Australian Society of Exploration Geophysicists

The Role of Geophysics in the Discovery of the Gonneville PGE-Ni-Cu-Co-Au Deposit, Julimar, Western Australia.

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ARMADA EXPLORATION SERVICES

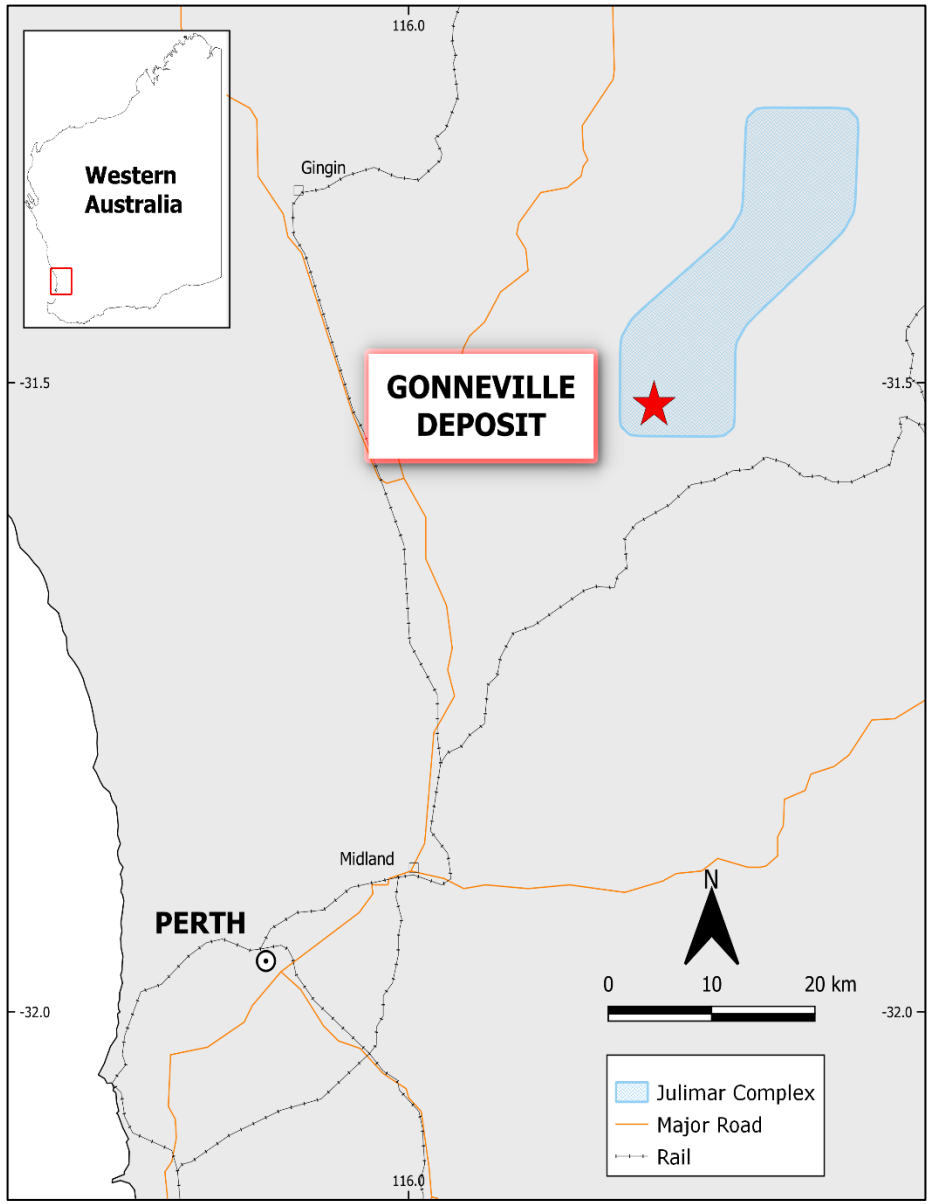
chalice

Presentation Outline

- Project location
- Geology
- Magnetics
- Gravity
- Electromagnetics
  - Moving-loop EM
  - Fixed-loop EM
  - Downhole EM
  - Airborne EM
- Julimar Complex Exploration
- Conclusion

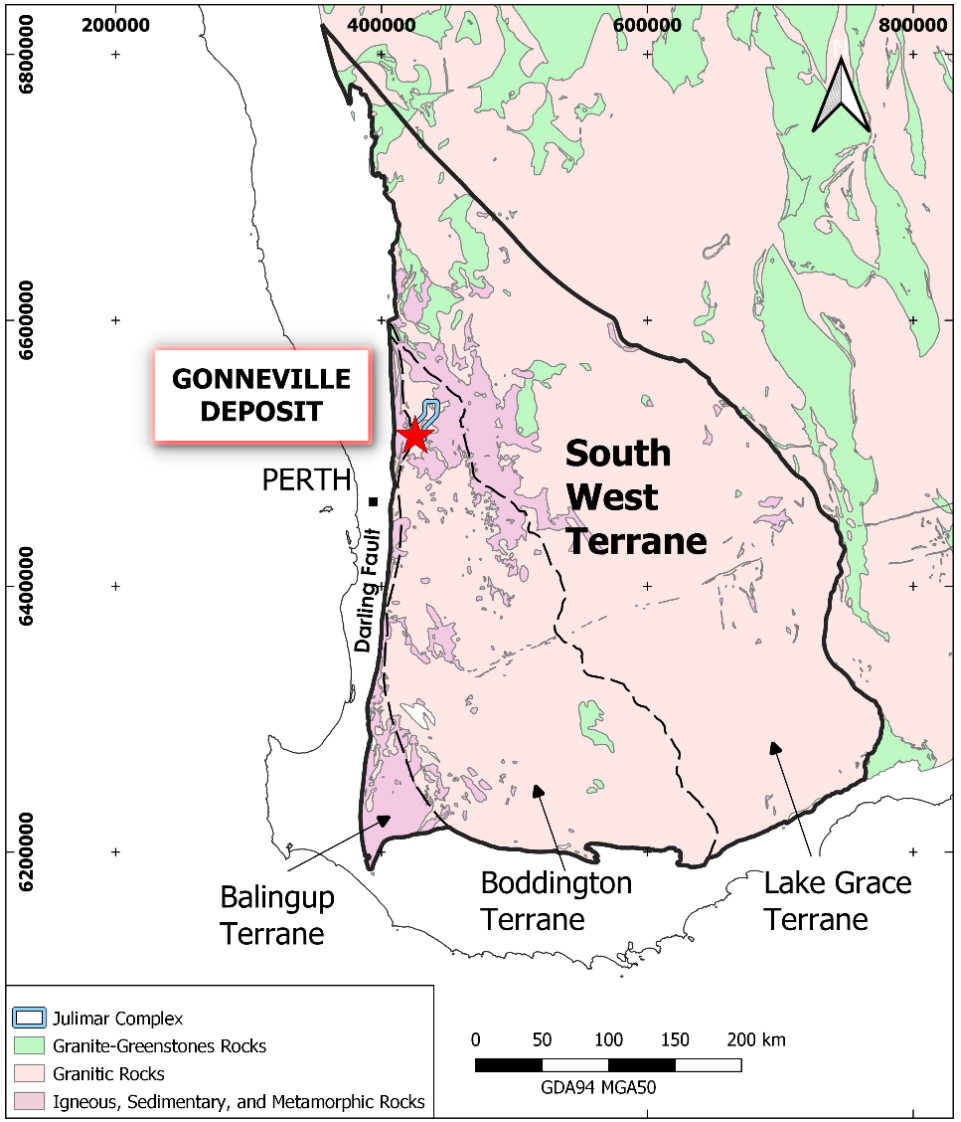
Location

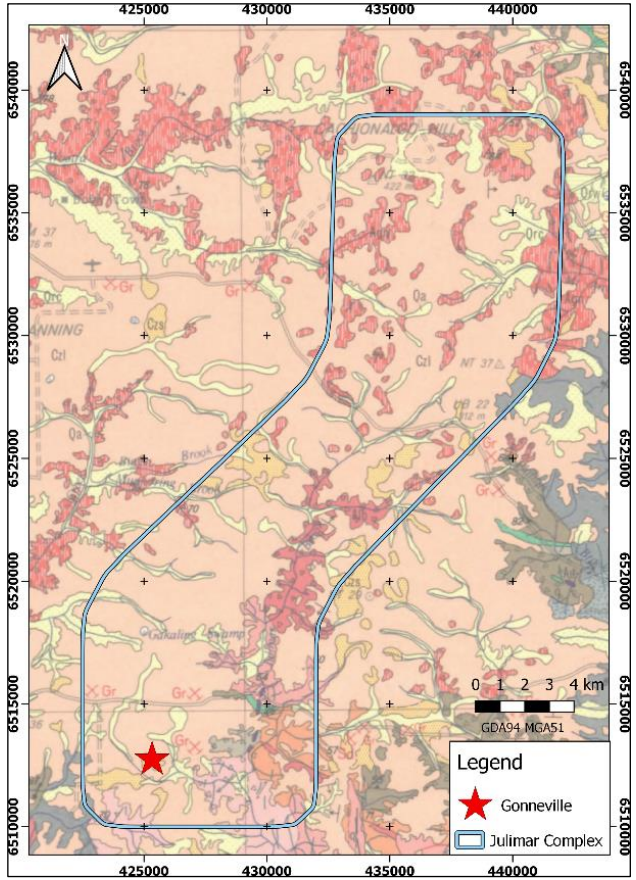
- Project is located 70km NE of Perth, Western Australia.
- Greenfield project staked by Chalice Mining in early 2018.
- Gonneville is located at the southern end of a >26km long, unexplored layered mafic-ultramafic complex (the Julimar Complex).
- Gonneville is the first significant discovery of an orthomagmatic sulphide deposit in the emerging West Yilgarn Ni-Cu-PGE province.



Regional Geology

- Located in the South West Terrane of the Archaean Yilgarn Craton.
- 1:250k Perth Map Sheet - No mapped outcrop over Gonneville, or the entire 26km strike length of the interpreted Julimar Complex.
- No definitive explanation for the Julimar Complex.

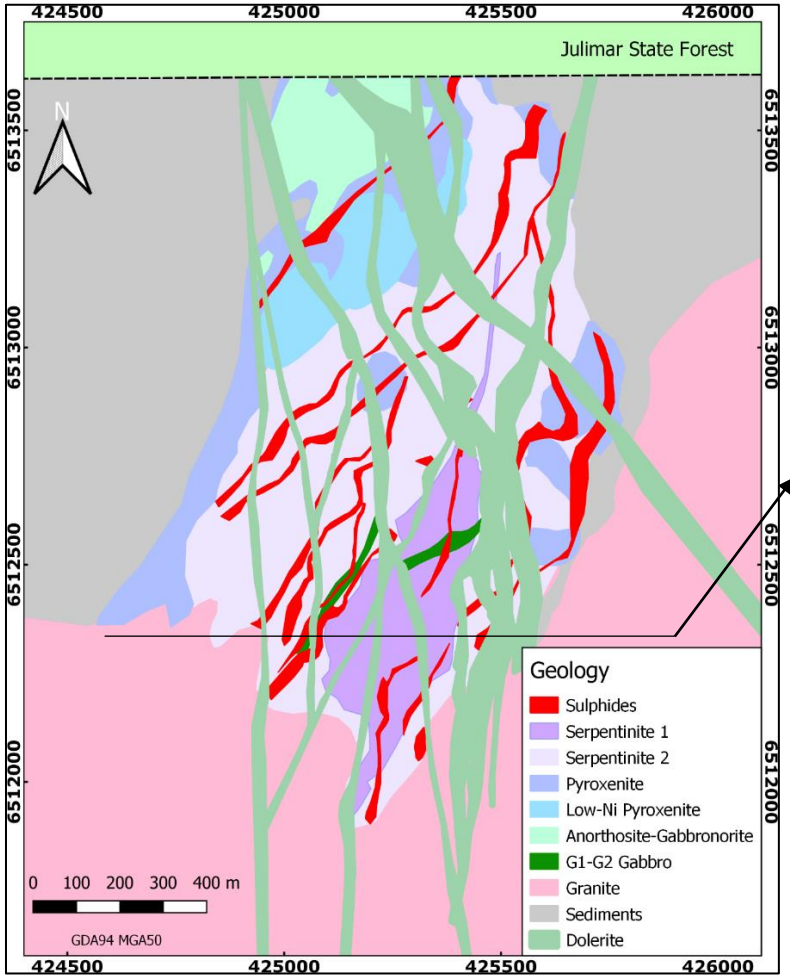


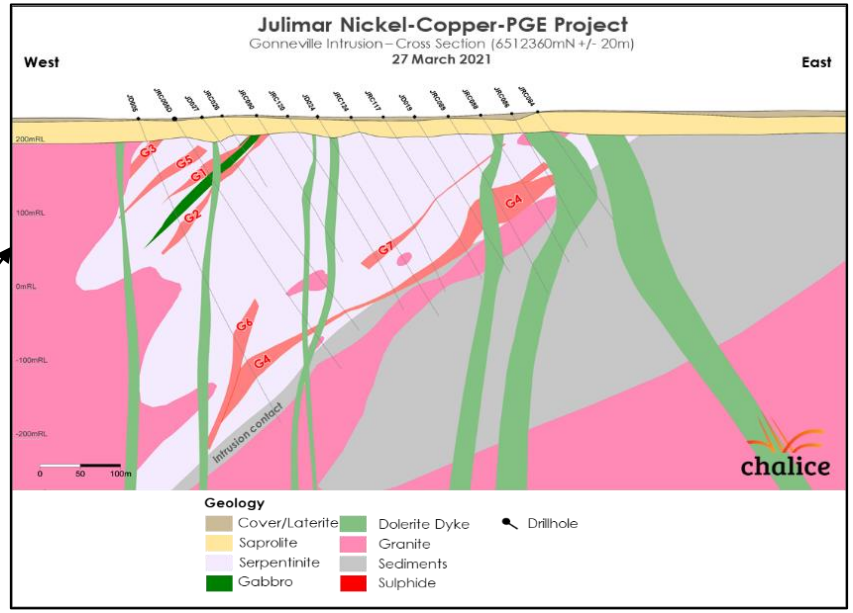


Gonneville Geology

- The Gonneville deposit is hosted in a 1.6km x 0.8km ultramafic-mafic intrusion.
- All intrusive rocks are metamorphosed.
- Gonneville comprises a series of sub-parallel sulphide-rich zones comprising a consistent assemblage of pyrrhotite-pentlandite-chalcopyrite.
- Maiden Mineral Resource announced November 2021 containing **330Mt @ 0.75g/t Pd, 0.16g/t Pt, 0.16% Ni, 0.1% Cu, 0.016% Co, and 0.03g/t Au** incl. 74Mt @ 1.4g/t Pd, 0.33g/t Pt, 0.22% Ni, 0.21% Cu, 0.021% Co, and 0.06g/t Au.

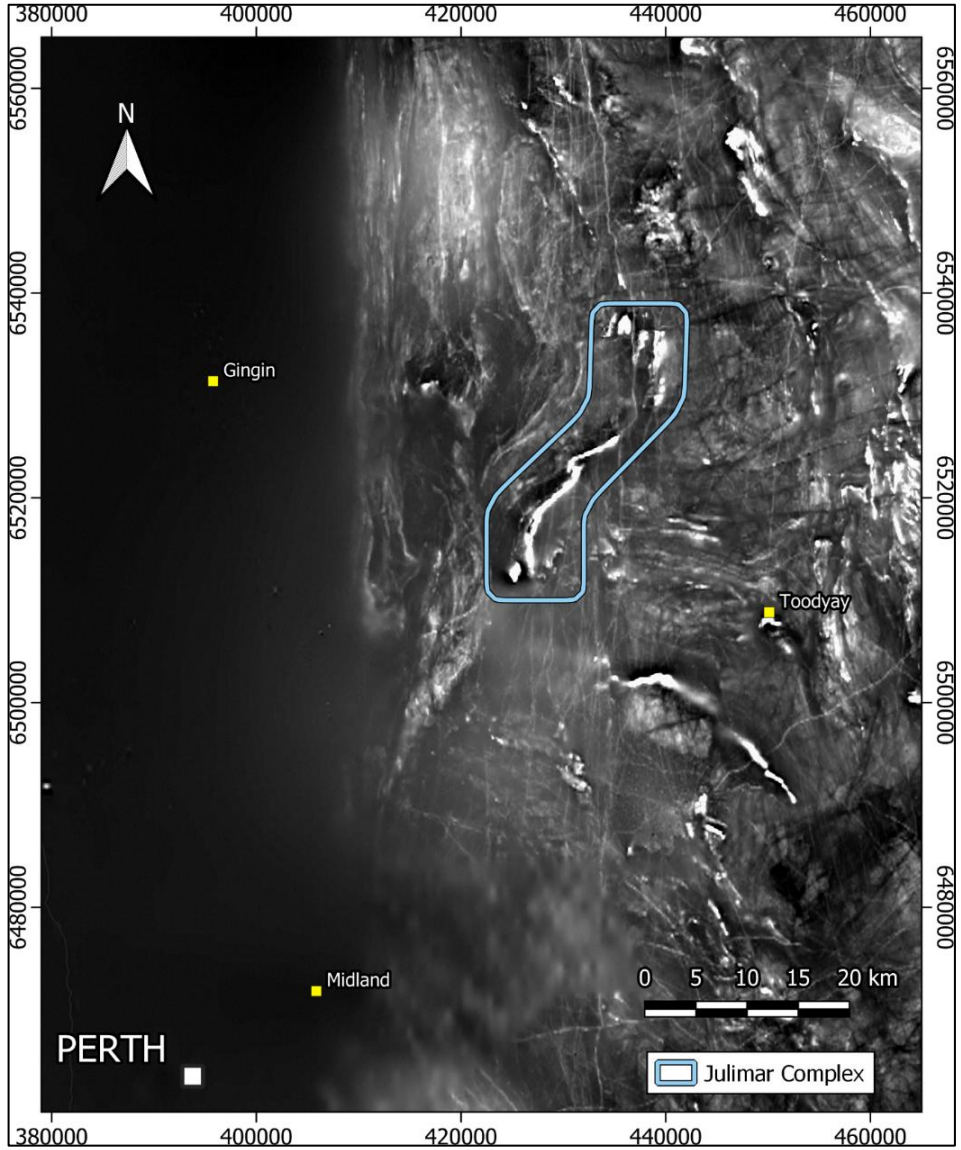
(CHN ASX announcement *Tier-1 Scale Maiden Mineral Resource at Julimar* dated 9th Nov 2021).



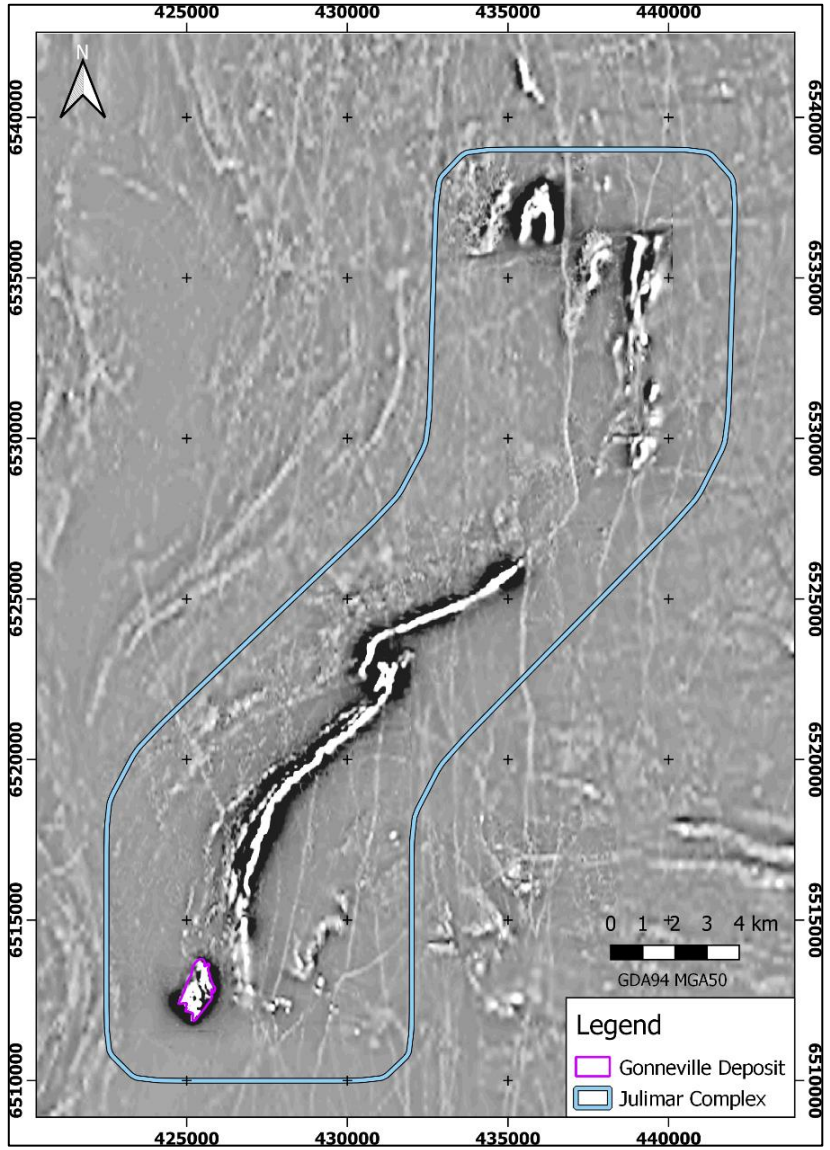


Regional Aeromagnetics

- 2011 Geoscience Australia aeromagnetic open-file dataset.
- 200m spaced E-W lines with a terrain clearance of 50m.



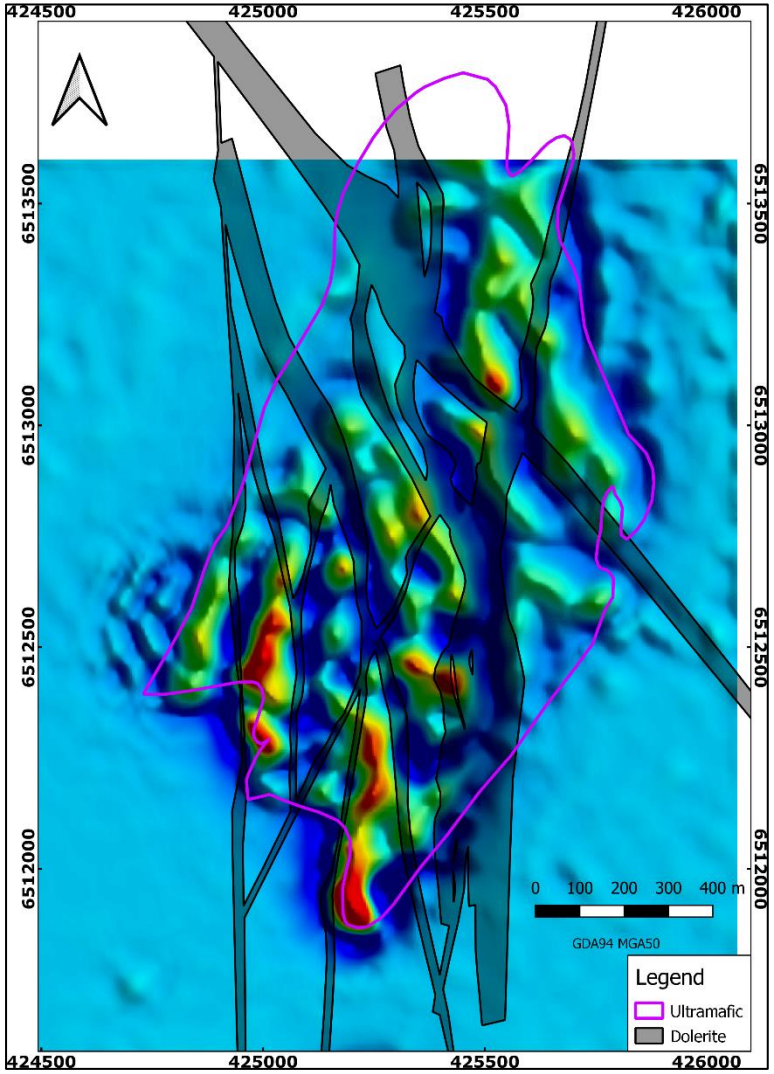
TMI-RTP (Brett J.W., 2020, 80m magnetic RTP merged grid of Western Australia 2020 version 1: Geological survey of Western Australia, <www.dmp.wa.gov.au/geophysics>)



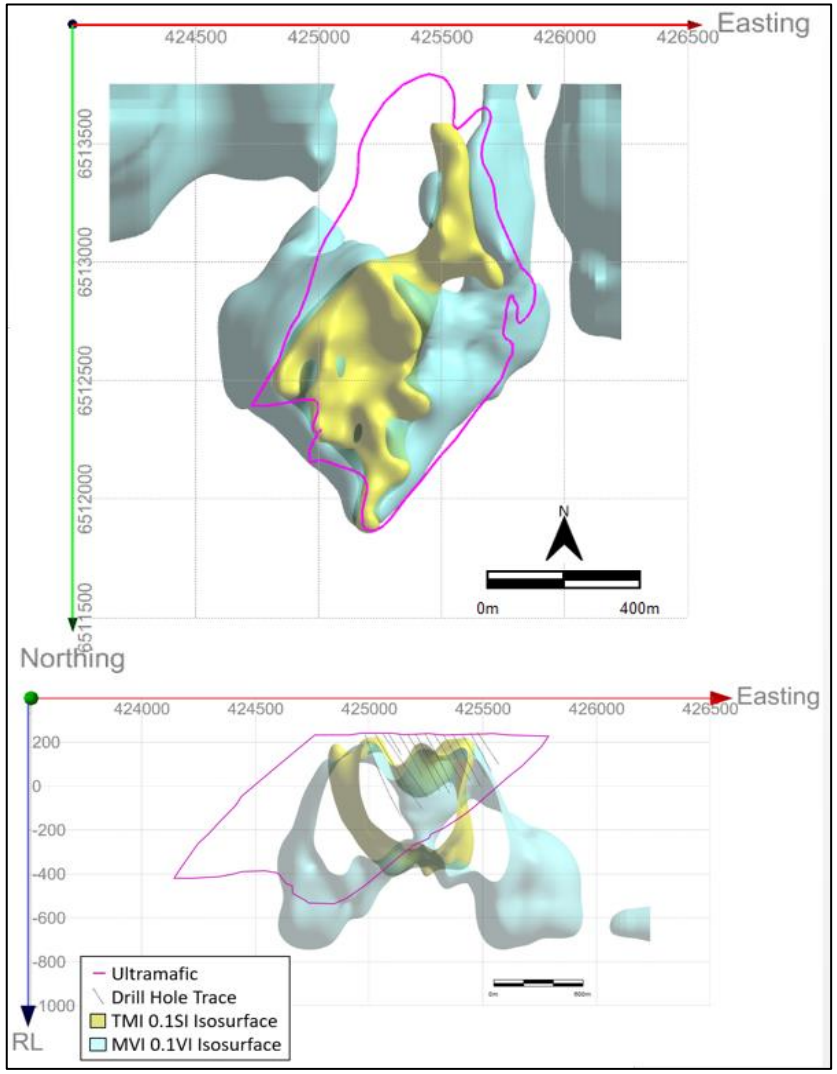
TMI-1VD-RTP

Gonneville Magnetics

- In April 2020, Pegasus Airborne conducted a UAV aeromagnetic magnetic survey.
- E-W lines at 25m and 50m line spacing, with a terrain clearance of 45m.
- Gonneville appears as a series of magnetic highs with amplitudes of +7000nT.
- Unconstrained Voxi TMI and MVI 3D inversions using a 10m x 10m X-Y mesh and 5m Z cell size.



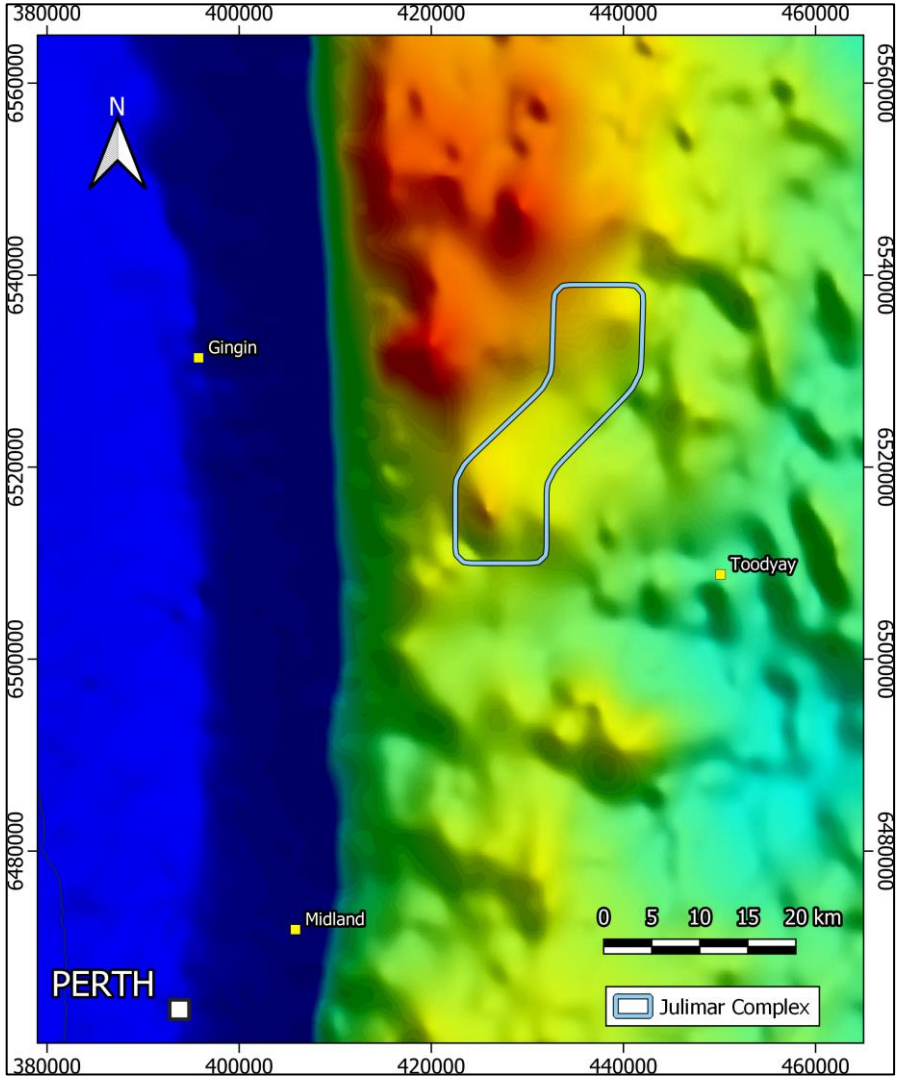
Magnetics (TMI-2VD-RTP)

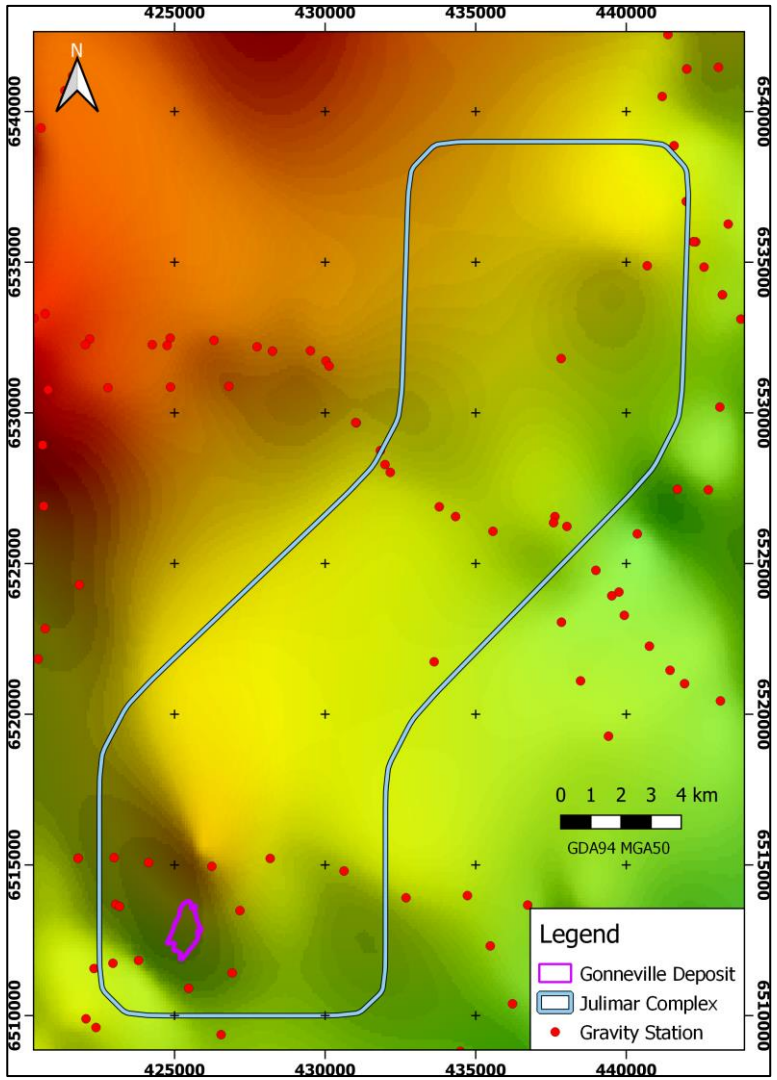


Unconstrained magnetic inversion

Regional Gravity

- 2015 Geoscience Australia gravity open-file dataset.
- Collected using light vehicle-borne gravity methods.
- 2km station spacing.

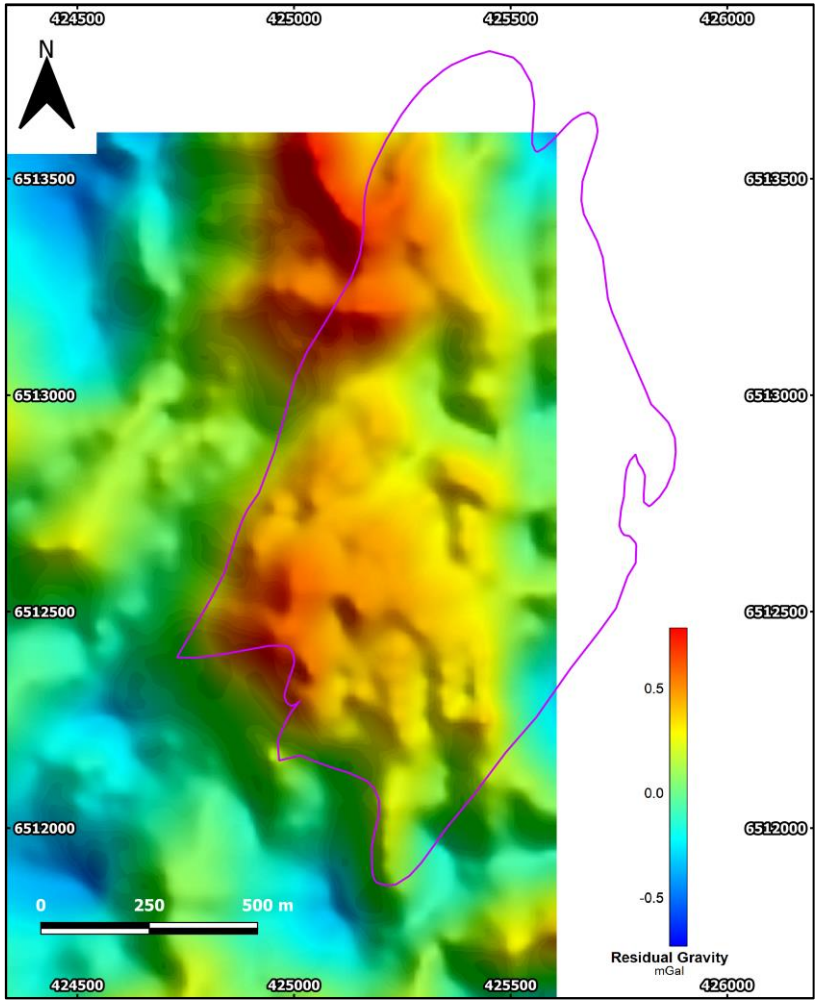




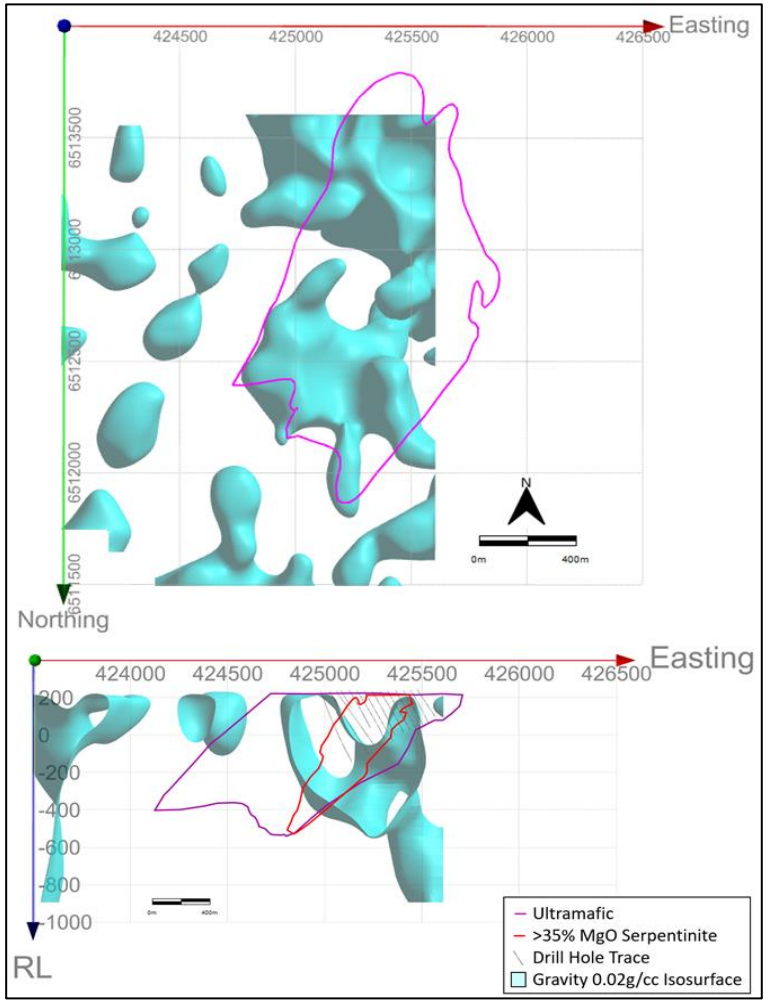
BG267 (Brett J.W., 2020, 400m Bouguer gravity merged grid of Western Australia 2020 version 1: Geological survey of Western Australia, <www.dmp.wa.gov.au/geophysics>)

Gonneville Gravity

- April 2020 and February-March 2021 gravity survey conducted by Atlas Geophysics.
- 1293 stations on a 100m x 100m grid over a 3.5km x 2.5km area and 50m x 50m over Gonneville (2.1km x 1km).
- Gonneville is characterised by a 0.7mGal high, coincident with the magnetic anomaly.
- Unconstrained Voxi 3D inversion using a 50m x 50m X-Y mesh and 10m Z cell size.



Bouguer gravity (residual)

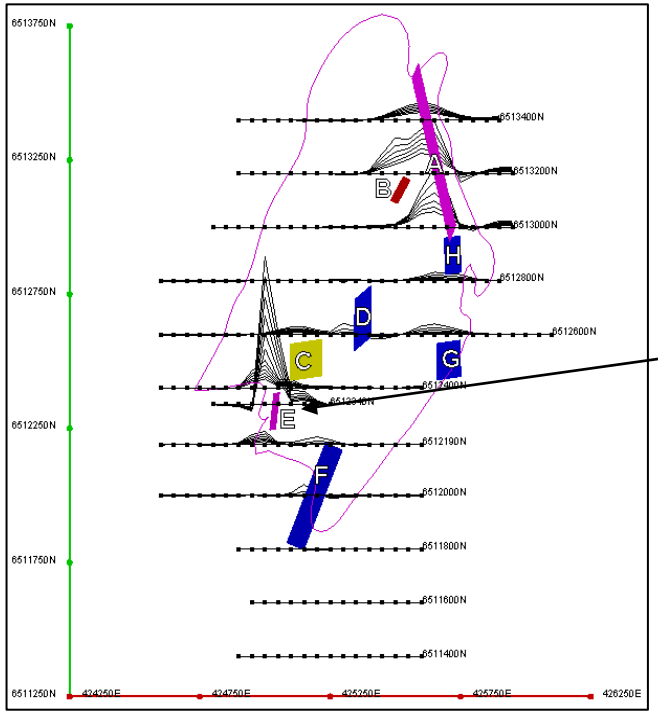


Unconstrained gravity inversion

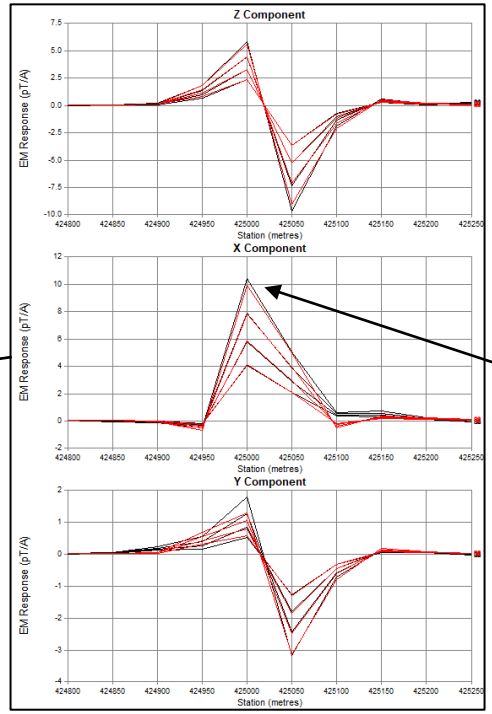
EM – Moving-loop EM

- May 2019 MLEM data collected by Vortex Geophysics.
- 200m line spacing and 50m station spacing. Slingram configuration, SMART Fluxgate sensor.
- Single turn 200m x 200m transmitter loops, current of 96A and a frequency of 0.5Hz. Infill on line 6512340N with 100m loops, 190A.
- Gonneville discovery anomaly had an amplitude of 0.16 pT/A in the latest time window (ch39, 324-416ms).
- Modelled with conductor E – 138m x 37m, 11800S.
- Conductors A and E screened with soil geochemistry. Conductor E showed up to 690ppm Ni, 1800ppm Cu.

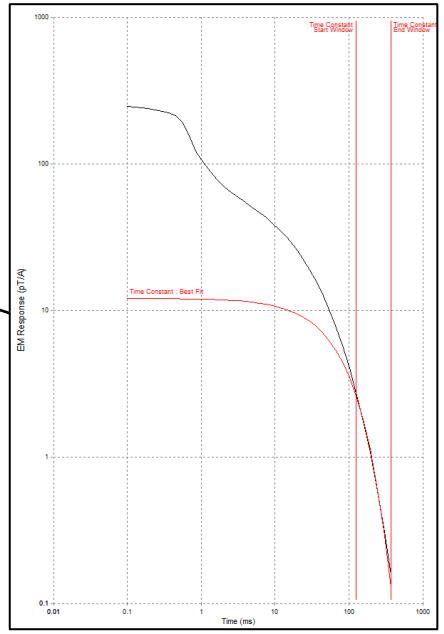
Plan view of modelled MLEM with X-component profiles ch25-30 (15 – 59ms)



Line 6512340N ch30-33 (46-114ms)



Line 6512340N Station 425000E Tau ≈ 80ms (X-comp ch34-39)

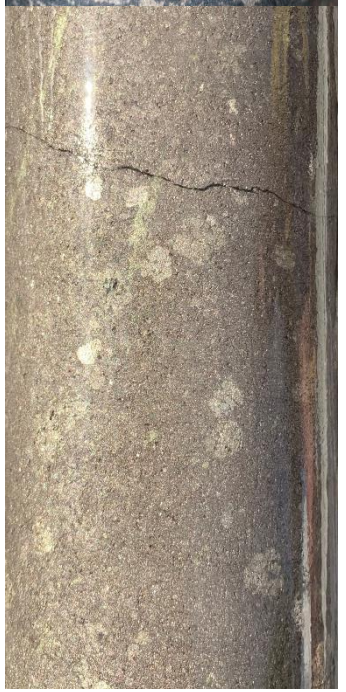


Gonneville Discovery

- Conductor E was drilled in March 2020 with RC hole JRC001.

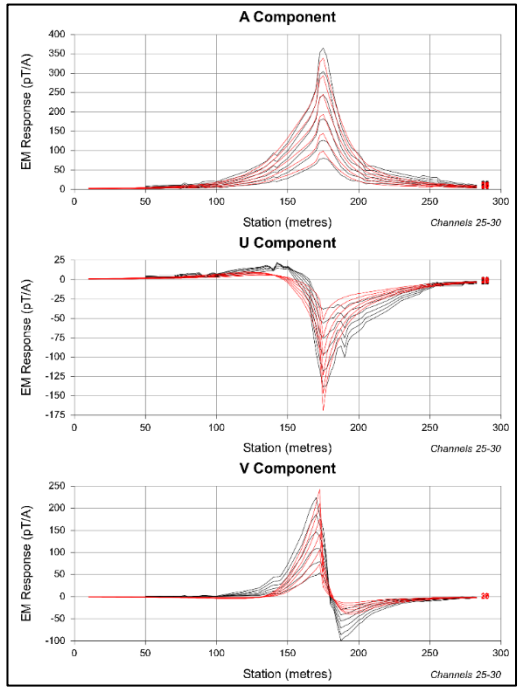
- Intersected massive, matrix and stringer sulphide mineralisation reporting **19m @ 8.4g/t Pd, 1.1g/t Pt, 2.6% Ni, 1.0% Cu and 0.1% Co** from 48m downhole.

- JRC001 was “scissored” with diamond hole JD002 which reported **75.1m @ 6.2g/t Pd, 1.7g/t Pt, 1.7% Ni, 0.7% Cu and 0.1% Co** from 34.9m, including **20m @ 11.1g/t Pd, 1.1g/t Pt, 3.1% Ni, 1.0% Cu, and 0.16% Co** from 47.7m.

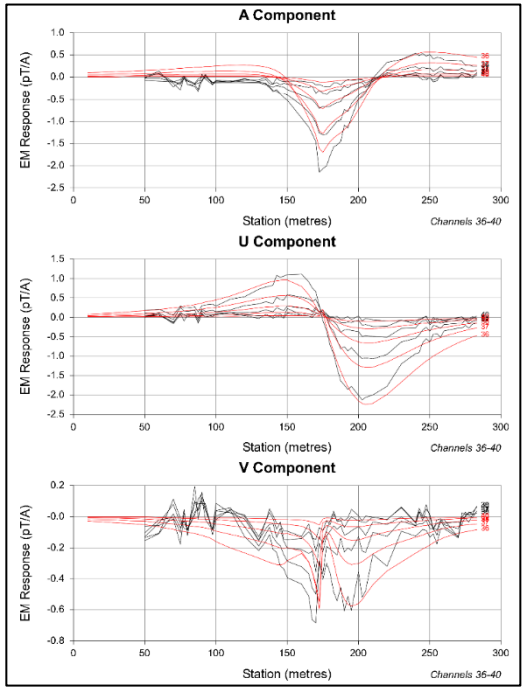


EM – Downhole EM

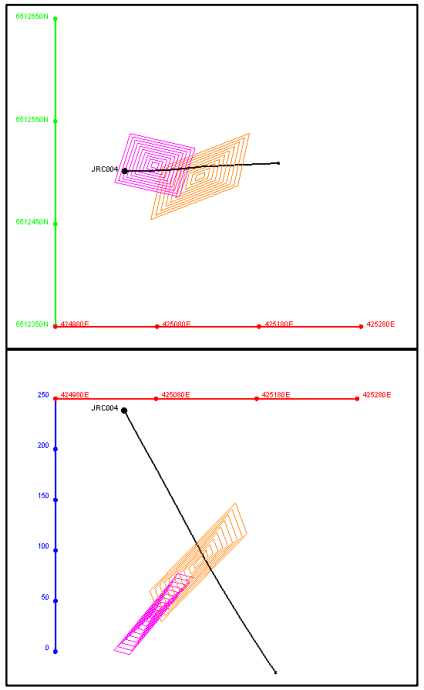
- In April 2020, JRC004 was drilled 185m north of the discovery hole to target MLEM Conductor C (modelled as a 135m x 400m, 1500S conductor).
- Although the hole intersected 58m @ 0.9g/t Pd and 0.24g/t Pt, the MLEM anomaly was unexplained.
- DHEM conducted with DigiAtlantis system using a 300m x 300m loop, transmitter current of 95A at a frequency of 0.25Hz.
- Off-hole anomaly modelled with a 60m x 100m, 15000S conductor.
- Suggested a massive sulphide source located below the drillhole.



In-hole response
ch 26-29 (19-48ms)



Off-hole response
ch 36-39 (169-417ms)



Plan (top) and view from south (bottom) of modelled DHEM conductors.

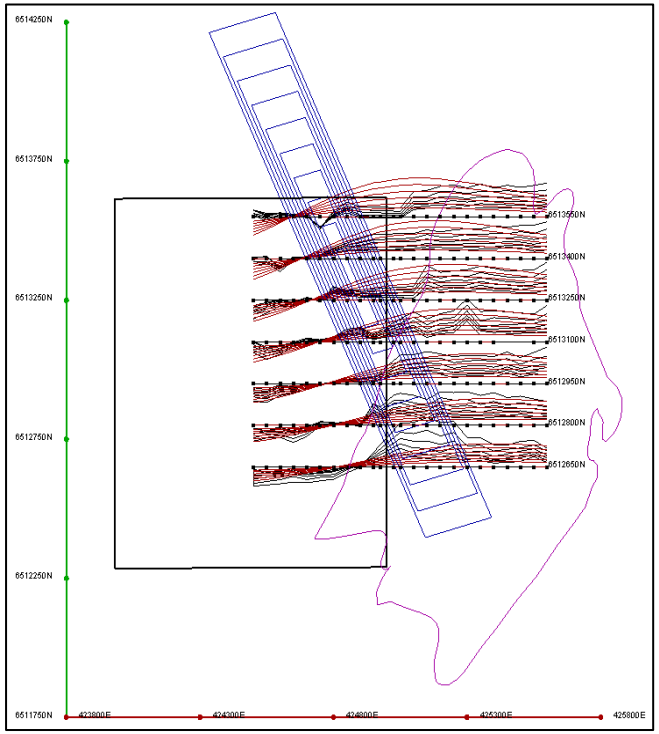
EM – DHEM Discovery

JD003 – 199.7m – 210.5m

- In May 2020, Conductor "JRC004_170m_OffHole_15kS" was drilled with diamond hole JD003.
- Intersected disseminated, matrix and massive stringer sulphide mineralisation reporting **17.6m @ 5.3g/t Pd, 1.0g/t Pt, 1.3% Ni, 0.6% Cu and 0.07% Co** from 191.4m downhole.

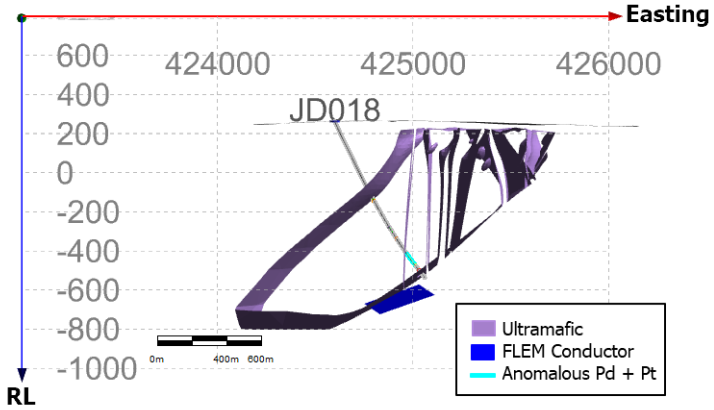
EM – Fixed-loop EM

- June 2020 FLEM data collected by GEM Geophysics.
- Supracon Jessy Deep High-Temperature SQUID employed.
- Two transmitter loops, single turn – 1330m x 1020m (north) and 740m x 1020m (south).
- Transmitter current of 60A at a base frequency of 0.25Hz.
- 13 lines with 150m line spacing and 50m station spacing.



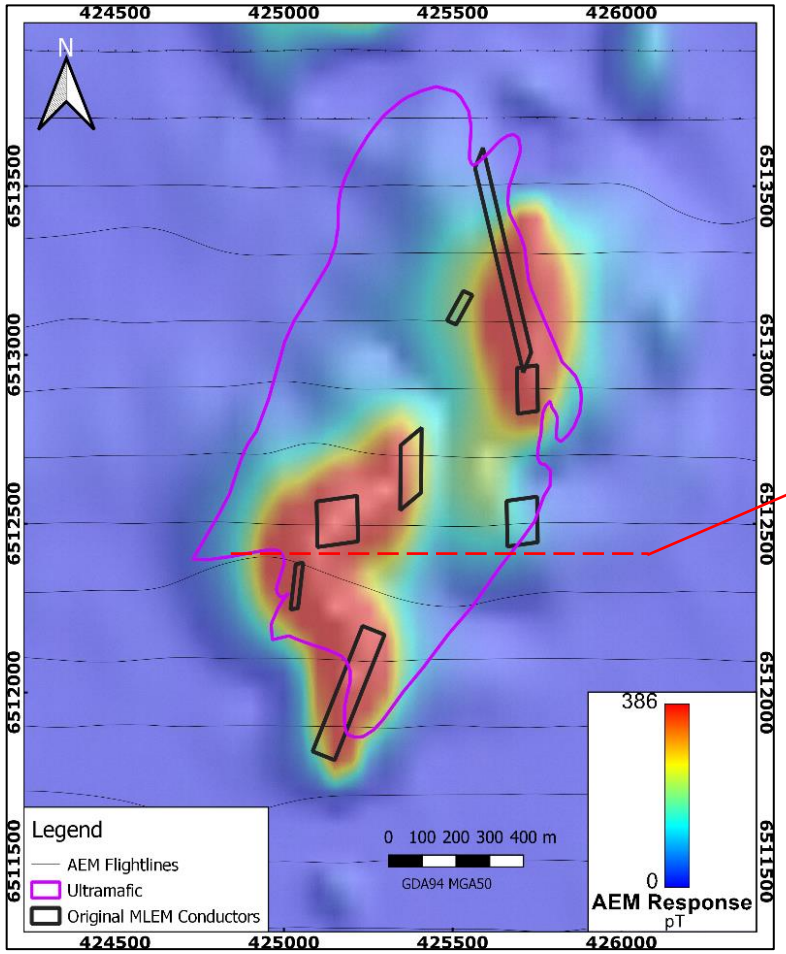
Modelled FLEM conductor with profiles of the X-comp channels 30 - 35 (46 – 175 ms).

JD018 intersected 113 m @ 0.6 g/t Pd and 0.1 g/t Pt in disseminated sulphides from 777 m downhole. Conductor explained by sulphidic sediments on footwall.

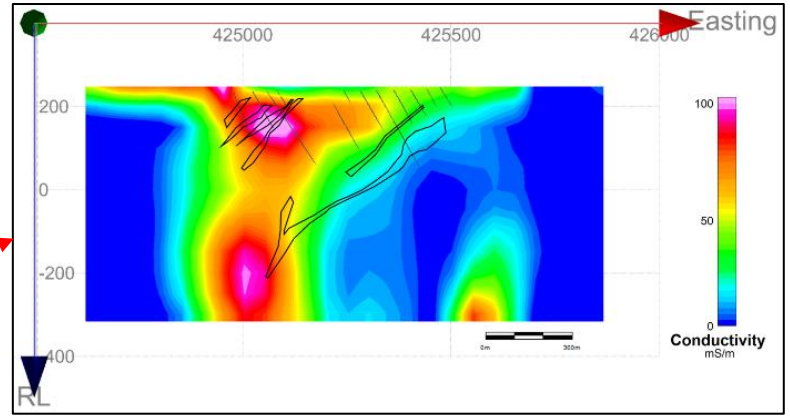


EM – Airborne EM

- In August 2020, CGG Geophysics flew a Helitem² survey over the Julimar Complex.
- Gonneville deposit is identified as a series of discrete early- to late-time anomalies.
- Anomalies match the positions of the MLEM modelled conductors.
- Differential conductivity provided by CGG shows a good correlation between the higher conductive zones and sulphide mineralisation.



Helitem Bz channel 15 (2.9-3.7ms)



Differential conductivity section at 6512400N

Julimar Complex Exploration

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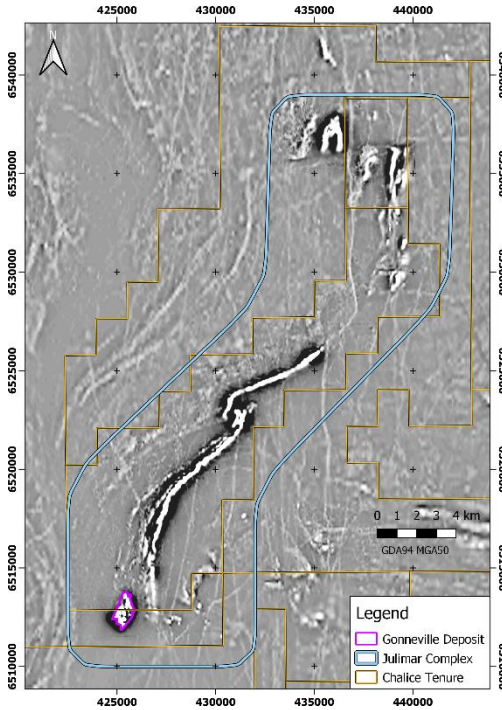
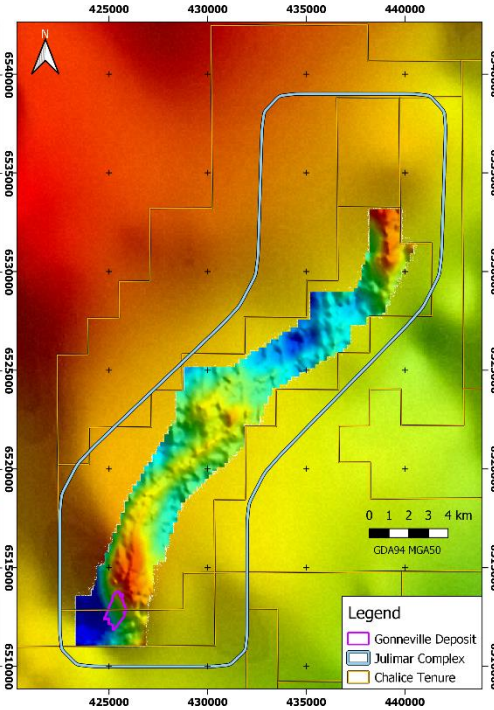
Magnetics (1VD-RTP)



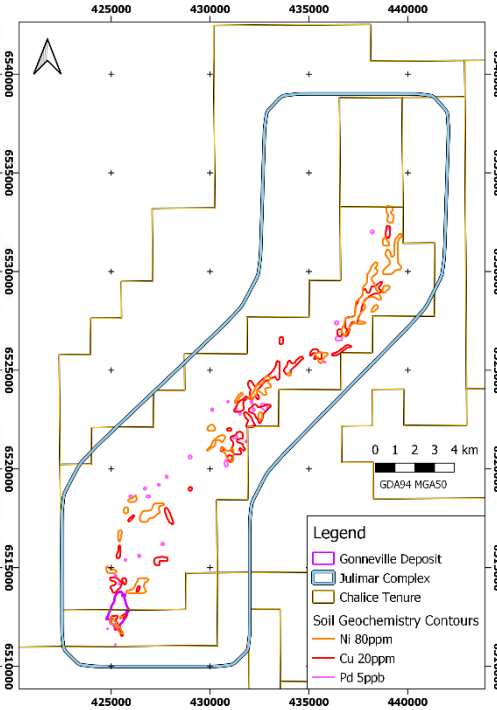
Merged 200m lines, 25m over Gonneville

Gravity (residual)



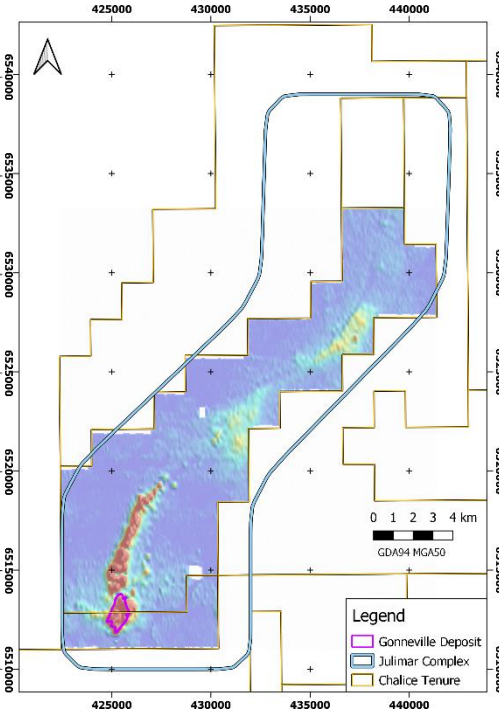
200m stations, 100m over Hartog, 50m over Gonneville

Soils Geochemistry



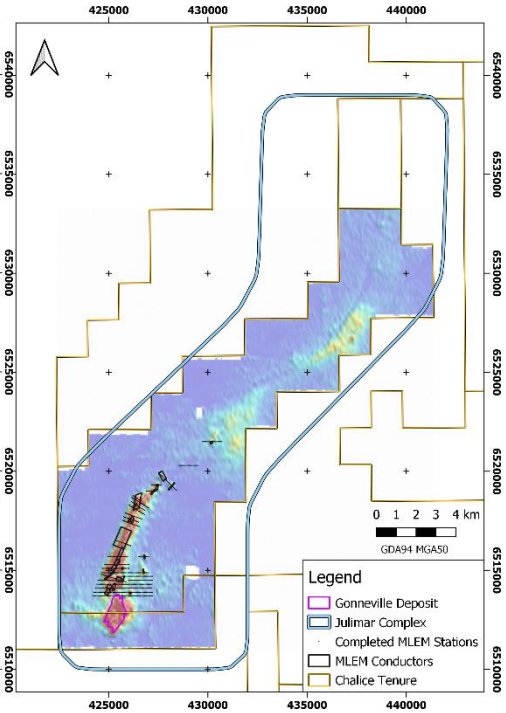
400m x 200m and 200m x 100m spaced grids

AEM (Channel 15)



200m lines

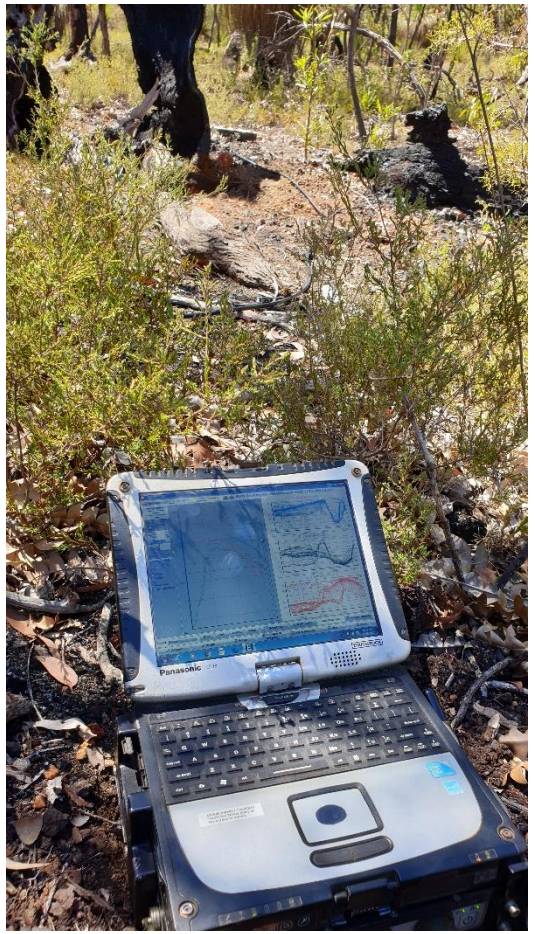
MLEM over AEM



50m stations, 100m loops

Chalice 3D tour of Julimar
https://inventum3d.com/c/chalicemining/julimar

State Forest MLEM



GEM Geophysics crew collecting MLEM data within the Julimar State Forest.

Conclusion

Gonneville discovery:

- The Gonneville deposit was discovered with systematic exploration.
- Regional open-file government magnetic and gravity data were used to target a large intrusive complex.
- A soil survey revealed anomalous Ni and Cu responses over at least some of the prospective geology.
- MLEM identified strong conductors consistent with massive sulphide mineralisation which allowed for precise drill targeting.

Following initial discovery:

- DHEM was used to identify additional sulphide mineralisation peripheral to the drillholes.
- Detailed magnetic and gravity data, and the associated inversions, have provided a broader understanding on the geology and structure of the intrusion.
- The success of ground EM methods led to a large AEM survey across the entire Julimar Complex. This revealed prospective conductors to the north and along strike from known mineralisation which are currently the focus of initial exploration outside of Gonneville.

Future geophysics:

- Continue to use DHEM to vector toward higher-grade parts of the mineralisation.
- Constrained inversions at Gonneville.
- Additional detailed gravity, magnetics and EM surveys over Chalice tenure.
- Explore other geophysical techniques such as seismic to see deeper at Gonneville.

Acknowledgements

- Fellow co-authors Kevin Frost and Bruce Kendall
- Chalice Mining for permission to present this paper
- Morgan Frejabise for his contribution including the initial conceptual targeting, area selection and initial target generation which led to this exploration discovery
- Matthew Demmer at Chalice
- Dave Stannard (formerly Resource Potentials)