Antarctica's *Glossopteris* forests

Stephen McLoughlin

The Prince Charles Mountains (PCMs) of East Antarctica were first spotted from the air during The United States Navy Antarctic Developments Program 'Operation Highjump' in 1946–47, but first visited nearly a decade later by Australian explorers. In the austral summer of 1994–95, Andrew Drinnan (University of Melbourne) and I ventured to the PCMs to search for fossil plants. Most of the rocks there are ancient — Archaean and Proterozoic granites and metamorphics — but one small area, the Amery Oasis, hosts Permian coal-rich strata and Triassic red-beds.

The Permian strata include one especially interesting coal seam of which the top 40 cm constitutes a permineralized peat. This layer of peat was impregnated by silica so rapidly that the original organic matter was entombed in three-dimensions before it could be compressed and coalified. When thin-sectioned for microscopic examination, the peat layer reveals exquisite anatomical details of the plants that grew in the 260 million-year-old swamp. Not only are the robust woody tissues of the plants preserved, but also delicate leaf cells, together with the hyphae and spores of fungi and water moulds that were actively decomposing the forest litter at the time of burial. There are even signs of animal life in the form of fragments of insect exoskeletons and the traces of arthropod activities. Some pieces of fossil wood contain regular holes around the growth rings that are filled with coprolites — the fossil dung left behind by the seasonal feeding activities of voracious mites. Other coprolites contain the pollen and spores of ferns and seed plants. Yet others contain the spores of fungi or fragments of leaf tissue denoting a diverse array of specialized feeding habits. The peat also contains bands of charcoal left by forest fires that scorched the Permian swamp vegetation. The peat layer is overlain by laminated siltstones indicating that the ancient swamp was eventually drowned by deepening lake waters. All these signs of physical and biotic interactions are now enabling us to piece together the architecture of the ancient coal swamp organisms and the complexity of their high-latitude ecosystems (Slater et al. 2015).

Leaves of *Glossopteris*, an extinct seed-plant characteristic of the Permian (300–252 Ma), are by far the dominant fossils in this deposit. The curious distribution of *Glossopteris* leaves across the Southern Hemisphere continents and

India was central to early arguments that these regions were once united in a vast supercontinent — Gondwana (McLoughlin 2011). Glossopterids were substantial trees, perhaps reaching 30 m tall, with roots containing distinctive chambers that provided an aeration system for growth in waterlogged soils. The *Glossopteris* plant was the main contributor of organic matter to the formation of coal, not only in the PCMs, but across the entire Southern Hemisphere in the Permian. The economies of India, Australia, and South Africa now heavily depend on extraction and use of these vast coal reserves.

Typical *Glossopteris* leaf in Permian lake beds overlying the permineralized peat in the PCMs.

In the PCMs, as in other parts of Gondwana, *Glossopteris* fossils persist until the uppermost Permian strata — then abruptly vanish. Thus, *Glossopteris* was one of the major casualties of the end-Permian biotic crisis, an event that Doug Erwin of the Smithsonian Institution has described as the mother of all mass extinctions. The ultimate decline of *Glossopteris* may have spanned only a few thousand years, before being replaced by new groups of small- and thick-leafed hardy conifers and advanced seedferns. The immediate causes for the abrupt demise of the vast *Glossopteris* forests are written in the overlying Triassic strata. The transition from coals, deposited under consistently moist conditions in the Permian, to red-beds, characterized by haematite staining, dessication cracks, and calcrete nodules indicative of semi-arid climates in the Triassic, indicates dramatic drying and warming across the temperate regions of Gondwana. Conditions simply became too dry and hot for *Glossopteris* to persist. Strikingly, the signs of warming and drying are evident throughout the globe at that time (McLoughlin et al. 1997). What constituted the trigger for such runaway heating and drying is a topic for another article, but it is pertinent in this time of modern global warming to recognize just how rapidly dominant plant groups and productive continental ecosystems can disappear under a changing climate.

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The front cover incorporates an *Asteroceras obtusum* carving by Alex Cullum. This ammonite lived in the Jurassic ocean about 190 million years ago, and the specimen Alex based his carving on was collected at Lyme Regis, UK.

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