Shallow Cuts: the geological sectioning of Newcastle, NSW —

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> There is nothing like geology; the pleasure of the first day's partridge shooting or first day's hunting cannot be compared to finding a fine group of fossil bones, which tell their story of former times with almost a living tongue.
>
> Charles Darwin, letter to his sister, 1834[1]

Coal is formed by ancient plant matter, left on the forest floor, that accumulates (sometimes through flood or fire) and is then compressed by subsequent layers of sediment, causing transformations in its physical and chemical composition. This compression causes these organic layers to crystallise into seams and, as the pressure and temperature are increased over time, they become enriched in carbon. In between can be thousands of years of relative geological stability.[2] These thin black seams form narrow, undulating layers in the shallow crust of the earth, marking its history and traumas. They occasionally emerge in the present in mountains or cliffs where the geology reveals itself as narrow layers of compressed time. While these coal seams represent, relatively, one of the most recent geological layers of the planet, they have played a far-reaching role in its spatial and economic development. With the advent of industrialisation, coal became a key resource for emerging imperial powers in Europe, who were anxious to fuel the rapid expansion of machines against a backdrop of dwindling timber resources. The extraction of coal also began to shape a different infrastructure above the ground. From the 18th century, the source of fuel to power machines shifted from living organic matter growing out of the earth to hardened, crystallised inert matter, compressed beneath it.

With new modes of extraction came new modes of drawing, of both the geographic and geological conditions of place. This also led to the emergence of the geological section as both a spatial and a speculative mode of representation. As coal became an essential commodity, these seams were drawn with increasing precision and confidence, in all dimensions. Like frottage drawings through the rings of a tree, such technical sections directly marked time in relationship to space, mapping chronologically the formation of coal seams from up to 300 million years ago to the present. They also indirectly depicted mining activity, as the data used to construct these drawings was extracted, like the coal, from the network of excavations across the city. Ironically, these vertical sections coincided with the expansion of 'planning' as a modernist strategy of accelerated horizontal expansion, particularly in cities of industrial production. The competing vertical and horizontal forces provided a complex living tapestry in which the modern city and its resources were intertwined.

What distinguishes coal from other geological phenomena is its formation in narrow seams of varying depths, separated by more stable layers of rock, known as conglomerate. In this sense, these delicate seams are the softer tissue within the earth's crust. The process of mining involves dropping vertically down into these seams through bores and then extending outwards horizontally. This creates a lateral excavation within the earth between much harder slabs of stable geological material. The character of these seams is directly related to time, both in terms of the depth at which they are found and the vertical dimension of the seam itself. The human and architectural scale of these – usually between one and two metres thick and rarely more than five – belies the vast time frames embodied in their formation over millennia.

Lying 120 km north of Sydney on the east coast of Australia, Newcastle is the largest coal-exporting port city in the southern hemisphere, linked to rich deposits in the Hunter and Newcastle coal fields. A third of global coal exports emanates from Australia, and Newcastle, on average, exports over 150 megatonnes per year. Coal, as a resource, directly led to the founding of the city, and is abundantly evident in every aspect of its subsequent development. The widespread mining of coal not only powered the 19th-century industrialisation of Australia, but also constricted Newcastle's urban morphology, where the dramatic (but invisible) underpinning of the city had a direct effect on contemporary building heights and the patterns of urban growth. Within the evolution of this sectioning of the ground, a new mode of architectural drawing emerged that privileged the geological section over the rationalising plan. The emergence of geological drawing provided new modes of interpreting and engaging the urban realm, as well as supporting new kinds of speculation and imagination. In this geological consciousness, the ground was shackled to an extensive network of extraction machinery that connected it to the greater landscape and its products to the world.

Newcastle is the second oldest city in Australia and it was the accidental discovery of coal that defined its location as a colony.[3] In a landscape inhabited and managed by indigenous Australians for over 40,000 years, the recent history of Newcastle has been tied to the immediate needs, first, of the colonial outpost of Sydney, and then of England, and later of the British Empire. This was manifested originally as a harsh penal colony and supplier of coal, then as a significant industrial port, steel manufacturer and, ultimately, as a gateway to the abundant mineral resources of the nearby Hunter Valley. From its European inhabitation, the geometry of Newcastle has been dominated by two grids: the Dangar north-oriented street grid, which marked out the most significant streets and monuments in the early city, and the mining grid, which follows the seams of coal, and extends in each direction below the surface. This latter protrudes outwards below the water and downwards into the earth, providing a horizontal subterranean network of buried but interconnected points. This submerged network only becomes visible as narrow seams in the vertical cliffs along Newcastle's coastal edge, now celebrated in the geological textbooks on the city.[4] Since European arrival, the individual seams that lie beneath have been named, positioned, drawn and mined, and are inseparable from the city's history.

All of this is revealed most strikingly in the mine subsidence mappings of Newcastle, which juxtapose the urban grid with the mining grid (Fig.1). The mining grid extends across the entire built fabric of the region, accessing, with different levels of intrusiveness, the individual seams below. While there is little physical correlation between these two spatial diagrams, their juxtaposition throws light upon the history of colonial occupation, and its relationship to urban morphology. The mining grid, despite its invisibility, directly limits the size and scale of urban development because of the exaggerated costs of construction on the plots that intersect the mines. A narrow east–west corridor through the heart of the city – the train line – was built originally for the distribution of coal and, as a result, was kept completely free of mining. Because of this, it offered virgin territory for urban expansion and speculation and, after the removal of heavy rail, ultimately became appropriated and consumed by commercial development. The rest of the city is constrained by the tunnelling below it that limited permissible heights and, inadvertently, escalated development costs, creating a unique symbiosis between the two grids. While the collision of these two systems is revealed in plan, it owes its history to the development of the section, as the primary representation of geological knowledge.

A further example of this intersection can be seen in the layout of the Burwood Colliery, which sits beneath an undulating piece of land to the south of the Central Business District (CBD). Here the suburban grid of mostly residential blocks is contrasted with the tight, Manhattan-like network of the mining grid (Fig.2). The plan, which is devoid of any sectional information at all, shows these two competing realities as a singular condition, with little to articulate the surface from underground. Hand-drawn in the 1970s, these plans offer a form of below-ground speculation. With the street grid already in place, they present an imaginary, soon-to-be-realised underground world, which has an entirely different purpose and scale from the one that sits above. These drawings are also fragmentary in nature, limited by the size of the page and the extent of the colliery they depict. They often extend over sheets of drawings stitched together like a patchwork tapestry.

Similarly, the various mining companies that have extracted the coal have left an abstract territorial claim across the urban grid of Newcastle, one that is connected more to its underground than to the surface. The 1905 survey of Newcastle and the Hunter Valley (Fig.3) not only includes the geographical features, topography, suburbs and

Fig.1 Newcastle Central Business District urban and mining grid juxtaposed (author photo).

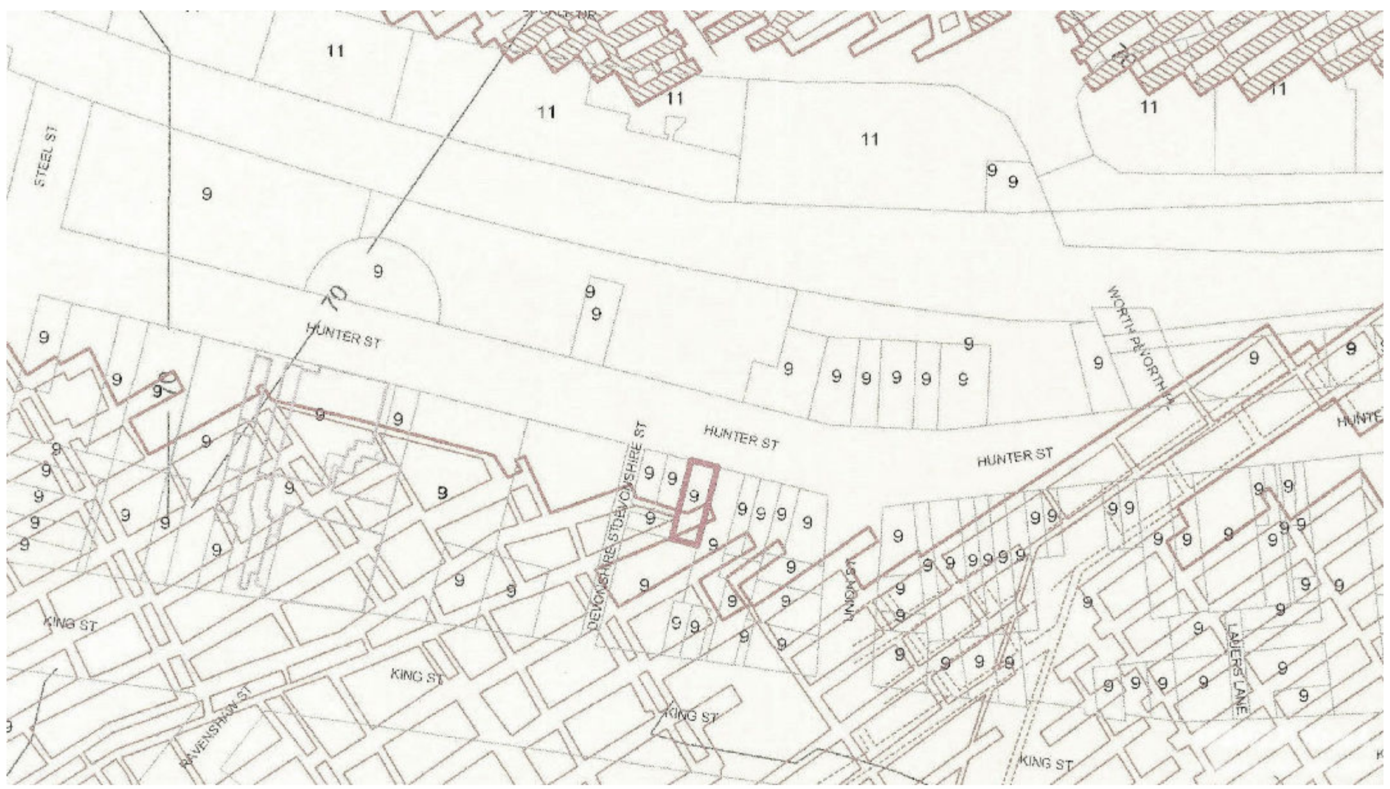


Fig.2 *Burwood Colliery, Victoria Tunnel Seam: Application to Extract Pillars* (14/09/1976). Courtesy University of Newcastle Special Collections.

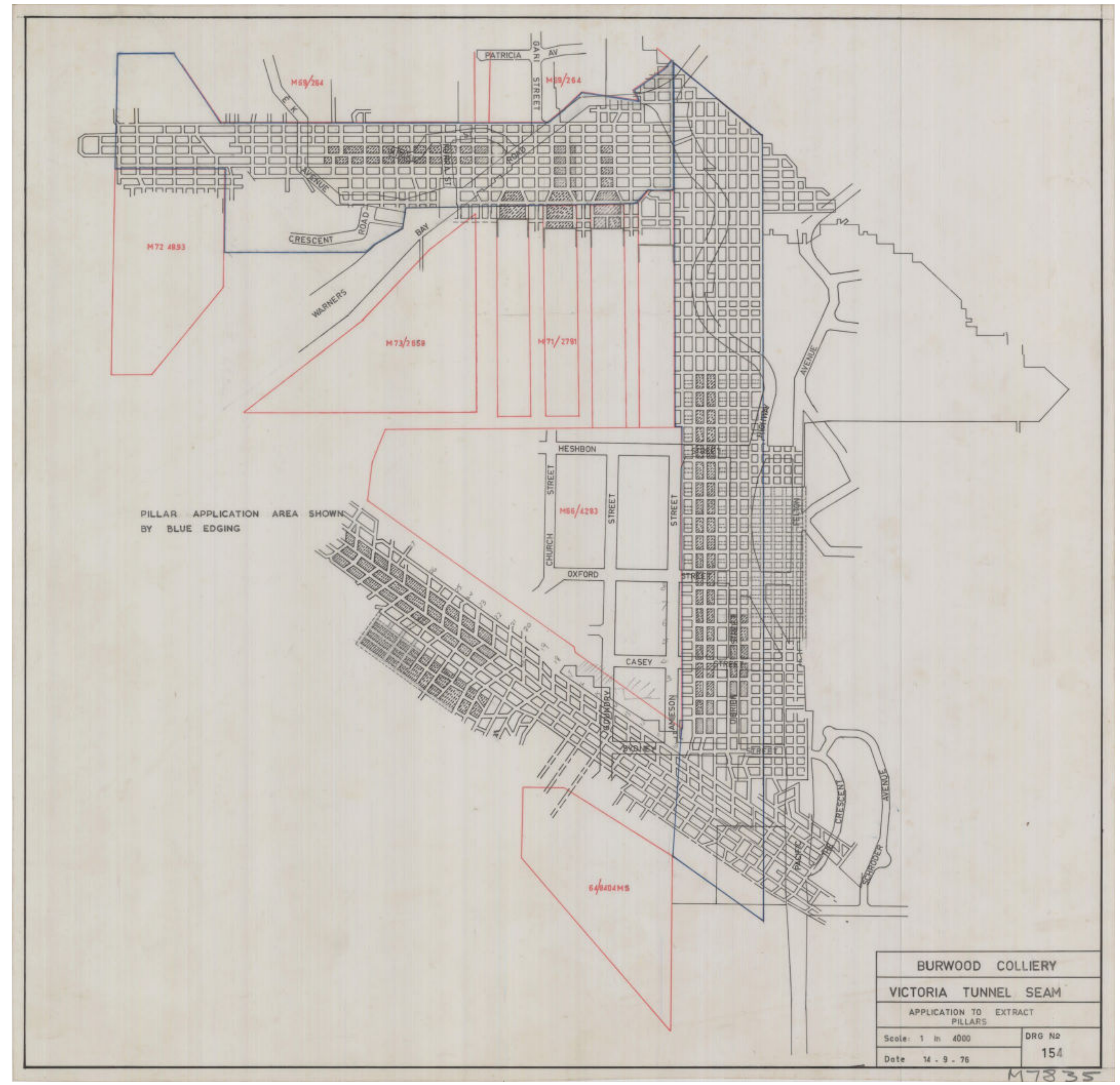


Fig.3 *Geological map of the Hunter River Coal Field from Newcastle to Singleton* (surveyed by T.W.E. David; 1905). Courtesy University of Newcastle Special Collections.

geological information, but also the various mining companies that have laid claim to the coal beneath. The map lays out the extensive network of rail lines connecting the coal to the economies that control it but, interestingly, does not include street names or urban features. Unlike the speculative mining maps of Burwood, the geological survey limits information to that directly relevant to the location and extraction of coal, indifferent to the urban morphology that it co-exists with. While names of suburbs and places link the region, as does that of the city itself, to its surrogate colonial ancestor (Newcastle in the north of England), there is a dramatically different scale and geology particular to the Antipodean context.

The progression of mining claims also speaks to the history of the city, as the evidence of coal extraction radiates outwards from the CBD.[5] The first mining claim was originally granted to the Australian Agricultural Coal Company in 1828, occupying a large stretch of land in the CBD and coastal fringe that was the location of the first mining operations in the area. This lease effectively provided the company with a monopoly on coal extraction in NSW for 20 years, but by the 1840s there were multiple companies starting to mine deposits in West Wallsend, Belmont and Lake Macquarie. By 1905, the plan reveals the proliferation of coal companies operating in the region, showing territories linked to, for instance, Newcastle Coal, Waratah Coal Co., Dudley Coal Co., Burwood Extended Coal Co., Redhead Coal Co., Burwood Coal, Newcastle Wallsend Coal Co., Maryland and Summerhill Collieries, West Wallsend Coal, Teralba Co-operative Colliery and Young Wallsend Coal. For every emerging suburb in the urban grid of Newcastle, there was a company owning and extracting the coal beneath it. The drawing often provides the only evidence of this. The emergence of other mining areas and claims over the next century creates the unique contradiction embodied in the plan, where the visible collective space of the city is undermined by private and commercial interests concealed below. Where airspace and height limits often encourage urban development in conventional commercial cities, in coal cities this speculation is primarily downwards, and value is originally seen underneath rather than above the urban grid.

Architectural drawing and geology

As a science that deals with vast scales in both time and space, geology has, since its inception, relied on the abstraction of drawing to condense and present information. Georgius Agricola's influential *De Re Metallica*, written in 1556, laid out in text and drawing the primary geological conditions, as well as the processes for extraction that could be used to mine them.[6] Book Three is devoted to the different types of veins, stringers and seams, illustrated extensively through simple sectional and elevational diagrams that explain the relationship of these geological phenomena to the broader natural (Fig.4) and urban (Fig.5) landscape. Agricola's work resulted in the widespread dissemination of basic ideas relating to geology, primarily through the success of the sectional and elevational diagrams in explaining these terms and developing a visual language through which geology could be communicated.

This relationship between geology and drawing continued as both the knowledge of natural science and the techniques of drawing became more sophisticated. Unsurprisingly, given the scale and complexity of the subject, drawing techniques developed to describe geology are frequently reductive, using coded legends and graphic simplification to communicate multiple layers of complex information. This information derives from physical investigations through drilling – the taking of a literal section through the earth – which is then transcribed into an abstracted graphic one. While these drawings are inherently architectural, and rely on the architectonic conventions of plan and section, a wide-ranging investigation of the influence of the two disciplines upon one another has never really been undertaken.

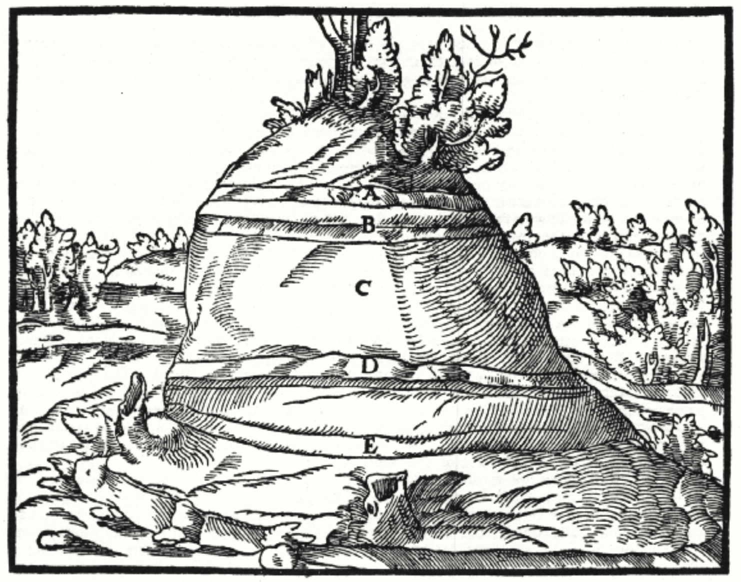
While sections had been central to geological explanation since the Renaissance, the first extensive horizontal mappings of geology began during the French Enlightenment, a context that also saw the expansion of architectural drawing as a communicative and speculative medium. The drawings of, for instance, Étienne-Louis Boullée, Claude-Nicolas Ledoux and Jean-Jacques Lequeu[7] from the late 1800s evince a concern for geology in the depiction of architecture and urbanism, one contemporaneous with far-reaching developments in science and engineering, as well as global exploration.[8] Evidence of this interest was foreshadowed in the highly descriptive depiction of geological features in Julien-David Le Roy's drawings of the Acropolis, first exhibited in 1758, which developed a new geological aesthetic for the depiction of architecture, and seemed to imply the intermarriage of the two, washed over by the ravages of time and ruination.

It was, however, primarily in the 19th century that the dramatic evolution of objective techniques for drawing geology emerged, through an appropriation of both plan and section.[9] As Tom Sharpe observes, William Smith's 1815 map was the first attempt at a geological plan of England and some of the surrounding British Isles.[10] While processes for mapping and representing geological strata were in existence prior to this, Smith was the first to map a national landmass at such a scale, coding rock types on the basis of time in a way that recast the spatial understanding of borders and territory. This effectively showed the geological evolution of an island over time, recording the history of the landform and, inadvertently, its geopolitical future. In the margins of Smith's map, which measured 2.6m x 1.8m, was a small cross-section (Fig.6), which extrapolated Smith's

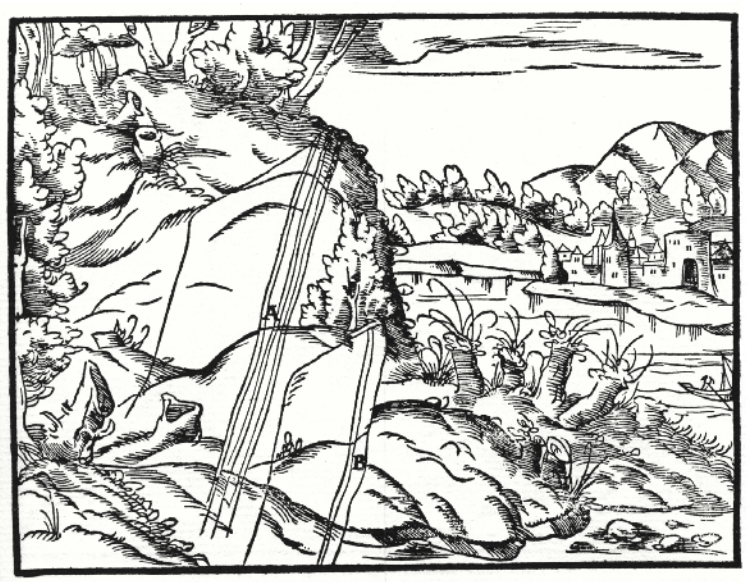
Fig.4 Georgius Agricola, Figure 50B, in Georgius Agricola, *De Re Metallica*, 1556 (republished New York: Dover, 1950).

Fig.5 Georgius Agricola, Figure 53, in Georgius Agricola, *De Re Metallica*, 1556 (republished New York: Dover, 1950).

Fig.6 William Smith, *A Delineation of the Strata of England and Wales, with Part of Scotland* (1815), detail with section in bottom right. Public domain, via Wikipedia Commons, https://en.wikipedia.org/wiki/Geologic_map#/media/File:Geological_map_Britain_William_Smith_1815.jpg [accessed 13.01.23].



A & B—*Venae dilatatae.* C—*Intervenium.* D & E—Other *venae dilatatae.*



A—Wide *vena profunda.* B—Narrow *vena profunda.*

observations as rock strata. This small but significant drawing condensed the geology of the continent into a small sequence of geological events, each linked to a particular period. More than the full map, this section communicates a clear and simple narrative that, while partly speculative, can be read through the section alone. The simplification of strata became a convenient and effective way of articulating *time* through section and *territory* through plan. This technique naturally coalesced with the expansion of the British Empire across the globe and its militaristic or exploitative approach to land.[11]

Without doubt, John Ruskin played a significant role in connecting architecture and geology in this period, not only advancing and popularising natural science, but romanticising it in his drawn representations of landscape. Ruskin saw himself as an academic contributor to matters of geology, as well as art history, and also saw these domains as highly compatible in the Victorian England that he inhabited. As Edward John Gillin has observed:

> In early-Victorian society, knowledge of rock types and their ordering in the earth's strata were considered to have practical applications for daily life. Britain's economic expansion was built on iron and coal, and the locating of these raw materials was a crucial concern for an increasingly industrialised society. The ability to determine areas that had coal deposits and to identify rock types rich in rare minerals were valuable geological promises.[12]

Ruskin, however, never saw geology through the lens of resources extracted for the service of industrialisation, but as an instructive science that provided context and perspective for understanding and describing the natural world and its origins.[13] Ruskin was committed to geology from an early point – indeed, his interest in natural science preceded his preoccupations with art and architecture.[14] This concerned not only his perceived contribution to geological knowledge,[15] but also his own drawings, which frequently engaged geological formations as well as, occasionally, processes of extraction. Ruskin saw geology as inseparably linked to aesthetics and art and fostered an appreciation of natural science throughout all aspects of his work.[16] In his landmark work *Deucalion* (1875–1883),[17] originally delivered as a series of lectures, he addresses geology directly and its role as a scientific and aesthetic medium. Illustrated by simply drawn geological sections, the work was the culmination of nearly two decades of observational study for Ruskin, interspersed with his lectures on art and architecture. His section through the Jura Alps (Fig.7) is also the intersection of these interests. Drawing on Smith's earlier example, the elegant section shows an economy of linework allocating broad time periods to geological phenomena through hatching, with a simple explanatory legend. For Ruskin, this section was not just a representation of these mountain forms, but a direct contribution to contemporary arguments concerning Alpine geology, about which he had already published in 1865.[18] The section was more than objective documentation; rather, it was a vehicle for deeper critical debate and exchange. Similarly, in his drawings of *The Chain of Mont Blanc* (Fig.8), reproduced as woodblock prints, he uses a skeletal line drawing paired with a more naturalistic landscape sketch in order to simplify the forces of erosion.[19] These geological sections can be seen as a significant counterpart to Ruskin's more naturalistic and figurative representations of natural landscapes. His scientific understanding of the earth enabled his artistic reproduction of it, similar to the way a knowledge of anatomy and the skeleton informed figure drawing.[20]

Ruskin's influence in framing geology as an artistic concern for this period has been recognised as part of an era of 'aesthetic geology',[21] which saw a flowering of earth sciences in the creative consciousness of the period.[22] This influence had a direct impact on the city of Newcastle and its own geological section. The primary surveying of the Newcastle coal seams was undertaken by T.W. Edgeworth David, who had studied under Ruskin at Oxford between 1870 and 1876 and inherited a romantic as well as a scientific appreciation of the natural sciences.[23] The meeting of these two figures at either ends of their impressive respective careers left indelible traces on the landscape of Newcastle and Australia, both actually and in its drawn representations.

The geological section

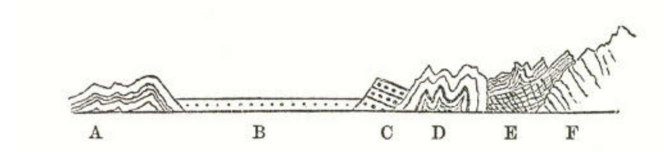
Writing in the 1960s, in the *Journal of Geology*, Allen Keller makes a distinction between what he calls 'general' and 'specific' geological cross-sections, dictated mostly by the extent of the line along which the section is cut. As Keller writes:

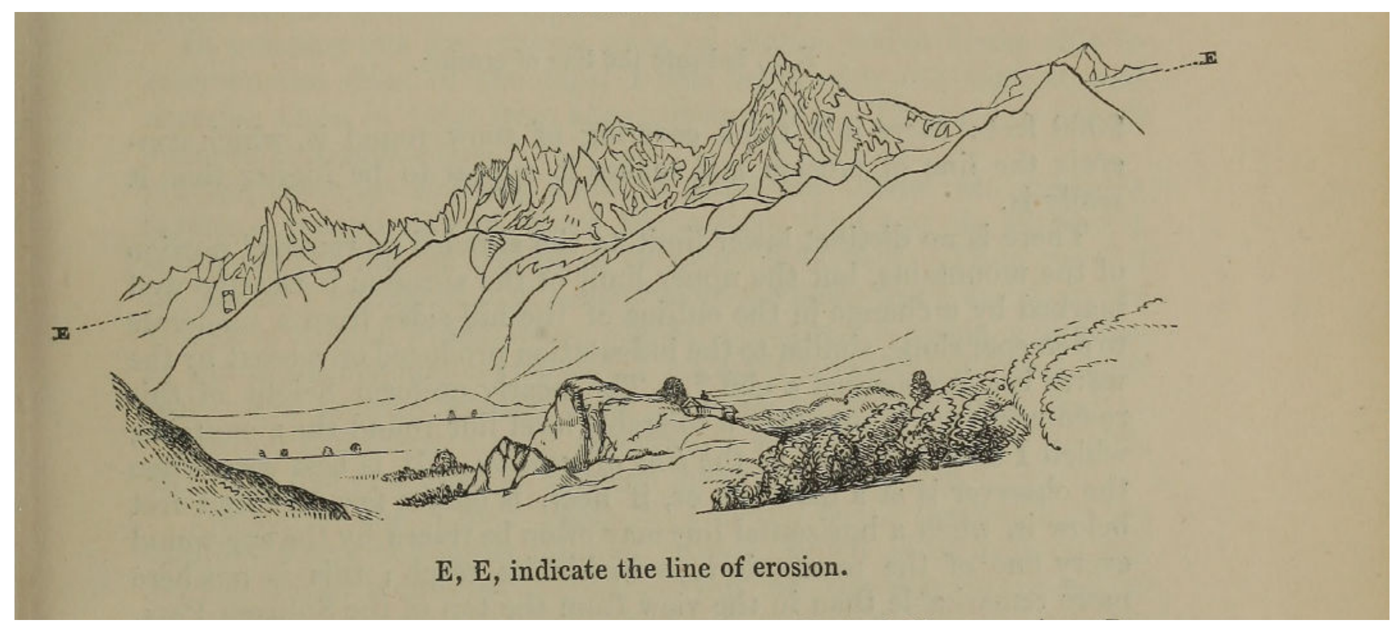
> A general cross section is an abstract view of an area drawn along an imaginary line, while a specific section shows part of an area along a definite line. Both types of sections may be used to show the relationships of strata and to help describe a sequence of events in the history of the earth. General cross sections are by nature more theoretical than are specific ones.[24]

Keller describes the role of imagination, speculation and assumption in the creation of geological sections, using examples from 1669 in Tuscany (drawn by Nils Steenson),[25] Pennsylvania in 1858 (drawn by Henry Darwin Rogers)[26] and the Appalachian Mountains in 1959 (drawn by Philip Burke King).[27] Across this history, Keller shows the development of drawing style as well as aesthetic taste, highlighting a range of approaches along a spectrum from objective representation to aspirations of pictorial beauty.

Fig.7 John Ruskin, Section of the Jura Alps, from *Deucalion* (1878).

Fig.8 John Ruskin, *The Chain of Mont Blanc as seen from the Valley of Chamounix* (1856), originally published in *The Quarterly Journal of the Geological Society of London*, vol.12 (1856).





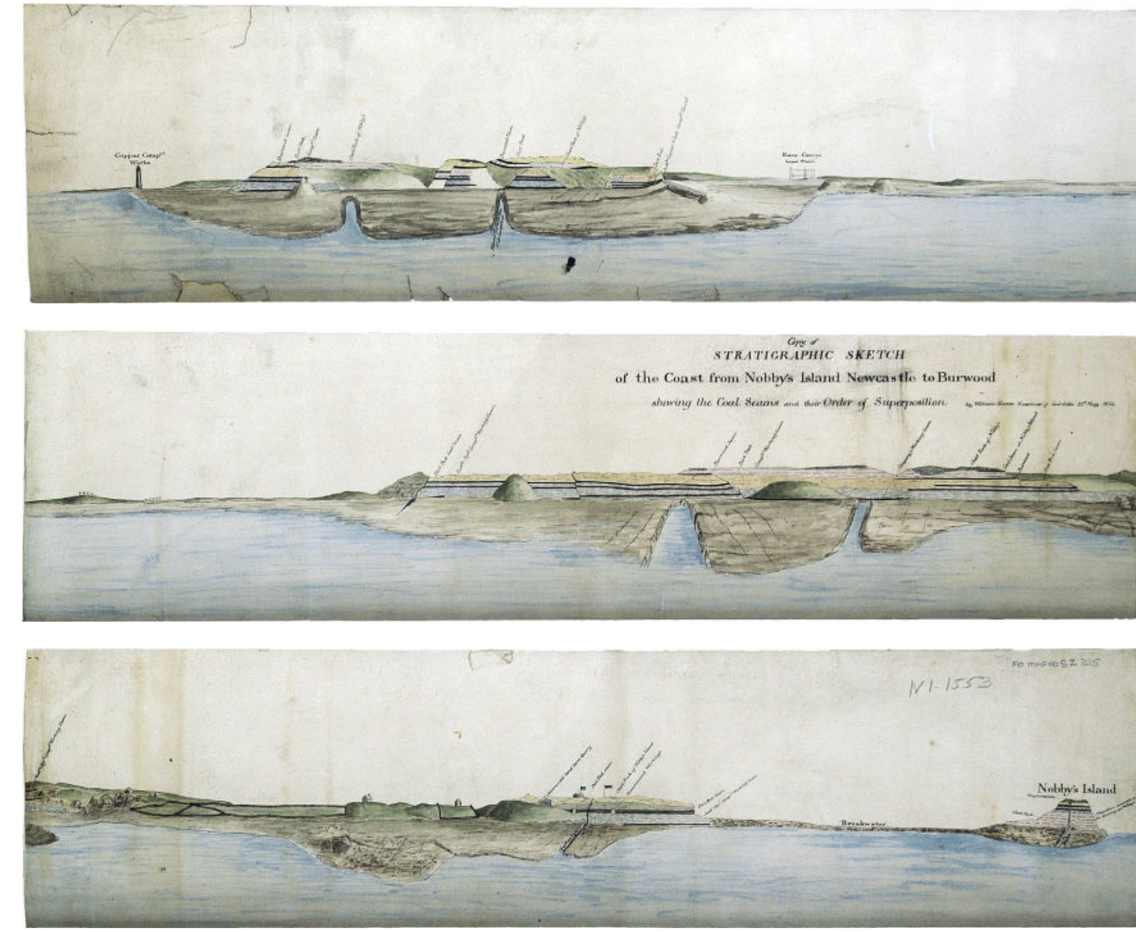


Fig.9a William Keene, *Stratigraphic Sketch of the Coast from Nobby's Island Newcastle to Burwood shewing the Coal Seams and their Order of Superposition*. Courtesy University of Newcastle Special Collections.

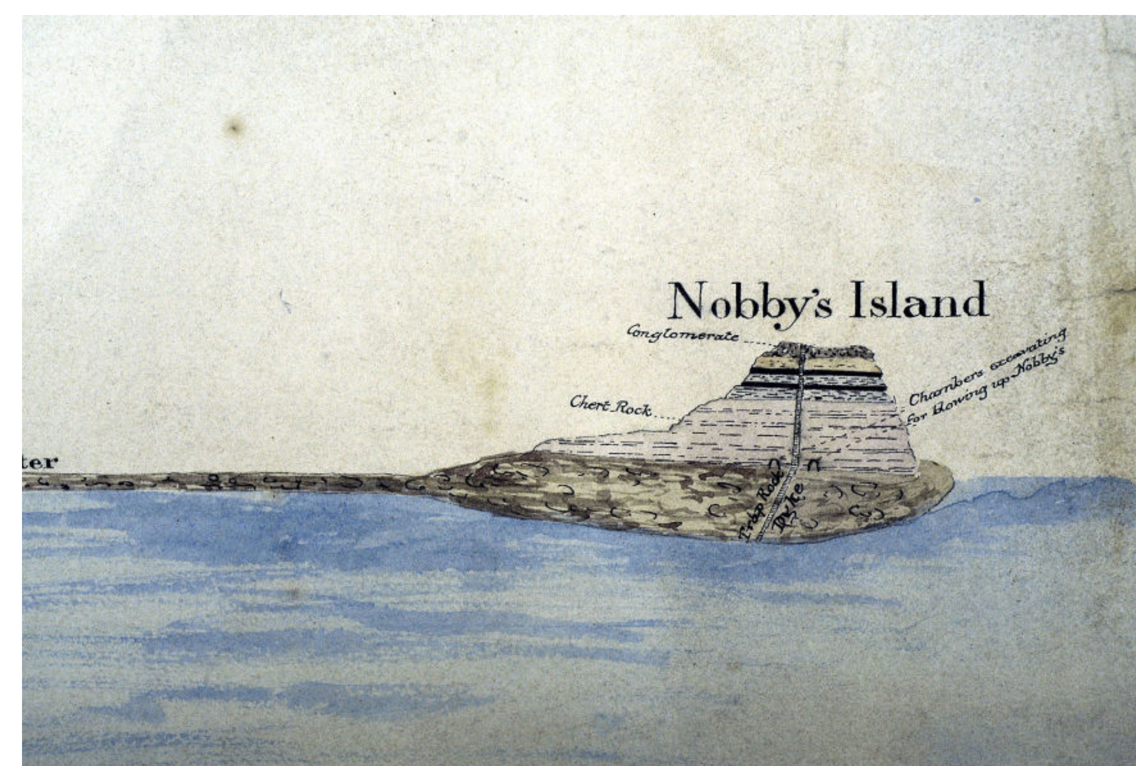


Fig.9b Nobby's Island, detail from Keene, *Stratigraphic Sketch*. Courtesy University of Newcastle Special Collections.

Fittingly, the period when geological and architectural representation most crossed over was one of industrial expansion across the colonies of European powers, and especially in Australia. The construction of cities and the extraction of resources coincided not only in drawing, but in the actual spatial demands of colonial expansion.

Regarding Newcastle, sections through the coal seams first emerged in early colonial representations of the city, although speculation regarding its geology can be traced back further. In his voyage along the east coast in May 1770, Captain James Cook had observed a 'small clump of an island lying close to shore',[28] which marks the entry to Newcastle harbour. This clump would be known in the colony as Coal Island before it was officially named Nobbys in the early 1800s. The island's silhouette is a recurring datum through almost all of the geological sectioning that followed. It marked not only the entry to the city's harbour, but also the starting point for the sectional drawing of its geology.

Nobbys was a distinctive feature in the early geological surveys of the infant colony, thanks partly to the visible seams that emerged from it. Truncated from the mainland, and floating in the sea, William Keene's 1854 section of the island (Figs 9a, 9b) marks out not only the seams of the coal, but an ambitious process of extraction. The descriptive title of the drawing belies its intention: *Stratigraphic Sketch of the Coast from Nobby's Island Newcastle to Burwood shewing the Coal Seams and their Order of Superposition.* A more holistic account of the full vertical section of the coal seams was published a few years later by Henry Taylor Plews in a paper titled the 'On the Coalfields of NSW'.[29] These drawings (Figs 10, 11) also extract the island from its geographic context, positioning and naming all the seams in relationship to the surface and removing information not explicitly related to coal extraction. These sections, contemporaneous with Ruskin's romanticisation of geology in the northern hemisphere, are practical and direct, testifying to a deliberate project of *extraction*, manifested first as a drawing and then as a spatial practice. If there is a romance to these early colonial sections, it is accidental rather than enculturated.

While there is extensive literature devoted to industrial architecture and its influence on, for instance, the avant-garde,[30] there is a less complete record of the architecture of extraction, or its impact on architecture more generally. During the 19th century, the relationship of machines to geology dramatically shaped new spatial conditions, repositioning architecture as a broader symptom of the resources that both underpinned and powered it. As the colony, city and empire became more demanding and depleting of resources, the mapping of territories and their geological strata required a different, highly strategic mode of analysis and also

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Fig.10 H.T. Plews, *Plan No. 2*: Section of Headlands, in 'On the Coalfields of NSW', *Transactions of the North of England Institute of Mining Engineers*, vol.VI (1858). Courtesy University of Newcastle Special Collections.

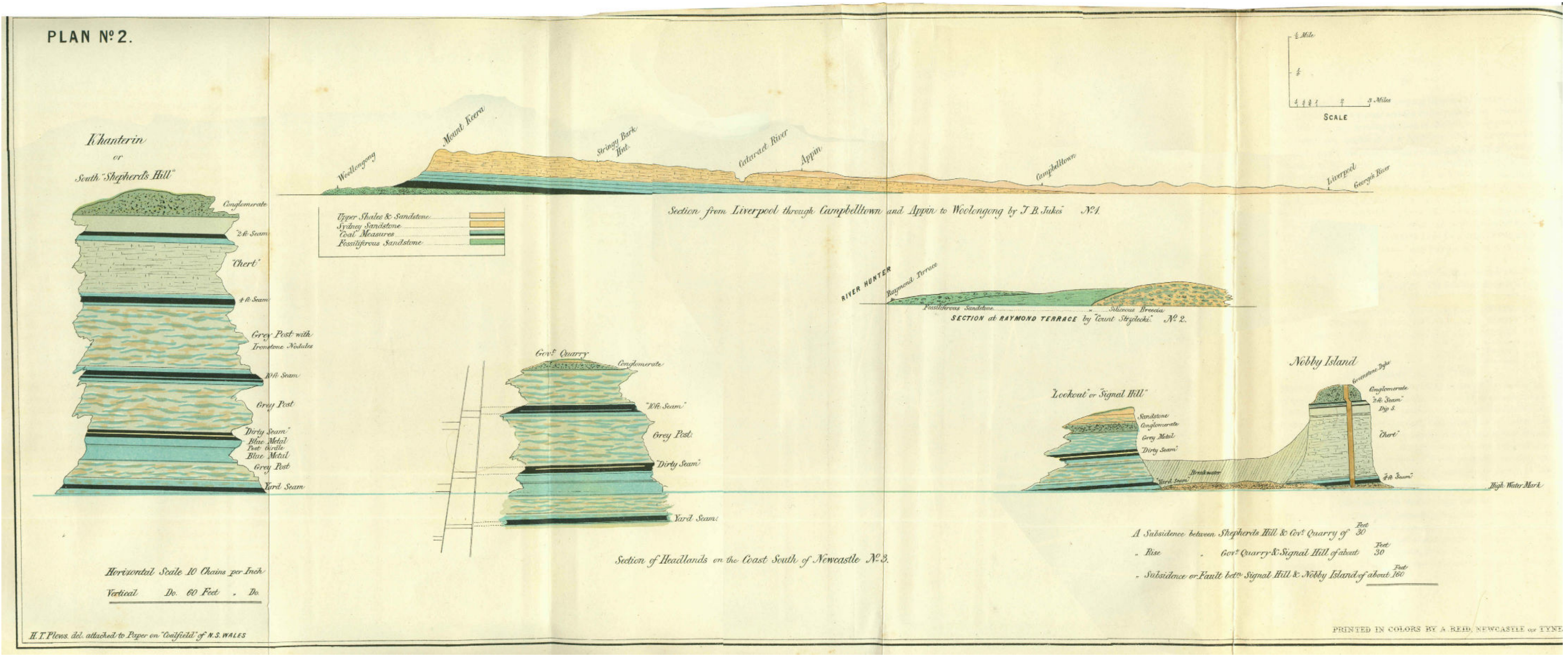
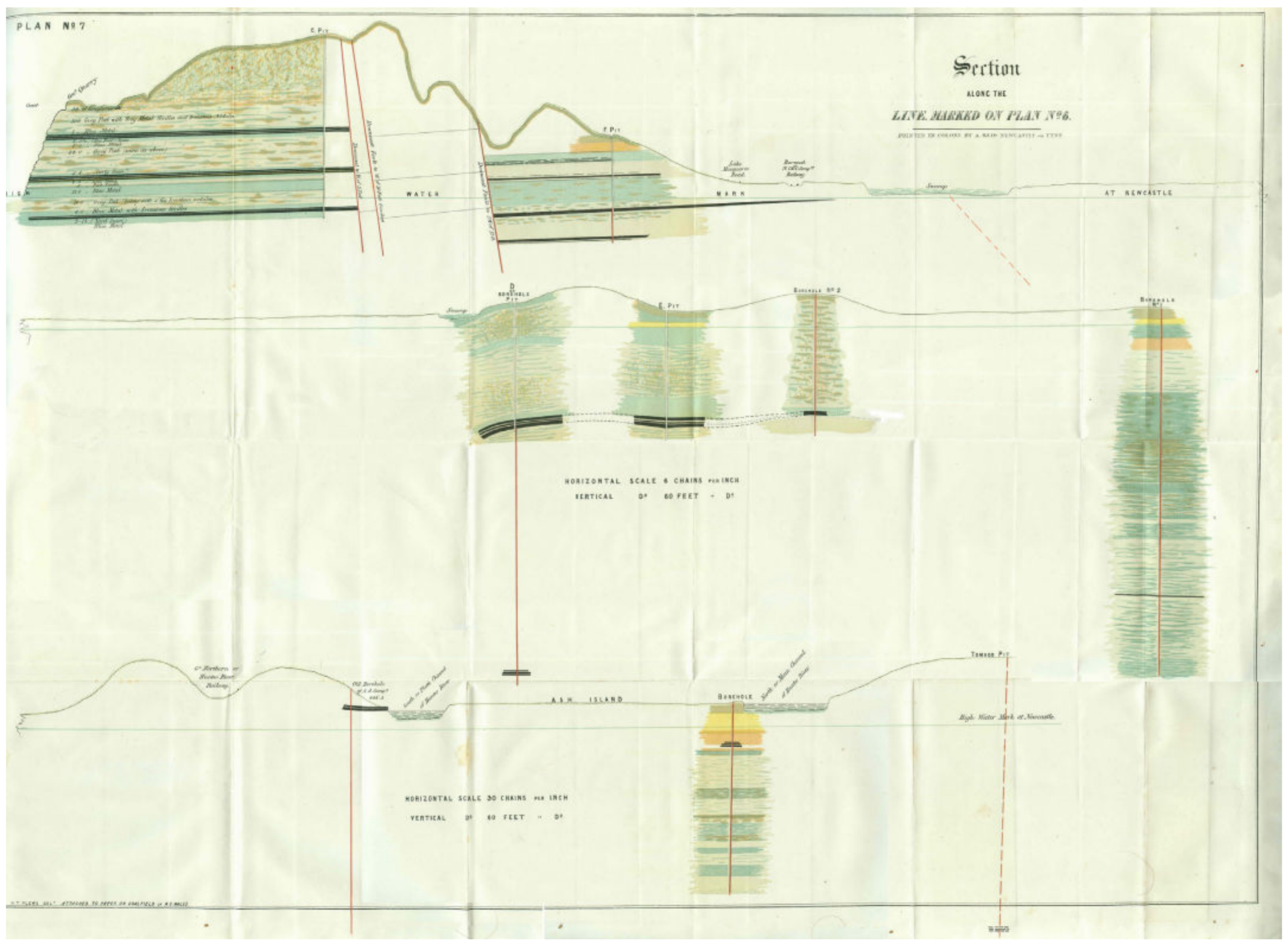


Fig.11 H.T. Plews, *Plan No. 7*: Section. 'On the Coalfields of NSW', *Transactions of the North of England Institute of Mining Engineers*, vol.VI (1858). Courtesy University of Newcastle Special Collections.



of drawing. While colonial processes of extraction started with the deployment of manual labour, the mass expansion of mechanisation was driven, to a large extent, by the requirement to optimise them. This was not just the extraction of resources from the ground but also the deployment of new infrastructures for distribution. In cities like Newcastle, there was little in the urban grid that was not directed to this purpose.

Writing in the 1930s, the eminent historian of technics Lewis Mumford described the impact of coal on the sensory experience of urban life in the Victorian city, writing:

> Coal dominated everywhere, from gray to black: the black boots, the black stove-pipe hat, the black coach or carriage, the black iron frame of the hearth, the black cooking pots and pans and stoves. Was it a mourning? Was it protective coloration? Was it mere depression of the senses? No matter what the original color of the paleotechnic milieu might be it was soon reduced by reason of the soot and cinders that accompanied its activities, to its characteristic tones, gray, dirty-brown, black.[31]

What Mumford alludes to is the way coal came to structure and permeate the everyday life of the citizens of industrialised areas. This was even more intensified in cities built above coal deposits. As well as the footprint beneath the ground, coal extraction created generalised environmental effects that went well beyond the physical processes of mining. This became part of the fabric and morphology of these cities and was played out across its districts, no matter which particular company or coal seam lay beneath it.

By the 1700s, most of the available coal seams in the British Isles had been located, even if adequate drawings and systems for surveying were not then available.[32] As the British Empire expanded, the understanding of coal and its powers also exponentially increased. For historians like Mumford, coal represented an entire technological paradigm, which was linked from its extraction to its combustion in a range of industrial and domestic machines, right through to its eventual dispersion in the atmosphere. The foreboding skies of the Romantic painters were juxtaposed with the greying of urban life through the particles of coal-dust that infiltrated the architecture and urban life of the modern city.[33] This infrastructure expanded beyond the physical limits of the recently industrialised city into the geological landscapes and panoramas beyond, linked by ribbons of railway and shipping lines that quickly became a global colonial network of extraction and supply.

The need for coal expanded in America in the same period, with the proliferation of coal yards and new infrastructure to assist its distribution.[34]

As timber stores declined under the pressures of colonisation, from the 1820s coal became an increasingly precious resource, its value dramatically escalating in the 50 years that followed. As industrial typologies for extracting and distributing coal were refined and mechanised, so geology and drawing offered new means of exploration and speculation. Across the British Empire[35] the securing of resources became a primary objective of colonial expansion, equivalent to the securing of borders and military defence. The geological drawings of this period played a role in condensing this vast and global landscape into a diagrammatic representation of its resources and, over time, their depletion. Equally, they prophetically represent this landscape's future.

The sectioning of Newcastle

The various strands of this complex colonial history started to coalesce when Sir Tannant William Edgeworth David took a posting as a field surveyor in the geological service of the government of NSW, arriving in Australia in 1882 at the height of the country's industrial expansion. After initially surveying the New England region in north-west NSW, he undertook a detailed investigation of the Newcastle coal field and the broader geography of the Hunter Valley, which occupied the next decades of his eventful life. This project was infused with the aesthetic influence of Ruskin as well as the speculative and imaginative potential that this complex landscape offered. Credited with discovering the Greta coal seam and the rich deposits to the north of Newcastle, David provided a forensic and rigorous mode of both surveying and drawing, which dramatically expanded the understanding of the geology of the region and became the basis for all subsequent work. As the proclaimed Antarctic explorer Douglas Mawson wrote in his obituary of David, who was his mentor:

> [the] investigation of the Hunter River coalfield, [was] a subject which occupied much of [David's] time during the succeeding twenty years. A key to the upper series with the Newcastle coal measures was revealed in excellent cliff sections along the coast, but the details of the immensely thick lower beds with the Greta coal horizon were, on account of the general absence of suitable sections, unravelled only by the exercise of a high degree of skill and devotion to the undertaking. David's discoveries in this field and the accurate delineation of the strata of such an important coal basin have furnished a classic feature in Australian geology and a contribution of outstanding economic importance.[36]

As well as the detailed map of the coal field of Newcastle, David produced a series of meticulous sections that still form the basis of the geological data available today. The drawings document the geology of Newcastle and the Hunter Valley in considerable

Fig.12 T.W. Edgeworth David, *Coast Section from Moon Island to Newcastle* (1905). Courtesy University of Newcastle Special Collections.

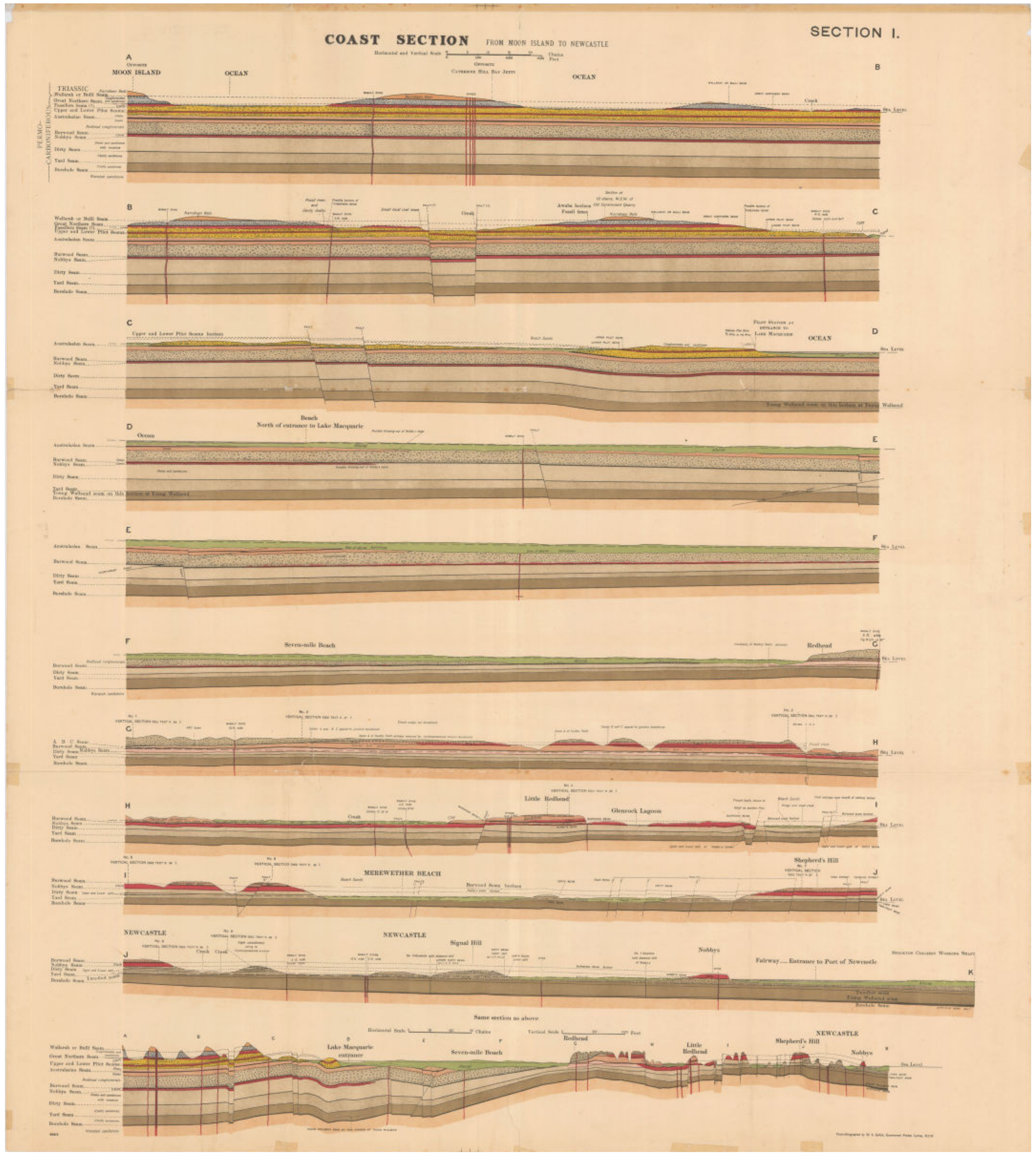
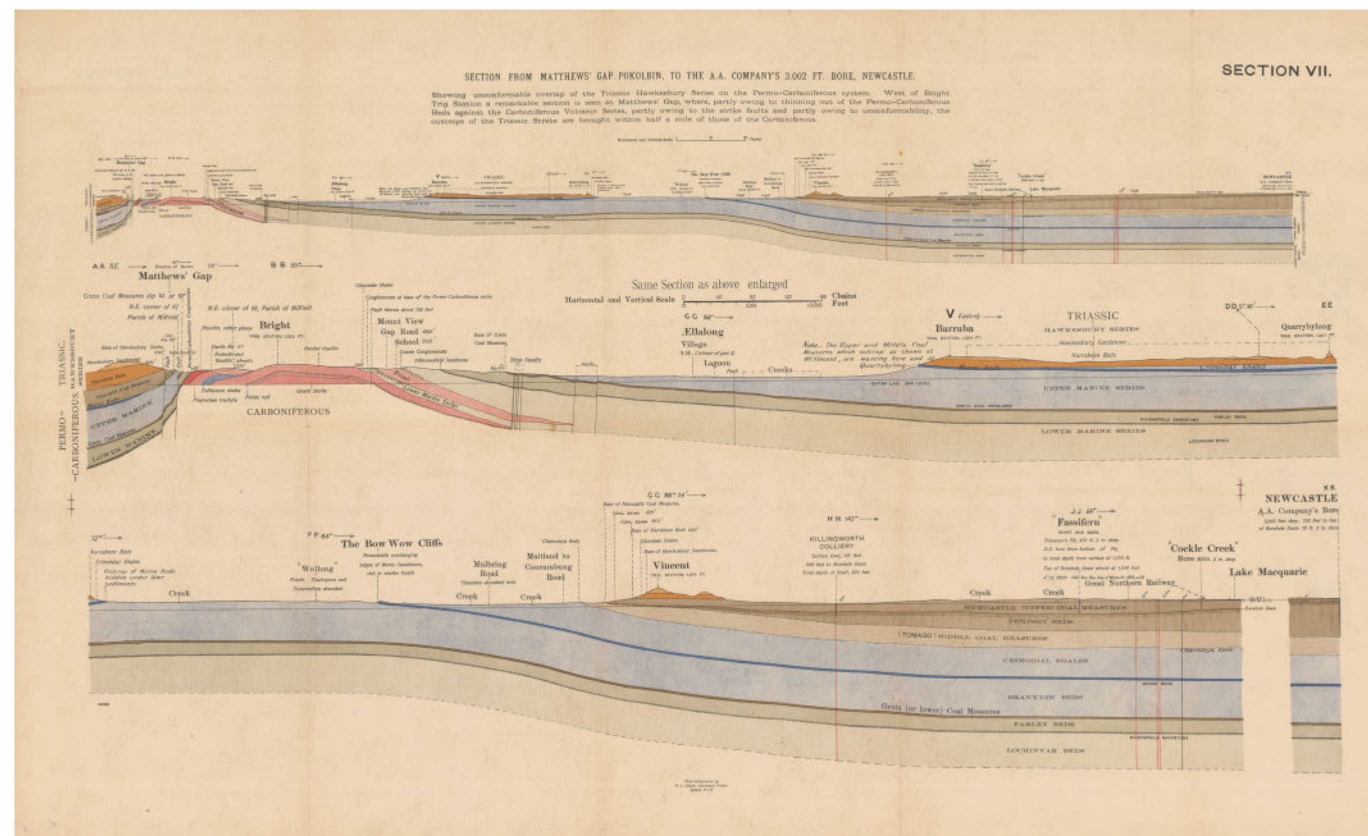


Fig.13 T.W. Edgeworth David, *Section from Matthews' Gap Pokolbin, to the A.A. Company's 3,002 ft. Bore, Newcastle* (1905). Courtesy University of Newcastle Special Collections.



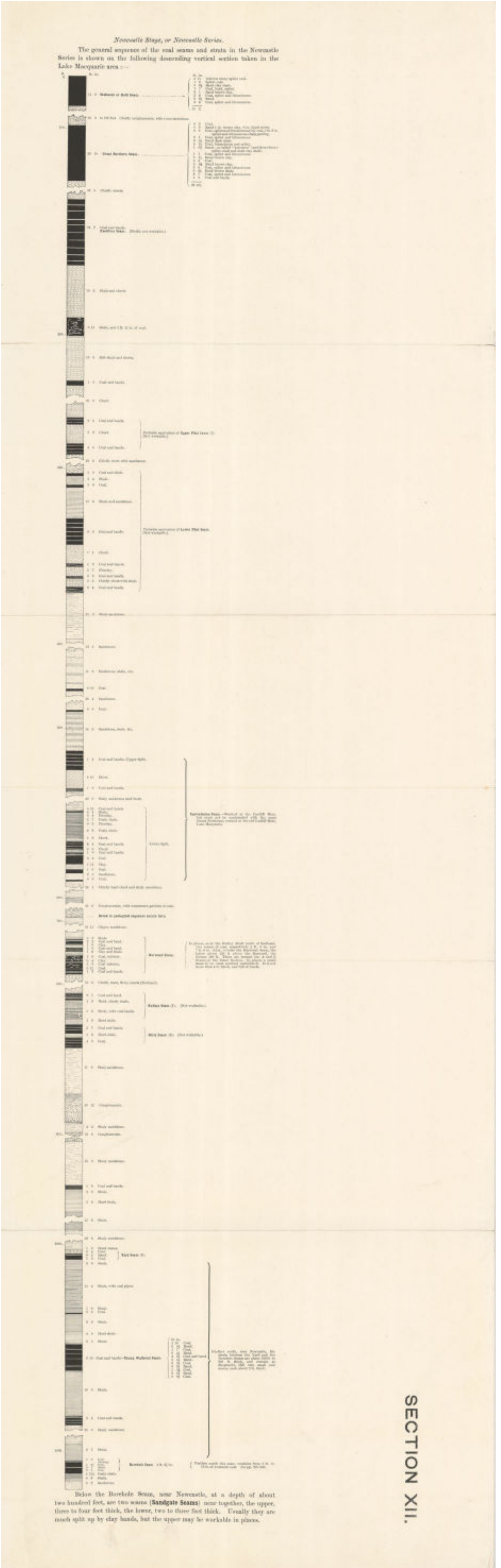
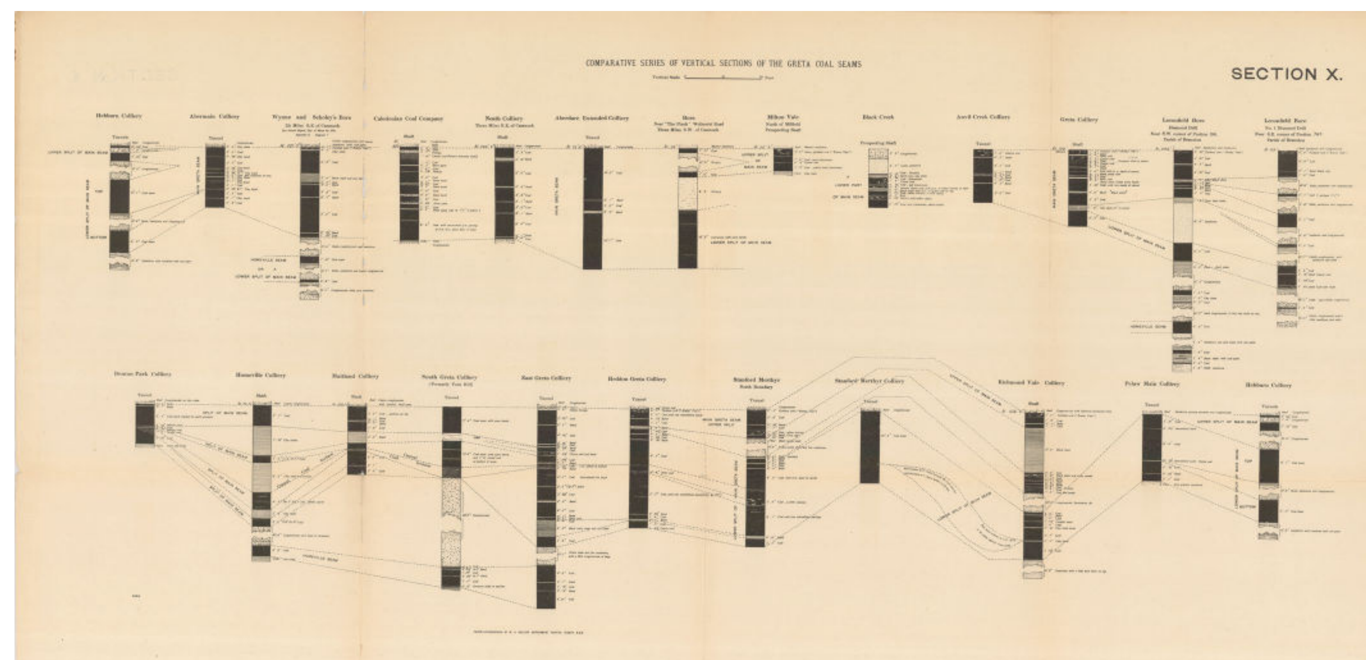


Fig.14 T.W. Edgeworth David, *Newcastle Series* (1905). Courtesy University of Newcastle Special Collections.

Fig.15 T.W. Edgeworth David, *Comparative Series of Vertical Sections of the Greta Coal Seams* (1905). Courtesy University of Newcastle Special Collections.



detail, with limited concern for urban or architectural features, but a rigorous mapping of the terrain and its coastline. The drawings also give us insight into the political and economic forces that, while operating outside their frame, are evident in their production. The geological sections were produced from vertical points where measurements were compiled through drilling and cross-referenced with observations on the ground. A geological section is compiled by extrapolating these measurements with the topographical data to create a complex measured drawing across vast distances. These sectional drawings function as independent timelines that can be compared and cross-referenced through the various coal seams, the geological periods and the relative distance to the surface.

The most extensive and all-encompassing section among the sequence of drawings that David produced is entitled *Coast Section: from Moon Island to Newcastle* (Fig.12), which depicts, in a series of segments, the coastline from Swansea in the south to the Newcastle CBD. This north–south cut takes in the major geological outcrops along the coast, and shows the progression towards the dramatic and undulating terrain that the CBD is built on. These stacked sections show the layers of coal seams from the youngest, the Wallarah and Bulli, to the oldest, or deepest, the Borehole. Marked as the permo-carboniferous period in the geological timeline, the Burwood, Yard, Dirty and Nobbys seams are mapped across all drawings, like a horizontal reference point. Marked by the coastal communities that now inhabit this section, the drawings use graphic conventions in order to show geological phenomena such as dykes and faults, depicted as diagonal slices through the rock structure that disrupts the continuity of the seam. As with the clarity and simplicity of Ruskin's drawings, these sections distil the complex forces of geology into simple and relatable transactions across both space and time. The temporal aspect of these drawings is embodied in a vast section David produced from Pokolbin to Newcastle, marking not only the relative position of coal measures, but the geological timeframes connected to them, shown as a timeline at the edge of each section (Fig.13). These are then reproduced and truncated at larger scales on the same drawing, to highlight the key geological points along that axis.

If these coast sections are the most extensive horizontal cuts in the series of drawings David produced, the vertical sections, mapping individual seams directly, are the most dramatic. These drawings have the graphic simplicity of the scientific diagrams of Ruskin, reducing the complexity of the various layers into legible moments that can be easily notated. David's vertical slice from the surface to the base of the borehole seam (Fig.14) is one of the most comprehensive sections through the city, marking each of its individual seams, positioning it, giving it a depth and then, a description of the matter that separates it from the next one. This vertical slice was taken somewhere near Lake Macquarie and provides a vastly different scale from the horizontal cuts. The layering of information is extracted, in a manner similar to the coal itself, drawing the layers out in relationship to the surface. While the base of the borehole seam is far from the lowest depth of geological activity accessible to David, it marks the limit of his interest and that of the drawing. The notes on each seam mark their size and quality, and also their relative economic value, or workability. In this sense, it is a cut through time, but marked by its relationship – economically and spatially – to the surface and the present.

Taken further, David's beautiful documentation of the Greta seam combined both approaches (Fig.15). The vertical sections that comprise this sequence include only the Greta seam, shown in black across multiple slices across the valley. The Greta seam was considerably deeper than the Newcastle measures and less visible from the surface. David presented the sequence of concurrent sections as tables, taken out of their geographical relationship and presented as data, in a manner similar to the earlier speculative sections of Keene and Plews. It is only in the horizontal cross-section that these graphic slices are positioned in relationship to each other, and so they function as an index offering a deeper source of information to the larger geological section, like a detail in a working drawing. The schematic section through Tomago repeats this relationship, locating the slices and their relationship to the surface (Fig.16) and linking the points through more hesitant lines. The relationship between the absolute and the speculative in this drawing enacts the process of extraction, embodying the uncertainty that permeates the mined city, at any point on the grid and at any moment in time.

David's mapping of the region as a vertical commodity is an important document in the colonial history of Newcastle, and of that of the Anthropocene in general. These drawings both documented and projected the future life of the city and provided the basis for the most detailed mapping of the coal seams to date. In the 1960s, half a century after David, the steel-producer BHP produced a drawing of all the coal seams in both plan and section (Fig.17), using colour-coding to position the location and age of the measures. The map dramatically shows the three-dimensional intersection of these seams and their complex relationship to the surface. The drawing also reveals the seams as natural elements, continuous with the coastal features, water bodies and topography, merging with a living interconnected ecological system. The naturalising of the seams in this mapping positions them in relationship to place and site, rather than as alien resources awaiting extraction. In contrast to the disjunction of the urban and mining grid that plays out in the modern city of Newcastle, this drawing creates a synthesis between the surface and the ground and marks a tentative endpoint to the cycles of extraction beneath.

Unlike David's coastal section, the section cut from this series slices east–west, from the edge of Lake Macquarie to the headland at Redhead, traversing Lake Macquarie at two points. As well as covering a large sweep of the surface terrain and its geographical features, this section divides the seams into sub-groups, based on time-periods and proximity to the surface, starting with Moon Island, Boolooroo, Adamstown and Lambton. Compared to the abstract partitioning of the 1905 city into geometric parcels distributed among mining companies, this mapping shows the seams as interconnected with the region's topography in a way that reconnects with Ruskin's earlier romanticisation of geology and much older indigenous histories. While there is still an absence of urbanism in this mapping, there is a sense of continuity between the place and its geology that, despite the intensive mining of this material, still locates it in the natural world and connects it to the experience of nature. While the section isolates a small band of relatively recent economic interest, the horizontal mapping shows a complete, interconnected and highly complex environment that has existed for aeons prior to the period we have come to call the Anthropocene.

The accompanying section is one of the few geological sections of Newcastle that does not cut through Nobbys Island, but this was rectified in the north-east/south-west section produced at the same time (Fig.18). Drawn in a similar style, with the same sub-categories, this section is a shorter, more dramatic slice but shows the complex interweaving of the seams and the turbulence where they collide with the surface and coastal cliffs. Like all the geological sections, the drawing ends with the end of the coal-measures, effectively marking the shallow crust of colonial value. What characterises this last section, though, is also what characterises the geology of Newcastle: the collisions between the seams and the surface, where these two distinct entities intersect.

The sectioning of the city of Newcastle over time reveals a number of important historical and geological forces that interact but also extend well beyond the points through which these sections are taken. As this section is drawn and redrawn, the next cycles of urbanisation will be more concerned with reconnecting with this ground, rather than removing it. Spanning over a century, each of these sections holds multiple entities in play simultaneously across the competing timescales, the geopolitical and social pressures and the spatial collisions between the ground and below. These drawings also, at this point in history, provide a lens through which to critically re-evaluate our relationship to these histories. The severity of these sections opens on to a broader history of the Anthropocene and drawing offers a lens through which to reposition and critique it. As our society moves to an era beyond coal, the sectional drawings of these seams of fossil fuel provide an archaeology of the voids and crevasses left behind by it.

Fig.16 T.W. Edgeworth David, *Comparative Series of Vertical Sections in the Tomago Coal Measures* (1905). Courtesy University of Newcastle Special Collections.

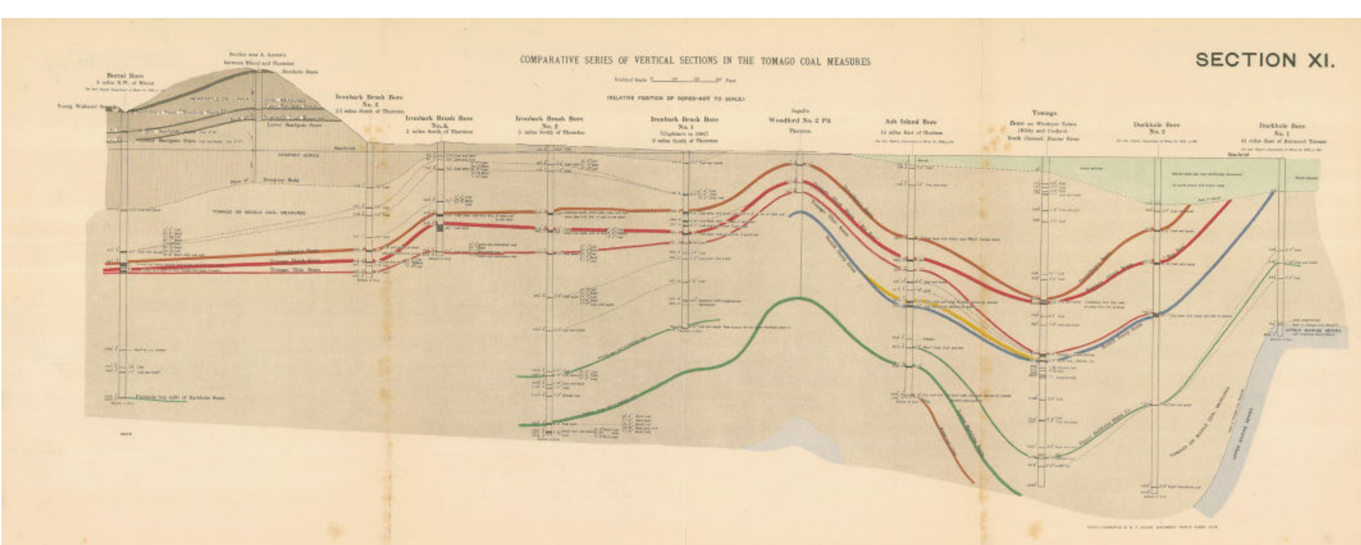


Fig.17 *Surface Geology, Newcastle Coal Field* (1965). Courtesy University of Newcastle Special Collections.

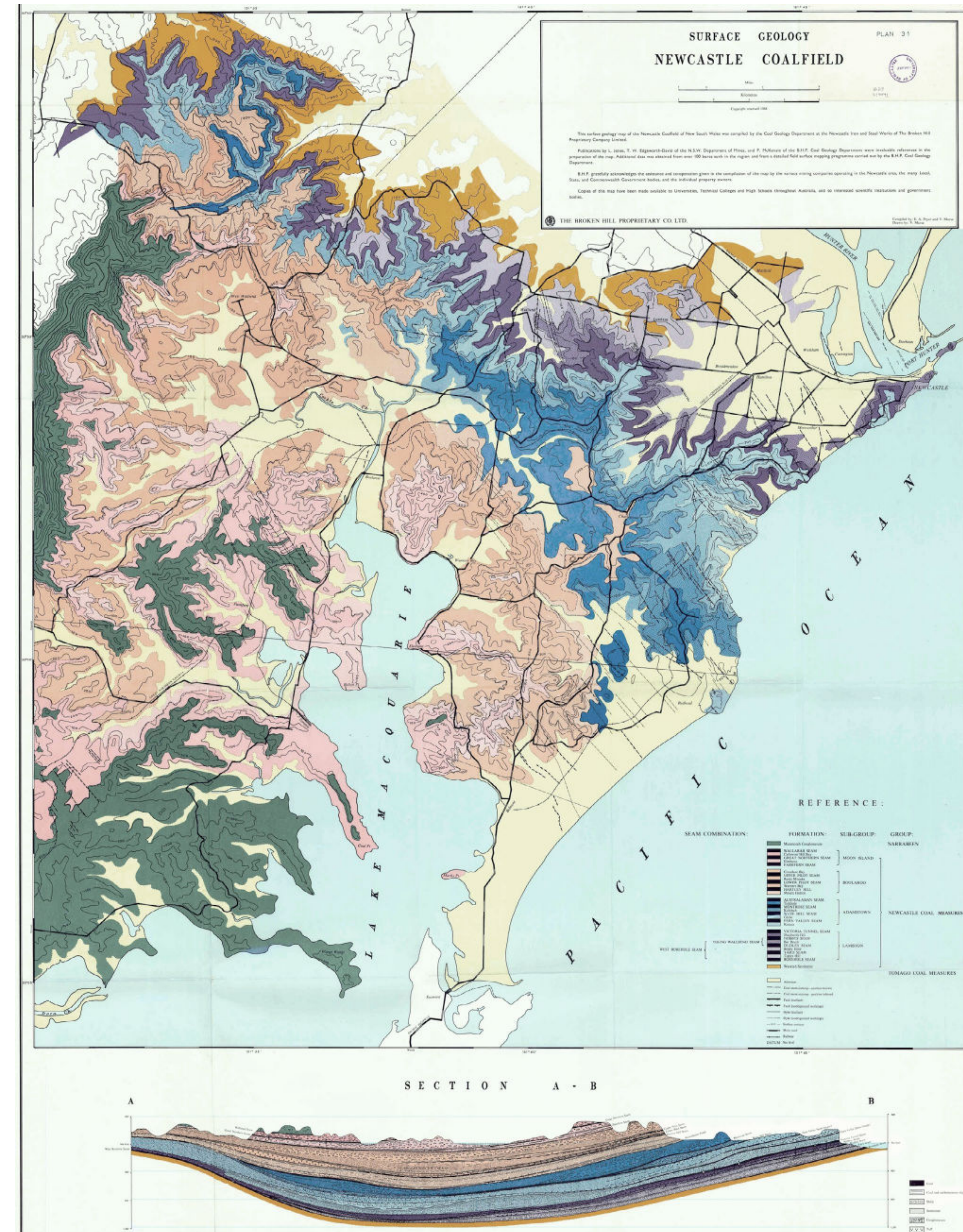
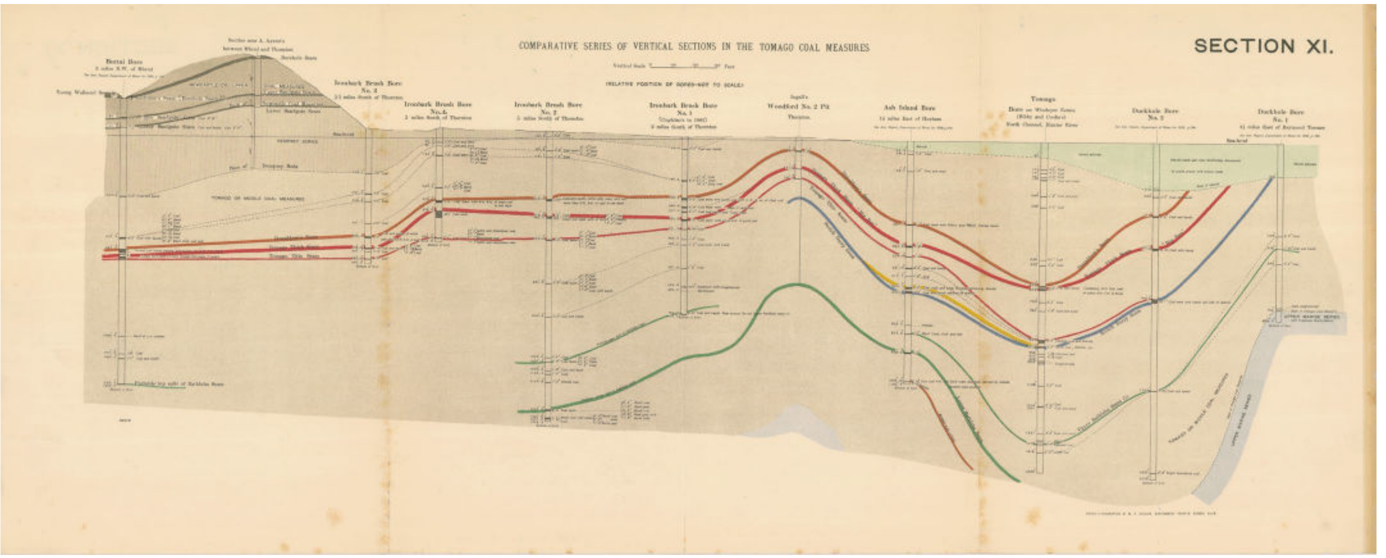
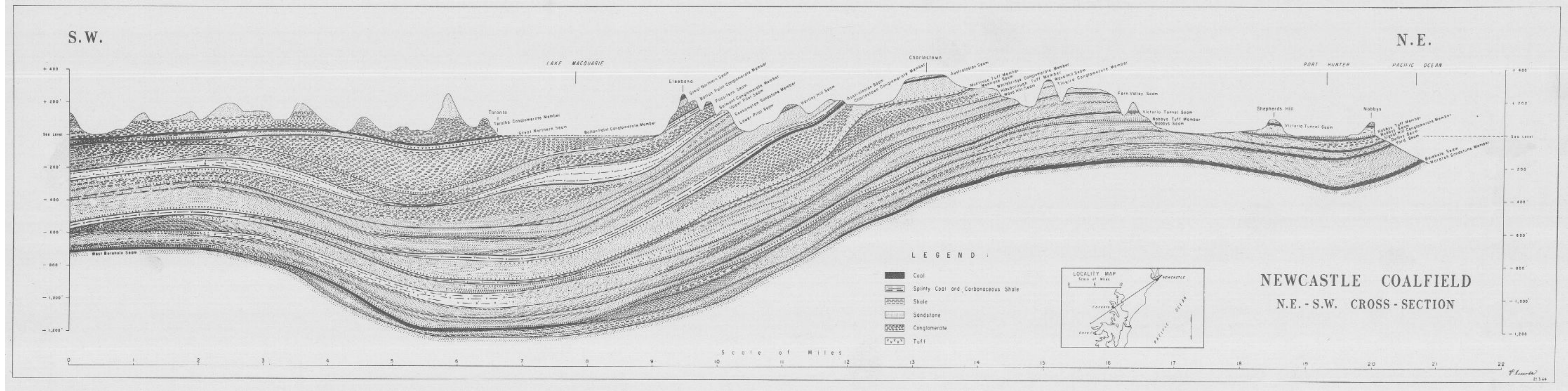


Fig.16 T.W. Edgeworth David, *Comparative Series of Vertical Sections in the Tomago Coal Measures* (1905). Courtesy University of Newcastle Special Collections.

Fig.18 *Newcastle Coal Field: NE/SW Section* (1965). Courtesy University of Newcastle Special Collections.





1 Charles Darwin, letter to Catherine Darwin, East Falkland Island, 6 April 1834, in Charles Darwin, Robert Fitzroy, *The Beagle Record: Selections from the Original Pictorial Records and Written Accounts of the Voyage of HMS Beagle* (Cambridge: Cambridge University Press, 1979), 196.

2 This paper would not be possible without the significant support of staff at UoN Special Collections at the University of Newcastle, and particularly Gionni di Gravio. I am also grateful for access to drawings from their collection.

3 See Jo Hanley, 'Newcastle: place of history, landscape of memory', in *Hidden Newcastle: Urban Memories and Architectural Imaginaries*, eds R. John Moore and Michael Ostwald (Sydney: Tower Books/Gadfly Media, 1997), 20.

4 See, for instance, Beryl Nasher, *Geology of the Hunter Valley* (Brisbane: The Jacaranda Press, 1965), 45.

5 For more on the history of coal mining in NSW and Newcastle, see Ann Hardy, 'Australian coal mining industry (1797–1820s): beginnings, history and vanished industrial heritage of early Newcastle', *From the Past to the Future: 18th Australian Engineering Heritage Conference 2015 [Newcastle]* (Barton, Australian Capital Territory: Engineers Australia, 2015), 1–8; David Branagan, *Geology and Coal Mining in the Hunter Valley* (Newcastle: Newcastle Public Library, 1972).

6 Georgius Agricola, *De Re Metallica*, 1556 (republished New York: Dover, 1950).

7 As well as the use of critical unbuilt typologies, it was the inclusion of geographic and atmospheric phenomena in their drawings which distinguished them from the orthographic standards that preceded them. See Emil Kaufmann, 'Three revolutionary architects: Boullée, Ledoux, and Lequeu', *Transactions of the American Philosophical Society* vol.42, no.3 (1952), 433–560.

8 The shift towards more geographical concerns in architectural drawing is documented in David Gissen, 'Architecture's geographic turns', *Log*, no.12, Spring/Summer (2008), 59–67.

9 See Allan Keller, 'Concerning cross sections', *The Journal of Geology*, vol.73, no.3 (May 1965), 498–504.

10 Tom Sharpe, 'The birth of the geological map', *Science*, New Series, vol.347, no.6219 (16 January 2015), 230–32.

11 In a similar period, Charles Darwin had maintained a deep interest in geology and, in the 1830s, while on his global voyage of the South Pacific, had produced diagrammatic sections for the geological history of coral reefs. Darwin was inspired by the work of Charles Lyell, *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation* (London: John Murray, 1830), which he had obtained while stopping at the port of Montevideo in November 1832. See Sandra Herbert, 'Darwin as geologist', *Scientific American*, vol.254, no.5 (May 1986), 120. See also Lyell, *op. cit*.

12 Edward John Gillin, 'Stones of science: Charles Harriot Smith and the importance of geology in architecture (1834–1864)', *Architectural History*, vol.59 (2016), 281–310.

13 Ruskin's ethical and theological approach to geology, as well as his belief in its universal educational and philosophical value, was captured in John Ruskin, *The Ethics of the Dust: Ten Lectures to Little Housewives on the Elements of Crystallisation* (Kent: G. Allen Press, 1877).

14 As Wagner reveals, Ruskin had planned a career in geology prior to his interest in art and architecture. Virginia L. Wagner, 'John Ruskin and artistical geology in America', *Winterthur Portfolio*, vol.23, nos 2/3 (Summer/Autumn 1988), 151.

15 Caroline Trowbridge, 'Speakers concerning the earth: Ruskin's geology after 1860', in *Repositioning Victorian Sciences: Shifting Centres in Nineteenth Century Thinking,* eds David Clifford, Elisabeth Wadge, Alex Warwick and Martin Willis (London: Anthem Press, 2006), 17–30.

16 For more on this, see Denis E. Cosgrove, 'Ruskin and the geographical imagination', *Geographical Review*, vol.69, no.1 (Jan. 1979), 45.

17 The most extensive account of this is in John Ruskin, *Deucalion: Collected Studies of the Lapse of Waves and the Life of Stones* (Orpington: George Allen, 1879).

18 John Ruskin, 'Notes on the shape and structure of some Parts of the Alps, with reference to denudation', *Geological Magazine*, vol.2, no.8 (1865), 49–55.

19 This was originally published in Daniel Sharpe, 'Elevation of the Alps', in *The Quarterly Journal of the Geological Society of London*, vol.12 (1856), 105.

20 Ruskin had used the term 'anatomy' to describe the geological process, as well as his ultimate shift towards a more naturalistic understanding of landscape. Ruskin wrote, 'I was quite sure that if I examined the mountain anatomy scientifically I should go wrong in like manner touching the external aspects. Therefore I closed all geological books and set myself, as far as I could, to see the Alps in a thoughtless and untheorising manner.' Quoted in Cosgrove, *op. cit*., 45.

21 For an overview of 'aesthetic geology' see Noah Heringman, *Romantic Rocks, Aesthetic Geology* (Ithaca: Cornell University Press, 2004), 1–29.

22 From Edward Muybridge's photographic exploration of Yosemite National Park to the panoramic landscapes of William Henry Holmes, there was a blurring of scientific and aesthetic modes in the representation of the Victorian world, as well as a re-evaluation of their artistic and economic use. See Mary V. Jessup Hood and Robert Bartlett Haas, 'Eadward Muybridge's Yosemite Valley photographs 1867–1872', *California Historical Society Quarterly*, vol.42, no.1 (March 1963), 5–26; George Kubler, 'Geology as a panoramic vision: William Henry Holmes (1846–1933)', *RES: Anthropology and Aesthetics*, 15 (Spring 1988), 156–62.

23 See David Branagan, *T.W. Edgeworth David: A Life* (Sydney: Antipodes Books and Beyond, 2004), 151.

24 Keller, *op. cit*., 498–504.

25 First published in Frank Adams, *The Birth and Development of the Geological Sciences* (New York: Dover, 1938).

26 First published in Henry Darwin Rogers, *The Geology of Pennsylvania* (Philadelphia: Lippincott, 1858).

27 First published in Philip King, *The Evolution of North America* (New Jersey: Princeton University Press, 1959).

28 Hanley, *op cit*., 10.

29 See Henry Taylor Plews, 'On the coalfields of NSW', in *Transactions of the North of England Institute of Mining Engineers*, vol.IV (1858).

30 The most famous examples are: Reyner Banham, *Theory and Design in the First Machine Age* (New York: Praeger, 1960); Reyner Banham, *A Concrete Atlantis: US Industrial Building and European Modern Architecture* (Cambridge, MA: The MIT Press, 1989); Fernand Léger, *The Machine Aesthetic: The Manufactured Object, the Artisan, and the Artist*, trans. Tim Benton (New York: The Whitney Library of Design, 1975).

31 Lewis Mumford, *Technics and Civilisation* (New York: Harcourt Brace and Co., 1934), 163.

32 See Gregory Clark and David Jacks, 'Coal and the Industrial Revolution, 1700–1869', *European Review of Economic History*, vol.11 (April 2007), 41–42.

33 This foreboding sentiment was captured by Ruskin in *The Storm-Cloud of the Nineteenth Century: Two Lectures Delivered at the London Institution, February 4th and 11th, 1884* (Kent: George Allen, 1884).

34 Daniel D. Mayer, 'The industrial archaeology of retail coal yards in upstate New York', *Journal of the Society for Industrial Archaeology*, vol.26, no.2 (2000), 4–18.

35 See, for instance, Ihediwa Nkemjika Chimee, 'Coal and British colonialism in Nigeria', *RCC Perspectives*, vol.5, *Energy and Colonialism* (2014), 19–26.

36 Douglas Mawson, 'Sir Tannant William Edgeworth David', *Obituary Notices of Fellows of the Royal Society*, vol.1, no.4 (December 1935), 494.

28 Hanley, *op cit*., 10.

29 See Henry Taylor Plews, 'On the coalfields of NSW', in *Transactions of the North of England Institute of Mining Engineers*, vol.IV (1858).

30 The most famous examples are: Reyner Banham, *Theory and Design in the First Machine Age* (New York: Praeger, 1960); Reyner Banham, *A Concrete Atlantis: US Industrial Building and European Modern Architecture* (Cambridge, MA: The MIT Press, 1989); Fernand Léger, *The Machine Aesthetic: The Manufactured Object, the Artisan, and the Artist*, trans. Tim Benton (New York: The Whitney Library of Design, 1975).