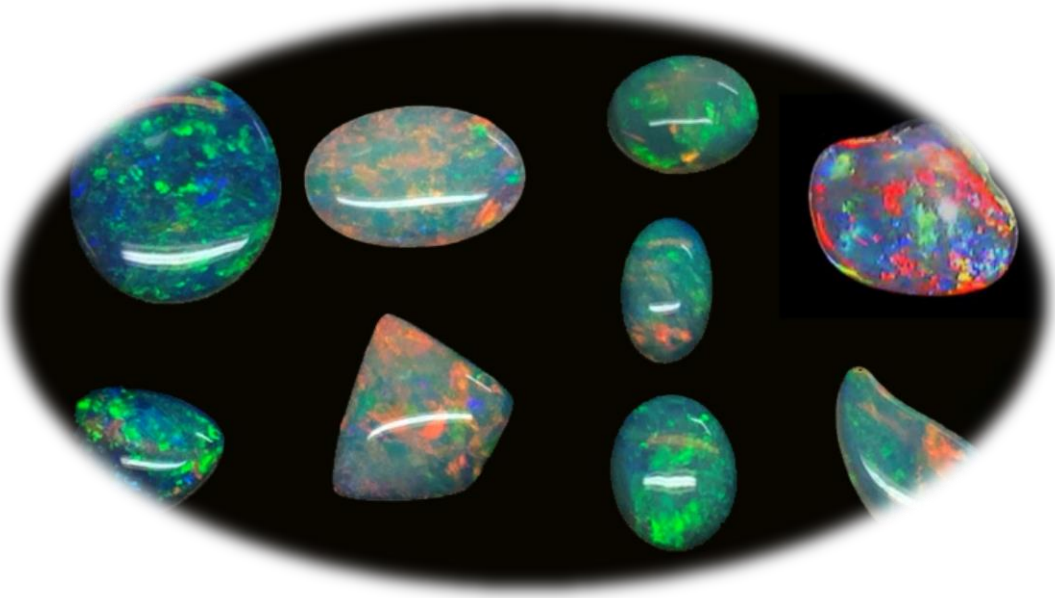
Opals are Very Special Gems

Information Booklet

Opal is one of the world's most fascinating gemstones. Its brilliant play of colours— changing and flashing as the stone is turned — sets it apart from all others. No two opals are exactly the same. Each one has an individual pattern, and there is no end to the variety available. A single opal can display a range of colours encompassing the entire visible spectrum.

The photograph below illustrates some varieties of coloured opal.

*In his play 'Twelfth Night', Shakespeare described opal as "**that miracle and Queen of Gems**".*



National Gemstone of South Australia & Australia

Australia produces 95% of the world's quality opal. South Australia is the opal capital of the world, since it produces 85% of Australia's opal. There is strong demand for this beautiful gem in many parts of the world.

Coober Pedy, in the arid country 849km north of Adelaide, is South Australia's — and the world's — opal capital. Over 200,000 mine shafts litter the area around the town of Coober Pedy.

In South Australia opal is also mined at Mintabie, about 300km northwest of Coober Pedy and at Andamooka, which is about 250km southeast of Coober Pedy.

The remaining 15% of Australia's opal is mined in New South Wales, Queensland, Mexico and Brazil.

The adjacent map shows the locations of Australia's major opal mining towns.

Opal is also mined in Mexico and Brazil and opal mining recently started in Ethiopia. However, Ethopian opal tends to crack, and some of it loses its colour when wet.

Table of Contents

1. Colours in Opals 3
2 The Nature of Opal 4
3. Formation of Opal 6
4. Life in the Eromanga Sea 8
5. Seeking and Mining 12
6. Processing Opals 18
7. Different Types of Opal 22
8. Valuing Opals 28
9. Caring for Opals 31

Appendix 'The Boy Who Found Opal 32

1. Colours in Opals

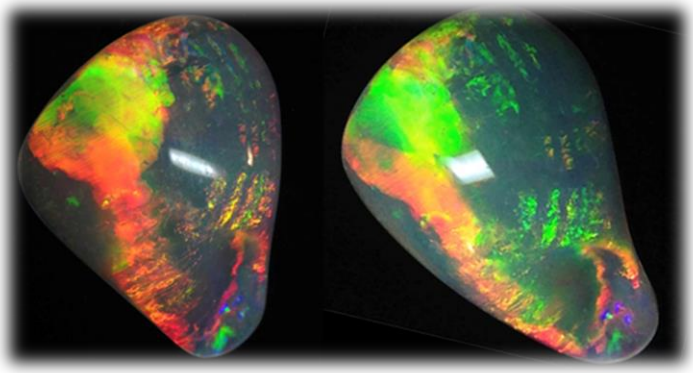
Other gemstones, such as the ruby and sapphire shown in the two left hand photographs below consist of only one colour, but every single opal contains a wide variety of colours, like the right hand gemstone in the photograph below.

Play of Colour

Not only does precious opal produce a brilliant display of colours, but also these colours change as you rotate the gem or look at it from a different angle.

The adjacent photographs show a single opal observed from two different directions.

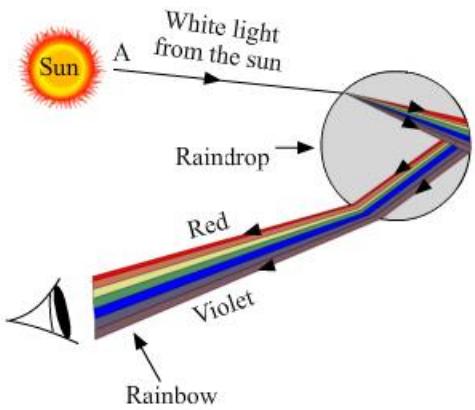
You can see differences in the colours displayed by the opal.



Unlike the ruby and the sapphire, or most coloured objects, opal does not contain any colour pigments. It does not possess any colours in the way that we normally think of colours. A piece of precious opal is actually either transparent or translucent.

The colours in opals are formed in a similar way to the colours of a rainbow. When it is raining and the sun is shining, sunlight and rain combine to form rainbows in a very specific way.

Sunlight is actually made up of a mixture of different colours that our eyes don't usually separate. This mixture is called white light. If the white light beam meets falling raindrops on at a certain angle, the different colours that make up the beam separate as shown in the diagram below. Hence we can see the different colours in the form of a rainbow.



The direction taken by each colour of a rainbow is different, because the colours change speeds at different rates when they enter and leave the raindrop.

As the adjacent diagram shows, light changes direction, or is 'bent' as it enters and leaves the raindrop. This bending is called refraction.

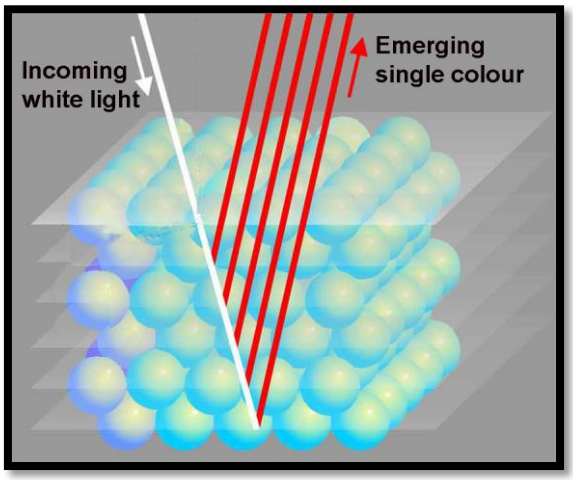
Light at different angles coming through many raindrops forms the rainbow that we see, in bands of red, orange, yellow, green, blue and violet.

2. The Nature of Opal

Opal is a unique form of a very common mineral — **quartz**, whose chemical name is silicon dioxide, or **silica** (SiO_2**)**. Unlike most forms of quartz, such as those shown in the photograph below, opal does not form crystals.

Quartz is normally found in 'lumps' It can also be found as crystals

Opal is a form of quartz that contains between 6% and 10% of water within its molecular structure, so that its chemical formula is $SiO_2.nH_20$. The letter 'n' in this formula stands for the number of water molecules that are combined with each silica molecule. This number varies between different types of opal.



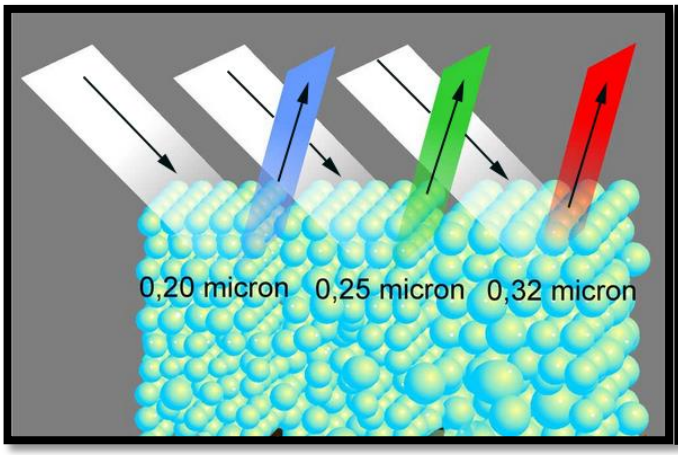
Unlike the crystalline structure of quartz, opal exists in the form of small spheres. The spaces between the spheres contain silica in solution. White light passes through the spheres directly, but when it reaches the silica in solution, it is deflected at different angles. These deflected beams of light may contain all the rainbow colours, or particular colours may predominate. The colour actually seen depends partly on the angle that the incident light makes with the spheres, as shown in the adjacent diagram.

However, the colors of opals are not necessarily the rainbow colors formed by refraction of light in water droplets; but a complex mixture of narrow bands of colours.
As shown in the photograph on page 1, every opal can show its own unique colours.
The two diagrams below show that opals do not show play of colours unless their spheres are arranged in regular layers, as shown in the left hand diagram. This diagram also shows that the size of the spheres also affects the colour produced by the opal.

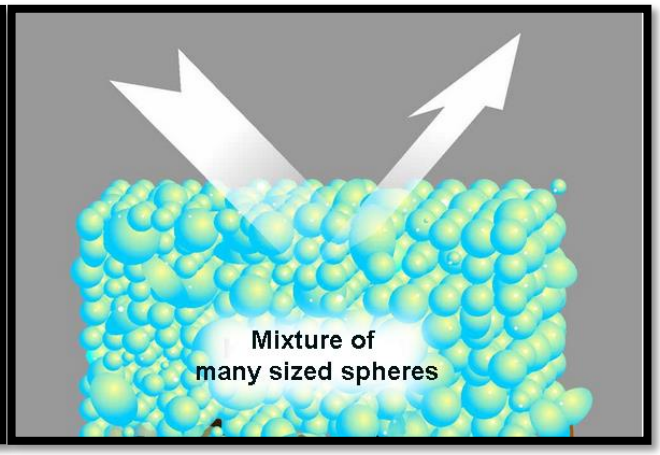
N.B. 1 micron is one millionth of a metre or one thousandth of a millimetre.

The right hand diagram shows that no colours are produced by when the spheres are arranged in an irregular fashion.

Opal that does not display a play of colours is called common opal, or **potch.** It can exist in a variety of colours.



Precious Opal



Potch

The intensity and brilliance of the colours depends on the uniformity of the sizes of the spheres and the regularity of the grid.

Opal is usually found in a raw, white form, which is known as potch. A small, valuable percentage of opal, however, contains segments with refractive properties, allowing the surface of the stone to alter the angle of observed light and give off a red, blue, yellow or green hue. Refraction adds tremendous eye appeal, and increases the value of this rock as jewellery, resulting in Australia's opal mining industry.

Some examples of potch

About 95% of the opal found in the opal fields is potch. Only about 5% has any value. Of this 5%, about 95% is of mediocre grade.

All opal is precious, but it has many different grades according to colour, clarity, rarity and size.

3. Formation of Opal

Precious opal occurs in very few locations across the world because its formation requires very special conditions. Scientific research over the last two centuries has provided comprehensive detail about the formation of most gemstones, but there is not yet any universally accepted theory to explain the formation of opals. The ideas presented below have formed the most widely accepted explanation since the 1960s.

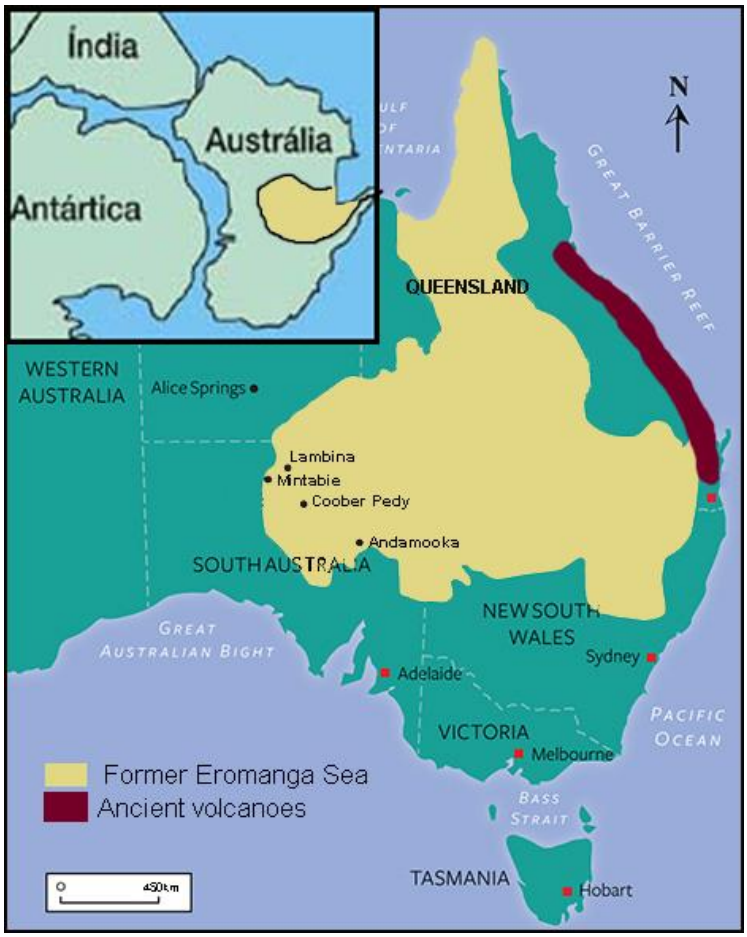
Opals are formed at relatively low temperatures. Under the right conditions, fluids rich in silica bubble through rocks beneath the Earth's surface and dry out to form opal. Opal is found all over the world in cracks and cavities in rocks. It can also fill the spaces left by plant and animal fossils.

Opals are formed in two types of rock, sedimentary and igneous. Australian opal is usually found within sedimentary rocks where groundwater rich in silica has deposited the opal in cracks and cavities.

In other parts of the world, silica rich fluids seep through volcanic rocks, depositing silica in hollows and cracks. Opal in volcanic rocks usually occurs in round pieces or nodules. Most of the opal deposits outside Australia are volcanic opal.

Between 135 and 97 million years ago, a sea now called the ancient Eromanga Sea flooded what is now Central Australia's Great Artesian Basin. Sediments rich in silica were eroded from nearby volcanoes and deposited on the sea floor.

The adjacent map shows the location and extent of this sea, the locations of the nearby volcanoes and the position of Australia as part of Gondwana at that time.



The Eromanga Sea was shallow, cold, stagnant and muddy. Bacteria that produce the mineral pyrite thrived in this environment, which contained little oxygen. The southern reaches of this sea would have contained icebergs during the colder parts of the year.

From about 100 million years ago, the Eromanga Sea began to dry out. The pyrite reacted with the increased oxygen in the environment and broke down to form sulphuric acid, one of the most aggressive naturally occurring acids.

The groundwater in the basin became acidic and leached silica from the volcanic sediments. This silica became trapped in cracks, cavities and the spaces between the grains of porous rocks. Over time it dried out to leave behind both precious opal and potch. Opal is often found close to faults and fractures in rock where groundwater would have flowed.

This mixture of geological conditions created an unusual weathering process that makes the Great Artesian Basin unusual on Earth. This is known as the acidic weathering model of opal formation.

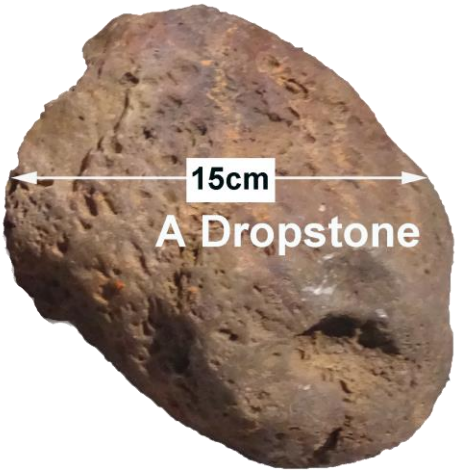
The type of opal that forms depends on the potential of the host rock to neutralise acid. For precious opal to form, the environment must be acidic enough to release silica from the rock and then be able to neutralise this acid. With the right balance, the silica-rich liquid can generate regular stacks of silica spheres, which creates the play of colour seen in coloured opal. When conditions remain acidic, opal forms without a regular array of silica spheres, producing coloured opal. The acid/alkaline balance is determined by the amount of pyrite dissolved in the silica-rich liquid as well as the amount of calcium carbonate, feldspar and volcanic ash in the surrounding rock.

Around 110 million years ago, dinosaurs lived on the land and great sea monsters like ichthyosaurs, plesiosaurs and kronasaurs ruled the oceans. Australia was joined to Antarctica as part of the great super-continent Gondwana.

The sediments at the bottom of the Eromanga Sea provide evidence that the climate was very cold at the time.

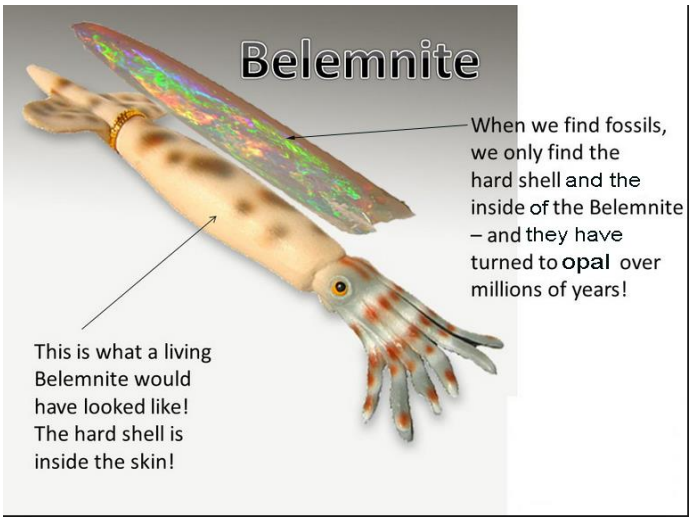
These sediments included ice-rafted dropstones — rocks collected, transported and eventually dropped by glaciers. The marks on the surface of the dropstone in the left-hand photograph belowwere made when a glacier was transporting the boulder. The boulders around it were continually bumping and scratching it.

Certain minerals in the sedimentary rocks also provide evidence that the environment of the very cold environment at the time. One very spectacular mineral that only forms in near freezing temperatures on the ocean floor is called **ikaite**. When the temperature warms up above 6C, the ikaite changes to the mineral calcite without losing its special shape. Eventually, opal may replace some of the calcite and 'opal pineapples' may be formed, such as the one shown in the right-hand photograph below.



4. Life in the Eromanga Sea

Many fossils of marine animals have been found in opalised cavities in rocks that formed on the Eromangan sea floor. These fossils tell us that the sediments were laid down about 110 million years ago, when the dinosaurs were alive. A few fossil bones from this time have been replaced by opal, which in exceptional circumstances can display a brilliant play of colour. Fossil remains of dinosaurs, marine reptiles, fish, mammals and invertebrates have provided a valuable insight into Australia's past life. The adjacent diagram shows how the hard hollow shell and insides of a squid-like animal called a belemnite can be replaced by opal over millions of years.

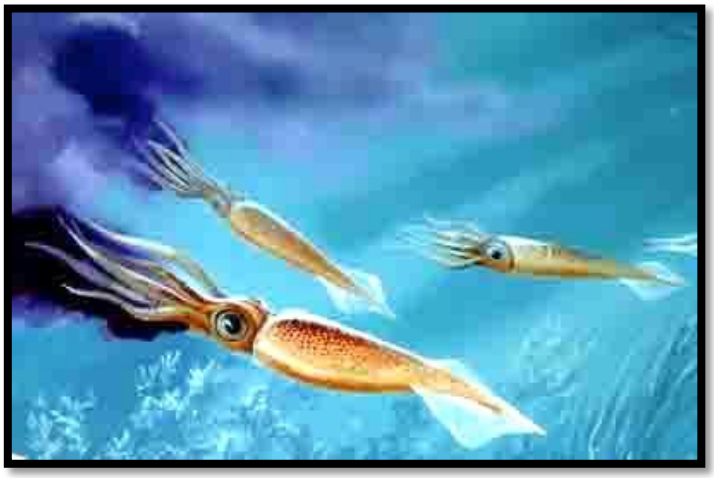


Belemnites

Belemnites were squid-like animals that looked something like cuttlefish and became extinct at the same time as the dinosaurs — 65 million years ago. They filled the shallow seas in giant, teeming schools.

They were carnivores that ate fish and any other marine creatures. Unlike squid and cuttlefish, which have suckers on their tentacles, belemnites had hooks. They could move fast by using jet propulsion and probably lay in wait among seaweed or rocks and darted out to catch passing fish.

In turn they made up a sizeable portion of diet for the sizeable predators of the time. Fossils of plesiosaurs, pliosaurs, and giant sharks have been discovered with stomachs full of hooks or bullet-shaped shells. It is also thought that the dolphin-like ichthyosaurs survived largely on belemnites. After feeding and digesting the mollusks, the ichthyosaurs probably vomited out the indigestible hooks and shells of belemnites much in the manner that sperm whales expel the hooks of giant squid!

The bullet shaped shells of belemnites have survived in vast numbers and are one of the most characteristic of all fossils from the age of dinosaurs.
Dolphin-like marine reptiles, known as ichthyosaurs are often found with the remains of belemnites in the area of their stomach. Some belemnite fossils seem to have an area in their bodies for an ink sac and they would have used a burst of ink in the water as a way of escaping predators.

The adjacent picture shows a school of belemnites discharging ink.