A Tale of Two Tunnels

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In the history of vertebrate palaeontology, to my knowledge only two tunnels have been excavated for the sole purpose of recovering dinosaurs and other fossils for exclusively scientific purposes. One of these, Dinosaur Cove, was on the coast of the Southern Ocean in the south eastern corner of Australia. The other, the Berry Adit, was on the left bank of the Colville River that cuts across the North Slope in far northern Alaska.

The steep slopes at Dinosaur Cove are 90 metres high. The tunnels there were excavated by volunteers trained on the spot. Located just above sea level, these tunnels were occasionally flooded by unexpectedly high waves even when the work was underway. Dinosaur Cove today is located at 38^{o} South in the temperate zone. The Berry Adit is located at the base of a 30 metre high bank of the Colville River. The adit [= tunnel with a single entrance] was cut by professional miners at just below river high water during the course of the year. This adit is located at 70^{o} North in the frigid zone.

- Common to both tunnels were the following:
- When the dinosaurs found at these two sites were living animals, both areas were at polar latitudes.
- Both were sites hard to access and consequently logistically difficult to work.
- Each was a pioneering effort.
- The initial idea to excavate them was mine.
- Both were a success in having achieved their primary goals. At Dinosaur Cove that was to recover dinosaur fossils.

At the Berry Adit, to determine what was required to excavate an adit into permafrost in order to recover dinosaurs in that way under the conditions prevailing on the North Slope. The former was an unqualified success while the latter, although the primary goals were achieved, was plagued with problems between members of the field parties, difficulties which limited the additional beneficial outcomes that might have otherwise been gained from that excavation. In addition to the physical differences between the two places, there were numerous other dissimilarities between the operations at Dinosaur Cove and the Berry Adit. In this article, I shall focus exclusively on those that were critical in determining the disparity of outcomes.

In many ways, the most critical differences in the excavation of the two tunnels stemmed from the way in which each was financed. Dinosaur Cove was initiated because the Friends of the then National Museum of Victoria simply insisted in 1983 that I take them on a dinosaur dig and would not take "No" for an answer. They provided the initial funding and about seventy eager and inexperienced volunteers. That, together with in kind support from the Swedish mining equipment company, Atlas Copco, paid the costs for the first excavation a year later. The result was a demonstration that significant fossils could be recovered at the site by tunnelling. In the following decade, in addition to those funding sources, consistent grant funding was successfully obtained from the Committee for Research and Explanation of the National Geographic Society.

Tunnelling at Dinosaur Cove began on a very modest scale and was, in fact, abandoned for the second and third field seasons when another site within Dinosaur Cove was found during the first season of work there by my principal colleague who also happens to be my wife. Only in the fourth year was tunnelling undertaken using explosives to advance the drive. Because the animals whose fossils were collected at Dinosaur Cove had lived at polar latitudes, for comparative purposes, my principal colleague and I had first visited in 1989 the Alaskan site where the Berry Adit would be eventually excavated.

On that visit, I came to realise that for reasons of safety, better preservation of the fossil specimens recovered, as well as dependable access, it would be worthwhile to try excavating a tunnel into the permafrost where the fossils were entombed to see if that would be a better method to recover fossils than the techniques employed previously in those circumstances. The previous techniques were the conventional approach which is to excavate in the open with hand tools. Carrying out an experimental excavation of an adit would allow us to move beyond mere conjecture to a practical assessment of the desirability of this approach to collecting fossil vertebrates on the North Slope. Eighteen years later, when support for the project had finally been found, the test excavation resulted in the Berry Adit. The rather lengthy time between the inception of the Berry Adit project and its execution was entirely owing to the lack of funding. Numerous conventional fund granting agencies and corporations were approached over the years, to no avail. Because of the location of the Berry Adit and the way it was proposed to be excavated, the budget was ten times what a palaeontological excavation would commonly cost in more accessible and less severe conditions.

Funding agencies have an expectation of what a project in a particular field costs. While projects in some other fields of science are typically equal to or even an order of magnitude larger than the amount requested for the work in Alaska, it is difficult in the extreme to persuade people accustomed to supporting work in a particular speciality area to change their expectations. A decade of tunnelling at Dinosaur Cove cost just over two and a half times in cash and in kind as the single excavation of the Berry Adit early in the spring together with one follow up trip the next summer to excavate fossils from the floor, A$1,075,000 for a total of 500 days of fieldwork spanning ten years versus A$379,000 for a total of forty-eight days over five months.. The average cost per day, again in cash and in kind, of the two operations was A$2,150 at Dinosaur Cove as opposed to A$7,900 at the Berry Adit. In kind support at Dinosaur Cove was about two-thirds of all the support received in contrast to less than 10 percent for the work at the Berry Adit, the balance there being in cash.

Funding agencies, unless flush with money, are conservative in the projects they will back, avoiding those which are judged to be unlikely to succeed. Unfortunately it is in the nature of things that proposed radical departures from the norm which might result in a major new insight are always inherently doubtful or they would not be revolutionary in their implications. In the end, what was absolutely essential for securing the funds to excavate the Berry Adit was a chance conversation that I had with a documentary maker who I was assisting in filming work at a fossil locality in southeastern Australia other than Dinosaur Cove. She responded to the idea of the Alaskan project with a quiet, "that would make a good documentary". After tireless work on her part over a number of years gathering together support from several media groups, in March 2007, she and I together with eight other people assisting us, found ourselves travelling across the frozen tundra of the North Slope to excavate what would become the Berry Adit.

Temperatures dropped to -40^{o}C, however logistically such conditions are favoured in northern Alaska for civil engineering projects because frozen ground and rivers can be crossed by sleds, tracked and wheeled surface vehicles, whereas in summer they cannot. Furthermore, excavation into permafrost is much easier in winter and early spring because the surface where the digging begins is frozen solid. While a formal agreement had been made between my institution and the documentary maker's organisation, what was most important was that both of us viewed the project in the same way. I envisioned that the purpose was to excavate an adit and a documentary be made about doing it. Neither had priority over the other simply because both were equally essential. On that basis I had anticipated friendly cooperation on all aspects of the project. To my chagrin, the documentary maker pictured it quite differently. She regarded her project as the first priority, with the excavation being an activity to be carried out in a manner to accommodate the filming.

On paper, this may seem to be a subtle or even trivial difference. But in reality, it was a difference of viewpoint that nearly destroyed the project. The documentary maker was clearly extremely frustrated that this pioneering effort did not go according to her expectations, as can be readily seen from reading her views, expressed publicly in *Nature*, on the way she interpreted how the project was carried out (Abbott 2007). The dig she filmed with my help in Australia had been underway for years and was essentially in a mature production phase. There one could reasonably anticipate what was going to happen. Alaska was quite different simply because nothing like it had ever been done before. Under those circumstances, one had to expect the unexpected and she did not appreciate that difference.

From the outset, my strategy for the Alaska work was to innovate as little as possible. Rather, I planned to build on my experience gained about the practicalities of tunnelling at Dinosaur Cove. To this end, I called upon the expertise of an experienced Arctic miner. He and his team were hired to drive the adit. Although I make no pretence of being an experienced miner, I did have experience working with miners having gained a Victorian government mine manager's certificate that allowed me to legally operate an underground excavation in that Australian State. After the adit was cut, the palaeontologists were to excavate the floor of the adit using methods familiar to me. Based on my experience gained over a decade of working Dinosaur Cove, I insisted on having compressed air tools, such as jack hammers, which in the past had proven essential in underground work, although I could not guarantee *a priori* that they would be used in the context of the Berry Adit. Still, they needed to be in place in case they could well be required in a way that could not be anticipated. Unfortunately, this expenditure infuriated the documentary maker because she interpreted it as frivolous as I could not in advance point out a specific need for them.

To her it was unwarranted in that it took money away from other things she had in mind such as the extensive animation she planned to include in the documentary. She was also repeatedly harsh in her judgement of my decisions concerning my field manner and safety evaluations, all approaches that had worked smoothly and effectively at Dinosaur Cove. In this she was joined by the Arctic miner cutting the adit and an Alaskan palaeontological colleague. On the other hand, it never crossed my mind to comment on her approach to making the documentary, no matter what my views, because I saw that as her area of responsibility. Likewise, having informed the Arctic miner about what was to be done, I regarded it as his business how he went about accomplishing his task, his area of expertise. However, without being judgemental of the basis for his decisions, I did want to know the reasoning behind them both as part of my own education as well as to further the principal goal of this project which was to provide a guidebook for anyone in the future contemplating a similar undertaking. Unfortunately, unlike the Australian miners I had worked with before who were pleased by my interest shown in this way, the Alaskan miner was affronted by it.

Perhaps he thought I was questioning his competence, which was not my intention at all. So I simply gave up. My experience with other documentary makers over the years has been very different. All but one group came on site and for a time observed what was happening, asked a few appropriate questions, and then basically went on to document what went on. They filmed what they saw without trying to alter the process or attempting to make actors out of the diggers. I therefore did not anticipate such a different approach in March 2007. After all, it was supposed to be a documentary about an actual event as it would have happened had no camera been present. However, as things started to falter, I repeatedly reminded myself that none of the other documentary makers had provided the majority of the funding for the project that was being filmed. Given the terms under which the funding was secured by the documentary maker, it is in retrospect possible to understand why she held the views she did. In my opinion, however, her views were counter productive in terms of achieving the best result both for her and for me.

Apparently, one of the principal sponsors of the documentary had exerted significant pressure on the documentary maker. One of these pressures was for the documentary maker to provide several scripts for this "movie" that in succession were deemed unsuitable. This sponsor made it clear that the payment of the money promised by her organisation would not be provided until a satisfactory script had been accepted. This became such a serious issue that the project was delayed for a year. Interestingly, as the documentary maker was in the process of writing these various scripts, she expressed the view to me more than once that it was pointless to write these hypothetical scenarios as she intended to film what actually happened rather than shoehorning the documentary into any preconception. The micromanagement by the sponsor reached the extreme when she insisted that, in order to please their American audience, the protagonist of their version of the documentary had to be a particular individual because he spoke with an American accent. He also happened to be vehemently opposed both to the project and my effrontery to be working on the North Slope at all. The latter despite the fact that he had never set foot in Alaska until years after I had formulated the excavation plan with another professional colleague in Alaska and taken significant and public steps to implement it. Ironically, although I have lived more than half of my life in Australia, I still speak with a distinct American accent.

This would have been a laughable situation if it had not resulted in yet more needless pressure on the documentary maker to conform to the demands of a sponsor totally out of touch with the nature of the project and the people involved. By the time the project got underway, the outside pressure to produce a documentary that following a prescribed sequence of events had evidently become so internalised by the documentary maker that she could not break out of this pattern when the filming commenced. She had her preconceptions and when things worked out differently, she was not happy. In April, it reached the point where she threatened to withhold the promised funding that would enable me to return the following August to excavate the floor and recover the fossils. Her plan was to ask a technician from Alaska to do that work although until this project, he had never had experience working underground in his life. Evidently, she must have felt that once the adit was cut, things would be so straight forward that my previous subterranean experience was superfluous.

Had I been able to recognise the core cause of this bizarre situation when the work got underway, perhaps I could have "acted". However, there are limits to altering reality. Had I yielded to her complaints about the compressed air tools, going against my own professional judgement, the fossil layer would not have been reached in the August excavation. So she would have had little to film then, and certainly not the recovery of any fossils from the adit floor. After the tunnel had been excavated in April, the Colville River rose during the annual ice break up in June to such a height that it flooded the adit. When we returned in August to begin the excavation of the floor, timbers and trash left behind by the miners the previous April were welded together by sixty centimetres of ice, intermixed with slush. Only the presence of the "frivolous" air tools made possible the removal of this detritus. Even then, it took four days to clear the floor before excavation of it could be attempted. Without the compressed air tools, we would have been stymied.

All the documentary maker could bring herself to say in the end was, "Your were lucky." No acknowledgement of the fact that my prudence in the matter of the necessity of having compressed air tools based on my previous experience had been borne out by circumstances. The reluctance shown towards the project by a number of my paleontological colleagues involved in the work in Alaska was because they did not see it as something worth their personal effort, but still felt compelled to participate in it if it was going ahead. Because of this, my bargaining position was very weak when it came to getting them to do their part: frustrating as trying to push a string. Eisenhower once remarked that his greatest contribution to victory in World War II was not fighting the Germans. Rather, it was keeping Bradley, Patton, Montgomery and De Gaulle fighting the Germans instead of one another. Unfortunately, I am not such a charismatic individual. A critical difference between the outcomes of the projects at Dinosaur Cove and the Berry Adit is that I inspire people to follow me only by example.

As leader of a project, I work hard and am dedicated to the objective of any one I take on. If those who assist me identify with the goals of the project, that is quite sufficient, and crew morale is high. In Alaska those personal abilities I do posses were not sufficient to excite an interest that was not initially there. More was needed. Had I shared Eisenhower's winning ways and famous grin, perhaps things would have gone more smoothly. Another marked difference between the two projects was the permitting process. In Australia, a single governmental permit was required. In Alaska, thirteen permits were required from different instrumentalities. In Alaska, it was necessary to specifying in detail beforehand the techniques to be employed in the excavation, totally unlike the situation in Australia. In Australia, the permit was given with the implicit assumption that I was qualified and the work would be carried in an appropriate manner, the techniques to be employed specified only in the broadest of terms. This permitted significant, immediate changes to procedures as experience was gained at Dinosaur Cove.

The rigid regulatory regime of the Americans significantly hampered the implementation of any innovation based on evaluation of circumstances arising during the course of the field work and in the end prevented the accomplishment of an important secondary goal of the project. Strangely enough, however, when it came to matters of occupational health and safety, the Australians were much more stringent than the Americans. Fortunately, that made no difference in the relative efficiency of how the two projects were carried out because of the manner in which appropriate occupational health and safety measures in both cases were identified in general terms before the work began that could readily be applied as experience was gained. At Dinosaur Cove, interpersonal relationships were not always smooth. Never, however, did the situation deteriorate to the unfortunate situation that developed in Alaska, because there were never simultaneously so many discontented people as to reach a social "critical mass".

Because of their involvement with the making of the documentary, or their institutional affiliations, there was no choice for those who proved to be unhappy: they had to participate in the excavation. Thus I did not have the freedom to choose who would be on the dig even if I could have foreseen those who would prove to be unsuitable. Clearly, it would have been much better for all concerned if those discontented people could have left when the work was underway. In August, four colleagues who had worked with me previously in Australia accompanied me to Alaska. With their aid, the fact that the permits were in my name, and sufficient funds independent of those provided by the documentary maker were available, it would have been possible to complete the excavation of the tunnel floor without her. However, as the documentary maker had done so much to get the project to that point, I did not feel it morally defensible to proceed without her if she wished to participate despite her having tried to oust me from the August dig the previous April. And return she did.Unfortunately, it was only after the work was underway in Alaska in March/April 2007 that these crucial differences surfaced in the attitude of the people involved in the work there as compared to that of those who helped me previously in Australia.

Then it was simply too late to make any change that might have improved the situation. Excavating tunnels for the purpose of recovering fossil vertebrates is not yet a familiar or accepted procedure in the paleontological community. Therefore, first and foremost, the goal for the work in Alaska was to establish the practicalities of this approach in the circumstances that prevail on the North Slope. If that was achieved and none of the secondary objectives were, the latter could always be tried later. If the primary objective had not been achieved in that initial attempt, those secondary ones probably would not be carried out in any other manner in the foreseeable future because an adit was needed to do so. That the primary objective for the project was in fact accomplished means that all the secondary goals can be achieved eventually if so desired. A brief paper summarising those engineering aspects of the project has already been published elsewhere (Rich & Vickers-Rich 2008). The documentary maker's film has been shown in Australia. In the United States, it was significantly altered owing to the perception by PBS/NOVA that what was given to them was unsatisfactory for their audience.

The secondary goals of the project may in part be achieved when laboratory work on samples collected for this purpose are analysed. But other secondary goals were reluctantly abandoned when it was realised that they could not be achieved in the social climate prevailing on site in August 2007. Although I may not have been the ideal person to have led the work in Alaska in terms of maximising the potential benefits of this novel project the first time it was attempted, a critical question from a management point of view remains. If the Alaskan project was worthwhile, and I had not played the role I did, would anyone else ever have tried to do it? Perhaps what made me see the opportunity and pursue it at length is somehow linked to my inability to be an inspiring leader to those who are not so motivated in the first place. Had the documentary maker been more flexible and easy-going, accepting my leadership in my area of expertise, would she have seen the opportunity to make such an unusual documentary when the project was first described to her in a casual conversation? Had she not seized upon it, working tirelessly for years to obtain the bulk of the necessary funding, it never would have happened.

Again, perhaps the different personality characteristics had to all be present or the project never would have jelled in her mind and be linked with the determination to see it through. It has been said of the American Revolution that it was fortunate that when the United States Constitution came to be written, most of the radicals who were responsible for the success of the Revolutionary War were either not in attendance or played a minor role. Likewise, perhaps it would have been far better for all concerned when the project was finally executed in Alaska, if the people who actually carried out the dig did not include the two persons who were central to its happening in the first place.Why were the two primary goals of the Alaska project achieved at all? Given the actual circumstances that prevailed on the North Slope when the work was carried out, why did the field party hold together long enough to reach the primary objectives despite so much angst? The answer to that is of at least of equal interest to the question of how the project could have been carried out in a less acrimonious and thus more productive way. In the final analysis, was it simply the fact that neither the documentary maker nor I were willing to give up short of our respective principal goals? Could "normal" people, whoever they are, have done this or did it require a "marriage made in Hell"? As is said in many physics text books, "the solution to this problem is left as an exercise for the reader".

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