

Weathered-profile-hosted precious opal deposits

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EXPLORATION MODEL

Examples

Mintabie, Coober Pedy and Andamooka (South Australia); White Cliffs and Lightning Ridge district (New South Wales); Kynuna, Winton, Quilpie and Cunnamulla districts (Queensland).

Target

- Widespread deposits, within or close to the Eromanga and Surat Basins.
- Variable from a few square metres to several square kilometres in area (opal fields).
- Deposits within 25 m of surface in kaolinitic weathered profiles.
- Stratigraphic or structural traps in the vicinity of former groundwater permeability barriers.

Mining and treatment

- Historically, a cottage industry (imposed by State legislation).
- Open cutting and shallow underground methods to depths of <25 m.
 - Open cutting (scrapers, bulldozers and excavators).
 - Underground (hand tools or mechanical diggers, blowers, conveyors and self-tipping hoists).
- Treatment includes hand sorting, wet processing (puddling), 'blocking out' and trimming with diamond saws.
- Specialised gemmological equipment for shaping and polishing opal for the jewellery industry.

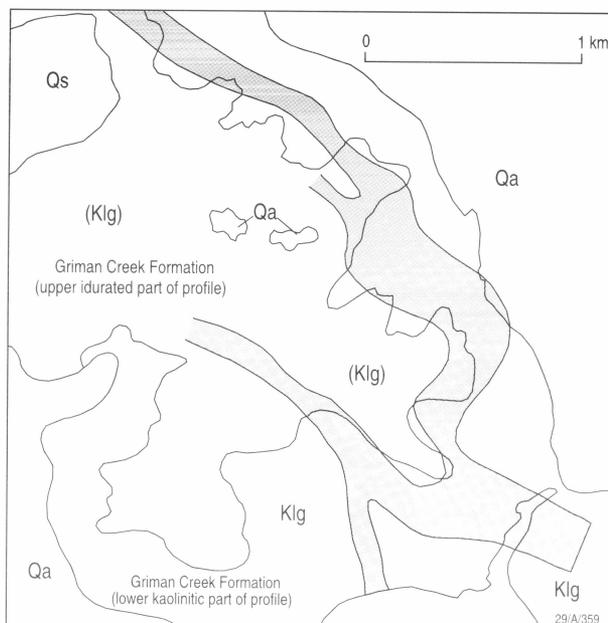


Figure 2. Aerial photographic interpretation of the distribution of mining activity in 1990 in the Coocoran opal field, NSW. The sinuous, divergent and convergent pattern resembles anastomosing channels and probably indicates that the deposits follow an early Cretaceous estuarine palaeo-channel.

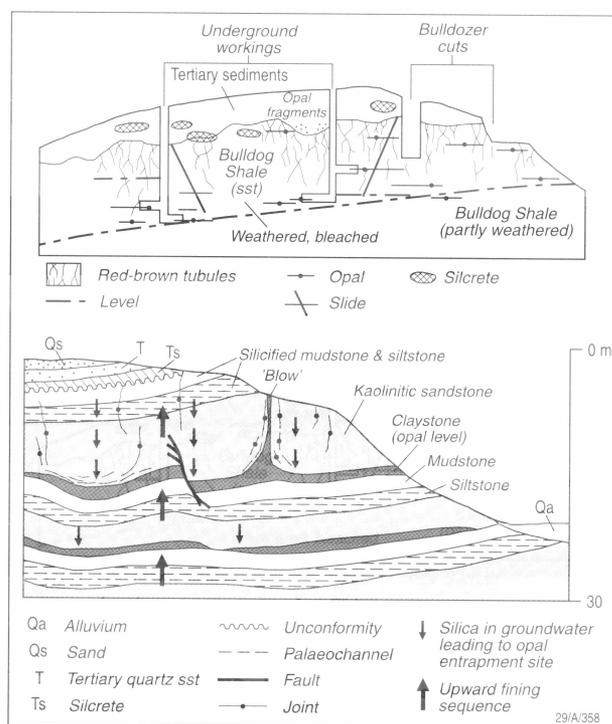


Figure 1. Cross-sections of typical opal fields: Coober Pedy (upper; after Barnes & Townsend 1982), Lightning Ridge region (lower).

Regional geological criteria

- Opal deposits are the product of widespread late Mesozoic and Cainozoic deep chemical weathering.
- Enclosing profile is dominantly kaolinitic with silicified and ferruginised components.
- Palaeomagnetic (Idnurm & Senior 1978) and oxygen isotope studies (Bird & Chivas 1993) indicate opalisation involved two weathering events.
- Deposits occur in faults or joints, or in cracks induced through swelling of former smectite clays.
- Opal entrapment sites lie close to former groundwater permeability barriers.

Mineralisation features

- Deposited from Si-rich groundwater.
- Occur within faults, veins or cracks, or as replacements of former soluble minerals and organic fragments, notably shell, bone or wood.
- A meniscus, flow structures and colour layering shown by some specimens indicate an initial aqueous phase followed by dehydration of a silica-gel, which hardened into opal.
- Precious opal occurs only in entrapment sites where conditions favoured development of a microstructure of silica spheres, which refract white light, giving a play of colours (Darragh et al. 1966).
- Gypsum, alunite and hollandite are common secondary minerals.

Local geological criteria

- In Queensland the deeply weathered profile in which opal deposits occur is known as the Canaway profile (Senior et al. 1977).
- In New South Wales the opal deposits occur in the Lightning Ridge profile (Watkins 1985).
- The weathered profiles may be unconformably overlain by quartzose pebbly sandstone of early–middle Tertiary age (Eyre Formation, Glendower Formation & Cumborah Gravel).
- These younger sedimentary rocks are commonly silicified (silcrete) and the silicification has led to induration in the upper part of the underlying kaolinitic profile.
- The silicification event contributed silica to groundwater which percolated downwards to potential opal entrapment sites.
- The host deeply weathered profile has cut across rocks of various age within the Eromanga and Surat Basins.
- Palaeozoic host rocks at Mintabie (Mintabie beds). Lower Cretaceous hosts include the Marree Formation at Andamooka, Bulldog Shale at Coober Pedy, Grimman Creek Formation at Lightning Ridge, and the Winton Formation in Queensland.

Alteration

- Weathered profiles up to 30 m thick.
- Zonation of Fe, SiO₂ and Al oxides frequently present.
- The upper portion of the profile is usually strongly indurated.
- Ferruginisation may increase towards the basal one-third of the profile, particularly in the Queensland (Winton Formation) deposits (Senior 1979).

Geophysical criteria

- SIROTEM, resistivity and seismic refraction could assist in outlining the geometry of a potential opal-bearing structure, such as a palaeochannel or fault/fracture zone.
 - Detailed magnetic surveys show promise in locating remanently magnetised sandstone bodies and, thus, indirectly locate potential ironstone-hosted (boulder) opal deposits (Senior et al. 1977).
 - The profiles appear to be too resistive for successful application of ground impulse radar.
 - Anomalously high radioactivity recorded in gamma ray logs of drill holes in the Lightning Ridge opal fields offers potential for development of a purpose-designed, spectral, down-hole logging tool.
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All precious opal deposits in the Eromanga and Surat Basins lie within a weathered profile which is likely to have undergone more than one phase of development. Opaline silica has accumulated in host rocks of various ages within open spaces associated with vertical and lateral permeability barriers. These barriers are associated with intraprofile structural and stratigraphic conditions. Although the distribution of precious opal can be equated with these common genetic parameters, there exist marked gemmological differences between opal types at both regional and local levels. For example, the southwest Queensland fields are characterised by opal veins within rounded, concretionary, ironstone nodules (opal boulders) ranging in size from a few centimetres to one or two metres across. In the Lightning Ridge area, small nodules (nobbies) up to 3 cm across may consist almost entirely of opal. The highly prized black opals are sourced from these nodules. Dark or black opals are also obtained from Mintabie, although there they are found in silicified joints. Coober Pedy opals, by contrast, are generally paler in colour and display colours emanating from a white or milky background. However, a wide range in variation from the dominant type is usually found in individual deposits.

Australia produces about 97% of the world's precious opal and, according to Olliver & Townsend (1993), the value of Australian rough opal production for 1990 was about \$111 million. New South Wales is the largest producer, with \$62 million, followed by South Australia (\$47 million) and Queensland (\$2 million). Value-adding during manufacturing and retail sales brings the total value for 1991 to \$420 million. Potential reserves are difficult to quantify, owing to a lack of factual data, but, on current rates of extraction, are likely to last at least another 100 years.

Historical data and calculated grade measurements from known fields show that the majority of opal deposits have a grade of \$100 per cubic metre or greater (Redfire Resources 1995). On this basis, the Lightning Ridge or Coober Pedy fields would have an inground value, at today's prices, in excess of \$1 billion.

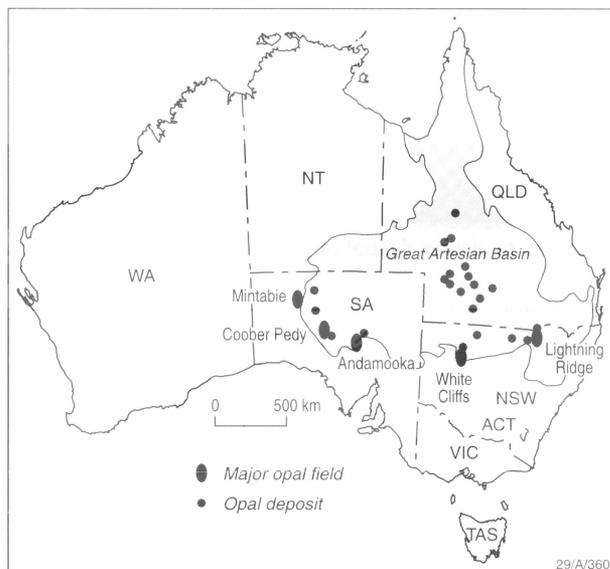


Figure 3. Location of Australian opal deposits.

In the past, company-style exploration for precious opal throughout South Australia and within the Lightning Ridge reserve (approx. 4500 km²) was not possible, owing to legislative prohibition and the restricted form of title available. In Queensland, the Minerals Resources Act 1989–1990 treats opal equally with other minerals. Similarly, in 1996 the South Australian State Government passed a new Opal Mining Act, allowing exploration licences for the first time. These legislative changes could lead to exploration and mining for opal using modern exploration and mining methods, utilising economies of scale prerequisite to establishment of a viable mine and organised marketing.

Redfire Resources NL (1995) undertook systematic exploration of the northernmost extension of the Lightning Ridge trend (Thomby Range) in Queensland. Grid drilling and innovative sampling techniques, which recovered and quantified both micro (0.05–5 mm) and macro (>5mm) opal, were used to establish opal mineralisation grades.

The wide distribution of known deposits across the Eromanga and Surat Basins (Fig. 3), which is a region characterised by poor outcrop, indicates that other potentially economic opal deposits are likely to be found.

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