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The power of plants: how ancient forests drive SA's economy

Dr Rosemary Prevec

In the wake of recent, widespread electricity and fuel shortages, energy has been on the minds of many South Africans. These lapses in supply of commodities we tend to take for granted have highlighted our precarious dependency on fossil fuels. Approximately 90% of South Africa's primary energy is produced from fossil fuels, the most important of these being coal.

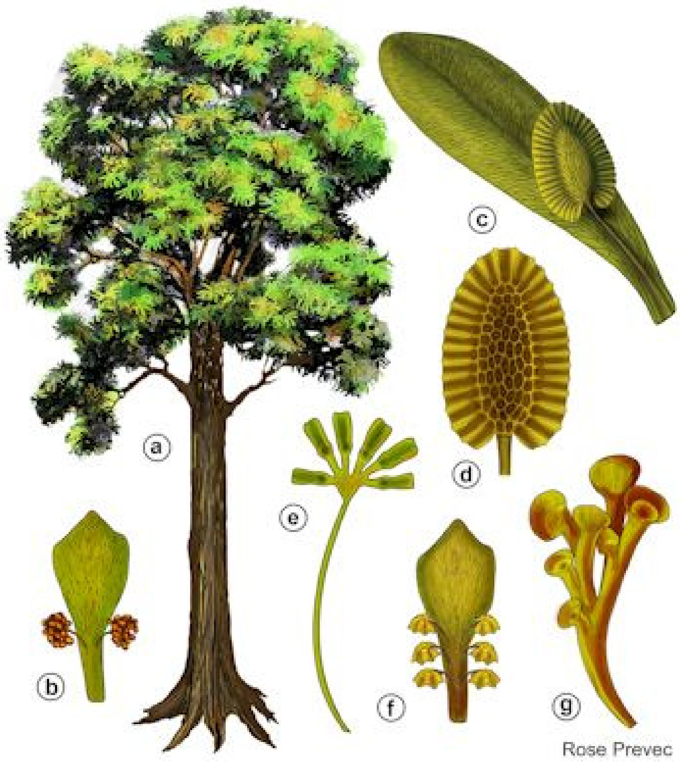
Sometimes referred to as 'black gold', coal not only forms the backbone of our economy, it pervades our way of life.

Statistics published by the Department of Minerals and Energy indicate that SA boasts 70% of Africa's coal reserves, 3.6% of the world's reserves (ranking 7th in the world), and is the 5th largest producer of coal in the world (4.7%). We are the 4th largest exporter of coal (11.1% of world exports) with coal being second only to gold as South Africa's most valuable export.

About 60% of coal consumed in SA is burned in coal-fired power stations, providing us with some of the cheapest electricity in the world. Nearly a quarter of domestically-consumed coal is used in the production of synthetic fuels. Using the Fischer-Tropsch coal liquefaction process, Sasol is able to use coal instead of crude oil to produce liquid fuels, and currently meets around a quarter of South Africa's petroleum demand in this way. Sasol, the world leader in synfuel technology, also produces a host of other hydrocarbon-based chemicals from coal.

An amazing variety of common household items contain coal-derived materials, such as plastics, fibres such as rayon and nylon, carbon fibre, solvents, dyes, filters, lubricants, cosmetics and shampoos, to name a few. Ammonia gas recovered from coke ovens is used to manufacture ammonia salts, nitric acid, agricultural fertilisers and explosives. Sasol is the world's largest producer of waxes. Coal has many other important uses, such as in the production of iron, steel, and other metals, and in the cement industry. It also provides a fuel source for many South Africans who do not yet enjoy the benefits of electricity in their homes.

Clearly coal forms an integral part of every South African's day-to-day activities, but there are probably few who are aware of its fascinating origins. Coal is formed through a slow process involving, over millions of years, the burial, gradual compression, heating and chemical alteration of dense mats of plant material. The huge coal reserves present in South Africa today were formed from organics that accumulated during the Permian Period (251 to 299 million years ago).



Reconstruction of a *Glossopteris* plant: a) A *Glossopteris* tree; b) the pollen producing organ (Eretmonia); c) a seed-bearing organ attached to a *Glossopteris* leaf; d-g) examples of different types of *Glossopteris* fructification.

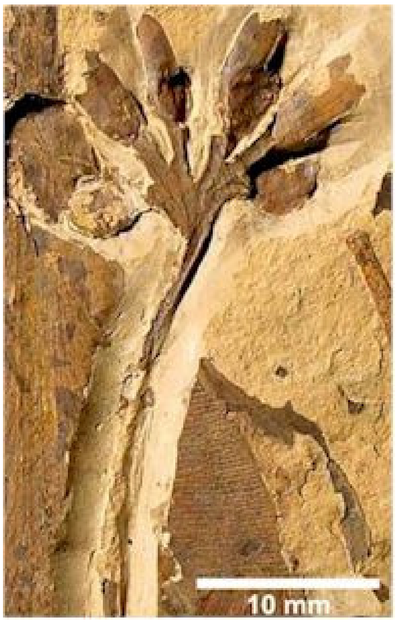
The Earth was a very different place during Permian times. There were no birds, no true mammals, and even the dinosaurs had not yet evolved. Flowering plants would only appear a hundred million years later. In fact, there were very few plants that you would not be surprised to see growing in your garden. Most of the plants we are familiar with today produce flowers, including grasses and pretty much all the crops cultivated worldwide.

During the Permian the plant kingdom in our part of the world was dominated by a peculiar group of plants called the glossopterids. These plants have a distinctive leaf type that was first described from India, in 1822, by the great French palaeobotanist Adolphe Brongniart. He named them *Glossopteris* ('tongue leaf').

Subsequently these distinctive leaves were also found in abundance in southern Africa, Australia, Antarctica and South America. The broad distribution of *Glossopteris* in these geographically separate regions was an important piece of information used in the development of the theory of plate tectonics, and in the reconstruction of the ancient supercontinent called Gondwana.

Despite the profusion of matted *Glossopteris* leaf deposits in the fossil record, this plant group has given palaeobotanists a tough time. Controversy has raged about virtually every aspect of the glossopterids, from their classification to their basic structure.

It was 130 years after Brongniart named *Glossopteris* that the first incontrovertible specimens of the seed-bearing structures of this plant were described. Credit is owed to two South Africans, Mr Stephanus LeRoux and Dr Edna Plumstead, for the discovery and publication in the 1950's of a variety of ovuliferous structures preserved in direct organic attachment to *Glossopteris* leaves.



Rigbya aberioides

These fertile structures are unlike anything found today or known in the fossil record. There are four major types of seed-bearing structures thought to be glossopterid in origin. They varied from curious branching structures with branches ending in a single seed attachment point and a terminal scale, to small umbrella-like organs which were attached in rows along the pedicel of a tiny leaf. The only fructifications which have been found in direct connection to *Glossopteris* leaves comprised a central, flattened head or receptacle with a peripheral, flange-like wing which was variously scalloped or lobed. Seeds were borne on one surface of the receptacle; the other surface had leaf-like venation. These structures were borne on stalks which were either axillary to a *Glossopteris* leaf or partially fused to its midrib, and were orientated with the seed-bearing surface facing the subtending leaf. These botanically unlikely structures have been interpreted in a variety of ways by different scientists.

Recent research conducted in South Africa has revealed that the reproductive organs of *Glossopteris* were morphologically more diverse than has been acknowledged previously, and hints at an affiliation with an extinct group of gymnosperms called the Cordaitales, rather than the seed ferns where the glossopterids have most commonly been placed.

Gradually, over the years, researchers have pieced together a reconstruction of the *Glossopteris* plant as a tree which grew in swampy and riverine environments and which had distinctive roots adapted for growth under water-logged conditions. Roots of the *Glossopteris* plant are assigned to the form-genus Vertebraria, and had a peculiar jointed structure with numerous air spaces, allowing for aeration of the tissues under the anoxic conditions that prevailed. These same anoxic conditions inhibited the activity of bacteria and fungi, and allowed for the accumulation of the organic material which later became our coal deposits. It is likely, however, that this prolific plant group adopted many different growth forms, including smaller shrubs and herbs, as it occupied a variety of ecological niches across a huge expanse of the globe.

The great *Glossopteris* forests of the world, along with a hefty proportion of all life on earth (perhaps over 90% of all living organisms), came to an end some 251 million years ago. The Permian-Triassic extinction event is the greatest known mass extinction event, and yet we still do not understand its cause. Many theories have been proposed to explain this time of cataclysmic biotic die-off, including: atmospheric changes resulting from great volcanic outpourings of lava in the Siberian Traps, the effects of an enormous (unidentified) meteorite impact, the release of huge amounts of gas hydrates (methane) from the ocean depths, massive degassing of CO_2 following overturn of the oceans, and widespread ocean anoxia. Or it may have been a sequence of closely spaced or coinciding calamities that plunged the world into chaos and ecological collapse - the debate continues. A recurring theme central to most of these theories, is the release of large quantities of greenhouse gasses such as CO_2 into the atmosphere.

We have a poor understanding of the past and present resilience and responses of our planet's biosphere to change, and yet we are currently altering our environment on a grand scale. South Africa's high dependency on coal as an energy source, and our particularly energy-intensive mining and industrial sectors, mean that we have one of the highest levels of CO_2 emissions per capita in the world (1.5%, ranking 6th, with the USA in the lead). No-one is entirely sure where the pollution of our atmosphere with greenhouse gases will lead, although most acknowledge that it spells bad news for the world's ecosystems.

So it seems there is a karmic twist in the end of this tale. Coal is essentially a concentration of carbon atoms, originally harvested through photosynthesis from atmospheric carbon dioxide by great *Glossopteris* forests that became extinct millions of years ago. This carbon is being returned by us to the atmosphere on a massive scale over a very short period of time, and may be contributing significantly towards what is being called the Sixth Great Extinction Event in the Earth's history.

More information:

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The Sasol Scifest will be held in Grahamstown, from the 22 - 28 March this year. View the programme and booking information at **www.scifest.org.za**

Additional reading

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