Rivers, relocation and ruin: the history and legacy of mining river diversions in Victoria

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Eager to strike gold and make their fortunes, the 1850s influx of miners was to have a dramatic impact on the demography, the economy and the environment of Victoria. The proportion of alluvial gold coming from Victoria was extremely high by world standards,[1] and much of the initial mining effort concentrated on the uncovering of alluvial gold deposits that lay within the bed and banks of river channels, or the adjacent floodplains, and the flow of the water within river channels was a key resource for mining success. The procurement and subsequent control of water resources was essential for success within alluvial mining and for settler hegemony.[2] However, Australia is notorious for its seasonal, and often unreliable water supply, with rivers experiencing some of the greatest flow variability in the world.[3] Subsequently, the gold mining rush within Australia caused a vast growth of population and unforeseen expansion and alteration to the waterways of the continent.

Rivers and their surrounding floodplains feature the remnants of mining activities, both in the construction of engineered structures such as sluices, the legacy of large tailings, and subsequent environmental alteration. The prevailing landscape and presence of historical artefacts is testament to the major work undertaken for alluvial gold mining. This included securing a stable source of water, which was essential for alluvial gold mining practices, while the diversion and subsequent transport of water was carried out frequently. Water supplies were transported long distances through the construction of long and complex water networks, called races, which were designed to convey water towards mining claims.[4] Water races were either temporary and made from timber or cut into the dirt as excavated channels. Water used within a consumptive sense, that is, either for mining, agriculture or domestic purposes, was very well documented within Victorian mining. Many records exist listing the acquisition and control of water supplies, including the detailed location and ownership of water races that traversed the landscape.[5] Once obtained, water was commonly used in mining tasks such as driving water wheels, tomming and ground sluicing (Fig. 1), and eventually hydraulic sluicing.

The use of water within the mining process progressed over time. Ground sluicing, referring to the channelling of water through a series of artificial channels into a creek or gully became common from 1853, while washdirt from this channelled water was then directed into a separate sluice box or tailrace.[6] By 1855, water was frequently transferred from rivers,[7] especially in mountainous settings where water flow was abundant, and the surface topography allowed for its free-flow downstream. If this was not feasible, horse drawn whims were used to draw a supply of water from beneath the ground.

Figure 1: *a) Illustrations showing tomming and b) common ground sluicing.*

Source: R. Brough Smyth, *Gold field and mineral districts of Victoria with notes on the modes of occurrence of gold and other metals and minerals*, Melbourne, 1869, p. 127.

Hydraulic works undertaken within the gold rush were far from primitive. Water supply works such as the Coliban system provide an example of the calculation and effort that went into securing an effective water supply.[8] It is estimated that by 1868, a period prior to the uptake of hydraulic sluicing, over 3,900km of races had already been constructed across Victoria.[9] In some areas, such as Beechworth, the proliferation of constructed races resulted in river flows becoming a mere trickle.[10]

Historic gold mining in Victoria led to major changes in water management and to river systems. The relationship between water and historic mining practices has largely been explored through its acquisition and use as a valuable commodity,[11] or through the legacy and environmental impact that alluvial mining practices have upon water resources.[12] Examples of this include the prevalence of tailings within river systems, mercury contamination,[13] metal contamination from tin mining, and the impact of hydraulic sluicing on waterways. These impacts have been well documented, but less well covered is the physical relocation of water, or diversion of river channels for mining.

A river relocation (or river diversion) refers to a purpose-built artificial channel constructed to redirect the riverbed and its flow. The new artificial channel replaces a section of a natural watercourse with a typically shorter section of channel that can be lined, sculpted through alluvial material, or blasted through bedrock.[14] This paper addresses the effects of numerous tunnels and channels specifically constructed to relocate the path of a river channel within alluvial gold mining. These relocations occur in the form of a tunnel (known as a blowhole), diversion sluices and channel cuttings located through stable islands in rivers,[15] or through the neck of a spur in the surrounding topography. Blowhole tunnels and channel cuttings through spurs differ from water races in that the flow is not immediately used in a consumptive sense. These river relocation channels were constructed in Victorian waterways to support alluvial mining ventures, predominantly to gain access to the riverbed. Such river tunnels and channels continue to divert river courses and continue to influence the biology of rivers to this day. This paper describes river relocation works constructed for gold mining within Victoria and explores the role and subsequent legacy of these historic river relocation channels.

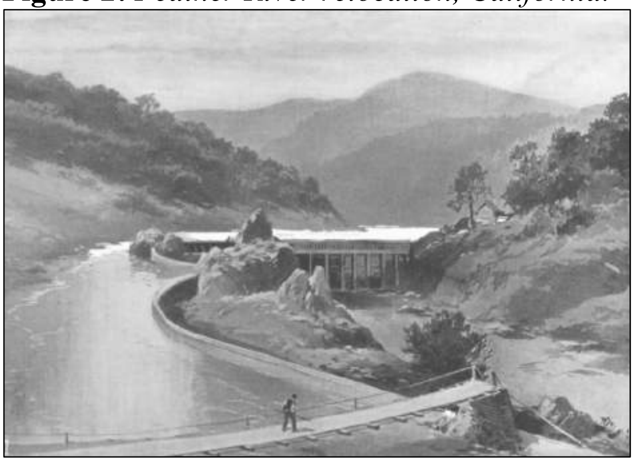
The most prominent of river relocation works within Victoria are bedrock river relocation tunnels (or blowhole tunnels). These channels were constructed to gain access to valuable deposits located within the sediments of the riverbed. Many other river relocations were carried out and these were largely small scale, local and unrecorded – the result of opportunistic miners.[16] There is typically less information surrounding the smaller-scale river relocation channels, and therefore the focus of this paper is directed to the larger bedrock tunnels and channels, concentrating on river relocations conducted to remove water, and not those utilising water in a consumptive sense. We firstly introduce bedrock river relocation channels, then known historical information surrounding their construction, novelty and performance. Lastly, we address the legacy of these tunnels today.

Bedrock river relocation

Permanent bedrock river relocation channels frequently alter the course of a river segment, using local topography to minimise the associated efforts in construction. Thus, bedrock river relocation channels were usually constructed through a meander bend or cut through resistant bedrock to create tunnels, the use of bedrock providing a means to confine the new channel and reduce construction costs. The new channel often took the form of a trapezoidal cut and being narrower than the original channel, caused the water to flow with increased velocity. During river tunnel construction, temporary dams were constructed to constrain the channel flow until the tunnel was able to convey the full flow of the river, the relocation making it possible to gain access to the dry riverbed, to carry out mining.

This process of relocating river channels was not restricted to gold rushes within Australia. Many European and Chinese rivers were subject to centuries of channel modification. Additionally, there are numerous examples of river relocation projects undertaken throughout California, such as the 243m long miners' tunnel near Hoyt's Crossing on the Yuba River,[17] and the Feather River relocation (Fig. 2), constructed in 1892.[18] The Feather River relocation involved the construction of a canal along the bank of the Feather River, which was 40 feet wide (12m) and 6,000ft (1.8km)[19] long, requiring the excavation of 50,000 cubic yards of material.[20] Later in 1916, gigantic timber river flumes were constructed within the Porcupine mining district in Alaska (Fig. 3).[21] In Australia, mining outposts would establish and feature both halcyon growth and gloomy decline.[22]

Figure 2: *Feather River relocation, California.*



Source: 'Illustration 1', (Drawn by Charles Graham), *Harpers Weekly,* 1895, vol. 39, p. 56.

Gold deposits that featured prominently within the Californian gold rush had been eroded from their host rocks more recently than the gold deposits found on the Australian continent. A result of this was that much of the auriferous material was found closer to the channels of Quaternary river systems found closer to the channels of modern river systems than was the case for Australia. This proximity of gold deposits meant that the majority of larger river relocation channels constructed within California were moderately successful ventures that motivated others to follow their example. The innovative techniques and conventions of the Californian gold rush or tin and coal mining from England, were frequently imitated in mining ventures across Australia, with experienced miners moving across the world to discover new ventures, while taking their skillset and experience with them.[23]

The gold rush in Australia saw an influx of miners from the goldfields of California in addition to miners from Europe and China, all hoping to make their mark on the growing mining landscape. Miners were experienced within niche geographic areas, such as Chinese miners who typically migrated from Southern China,[24] from the lush and fertile provinces of Guangdong and Fujian[25], both being regions with ample rainfall and steep topography. Of the European miners, many came from Britain[26] and were described by Cathcart as 'wet country people' whose mining methods focused around a plentiful water supply.[27] Preceding mining booms had occurred within the Cornwall and Devonshire counties of Britain, areas characterized by moderate rainfall and ample flowing water which ultimately aided many aspects of the mining process.[28] Bounteous attitudes towards water potentially predisposed miners' behaviours towards scarcer Australian water resources. Victoria experiences high inter-annual stream flow variability by world standards.[29] This variability, which included floods and droughts, proved bewildering to miners accustomed to consistent and regular flows. The oscillations between flooding and drought were slowly recognised by miners but it took decades before this cycle was accepted as a regular occurrence.

Figure 3: *Creek flume, Alaska.*

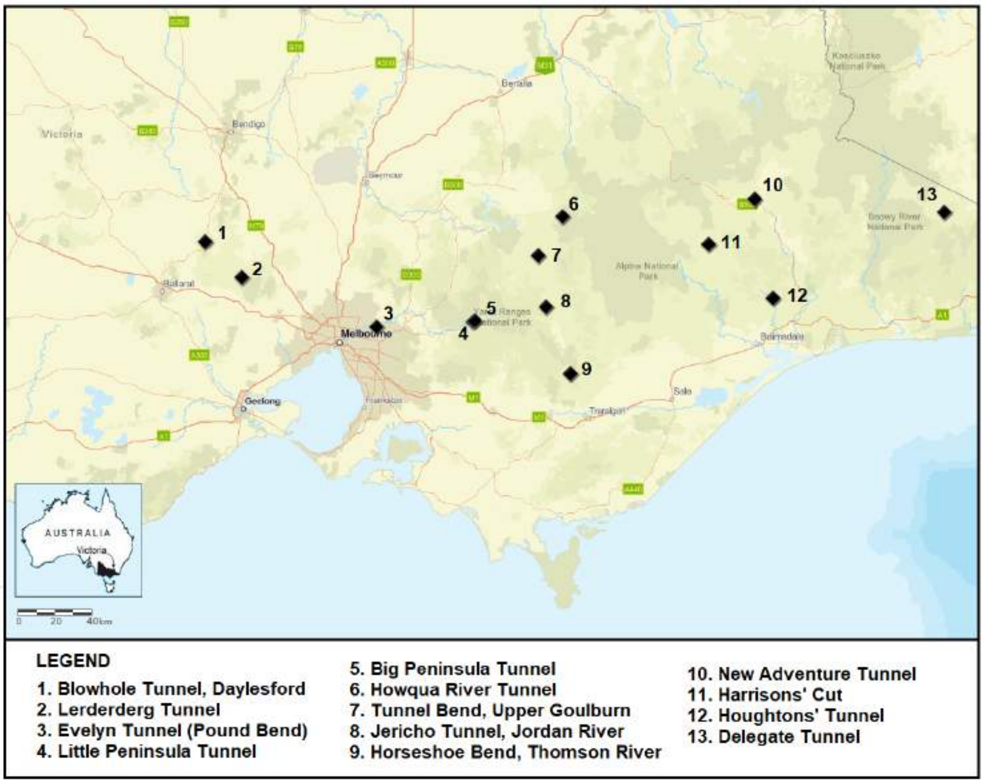
Source: Haines Sheldon Museum Vignettes 'Porcupine Gold Rush', accessed from: http://www.sheldonmuseum.org/vignettes/porcupine-gold-rush

Gold is heavier than most of the material transported by river flow, and alluvial gold deposits are frequently concentrated in hollows or trapped within gravels and clays in the riverbed.[30] These secondary gold deposits were therefore found in localised geographic points. Additionally, the auriferous deposits in Victoria were located between the branches of contemporary river channels, as the concentration of gold took place hundreds of millions of years ago,[31] and in the time since the gold accumulated within this environmental setting, the rivers had modified their course. Both the geomorphic and hydrologic conditions in Australia meant that work undertaken to relocate a riverbed was a gamble, as the exact location of alluvial gold was hard to predict and once discovered, its quantity was unassured.

Despite these challenges, proven success of river relocation overseas, advancements in mining technology and a steady influx of experienced miners, all contributed to the sustained modification of the Victorian waterways. Advancements in explosives, such as the import of dynamite to Victoria in 1872, and the patenting of a more stable explosive, gelignite, in 1876, ultimately transformed the way in which river relocation channels were constructed.[32] The artificial river channels constructed with dynamite are referred to as blowhole tunnels and represent the most common artefact of river relocation in colonial Victoria. The second type were commonly diversion sluices, excavated directly into the surrounding landscape and sometimes reinforced by stones and material found close to the site. Diversion sluices commonly used the river flow for consumptive purposes to wash alluvial dirt and therefore are not widely considered under the scope of this investigation.

We have found records of thirteen bedrock river relocations cut between 1868 and 1912, within Victoria (Map 1). Most of the tunnels were constructed on successful goldfields, though largely after the initial surge of alluvial mining methods were underway. Where known, the location of the tunnels is described, as are the conditions surrounding their formation, or any notable history, and finally the contemporary condition of each tunnel is summarised.

Map 1: *River relocation tunnels in Victoria.*



Source: Compiled by co-author, Alissa Flatley.

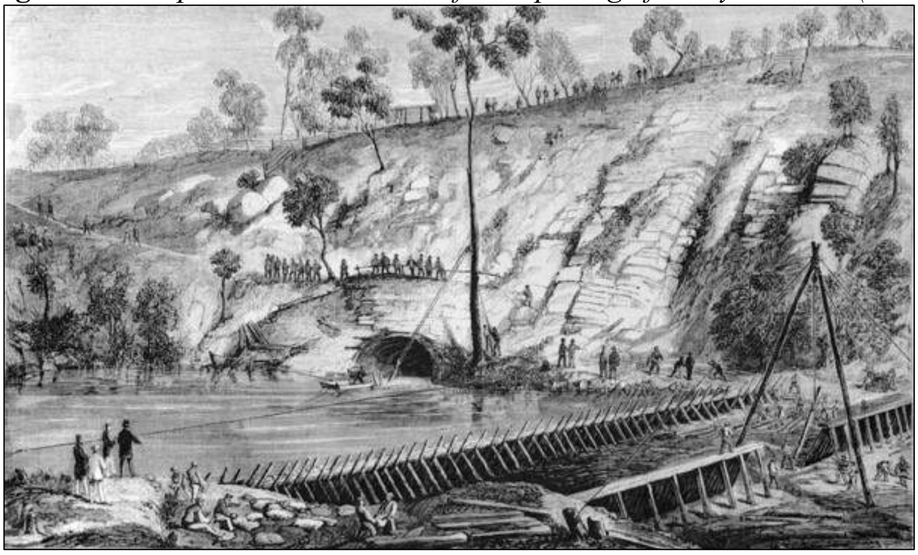
The spectacle of the Evelyn Tunnel

The Evelyn Tunnel (also known as Pound Bend Tunnel) is an example of a river relocation undertaken in the early 1870s by the Evelyn Tunnelling Gold Mining Company in the former Warrandyte Goldfield, known as Andersons Creek.[33] The Evelyn Tunnel

Gold Mining Company occupied a lease on the bed of the Upper Yarra that extended some six miles and included the associated flats.[34]

Prior to the tunnel's construction, the Warrandyte Goldfield had been mined on a small-scale, the previous occupant of the gold mining lease Chatty, a Chinese miner, predominantly worked the claim in the summer when the river was low. He worked the area by turning out washdirt and he constructed a rudimentary cofferdam. A cofferdam is defined as a watertight enclosure from which water is pumped to expose the bottom of the enclosure to allow construction. Chatty's cofferdam was constructed in 1856 and the remaining stakes of the cofferdam are still visible at low water. His appliances were described as primitive, but he was known to have made money and prospered.[35] A series of floods during 1856 and 1870 inundated the cofferdam, highlighting the insecurity of such a contrivance for removing water from within the channel.[36]

Figure 4: *An upstream illustration of the opening of Evelyn Tunnel (1870)*



Source: *Illustrated Australian News for Home Readers*, 1870.

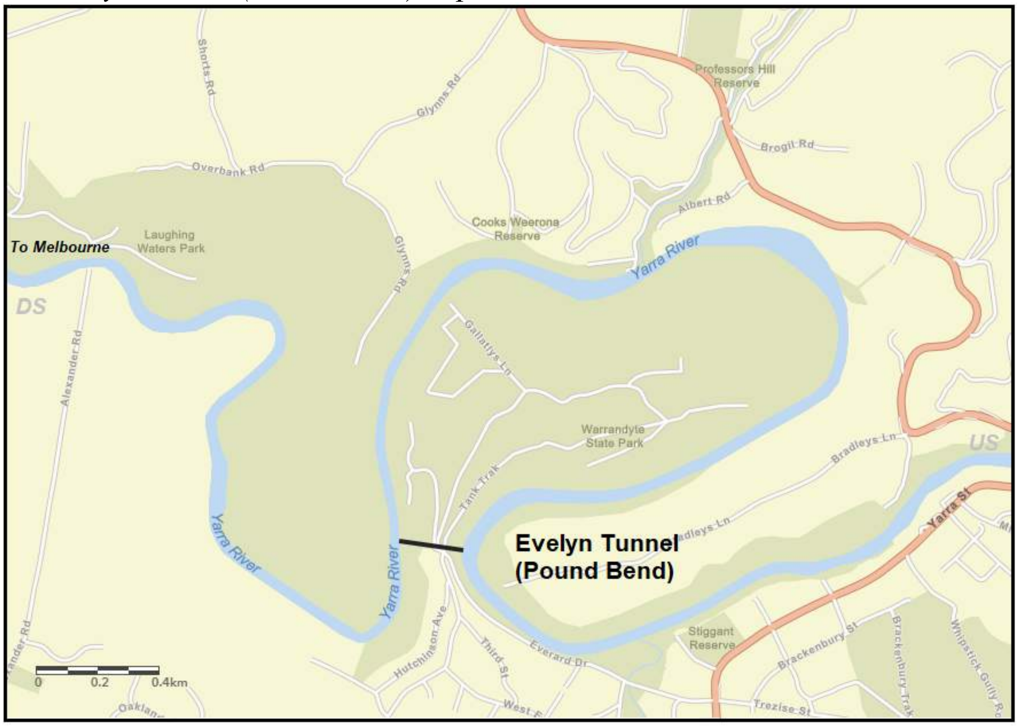
Chatty's mining lease was bought out by the Evelyn Tunnel Gold Mining Company, and despite the obvious threat of flooding, planning for the excavation of the large tunnel was soon underway. The Evelyn tunnel is located on the neck of the isthmus, a ridge causing a sharp bend in the Yarra River [Map 2].[37] The site leased by the Evelyn Company was located at a large meander bend with the local Warrandyte Pound situated on the flats between the river channel. The meander was so sinuous that the whole six-mile river bend stretched no more than a mile-and-a-half directly from one end to the other. An initial survey was undertaken in 1859 and the location of the tunnel was chosen from three potential sites,[38] the final site being preferred, as it contained the least amount of ground to be excavated for the tunnel to break through.[39] This site allowed the construction of a 145m tunnel through hard basaltic rock, that would when operational, expose five km of riverbed. The lithology was described as 'a clay slate rock or a very hard description, so hard that every foot of the tunnel had to be blasted'.[40] The tunnel outlet has a square hole blasted through bedrock and is 10ft lower than the tunnel entrance, and additional brickwork within the tunnel was deemed unnecessary owing to the strength of the surrounding rock. The estimated discharge was 15,000 gallons of water per second (68 m^3/second).[41] A large, new cofferdam was constructed at the inlet of the tunnel to divert water through the newly completed tunnel. The cofferdam reportedly comprised of 11,000 sandbags and elaborate bush carpentry,[42] was finished by December 1870. A mining surveyor and registrar of the sub-division, Mr Alfred Armstrong remarked that:

> should the companies [*sic*] enterprise be attended with success, I anticipate that alluvial mining in the neighbourhood will also attract considerable attention.[43]

The tunnel was projected by mining engineers to cost £10,000 and should have taken 12 months to complete.[44] However, aided by an old Californian digger who took the contract in hand, and being seconded by the contractor Mr Yeamans, the tunnel took only 3 months to construct at a substantially reduced cost of £2,400.[45] The opening of Evelyn Tunnel proved a public spectacle, (Fig. 4), with a newspaper article from 1870 commenting:

> a party of gentleman assembled at the works of the Evelyn Tunnel Gold Mining Company to witness the diversion of the River Yarra from its ancient bed, along which it has flowed for unnumbered ages....[46]

Map 2: *Evelyn Tunnel (Pound Bend). Upstream and downstream directions marked.*



Source: Compiled by Alissa Flatley, co-author.

The following year, an additional report on the Evelyn Tunnel was printed in the Argus. The newspaper reported on the dimensions of the new cofferdam, an impressively solid structure that was 14ft wide at the top.[47] The operations of the claim were stimulated by the aid of Mr John Wallace, a famous Scottish mining entrepreneur and politician (Fig. 5) who was struck by the value of the river claim which attracted his attention. The Yarra was identified as extremely tortuous at this location, with the richest yields coming from abandoned meander bends in the river. The river channel at this location was described in *The Argus* as:

> a series of S's so peculiarly bent and twisted that they very frequently – at least so far as they have been traced, cross the line which afterward became the new bed. These crossings are now found to occur within a few yards of each other so often indeed that the line of the stream would appear to have shifted several times before it took its present course.[48]

Figure 5: *Sketch of Hon. John Alston Wallace* (1874)

Source: The member of the Upper House "One of the Olden Time" [The Hon. John Alston Wallace [M.L.C] from the series 'Masks and Faces', 1874. By Tom Durkin and *The Weekly Times*. National Portrait Gallery.

Reworking the paleochannel or abandoned meanders provided substantial yields of gold, even after reworking sites on which Chatty had previously concentrated. The company made 1 oz of gold for every pound (lb) Chatty had obtained (calculated as 1/16 of the yield achieved by Chatty). In the space of 12 days, 22 miners obtained 70oz 9dwt of gold from just 15 yards^2 of ground.[49] The gold at this location was found alongside particles covered with amalgam, thought to derive from further upstream, and higher in the Yarra Valley.[50]

Encouraged by early success in such a small area, the company then planned to lay the whole six miles of their claim bare, but after identifying the provenance of the gold found within the channel to be from higher up in the catchment, the company decided to construct two additional tunnels upstream to relocate the Yarra River in supposedly rich alluvial ground. Unfortunately, the mining venture at Evelyn Tunnel eventually failed due to unexpected costs of mining through deep mud that covered the Yarra riverbed.[51] The company had to remove up to 14m of silt prior to beginning sluicing.[52] The cost of constructing the Evelyn Tunnel was the same as the returns from the initial exposed channel, causing the company to be wound up in 1872 with little financial recompense.[53] The modern use of the tunnel is a swimming hole and the interior of the tunnel is home to a colony of bats.[54]

The Peninsula Tunnels on the Upper Yarra

The Peninsula tunnels, known as the Big Peninsula and Little Peninsula [Map 2], are located on the Upper Yarra River, on McMahon's Creek and Reefton Goldfield, on the Upper Yarra, described as one of the richest fields in the State.[55] Gold was discovered in the vicinity in the late 1850s and mining intensified around 1859.[56] By the 1860s, McMahon's Creek was a favoured sluicing place with minor stream diversions frequently undertaken to gain access to the loose shale on the bottom of the creek.[57]

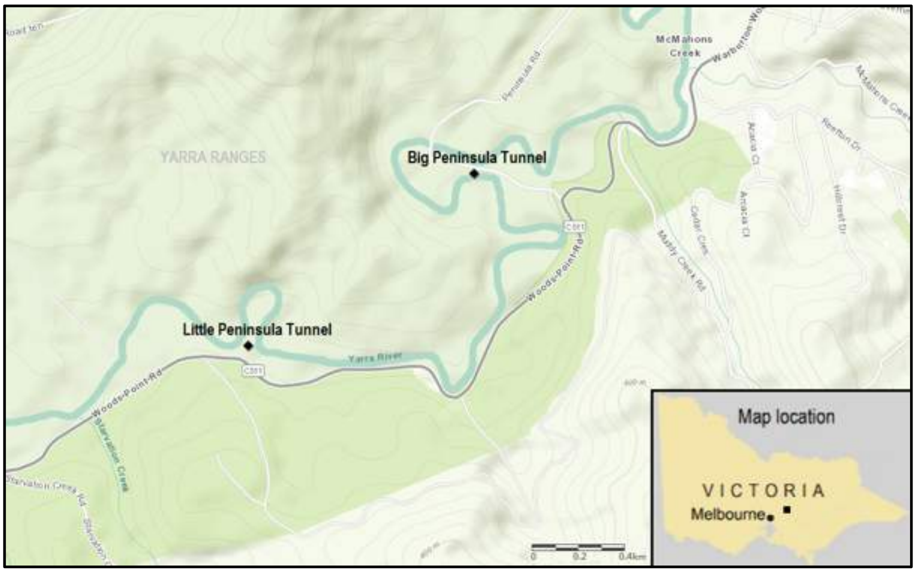
The Big Peninsula Tunnel (Fig. 6) was reportedly constructed in 1864;[58] in the same year, an unnamed field naturalist described an undertaking by four men drilling a ragged 6ft tunnel through a peninsula comprising 50ft of solid rock, and subsequently diverting the course of the Yarra.[59] The rewards obtained from this venture included the uncovering of three quarters of a mile of dry bed in addition to a yield described as 5 to 6 grains to the dish.[60] In total the venture obtained just enough gold to recuperate the expenses of the tunnel itself.[61] Conflicting information states that the tunnel exposed two miles of riverbed and is also credited to Chinese miners.[62] The former course of the river is overgrown with vegetation and is now fully incorporated into the surrounding scrub.[63] The tunnel is used as a swimming spot, and Parks Victoria describe the scene as a terrific pool that is almost spa like.[64] The Big Peninsula site is now also designated as a site of geological and geomorphological significance.[65]

Figure 6: *The Big Peninsula Tunnel, Upper Yarra (looking downstream)*

Source: Photo by co-author Ian Rutherfurd.

The Little Peninsula tunnel (also known as the Pipeline Tunnel is also located on the Yarra River, downstream of the Big Peninsula Tunnel (Map 3). Its construction has also been credited to Chinese miners who dug 30m through the meander bend.[66] The tunnel consists of a square section about 2m high and 25m long.[67] The year of construction, alongside the value of the gold recovered is unknown.

Map 3: *Map of Peninsula Tunnels, Upper Yarra*



Source: Compiled by Alissa Flatley, co-author.

Drama at Horseshoe Bend, Thomson River

Located on the Thomson River, a major waterway in the Walhalla Goldfield in Gippsland, the Horseshoe Bend (Fig. 7a) blowhole tunnel was constructed by the Thomson River Alluvial Gold and Tailings Recovery Company between 1911 and 1912,[68] and is located 4km south west of Walhalla below the confluence of Stringer Creek and the Thomson

River. Alluvial mining was carried out from 1870 at Coopers Creek, a tributary of the Thomson river, and saw increased occupation in 1879 with miners making up to £4 a week per person.[69]

The tunnel was blasted through a slate ridge called Stockriders Spur, a topographically favourable location that had a proven track record of payable gold.[70] The tunnel is the longest river relocation in Victoria, measuring 220 meters in length and relocating a 1.2km stretch of river channel (Fig. 7b).[71] The tunnel was constructed from the bottom up, with initial work beginning on the tunnel outlet. It was constructed on an incline with several sharp changes in angle of the tunnel both near both the inlet and outlet.[72] The contract for the tunnel was awarded to William Jack Hannaford [Jack] (Fig. 7c) after the initial construction of the tunnel stalled due to labour issues while building the first 215 feet.

The opening of Horseshoe Bend was carried out on 11th November 1912 (Fig. 7d) did not proceed quite as expected. The tunnel was to be opened by a final blast within the tunnel, breaching a thin wall of rock standing at the inlet end. Jack was joined inside the tunnel by his wife and three oldest children for one last ride in the tunnel trolley, but meanwhile, a miner in charge of setting off the final explosives, got impatient and prematurely lit the fuse. The blast caused a torrent of water to flood through the tunnel, sweeping the family into the river. Fortunately, Jack's wife Clara was a good swimmer and managed to save the family who had been swept into the river, struggling in the water.[73]

Figure 7: *a) Horseshoe Bend Tunnel b) Tunnel setting c) William John 'Jack' Hannaford b. 1884 and d) Tunnel opening ceremony (1912).*

Source: a) & b) Thompson River Diversion Tunnel Site', Victorian Heritage Database Report, 2017, p. 1. c) Friends of Horseshoe Bend Tunnel. d) 'Thomson River Project Summary Report' Thompson Berrill Landscape Design Pty Ltd, 2014, p. 3.

River Relocation in the high country

There were several important precursors to mining within the high country. Miners were attracted there and to the Australian Alps due to promising gold finds in adjacent major goldfields. Initially, a quest for good grazing land brought settlers to the Omeo area in the mid-1830s,[74] while Key mining discoveries occurred in Omeo in 1851;[75] and Beechworth in 1852, and many smaller settlements were also established, such as the Dargo Township and the larger town of Grant.[76] Gold discoveries were widespread, and it was understood that wealth could occur anywhere. Several mines were above the snowline but the alpine environments seasonality restricted mining operations. Broadly, rugged terrain made access to mountain diggings difficult and mining within the region was known to be challenging.[77] Where viable, alluvial diggings were linear and extended for considerable distances along the rivers.[78] In addition to access issues and uncertain prospects,[79] frequent flooding was an issue there for alluvial mining ventures. The major river modifications that remain in the highland landscape of Victoria are diversion sluices; some examples include the Jim Crow Creek diversion sluice, Upper Dargo diversion, Jungle Creek Falls diversion sluice, and Yackandandah Creek gorge gold mining diversion sluice. An additional site of interest is the Howqua River tunnel, constructed as part of an extensive headrace to power a nearby waterwheel.[80] Other river relocations that occurred include the Upper Dargo Diversion, Howqua Harrison's Cut, New Adventure (Griffith's) diversion tunnel and Houghton's diversion.

Detective work on the Dargo Diversions

The Dargo township established originally as a supply town for the Crooked River Goldfield, was located in the lower valley of the Dargo River. Its position on the broad river flat made it suitable for agriculture, and its long-term survival was not contingent on mining.[81] The Dargo River had been worked by alluvial miners from the early 1850s but the first major rush near the Dargo township occurred in 1862. This rush coincided with an intensified pattern of grazing around the Dargo High Plains, during the aftermath of the bush fires of Black Thursday in 1851,[82] and by 1862, the Upper Dargo (now Alpine National Park) had become the focus of both quartz and alluvial mining efforts.[83] The Dargo River has a very steep gradient, a gravel and rock substrate and flows through a forested mountainous region.[84] The river had poor access, particularly within the high plains area, making travelling by horse near impossible,[85] but the first diggings on the Upper Dargo were opened up earlier, in about 1854.[86] The alluvial ground was reportedly worked predominantly by Chinese diggers who occupied the landscape from the 1850s until the turn of the century. By 1860, it was clear that substantial work had been done on the Upper Dargo, with evidence of sluice boxes, several large races, and large log cabins that were later abandoned due to the harsh weather and winter floods.[87] Eventually alluvial yields on the Upper Dargo declined with the exhaustion of alluvial deposits followed by the failure of reef mines to fulfil early promise.[88]

Upper Dargo Diversion

The Upper Dargo river relocation is situated near Sydney Reef, north of Louisville. Its structure is different to the blowhole tunnels and was likely used in a consumptive sense as a diversion sluice, however, it continues to relocate the Upper Dargo River to this day. The relocation structure was made from a 4m-deep stone-retained channel that runs through a pebble dump, which is 20m wide with several dumping lines.[89] The river runs through the channel with a waterfall created at the downstream point, and it is likely that the channel was constructed by Chinese miners sometime between the 1850s and 1869, for after this period, they shifted their attention to the Lower Dargo.[90] Additionally, the elongated mounds of water worn stone neatly packed in vertical mounds are regarded as characteristic of Chinese mining sites.[91]

Harrisons' Cut Diversion Sluice, Middle Dargo

The Middle reaches of the Dargo River were worked extensively in the 1880's, with several claims providing very good returns. In 1886, Antonio and mate 'won 40oz in six weeks from their claim on that stretch of the river'.[92] Harrisons' Cut diversion sluice was likely constructed around this time, when local claims were profitable. This river relocation is 50m long, 6m deep, and 2.4m wide, cut through a narrow spur in the rock (Fig. 8), and was used to exclude a large section of the Middle Dargo, which would already have been extensively mined.[93] Little is known about the origin of Harrisons' Cut, although there is a strong name connection with the area to Edward Harrison, former mining registrar for the Crooked and Dargo Rivers from 1879 to1882, who was succeeded by his brother Henry Harrison from 1884 until the 1890s.[94] Henry was also a former mine owner, storekeeper and one of the last residents of Grant.[95]

Figure 8: *Harrisons' Cut narrow spur.*

Source: Heritage Council Victoria, Harrisons Cut Gold Diversion Site, place 4988.

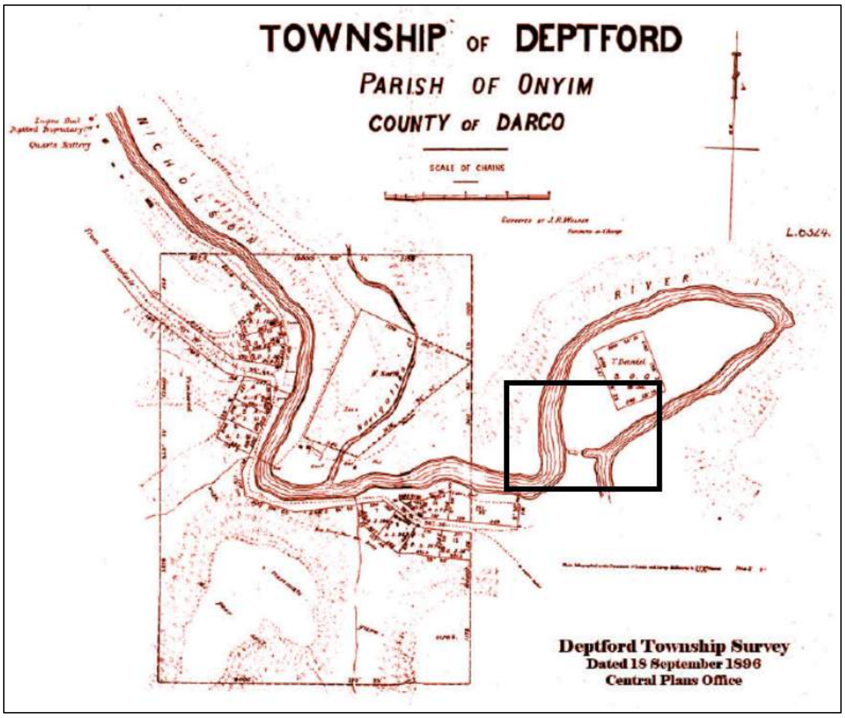
New Adventure (Griffiths') Diversion Tunnel

Gold was discovered near Omeo in the early 1850s.[96] The New Adventure Diversion Tunnel (or Griffiths' Tunnel) is located on the Omeo Goldfield on Livingstone Creek in East Gippsland.[97] In 1868 Griffiths and party constructed the river relocation through a high rocky bluff known as Frenchman's Hill, and its completion allowed for the extensive reworking of the most promising parts of the creek bed. The tunnel is 75m long and has a 20m cutting. By 1870, easily mined alluvial gold was diminishing within the area[98] and the New Adventure Claim was in abeyance. However, the claim was bought by a Chinese party, alluvial mining work was restarted, and it became known as the Oriental Claims.[99] In 1871 disastrous flooding levelled most of the creek claims along Livingstone Creek but the Oriental Claim continued to be the premier alluvial ground on the river.[100] Contemporary use of the tunnel has resulted in a different fate, as in 1925, a swim hole was formed at the tunnel entrance, and used as a swimming pool for residents of Omeo.

Houghton's Diversion Tunnel

Houghton's Diversion tunnel is cut through a 50m wide neck of the Nicholson River at Houghton's Flat (also known as McCoy's Flat) at the southern end of the former Deptford township[101] (Fig. 9). Still within the Deptford River Goldfield, the location is known locally as Piggery Point.[102]

Figure 9: *Houghton's Tunnel (annotated) on Deptford Township Survey (1896).*



Source: State of Victoria, Department of Sustainability and Environment, 2010, Deptford Picnic Area DSE Bairnsdale, FS0103.

Chinese miners are credited with driving the tunnel through the horseshoe bend around Houghton's Flat to enable the working of that section of the riverbed. The inlet is blocked by a concrete wall, through which passes a pipe, carrying the river flow into the tunnel. Mining activity at Deptford was poorly reported during the period and only one large-scale alluvial mining operation was recorded during the period of the tunnel's construction. The mining registrar recorded that in 1873, a long water race was constructed by the Nicholson River Sluicing Company, 'for the purpose of working ground hitherto inaccessible to the individual miner'.[103] It is possible that the scheme included this river diversion tunnel.

The Delegate River Relocation

The Delegate River tunnel is a river relocation channel with contested origins. The Delegate River Tunnel is an 80m long tunnel cut into hard rock located on the Bendoc-Bonang goldfield above the junction with Chinaman Creek, East Gippsland. There are two conflicting accounts of its creation. The first attributes its construction to Chinese miners in the 1860s;[104] the second is that the Delegate River Diversion was actually excavated in 1889 by the Delegate River Gold Sluicing Company.[105] This Company was formed to sluice the terrace wash above the alluvial flats below the point where the Bendoc to Bonang road crossed the Delegate River. At this point, it is reported that a water-race, 1 mile and 55 chains long, with a depth of 2ft was cut, alongside a tunnel of approximately 60m that was driven into the hard rock as a tail race.[106] Supposedly, three contracted European men, Bowman, Dean and Dingle constructed the tunnel. A quarterly mining report from 30th September 1889 reports that the Delegate River Sluicing Company NL had almost completed a 216-foot tunnel through hard rock.[107] A total of 1,000 tonnes of rock was removed and used to construct a bank (cofferdam) across the river.[108]

The confusion surrounding the genesis of the tunnel was perhaps due to reports of a flood-race of considerable length constructed by a party of Chinese miners on the Upper Delegate. In 1868, the Chinese miners had built the flood-race intended to carry all of the Delegate River,[109] but this sounds more like a channel than a tunnel. Depending on the true creators of the tunnel, it could have been operational in the 1860s or constructed later, in 1889. There is further speculation. as there are additional accounts of a solitary man with hand tools and dynamite constructing the tunnel at the end of the 19th century.[110] The tunnel remains operational today, but the sluiced riverbed is quite unrecognizable and overgrown with blackberries.[111]

The Blowhole at Daylesford

The Blowhole diversion tunnel at Daylesford is another example of a blowhole tunnel (Fig. 10). It was constructed on Sailors' Creek (also known as Jim Crow Creek),[112] near Hepburn in the early 1870s,[113] although other sources indicate it was probably built in the 1860s when European and Chinese miners extensively worked Jim Crow Creek.[114] Sailors' Creek was nicknamed after a party of sailors who jumped ship, went prospecting, and found gold there.[115] During December 1870, alluvial claims within the area saw 10,000oz. of gold for the quarter, which was 'a consequence of the rainfall contributing to swell our gold crop'.[116] The tunnel is 20m long and was constructed when other areas had already been picked over.

Figure 10: *The Blowhole, Daylesford.*

Figure 11: *Flood damage, The Blowhole*

Sources: **Figure 10:** State Library of Victoria. Image H32492/1245 Rose Stereograph Co. (1920-1954).
Figure 11: 'Hepburn Blowhole Storm Recovery', Parks Victoria, 2017.

The Blowhole tunnel is constructed through sedimentary rock cliffs and the tunnel outlet is elevated above the downstream creek by a height of several meters. Sailors' Creek is an ephemeral river, naturally dry for several months of the year, but when in flow, this artificial knickpoint causes the river flow to cascade over the rock face into the pool below. By 1906, alluvial mining within the Daylesford division was at a low ebb, and by 1911 alluvial mining had practically ceased to exist, aside from a few fossickers and ground sluicers.[117] The blowhole tunnel area can now be explored by a walking trail with a viewing platform, but in September 2016 a flood caused substantial rockfall and erosion at the inlet and outlet of the tunnel (Fig. 11). Additional seepage occurred through the top of the rocks, affecting the stability and safety of the constructed walking pathway, which passes over the top of the tunnel.[118]

Tunnel Bend Diversion, Goulburn River

The Tunnel Bend Diversion is on the Goulburn River below Gaffney's Creek.[119] Prior to 1866, using wing dams from its banks, Chinese miners had worked it,[120] but that year the Goulburn Valley Sluicing Co. constructed the tunnel, which is approximately 3m wide, 2m high and 200m in length. During periods of low flow, the tunnel can be walked through. By mid-1867, the Goulburn Valley Sluicing Company employed 14 men who were building an additional dam, and sawing timber for boxes in order to construct a sluice.[121] However, severe floods in mid-1867 carried away the dam which would have enabled the sluicing for gold, and furthermore, the companies 'works were damaged and cost £700 to £800 to repair'.[122] It appears that the mining ceased after the floods.[123]

Lerderderg Tunnel

The Lerderderg tunnel is 25m long, located on a meander of the original bend on the Lerderderg River west of Melbourne.[124] Little is currently known about the history surrounding this tunnel. In 1903, *The Age* reported a man called Geo [*sic*] Olsen being killed by falling earth whilst tunnelling on the Lerderderg River with a mate called Hammond.[125] It is probable this incident occurred while the Lerderderg Tunnel was being constructed. The downstream side is now unobstructed (Fig. 12), but the upstream entrance of the tunnel is now blocked by a large amount of woody debris.

Figure 12: *Lerderderg Tunnel Outlet*

Source: 'Lerderderg River tunnel', 2018. Image credit: Corbpie.

Discussion

Overall the relocation tunnels examined in this paper cut 1,165m of channel to expose over 13 kilometres of riverbed (Table 1). River relocation tunnels were cut officially by a few men at each location, such as the Thomson

River Tunnel, or later as part of a major engineering process. Gold mining was characterised by successive waves of technology and as different mining areas were progressively exhausted, new techniques were required. However, river relocations and tunnels do not appear to have been a particular technological approach that arrived and then waned. Instead tunnelling to expose the riverbed appears to have been a technique that was applied to alluvial gold fields after most of the easily won gold was gone. The first tunnel was cut just 13 years after gold was discovered, and the last one in 1912, and the pattern of river relocation tunnelling shows how frequently alluvial goldfields were constantly reworked, sometimes over a long period. The earliest of the Victorian river relocation tunnels was reportedly constructed in 1864, before the widespread availability of black powder and dynamite. These earliest tunnels were constructed in waves correlating with good fortunes on the goldfields that surrounded them, while other tunnels were built as a last-ditch attempt to win payable gold, but by the 1880s, tunnel construction seemed to be in decline.

Table 1 highlights the known dates of tunnel construction, alongside key statistics associated with channel displacements that had environmental impact in the pursuit of alluvial mining. Although we do not know the success of several of the relocation enterprises, those we do know, range from highly lucrative, to complete failures, as set out below:

Table 1: *Summary of river relocation channels in Victoria*

Relocation Tunnel	Construction Date	Tunnel length	Channel displacement	Venture Outcome
Blowhole Tunnel, Daylesford	1860*	20m	940m±	Unknown
Lerderderg Tunnel	1903*	25m	526m±	Unknown
Evelyn Tunnel (Pound Bend)	1870	145m	5km	Company wound up in 1872
Little Peninsula Tunnel	1860-1870*	25m	704m±	Unknown
Big Peninsula Tunnel	1864	65m	1.14km±	Unknown
Howqua River Tunnel	1880-1882*	100m	Unknown	Unknown
Tunnel Bend, Upper Goulburn	1866	200m	1.16km±	Sluice damaged in flooding
Jericho Tunnel, Jordan River	1861-1865 or 1872	30m	250m±	Unknown
Horseshoe Bend, Thomson River	1912	220m	1.2km	Unknown
New Adventure Tunnel (Griffiths)	1868	75m	752m±	Original company was in abeyance in 1870
Harrison's Cut	1886*	50m	450m±	Unknown
Houghton's Tunnel	1873	50m	1.03km±	Unknown
Delegate Tunnel	1889	65-80m	448m±	Unknown
Upper Dargo	1850-1869*	80m±	380m±	Unknown

*Likely date of construction. ± Calculated using GIS.

The legacy of river relocation works

All the river relocation works except the aforementioned diversion sluices continue to fully divert the river. Only several, such as the Lerderderg Tunnel and the Griffiths'

Tunnel are partially blocked by large woody debris, or additional tunnel modifications. In most cases the diverted riverbed has become vegetated and built up with soil, although all the former channels carry flood flows. The tunnels are now important cultural features.

The construction of relocation tunnels was often a hazardous affair. Miners occasionally died during their excavation from falling earth, with the additional threat of drowning or the untimely triggering of explosives. These risks were not unique to alluvial mining and were common in sub-surface mining, which overall remained more perilous.[126] In modern times, visitors to the tunnels have suffered accidents, as blowhole tunnels provide a site of interest for tourism and feature prominently on recreational walks. The more accessible tunnels are popular as day hikes, and the more remote are popular on 4WD excursions. In the warmer periods, the tunnels become bathing spots, sometimes also makeshift flumes because of heightened flow velocities. At some blowhole tunnels there are additional waterfalls at the outlet, a function of increased water velocity, the design of the tunnel to reduce construction costs, or perhaps miscalculations during their construction.

The conservation of these tunnels is important for mining heritage but there are also occasions where their placement has caused significant alterations to the physical and ecological condition of the waterway. A consequence of the many waterfalls or heightened velocities associated with the blowhole tunnels is that they become a barrier for fish passage, particularly for migratory native fish such as the Tupong, Common Galaxias and the Australian Grayling.[127] The Big Peninsula Tunnel and the Horseshoe Bend tunnel are an identified obstructions for fish passage and for riverine connectivity between headwater and downstream reaches.[128] Engagement of the old channel is important to enhance the habitat for macroinvertebrates and native fish. However, environmental improvements such as the construction of fish ladders and the reengagement of abandoned channels can create tensions between stakeholders due to the delicate balance of competing objectives, in addition to the desire to preserve the tunnels due to their historical significance and amenity values.

The amenity value of these tunnels comes with the additional maintenance requirement for access, hazard prevention and tunnel upkeep. This becomes a problem in a landscape where flooding can cause damage (in the example of the Blowhole, Daylesford) or where tunnels can become blocked by logjams (Lerderderg Tunnel). In turn, the tunnel itself can restrict the transfer of woody debris, which plays a vital role in the functioning of healthy freshwater ecosystems.[129]

Conclusions

The construction and opening of these river relocation tunnels represent a novel venture undertaken typically within successful goldfields that had once or twice been sluiced once or twice by previous parties. Most of the historic information surrounding Victorian blowhole tunnels can be found in mining registrar reports or newspaper articles focusing on the spectacle of the venture. As mine tenements exchanged ownership frequently, some of the details surrounding their construction have conflicting, or multiple origins.

In addition, there are often differing local names used when referencing nearby goldfields, claims and geographic locations. For these reasons, tracing the true history behind these tunnels can be problematic. We have attempted to collate and synthesise the current known information surrounding these tunnels, acknowledging that there are many truths as well as anecdotes left to discover. Despite sometimes-contradictory information surrounding their construction, these tunnels have left a legacy of mining heritage, intrigue and physical change for the riverways of Victoria

Relocating a river was a time consuming and costly venture that did not always pay dividends. A combination of environmental and anthropological factors meant that tunnel construction was largely a gamble, but nonetheless it became a frequent enterprise during the gold rush for most forms of mining. River relocation through the construction of blowhole tunnels is a small part of the overall impact to waterways; river systems were diverted, dammed and irrigated to support the requirements of miners as well as inhabitants of newly formed small towns and communities. Blowhole tunnels remain within the landscape, alongside clusters of races and sluices, providing evidence of large-scale alterations and a sometimes still undiscovered past.

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