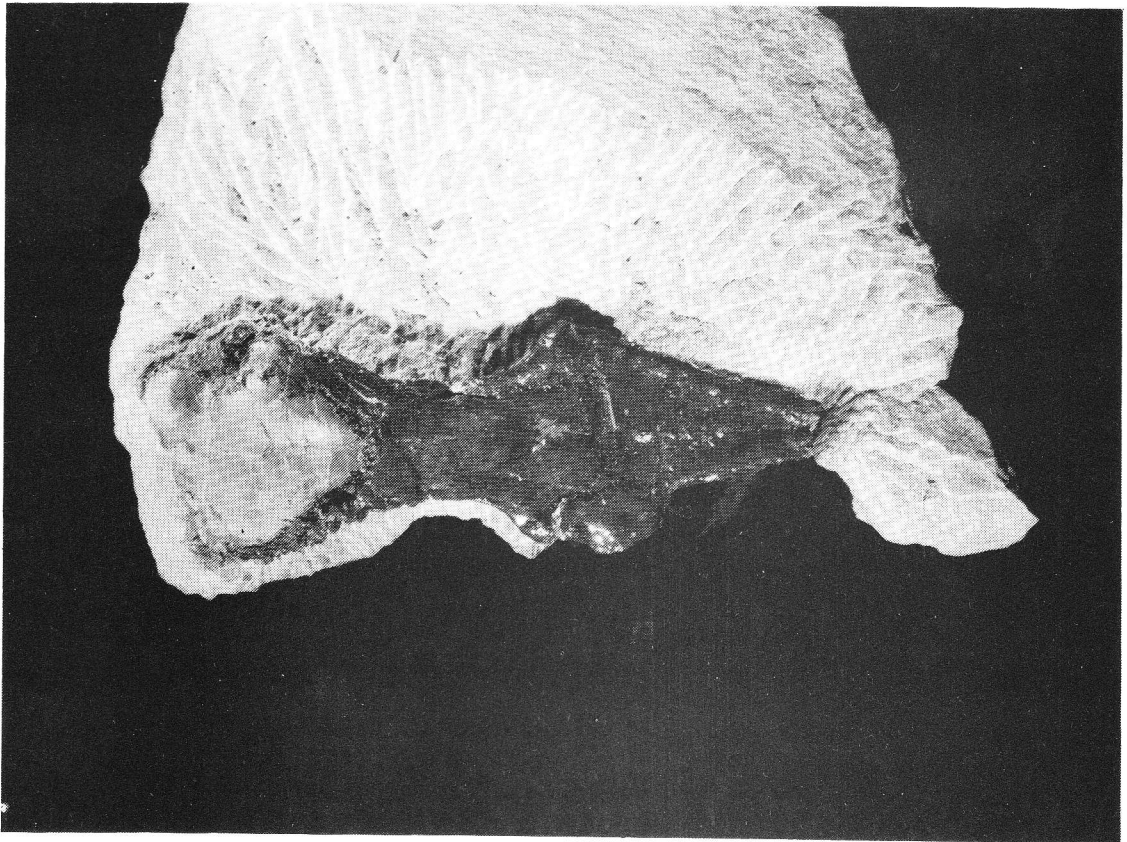


# *Dig at Dinosaur Cove*

1987



Looking down on the skull of the dinosaur found at Dinosaur Cove in February, 1987. Note the natural cast of the brain at the bottom part of the skull. Two and three-quarters times natural size.

## DIG AT DINOSAUR COVE 1987

### Background

Dinosaur Cove is a fossil locality on the Otway coast of Victoria, southeastern Australia, that has produced a small variety of fossil vertebrates approximately 110 million years old. Among these are three to six different ornithomimid dinosaurs, flying reptiles or pterosaurs, aquatic plesiosaurs, turtles, lungfish and bony fish.

Within the cove are three distinct fossil sites, Dinosaur Cove West, Dinosaur Cove East, and Slippery Rock. The latter was discovered in 1985, and the following year most of the excavation effort was devoted to it. This was because initial testing there suggested this site was richer than the other two.

By undermining the fossiliferous layer where it was exposed for 9 metres along the cliff face, an advance of 75 centimetres was made in 1986. From this volume of rock, most of the 1024 specimens collected that year were recovered. This was more than twice the number of specimens that had been recovered the previous year at Dinosaur Cove, demonstrating the relative richness of the site. Equally attractive was the fact that the fossils tended to be of smaller vertebrates, closer in size on average to that expected of birds and mammals of the age of the rocks in Dinosaur Cove than those found at the other two sites there.

By the end of the work at Slippery Rock in 1986, it was evident that digging further by undermining along the entire length of the exposed fossiliferous rock was no longer feasible. With each advance, the danger of roof collapse increased. Therefore, it was decided that rather than undermine across the whole 9 metre extent of the fossiliferous layer, narrower tunnels would be put in above that layer. In this manner, the fossils could be excavated in the floor of the tunnel by conventional means. The tunnel giving access to the area would first be blasted out of non-fossil-bearing rock above the fossiliferous layer.

### The 1987 Excavation

The schedule of prior preparations for the dig was seven weeks behind during the Spring of 1986 owing to a problem with my eyes that persisted from mid-August until early October. Fortunately, several people helped at critical moments during the time available to get the preparations completed by early January.

Notable among these was Mr. Arnis Heislars of National Parks who managed to see that the necessary excavation permit was processed during the last two weeks of December when it should have been received by mid-October.

Equally helpful was an anonymous donor who made possible the placement of an advertisement (see below) for a volunteer mine manager and underground shotfirer. After more than six months of unsuccessfully trying to locate such people, this advertisement was quite successful. Without these qualified volunteers, the 1987 expedition could not have taken place.



**Qualified volunteers  
wanted to dig  
dinosaurs**

A mine manager and underground shot-firer are needed to help excavate dinosaurs near Cape Otway for part or all Jan.-Feb. 1987. Must have credentials recognised by Victorian Government. Please contact Dr. Tom Rich, Museum of Victoria 669 9959

Setting up the camp at Dinosaur Cove began on 5 January and site preparation started five days later. With the advent of tunnelling by means of explosives, there were several preliminary tasks that had to be accomplished before driving into the rock itself could begin. Eleven days were required to accomplish such things as constructing a powder magazine for storage of the gelignite and dislodging those rocks above the Slippery Rock site which appeared likely to fall after repeated shaking once blasting was underway.

Initially, the plan called for two tunnels to be driven simultaneously in parallel to one another. One was to be at the western extreme of the fossiliferous layer (West Tunnel) and the other 6 metres to the east (East Tunnel). Access to the site for the East Tunnel was more difficult. Because of this and the fact that the problems with getting started at the West Tunnel were formidable enough, excavation of the East Tunnel was soon temporarily abandoned.

Much experimentation was necessary before the West Tunnel was finally started properly. The most favourable pattern for placing explosive charges on the face had to be established as did the amount of gelignite used in each blast and the method of detonation. Because of all this, it was several days before a proper tunnel was defined. Initially, the blasting loosened up much of the face that it had been intended to leave in place. With experience, a more optimal combination of pattern, quantity of gelignite, and detonation method was found. Refinements were

added all through the excavation right to the end of tunneling in late February. This was necessitated in part by the changing character of the rock as the tunnels became deeper and consequently the amount of weathering the rock had undergone, less.

The initial phase of the excavation in the West Tunnel was further frustrated by the foul weather and consequent high seas. Work had to be called off on four days because high seas made access hazardous. On other days, the work had to be terminated early as high seas on a rising tide threatened to inundate the excavation site.

Particular difficulty was encountered in trying to maintain an adequate water supply for the Panther rock drill. Two generators and an electric pump were seriously damaged when seawater shorted out their circuits. Another petrol driven pump was damaged in the same manner but could be repaired locally so that the work could continue. The problem of protecting the pumps from the sea was never adequately solved. Although a watch was always kept on the sea, unexpected high waves did occur that would inundate a pump before someone could bring it to higher ground. One pump would have been lost completely except for the prompt action of Mr. Don Manning who raced out into the surf and recovered it.

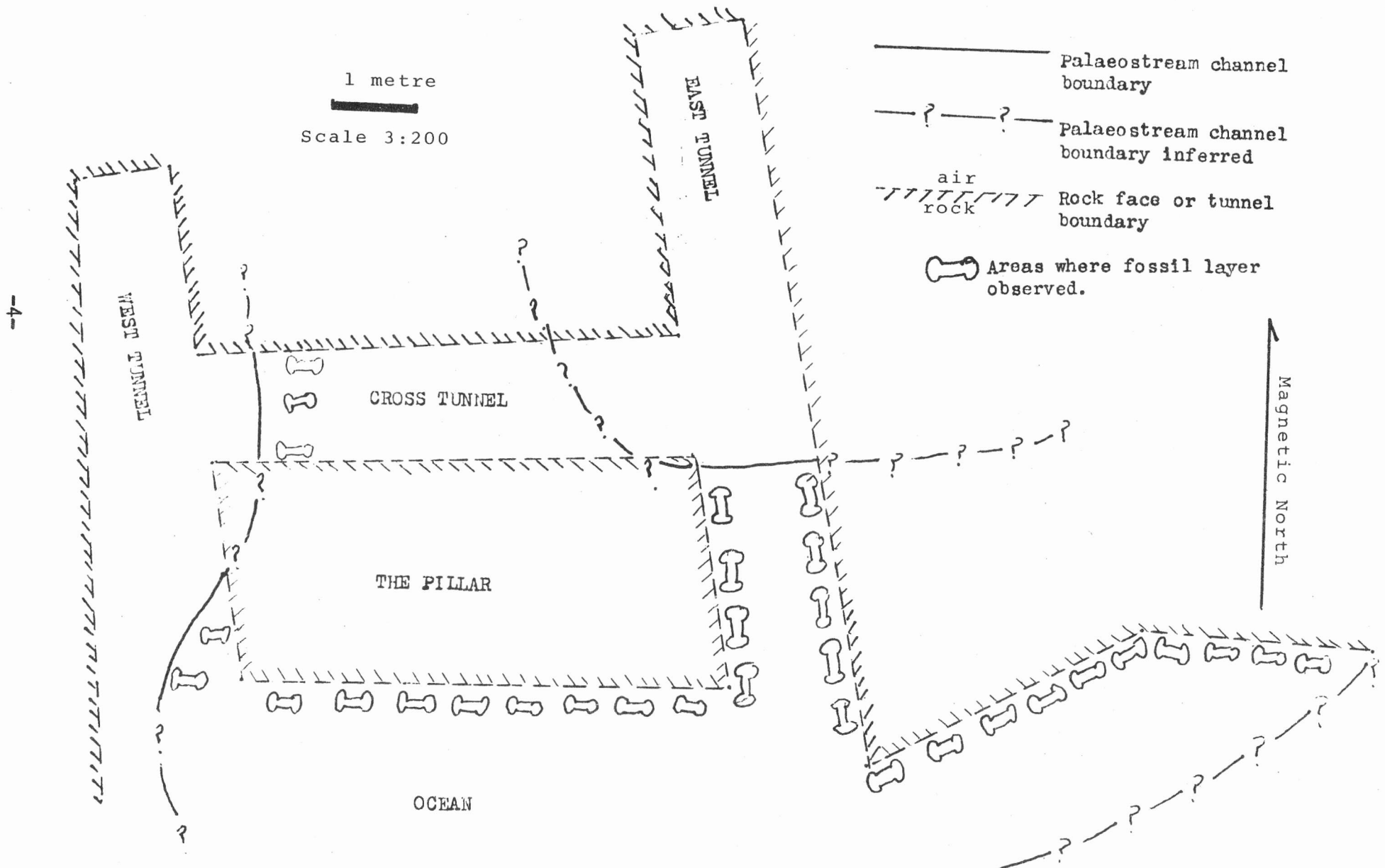
Once the excavation technique had evolved in digging the West Tunnel to the point where reasonable progress was being made, a second, successful attempt to start the East Tunnel was carried out.

With the completion of the West Tunnel on 26 January, an attempt to find fossils there was begun. It was disappointing in the extreme. Only a small area of less than 1 square metre at the mouth yielded any fossils as the floor was taken up. For the remainder of the 6 metres excavated, there was not a bone scrap to be seen. This contrasted quite markedly with the results on the rock face outside. Immediately east of the West Tunnel opening, exquisitely preserved partial skeletons of fish were recovered together with a partial jaw of a hypsilophodontid dinosaur. Apparently the West Tunnel had been placed 1 metre too far west.

On 10 February, the East Tunnel was completed. Taking up the floor, bone fragments were found for the first two metres inward from the mouth and then the fossil layer pinched out. At this stage, it appeared likely that fossils would be found only close to the surface.

Two days later, excavation of a tunnel between the East and West Tunnels, the Cross Tunnel began. Completed on 21 February, not much was found in it at first. Then on 23 February, the fiftieth day of the 1957 excavation, fossils started turning up in abundance in the Cross Tunnel. The following day, a partial skull of a small dinosaur was found in two pieces about 20

Stream Channel geometry hypothesis, Slippery Rock Site,  
Dinosaur Cove, Victoria, as at 23 February 1987



1 metre

Scale 3:200

Palaeostream channel boundary

Palaeostream channel boundary inferred

air  
rock  
Rock face or tunnel boundary

Areas where fossil layer observed.

Magnetic North

-4-

centimetres apart. The next day, two segments of vertebrae were found, one of which later was discovered to be associated with a partial hind limb. This was the first partially articulated dinosaur skeleton from Dinosaur Cove.

Once it was realised that the floor of the Cross Tunnel was relatively rich in fossils, it was decided to continue the work at Dinosaur Cove for another week to enable the entire fossiliferous layer to be collected. It was thought that the sea might rip up this layer and it would be lost forever.

Not all the 1987 excavation took place at the Slippery Rock site. A one metre wide strip was removed from the west side of the Dinosaur Cove East site revealing a number of fossil bones. The fossiliferous layer there appears to continue still further westward. The primary reason for not following it yet farther westward is that it is plunging into the cove, presenting progressively more formidable problems to keep out the ocean. Any more work on the west side of Dinosaur Cove East will require a major effort in constructing a dike. Tunnelling eastward, on the otherhand, the fossiliferous layer rises above sealevel, eliminating the problems of drainage.

With the help of the Friends of the Otways National Park Association, the camp was packed up and the collecting gear hauled out in four days, finishing on 8 March. As with the put in, this was done in drizzling to pouring rain for the most part.

#### Results of the 1987 Excavation at Dinosaur Cove

The partial dinosaur skeleton found on the fifty-first day of the excavation is about 25 percent complete and only the fourth one from anywhere in Australia. About half the skull is preserved. There is only one other dinosaur skull known from Australia besides this specimen. The teeth suggest it is one of the small, bipedal ornithopods so common among southern Victorian dinosaurs but rare elsewhere. It may be yet another species or is perhaps referable to one already recognised at Dinosaur Cove.

Preliminary analysis suggests this skull is quite unusual in that the brain is about ten times the volume to be expected for a reptile. This makes it about as large as one would expect for a bird or mammal with a skull this size. While there are a few small saurischian dinosaurs thought to be closely related to birds which have brains of this relative size, no ornithischian was known to until the discovery of this skull.

What is now Dinosaur Cove was within the Antarctic Circle when the fossils now found there lived and died. It has been suggested that the enlarged brain was an adaptation to enhance the visual, olfactory, and(or) auditory powers of the animal to enable it to cope with the problems of surviving in a habitat that would therefore have experienced three months or more of darkness annually.

Quite in contrast to this advanced feature of the brain, this dinosaur is unusual in the opposite respect. It possesses small teeth on the palate, interior to the main tooth row on the margin of the skull. Although some of the most primitive archosaurs, the group that gave rise to the dinosaurs more than 200 million years ago, possessed such palatal teeth, no other dinosaurs are known to have had such a primitive feature.

This analysis is a very preliminary one and when comparisons are eventually made with other ornithischian dinosaurs in overseas museums, it will undoubtedly be modified and refined.

Besides this partial skull and skeleton, the front one-third of a jaw as well as about half a dozen isolated teeth of dinosaurs were found at Slippery Rock. In addition there were numerous isolated bones of dinosaurs together with partial skeletons of four or five fish. Among these was part of the pelvis of a dinosaur probably larger than any other yet found in Dinosaur Cove. Altogether, more than 600 specimens were catalogued. While this was less than the 1023 catalogued in 1986, the quality of the material was higher on average. This was owing in large part to the fact that many of the fossils were found in claystone rather than exclusively in the clayball-rich sandstone. Fossils that were buried in what is now the claystone came to rest in extremely quiet water, the currents being so weak that they were incapable of moving even sand grains. In contrast, the clayball-rich sandstones were deposited at the bottom of streams with much faster flowing water which tended to break apart the bones of skeletons as well as individual bones. This discovery of claystones which yielded fossil vertebrates was one of the most significant discoveries of the 1987 dig because it offers the potential for recovering more specimens as exquisitely preserved as the one dinosaur skeleton that was found during this season's efforts.

In order to follow the ancient stream channels to best advantage, it is now clear that tunnelling above them using explosives to remove the overburden is the only effective manner in which to proceed. There are no longer known productive sites within Dinosaur Cove where any less laborious approach is possible. Those that did exist have now been exhausted or for other reasons present technical difficulties greater than those of tunnelling. Therefore, the fact that a group of people now exist who have firsthand experience in the problems of tunnelling for the purpose of excavating fossil vertebrates in the often harsh conditions at Dinosaur Cove was one of the foremost gains of the 1987 field season. Just as the 1984 dig provided the basis of experience upon which the 1985 and 1986 excavations were based, this latest effort will form the basis for subsequent digs where tunnelling using explosives will be the strategy employed.

As the tunnels at the Slippery Rock site were excavated, note was taken of its detailed geology. The picture that has emerged is that the ancient stream which deposited the fossiliferous rock at this site made a 90° bend, turning from an

east-west to a north-south heading. At the outside of this bend is where most of the fossils occurred. The East and West Tunnels neatly straddled this stream channel and the Cross Tunnel cut a perfect cross section across it. The known extent of the fossiliferous rock is the margins of the Pillar and the north wall of the Cross Tunnel. Just how far the fossiliferous ancient stream channel deposit may extend northward from the Cross Tunnel is uncertain. It could go for hundreds of metres or be cut off in the next ten centimetres by a joint or subsequent channel.

#### Critique of the 1987 Excavation

Much inefficiency was encountered as the fossil collecting and tunneling were carried out. Because the East and West Tunnels were only 6 metres apart, when loading of the explosives and blasting were being done in the former, it was unsafe to be working in the latter. In addition, when the Panther rock drill was in operation, it required all the compressed air resources available on site. This meant that while holes were being drilled for explosives in the East Tunnel, airtools could not be used in the West Tunnel.

Consequently, the winning of fossiliferous rock was much slower than had been anticipated, based on the experience of previous years. This led to the frustration of the many people who had come primarily to break up rock and find the fossils. Ironically, it did result in them breaking up a lot of rock considered to be devoid of fossils and finding some fish material that otherwise would never have been recovered.

In order to reduce the dust hazard, water was continuously pumped through the drill steel whenever the Panther rock drill was in operation. The only water available was from the ocean itself. While the supply may have been adequate, great difficulties were encountered in utilising it. Because of the rise and fall of the waves, it was difficult to always insure that the inlet hose was submerged but the pump remained dry. Saltwater shorted out the electrical circuit of several of the generators and pumps used, causing severe damage in many cases and totally destroying a piece of equipment in one instance. One possible solution to this problem would be the construction of a 5,000 litre tank thirty or forty metres above high tide level. Such a tank could be filled from time to time when continuous attention could be paid to the pump and its inlet hose. Then it could be tapped with no more attention having to be paid to it until the tank was emptied. As it was, an unusually high wave could destroy an operating pump at any time during several hours of each day when drilling was underway. The arrival of such a wave could be anticipated by less than 30 seconds, often not enough time to both rescue equipment and get to high ground when no one happened to be close to the equipment when the warning was first sounded.

When the parts of the dinosaur skeleton were discovered, I



was not on site. (Some of the crew were convinced that fossils could not be found when I was there.) Be that as it may, the reason I was not on site was because there was no other licensed driver in the crew who could legally drive the Museum of Victoria vehicle. A streamlined administrative procedure must be found that will allow qualified drivers to drive Museum vehicles although they are volunteers rather than employees of the Victorian government. Although I am sure that the people who found the various parts of the specimen did a quite competent job, it would have been much better had I been there to insure that all the contextual information that could be desired was recorded. Once the specimen was moved, as it had to be under the circumstances in which it was found in order to preserve it, this type of information not already recorded was lost forever.

#### Future Directions

Major excavations have now taken place at Dinosaur Cove during the four successive summers of 1984 through 1987. With the discovery of the exquisite partial dinosaur skull and skeleton, a specimen of world class quality in the state of its preservation, the next sensible move at Dinosaur Cove is obvious. What will be done is to attempt to follow the ancient stream channel at the Slippery Rock site northward from the Cross Tunnel. If it disappears, then the final phase of the operation at the Slippery Rock site will be to remove the pillar of rock between the Cross Tunnel and the ocean because that is known to have yielded partial fish skeletons in claystone on one side and a dinosaur skull and skeleton on the other in the same kind of rock.

A second course of action will be to put in a series of drives eastward from the existing tunnel at Dinosaur Cove East. This will give access to the fossiliferous rock there which has yielded much material in the past. With the expertise now acquired in tunnelling, this is a reasonable approach to take to exploit this site.

It is proposed that the next excavation at Dinosaur Cove be during the first three months of 1989 if funding and volunteers can be found. In order to allow the scientific evaluation of the specimens already collected, no excavation will take place at Dinosaur Cove in 1988. In the meantime, funding will be sought to pay for the preparation of specimens by technicians, illustration of the fossils by a scientific illustrator, and comparison of the Dinosaur Cove material with similar dinosaurs housed in Europe, Asia, and North America.

The following persons participated in the excavations at Dinosaur Cove in 1987.

William Alley	Daphne Hardf
Trevor Almeida	John Herman
Andrew Anastasious	Allan Hey
Sofia Bartoszewicz	Graeme Hird
Warren Batchelor	Fam Hutchinson
Dianne Beevers	Roslyn Jamieson
Alastair Blaikie	Ljubica Jelacic
Ray Blandford	Ronald Johnson
Mark Blows	Merren Jones
Steven Birch	Dawn Kanost
April Boughton	Nick van Klaveren
Iris Brailey	Amanda Kool
Helen Brown	Lesley Kool
Peter Brown	Eric Leach
Ted Bryan	Penny Love
Giacoma Bryan	Gwen Mann
Ian Butler	Don Manning
Karen Butler	Karen Manwaring
Kathy Chintoanu	Wayne Marks
Phyllis Collet	Takahito Masuda
Michelle Colwell	Anne McNess
Martin Cook	Karl Millard
John Doyle	Jenny Mills
Phillip Eagles	Shinko Mori
Gilbert Elliot	Mark Morrison
Jerry Fischer	Derrick O'Brien

Graeme O'Brien  
Peter O'Donnell  
Jennifer de Pagny  
Emma Poole  
Rosalinde Poole  
Lesla Poulter  
Scott Pownall  
Fam Proctor  
Nathan Randall  
Patricia Rich  
Thomas Rich  
Linda Russell  
Rupert Russell  
Natallie Schroeder  
David Schultz

Leone Sharpe  
Stephen Sheers  
Daniel Smith  
Katherine Smith  
Mark Spalding  
Gordon Spark  
Frank Stewart  
David Taylor  
Robert Tranter  
Rebecca Veitch  
Darren Watson  
Thomas Whitelaw  
John Wilson  
Wendell Zipse

Many people, although not formally expedition members, helped make the work a success. Without their cooperation and assistance, it would have been much more difficult if not impossible to accomplish the results achieved.

John Angel  
Alan Bridgeman  
David Denney  
Winsome Denney  
Judy Forrester  
Arnis Heislars  
Spencer Hird  
Broniek Karcz

Terrance Lawrence  
William Loads  
Jack Mackenzie  
Max Manley  
Patrick O'Neill  
Alan Rampel  
Chris Wilkinson  
Joy Wilkinson

Many different organisations helped to make the excavation at Dinosaur Cove possible. in 1987.

Atlas Copco: loaned the mining equipment

David Holdings: provided food

Earthwatch: provided six volunteers and funds for purchase of food, equipment, and payment of salaries

ICI: provided all explosives

Mobil Oil: provided all diesel fuel

National Geographic Society: provided vehicle

Friends of the Museum of Victoria: purchased safety equipment

Council of the Museum of Victoria: provided funds for the purchase of food and equipment

Thomas H. Rich  
2 June 1987