Otago University Academic Misconduct

Mike Pole (PhD, Otago)
murihiku@yahoo.com
19.03.18

This complaint centres on a PhD thesis, and (mainly) a publication, which, with very minor differences, is Chapter 4 of that thesis.

The supervisors have condoned a consistent pattern of behaviour in the thesis which includes plagiarism, data fabrication or manipulation, a pervasive thread of ignoring key publications in the field, misrepresentation, and generally vacant of critical thought or basic competence in the subject. The supervisors have further involved themselves by collaborating as co-authors on published versions of the thesis.

The thesis: Reichgelt, T. 2014. Reconstructing southern New Zealand Miocene terrestrial climate and ecosystems from plant fossils. Unpublished PhD thesis, Department of Geology. University of Otago, Dunedin, New Zealand.

The paper: Reichgelt, T., Kennedy, E.M., Conran, J.G., Mildenhall, D.C., and Lee, D.E. 2015. The early Miocene paleolake Manuherikia: vegetation heterogeneity and warm-temperate to subtropical climate in southern New Zealand. *Journal of Paleolimnology,* 53:349–365. [essentially Chapter 4 of the thesis]

For brevity, these are refereed to as Reichgelt (thesis/et al.) where appropriate.

A. Primary plagiarism and data fabrication/manipulation

1. In two instances, fossil collections I made at Bannockburn (F41/f220 and F41/f235; the 'Bannockburn Sequence', Pole 1993), were 'relocated' by the student to a locality on the Kawarau River, near Cromwell ('Kawarau Sequence' Pole 1993), which was flooded beneath Lake Dunstan in 1993, before the student was born. My fossil localities were fully recorded in the NZ Fossil Record system. The point of this is accurate location (to a few metres), and stratigraphy (to a few centimetres). The student has obviously accessed that database (it's public), but then 'relocated' each of three collections to other locations several kilometres away.

2. In his PhD, the student indicates those two 'relocated' Bannockburn collections on a detailed measured stratigraphic section of the Kawarau Section. It cannot be the student's work, because the student could never have seen it. The diagram has clearly been redrawn from another Otago Geology Department PhD, that of Dr Barry Douglas, without acknowledgement. Douglas's PhD was on the sedimentology of the Manuherikia Group (and furthermore, the 1985 Douglas thesis – uncitable without the author's permission, is cited and not the publication, Douglas 1986).

This manoeuvre is even more alarming because the student apparently managed to relocate one of my fossil horizons at Bannockburn (it remains well-exposed), recognise the horizon that is my number F41/f220, and collect some additional fossils himself (OU34656, 34657, 34658) – but still claim they came from a spot several kilometres away below the waters of Lake Dunstan.

3. My third fossil collection (H41/f046) comes from a small farm outcrop near Lauder. It was 'relocated' by the student to Vinegar Hill, several kilometres, near St Bathans. The student shows it at a fictitious level (73 m) on another detailed geological section. The new location puts the fossils in an entirely different geological formation, devoid of leaf beds. By choosing to 'relocate' the fossil collection there, the student is demonstrating that he has no knowledge of the section – ie, he could not have spent the considerable time needed to measure it. Once again, the section is a simplified version from another PhD, Dr Barry Douglas. Once again, unacknowledged.

4. At a fourth locality, Grey Lake, the student did make his own fossil collection, but described it as "a newly discovered mudstone lens". This omits that I had previously published the coordinates of that lens and referred to its fossils in three earlier papers (Pole 2007, 2008 2014). The geological section in this case, is original, but guesswork. It shows the fossil horizon as 5 m above basement. One only has to stand on the outcrop to see it's tens of meters.

5. The student has analysed a fossil pollen dataset (Reichgelt thesis, Appendix B, on CD and not seen by me/et al. Supplementary information ESM D) supplied by another researcher (Mildenhall; of taxa presence by sample), and for each sample, calculated fossil climate. However, if one checks this, around 10% of all datapoints that are claimed, do not occur in the dataset. This means that for any individual calculation of climate, sometimes 50% of the datapoints, apparently do not exist. For just the Kawarau Section alone, there are over 80 instances of taxa shown in sample diagrams for deriving paleoclimate, that do not appear in the primary data set, and about 18 cases of where a taxon is in the diagrams, but do not occur in the primary data set at all, and while the dominant taxa (*Nothofagus*) are ignored without comment.
In addition to this, even the taxa identified with the pollen, are inconsistent with the authority cited, or common usage. As just one example, the tropical-restricted *Gymnostoma* is shown. However, the data source for this (Raine et al., 2011) states that the pollen type in question cannot be identified with any of the genera within the family (i.e it includes the widespread non-tropical taxa), and might represent other families.

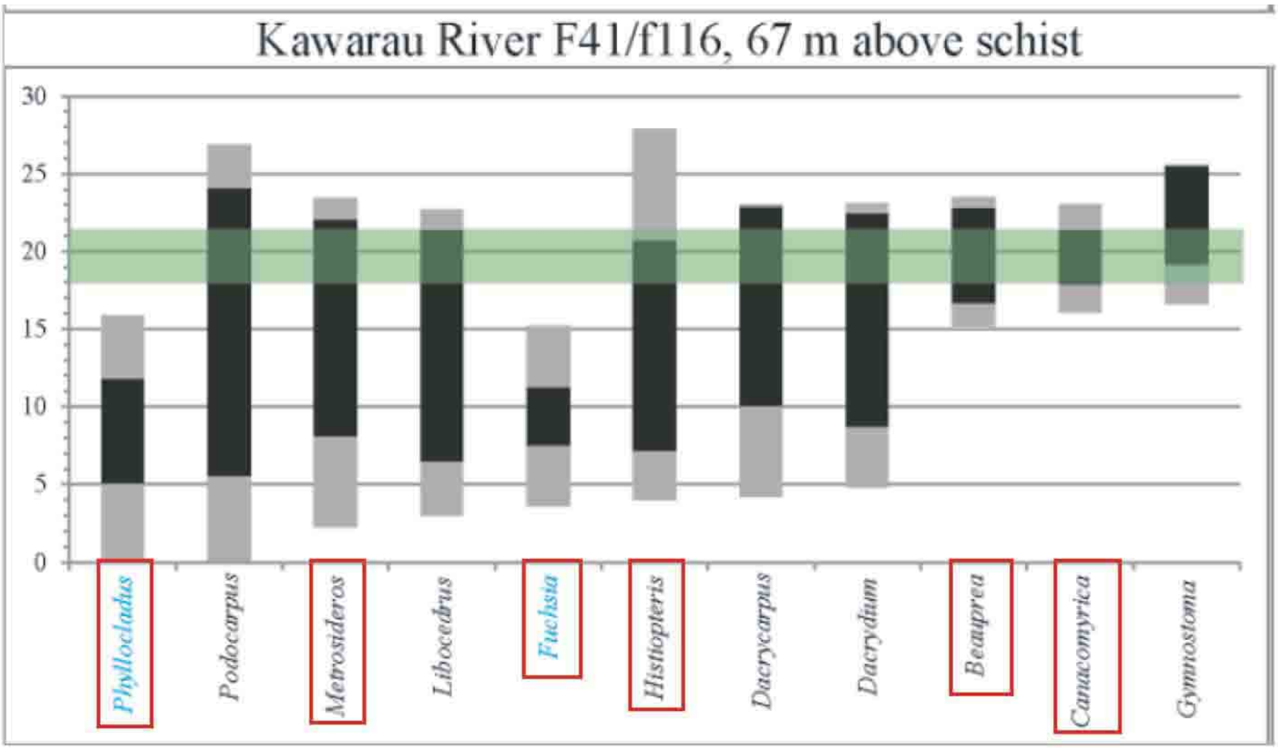

Illustration 1: An example of a single diagram from Reichgelt (thesis, p. 376/et al. Supplementary information ESM J). It shows ranges of Mean Annual Temperature for the taxa present. The taxa outlined in red do not occur in the basic data set.

height above basement	3	21	24	39	41	42	45	46	48	49	61	62	63	67	68	69	69	69,5	70	72	74	75	78
Proteacidites minimus																							
Bluffopoliss scabratus																							
Acaciapollenites																							
Plagianthus																							
Paesia																							
Caloclaena																							
Gothanipollis																							
Pisonia																							
Dicksonia																							
Stephanocolpits sphericus							1																
Pseudowin terapollis			1							1													
Proteacidites parvus			1		1																		1
Podocarpidites sp.	22	53	100	9	17	1	29	10		20	2		1	1		6	6	11	7	7	2	8	50
Phyllocladus	3	12	15	3	6	1	2	6		2	2		3					*1*					
Phyllocladidites mawsonii				1										1									
Phormium		2																					
Periporopollenites vesicus																					2		
Parsonsidites psilatus										*3*			1										
Palaeocoprosmadites zelandiae		1						*1*															
Nyssapollenites endobaUens		1																				90	
Nothofagidites spinosus	1							1															2
Nothofagidites mataurensis	100	39	57	2	27	*3*	24	55	12	65		7	62		*3*	9	10	5	4	5	4	14	33
Nothofagidites lachlanae	*13*	23	56		12	16	9	21	3	*6*	4	1	19	2		1	1	1	1	1	2	*8*	9
Nothofagidites asperus	1	5	12	1	1		4	2		2		2	1					1					*5*
Myrtaceidites parvus				200		2		2	1	1		2				1						2	1
Myrtaceidites mesonesus	43	1	2	56		*60*	1	24	51	11	*70*	100	75		15	150	21	50	50	5	*6*	100	100
Myricipites harrisii	18	100	*93*	3	1	150	150	100	28	100	150	33	###	250	*5*				2			1	18
Monosulcites waitakiensis								2			1												
Monosulcites otagoensis	2	3	2	20	100		4	*6*		20	16	70	21		*84*	24	###	27	22	1	1	1	13
Malvacipollis			1							4													
Malvacearumpollis mannanensis		1																					
Loranthaccac																							1
Liliacidites variegatus	8		1			2	3				4	*42*			110	20	25	1	100			1	1
Libocedrus	8	5	23	2	6	1								1	1							1	
Haloragacidites canacomyricoides											7												
Halocarpus		1	3		3		3								1	2			10	1			14
Guettardidites ixirensis																					2		2
Fuchsia		2								1													
Freycinetia												*1*	1			1				1			
Dacrydium	10	15	*6*	1	5		15	7		2	2	2	2	1	3	1	5	2	1	1	1	2	18
Dacrycarpus	1	6	15					4	3	3	1		2	3	1	2			2			1	5
Cupanieidites orthoteichus						1										1							
Clavatipollenites ascarinoid	1	1						3															
Beaupreaidites elegansifbrmis												*13*	1					1					
Araucariacites australis	23	12	46				2					*1*						1	4	*3*		1	
Alectryon																						1	
Polypodiisporites minimus		1	3	9	8					1													
Lygodium	1	1																					1
Polypodiisporites histiopteroides		1		11	50					7									1				
Cyathea	21	28	24	32	57	11	15	10	14	18	5	*8*	9		6		5	90	*6*	44	22	21	337
Baculatisporites disconformis		4	3																				

Illustration 2: The Kawarau Section palynological dataset filtered for taxa used in climate overlap diagrams (from Reichgelt thesis, Appendix B/et al., Supplementary material ESM D). Red cells are for taxa shown in individual climate overlap diagrams, but do not appear here. Purple cells are for taxa that do occur in this dataset, but were not used in climate overlap diagrams, either in individual cases where they are used elsewhere, or for Nothofagus, which are a dominant component, but not used at all. Taxa in orange cells which are found in individual climate overlap diagrams, but have no corresponding taxon in this dataset. Data cells in blue are empty or match

B. Broader issues of academic misconduct

How is it that a student can be given access to a very large fossil collection made by a previous PhD working in the same department (me), which I had fully published in over 10 papers, then team up with his supervisors as co-authors to pre-publish one chapter of his thesis, in which the same collections are analysed - and not even cite any of those papers? A random selection of these were simply added as a list of 'Additional references' in a 'Supplementary Information' file. The list pointedly omits the critical synthesis paper dealing with the precise subject, localities and actual specimens the student is studying. The later thesis, again, merely lists a few of these references.

How is it that the student, while ignoring a fully published, illustrated, keyed taxonomy, can skip doing any taxonomy himself, and instead is allowed to carry out the core analyses of his PhD on his own taxa that are simply photographs – with no justification given for them whatsoever, and no catalogue numbers given for specimens regarded as conspecific in other samples?

How is it that I, drawing on over 30 of my publications on this topic, can publish an 80 page synthesis, including a detailed look at the very localities and collections the student has chosen to work on, and the student, whose PhD is on the same topic, can dismiss all of this with the comment:

"Recent results of Pole (2014) echo the results from Chapter 2 and 8 and conference abstracts"

None of this could be done without a nod from his supervisors. Is it no longer necessary at Otago for doctoral students to demonstrate critical competence in a subject? When did it become acceptable at OU for supervisors to allow students to disregard all the publications on the material provided to him, by the person who collected it, who worked in the same department, and that a comment that the major publication on his subject "echoes" his thesis, can substitute for any critical analysis?

---

3. There are several examples where both student and supervisors show a lack of basic competence.

1. Age of the Manuherikia Group

Reichgelt (thesis, p. 110/ et al. 2015, p. 350) state: *"The Manuherikia Group ... is of early Miocene age, spanning ~3.6 million years in the Burdigalian–Langhian (Altonian– Clifdenian New Zealand Stages 18.7–15.1 Ma) (Mildenhall, 1989; Pole and Douglas, 1998; Raine et al., 2012)".*

The figure of 18.7-15.1 Ma and thus a figure of 3.6 million years as the span of the Manuherikia Group given by Reichgelt thesis/et al. is simply the Otaian-Altonian boundary to the Clifdenian-Lillburnian boundary as given in Raine (2012). Mildenhall (1989, p. 27) wrote: "Most of the Central Otago lignites are regarded as early Miocene (Altonian) in age, but little is known about the older Otaian Stage, which cannot be readily differentiated from Altonian. The younger middle Miocene stages, Clifdenian and Lillburnian, are also difficult to differentiate palynologically and, although both may be represented in Central Otago, a time range of Altonian-Clifdenian is accepted for the Central Otago lignites. The youngest sediments, at Lowburn, Ranfurly and Gimmerburn, appear to be of Late Miocene Taranaki Series age (i.e. Tongaporutuan or Kapitean stages)."

Thus when Reichgelt thesis/et al. write of the Manuherikia Group "spanning ~3.6 million years", what they mean is that the shortest (least-likely) age estimate of the 'lignite-bearing' strata alone, which occur only in the lower Manuherikia Group (Douglas, 1986), date to somewhere within a range of 3.6 million years. That's the accuracy of the date, not the span of sedimentation. However, as Mildenhall (1989) stated, the Otaian and Altonian can't be resolved, so the older figure could be as much as 21.7 Ma, and as the Clifdenian -Lillburnian also can't be resolved, the upper date may be as little as 13.05 Ma. Moreover, Reichgelt thesis/et al., (2015) appear unaware that the Grey Lake material comes from the incised valleys of the St Bathans Member (Douglas, 1986), which stratigraphically underlies all samples studied by Mildenhall (1989) and Mildenhall and Pocknall (1989) and will be significantly older still.

The Manuherikia Group spans most of the Miocene (Mildenhall and Pocknall, 1989) with both Pole and Douglas (1998) being incorrectly cited by Reichgelt thesis/et al., (2015) as supporting an Early Miocene date of the Manuherikia Group.

How can Professor of Geology not recognise that the precise dates a student is using are the well-established boundary dates for a national time-scale, and not in any sense bounding-dates for his rock unit?

2. Bioclimatic analysis method

Reichgelt (thesis p. 122/ et al. 2015, p. 356) wrote:

"*Best zones of overlap were found by identifying outliers and by constraining the temperature/precipitation of the taxa with the lowest maximum temperature/precipitation tolerance and the taxa with highest minimum temperature/precipitation tolerance (ESM J1–J5 and K1–K5). Using best zone of overlap instead of the mode or the mean (Pole, 2014) ensures that climatic information from taxa living in a restricted climate zone is not obscured.*"

The 'best zones of overlap' are nothing more nor less than the modes. They are the climate interval in which most taxa coexist. Reichgelt thesis/et al. state that their BA method follows Greenwood et al. (2005), but these authors (p. 170) explain that BA "... is essentially the same as the co-existence approach of Mosbrugger and Utescher (1997)", while those authors in turn (Mossbruger and Utescher, 1997, p. 66) explain that "a histogram is printed showing the number of taxa that can coexist within a given subinterval" and for which "statistics such as mean, standard deviation, variance and median are given." The histogram graphically indicates the maximum number of taxa that can occur for an interval of temperature – the mode.

If the student and supervisors are not aware that their method is based on finding the mode – it begs the question, how do they get their results?

3. Canopy closure

Reichgelt thesis/et al. used CLAMP methodology (ordination by Canonical Correspondence Analysis; Wolfe, 1990; Yang et al. 2011) as the basis of a method to determine an aspect of vegetation structure - canopy closure. They first uploaded results (based on unsubstantiated taxa) to the on-line CLAMP site, to obtain values of Relative Humidity (RH) for leaf macrofossil assemblages.

Their results were indistinguishable:

Shale Creek	c. 71±10.5 %
Kawarau River 235	c. 72±10.5 %
Kawarau River 220	c. 78±10.5 %
Lauder Farm	c. 76±10.5 %
Grey Lake	c. 73±10.5 %

Despite being indistinguishable, the RH values were then introduced in a *second* ordination: Categorical Principal Components Analysis (CATPCA) (Reichgelt thesis. p. 118/et al. 2015, p. 354): “Additionally, results of CLAMP analysis for RH and MAT for each site were categorized with the same principles of PCA and were superimposed on the plot”).

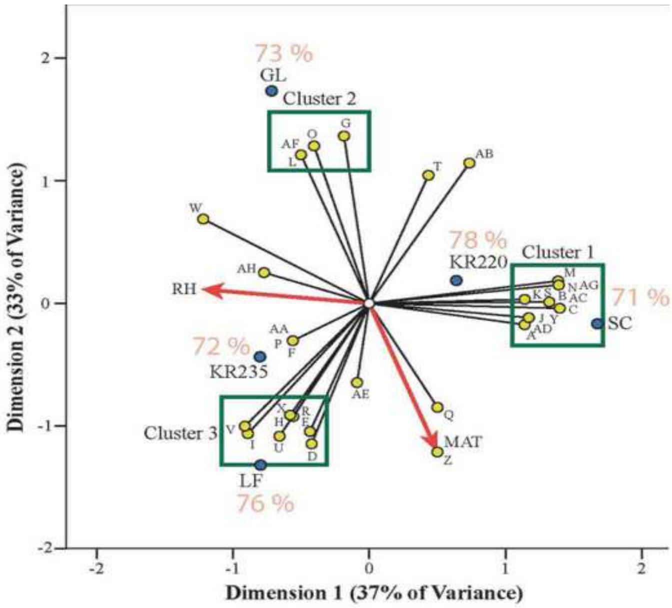

Illustration 3: Fig. 4 of Reichgelt et al (2015) modified to show both the CATPCA result with "vector loadings of relative humidity (RH)” with the addition of red figures to indicate RH values from their CLAMP ordination.

The results shuffle the relative values of RH from the CLAMP ordination.

Nothing is made of this.

Ignoring the CLAMP results, they then (Reichgelt thesis, p. 129/et al. 2015, p. 361) asserted that the RH vector in their CATPCA analysis was a “relative proxy for the forests’ capability to capture moisture”, and further, that this reflects canopy closure. From this they concluded that “Grey Lake, Kawarau River 235 and Lauder Farm floras were relatively dense compared to those at Kawarau River 220 and Shale Creek.”

Then Grey Lake and Kawarau River 235 were simply declared “rainforest” (et al. p. 363) and “dense forest” (table 3) and Shale Creek and Kawarau River 220 “open forest” (et al. p. 363) and “Open forest/woodland” and “Open swampy forest” (table 3).

There was no explanation as to how **relative** canopy closure results became **absolute.**

The phenomenon of open and closed canopy vegetation (sensu Specht, 1970) lying side by side across Australia, independent of climate (and RH), is the defining issue of Australian vegetation ecology. Because of that, it has an abundant literature, with fire being a major, if not the core factor.

Fire is well established as an ecological force in the Manuherikia Group. Charcoal has been documented (Mildenhall 1989; Pole 2003), pyrophyllic plant taxa identified (e.g. Gyrostemonaceae, Mildenhall, 1989; *Eucalyptus*, Pole, 1993d) and multiple discussions of fire in the literature (Pole 1993g, Pole 2003, 2014, Pole et al. 2003). The vegetation structure of three of those fossil assemblages (Bannockburn 220, 235 and Lauder Farm) have been discussed in detail in Pole (1993). But Reichgelt (thesis/et al.) ignore the lot - there is not a single mention of **fire** in either.

The student's supervisors have here condoned a chain of actions: starting with ignoring that results are indistinguishable, the curious practise of ordinating an ordination, followed by ignoring one set of results in favour of another, wild speculation, leaping to unfounded conclusions and then ignoring all literature. No normal impartial supervision of a PhD would tolerate such a contribution, devoid of any critical analysis.

4. Stratigraphy

Reichgelt et al. (2015, fig. 2) merged three measured sections, spread across c. 70 km, and separated in both cases by over 600 m of mountain topography, to obtain one long palynological record. They claimed in their caption to fig 2 that this was based on the "stratigraphic correlations" of Douglas (1985) and Mildenhall and Pocknall (1989). The relative position of the sections originates from figure 8 of Douglas (1986), which is a basin-wide lithostratigraphic scheme, (as captioned) "schematically depicting relationships of Manuherikia Group units". To simply horizontally concertina geological sections crossing a variety of lithological units across tens of kilometers in a way that implies stratigraphic correlation to within a few meters, is absurd. This is gross incompetence coming out of a Geology Department.

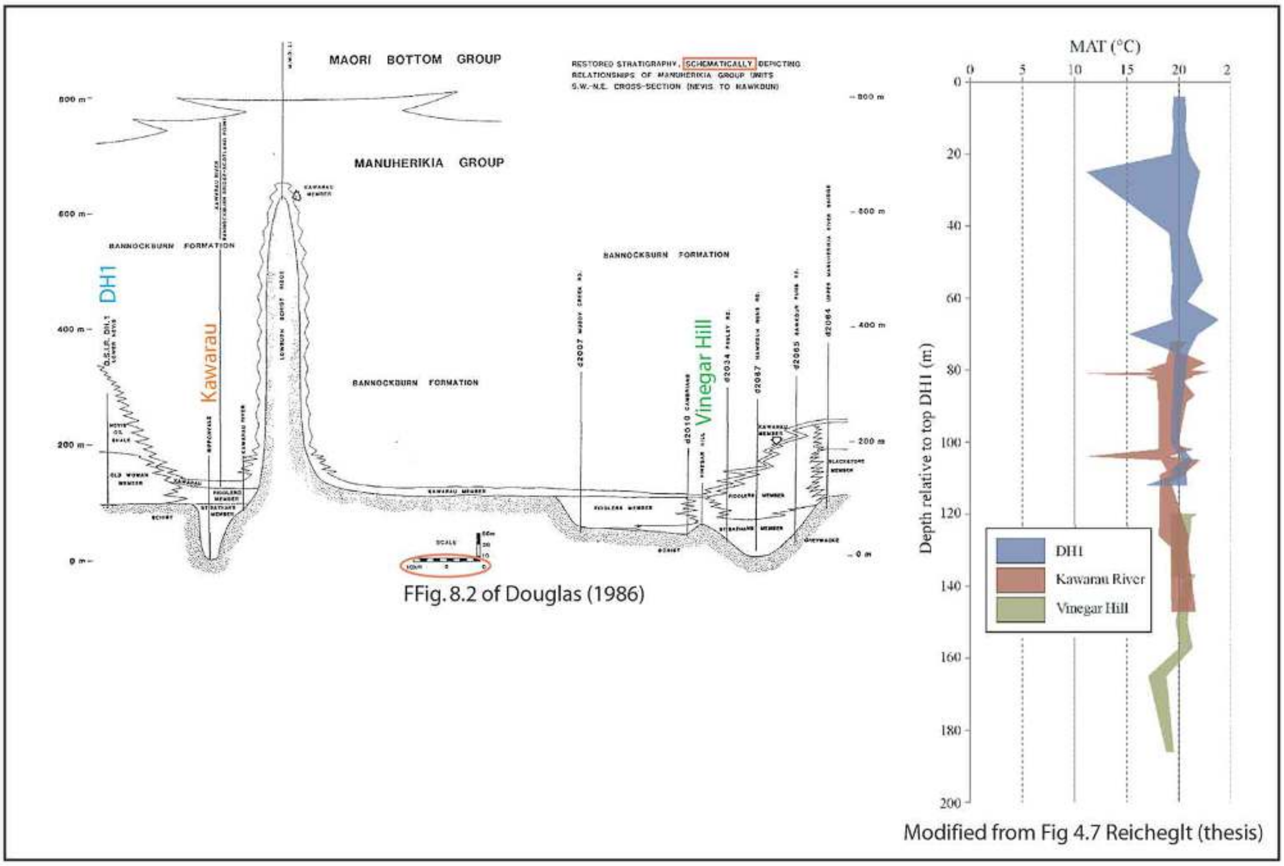

Illustration 4: Left is the basin-wide schematic lithostratigraphy of Douglas (1986) with the DH1, Kawarau and Vinegar Hill localities added in colour. To the right is a modified figure from Reichgelt (thesis) showing the result of compressing these localities horizontally across tens of kilometers.

There is no discussion of the palynological zonation of Mildenhall and Pocknall (1989), despite that paper dealing with the very same sections. The publication of Pole and Douglas (1998) - the only one which has tried, by means of changes in the ratios of dominant pollen taxa, to show actual palynological correlation horizons across the Manuherikia Group – specifically dealing with the same stratigraphic sections of Reichgelt thesis/et al., was ignored. The paper is referenced, but only incorrectly as an authority that the Manuherikia Group is Early Miocene (Pole and Douglas, 1998 includes a diagram and multiple references to the Manuherikia Group spanning Early-Late Miocene).

While using a schematic lithostratigraphy for biostratigraphic correlation, Reichgelt thesis/et al. not only ignore published attempts at biostratigraphy – but their own data as well. The lack of correlation is illustrated by Reichgelt (thesis, fig. 4.2/ et al, fig. 2) overlapping the Kawarau Section and DH1 Drillhole. In the Kawarau Section they document a sustained dominance of *Nothofagidites matauraensis* pollen and complete absence of *N. cranwelleae*. But in the DH1 drillhole, *N. cranwelliae* dominates, and *N. matauraensis* is present in only trace amounts. Not only should this raise serious concerns about the correlation, but to the age as well. A dominance of *N. matauraensis* would place the Kawarau samples into the *N. matauraensis* Assemblage/Zone – of Oligocene age (Raine, 2004).

How is it that a professor of Geology can condone a student carrying out an infantile concertina of a schematic, basin—scale lithostratigraphy, and presenting it as a 'correlation' to centimetre accuracy?

5. Paleotopography and Atmospheric Circulation

Reichgelt et al. (2015, p. 361) concluded that "The paleotopography would have controlled the distribution of rainforest (such as ...Kawarau River 235) and open forest (such as ... Kawarau River 220) as topographical orientation and minor altitudinal gradients are associated with major differences in precipitation ... and irradiance". This was emphasised with a diagram (thesis fig. 4.10) showing how rainfall changes today with hundreds of meters of topography on New Caledonia and Hawai'i.

The 'Kawarau River' 220 and 235 collections are three metres stratigraphically apart in a clay-mudstone sequence. No competent geologist would remotely consider that there was either significant topography in the area, let alone a significant difference between the deposition of these two fossil assemblages. Where is the geological supervision here?

C. Misrepresentation of other publications

Although the focus here is on a single chapter in the thesis, the same pattern is observed in other chapters, which have also been published separately. e,g:

Reichgelt (thesis chapter 2, et al. 2013) analyses climate from the Foulden Maar. The leaf taxa this is based on are illustrated but, as with the Manuherikia Group, there are no accompanying descriptions or comments as to why they are separate taxa. A detailed descriptive taxonomy on Foulden Maar leaf taxa exists: Pole (1996), but was ignored – it is not referenced.

***

Reichgelt (thesis chapter 5, p. 145/ et al. 2014, p. 10) states:
"Lauraceae are an important component of Miocene vegetation in southern New Zealand. To date 14 species have been described and formally named (Holden, 1982a; Bannister et al., 2012) and assigned to Cryptocarya R.Br., Litsea Lam. and Beilschmiedia Nees and putative occurrences of Endiandra R.Br. (Pole 2007b)"

Actually what happened was that Holden (1982) described *Cryptocarya, then* Pole (2007) formally identified *Cryptocarya*, *Litsea*, *Beilschmiedia* and *Endiandra*. Following which, Bannister et al., (2012) placed all their material into the non-committal organ genus *Laurophyllum.*

The Reichgelt (thesis/et al.) comment is a blatant misrepresentation.

***

Reichgelt (thesis, chapter 5, p. 149/et al. 2014 p. 14) “Putative *Eucalyptus* fossils have been recovered from the Early Miocene of Central Otago (Pole, 1993b). The identification is based on multiple impressions of lanceolate or ‘a lanceolate, very narrow elliptic shape’ (Pole, 1993b; p.77).

This quote omits the immediately preceding words: “Differs from all other Manuherikia Group taxa in having ...”.

The student ignores what the taxon identification was based upon – which was very clearly stated (Pole 1993, p. 76):

“The identification of *Eucalyptus* s.l. is based on the falcate shape of the leaves, the longitudinal vein which parallels the margin right from the base with little extralateral venation, and the presence of laminar glands. In particular, lanceolate to linear leaves which are falcate suggests a leaf which hangs vertically with identical surfaces ("amphisophyll", sensu Johnston and Lacey, 1984). This feature in combination with the others is unique to *Eucalyptus* s.l.”

Having trivialised the identification by misrepresenting a key local distinguishing character for the taxon-identifying features, Reichgelt (thesis, p. 149/et al. 2014 p. 14) then add: “The leaf from Double Hill fits the description of the *Eucalyptus* sp. specimens from Kawarau River; however both leaf types could well belong to *Syzygium*.”

“Could well”? Are Otago PhDs no longer required to back up assertions with some kind of facts or discussion?

***

Reichgelt (thesis, chapter 5, p. 139/et al. 2014 p. 5): “Pole (1992a) describes sharp leaved thick ribbed *Podocarpus alwyniae* Pole from the Early Miocene of Central Otago; under modern phylogenetic revisions it would most likely be allocated to *Prumnopitys* (Kelch, 1997; 1998; Conran et al., 2000; Biffin et al., 2011).”

For this comment to make any sense, “modern revisions” would need to synonymise *Podocarpus* with *Prumnopitys*. No one has ever suggested this. Furthermore, three of the references given are revisions based on molecular data, and are irrelevant. Kelch (1997) includes epidermal data which demonstrably do not distinguish between *Podocarpus* and *Prumnopitys.* This is just another fatuous comment.

References

Bannister, J.M., Conran, J.G., Lee, D.E., 2012. Lauraceae from rainforest surrounding an early Miocene maar lake, Otago, southern New Zealand. Review of Palaeobotany and Palynology 178, 13–34.

Biffin E, Conran JG, Lowe AJ 2011. Podocarp evolution: a molecular phylogenetic perspective. Smithsonian Contributions to Botany 95: 1–20.

Conran JG, Wood GM, Martin PG, Dowd JM, Quinn. CJ, Gadek PA et al. 2000. Generic relationship within and between the gymnosperm families Podocarpaceae and Phyllocladaceae based on analysis of the chloroplast gene rbcL. Australian Journal of Botany 48: 715–724.

Douglas, B.J. 1985. Manuherikia Group of Central Otago, New Zealand: stratigraphy, depositional systems, lignite resource assessment and exploration models. Unpublished PhD Thesis, University of Otago, Dunedin, New Zealand.

Douglas, B.J. 1986. Lignite resources of Central Otago. New Zealand Energy Research and Development Committee Publication, P104, 367pp.

Greenwood, D.R., Archibald, S.B., Mathewes, R.W., and Moss, P.T. 2005. Fossil biotas from the Okanagan Highlands, southern British Columbia and northeastern Washington State: climates and ecosystems across an Eocene landscape. *Canadian Journal of Earth Science*, 42:167–185.

Holden, A.M., 1982. Fossil Lauraceae and Proteaceae from the Longford Formation, Murchison, New Zealand. Journal of the Royal Society of New Zealand 12, 79–90.

Kelch DG 1997. The phylogeny of the Podocarpaceae based on morphological evidence. Systematic Botany 22: 113–131.

Kelch DG 1998. Phylogeny of Podocarpaceae: comparison of evidence from morphology and 18S RDNA. American Journal of Botany 85: 986–996

Mildenhall, D.C. 1989. Summary of the age and paleoecology of the Miocene Manuherikia Group, Central Otago, New Zealand. *Journal of the Royal Society of New Zealand*, 19:19–29.

Mildenhall, D.C. and Pocknall, D.T. 1989. Miocene-Pleistocene spores and pollen from Central Otago, South Island, New Zealand. *New Zealand Geological Survey Palaeontological Bulletin*, 59:1–128.

Mosbrugger V., and Utescher, T. 1997. The coexistence approach—a method for quantitative reconstructions of Tertiary terrestrial palaeoclimate data using plant fossils. *Palaeogeography Palaeoclimatology Palaeoecology,* 134:61–86.

Pole, M.S. 1992a. Early Miocene flora of the Manuherikia Group, New Zealand. 1. Ferns. *Journal of the Royal Society of New Zealand*, 22:279–286.

Pole, M.S. 1992b. Early Miocene flora of the Manuherikia Group, New Zealand. 2. Conifer. *Journal of the Royal Society of New Zealand,* 22:287–302.

Pole, M.S. 1992c. Early Miocene flora of the Manuherikia Group, New Zealand. 3. Possible cycad. *Journal of the Royal Society of New Zealand*, 22:303–306.

Pole, M.S. 1993a. Early Miocene flora of the Manuherikia Group, New Zealand. 4. Palm remains. *Journal of the Royal Society of New Zealand*, 23:283–288.

Pole, M.S. 1993b. Early Miocene flora of the Manuherikia Group, New Zealand. 5. Smilacaceae, Polygonaceae, Elaeocarpaceae. *Journal of the Royal Society of New Zealand, 23*:289–302.

Pole, M.S. 1993c. Early Miocene flora of the Manuherikia Group, New Zealand. 6. Lauraceae. *Journal of the Royal Society of New Zealand,* 23:303–312.

Pole, M.S. 1993d. Early Miocene floras of the Manuherikia Group, New Zealand. 7. Myrtaceae, including *Eucalyptus*. *Journal of the Royal Society of New Zealand*, 23, 313–328.

Pole, M.S. 1993e. Early Miocene flora of the Manuherikia Group, New Zealand. 8. *Nothofagus*. *Journal of the Royal Society of New Zealand,* 23:329–344.

Pole, M.S. 1993f. Early Miocene flora of the Manuherikia Group, New Zealand. 9. Miscellaneous leaves and reproductive structures. Journal of the Royal Society of New Zealand, 23:345–391.

Pole, M.S. 1993g. Early Miocene flora of the Manuherikia Group, New Zealand. 10. Paleoecology and stratigraphy. *Journal of the Royal Society of New Zealand*, 23:393–426.

Pole, M. 1993h. Keeping in touch: vegetation prehistory on both sides of the Tasman. *Australian Systematic Botany*, 6:387–397.

Pole, M.S., 1996. Plant macrofossils from the Foulden Hills Diatomite (Miocene), Central Otago, New Zealand. Journal of the Royal Society of New Zealand 26, 1-39.

Pole, M.S. 1997. Miocene conifers from the Manuherikia Group, New Zealand. *Journal of the Royal Society of New Zealand,* 27:355–370.

Pole, M.S. 1998. The Proteaceae record in New Zealand. *Australian Systematic Botany,* 11:343–372.

Pole, M.S. 2003. New Zealand climate in the Neogene and implications for global atmospheric circulation. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 193:269–284.

Pole, M. 2007a. Conifer and cycad distribution in the Miocene of southern New Zealand. *Australian Journal of Botany,* 55:143–164.

Pole, M. 2007b. Lauraceae macrofossils and dispersed cuticle from the Miocene of southern New Zealand. *Palaeontologia Electronica* 10 1**: 3A**:1–38 palaeo-electronica.org/2008_3/153/153

Pole, M. 2007c. Monocot macrofossils from the Miocene of southern New Zealand. *Palaeontologia Electronica* 10, Issue 3; 15A:1-21 palaeo-electronica.org/2007_3/125/125

Pole, M. 2008. Dispersed leaf cuticle from the Early Miocene of southern New Zealand. *Palaeontologia Electronica* 11 (3) 15A:1–117 palaeo-electronica.org/2008_3/153/153

Pole, M. 2010. Was New Zealand a primary source for the New Caledonian flora? *Alcheringa,* 34:61–74.

Pole, M.S. 2012. Plant macrofossils, p. 460–475. In Gordon, D.P. (ed.), *New Zealand Inventory of Biodiversity Vol 3*. Canterbury University Press, Christchurch.

Pole, M. 2014. The Miocene climate in New Zealand: Estimates from paleobotanical data. *Palaeontologia Electronica* 17(Issue 2;27A):1–79 palaeo-electronica.org/content/2014/780-miocene-climate-of-new-zealand.

Pole, M. and Douglas, B.J. 1998. A quantitative palynostratigraphy of the Miocene Manuherikia Group, New Zealand. *Journal of the Royal Society of New Zealand,* 28:405–420.

Pole, M.S., Douglas, B.J. and Mason, G. 2003. The terrestrial Miocene biota of southern New Zealand. *Journal of the Royal Society of New Zealand,* 33:415–426.

Pole, M., Dawson, J., and Denton, T. 2008. Fossil Myrtaceae from the Early Miocene of southern New Zealand. *Australian Journal of Botany,* 56:67–81.

Pole, M. and Mcloughlin, S. 2017. The first Cenozoic *Equisetum* from New Zealand. *Geobios*, 50:259–265.

Raine, J.I. 2004. Appendix to Chapter 11. New Eocene and Oligocene miospore zones and subzones, In Cooper, R.A. (ed.), The New Zealand Geological Timescale. *Institute of Geological and Nuclear Sciences Monograph*, 22:162–163.

Raine, J.I,, Mildenhall, D.C. and Kennedy, E.M. 2011. New Zealand fossil spores and pollen: an illustrated catalogue. 4th edition. GNS Misc Ser 4. http://data.gns.cri.nz/sporepollen/index.htm

Reichgelt, T., Kennedy, E.M., Mildenhall, D.C., Conran, J.G., Greenwood, D.R., and Lee, D.E. 2013. Quantitative palaeoclimate estimates for Early Miocene southern New Zealand: evidence from Foulden Maar. Palaeogeography, Palaeoclimatology, Palaeoecology,378:36–44.

Reichgelt, T. 2014. Reconstructing southern New Zealand Miocene terrestrial climate and ecosystems from plant fossils. Unpublished PhD thesis, Department of Geology. University of Otago, Dunedin, New Zealand.

Reichgelt, T., Jones, WA, Jones, DT, Conran, JG, Bannister, JM, Kennedy, EM, Mildenhall, DC, & Lee, DE 2014. The flora of Double Hill (Dunedin Volcanic Complex, Middle–Late Miocene) Otago, New Zealand, Journal of the Royal Society of New Zealand

Reichgelt, T., Kennedy, E.M., Conran, J.G., Mildenhall, D.C., and Lee, D.E. 2015. The early Miocene paleolake Manuherikia: vegetation heterogeneity and warm-temperate to subtropical climate in southern New Zealand. *Journal of Paleolimnology*, 53:349–365.

Wolfe, J.A., 1990. Palaeobotanical evidence for a marked temperature increase following the Cretaceous/Tertiary boundary. *Nature*, 343:153–156Specht RL (1970) Vegetation. In: Leeper GW (ed) Australian environment, 4th edn. Melbourne University Press, Melbourne, pp 44–67

Yang J, Spicer RA, Spicer TEV, Li C-S 2011. ‘CLAMP Online’: a new web-based palaeoclimate tool and its application to the terrestrial Paleogene and Neogene of North America. Palaeobiodivers. Palaeoenviron. 91:163–183

Mike Pole 19.03.18