Strzelecki's Geological Map of Southeastern Australia; An Eclectic Synthesis

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Introduction

Paul Edmund Strzelecki (1797–1873) arrived in Sydney on board the *Justine* on 25 April 1839. On 22 April 1843 he departed for England via China and the East Indies aboard the *Anna Robertson*.[1]

Perhaps the most experienced 'geologist' to visit Australia up to 1839, during his four-year stay Strzelecki undertook extensive journeys throughout southeastern Australia, some into unexplored country.

Based on his travels he prepared a large geological map. This map was the basis of the greatly-reduced coloured geological map which is folded and bound in Strzelecki's *Physical Description of New South Wales and Van Diemen's Land*, published in 1845 (Figure 1).

Strzelecki also drew a number of large coloured topographical-geological cross-sections. One of these, greatly reduced and simplified, was reproduced in black and white in the published volume.

Since the 1850s, Strzelecki's original map with cross-sections has been in the possession of the Geological Survey of Great Britain (or its descendant). It is now in the British Geological Survey Library, recently moved from London to Keyworth, Nottinghamshire. Probably because Strzelecki's work was listed in the library index solely as 'Van Diemen's Land and Adjacent Australia 1850', these documents remained forgotten until 1972, when I was fortunate enough to examine them and recognise their historical significance.[2]

Through the co-operation of the Geological Survey (then the Institute of Geological Sciences) and the Australian Joint Copying Project, colour and black-and-white photos and colour slides were made of the original figures. Sets are now held by the National Library, Canberra, the Mitchell Library, Sydney, and the present author. I believe there is also a set in the Institute of the History of Science and Technology of the Polish Academy of Sciences, Warsaw.[3]

Copies of the map and sections, at about one-third the original scale of 4 inches: 1 English mile, were reconstructed by this author from the colour prints. These reconstructions were displayed during the 24th International Geological Congress in Sydney in 1976, at the Australian and New Zealand Association for the Advancement of Science meeting in Adelaide in 1980,[4] and in the 1984 Philatelic Exhibition (Australian Explorers) in Sydney.

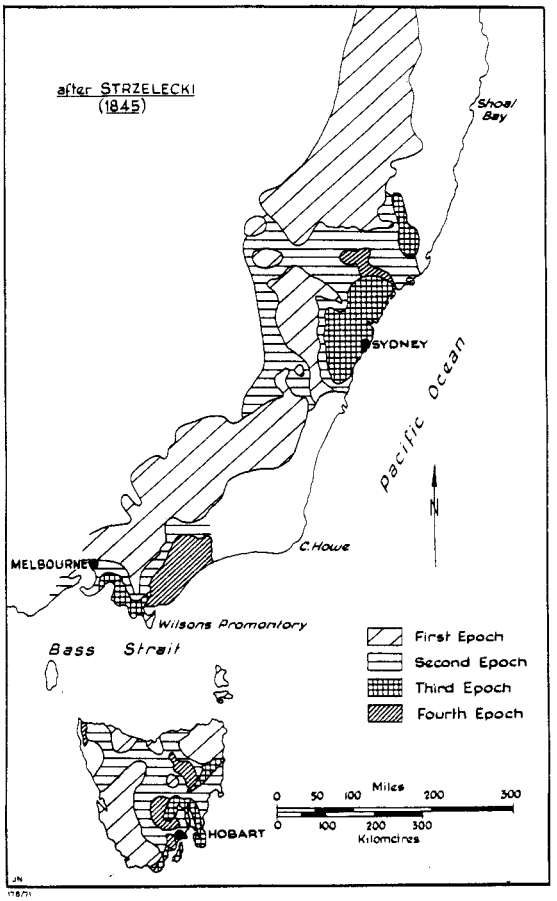

Figure 1. Strzelecki's final map (1845), redrawn by J. Neilsen (Branagan, op. cit. n.5).

Since 1974 the original map has been mentioned by various authors.[5] However, no detailed analysis of Strzelecki's Australian geology, based on his original map, has yet been undertaken. That analysis is presented in this paper.

Strzelecki's Geological Training

Although there has been a number of biographical studies of Strzelecki,[6] little is known of his education. Heney believes that his geology, like other subjects, was largely self-taught after he left Poland permanently in about 1830.[7] However, she also suggests that he had earlier visited the mines of Saxony as well as Mt Vesuvius in Italy. If he did visit the former, no doubt he made the pilgrimage to Freiberg where Abraham Werner (1749–1817) had long been influential. The Wernerian influence is evident in much of Strzelecki's writing. This may have come from his visit to Saxony and through later contacts in Scotland with the teachings of Robert Jameson (1774–1854), the Irish Wernerian Richard Kirwan (1735–1812), and others.[8]

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Strzelecki spent some time in France, a fact relatively ignored by his biographers, and there is considerable evidence in his work that he was influenced by the geological thinking of Alexandre Brongniart (1770–1847), Élie de Beaumont (1798–1847) and especially François Beudant (1787–1850), as well as other French geologists whose ideas were derived in part from Werner's systematic teaching, particularly of mineralogy and lithological stratigraphy.[9]

On the other hand, Strzelecki was in England for part of 1833 and 1834 at the time when Charles Lyell's newly published *Principles of Geology* was being widely discussed in intellectual circles. The Count, as he was apparently then being called, was not averse to such company.

In 1834 Strzelecki left England for what would prove to be a ten-year journey through many little known countries. His interests were essentially practical and utilitarian, as he visited many mining centres in North and South America, and spent time studying soil conservation and analysing crops.[10] There is evidence that Strzelecki supported himself by the collection and sale of mineral specimens, mainly to continental European museums through his agent, André and Cottier, in Paris.[11]

Geological Contacts in Australia

As an invited guest on H.M.S. *Fly* during 1838–39 Strzelecki visited many parts of the Pacific, climbing the Kilauea volcano in Hawaii and writing a description of its geology, and studying the extinct volcanoes of Tahiti.[12] After a brief stay in New Zealand, including a cross-country trek from the Bay of Islands to Hokianga, Strzelecki crossed the Tasman and disembarked in another land of opportunity, Australia.

Aged 43, with a considerable background of practical experience and awareness of contemporary geological thought in both Europe and the Americas, he was well equipped to describe geologically and to map the country. However, his original intention may well have been to collect and sell minerals.

Amongst the introductions he had in New South Wales was one to Phillip Parker King (1791–1856), who had more than a passing interest in geology.[13] King was a retired explorer of note, in touch with those who might help Strzelecki in his self-appointed task. He was just then becoming practically involved in the affairs of the Australian Agricultural Company with its estates north of Sydney at Port Stephens and its coal workings in Newcastle. Although his main contribution to Australian geology — the rock collection gathered during his coastal survey — had been made twenty years before, his work in South America and interest in soils and other scientific matters, both theoretical and practical, must have drawn the two men together. King's son, Philip Gidley King (1817–1904), was keenly interested in geology, and had considerable contact with Strzelecki during his stay in Australia and in later years.[14]

Thomas Mitchell (1792–1855), the Surveyor-General of New South Wales, did not return to Sydney from London until 1841, well after the publication of his book *Three Expeditions in the Interior of Eastern Australia* (1838), which included the first published geological map of any part of Australia (the Wellington Caves area, New South Wales).[15] However, the book became available in Sydney in 1839 and was widely discussed. In his own book, Strzelecki refers a number of times to Mitchell's writings and ideas. Mitchell was probably the major Australian influence on Strzelecki's work, even though they could have met only briefly if at all when Strzelecki returned to Sydney from Tasmania in 1843, after his fieldwork was complete.[16]

John Lhotsky (1795–1866), a fellow eastern European, but by all accounts lacking Strzelecki's personable nature,[17] made valuable observations in both New South Wales and Tasmania between 1832 and 1838, which Vallance argues were among the best by any Australian resident of the time, and depended only on Lhotsky's own skills as mineralogist and geologist without the advice of experts in Europe.[18] Strzelecki makes no mention of Lhotsky's mineral observations. However, Vallance believes that he must have read Lhotsky's *Journey to the Australian Alps*, at least that part which was published. He would certainly have read the reports Lhotsky wrote for Lieutenant-Governor Franklin on his work in Tasmania.[19]

Although Strzelecki had stayed with James Busby (1801–1871) in New Zealand and been furnished by him with a letter of introduction, he does not seem to have had any scientific contact with James's father John (1765–1857), the ageing mineral surveyor, essentially a practical engineer, who finally completed the tunnelling project that ensured a regular water supply for Sydney. Although initially interested in mineral occurrences, Busby's single-minded attention to local Sydney geology during the 1830s would not have helped Strzelecki's knowledge very much, and indeed Busby had retired to the Hunter Valley in 1837.[20]

In December 1839 Strzelecki, just returned from his first expedition, a journey through the Blue Mountains to the central west of New South Wales, met two people who were to make very important contributions to the geological knowledge of eastern Australia.

The unexpected arrival in Sydney Harbour of the United States Exploring Expedition under Lt Charles Wilkes (1798–1877) caused a mild panic on the morning of 1 December, some residents thinking a Russian invasion had occurred! On board was James Dwight Dana (1813–1895), then aged 26 and avid for geological knowledge.[21] Dana and other scientific members of the expedition were immediately welcomed by William Sharp Macleay (1792–1865), himself only a few months in the col-

ony, together with other scientifically minded members of Sydney society including the Rev. William Branwhite Clarke (1798–1878), who had arrived in Sydney in May of the same year.

The three geologists Strzelecki, Clarke and Dana met briefly, the first apparently reporting to the others that the geology of the Blue Mountains was 'very tame', perhaps an indication of Strzelecki's disappointment that there were no easily-located mineral deposits. There was little time, however, for discussion of local geology.[22] Clarke was apparently impressed by Strzelecki, noting in his diary that Strzelecki's speech at the welcoming party was the most stimulating and science-orientated of all those made.[23] It is a pity that Strzelecki did not accompany the other two on various local excursions they made, particularly one to the south coast after Christmas.

From their observations near Wollongong (and a visit by Dana to the Hunter Valley) came a splendid summary by Dana of the geology of what we now call the Sydney Basin. The work unfortunately was not published until 1849 so that Dana's ideas were preceded by publications by Strzelecki and Joseph Beete Jukes (1811–1869) to which Dana refers. The precise observations of Dana, and his geological astuteness, stand the test of time better than the work of these other authors, invaluable though theirs was at the time.[24]

When Strzelecki moved to Tasmania (then still called Van Diemen's Land in official circles) in 1840, he received strong support from both Lieutenant-Governor Sir John Franklin (1786–1847) and his wife, Jane (1792–1875). Franklin's enthusiasm for natural science was very strong but his geological knowledge was not deep, although he did claim some expertise.

On the other hand, Dr Joseph Milligan (1807–1884), surgeon and later Superintendent of Aboriginals, was a man of considerable knowledge and skill who made significant geological observations in Tasmania. Strzelecki does not refer to Milligan's work, but it is clear that they were acquainted. Writing to Strzelecki after returning from Port Davey, Franklin commented 'Mr Milligan has certainly collected whatever he could of its plants and rocks'.[25] It is likely that Milligan showed Strzelecki around some parts of Tasmania.[26]

John Lort Stokes, commander of H.M.S. *Beagle* then surveying Australian waters, makes numerous references to his friend Strzelecki's observations in Tasmania but does not refer to Strzelecki's investigations on board the *Vansittart* in Bass Strait.[27] Stokes (1812–1885), like many other hydrographers, had a keen interst in geology and was able to give Strzelecki information on many parts of coastal Australia.

Before he left Australia, Strzelecki spent some time with P.P. King at Port Stephens. Here he was visited by Jukes, from H.M.S. *Fly*, who wrote to W.B. Clarke, 'I am staying with *Strzelecki*, whom on further acquaintance I like very much. I learn mineralogy of him, and as he has Murchison's book we are making out many fossils. He is a good mineralogist and chemist, apparently, as he analyses and manipulates neatly'.[28]

Hence it is clear that Strzelecki discussed his geological work with many friends and acquaintances. Although he undoubtedly took note of much earlier work and indeed incorporated it in his own writing with only slight acknowledgement, the overall influence of others in Australia on his interpretations was probably minimal.

Deciding on a Study

Strzelecki's decision to undertake a geological study of eastern Australia seems to have been almost accidental. In 1845 he stated that the main purpose of his visit to New South Wales was to examine the mineralogy but as there proved to be 'a scarcity of simple minerals' and the 'scope for extensive mineral researches being narrowed', he realized from his early trips that there was a 'vast field for a most exciting and interesting geological investigation'.[29] Earlier, in 1840, he had felt that his failure to find minerals was 'not because nature had refused to this part of the world mineral treasures, but because the bad luck of the explorer did not allow him the discovery of it'.[30]

Strzelecki's comments on minerals and mineralogical research are probably a gloss he put on his disappointment that there were not readily accessible specimens which he could collect and send to Europe for sale.

There are some contradictions in Strzelecki's approach to the geology he was about to study. Although he writes of venturing on a geological '*terra incognita* without guide or guidebook', he thought of his geological findings 'not . . . as furnishing new lights thrown upon the origin of things, but as yielding additional evidence that the structure to which they relate is analogous to that of the rest of the globe'.[31] His certainty that the order of geological events widely accepted in Europe would be found also to have occurred in Australia is indicated by his comment that the 'mode adopted in my enquiry was as simple as is the geological configuration of the country. . . . [T]he masses and strata assuming, with few exceptions, a direction from N.E. to S.W. the determination of their horizontal and vertical positions was accomplished by means of a series of zigzag sections, made across the country, and by the examination of the flanks of the Dividing Range, against which the different strata abutted'.[32]

The 1840 Report

Strzelecki's first published statement on the geological nature of southern New South Wales (including what is now Victoria) was written in Melbourne in June 1840 after he had travelled overland with James MacArthur (1813–1862) and James Riley (b. 1820) and party.[33] This is an important early statement on the geology of

south-eastern Australia that is little known, although it has been republished. Because of its significance in showing Strzelecki's geological attitudes at that time, portions of the report are quoted in the following pages and examined in the light of his later writings.[34]

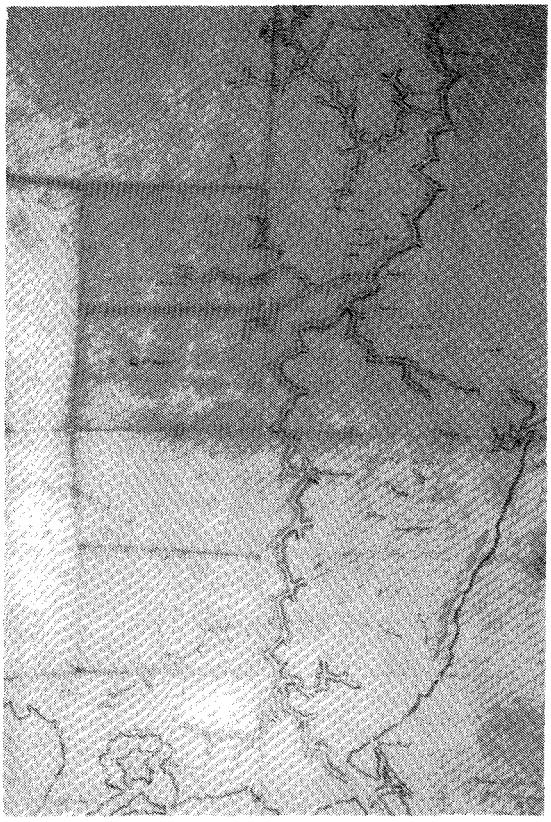

Figure 2. Sketch of Strzelecki's route through eastern Victoria 1840, from the original Riley Papers, La Trobe Library, Melbourne, Victoria.

Strzelecki gives the impression that he was the organizer and leader of the expedition that travelled through much of the Australian Alps to Gippsland and thence Melbourne. However, there is clear evidence in the correspondence of MacArthur and Riley[35] that the expedition was designed by them to search for squatting areas near Corner Inlet (Figure 2). A separate party was despatched by the pastoralists to travel *via* Melbourne with carts, equipment and stock, while the expedition took a more direct route through rugged country.

In the circumstances, Strzelecki's results are very good. His approach at this time was still largely geognostical. Greene discusses the changing meaning of the 'elusive term' geognosy,[36] and the generally accepted 'definition' of Breislak[37] that it was 'the observational science which considers the arrangement of minerals in the crust and their topographical occurrences'.[38] Geognosy contrasted with geology which depended on a foundation of physics and chemistry to bring such factual data together into a complex history of the earth.

Strzelecki was concerned to co-ordinate what he believed would be purely factual information about the Earth's crust. Since elevation was believed by many at the time to be commensurate with age, the highest ranges containing cores of ancient rock, he had to take accurate barometric readings of altitudes and to draw careful vertical sections showing both topography and geology. These sections were needed to explain his geological map of Australia, already being prepared.[39] In his 1840 report he lists eight substances of which he had obtained specimens, clearly anticipating that more luck and search in other places would bring success in finding sizeable mineral deposits. The substances listed were gold, silver, iron, coal (including deposits in Gippsland and Western Port), clays, lime, serpentine, and earthy salts; the last named included 'hair salt of Werner'.[40]

Strzelecki at this time[41] recognised three 'geognostic divisions as are deserving separately of my humble remarks on the physical geography of the country I visited' (south-west from the present position of Canberra). The first, embodying the country between the Murrumbidgee and

> a range subordinate to the main one . . . presents on its surface perturbations of no ordinary kind; to the east of the meridian 148° they crown themselves by many culminant and characteristic eminences; to the west, grouped in confusion, they present a broken, rocky, and often empassable country. . . . [V]alleys proved to vary from 1,200 to 1,800 feet above the level of the sea, and, as regards the tops of subordinate ranges from 2,500 to 3,000 feet.
>
> Primary and transitional rocks, at first sight somewhat intermingled, but on a closer inspection offering everywhere regular and connecting links, by which their common boundaries were easily ascertained, constitute the formation of that portion of the country. Amongst the first, mica-schist, gneiss and protogene predominate; of the second, we find sienitic porphyry and grauwacke.
>
> No others offer to my knowledge any of those simple minerals or ores worth to be noticed in reference to the economical mineralogy.

Strzelecki believed that younger rocks had been stripped away, the older rocks 'with their superincumbent soil, [being] partly derived from their own composition, partly from that of others formerly superposed on them'. This is an interesting comment in view of present controversies on the erosion of the eastern highland.[42]

> [The second division] offers from its [larger] extent, and from having the highest protruberances of New South Wales, a wider and more interesting field to investigation and comment.
>
> As to the geognosy, the formations continue to offer . . . both primitive and transition rocks; the siliceous slate being predominant in the first, the grauwackes in the second both running parallel to the Dividing Range.
>
> To the west of the meridian 148°, and on the latitude of 36°, the formations presented an intermixed series of primitive rocks of whitestone [eurite], sienite, and

finally that of mica slate, which crowns Mount Kosciusko, the peculiarity of this last rock in this country being, that it appears in high and steep cliffs, such as I am not aware of its presenting in any other: the general aspect of the mountains where this rock abounds is undulated, presenting long elevated ridges, but nowhere else crowning the highest tops in such ıtastic, such heaped up and picturesque peaks as ıere in the Australian Alps.

The country between the Murray and the vicinity of Lake Omeo shows on an extensive scale the primitive and the secondary rocks; argillite and quartz rock, on the one side, to the east; old red sandstone with conglomerates, on the other, to the west; the petrosiliceous porphyry, as intermediate or transition rock, appears as if only to indicate their respective limits. The numberless streams of lava, the trachitic rocks and others, which through intense heat have had some of their constituent ingredients altered, give evident proofs of volcanic agency, to which Lake Omeo may have originally served as a laboratory.

At 17 miles from Omeo to the S.S.E., and at the crossing of the Dividing Range begins the third division, which the meridian 148° limits from the N.E.; the sea-coast and the Dividing Range from E. and W.; Corner Inlet and Western Port from the S. and S.W. . . .

The geognostic observations showed some interesting facts, relative to the mineralogical constitution of the country. After the primitive formation of gneiss and sienitic rocks, bordering it from the N.W., follows alluvial deposits, consisting of those beds of clay, sand, gravel, pebbles, fragments of different rocks, numerous organic remains, which the banks of rivers, the bottom of valleys and sea-cost [sic] range exhibit, and which constitute the largest formation of this division . . .

In conclusion to this humble sketch, I take the liberty to subjoin a few rapid remarks on geognosy, economical mineralogy, together with some barometrical and meteorological observations relating to the whole country between latitude 31° 45′ and 38° 30′, which it has been my good fortune to visit and explore.

All the notes and observations recorded in reference to geognosy, compared, linked together and summed up, lead me to believe that the disturbing forces which give origin to the now modified structure, position and relative situation of minerals in New South Wales, assumed one course; that the main range which divides the eastern from the western waters may be fairly considered as the great axis of perturbation; that all the elevations, subsidences and inclinations which exist on both sides of it are posterior, subservient, and perfectly in relation to the effects of the convulsions of that axis; that these convulsions, though keeping invariably their north and south course, did not affect the crust simultaneously; that the dislocation, fracture and contortion took place at different and distant periods; that in these periods the action of different causes greatly and alternately altered the heaved-up surface; and finally, that, though altered, the great order of superposition of compound minerals remains undisturbed, and in perfect identity to that observed on the rest of the globe.

The description of the distribution of these compound minerals, as classed among the primary, transition, secondary and tertiary, on that extent of country between the Liverpool Range and Western Port, would exceed the boundaries of this rapid sketch. My geological map, when finished, will supply its place, and better explain the mutual relations of the formations . . .[43]

Strzelecki's Synthesis in 1840

From this report and a few other sources[44] we can gain a good idea of Strzelecki's understanding of the geology of southeastern Australia. He recognised a number of geomorphic regions which were largely dependent on rock type and structural relationships. He recognised four age divisions — primary or primitive, transitional, secondary and tertiary — apparently placing his 'alluvial deposits' near the Victorian coast in the last division, and he used a specific 'stratigraphic' name, 'old red sandstone', to identify one rock type. He recognised that deformation of the region had produced characteristic north-south trends in the rocks and attributed it to repeated convulsions at different locations and times along a single axis. Igneous activity, he thought, had played an important part in such convulsions. All these observations served to confirm his faith in the 'great order of superposition . . . in perfect identity to that observed on the rest of the globe'.

To gather these ideas into a unified scheme, Strzelecki had devised a system of colours and symbols for showing, on his large map and accompanying topography sections, the rock types and to some extent the structures.

While these ideas were firming in his mind he continued to gather, for further study, whatever fossils he could find.

Geology in Melbourne

Strzelecki's report, naming a portion of the continent after him, pleased Governor George Gipps, with whom Strzelecki was friendly at the time, and Gipps soon sent off a copy to the Colonial Office in London.

Those sections of the report dealing with physical aspects of the landscape and the prospects for settlement were published in the *Port Phillip Herald*. This material was transmitted to the editor by Strzelecki's friend H.F. Gisborne (1813–1841).[45] The geognostical matters outlined above do not, however, appear in the *Herald*, being apparently omitted by Gisborne because of their length and presumed limited interest to the newspaper's readers.[46]

While Strzelecki's exploits and report were given considerable coverage in the *Herald*, he was virtually ignored by the rival *Port Phillip Gazette* under its youthful owner/editor George Arden (1820–1854). Instead, the *Gazette* gave space to a lecture[47] by Dr A.F.A. Greeves (1805–1875)[48] at the Mechanics' Institute: 'A most entertaining and interesting discourse, although only an introductory one upon the science of Geology, or as the 'learned Count' would call it, "Geognosy" '. The lecture considered the differences between the Wernerian and Huttonian schools, concluding that

'fire and water had an equal share in causing the wonderful and for a long time incomprehensible changes which meet the geologist at every step'.

However Greeves could not finish his lecture without impressing on his audience the 'importance of the study of geology to the inhabitants of a country evidently so rich in mineral resources. . . . The geological character of the country was of the most primitive kind, and its characteristics, from their simplicity, both easy to understand and explanatory of the various questions elicited by a study of the science'. Greeves — later described as speaking with 'pedantic fluency' and 'a fair share of small ability and a great ambition for public fame or notoriety'[49] — proceeded to rouse his audience. His short residence had not enabled him to examine the local geology thoroughly but as he was 'engaged in extended researches, he trusted at some future period to give them the result of his labours (cheers)'. In a sterile country like Australia with thin and poor soils, its bowels were stored with precious minerals. Coal, limestone and other minerals occurred everywhere in Australia Felix. Greeves was 'satisfied a common specimen which he held in his hand would pay to work here . . . (great cheering)'.

Greeves's lecture provoked an interesting reply in the *Gazette*[50] expressing surprise that after Greeves had presented proofs of the Huttonian theory, he had claimed it was, like Werner's, a fallacy. The writer continued:

> I do not mean for a moment to deny the agency of water in modifying the surface of the earth; but to argue that *heat was originally the grand, if not the sole agent* in the formation of this our mundane sphere.
>
> I regret exceedingly my not being present at the lecture. Very probably many minor details have been left out in your report which would clear up what appears so strange in its present shape.

The letter is signed 'A well-wisher to Doctor Greeves and the Mechanics Institution'.

There is no evidence to indicate that this letter came from Strzelecki but it is possible, as he clearly believed in the importance of upheavals of the earth caused by internal forces. If he were the letter writer, it is clear that he saw no incongruity in using Wernerian stratigraphic methods to record observations that were based to some extent on Huttonian concepts.

On the other hand one can only wonder why, if Strzelecki were the letter writer, he did not defend his use of the term 'geognosy'. But perhaps he was becoming aware that the term was no longer popular. It is noticeable that in the final published version of his work, Strzelecki uses the term 'geognosy' only once and his results are referred to in terms of 'geology'.

Gisborne's departure from Melbourne in June 1840 left Strzelecki without his strongest local supporter, and this may be what decided him to cross over to Tasmania where he had an introduction to Lieutenant-Governor Franklin. He had indeed already met Lady Franklin.[51]

One of Strzelecki's hopes was to obtain a boat and investigate the Gippsland coast. Not till January 1842, however, did he manage to study the Bass Strait islands and make a hasty trip to Wilson's Promontory.[52]

As it turned out, Strzelecki stayed longer in Tasmania than on the mainland and the detail on the Tasmanian portion of his original geological map (actually a separate sheet) is much greater than for the mainland. Furthermore, he drew more geological cross-sections in Tasmania than on the mainland (Figure 3).

The Geological Map and Sections

Most of the draughting of his large geological map (some 7.5 m × 1.5 m) and sections (totalling 8 m × 1 m) was done in Launceston, where Franklin provided Strzelecki with the use of the government cottage and Dr William Pugh (1805?–1897) made his laboratory available for analytical work.[53] Strzelecki re-commenced work on his map soon after his arrival in Launceston in July 1840 and worked on it systematically between his several long Tasmanian field excursions, until he left the island in September 1842.[54]

The geology is superimposed on a topographical map of Strzelecki's own 'devising', according to which

> The geographical portion of the greatest part of that map was compiled from the hydrographical and topographical charts of New South Wales and Van Diemen's Land, where the colonial survey ceased . . . the continuation of the dividing mountain range between 36°-44° latitude was projected from my notebook.[55]

Arrangement of Strzelecki's Geological Cross-sections

1. Frenchmans Cap to Launceston (Tasmania)
2. Nile River to St.Patricks Head (Tasmania)
3. Mt. Wellington to Richmond (Tasmania)
4. Table Cape elevated beach (Tasmania)
5. Cape Grim elevated beaches (Tasmania)
6. Green Island elevated beaches (Bass Strait)
7. Ben Nevis (Tasmania)
8. Jericho to Richmond (Tasmania)

Cape Portland to Wilsons Promontory (Bass Strait)

17. Gidleigh to Long Swamp (New South Wales)
18. Lake George (New South Wales)

Kings Tableland & Mt. Tomah (New South Wales)

13. Mt. Koscuisko & Cowrang Range Victoria
14. Mt. Kosciusko
15. Mt. Kosciusko to Lake Omeo (Victoria)
16. Dividing Range & Lake Omeo (Victoria)

Bathurst to Sydney (New South Wales)

Figure 3. Table showing arrangement of Strzelecki's original cross-sections.

John Arrowsmith's compilations from the original surveys by Thomas Mitchell, George Frankland and others were therefore the basis for the landmarks and ranges shown, except for the area between the Australian Alps and Bass Strait, mapped by Strzelecki himself.

Adjacent to the legend on his large map, Strzelecki has a small sketch map entitled *The part of Australasia to which the geological map refers.* This sketch map contains the main topographical features (ranges, rivers, bays) and a few locality names. Slabczynski reproduces a map very similar to this sketch, but with a title in French, which is held in Warsaw.[56]

Of the eighteen sections that accompany the original MS map, only one, from Macquarie Harbour to Launceston, was published, and that in greatly simplified form. The other published section, of the coast at Newcastle showing the coal stratigraphy, was probably prepared by Strzelecki during his last weeks in Australia.

Strzelecki's published map (1845) is entitled *Map of New South Wales & Van Diemens Land. . . . From the original geological map by P.E. de Strzelecki, reduced J. Arrowsmith*, and is at a scale of about 1 inch : 48 English miles. Arrowsmith added some topographical features, mainly ranges in the southeastern part of the present New South Wales near Cape Howe. This part of Strzelecki's large map is blank. Arrowsmith 'tidied up'

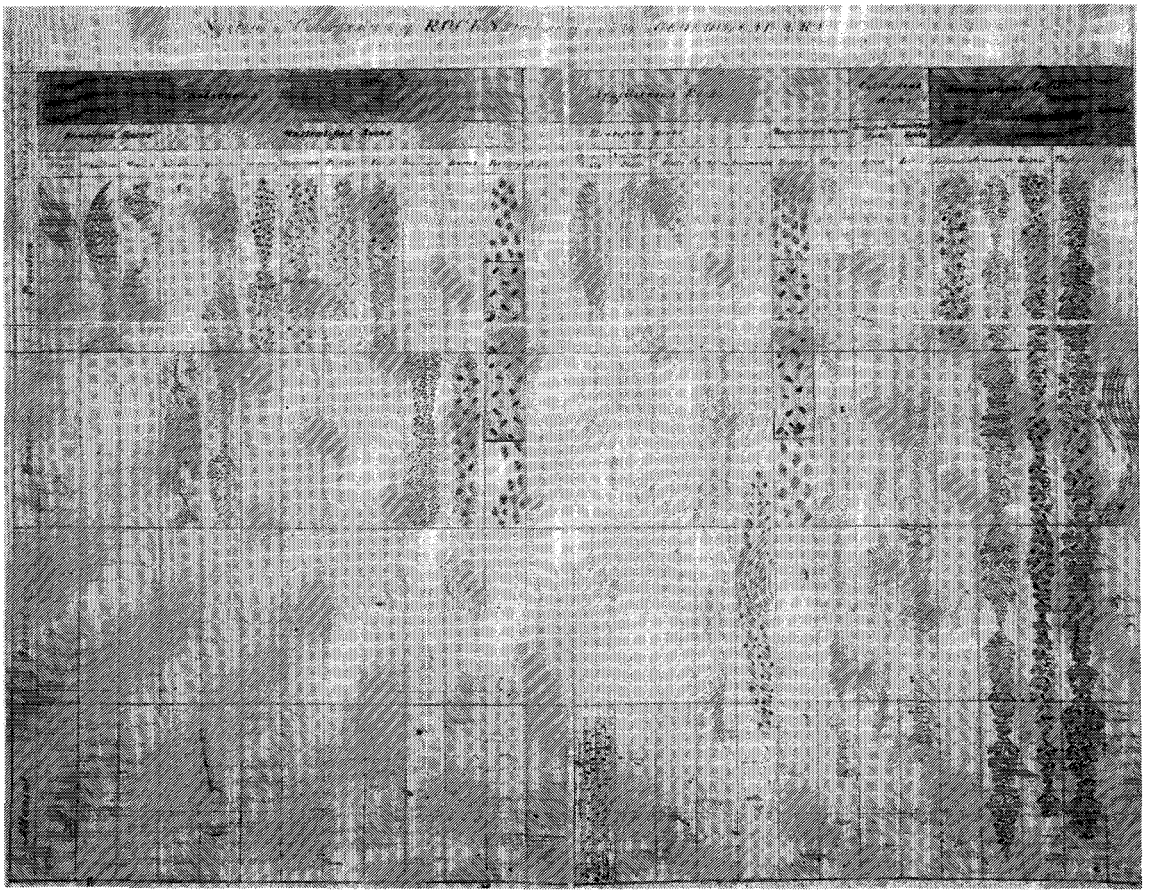

Figure 4. Legend of Strzelecki's original map showing system of colours and patterns.

The legend consists of four sections cut and mounted on to a single piece of backed canvas measuring 0.6m × 0.5m so that it can be folded to approximately foolscap size.

Contained in this index sheet, above the legend, is a sketch showing the *'Part of Australasia to which the Geological Map refers'.*

The legend shows *'System of Colonisation of ROCKS combined with the GEOLOGICAL ERA'.*

Strzelecki uses five colours to show his lithological-chemical subdivision of the rocks: siliceous (blue), argillaceous (red), calcareous (brown), serpentinous, augitic and hornblende rocks (green) and coal (grey-black).

The first three groups are divided into stratified and unstratified types.

Siliceous stratified are: siliceous slate, mica slate, gneiss, sandstone.

Siliceous unstratified are: quartz rock, granite, hyalomicte, sienite (sic), eurite, grauwacke, breccia, prophry (sic).

Argillaceous stratified are: argillite, chlorite slate, argillaceous slate, graphite slate, sandstone, conglomerates.

Argillaceous unstratified are: porphyry (sic) clays.

Calcareous (lime rocks) are identified as either stratified or unstratified.

The serpentinous rocks, essentially unstratified, are: serpentine, greenstone, basalt, trachyte.

In present day terms the stratified/unstratified subdivisions would not be regarded as useful. The stratification indicated for Strzelecki's Siliceous rocks is probably a layering induced by metamorphism, while on the other hand grauwacke would be considered as being stratified during its original period of deposition.

The age subdivisions in the left hand column, in descending order, are Primitive, Transition, Secondary, Alluvial. These are shown by a light background wash over appropriate portions of the map, Primitive in red, Transition brown, Secondary blue and Alluvial pink. Unfortunately these colours, like the others, have faded considerably and the original map surface has yellowed so that only the blue is readily identifiable (as in the region around Sydney).

Consequently for those rock types which are shown on the legend as having different ages in different areas (e.g. the unstratified argillaceous clay, unstratified calcareous rocks, greenstones or basalts) the age has to be determined by reference to Strzelecki's simplified map (Figure 1) or to the detailed discussion of rock occurrences and localities in his 1845 publication.

Figure 5. A portion of Strzelecki's original map

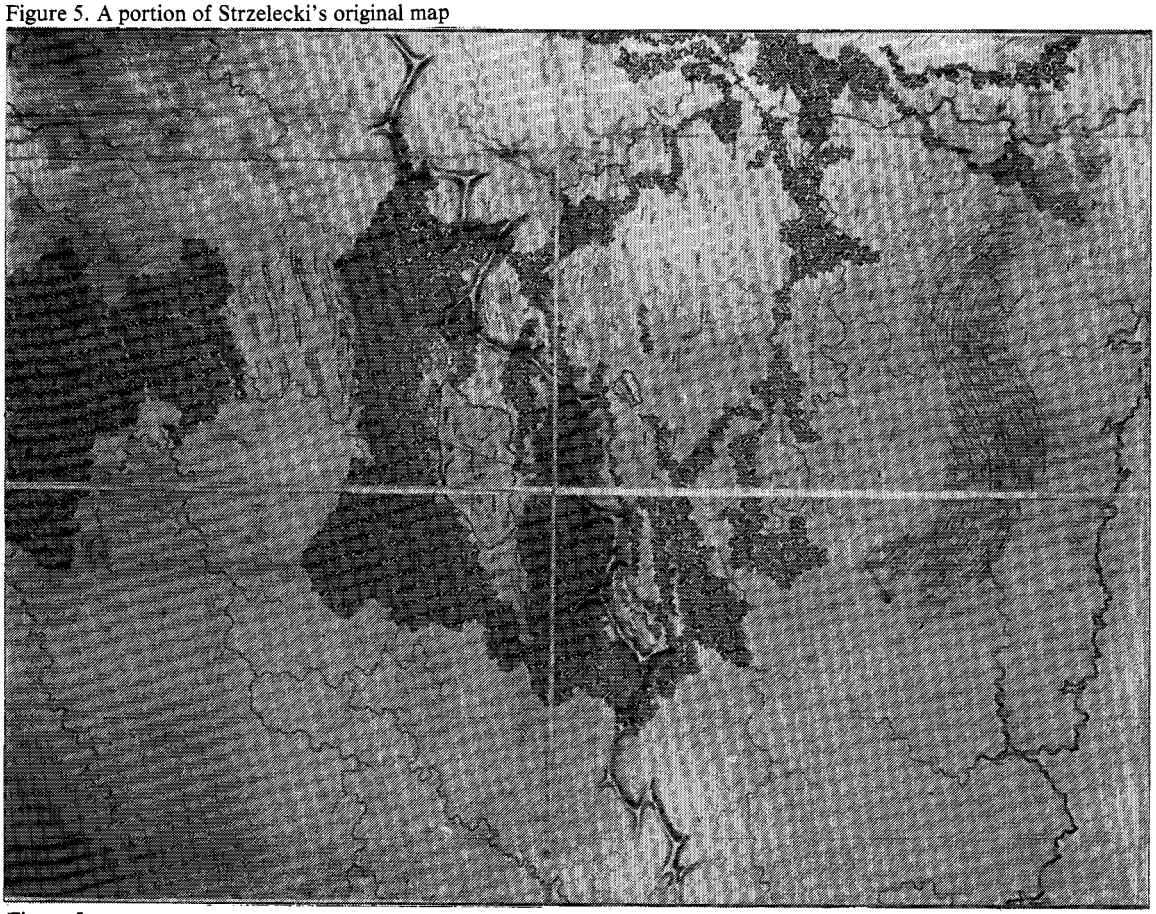

Figure 5a

The map is in three sheets, each mounted for folding into a final shape approximately of foolscap size.

The three sheets as mounted are designated Map 1 (covering Tasmania), Map 2 (eastern Victoria and southern New South Wales) and Map 3 (New South Wale north to the Manning River). Each sheet measures about 2m × 1.5m.

The portion illustrated (from Map 3) covers the area from Moruya on the New South Wales coast (bottom right hand side) west to beyond the Murrumbidgee River, north to near Rye Park, thence east towards Kiama on the coast. The map is dissected by Strzelecki's depiction of the Great Dividing Range, a topographical feature of considerable significance to his interpretation of the geology. He continues his depiction of this feature through the three map sheets.

On this portion of the map Strzelecki identifies Lake George, Lake Bathurst, and the Wollondilly and Shoalhaven Rivers and shows others including the Murrumbidgee and Clyde Rivers. He also marks the settlements of Goulburn, Towrang, Marulan, Glenrock and Arnprior and two significant landmarks, Pigeonhouse and Currockbilly Mountains, towards the eastern side of the map.

The rock type subdivisions are shown on the underlying sketch. Refer to Figure 4 and its accompanying text for identification of the rock types.

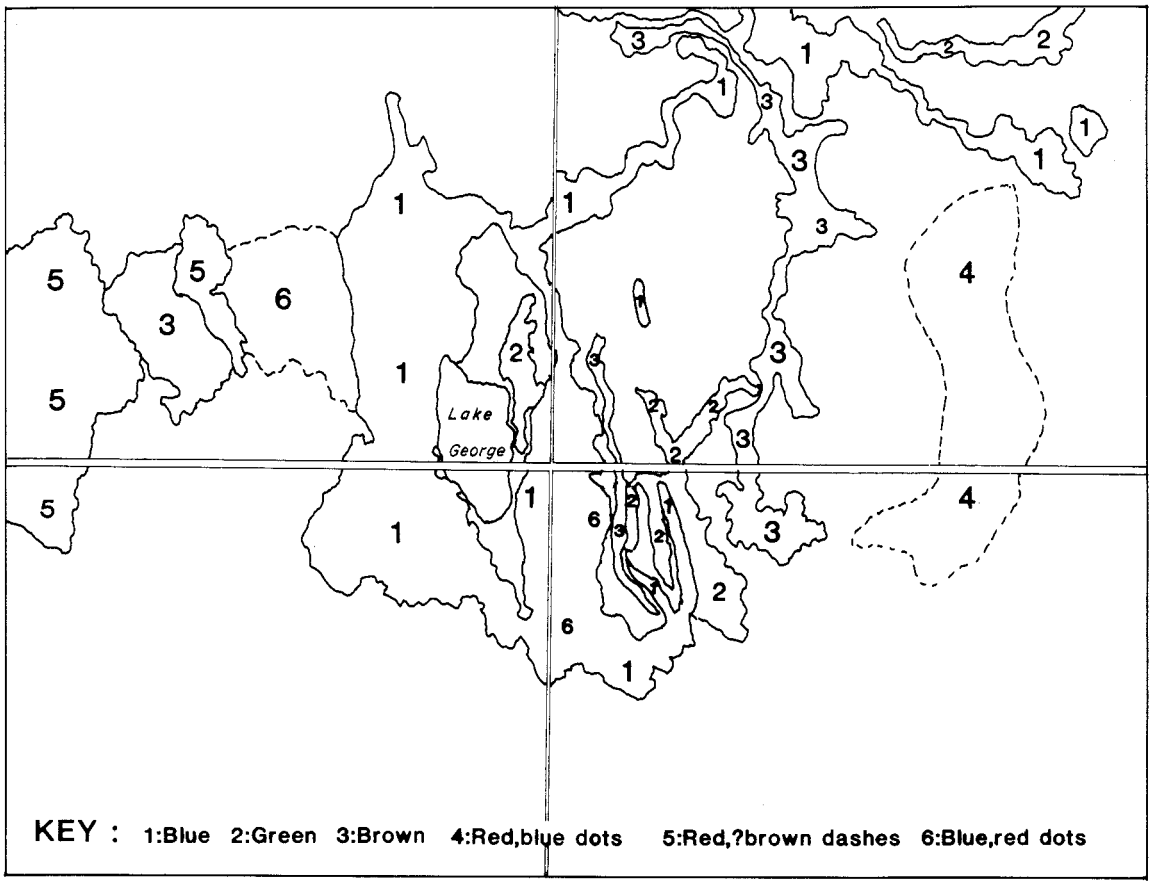

Figure 5b

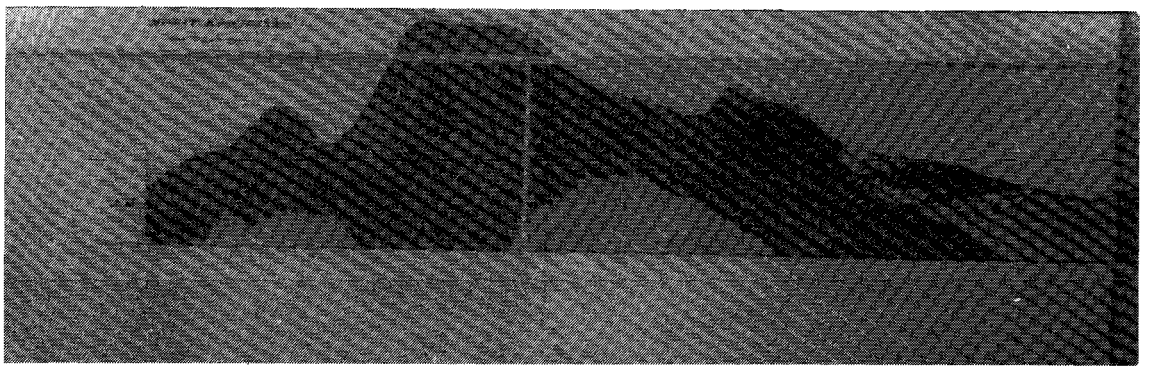

Figure 6. Cross-section of Mt. Kosciusko

Portion of one of three cross-sections of this area drawn by Strzelecki (see Figure 3). This figure iks labelled by Strzelecki 'Vertical Section of Mount Kosciuszko [*sic*] towards Lake Omeo'. The portion shown is about 0.6m long on the original diagram. This section (no. 15) concludes at Mt. Turno (not shown on this portion). The view shown extends from north east (on the left) to the south west.

The mountain is depicted as unstratified siliceous rock hyalmoicte (i.e. greisen — a quartz mica rock). To the south west on the lower area both mica slate and gneiss are depicted, underlain by argillite and argillaceous slate. All the rocks are designated as belonging to the Primitive Era.

Note that Strzelecki (1845) also mentions the occurrence of granite and siliceous slate in the vicinity of Mt. Kosciusko.

The positions of all Strzelecki's sections are clearly marked on his map.

A portion of Strzelecki's cross-section from Bathurst to Port Jackson showing Mt Banks and the Grose River area in the Blue Mountains was published in D.F. Branagan, 'The Blue Mountains — A Personal Perspective', in *The Blue Mountains, Great Adventure for All*, ed. P. Stanbury and L. Bushell (Sydney, 1985).

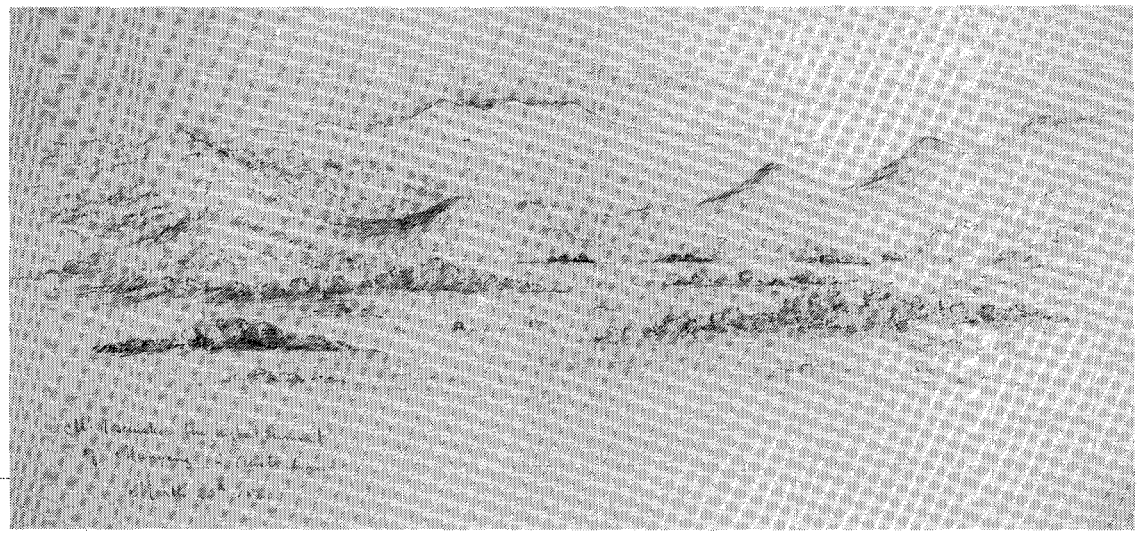

Figure 7. Sketch of Mount Kosciusko from a set of five sketches in the Riley Papers, La Trobe Library. These sketches are with Strzelecki's map presented to Riley. There is no attribution. However the handwriting on the sketch shows some similarities to the note appended by Strzelecki to 'his fellow monkey eater Riley'.

Strzelecki's somewhat crude coastline (more so on the mainland than in Tasmania) and named numerous additional features.

No work sheets of Strzelecki's geological map have been found, but there are two versions of the topographical route map from Kosciusko to Westernport, both in Strzelecki's hand, in the La Trobe Library, Melbourne (see Figure 2).[57] The more detailed of these two maps is the basis for the topography shown on both the large geological map and the published version.

A small sketch showing the topography of Lake Arthur in Tasmania has also been preserved, in the Tasmanian Archives.[58] This sketch may have been sent by Strzelecki to Franklin in response to the latter's comment (24 May 1842), 'I entertain the hope that you will be able to supply the position of Lake St Clair and of some points of the mountain Ranges which I consider to be not at all correctly placed'.[59]

As we shall see, the published map separates the rocks into four epochs from first to fourth. The original approach is quite different, as shown on the accompanying table (Figure 4). Here the time scale used is Primitive, Transitional, Secondary and Alluvial, referred to as Geological Eras. This subdivision is essentially Wernerian, of the sort discussed by Jameson (1808) and used by, amongst others, Amos Eaton (1824) and Jacob Peck (1833) in North America.[60] Many people Strzelecki included, seem to have been happy to use such a time scheme, while not necessarily agreeing with Werner's ideas on the origin of particular rocks.

Something Borrowed, Something New

Is it possible to find an 'acceptable model' for Strzelecki's map? Heney refers to mapping by Stanislaw Staszic as a possible influence on Strzelecki.[61] However, this seems unlikely. Staszic's work was published in 1815.[62] Fülop[63] refers to a map-supplement of Staszic's which he apparently has examined.[64] No copy of this seems to be listed in Australian, British or American libraries and I have been unable to examine it. Fülop states that Staszic slightly modified Werner's classification, distinguishing five groups of geological formations (Montaigne primitive, M. secondaire ou première stratiforme, M. antemarine, M. marine and Terres d'alluvion). Mineral, rock and fossil occurrences are indicated by numbers on the map and the strike of the strata is also shown. Staszic's scheme is unlike Strzelecki's.

In his description of rock types, Strzelecki refers often to F.S. Beudant. It thus initially seemed likely that he could have used Beudant's map of Hungary as a basis for his own.[65] However, the influence could only have been peripheral.

Beudant's major divisions are (a) Terrains primitifs, (b) Terrains intermédiaires, (c) Terrains secondaires, (d) Terrains tertiaires and (e) Terrains indépendants (including Trachytique). As both Beudant and Strzelecki were following Wernerian methods and, to some extent, ideas, there is a natural agreement between them in the grouping of rocks such as granite, hyalomicte, micaschiste

(Strzelecki's mica slate) and schiste argileux (Strzelecki's argillaceous slate) in the oldest division. However, there is no agreement on the classification of syenite and the greenstones, and Beudant makes no attempt to separate the siliceous, argillaceous and calcareous rocks or to indicate variations in the degree of stratification. On the other hand he separates the Magnesian and Jura limestones, chalk, calcaire grossier parisien and calcaire à Lymées, a much more sophisticated litho-stratigraphic division than Strzelecki's. In 1842 the latter made moves to introduce some of these stratigraphic terms into his explanation of the geology (see later).

Some basis for Strzelecki's mapping can also be recognised in works by Von Buch and others. A map by Von Buch (1810) identifies eight rock types. The order of naming, namely (a) granite, (b) gneiss, (c) mica slate, (d) porphyry, (e) primitive greenstone, (f) old sandstone, (g) new sandstone and (h) basalt, is based on a presumption of age but no broad time division is shown on the legend.[66]

On his original map (see legend, Figure 4 and Figure 5), Strzelecki seems to have come closer to a graphic presentation of Werner's classification than any other geologist, in attempting to show the relations between lithology and (assumed) superposition. This involved the use of both colours and symbols which I have not found on other maps of the period that I have been able to examine.[67]

The siliceous, argillaceous (clay-rich) and calcareous (including magnesian) grouping can be recognised in the work by Jameson[68] which, as mentioned earlier, was probably one of Strzelecki's sources. However, as Strzelecki writes, 'the colouring of both the map and sections has been executed according to a novel method, "not perhaps", as *Montaigne* says, "the best, but which is my own" '.[69] As far as I can ascertain, this is true.

Changing Ideas

Not long before Strzelecki left Australia, he drew up a proposed format for his book. P.P. King wrote to Franklin[70] enclosing a copy of Strzelecki's outline that reads as follows:

> Prospect of the Work in Question with maps, vertical sections, plates illustrative of the fossils etc etc in 2 volumes — Phisical [sic] Geography of New South Wales & Van Dieman's [sic]
>
> **Contents**
>
> Section 1st *Hydrography & Topography*
>
> Account of progress of discoveries & marine & land surveys.
>
> Section II *Geology & Mineralogy*
>
> Chapter I Introduction — General view of the country included in the geological survey. Description of the dividing range from 30° Lattitude [sic] to 44°.
>
> Chapter II Glance on the Geological Phenomena which the primary series are presenting. Description, Mineralogical, Phisical [sic], Chemical and Geological of Rocks belonging to that series as Granite, Protogene, Gneiss, Sienite, Eurite, Hyalomicte, Mica Shist [sic], Chlorite Slate, Quartz rock, Siliceous Slate, Argillaceous Slate, Limestone and Aluminous Slate — Description of igneous rocks contained in that series as Serpentine, porphyry, Hornblende Rock, Basalt, Trachyte— Recapitulation of facts and inferences drawn relatif [sic] to the Primary Series.
>
> Chapter III Glance on the Geological Phenomena which the Transition Series are presenting. Description, Mineralogical, Phisical [sic], Chemical & Geological of Rocks belonging to it, as Breccia, Grauwacke, non-fossiliferous, old red and fossiliferous Grauwacke, Mountain limestone — coal deposits. Description of igneous rocks contained in that series as Hornblende rock, Basalt, Trachyte— Recapitulation of facts and inferences drawn relatif [sic] to the Transition Series.

Figure 8. Comparative Terminology, 1806-1845

Staszic (1806)	Jameson (1808) (volcanic)	Beudant (1822) (Terrains indépendants)	Strzelecki Map (1842)	Strzelecki text proposal (1842)	Strzelecki Final Map & text (1845)
Terres d'alluvion	Alluvial	Terrains tertiaires	Alluvial	diluvial deposits	Fourth Epoch
[Montaigne antemarine [Montaigne marine	Floetz				Third Epoch
		Terrains secondaires	Secondary	New Red Sandstone Group	Second Epoch
Montaigne secondaire (première stratiform)	Transition	Terrains intermediaires	Transition	Transition Series	First Epoch
Montaigne primitive	Primitive	Terrains primitifs	Primitive	Primary Series	

Chapter IV Glance on the New Red Sandstone Group and the Phenomena which it presents. Description, Mineralogical, Phisical [sic], Chemical and Geological of rocks belonging to it as the Rothe todt liegende, the Grès de Vosges-Magnesian Limestone — Rauchwacke. The New Red or Grès Bigarrée. Description of the igneous rocks contained in that Group as Hornblende rocks, Basalt and Trachyte. Recapitulation of facts and inferences drawn relatif to the Group.

Chapter V Glance on the Geological Phenomena which the Diluvial deposits present. Description of Soils, their Phisical [sic], Chemical and Agricultural character. Description of Mineralogical and fossiliferous contents. Description of igneous rocks found in the alluvial deposits. Recapitulation of facts relating to the Primary Transition and New Red Sandstone Group and the Alluvial Deposits — Influences and Conclusions.

Section III *Climatology*
Meteorological Phenomena of N.S.W. & V.D. as wind, atmospheric currents and processes.[71]
Calorific effects of solar rays
Absorption and Radiation
Evaporation and Condensation and the Temperature.

Section IV *Botany*
Geographical distribution of plants in N.S.W. & V.D. considered in point of utility to man etc etc

Section V *Zoology*
Geographical Distribution of Mammalia, Birds and Molusca [sic]

Section VI *Aborigines*
Cursory view of their Phisical [sic] and Moral Condition, as standing in relation to Mankind. Examination and causes of their decrease.

This outline shows that Strzelecki had moved slightly from his position of 1840, replacing his secondary age division by the 'New Red Sandstone Group' and his alluvial deposits by 'Diluvial'. He was also prepared to correlate many of his rocks with named units in Europe, such as the mountain limestone, Magnesian limestone, and grès de Vosges.

The outline does not enable one to draw conclusions about Strzelecki's understanding of the relationships between the various divisions and their causes. It seems likely, however, that he intended all his cross-sections to be published as they show many relationships that are not evident on his map, where the positions of section lines are marked.

That he regarded the fossils as important is clear. He intended them to be illustrated, but whether he proposed to publish his own descriptions and sketches is uncertain.

The 1845 Publication

The published work shows a different pattern of sections and chapters.[72] There are eight sections, rather than six, and they consist of I. Marine and Land Surveys; II. Terrestrial Magnetism; III. Geology and Mineralogy; IV. Climatology; V. Botany; VI. Zoology; VII. Aborigines; VIII. Agriculture. The new section on terrestrial magnetism is brief, but gives Strzelecki a chance to pay tribute to the work being carried out at Hobart with Franklin's encouragement and to present values of the declination measured in New South Wales and Tasmania. The final printed presentation of the geology and mineralogy follows reasonably closely the 1842 outline suggested earlier by Strzelecki, but there are some significant differences that are discussed further below.

Strzelecki arrived back in London in 1844. His map and sections were complete and he had a text apparently close to completion. However, he must have soon realized that some important changes of emphasis would be required in his geological chapters. Furthermore he found that though his map caused considerable interest, the possibility of its publication at or near full size was unlikely because of the huge cost involved, and that a reduced map must be prepared.

Strzelecki was probably to some degree unfortunate that he had been mapping in Australia while rapid changes were occurring in Europe in the sub-division of strata and their representation on geological maps.[73] He had been absent from Europe during the crucial years when the major terminology for the geological time scale had become established, and when the majority of British geologists came to espouse the uniformitarian principles so persuasively presented in Lyell.

Having decided to become an Englishman by adoption and therefore a British geologist, Strzelecki must have been in somewhat of a geological dilemma. He was moving into a system which was essentially based on palaeontological stratigraphy, whereas his work was largely based on lithological stratigraphy. Moreover, he was interested in mineralogy and structure, topics rather neglected, at that time, by British geologists.[74] The framework for his geology was distinctly continental, of Wernerian origin, and perhaps rather old-fashioned. It was clearly impossible for him to return and re-map, using the methods and concepts employed by the British Survey under De la Beche, and Jukes had in a general way already done this, as Strzelecki knew.[75]

Consequently he apparently set about modifying his text and map. The major divisions of his map — Primary, Transition, Secondary and Alluvial — were decidedly Wernerian and his proposed chapter headings of Primary, Transition, New Red Sandstone and Diluvial series were partly so, with the last-named more and more out of fashion as glacial ideas took hold.

Strzelecki was probably strongly influenced by the reports on the fossils he had collected that he received from J.W. Morris (1810–1886) and William Lonsdale (1797–1871), which he published (see later).[76] Morris's ideas, in particular, must have thrown him into some confusion, for Morris cast doubt on the contemporaneity of the coal basins of Tasmania and New South Wales and pointed out the considerable differences between the 'carboniferous' floras of Australia (and India) and of Europe. He also identified several specimens as being of 'Pleiocene' age, a very distinct use of Lyell's Tertiary terminology.

Morris believed that many of the shelly fossils described by himself and Lonsdale were Palaeozoic and that the 'Palaeozoic Series of Australia may be regarded as partly the equivalent of the Devonian and carboniferous system of other countries'.

Whether Strzelecki understood all the implications of Morris's report is uncertain, but the latter's interpretation of the fossils did not support Strzelecki's idea of the world-wide uniformity of geological events and made his correlations with European units uncertain.

An 'Epoch-making' Solution

Ever adaptable, Strzelecki hit upon a way of presenting his data that might be acceptable to all his readers. He would describe his material in terms of four broad epochs that might, or might not, according to the reader's fancy, accord with major sub-divisions of geological time. As Greene says, 'the disjunction of fauna and the interruption of the regular series of deposits meant for Hutton and his followers only that the tilted and horizontal strata belonged to two different epochs in the history of a continental platform'.[77] Élie de Beaumont on the other hand could argue that 'it follows from this difference, always clear and without passage, between the uptilted beds and those which are horizontal that the elevation of the beds . . . was sudden and of short duration'.[78] Thus considered, Strzelecki was able to present his mineralogical (i.e. lithological) information without getting enmeshed in a web of new stratigraphic terminology.

The chapter sub-division of his geology section was dropped. Instead he gave in the book a full description of his original map sub-divisions, with some of the specific terminology changed. In particular, terms such as 'mountain limestone', 'Rothe todt liegende', 'grès de Vosges', grès bigarré(e) and 'diluvium' were dropped, despite the fact that many of these particular names had become entrenched in the literature.[79] The omission of these terms suggests that Strzelecki probably had second thoughts on their applicability to Australian rocks, a matter to which he alluded on several occasions; or perhaps he just did not wish to commit himself.[80] He wrote: 'The mineralogical constituents of each epoch are distinguished by a strictly mineralogical nomenclature, in preference to a geological, as the latter cannot as yet be applied to Australian rocks without involving questionable analogies, or implying identities with eras of deposition in other parts of the world'.[81]

These cautionary comments might well have been heeded by the Rev. W.B. Clarke and Professor F. McCoy when, shortly afterwards, they began a long dispute on the age of Australian coal that sent Australian geology off on a tangent.[82] Despite them, Strzelecki allows himself occasional brief comments on, for instance, the possible Palaeozoic age of some strata, explaining that 'their geological relations have nevertheless been carefully taken into account'.[83] He does not, however, indicate how he has done this. He contents himself with identifying twelve siliceous rock types, four stratified, the others unstratified; eight argillaceous rocks, six of them stratified; and calcareous rocks which may be either stratified or unstratified. Serpentinous, augitic and hornblende rocks comprise a variety of igneous rocks, mainly mafic; and coal (the twenty-seventh rock type) is placed alone in a separate category.

In his book, Strzelecki included in the first epoch

> all the Phenomena connected with the irruption of crystalline rocks amidst the submarine crust of the earth, and by which a tract of land belonging to New South Wales and Van Diemen's Land appears to have been raised, so as to preclude any further accumulation of marine deposits. This irrupted or upheaved land is composed either of crystalline and unstratified rocks. Amongst the former are — Granite proper, porphyritic granite, glandular granite, protogene, sienite, hyalomicte, quartz rock, serpentine, eurite. Amongst the latter are — mica slate, argillite.

Strzelecki goes on to describe the various rock types in some detail 'under the consideration that, at the distance of the European reader from the Australian colonies . . . he should be put in possession of the specific character of each species of rock treated in the geological enquiry, and thus understand the meaning of the nomenclature employed'.

Although the original map shows only undifferentiated granite (with no mapped boundaries), Strzelecki recognised three varieties: 1 Granite proper — an equigranular quartz, pink feldspar, biotite rock; 2 Glandular granite — oval shaped masses of granular mica (biotite), tabular quartz and feldspar, irregularly interspersed through a quartzose paste (i.e. groundmass); 3 Porphyritic granite — quartz and mica (biotite) with large irregular crystals of feldspar 'confusedly embedded in the masses'. He remarks that

> the granite of the three above varieties exhibits in some cases evident traces of a *flow*, similar to that of a *nappe de basalte*. The first variety presents very often the appearance of an intumescent paste, forming an extensive tract of New South Wales, *where neither mica slate or gneiss is to be found.* The last two varieties have seldom this appearance. They consist mostly of moderate ridges, and serve as bases to other crystalline, stratified, or unstratified rocks.[84]

As we now know, the granitic rocks which occur in the areas named by Strzelecki (e.g. Hartley, Kosciusko) have ages ranging from Ordovician to Carboniferous and consist of different types of granite. He also probably included rhyolite in this group.

The concluding section of Strzelecki's published geology stresses his ideas on uplift of the Dividing Range, the absence of gneiss amongst the earliest rocks, the apparent thinness of the sedimentary strata and 'the formidable revolutions produced by the eruptive greenstone and basalt', basalt having been erupted during the last two epochs, while 'greenstone operated continually throughout all the four'. These ideas are those which Strzelecki had set out in 1840 and which he continued to hold firmly. Although they were distinctly European ideas, Strzelecki was not prepared to modify them to suit his British readers.

Specific fossil occurrences having been mentioned by name throughout the text, complete lists of fossils found in the second, third and fourth epochs are then given. Many of these are newly named by Lonsdale and Morris, but there is no analysis.

Strzelecki finishes the geological portion of his book by making a strong recommendation for the establishment of an official geological survey of the two colonies, something he worked for assiduously on his return to London.[85]

The sections on botany and zoology are considerably enlarged in the 1845 book compared with Strzelecki's 1842 outline, because of the additional descriptions of fossil plants and animals provided by Lonsdale and Morris. Perhaps consciously, Strzelecki left Morris's stratigraphical discussion in this portion of the book and did not attempt to integrate it into the geological section.

Strzelecki concluded the introduction to his geology section as follows:

> We have now endeavoured to present the reader with a sketch, upon which, as upon that of an intended picture, the delineation of the geology of the two colonies will be rendered more clear and perspicuous.
>
> Its most prominent and striking features consist partly in the character of the mineral masses which form the dividing range, which are composed of granite, sienite, hyalomicte, protogene, quartz-rock, petrosilex porphyry, sienite, serpentinous hornblende and augitic rocks; partly in the character of the sedimentary rocks, of siliceous, calcareous, argillaceous, aluminous, and bituminous character, which are confined to the eastern and western talus of that range, resting on it either in a vertical, inclined, or horizontal position.
>
> Its main phenomena are referable to epochs of terrestrial revolutions; some relating to periods marked by partial quiescence, and the deposition of sedimentary rocks; some to perceptible changes in the condition of the organic life inhabiting the sea; some other, again, to catastrophes which swept from the surface of the earth all its animal and vegetable kingdom.
>
> We shall now select for our illustration of the geology of New South Wales and Van Diemen's Land such only of these epochs as we can classify by the incontrovertible evidence of superstructure, or by organic remains; and we shall review them in the stratigraphic order in which they present themselves to our investigation, beginning with those which belong to the remotest epoch.[86]

The Book Reviewed

How was Strzelecki's work received? The *Physical Description* was published on 21 May 1845.[87] In the following few months it received a number of reviews. While these were generally laudatory, they were also discursive, and usually begged off any critical analysis of the scientific content and especially the geology. They preferred merely to describe Strzelecki's findings or discuss his ideas on agriculture and Aborigines.[88] However four of the reviews examined Strzelecki's geological ideas in some detail, treating them with respect.[89]

The *Athenaeum*, after describing the distribution of rocks 'illustrated by an admirable original map of the districts explored', drew attention to

> the fossils of the second, third and fourth of these geological epochs, for they are successive in time, which have been carefully worked out, and are fully described and beautifully figured in this work. The results are interesting to the naturalist, for it would appear that even at a very early period of the earth's history during the epoch of the deposits styled by geologists Palaeozoic, the Australian Fauna and Flora had characters of their own, peculiarities marking out that portion of the world from the rest, just as it is marked out now by the strange assemblage of animals and plants, seen nowhere else.

The *Quarterly Review* remarks that Strzelecki's classification of the rocks comes 'under four heads of epoch . . . we will not quarrel with this arrangement as a provisional one in a new country, but it will require alterations hereafter to bring it into closer bearing with the more recent methods of geologists in Europe'. This reviewer also dwelt on the implications of the work of Lonsdale and Morris as showing that 'some of the rocks of the second epoch' correlate with 'the Palaeozic series of other countries though the points of relation require still to be more clearly made out' and that the fossil flora shows a 'total absence of carboniferous types' but 'strong analogies perhaps' with the Burdwan coalfield of India. He felt that the arrangement of Strzelecki's book would have been better had the zoological and botanical chapters followed the geological.

Some of the attention that might have been directed in Britain to Strzelecki's geological ideas was given to criticising the fourth edition of Robert Chambers' *Vestiges of the Natural History of Creation*. The *Edinburgh Review* devoted a long review to aspects of the stratigraphic nomenclature linking new and old terms pointing out that Chambers 'presumes New Holland young' whereas the evidence is that 'it is old throughout'.

The most penetrating review appeared in the *Sydney Morning Herald*. Although, like the other

reviews, unsigned, it was undoubtedly the work of W.B. Clarke,[90] who commented:

> it may be suspected, that future investigations will show the necessity of considerable modifications of some of the divisional boundaries of his territory. The reduced map embracing only general features, must be, by far, the safest. . . . [T]he author refers the phenomena he investigated to *four epochs* of terrestrial revolutions. . . . [H]owever correct the details may, for the most part, be, much remains to fill up the outline thus given and perhaps one of these so called *epochs* will be merged in the others.
>
> The author has, however, shown a very philosophical spirit in thus speaking of the geological formations of Australia, for it is the height of rashness to bind down the conditions of a new country to the predetermined arrangements of a theory which originated in the development of phenomena exhibited in another hemisphere, and under different conditions.

In support of his own ideas, Clarke went on to read more into Strzelecki's writing than was there, commenting:

> all those persons . . . who have any pretence to judgement, . . . have come to the same conclusion as our author's; and have, far from adopting the *vulgar prejudice as to the recent* origin of New South Wales, expressed their conviction that it is chiefly composed of rock formations that lie in the exact parallel of the carboniferous rocks of Europe and the underlying Devonians, which overlie deposits and amorphous rocks of ages equivalent with those of the Silurian and partly primary systems.

Clarke goes on to push his idea which 'perhaps the author has not sufficiently weighed' that 'all the deposits above the English great coal formation, in short the whole of the lower and upper secondary systems — are wanting in Australia', and later he expresses surprise that Morris, like Brongniart before him, should have pointed out a resemblance between the plants of the Australian coal measures and those of the oolitic of Europe and suggested that the Australian coal measures were not Palaeozoic.

It is clear from these reviews that the palaeontological evidence as presented mainly by Morris (but also by Lonsdale) drew the most critical notice, Strzelecki's ideas being accorded consideration and his work being regarded as a useful contribution to geological knowledge.

Soon after the publication of his book Strzelecki became embroiled in his Irish famine relief work and opportunities for scientific work ceased. During the 1850s, he became involved at a distance in Australian geological matters through contacts with P.G. King and geologist Friedrich Odernheimer (1808-1885).[91] Some sign of Strzelecki's acceptance in British scientific circles can be seen in his election to both the Royal Geographical Society and the Royal Society of London in 1853. Among those nominating him to the latter society were Charles Lyell and Robert Brown.

Conclusion

Strzelecki's place in the history of geology is interesting because he stands at the interface between a long established continental tradition and a rapidly changing British geology.

The latter was concerned largely with building up an interpretive time scale. Some of its units (e.g. Carboniferous, Cretaceous) were originally largely descriptive, whereas the later-named Devonian, Permian and Tertiary epochs were initially defined on fossil evidence.

Strzelecki's acquaintance with Murchison's *Silurian System* (1839), which he worked through with Jukes at Port Stephens, would have given him some insight into the evolving stratigraphic story. However, once in London and concerned to get his book published, he could have had little time or opportunity for really informing himself on the state of geological thinking. He may have learnt something from Charles Stokes (1784–1853), who became a firm friend, and from brief meetings with Sir Roderick Murchison and others, but he did not join the Geological Society of London. As already mentioned, the reports from Morris and Lonsdale probably served only to confuse rather than clarify his thought. Whether he had time to digest the later editions of Lyell's *Principles* is uncertain, but he was certainly acquainted with Lyell himself.[93]

All the signs are that Strzelecki did not face the problem squarely. Time was against him, and there is also some evidence that at this time Strzelecki was short of money and could not afford to delay the completion of his work.[94] Perhaps also (as Heney argues) it was an inherent weakness in the man to take the easy way out, though Kaluski (1985) and others would not agree.

For his apologia, Strzelecki quotes Whewell 'I should regret its publication, if I suppose it likely that any intelligent person would consider it otherwise than *an attempt to combine such information as we have, and to point out the want, and use of more*; I shall neither be surprised, then, nor mortified, if the outline which I have drawn turns out to be in many instances widely erroneous'.[95]

Acknowledgments

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References and Notes

1. Details of Strzelecki's life can be found in Helen Heney, *In a Dark Glass: The Story of Paul Edmund Strzelecki* (Sydney, 1962), and G. Rawson, *The Count: A Life of Sir Paul Edmund Strzelecki, K.C.M.G., Explorer and Scientist* (London, 1953). More recent biographies are: Marian Kaluski, *Sir Paul E. Strzelecki, a Polish Count's Explorations in 19th Century Australia* (Melbourne, 1985) and Lech Paszkowski, 'Sir Paul Strzelecki and His Achievements', in *Polish People and Culture in Australia*, ed. R. Sussex and J. Zubrzycki (Canberra, 1985).
2. D.F. Branagan, 'Strzelecki's Geological Map', *Records of the Australian Academy of Science*, 2(4) (1974), 68–70.
3. Correspondence with Dr J. Babicz, History of Natural Sciences Department, Institute of History of Science and Technology, Polish Academy of Sciences, Warsaw.
4. D.F. Branagan, 'Strzelecki's Geological Map', Abstracts, Section T (History, Philosophy and Sociology of Science), *ANZAAS*, Adelaide 1980.
5. T.G. Vallance, 'Origins of Australian Geology', *Proceedings of the Linnean Society of New South Wales*, 100(1) (1975), 13–43. J. Dobrostanski, 'Kronika Australijska', *Wudarzenia Miesiaca: Kultura-Revue Mensuelle*, 5(332) (1975), 148–149. K. Maslankiewicz, 'Geological Investigations of Pawel Edmund Strzelecki (1797–1873)' (includes Polish and Russian translations), *Przeglad Geologiczny*, 6(278) (1976), 297–308. D.F. Branagan and K.A. Townley, 'The Geological Sciences in Australia — a Brief Historical Review', *Earth Sciences Review*, 12 (1976), 323–346. J. Babicz, W. Slabczynski and T.G. Vallance, 'Pawel Edmund Strzelecki', in *Geographers: Biobibliographical Studies*, ed. T.W. Freeman and P. Pinchemel (London, 1978), vol.2, 113–118. D.F. Branagan, 'The History of Geological Mapping in Australia', in *Some Sources for the History of Australian Science*, ed. D.H. Borchardt (Sydney: History Project Incorporated, University New South Wales, 1984) (Historical bibliography monograph, 12) pp.33–46. D.F. Branagan, 'History of Concepts of Precambrian Geology in Australia', in *History of Concepts in Precambrian Geology*, ed. W.O. Kupsch and W.A.S. Sarjeant (Toronto, 1979) (Geological Association of Canada Special Paper 19).
6. See footnote 1 and W.L. Havard, 'Sir Paul Edmund Strzelecki', *Journal and Proceeding of the Royal Australian Historical Society*, 26 (1940), 20–47.
7. H. Heney, 'Paul Edmund Strzelecki', in *Australian Dictionary of Biography*, vol.2, ed. D. Pike (Melbourne, 1967), pp.494–5.
8. The Wernerian Natural History Society of Edinburgh, founded in 1808 with Robert Jameson as permanent president, was still active in the 1830s.
9. See Vallance, *op.cit.* (n.5), pp.22 et seq. for discussion of the European influences in Australia. See also M.T. Greene, *Geology in the Nineteenth Century: Changing Views of a Changing World* (Ithaca, N.Y., 1982).
10. Even after he had left Australia, Strzelecki maintained this interest. Writing to P.P. King from Hong Kong in May 1843, he asked him to send soil samples from the Stroud area for analysis, and in the *Physical Description* he acknowledges the help of Richard Phillips F.R.S. and his son and the use of the Laboratory of Economic Geology.
11. 'I . . . cover all costs of the expedition through the sale of collected specimens' (Letter to Adyna Turno, quoted by Rawson, *op.cit.* (n.1), p.25).
12. The Kilauea description was published in the *Hawaiian Spectator*, vol.1, October 1838, pp.434–7, and later in *The Tasmanian Journal of Natural Science*, 2 (1846), 32–41.
13. D.F. Branagan, 'Phillip Parker King, Colonial Anchor Man', in *From Linnaeus to Darwin: Commentaries on the History of Biology and Geology*, ed. A. Wheeler and J.H. Price (London, 1985) (Society for the History of Natural History Special Publication, 3) pp.179–193.
14. P.G. King and Strzelecki were involved in the affairs of the Peel River Land and Mineral Company in the 1850s, King as Superintendent in Australia, Strzelecki as Chairman and Managing Director in London. The Company papers are in the Archives of Business and Labor, Australian National University, Canberra.
15. Mitchell seems to have put this map into his book almost as an afterthought. He does not discuss it in the text, despite the significance of some of the rock relationships it shows. See Branagan, 'Geological mapping'.
16. Although they may have met, Mitchell's comments on Strzelecki's 1840 exploration were somewhat derogatory. See Heney, *op.cit.* (n.1), pp.99–101, 239.
17. V. Kruta *et al.*, *Dr John Lhotsky, the Turbulent Australian Writer, Naturalist and Explorer* (Melbourne, 1977) (Australia Felix Club, Documentary and Historical series, 2).
18. See Vallance, *op.cit.* (n.17), p.50, and Vallance, *op.cit.* (n.5).
19. Vallance pers. comm. Heney, *op.cit.* (n.1), p.117.
20. See *Australian Dictionary of Biography*, vol.1, pp.188–189, and D.F. Branagan, 'An Overview of the Geology of the Sydney Region', in *Engineering Geology of the Sydney Region*, ed. P.J.N. Pells (Rotterdam, 1985), pp.3–46.
21. For details of the expedition, see W. Stanton, *The Great United States Exploring Expedition* (Berkeley/Los Angeles, 1975) and Ann Mozley, 'James Dwight Dana in New South Wales, 1839–1840', *Journal and Proceedings of the Royal Society of New South Wales*, 97 (1964), 185–191.
22. A garden party was held in wet weather and the

mingling of guests and many speeches, often tedious in Clarke's opinion, did not allow much serious discussion (W.B. Clarke, Diary, ML MSS 139/7).

23. See n.22.
24. J.D. Dana, *United States Exploring Expedition Vol. X: Geology* (Philadelphia, 1849). See Stanton, *op.cit.* (n.21), for the problems concerning the Expedition's publications. P.E. Strzelecki, *Physical Description of New South Wales and Van Diemen's Land* (London, 1845). J.B. Jukes presented his results in three papers and a book between 1846 and 1848 before summarising the whole in another book in 1850: 'Sketch of the Geological Structure of Australia', *British Association Report*, (2) (1846), pp.68–69 (reprinted elsewhere); 'Notes on the Palaeozoic Formations of New South Wales and Van Diemen's Land', *Quarterly Journal of the Geological Society of London*, (iii), (1847), 241–249; 'On the Geology of the Coasts of Australia', *Quarterly Journal of the Geological Society of London*, (iv) (1848), 142 et seq.; and *Sketch of the Physical Structure of Australia, so far as it is at present known* (London, 1850).
25. J. Franklin to Strzelecki, 24 May 1842; see Heney, *op.cit.* (n.1), p.124. For biographical details see W.G. Hoddinott, 'Joseph Milligan', in *Australian Dictionary of Biography*, vol. 2, ed. D. Pike (Melbourne, 1967), pp.230–231.
26. See Havard, *op.cit.* (n.6), p.77.
27. Letter to James MacArthur, 8 February 1842, in Rawson, *op.cit.* (n.1) p. 130.
28. Clarke Papers, Mitchell Library, ML MSS139/40/209–212. The book was Murchison's *Silurian System*, published in 1839.
29. Strzelecki, *op.cit.* (n.24), p.51.
30. Papers respecting New South Wales, Despatch No. 2, Sir G. Gipps to Lord John Russell, 28 September 1840, Appendix C.
31. Strzelecki, *op.cit.* (n.24), p.51.
32. *Ibid.*, p.52.
33. Riley Papers, La Trobe Library, Melbourne, MS 9853, contain letters from Riley, material on MacArthur and sketches possibly by Strzelecki. See also J. MacArthur, Mitchell Library, ML/AN 43.
34. See n.30. Reprinted in British Parliamentary Papers, Colonies (Australia), vol.6, sessions 1840–41, pp.657–663 (Irish University Press, 1970).
35. See n.33.
36. Greene, *op.cit.* (n.9).
37. S. Breislak, *Institutions géologiques*, 3 vols. (Milan, 1818).
38. R. Jameson, *System of Mineralogy, vol. III* (Edinburgh, 1808), reprinted as *The Wernerian Theory of the Neptunian Origin of Rocks* (New York, 1976).
39. *Op.cit.* (n.30), pp.12, 17.
40. *Ibid.*, p.19.
41. *Ibid.*, p.12.
42. P. Wellman, 'On the Cainozoic Uplift of the South-Eastern Australian Highlands', *Journal of the Geological Society of Australia*, 26 (1979), 1–9. P. Bishop and R.W. Young, 'Discussion: On the Cainozoic Uplift of the South-East Australian Highlands', *Journal of the Geological Society of Australia*, 27 (1980), 117–119. R.W. Young, 'Denudational History of the South-Central Uplands of New South Wales', *Australian Geographer* 15(2) (1981), 77–88.
43. *Op.cit.* (n.30), pp.16–17.
44. See, for example, letters to James Walker, 16 October 1839; James MacArthur, 26 October 1839; P.P. King, 26 October 1839, referring to his geological findings in the central west of New South Wales (quoted by Kaluski, Heney and Rawson, *op.cit.* (n.1).
45. *Port Phillip Herald*, 2 June 1840. See *Australian Dictionary of Biography*, vol.1, pp.453–4, for details of Gisborne's life. Gisborne resigned in May 1840 from his position as Commissioner for Crown Lands of the Port Phillip District. He was busy working for the local committee preparing a case for the separation of the Port Phillip region from New South Wales and went to Sydney in June to present a petition on this matter to Governor Gipps. While in Sydney he came to Strzelecki's defence about his exploratory work and his report, in a long letter to *The Australian* replying to comments in the Rev. J.D. Lang's newspaper, *The Colonist*. See Kaluski, *op.cit.* (n.1), p.41. Several authors, e.g. Paszkowski p.60 and Kaluski p.41, state that Gisborne helped Strzelecki write his 1840 report and hint that this was because of his poor English. I have found no evidence of this. Although W.B. Clarke (n.22) refers to Strzelecki's foreign accent he makes no adverse comment on his spoken English, and by this time, after more than six years in English-speaking countries, Strzelecki was probably quite competent to write his own report. See also n.51.
46. A portion or all of the report was apparently published as a pamphlet in Melbourne but I have not seen a copy. Paszkowski (*op.cit.* [n.1], p.60 and his n.62) gives further details. It is uncertain how widely Strzelecki's complete report was circulated in Melbourne. The exploration aspects were obviously discussed in detail but Arden's comments (see the following text of the paper) reveal a knowledge of Strzelecki's geological ideas, and there was clearly an interest in the mineral potential of the region. The report was also published in the *Sydney Morning Herald*, 19 August 1841.
47. *Port Phillip Gazette*, 10 June and 20 June 1840.
48. For details of Augustus Frederick Adolphus Greeves, see *Australian Dictionary of Biography*, vol.4, pp.292–3.
49. Said by William Kelly, quoted by R.W.G. Willis (see n.48).
50. *Port Phillip Gazette*, 27 June 1840.
51. Strzelecki and Lady Franklin met in Sydney 7 June 1839. By his own reckoning, Strzelecki was already behind in his schedule. He wrote to Stuart Donaldson (21 December 1839): 'I am off to the Snowy Mountains this very moment — from thence for Port Phillip and Launceston — and Hobart Town — and Sydney again — how long this peregrination will take God knows — I hope *humanly* speaking to shake hands with you about May'.
52. On board the *Vansittart*, not the *Beagle* as Rawson (*op.cit.* (n.1), p.129) suggests.
53. Havard, *op.cit.* (n.5), p.70; Heney, *op.cit.* (n.1), pp.118, 121. Pugh's help was acknowledged by Strzelecki; see *Physical Description*, p.131, and *Australian Dictionary of Biography*, vol.2, p.355.
54. Apparently the map was completed to Strzelecki's satisfaction by January 1843. See Heney, *op.cit.* (n.1), p.134.
55. See Strzelecki, *op.cit.* (n.24), p.54.

56. W. Slabczynski, *Pawel Edmund Strzelecki, Podrose . . . odkryca . . . prace* (Warsaw, 1957).
57. See Riley papers (n.33).
58. Strzelecki file, Tasmanian State Archives, Hobart.
59. See also Franklin to Strzelecki 6 June 1842; quoted by Havard, *op.cit.* (n.6), p.73.
60. See n.27; A. Eaton, *A Geological and Agricultural Survey of the District adjoining the Erie Canal in the State of New York* (Albany, N.Y., 1824); and J. Peck, 'Geological and Mineralogical Account of the Mining Districts in the State of Georgia, Western Part of North Carolina and of East Tennessee', *American Journal of Science*, 23 (1833), 1–10. For a discussion of Wernerian geology in North America, see Mary C. Rabbitt, *Minerals, Lands and Geology for the Common Defence and General Welfare, Vol.1: Before 1879* (Washington, 1979).
61. See n.1.
62. S. Staszic, *The Structure of the Carpathians and of the Other Mountains and Plains of Poland* (in Polish) (Warsaw, 1815).
63. J. Fülop, 'Geological Mapping in Hungary: Past, Present and Future', in *One Hundred Years of the Hungarian Geological Institute*, ed. J. Fülop and T. Kubacska (Budapest, 1969), pp.86–107.
64. S. Staszic, *Carta geologica totius Poloniae, Moldoviae, Transilvaniae et partis Hungariae et Valachiae* (1808).
65. F.S. Beudant, *Voyage minéralogique et géologique en Hongrie* (Paris, 1822).
66. L. von Buch, *A Mineralogical Description of the Environs of Landeck in the County of Glatz with a Mineralogical Map.* Translated from the French with notes by Charles Anderson, M.D. (Edinburgh, 1810).
67. See the discussion on such maps by M.J.S. Rudwick, 'A Visual Language for Geology', *History of Science*, 14 (1976), 149–195, and by G.R. Engewald, F. Ellenberger, M. Guntau and G. Papay, and J. Urban in *Contributions to the History of Geological Mapping*, ed. E. Dudich (Budapest, 1984).
68. See n.38.
69. Strzelecki, *op.cit.* (n.24), p.54.
70. Quoted in part in Heney, *op.cit.* (n.1), p.1. Copies are in Mitchell Library, MSS A40590.
71. This word is not clear in the handwriting.
72. See Strzelecki, *op.cit.* (n.24) in general and especially p.48 for Franklin's encouragement of meteorological observations.
73. See for instance M.J.S. Rudwick, 'Charles Lyell's Dream of a Statistical Palaeontology', *Palaeontology* 21 (1978), 225–244; M.J.S. Rudwick, 'The Devonian: A System Born from Conflict', *The Devonian System* (1979) (Special Papers in Palaeontology, 23), pp. 9–21; T.G. Vallance, 'The Fuss about Coal', pp.136-176 in *Plants and Man in Australia*, ed. D.J. and S.C.M. Carr (Sydney, 1981); E.E. Milanovsky, 'Evolution of the Geological Map Content relative to the Development of Geological Science', pp.3-8 in *Contributions to the History of Geological Mapping*, ed. E. Dudich (Budapest, 1984); and Branagan, *op.cit.* (n.5). See also D.F. Branagan, *Geology and Coal Mining in the Hunter Valley, 1791–1861* (Newcastle, 1972) Newcastle History Monographs, No. 6).
74. For instance Lyell in his *Principles of Geology* devoted little attention to the problems of mountain building, and De La Beche, *The Geological Observer* (London, 1851) quotes many French and German sources in discussing the mineral composition of rocks.
75. Jukes, *op.cit.* (n.24).
76. Strzelecki, *op.cit.* (n.24).
77. See n.36.
78. Quoted by Greene, *op.cit* (n.9), p.25.
79. See e.g. De La Beche, *op.cit.* (n.74).
80. See also J.B. Jukes, 'A Few Remarks on the Nomenclature and Classification of Rock Formations in New Countries', *Tasmanian Journal of Natural Science*, 2 (1846), 1–12.
81. Strzelecki, *op.cit.* (n.24), p.53.
82. Vallance, *op.cit.* (n.73).
83. Strzelecki, *op.cit.* (n.24), p.53.
84. *Ibid.*, p.75.
85. See Strzelecki's correspondence with P.P. King (Heney *op.cit.* (n.1), p.153). He does not seem to have wanted a position himself. Vallance (pers. comm.) believes that Strzelecki did not intend to continue with geology once he settled in London, and that his lack of interest in the Geological Society is an indication of this.
86. Strzelecki, *op.cit.* (n.24), p.70.
87. Advertised in *The Athenaeum*.
88. General reviews include: *The Times*, 8 October 1845 (reprinted, *Sydney Morning Herald*, 28 January 1846 and *Port Phillip Herald*, 17 March 1846); *The North British Review*, vol.IV, No. VIII, *November 1845*, pp.281–312 (Babicz *et al.* (n.5) attribute this review to David Brewster); *The Calcutta Englishman* (reprinted, *Sydney Morning Herald*, 20 January 1846, and *Launceston Examiner*, 7 February 1846); *Port Phillip Patriot*, 7 April 1846; and J.H. Perkins, 'A Glimpse of Australia', *North American Review*, 25 (1850), 196–7.
89. Reviews considering the geological content appeared in: *The Athenaeum*, No. 925, 19 July 1845, pp. 712 *et seq.*; *The Quarterly Review*, vol.LXXVI, September 1845, pp.488–519 (Babicz *et al.* (n.5) state that this review was written by Dean Buckland; it is certainly by someone with a good understanding of recent geological ideas in Britain); and *Sydney Morning Herald*, 27 March and 3 April, 1846.
90. Clarke wrote and reviewed for the *Sydney Morning Herald* for many years. See Clarke Papers, ML MSS 139, and Branagan, *op.cit.* (n.73).
91. See n.14.
92. See Kaluski, *op.cit.* (n.1), p.61.
93. Strzelecki sent an inscribed copy of his book to Lyell. The inscription indicates that they were friendly. The copy is still in the family library at Kinnordy Castle, Scotland. I am grateful to Lady Lyell for her confirmation.
94. See Heney, *op.cit.* (n.1), p.152. Strzelecki's offer to sell his rock collection for £200 (see Branagan, *op.cit.* (n.2)) at this time, also suggests a shortage of funds. In 1849 Strzelecki donated the collection and his geological map to the Museum of Economic Geology. The fossils, which Strzelecki sold to Morris, were sold by him in 1859 to the museum for £20.
95. See Strzelecki, *op.cit.* (n.24), p.158.