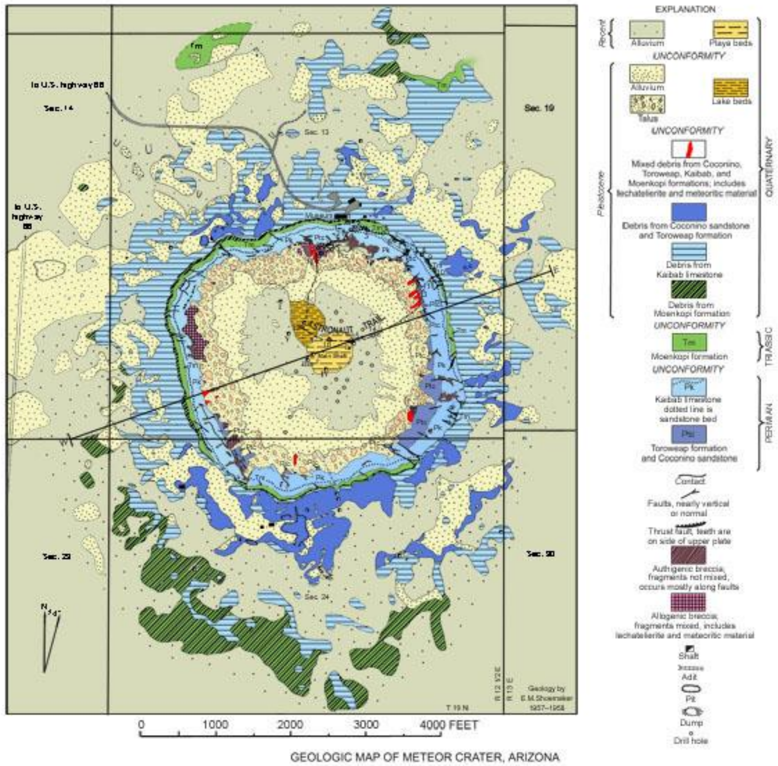
Resource Potentials

- **Little to no glass droplets, but some pseudotachylite along faults**
- **Shattered, but no shatter cones so far, they are likely to occur, requires breaking up core and drilling new holes in crater centre**
- **Lots of carbonate alteration – why?**

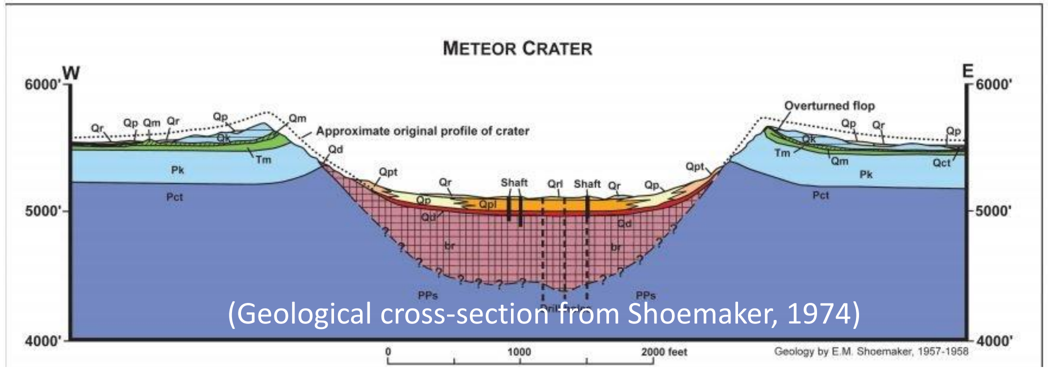
Similar size to Barringer Crater, Arizona, USA

Resource Potentials

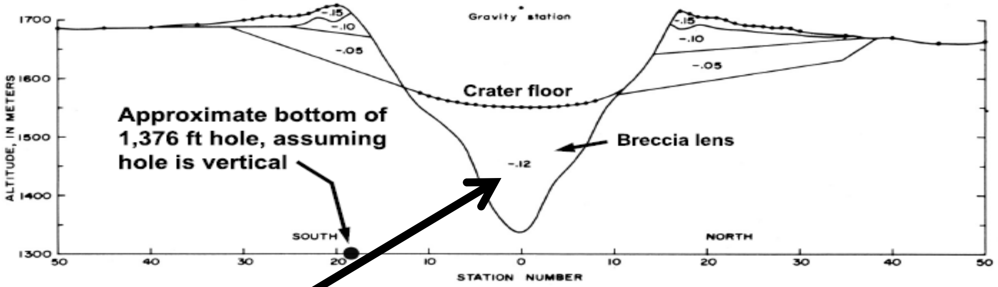
Diameter: 1,200m
Depth: 170m
Asteroid: 50m “Canyon Diablo Meteorite” *Canyon Diablo Troilite standard for ^{34}S*
Age: 50Ka
Discovery: 1903 D Barringer, after USGS said volcanic in 1891
Method: mapping
Gravity: -1mGal in base
Impact: 5GPa



(Geology from Kring, 2007)



(Geological cross-section from Shoemaker, 1974)



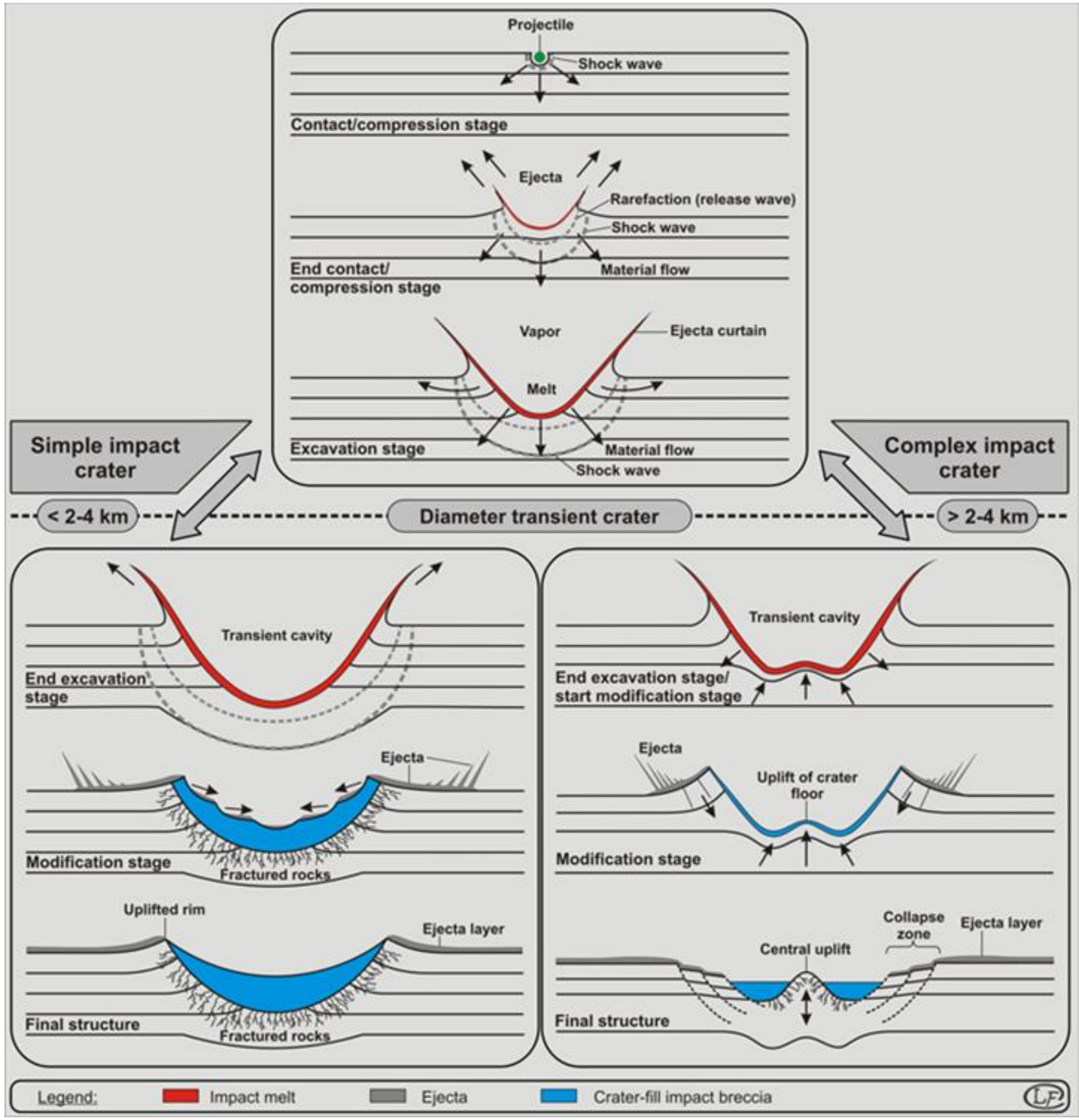
Fang shaped low density zone

(Gravity model from Regan and Hintze, 1975)

Simple crater, impact pressure < 5GPa

Resource Potentials

- Bowl shaped crater morphology; <4 km in diameter, no ring fractures or central uplift, deep shatter breccia zone below
- No evidence for diatreme or maar origin
- Small size and low pressures means: possibly no shatter cones (?), no coestie/stishovite, maybe no PDFs, shocked minerals (at or below 5 GPa)
- Polymict breccia over monomict breccia, with suevite breccia ejecta layer in between, some pseudotachylite
- Steep sides caused slumping of greenstone blocks into crater fill deposits, deformed peat around blocks
- Raised rim prevented clastic input for long time span, anoxic swamp and lake (tens of Ka to Ma), until rim was breached by erosion allowing clay cap to form
- Needs triple-tube or sonic core drilling into deep centre
- Confirmation to be carried out by finding shatter cones, petrology, mineralogy, siderophile chemical anomalies (Ir, Pd, etc), meteor fragments, etc.
- Dating upper limit by pollen in basal peat layers, and impact event by 40Ar/39Ar of preserved glass or other methods, (U-Th)/He apatite-zircon, He-zircon, etc.

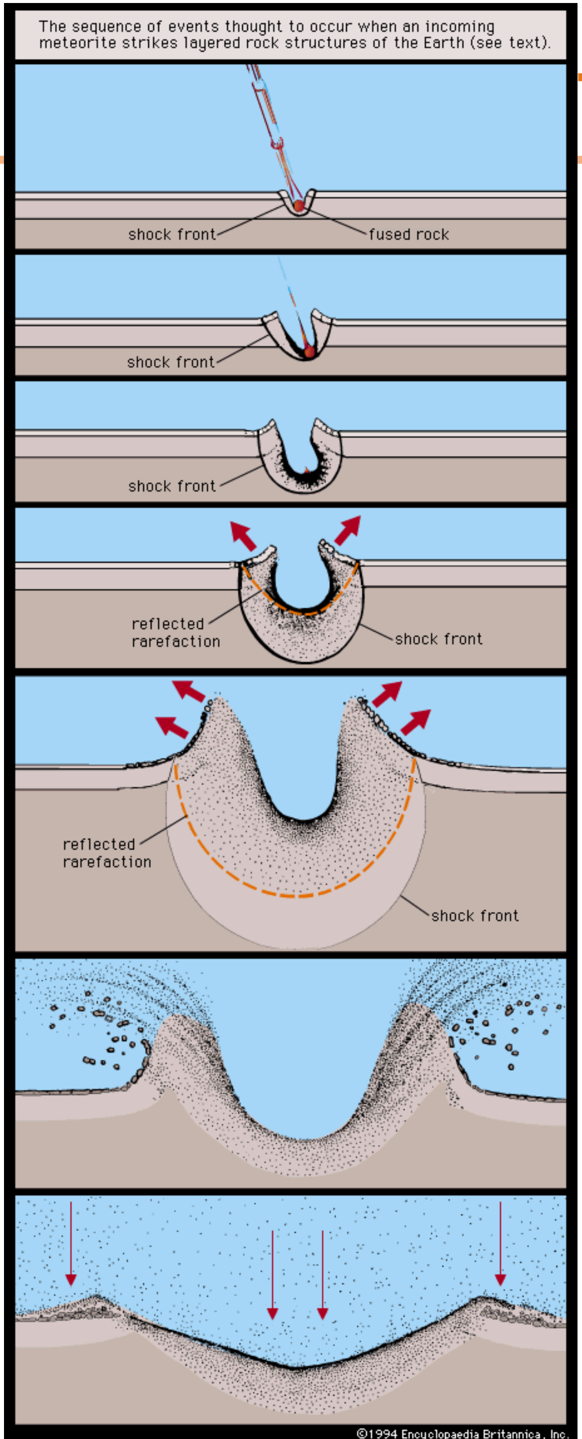


Simple crater, impact pressure < 5GPa

- **Most of remaining asteroid / meteorite vapourised on impact within 1 second**
- **Steep walls collapsed to form polymict breccia, shatter breccia below in monomict zones, reverberation and slumping caused continued mixing, faults reactivated to form breccia dykes, possibly with friction glass (pseudotachylite)**
- **Glassy droplets, dust cloud and Firestorm radiated 10s of kilometres away from impact site**

Shatter breccia (weathered zone)

Pseudotachylite (weathered zone)



Collaborative scientific drilling, GSWA and ???????

Resource Potentials

e.g., Hickman Crater, Hamersley Range, WA (from GSWA)

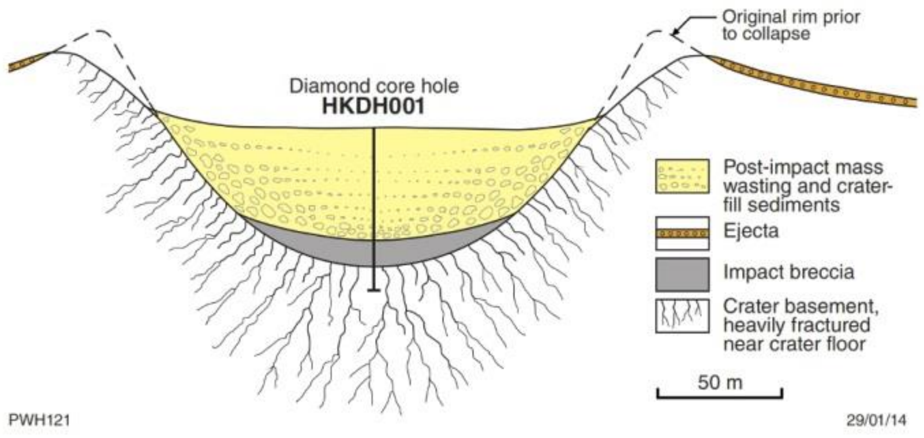
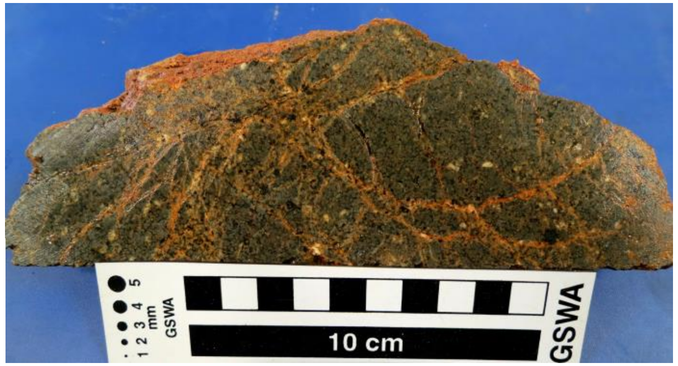
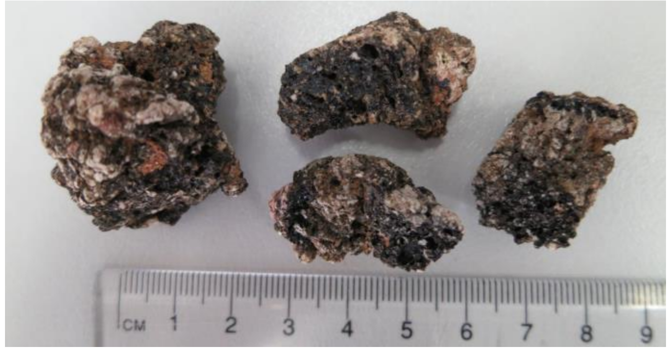


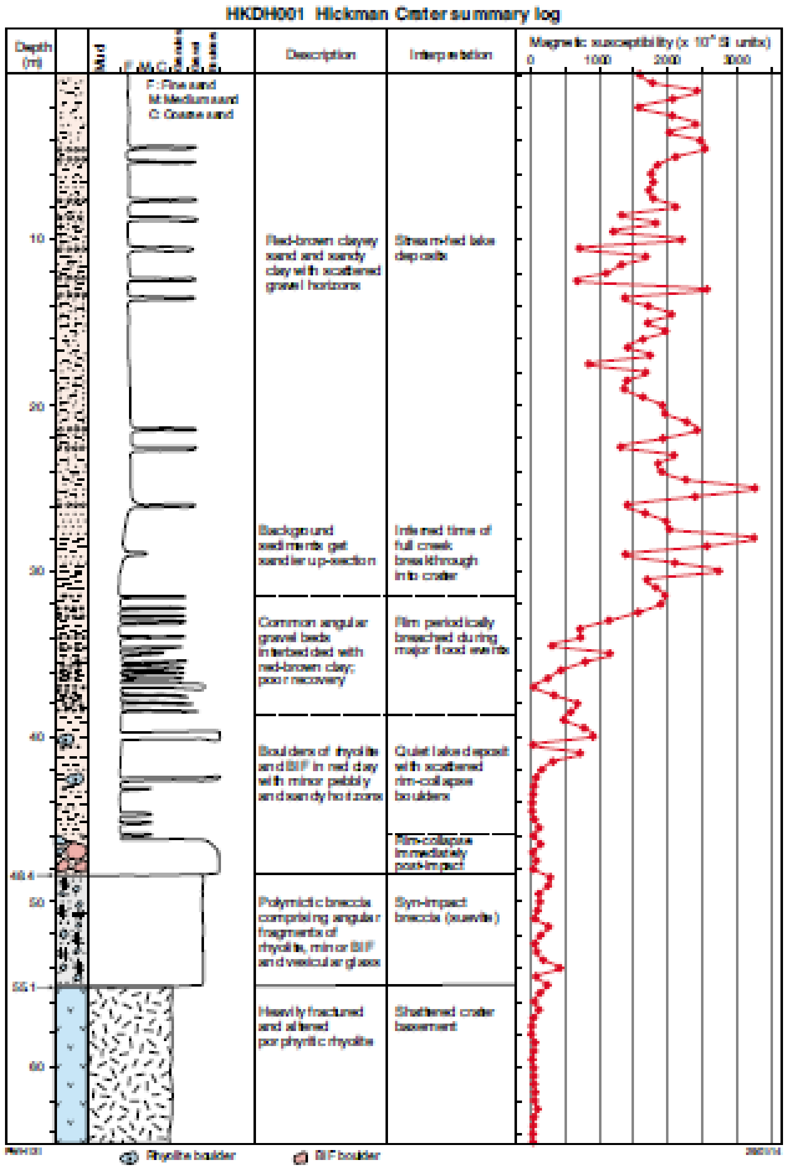
Figure 2. Interpreted cross section through Hickman Crater and the drillhole (no vertical exaggeration)

Brecciated rhyolite



Vesicular glass



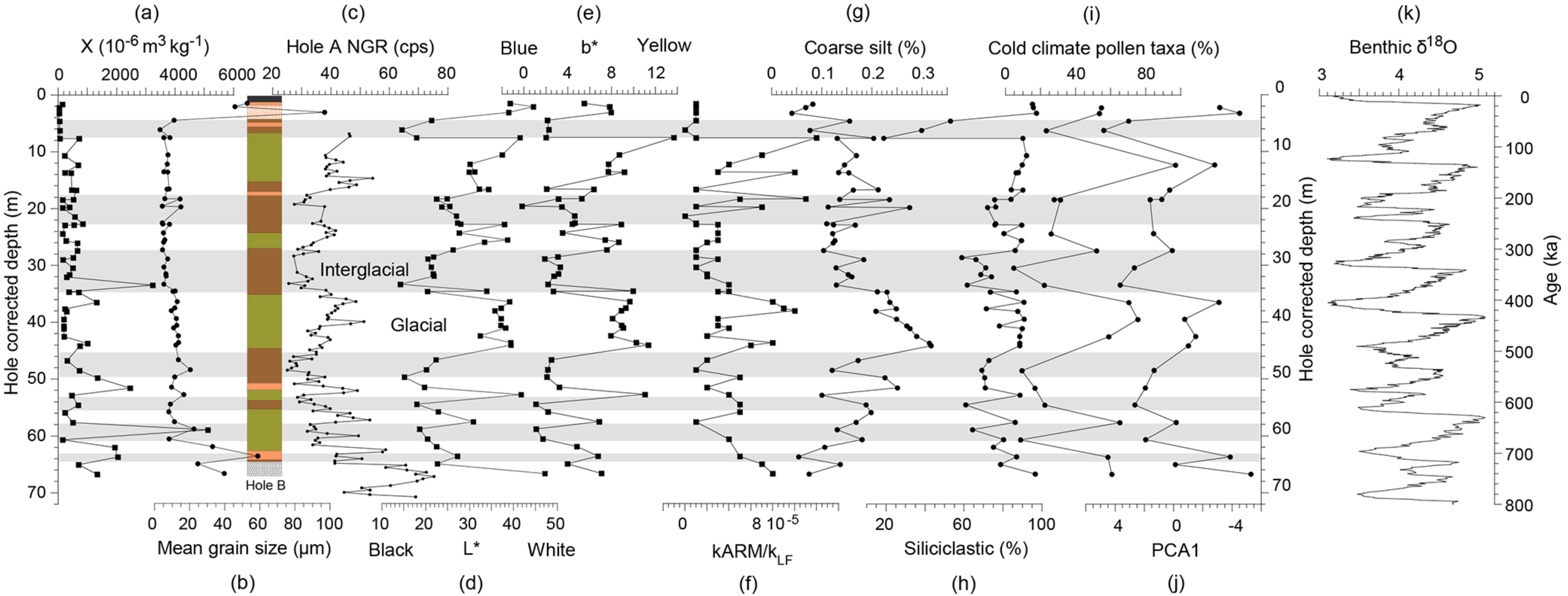


Crater deposit time capsule for paleoclimate/environment

Resource Potentials

e.g., coring of Pleistocene deposits in Darwin Crater in Tasmania (images from Lisé-Pronovost et al., 2019)

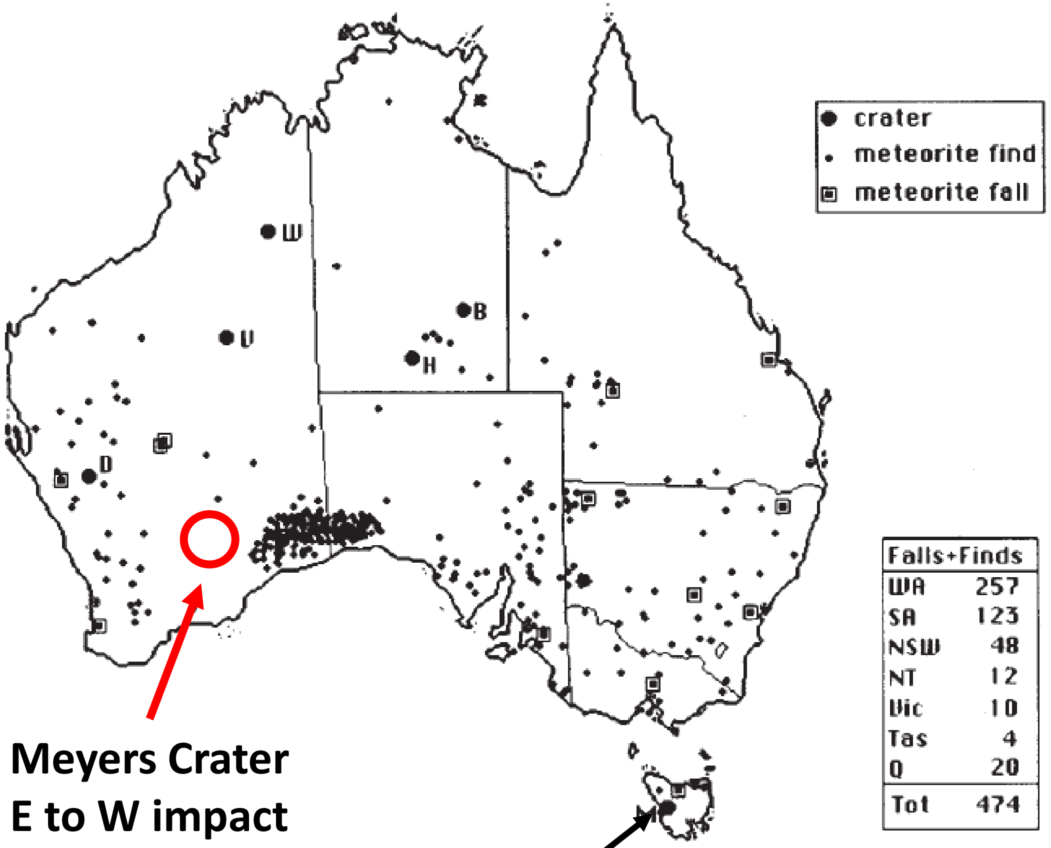
Meyers Crater similar size and filled with preserved organic deposits



Any relation to meteorite fields and 800Ka tektite event?

Resource Potentials

Meteorite finds (after Bevan, 1996)

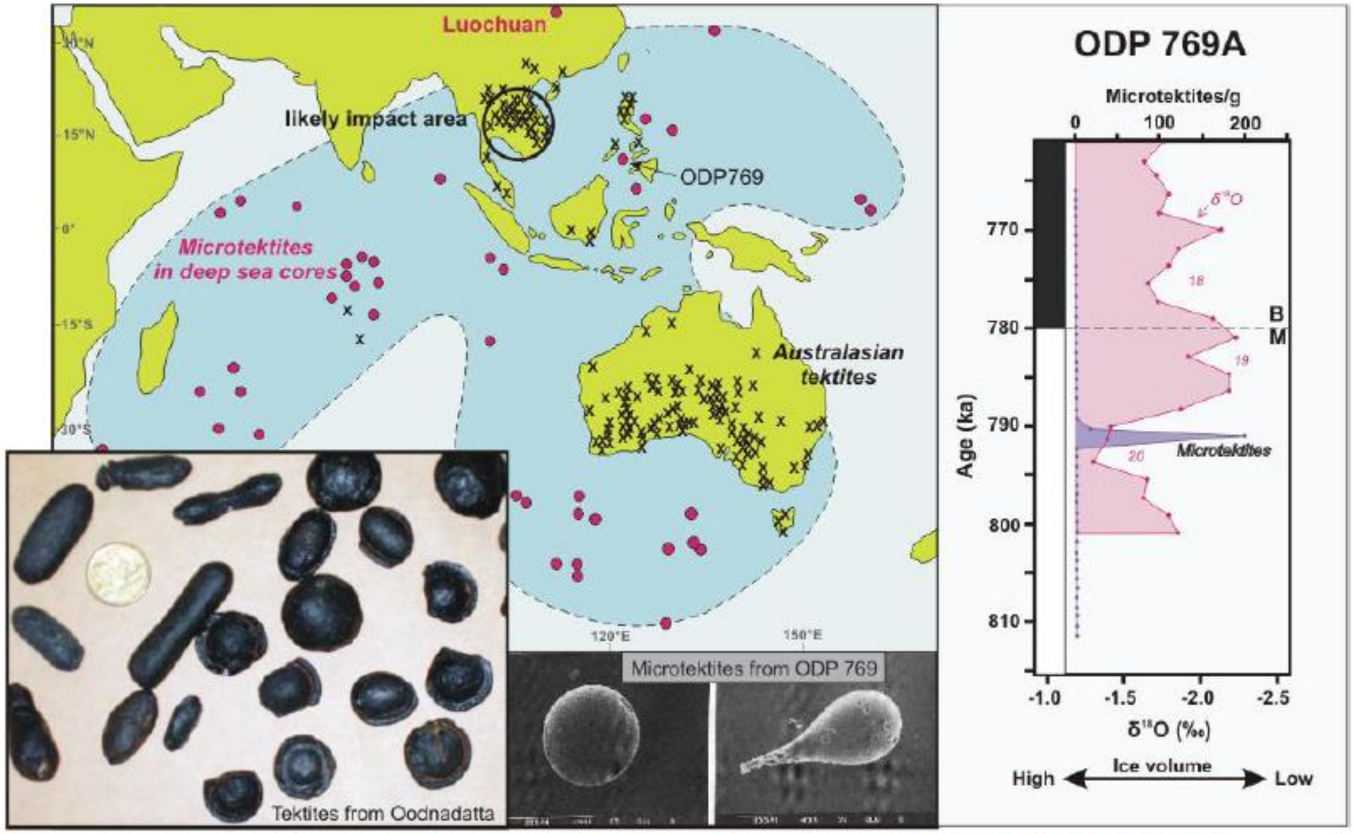


Falls+Finds	
WA	257
SA	123
NSW	48
NT	12
Vic	10
Tas	4
Q	20
Tot	474

Meyers Crater E to W impact 800Ka??

Darwin 800Ka

Australasian tektite strewn field (after Pillans et al., 2012)



Kalgoorlie tektites (from Pillans et al., 2012)

Acknowledgements

Resource Potentials

Peter Hepburn-Brown – ex Focus Minerals
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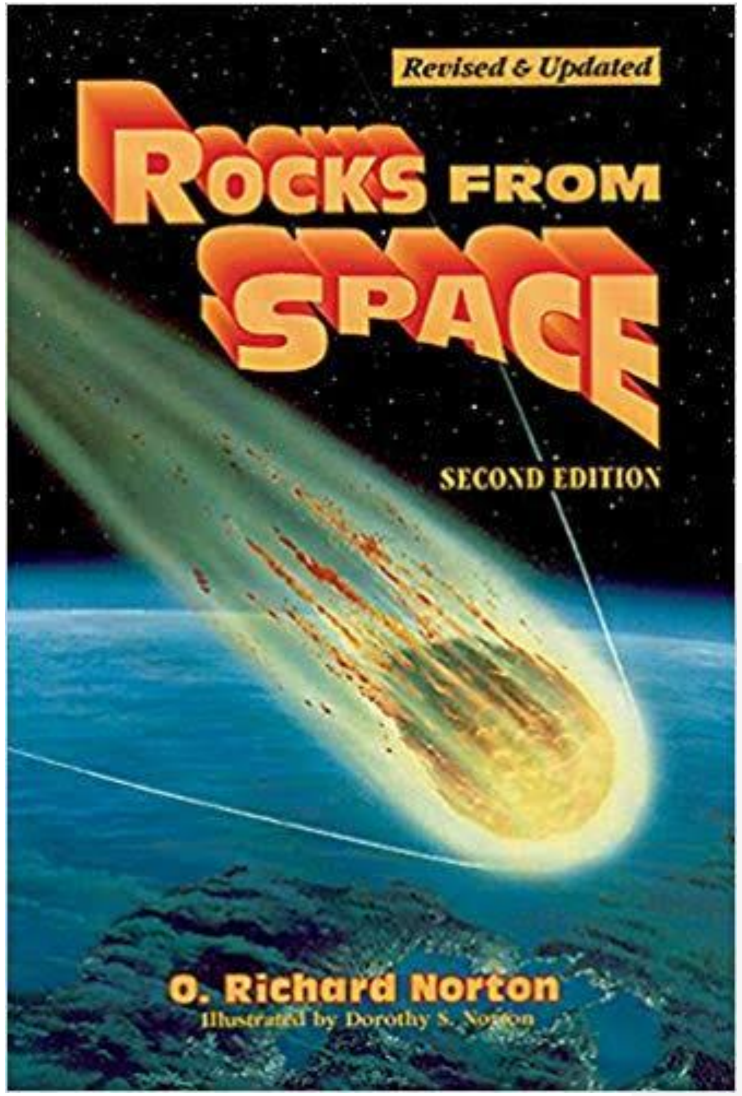
Matt Mayne – Wireline Services



Warning:

1 MORE IMPACT CRATER AND 1 IMPACT SRUCTURE, BOTH ABOUT 3KM ACROSS, ALSO RECENTLY FOUND IN EASTERN YILGARN TO FRASER COMPLEX

I WILL PRESENT ON THEM SOON, SO WATCH THIS "SPACE"….