# Title: Fossil Focus: Dinosaurs Down Under

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# Fossil Focus: Dinosaurs Down Under

by Stephen F. Poropat[*1,2]

## Introduction:

Ask the average person in the street to name an Australian dinosaur, and you will be lucky if you get a correct answer. If they say crocodile, they are in the right postcode but have the wrong address. If they say emu, then they are correct, strictly speaking, but they are either lucky or being smart. If they say kangaroo, back away slowly and avoid eye contact. If they say koala bear, run home and take a few Panadol.

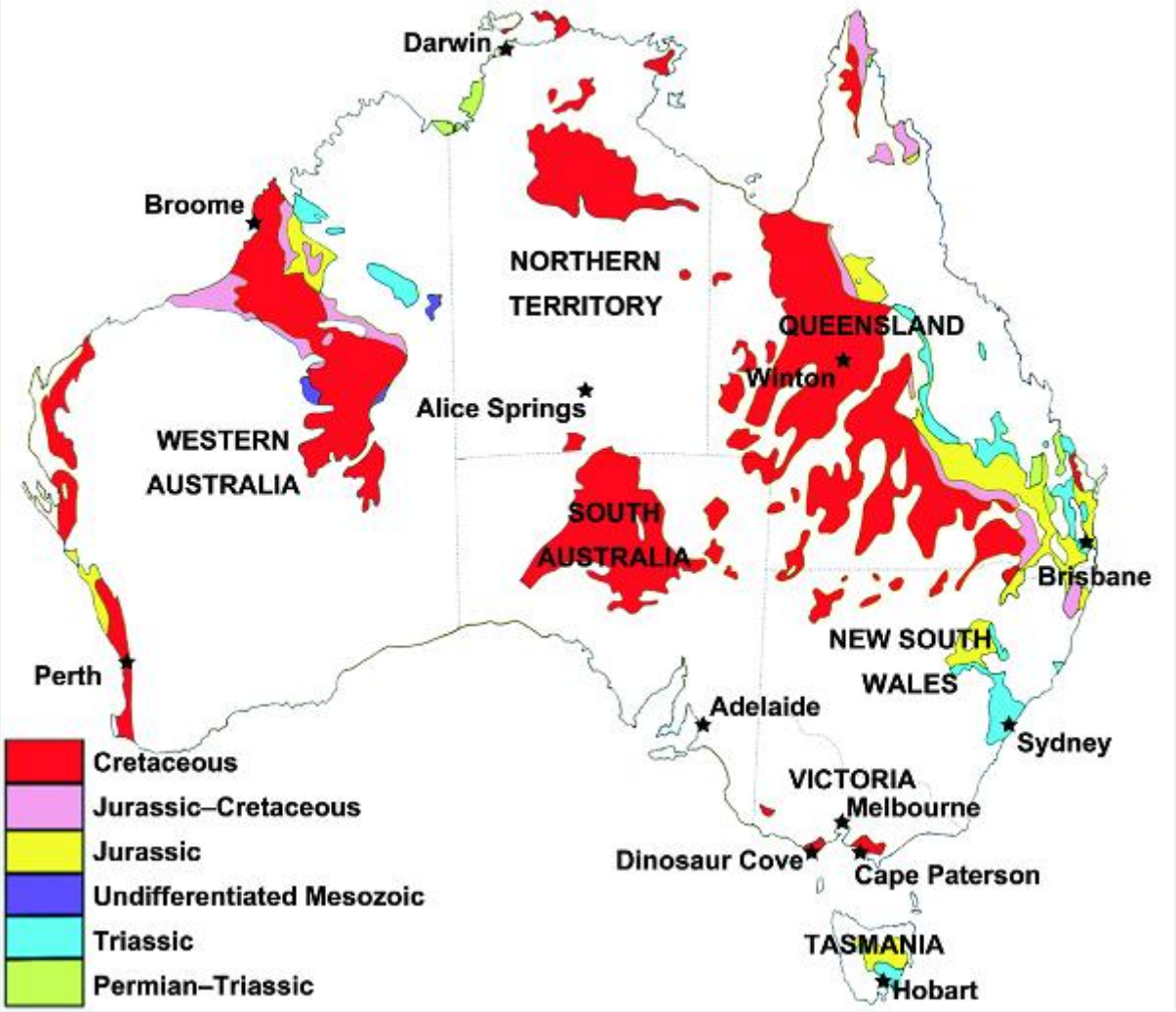


Figure 1 — Map of Australia showing approximate boundaries of Mesozoic sedimentary exposures. Modified from Kear and Hamilton-Bruce (2011).

I could forgive most people for not being able to identify any Australian dinosaurs. First and foremost, there are not many to know: only 18 Australian dinosaurs (including one bird, *Nanantius*) from the Mesozoic era (251 million to 66 million years ago) have been officially named. And yet, the first discovery of Mesozoic dinosaur remains in Australia was made in 1903. Geologist William Hamilton Ferguson, in the process of mapping Cape Paterson, Victoria, found a single theropod claw; the discovery was reported by palaeontologist Arthur Smith Woodward in July 1906. In the century since then, Australia's Mesozoic sediments (Fig. 1) have seemingly only begrudgingly yielded more dinosaur fossils. They are often fragmentary, sometimes fantastic, and always fascinating.

# A quick history of Australian dinosaur palaeontology:

Between Smith Woodward's claw report and 1979, discoveries of dinosaur remains were few and far between in the land down under. Heber Longman, director of the Queensland Museum in Brisbane from 1918 to 1945, described two sauropods: *Rhoetosaurus* from the Jurassic period (200 million to 146 million years ago) in 1926 and *Austrosaurus* from the Cretaceous period (146 million to 66 million years ago) in 1933. Both had been found in Queensland. The famous German palaeontological jack-of-all-clades (and master of most) Friedrich von Huene named three dinosaurs in 1932: *Rapator*, *Walgettosuchus* and *Fulgurotherium*. Each was established on the basis of a single bone preserved as opal from New South Wales, and all were interpreted as theropods. In addition to these body fossils, footprints were reported from Queensland by Alan Bartholomai in 1966, and from Western Australia by Ludwig Glauert in 1952, and by Edwin Colbert and Duncan Merrilees in 1967. In his 1966 report, Bartholomai mentioned the discovery of an ornithopod skeleton in Queensland, but then left the public hanging… as shall I, at least until the next paragraph….


Figure 2 — Clockwise from top left: Skeletal reconstruction of *Muttaburrasaurus langdoni* at the Queensland Museum, Brisbane (photo P. Poropat); *Minmi* sp. in the Queensland Museum, Brisbane (photo P. Poropat); Lark Quarry Dinosaur trackways (photo E. Hilder); Lark Quarry Conservation Park (photo S. Poropat).

In 1979, Tony Thulborn and Mary Wade announced the discovery of a truly remarkable footprint site from the Cretaceous in Queensland — the famous Lark Quarry Dinosaur Stampede. Between these authors' initial publication in 1979 and their monograph in 1984, a relative bevy of Australian dinosaur papers was published, with Ralph Molnar (then Queensland Museum curator) involved in all of them. These papers described: *Kakuru*, the first dinosaur from South Australia; *Minmi*, Australia's first ankylosaur; *Muttaburrasaurus*, Australia's first large ornithopod; five sauropod specimens from the Cretaceous of Queensland, attributed to *Austrosaurus* sp.; and the first non-avian dinosaur specimen found in Victoria since 1903, a theropod ankle bone attributed to *Allosaurus* sp. The floodgates were open. Bartholomai's mysterious ornithopod (*Muttaburrasaurus*) had been revealed — and Australia's dinosaurs were unleashed (Fig. 2).

Although a handful of dinosaur specimens have come to light in Western Australia (including *Ozraptor*, found in 1966 but not described until 1998) and although opalized dinosaur remains turn up now and then in both New

South Wales and South Australia, the bulk of the work on Australian dinosaurs since the 1980s has been conducted in two states: Queensland and Victoria. I have been very privileged to be involved in several excavations in each of these states over the past decade — in Victoria as a volunteer during my undergraduate and postgraduate studies, and in Queensland as a professional palaeontologist. Although there is, geologically speaking, relatively little difference in age between the Cretaceous dinosaur sites in Victoria (about 125 million to 105 million years old) and Queensland (about 100 million to 92 million years old), the respective faunas of the two areas, and the ways in which these fossils are excavated, could hardly be more disparate.

# Excavating Victoria's Cretaceous dinosaurs:

On the Victorian Cretaceous coast, there was a seven-decade hiatus after Ferguson's 1903 theropod claw discovery. Exploration was reinvigorated in 1978 by two cousins who had an interest in fossils: John Long (now at Flinders University in Adelaide) and Tim Flannery (now working for the Australian Climate Council). Palaeontologists had searched for, and failed to find, dinosaur remains in these rocks, but Long and Flannery's finds (including the theropod ankle bone mentioned earlier) demonstrated the potential for future discoveries. This prompted Tom Rich of Museum Victoria in Melbourne and Patricia Vickers-Rich of Monash University, also in Melbourne, to coordinate further prospecting trips along the coast, leading to the discovery in 1980 of a particularly rich site a few hours' drive west of Melbourne, officially dubbed Dinosaur Cove in 1981. Exploration of this locality continued for more than a decade, but it was not easy — the fossils were inside a difficult-to-access, sea-facing cliff. The extremely hard rock had to be blasted with explosives to facilitate its removal and to allow tunnelling into the cliff. Once the fossils were out of the ground, they still had to be transported to safety. This was achieved using a 'flying fox' (a wire from which heavy items could be suspended) that ran from the base of the cliff to its summit. In 1994, excavations at Dinosaur Cove ceased. Until recently, annual excavations were instead held at a site known as Flat Rocks, a few hours' drive east of Melbourne (Fig. 3). The digs were run by the group Dinosaur Dreaming, and led by the indefatigable Lesley Kool, a fossil preparator at Monash.

I participated in digs at Flat Rocks in 2004, 2005, 2006 and 2009. Less than two hours' drive from the centre of Melbourne, and located on the beach, the site is truly a breath of fresh air. Excavation of the rocky shore platform is conducted using jackhammers, crowbars, hammers and chisels — sadly, the rock is much harder than the bones it preserves, meaning that almost every discovery is made as a result of specimen breakage! Because of this, volunteers spend their days on the beach, in the sun, 'breaking rock': using a hammer and chisel to disintegrate excavated rock chunks into sugar-cube-sized pieces. This laborious process was put in place to minimize the chances of fossils being overlooked. Many of the more significant vertebrate fossils recovered from Flat Rocks are less than 2 centimetres long.

Each day on the beach, the team is at the mercy of the tides — the potential for rock-falls means that the beach is treacherous enough without having waves lapping at one's ankles! On days when low tide does not correspond with reasonable digging hours (read: when the sun is at least slightly above the horizon), the team breaks rock back at the living quarters. At the end of a day spent fossil-hunting, be it on the beach or at the quarters, good food, delicious beverages and croquet are par for the course, book-ended with conversations about all things palaeontological. In 2013, the team marked their 20th consecutive year of excavation at Flat Rocks; sadly, no further digs are scheduled to take place there. Nevertheless, Dinosaur Dreaming lives on — it is now excavating a new (and very promising) site west of Melbourne.

Thanks to the efforts of professionals and volunteers alike over the past three decades, Victoria's coastal Cretaceous sediments have yielded a wealth of fossilized vertebrates. By far the majority of the fossils belong to small ornithopod dinosaurs, superficially similar to *Hypsilophodon*. Three of these have been named: *Atlascopcosaurus*, *Leaellynasaura* and *Qantassaurus*, probably still the only dinosaur to be named after an airline! Alongside these lived a variety of theropod dinosaurs (including *Timimus*, as well as birds), a handful of ankylosaurs and a small ceratopsian, *Serendipaceratops*. These dinosaurs shared their environment with an abundance of small mammals (including *Ausktribosphenos*, *Bishops*, *Corriebaatar*, *Kryoryctes* and *Teinolophos*), turtles (including *Otwayemys*), lungfish, crocodiles, marine reptiles (specifically plesiosaurs) and even the latest-surviving temnospondyl, the wonderfully named *Koolasuchus*.

Figure 3 — Clockwise from top left: Sledgehammers and chisels in action at Flat Rocks (photo L. Kool); jackhammering holes for chisels at Flat Rocks (photo L. Kool); 'breaking rock' back at the quarters (photo L. Kool); Flat Rocks ornithopod femur (photo L. Kool); Flat Rocks theropod tooth (photo L. Kool).

# Unearthing Queensland's Cretaceous dinosaurs:

One particular group of dinosaurs, the long-necked Sauropoda, is conspicuous by its absence from the Victorian Cretaceous. In Queensland, the situation is entirely different: sauropods are by far the most commonly encountered dinosaurs in Cretaceous terrestrial sediments. And yet, until the early 1980s, the only Australian Cretaceous sauropod specimens that had been published were *Austrosaurus mckillopi*, described on the basis of a few incomplete neck and back vertebrae, and the 'Hughenden sauropod', represented by the back half of a single neck vertebra. Other specimens found in the Winton shire of central Queensland were attributed tentatively to *Austrosaurus* in 1981, but from then until 1999, no additional sauropod discoveries (other than a breathtaking Cretaceous footprint site in Western Australia) were reported. This is despite the fact that in 1996, Ralph Molnar announced the discovery of the most-complete dinosaur skeleton ever found in Australia, a specimen of the ankylosaur *Minmi*, and another specimen of the ornithopod *Muttaburrasaurus*, both found in the Cretaceous of Queensland.

Things changed in 1999, when David Elliott, a Winton farmer, discovered an odd-looking rock on his property. He alerted officials at the Queensland Museum, who excitedly informed him that he had found the bottom end of a dinosaur thigh bone. From the size and shape of the fragment, it had to come from a sauropod, possibly the largest ever found in Australia (at the time, at least). The dinosaur was dubbed Elliot (note the misspelling — we Aussies are known for our laidback nature), and over the next few years David, with the assistance of his wife Judy, his family, the Queensland Museum, the University of Queensland and a plethora of enthusiastic volunteers, held annual excavations on his property with the aim of finding more dinosaurs. They succeeded: from the Elliot site as a whole, they collected hundreds of bones representing several sauropods and a handful of other vertebrate groups.

The reason that the Elliott family started to find much better material than had hitherto been found in the Winton area was that they understood their land, and how to deal with it. Around Winton, the only regions that produce what would be called rocky outcrops — areas where the bedrock is visible and fossils are usually likely to be found — are the sides of the flat-topped mesas, or table hills. That is where searches have often been concentrated — and yet very few dinosaur bones have been found anywhere near them. Instead, the dinosaur bones are found on the flat country, in the 'black soil'.

Before 1999, very few dinosaur sites had been systematically excavated in central Queensland. When dry, the black soil (which is actually brown…) is as obstinate as any rock; when wet, it is as sticky as treacle. Attempts to dig through it have bent many a screwdriver, broken many a shovel handle, and tried many a person's patience. After growing impatient one year, David took it upon himself to remove the black soil with heavy machinery — specifically a front-end loader. That year, more dinosaur bones were found in a two-week period — below the black soil — than had been found in the preceding two seasons. Needless to say, this method of removing the black soil in bulk has been employed ever since.

By 2003, with their collection building, David and Judy decided that they wanted to set up a museum in the town of Winton — they did not want the fossils they were finding in their local area to be whisked away to Brisbane and locked in a storage facility. So they founded the non-profit organization Australian Age of Dinosaurs (AAOD) and set up a small museum in town, as well as a preparation laboratory on their property. They continued to hold annual digs over the next six years. Operations shifted to a different property from 2006, but David had always envisaged the museum being set away from the (relative!) hustle and bustle of Winton, and the preparation facility being located off his property. A local family, the Brittons, donated an expansive mesa, now known as the Jump-Up, to AAOD, and it was here that the museum was built. The doors opened on the same day that the labours of the Elliott family and their throng of enthusiastic volunteers were revealed to the world through a paper in *PLoS ONE*.

In that paper, published on 3 July 2009, Scott Hocknull (senior curator at the Queensland Museum) and a cohort of co-authors named three new Australian dinosaurs discovered in Winton: *Diamantinasaurus matildae*, *Wintonotitan wattsi* and *Australovenator wintonensis* (Fig. 4). Parts of *Wintonotitan* (known as Clancy) had been excavated in 1974 (and published as *Austrosaurus* sp. in 1981), but excavation of the original site by AAOD led to the recovery of more of the same specimen, allowing it to be diagnosed as a new taxon. By contrast, the 'Matilda' site that produced *Diamantinasaurus* (Matilda) and *Australovenator* (Banjo) was found by the property owners in 2005 and thus represented a fresh site. Fossils were recovered from the Matilda site over a five-year period (2006–10); *Diamantinasaurus* is one of Australia's best-preserved and most complete sauropod skeletons to date, and *Australovenator* is the only (non-avian) theropod specimen from Australia comprising more than a single bone. Only after the last dig at the Matilda site did I become involved with AAOD.

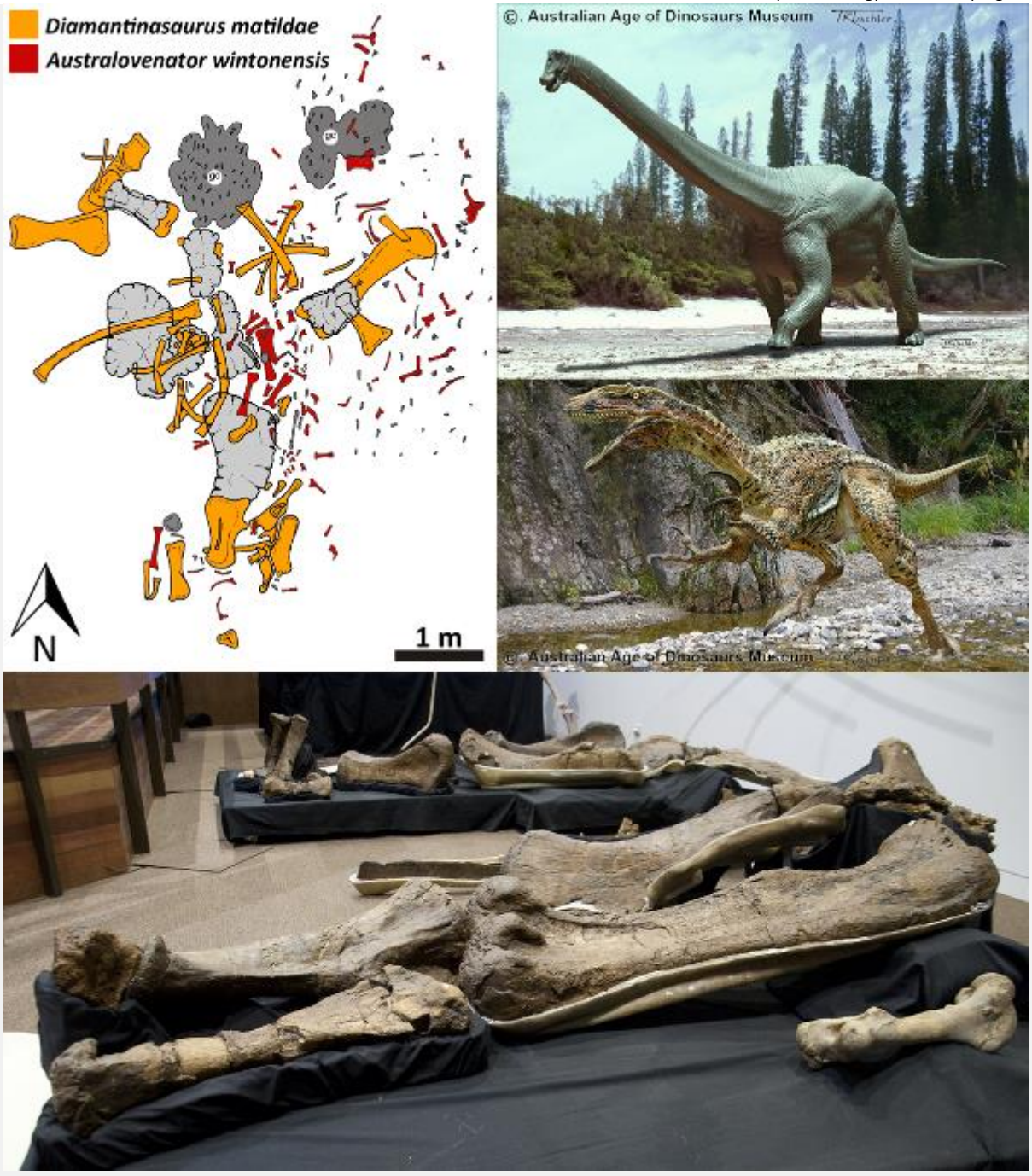


Figure 4 — Clockwise from top left: Map of the Matilda site marking the positions of the bones of the large sauropod *Diamantinasaurus matildae* and the small theropod *Australovenator wintonensis* (image courtesy S. Hocknull, modified from Poropat et al. in press a); life restoration of *Diamantinasaurus matildae* (image courtesy T. Tischler, © AAOD); life restoration of Australovenator wintonensis (image courtesy T. Tischler, © AAOD); and the type specimen of *Diamantinasaurus matildae* as it appears on display at the Australian Age of Dinosaurs Natural History Museum (photo S. Poropat).

# Me and AAOD:

In November 2010, I travelled to Winton for the first time. The first thing that struck me about central Queensland was how flat it was. The second was how dry it was (although after storms roll through, it can appear greener than the Emerald Isle). The third was how isolated it was. These feelings can become a little overwhelming on the 170-kilometre drive to Winton from Longreach, the nearest town. The road is long. The horizon seems to stretch on forever, with interminable paddocks on either side of the road. The sun beams down from the cloudless blue sky. Kangaroo roadkill litters the bitumen. The only manifestations of human interference (other than the road itself) are fences, the odd windmill and the vehicles of other road users.

Fifty km outside Winton, a series of mesas creeps into view. It is on the last and largest of these that the AAOD preparation laboratory perches. By late 2010, it had been operating for almost a year and a half — a huge green warehouse, packed to the rafters with plaster jackets on one wall, and otherwise dominated by the preparation

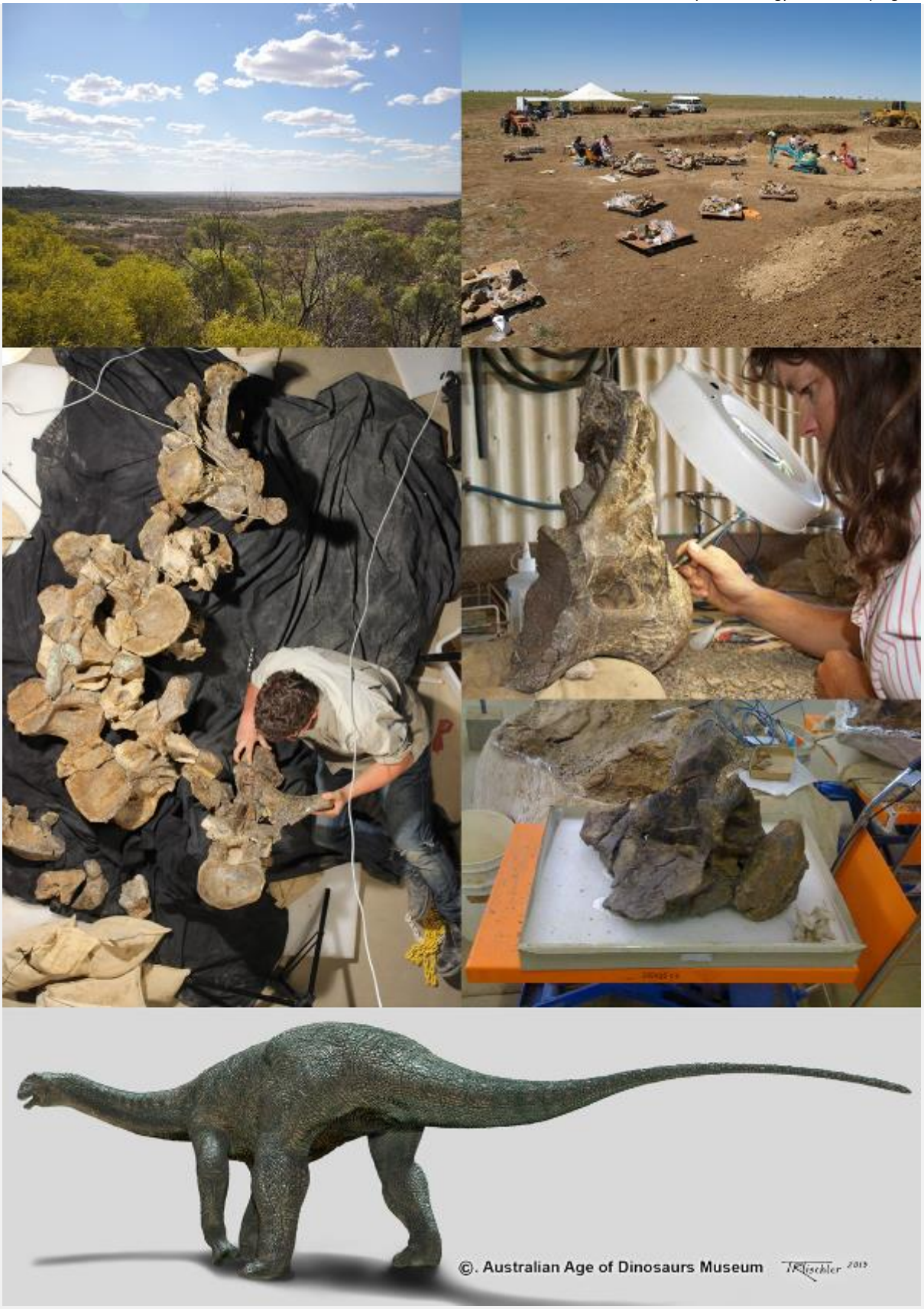


Figure 5 — Clockwise from top left: the Winton Shire from the Jump-Up (photo S. Poropat); the Ho-Hum Site, from which Wade was excavated, 2005 (photo D. Elliott); Judy Elliott preparing a vertebra from Wade using an air scribe (photo D. Elliott); a Wade vertebra nearly finished at the AAOD lab (photo S. Poropat); life restoration of Wade (image courtesy T. Tischler, © AAOD); and the author orienting five of Wade's vertebrae as they would have been when encased in rock (photo courtesy J. Elliott).

area and shipping containers containing prepared specimens. Approaching the building, I was greeted by a cacophony of pneumatic tools, screaming in protest as they were forced to burrow through the stubborn, consolidated, fossiliferous rock. When I arrived, the staff and volunteers were working pretty intensively on a dinosaur nicknamed Wade (Fig. 5), which happened to have been buried in a particularly recalcitrant concretion. But I was more interested (then, anyway) in seeing the bones of *Diamantinasaurus*, because I was to work on it and the other sauropods at AAOD for my postdoctoral research.

# Disentangling Queensland's Cretaceous sauropods:

As I am sure is the case with any fossil group, there are a few frustrating things about working on sauropod dinosaurs. The first is that they are often befuddlingly large, so most of their bones are huge. When a fossil is both large and fragile, you can forget moving it. That is why, to this day, I have only ever seen the front surface of *Diamantinasaurus*' thigh bone in photographs — it is so fragile that it cannot be removed from its supporting cradle. The large size of sauropods also means that it takes a long time to excavate their remains and to prepare them out of the rock, even with a veritable glut of willing volunteers. Finally, sauropod specimens are often frustratingly incomplete. This means that you are often unable to compare two separate specimens directly, because one will preserve the tail, for example, and the other the thigh bone, but not vice versa. These frustrations aside, however, working with sauropods is generally wonderful.

Since 2010, I have travelled to Winton ten times and have participated annually in digs with AAOD. In that time, we have made some incredible discoveries. On my first dig with AAOD in 2011, we excavated Dixie, a large sauropod. In 2012, we visited six separate sites: four were effectively barren, but one produced Oliver, Australia's first juvenile sauropod. The other site discovered that year (a mere stone's throw from the Dixie site) produced Pete — another large sauropod, and one that kept us occupied throughout the 2013 season as well. In 2014, we jumped sites again, although the last site explored, the Jenna site, will probably keep us occupied for all of 2015. Of these sites, I was more excited about Dixie and Pete than Oliver, because they seemed to preserve adult sauropods, and we need more of those.

The reason we need more adult sauropods is that my colleagues and I have been trying to establish exactly how many different sauropod species co-existed during the mid-Cretaceous in northeastern Australia. Juvenile specimens might hinder, rather than help, in this endeavour. The famous confusion between *Apatosaurus* and *Brontosaurus* occurred because a subadult specimen (named *Apatosaurus ajax* in 1877) was compared with, and thought to be different from, adult specimens of the same genus (named *Brontosaurus excelsus* in 1879). When it was determined that sauropods, like other animals, changed aspects of their anatomy as they grew, it was decided that both were probably members of the same genus, and the name coined first (*Apatosaurus*) had to stand.

To establish the number of sauropod species in the mid-Cretaceous of Queensland, we reassessed the anatomy of the type specimens of *Diamantinasaurus* and *Wintonotitan*. Satisfied that these specimens represented different taxa, we compared the specimen nicknamed Wade with both, and concluded that it, too, was distinct. Once Wade is published (alongside another exciting specimen which has to remain secret), we will direct our attention to other sauropod specimens from central Queensland, hoping that at least some will be referable to *Diamantinasaurus*, *Wintonotitan* or Wade. This will help us to better understand the anatomy of each of these dinosaurs, which will provide information about how they lived and how they were able to co-exist. I predict that their dietary preference was a big factor, but skulls, teeth and/or stomach contents will be needed for us to be able to say this with certainty.

# Where to from here for Australian dinosaur palaeontology?

It should be abundantly clear from this article that I am optimistic about the future of Australian dinosaur palaeontology. Old sites along the Victorian coast keep turning up new fossils, and new sites continue to be identified. AAOD's annual digs continue to produce new dinosaur finds, and the organization opened a second building in 2012, complete with a life-size bronze model of *Australovenator* (Fig. 6). The Outback Gondwana Foundation in southwest Queensland, spearheaded by Robyn and Stuart Mackenzie, is also finding dinosaur fossils and is currently building the Eromanga Natural History Museum. Perhaps the most significant contributing factor to my optimism is that the potential for future dinosaur discoveries in Australia is simply staggering. The sheer volume of virtually unexplored Mesozoic sediments on this continent is mind-boggling, and I have no doubt that dinosaurs of all shapes and sizes are out there just waiting to be found — as long as people get to them before the harsh Australian environment does!

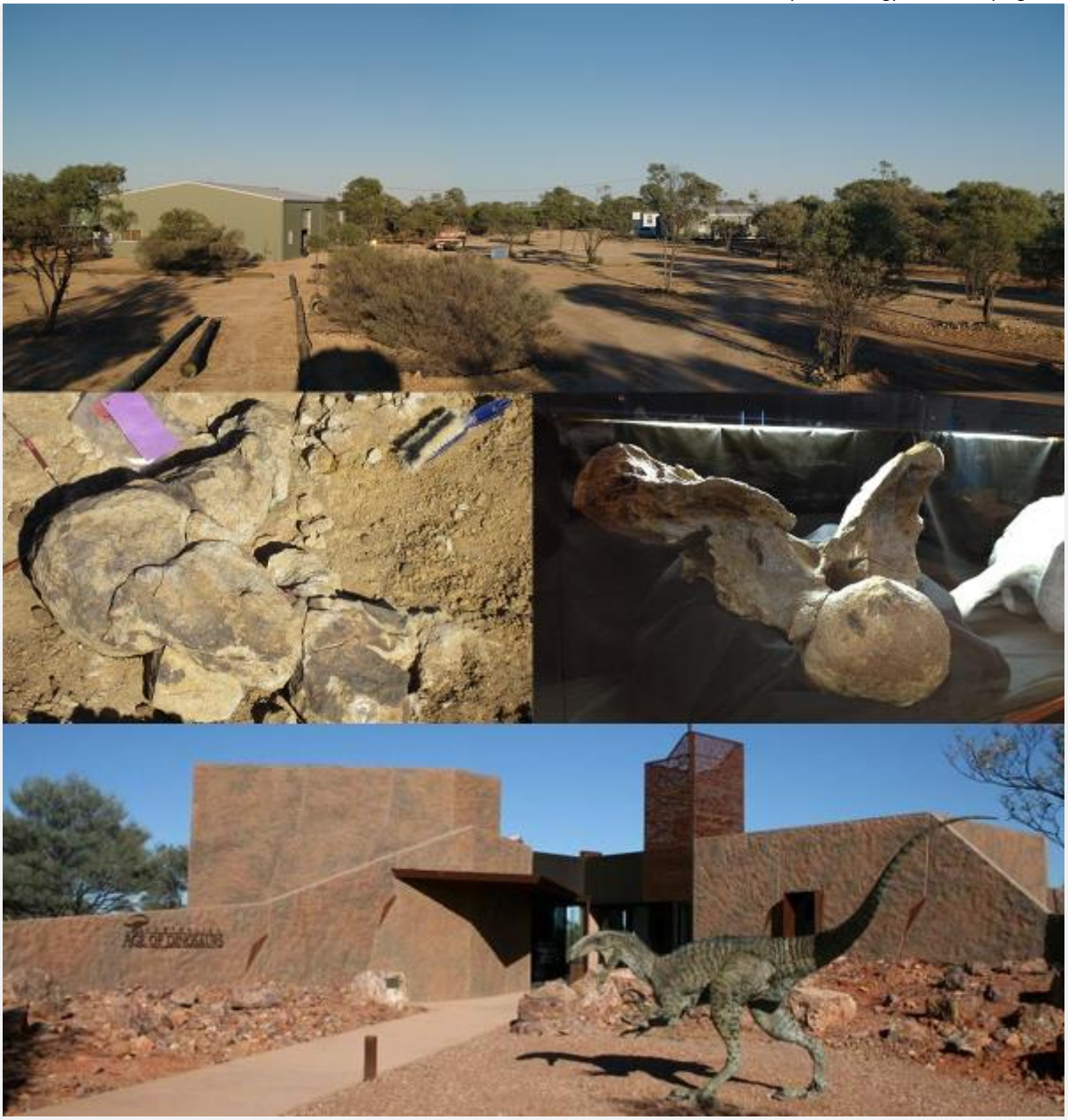

Figure 6 — Top: AAOD Preparation Laboratory (photo D. Elliott). Middle: A vertebra of Dixie in the field (left, photo S. Poropat) and after preparation at AAOD (right, photo T. Sloan). Bottom: AAOD Reception Building, where guests are greeted by a life-size bronze model of Banjo and are able to view the type specimens of *Diamantinasaurus matildae* and *Australovenator wintonensis* (photo D. Elliott).

# Suggestions for further reading:

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http://www.dinosaurdreaming.net/index.htm — Dinosaur Dreaming

http://www.enhm.com.au/ — Eromanga Natural History Museum

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