ated with brittle fracture along the ore shoots, deposited gold and sulphides from solution in response to elevated CH_4 and/or CO_2 contents in the moderately saline fluid (equivalent Type 3?) derived from interaction with wall-rocks away from the site of ore deposition at approximately 320 °C. This fluid would have been trapped by impermeable lithologies in suitable structural sites at various levels along anticlinal crests and at the margins of domal structures thus allowing maximum interaction of the fluid with the wall rocks to occur. With further reactivation of the hosting structure fluid pressures would have increased resulting in hydraulic fracturing of the host lithologies and the subsequent deposition of gold mineralisation. This may account for the apparent formation of saddle type structures at various levels along a fold such as the Howley Anticline. According to Darnley (1982) the Cullen Batholith granites may be classified as uraniferous. The average uranium, thorium and potassium content for the Batholith is 15 ppm U, 40 ppm Th and 4 % K. The Cullen Batholith is more radiothermal than many of the high-heat-producing (HHP) granites in Britain, including the Cornubian Batholith with DHR project (4.0–5.7 $\mu W/m^3$ in Webb et al, 1985). This compares with radiothermal heat production (pre-weathering) of 4.2–12.8 $\mu W/m^3$ for radiogenic Bushveld granites (McNaughton et al., 1993), and 5.7–6.3 $\mu W/m^3$ for radiogenic granites from northern Australia invoked by Solomon & Heinrich (1992) as the heat source for the giant Pb-Zn deposit of the Mount Isa and McArthur River areas. The longevity of intrusion and the HHP potential of the granites of the Cullen Batholith appears to be the key in the generation of sufficient hydrothermal fluid to produce the maximum fluid to rock ratios required to scavenge gold and base-metals from the surrounding sedimentary rocks. These sedimentary rocks were not only the source for the metals but also provide structural and geochemical traps higher in the succession as the hydrothermal systems cooled to form economic mineral deposits.

For the origin of the gold mineralisation in the Pine Creek Geosyncline three a stage model is proposed:

Stage 1. Sedimentary preparation

The first step in the complex genesis of these gold deposits seems to require synsedimentary and/or diagenetic preconcentration of gold in sediments. Different gold content in sediments is controlled either by distance from the continent or by their primary chemical composition (carbonaceous and/or iron rich composition).

Stage 2. Metamorphic upgrading

In areas of pervasive regional metamorphism a small part of the metallic gold may be dissolved and redistributed by metamorphic fluids containing sulphur compounds. These fluids are produced by prograde dewatering process during formation of metasedimentary rocks water under definite PT conditions (2–3 kb and 550 °C). Gold was precipitated in rock-forming minerals representing greenschist assemblages.

Stage 3. Hydrothermal mobilisation

Large granite plutons produced a broad aureole of contact metamorphism which hornfelsed the mineral assemblages of greenschist facies. Magma emplacement has been responsible also for structural modification of the country rocks. These processes have produced the mass expansion and communication (decompression) with the paleosurface (faulting, brecciation, volcanic activity and rock dykes). Duration of the high thermal regime inside and around the batholith has been extended by a considerable contribution of radiothermal heat. This long-lasting cooling of the batholith has been accompanied by circulation of fluids coming from different sources. The poorly mineralised meteoric fluids have been diluted by portions of magmatic and metamorphic waters. Such a mixture of fluids produced hydrothermal alteration of pre-existing greenschist mineral assemblages, leaching of gold from sedimentary rocks and the transport of gold in thio-complexes into a new brittle-ductile (saddle reefs) and/or brittle (array of veins or stockworks) structural environment at the periphery of the thermal aureole of the batholith. Gold precipitation into economic concentration has been controlled by wall-rock interaction and fluid mixing which lowered total dissolved sulfur and changed pH and fO_2 of the fluids over a wide range of temperature from 100 to 320 °C within the structurally prepared traps.

According to this model the origin of the gold mineralisation in the Pine Creek Geosyncline is a multistage, long term process which is represented by a number of quartz vein generations. It started prior to the Cullen Batholith emplacement (stage I and II), culminated during the heating and subsequent cooling of the country rock around the batholith (stage III), and ceased after cooling of the batholith roof below 300 °C. The end of the process is documented by late quartz veins containing gold and cutting the Mount Shoobridge Granite.

The scenario which has been recognised for the origin of the gold deposits in the Pine Creek Geosyncline may be generally compatible to that of a number of major styles of gold deposits in Australia (Tanami, The Granites, Tarcoola, Selwyn and Telfer).

10. Conclusions and Prospectivity Rankings

The main aims of the study were to assess the role of granites of the Cullen Batholith in the formation of ore deposits in the Pine Creek Geosyncline, especially gold mineralisation. It was hoped that a set of criteria could be developed to prioritise exploration targets in the Pine Creek Geosyncline and possibly in other Precambrian terrains. In summary the main findings from the study are:

1. Economic tin and gold mineralisation is located within the inner zone of the thermal aureole spatially and temporaly related to the 1 800–1 835 Ma Cullen Batholith. Spatial distribution of both deposit types is generally controlled by geometry of the granite contact. The granites show both inward and outward dipping contacts.
2. Generally older tin mineralisation occurs within endo-

and exo-contacts mostly of the Transitional Igneous Suite. Economic gold mineralisation is more distal, mainly located within the country rocks of the batholith.

3. Cooling of the batholith from 800 °C to 300 °C lasted over 100 Ma. The long term thermal efects on the country rocks are manifested by an intense magnetisation (pyrrhotisation) of the host rocks. Stump-like roofs of plutons are characterised by non-magnetic plateaus in the regional magnetic field.

4. Radiothermal heat production of the batholith is two times higher (5.79 $\mu W/m^3$) than the heat production of average granite. HHP granites of the batholith are responsible for considerable prolongation of the high heat regime inside and around the batholith and width of the thermal aureole. Tin, gold, base-metals, uranium, epithermal deposits and thermal springs are the products of the intermitent thermal activity of the batholith in a very broad time span since its emplacement in 1835 Ma up to the present.