

Meteorite impact structures of Western Australia

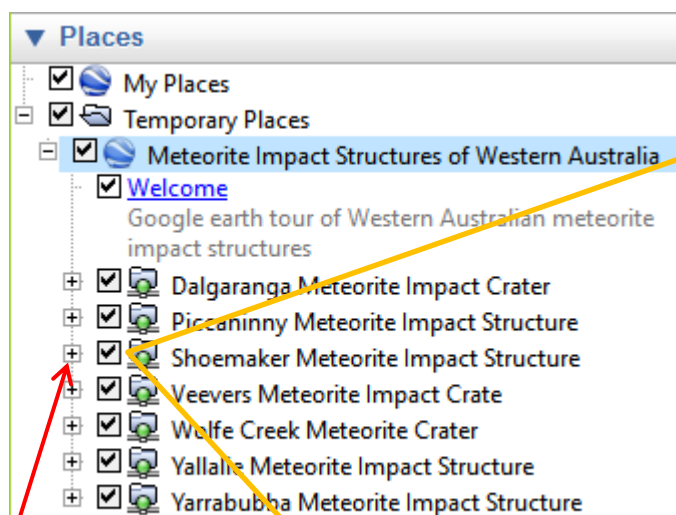
Features of the impact structures virtual tour

Impact structures in the virtual tour can be viewed in any order, and selected parts of the tour can be viewed at random.

Please note: It is not possible to have more than one placemark window open at any time. In addition, opening an external figure via a hyperlink will cause the current placemark window to close. *These are limitations of Google Earth.*

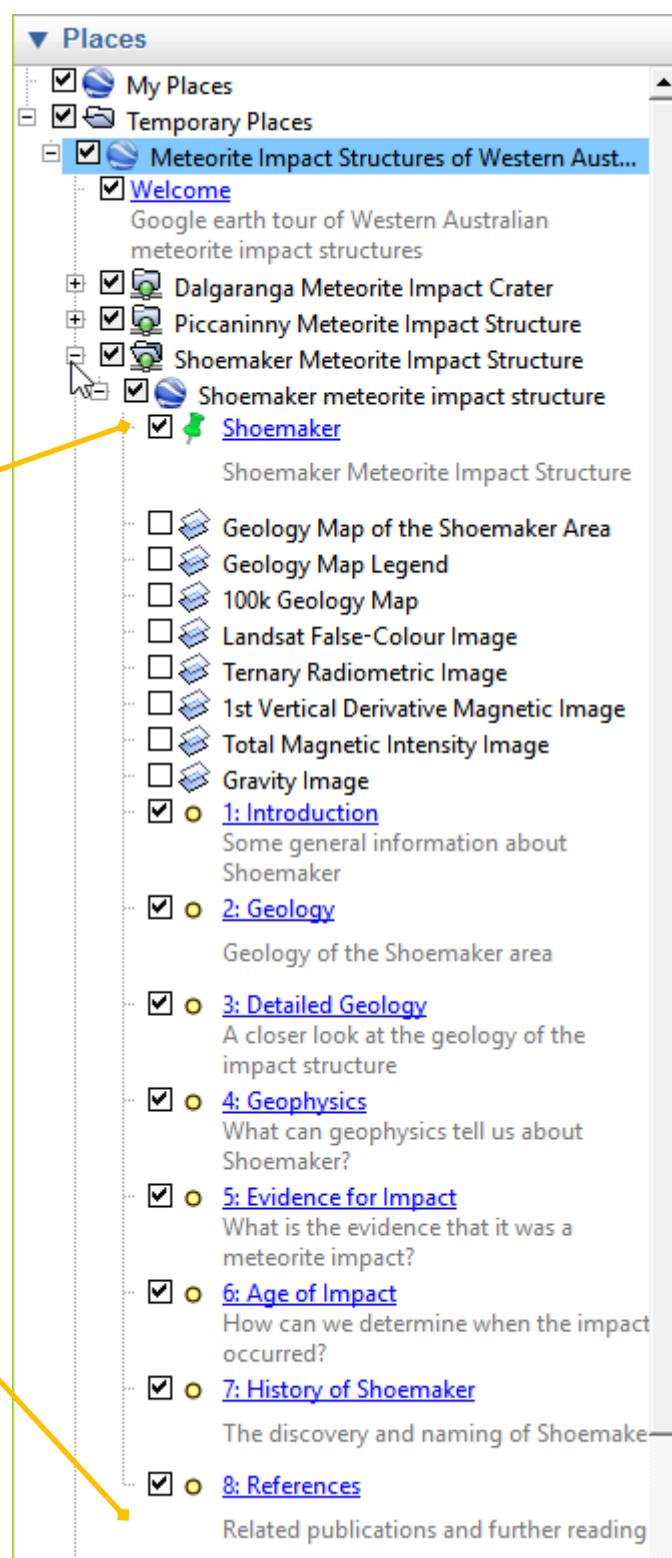
(1) Places panel

The places panel on the left hand side of the Google Earth window shows a folder-like list of all the impact structures in the tour and allows you to expand or collapse the individual parts of the tour. The list is collapsed when the tour is first opened:



A click on the expand/collapse symbol for the Shoemaker impact structure expands the list to show all of the available content for Shoemaker

The list of places can be expanded (or collapsed) by clicking on the expand/collapse controls (plus/minus, or rotating arrow symbols depending on the set-up of your computer). In addition, sections of the tour (placemarks, overlays, or even entire impact structures) can be turned on or off as desired using the check boxes.

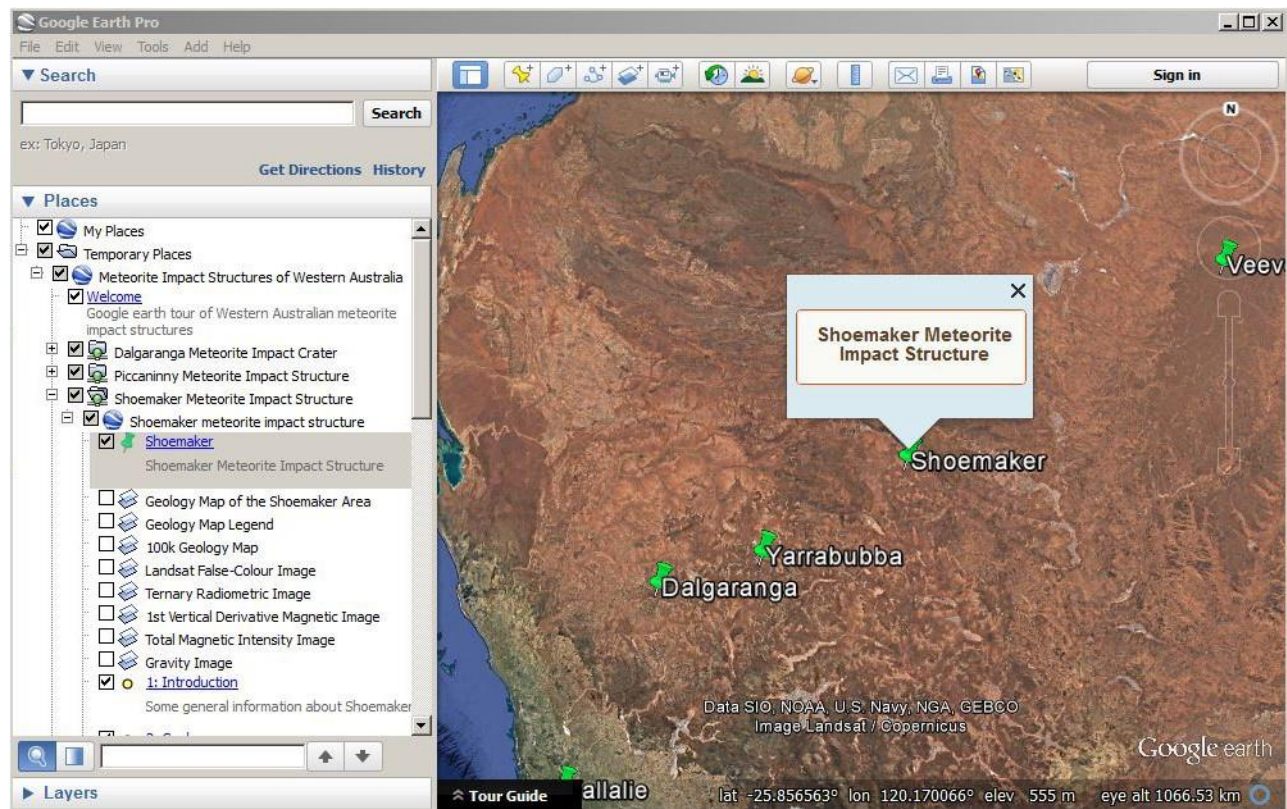


Click on the links (blue; underline) to view the placemark window for localities of interest. A double-click will make Google Earth 'fly' to the locality before opening the placemark window.

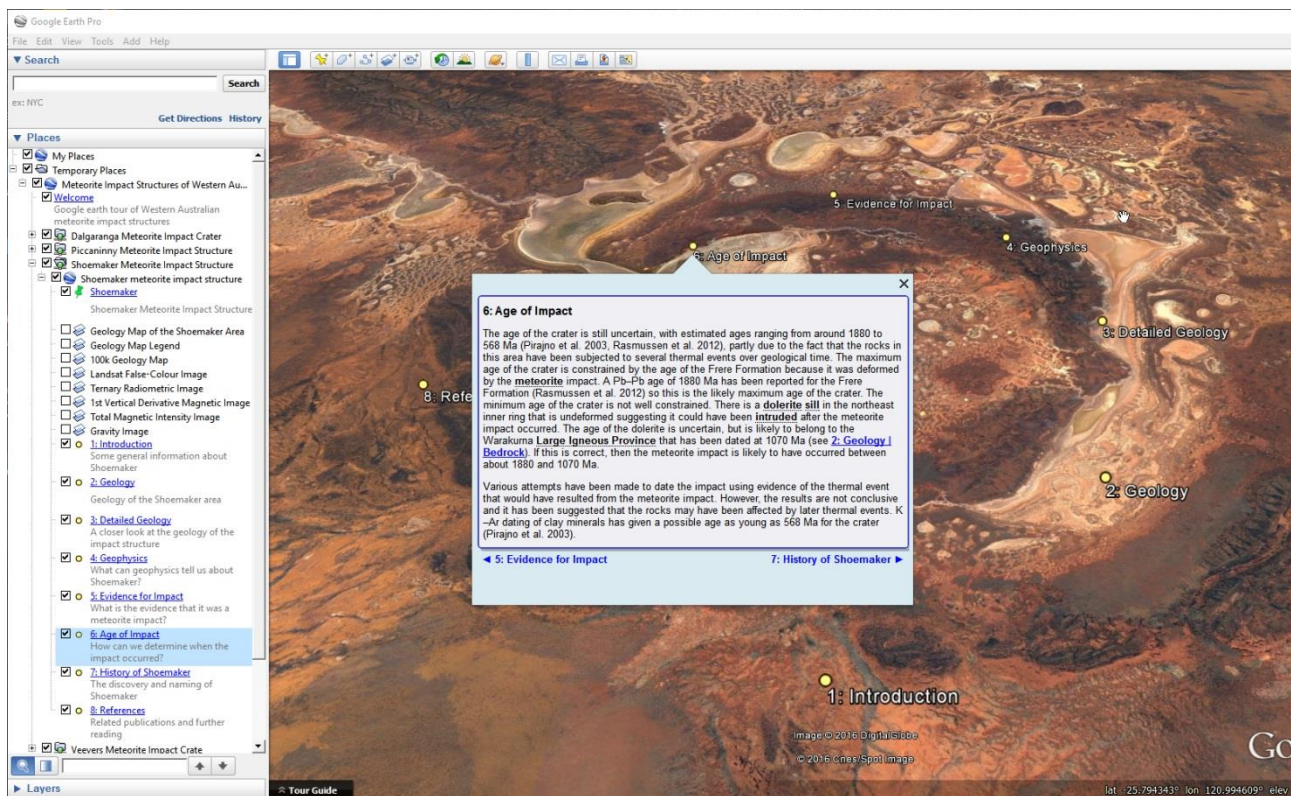
Map or image overlays for each crater (if available) are found near the top of the places list. They can be checked on or off as desired. By default they are semi-transparent when turned on and the terrain remains partly visible through the overlay. The transparency of the overlays can be adjusted through the overlay properties. Overlays are displayed in the order that they are turned on — the first overlay to be turned on is displayed on the bottom, and overlays turned on subsequent are displayed on top of any other visible overlays.

(2) Placemark windows

The placemark windows can be opened through the places panel, or by clicking on the placemark pins in the terrain view. There are two levels of placemark. The highest level, which is marked by a green push pin, is simply a location sign to indicate the name and location of a meteorite impact structure.



The lower level placemarks are shown by a yellow dot and are only visible when the view is zoomed-in close to an impact site. They contain information about the points of interest, images or diagrams to illustrate some of the interesting features, and links to relevant discussion points in other placemarks. Some placemarks also have links to external websites. On the bottom margin of the information window there are links that allow you to 'fly' to the next or previous window. They also show a change in colour and cursor shape as the mouse is moved over them.



(3) Figures

Most figures are embedded in the placemark windows and can be viewed together with the text. Some figures are responsive and can either be enlarged by a mouse click, or opened for viewing in an external window. Responsive figures react to mouse movement by showing a highlighted border and a change in the shape of the cursor. A tool tip indicates how the figures respond.

The Barlangi **Granophyre** likewise shows unusual microscopic textures. It has a **groundmass** with a **skeletal texture** where the quartz and feldspar crystals are typically needle-like in shape, in contrast to the more common rectangular shapes. This difference in appearance is typical for crystals that have cooled extremely rapidly. The needle-like crystals also tend to radiate outwards from other larger, more rounded quartz **xenocrysts**.

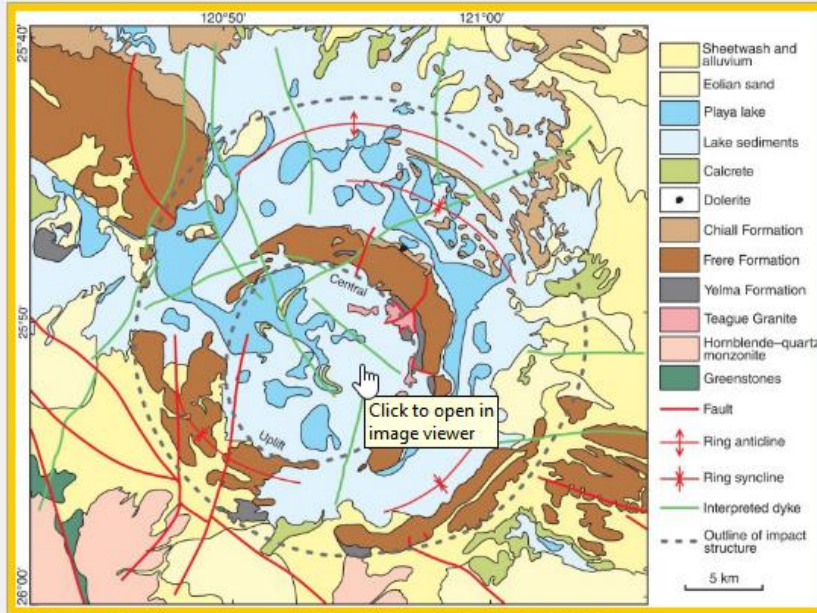
Microscope image of the Barlangi Granophyre showing a quartz xenocryst (X) in a skeletal-textured groundmass (G)

3. The Barlangi Granophyre is thought to represent an **impact melt** derived from melting of the surrounding Yarrabubba Granite. When the meteorite impacted, the target rocks of the Yarrabubba Granite underwent melting and then this molten rock was injected along **faults** or fractures and then ultimately solidified to produce the Barlangi Granophyre. Evidence to support this comes from detailed chemical analysis of the **trace elements** and **rare earth elements (REE)** in both rocks that show they have virtually identical chemical profiles and so must be related (see diagram).

2: Geology

The Shoemaker **meteorite** impact crater is located within **sedimentary rocks** of the **Proterozoic Eoraheedy Basin** which overlie the **Archean granite-greenstone bedrock** of the **Yilgarn Craton**. The target rocks that were affected when the meteorite impacted are now predominantly covered by **Quaternary regolith** units.

The crater is defined by two concentric rings of upland areas and low hills. In between the inner and outer rings there are three main transient **playa** lakes — Lake Nabberu to the northwest, Lake Teague to the north and Lake Shoemaker to the east. The lakes contain **lacustrine**, **alluvial** and **eolian** sediments that are part of a **paleodrainage** system that was active in the **Cenozoic**.



Geology of the Shoemaker area (adapted from Pirajno et al., 2003)

(4) Glossary definitions

Glossary terms are shown in bold black text with a dotted underline on the first occurrence of the term in a placemark. The terms are responsive. The background and mouse cursor shape will change when the mouse is moved over them. A definition of the glossary term can be viewed in a pop-up window by clicking on the glossary term. The definition window remains visible until the mouse is moved off the glossary term.

X

4: Geophysics

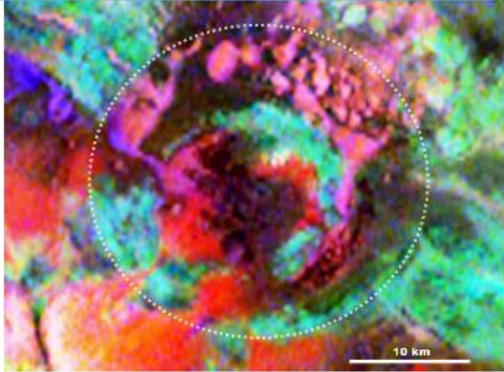
Geophysical evidence includes using techniques such as **seismic surveying**, **aeromagnetic surveying**, **gravity surveying**, heat flow and radioactive decay. These physical properties are measured and used to infer information about the Earth in terms of its composition and layering, the ages of different rocks, structures below the surface, and processes occurring deep within the Earth.

Numerous geophysical surveys have been carried out at Shoemaker beginning with surveys by the Bureau of Mineral Resources (BMR; now Geoscience Australia) in 1971–1972. Since then more studies have been undertaken and this now provides us with a large amount of quality information about the structure and underlying substrate. Below we discuss the data from 1) **radiometric surveying**, 2) aeromagnetic surveying and 3) gravity surveying.

Radiometric data
Aeromagnetic data
Gravity data

Radiometric survey images show variations in **gamma radiation** just above the ground as measured by low-flux **gamma-ray spectrometry** of certain **radioactive isotopes** such as potassium, thorium and uranium. Click for definition

Gamma radiation = a type of electromagnetic radiation emitted by radioactive substances; has a wavelength of 10^{-10} to 10^{-14} and is shorter in wavelength than X-rays



Ternary radiometric image over the Shoemaker Meteorite Impact Structure

It shows the green colouring of the Frere Formation hills that trend northwest across the image, and form the prominent ring around the northern and eastern edges of the crater. The green colouring represents an area with relatively high gamma ray counts from thorium, but low potassium and uranium counts which is typical of iron-rich rocks.

The **playa** lakes are represented by the weak potassium radiometric response (pink to purplish colour) most likely due to the high salt content of the soil here.

The **granitic rocks** directly to the south of the Shoemaker structure, and the Teague Granite on the eastern edge of the central uplifted area, are both represented by a red colour. This is due to a strong potassium reading.

◀ 3: Detailed Geology
5: Evidence for Impact ▶

Pop-up diagrams and images are indicated by clickable buttons in the body of the text. They are shown with bold text on a green background. They respond by changing colour and cursor shape when the mouse moves over them.

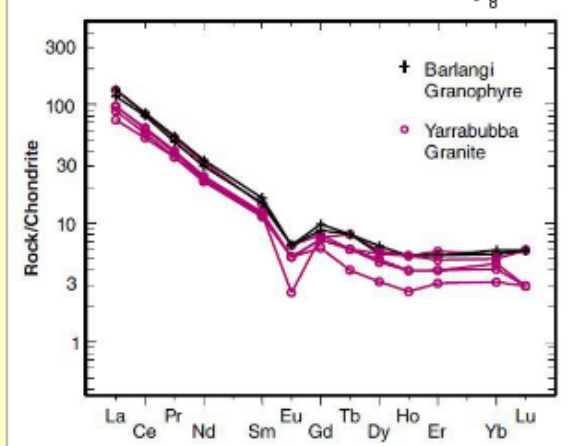
3. The Barlangi Granophyre is thought to represent an **impact melt** derived from melting of the surrounding Yarrabubba Granite. When the meteorite impacted, the target rocks of the Yarrabubba Granite underwent melting and then this molten rock was injected along **faults** or fractures and then ultimately solidified to produce the Barlangi Granophyre. Evidence to support this comes from detailed chemical analysis of the **trace elements** and **rare earth elements (REE)** in both rocks that show they have virtually identical chemical profiles and so must be related (**see diagram**). Click for diagram
4. **Pseudotachylite** is a glassy rock that is commonly associated with impact craters, but it is not unique to them because it can also form via other geological processes that produce intense frictional melting, such as movement along **fault planes**. In **2.1: The Granites** it was noted that the Yarrabubba Granite contains dark-coloured veins of pseudotachylite and these are thought to have formed when the crater was originally excavated.

When a meteorite first hits the ground, a relatively large, deep crater is formed, but then almost immediately the outer walls begin to slump inwards to produce a wider and shallower crater. As the rocks of the crater walls rapidly collapse inwards, the base along which they slide undergoes immense frictional heating and melting. This molten rock lubricates the movement of rocks but it also solidifies very quickly into dark, glassy layers. It is this dark glassy rock that is left behind as pseudotachylite veins and they often contain fragments of larger rocks within them that were too big to melt in the few minutes before the pseudotachylite cooled. The fact xenoliths of the Yarrabubba Granite are seen within some pseudotachylite veins supports an impact origin for the pseudotachylite at Yarrabubba.

Clicking on them brings up the associated diagram, which remains visible until the mouse is moved away.

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4.



5.

A comparison of the REE profiles of the Yarrabubba Granite and the Barlangi Granophyre

associated with impact craters, but it is not unique to craters that produce intense frictional melting, such as is noted that the Yarrabubba Granite contains dark-veined rocks that have formed when the crater was originally

A deep crater is formed, but then almost immediately filled with a shallow and shallower crater. As the rocks of the crater walls undergo immense frictional heating and melting. The melt also solidifies very quickly into dark, glassy layers. It contains dark, glassy layers and they often contain fragments of larger rocks before the pseudotachylite cooled. The fact that pseudotachylite veins supports an impact origin for

Impact Breccia). This type of rock is composed of melt particles that later solidified into a rock. They are the actual impact occurred.

The melt component is formed by the shock waves from the impact producing extremely high temperatures and pressures in the target rocks, causing them to melt. The angular fragments in the **breccia** are due to the target