Geology and geophysics of the Ora Banda asteroid impact structure, Western Australia

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SUMMARY

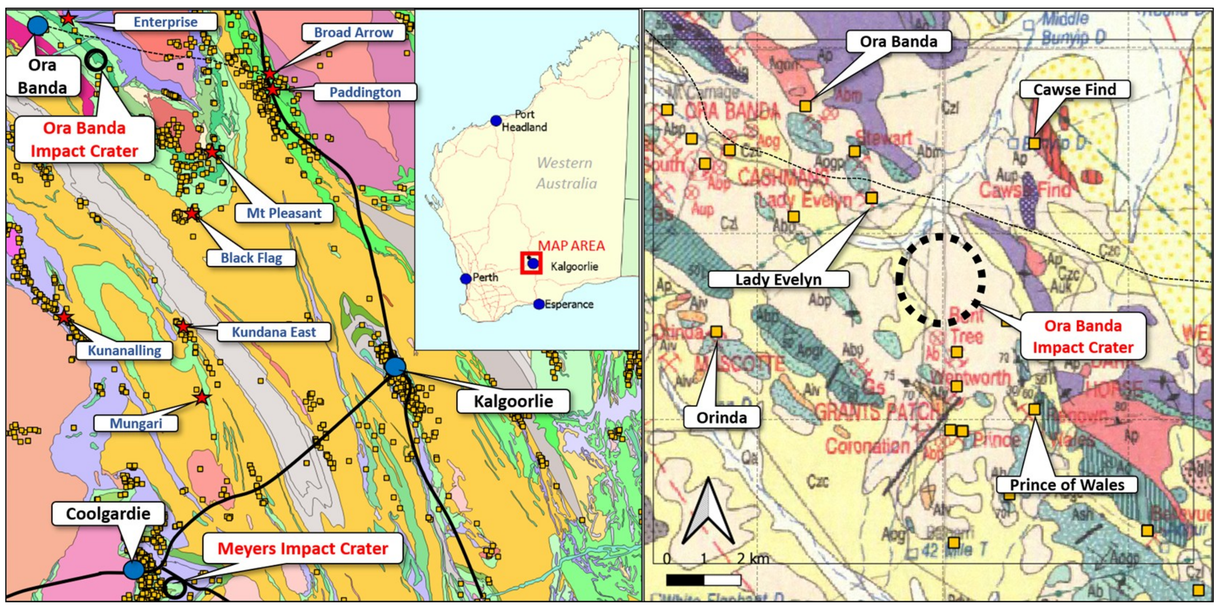
The Ora Banda asteroid impact structure is a 5km wide complex crater discovered during gold exploration in 2020, located 50km to the west of Kalgoorlie. There is no topographic expression, because it is hidden below Cainozoic regolith cover. It was uncovered by ground gravity, aeromagnetic and passive seismic HVSR geophysical surveys, diamond and reverse circulation drilling, and outcrop mapping in an exposed window of a central uplift. The impact rocks are Archaean greenstones containing shatter cones, an overlying fall-back suevite breccia containing glass droplets and shocked quartz, which is overlain by post-impact sand-silt crater fill at the base having palynofloral assemblages providing an impact upper age limit of 130Ma (Early Cretaceous), which is then overlain by Cainozoic silt-clay and laterite.

Key words: Ora Banda crater, asteroid impact, meteorite, Eastern Goldfields, passive seismic HVSR, shatter cones, planar deformation features

GEOLOGY OF THE ORA BANDA IMPACT STRUCTURE

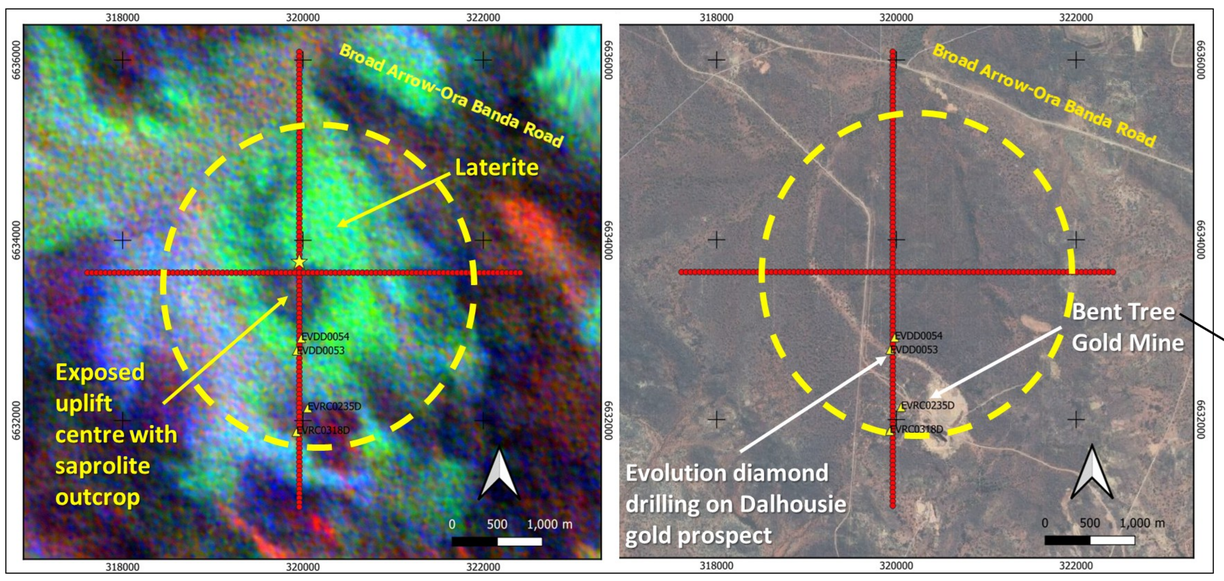
The Ora Banda impact rocks are Archaean greenstones (ca 2.75Ga), mainly tholeiitic basalt flows and gabbro sills (see Meyers et al., 2001). Palynofloral assemblages in post-impact sediment layers filling the bottom of the crater basin provide an upper age limit for the impact at about 130Ma (Early Cretaceous; Nguyen, 2021). The impact structure has no discernible morphological crater features at surface, it is mostly hidden by regolith cover, and it is surrounded by gold and nickel mines, contains the Dalhousie gold prospect, and mineral occurrences, of the Ora Banda mining district.

MESOZOIC AND CAINOZOIC IMPACTS INTO ARCHAEAN GREENSTONE BELTS

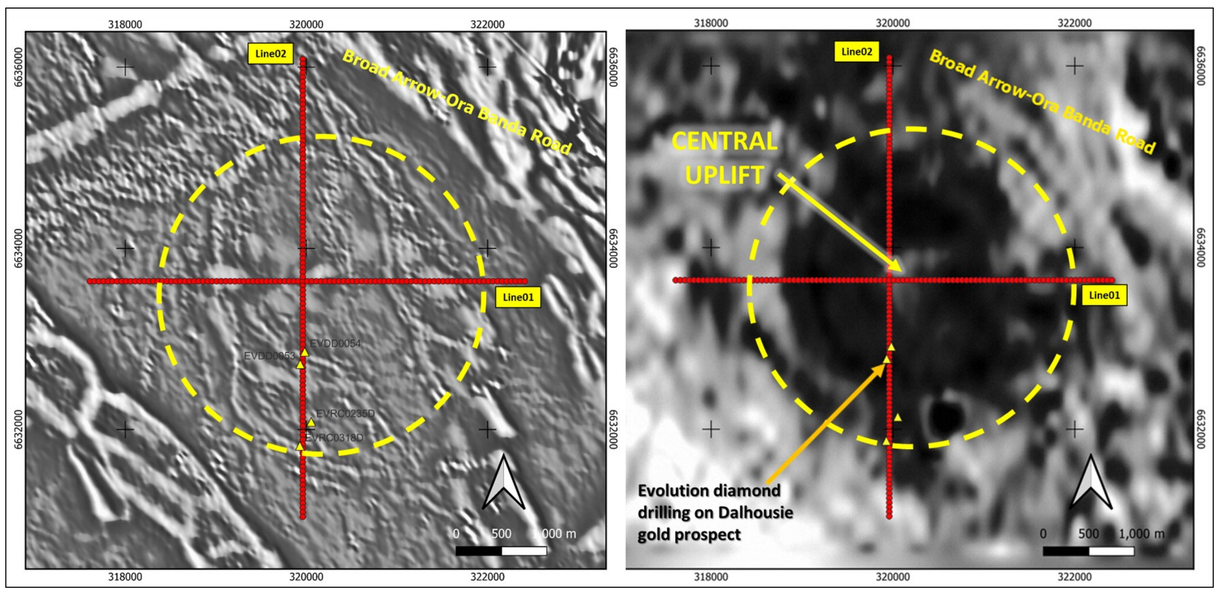


GEOPHYSICS OF THE ORA BANDA IMPACT STRUCTURE

RADIOMETRICS AND GOOGLE EARTH SATELLITE



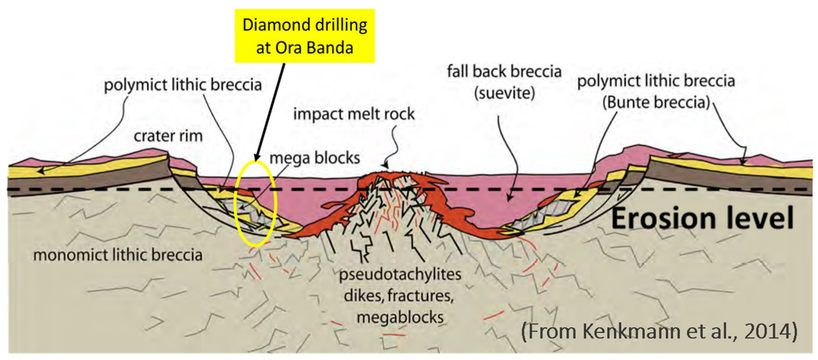
FILTERED AEROMAGNETIC AND HIGH RESOLUTION GRAVITY



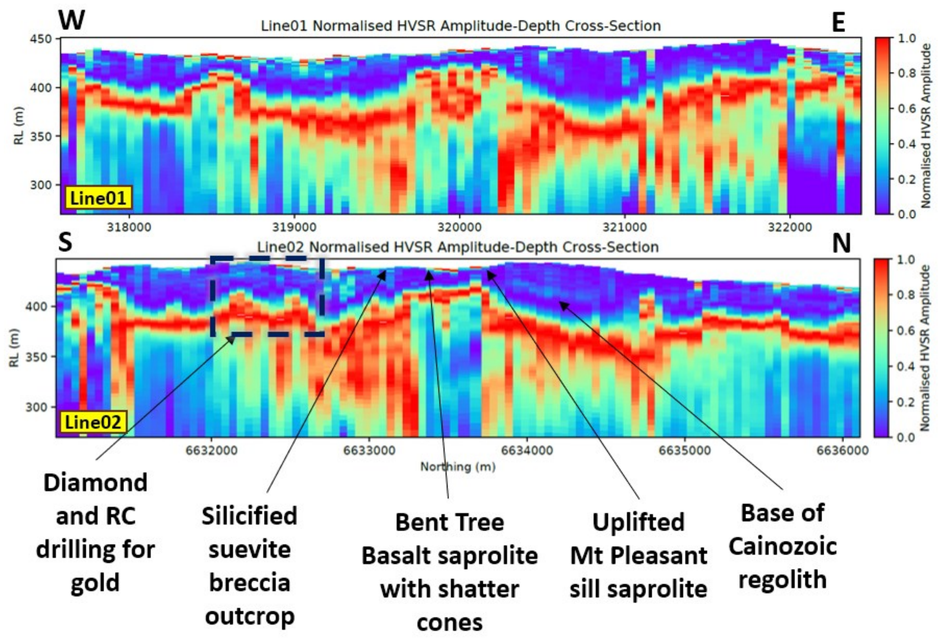
Radiometric data map out laterite in Th formed over the crater structure to form an inverted valley, but this layer has been stripped by erosion over part of the central uplift. High-resolution gravity data were key in defining the Cainozoic nature of the impact structure with present diametre of 5 km. A circular gravity anomaly low forms a ring around a high zone in the middle central uplift zone, forming a complex crater structure, later confirmed by drilling, greenstone outcrop and passive seismic surveying.

MODEL CROSS-SECTION OF A COMPLEX CRATER AND PASSIVE SEISMIC HVSR CROSS SECTIONS

Uplift of the Yilgarn Craton and lower sea levels since the Cretaceous has led to erosion of the top of the impact structure by several hundreds of metres. Only a small window of basalt and gabbro outcrop, and saprolitised/silicified suevite breccia, are exposed in the central uplift area, which is mainly surrounded by Cainozoic laterite forming an inverted valley and by younger colluvium. HVSR cross sections show acoustic bedrock being fresh greenstone below impact deposits and regolith, and define a classic complex crater structure.

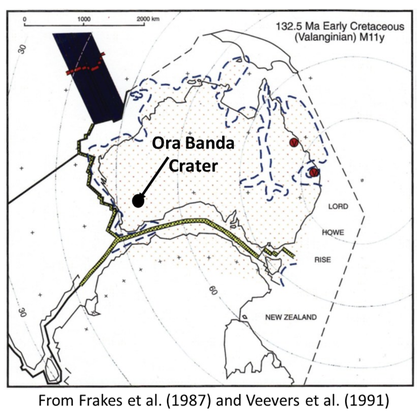


Model cross-section of a complex crater reproduced from Kenkmann et al. (2014), showing the present erosion level for the Ora Banda crater.



Tromino HVSR passive seismic surveying

HAUTERIVIAN PALEOGEOGRAPHY – RELATIVELY HIGH SEA LEVEL AND POST-IMPACT VEGETATION



From Frakes et al. (1987) and Veevers et al. (1991)

Basalsands over suevite breccia contain Early Cretaceous brackish water dinoflagellate cysts Gagiella mutabilis and maybe Canningia reticulata, and pollen spores from surrounding temperate forest, confirming Early Cretaceous age for base of post-impact crater fill as an upper age limit.

Pollen grains

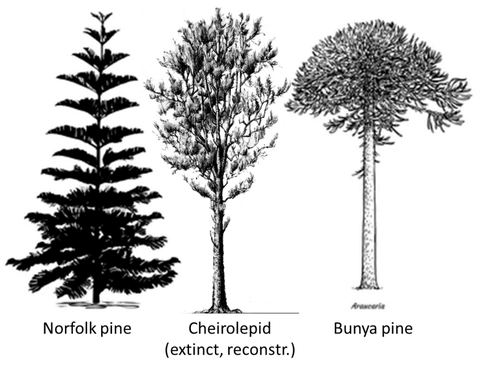
Spores

Understory composed by ferns (Osmundaceae, Matoniaceae)

Conifer forests including dominant Araucariaceae (family of the Norfolk pine), Podocarpaceae (plum pine family), intermixed with extinct conifer family Cheirolepidiaceae

Pseudotachylite veins in outcrop at Bent Tree Gold Mine

Middle tier including tree ferns (Cyatheaceae), Cycadales and Bennettitales



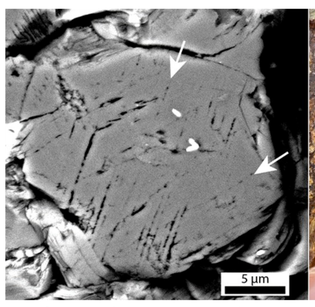
EVIDENCE - SHATTER CONES, SUEVITE BRECCIA, SHOCKED QUARTZ, PSEUDOTACHYLITE AND ELEVATED Ir, Pt, Pd and Ni IN GLASS DROPLETS

Shatter cones in drillcore

Shatter cones in weathered outcropping basalt

Suevite breccia in drillcore

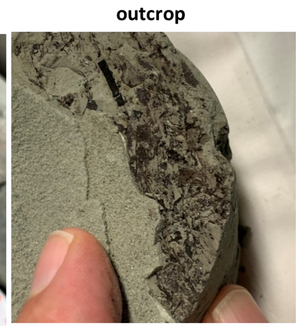
Silicified suevite breccia outcrop



Planar microstructures in quartz from suevite breccia drillcore

Macroscopic shocked quartz in outcrop at central uplift zone

Pseudotachylite on reactivated fault in drillcore



Basal Cretaceous sandstone containing plant microfossils

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