Gondwana and Geophilosophy: Negotiating Planetary Thresholds on a 4D Earth

Forthcoming in *Gondwanaland: Modern Histories of an Ancient Supercontinent*
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University of Pittsburgh Press

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Other worlds

"When European scientists first ventured into these forests, about two hundred years ago, it must have seemed (pause) otherworldly," intones narrator George Henare (Ngāti Porou and Ngāti). The forests in question are home to the flightless kiwi, the giant cricket-like wētā and the burrowing bat, as the 2001 TV documentary *Ghosts of Gondwana* recounts[1], fauna that are at once relicts of the ancient mega-continent and totally unique. While reference to Gondwanaland imbues these creatures with deep and mysterious origins, it is their subsequent post-Gondwana isolation – "pummelled by nature's fury" on the geologically turbulent island arc of Aotearoa New Zealand – that forges them into bodily and behavioural forms found nowhere else on Earth.

Ghosts of Gondwana doesn't dwell on the geopolitical affiliations Gondwana might invite or the fact that Māori origin stories point elsewhere. What the documentary is keen to affirm is complementarity between western science and Māori knowledge, and the respective "other worlds" they depict. "We know these creatures," observes Hirini Melbourne (Tūhoe and Ngāti Kahungunu) offering a traditional Māori perspective on the biota featured in the film. "They came from the underworld; they haunt our forests." European-Australian palaeontologist Michael Archer offers a western scientific perspective on the same species that conveys a sense of awe about their strangeness and uniqueness. The two cultural visions

[1] *Ghosts of Gondwana*, dir. R. Morris, Natural History New Zealand (2001).

converge on the threat of bioinvasion and habitat destruction, whose ravages "mean that there is a little less magic in the world."

But there are other ways to tell this story, or other stories to tell. In an essay that accompanied a 1991 art exhibition, Pākehā biologist Robin Craw and Māori curator George Hubbard (Ngāti Kuri, Te Aupōuri, Te Rarawa) offered their own reflections on the landform and lifeforms of Aotearoa New Zealand*:*

> Contrary to popular belief, very little of present-day New Zealand was ever part of the great southern Gondwana continent…. Aotearoa was formed by convergent forces radiating out from at least three oceanic spreading centers. This triple plate junction is a complex mosaic of numerous terrains of disparate origin, formed in widely spaced settings, and then welded together and metamorphosized by immense tectonic forces. New Zealand is a biogeographic/geological composite or hybrid area, an orogenic collage of fragments . . . Its animals and plants are an uplifted, downwarped and tectonically transposed hybrid swarm.[2]

Insistent in their own way that western and Māori worldviews can converse, Craw and Hubbard are attentive to how the Gondwana origin story conveys cultural nationalist sensibilities – and see such suturing of nationhood and natality as an unfortunate transplant from the Old World to the Southern hemisphere. What Craw brought to the collaboration was his own angle on biogeography, a version of the study of the evolution and distribution of life that stressed mutual relationships between geological and biological processes. As he wrote in a biology journal article in the 1980s: "The relatively complex nature of organisms and our own privileging of life has perhaps discouraged previous deconstruction of the opposition earth/life in the earth and life sciences," a reflection that drew explicitly on the philosophy of Jacques Derrida.[3] And here I need to position myself and signal my debts. Invited into the conversation around this time, I was simultaneously inducted into theories of plate tectonics and pointed in the direction of Derrida's thought.

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[2] R. Craw and G. Hubbard, "Cross Pollination: Hyphenated identities and Hybrid Realities (or ALTER/NATIVE to What?)," *Midwest* 3 (1993): 32.
[3] R. Craw and M. Heads, "Reading Croizat," *Rivista di Biologia Biology Forum* 81, no. 4 (1988): 514.

It matters where we are speaking or writing from. Over the intervening years this has increasingly come to mean inhabiting a ground rendered unstable by human activity – or at least certain activities undertaken by some humans. From the late 1980s, studies of global climate moved in the direction of rapid rather than gradual change,[4] while the 1987-2015 International Geosphere-Biosphere Programme's more general explorations of the way the Earth operated as a unified system also pointed towards the possibility of changes in the planet's overall operating state. The latter 1980s and 1990s was also a time of ascending interest in the more-than-human in the social sciences and humanities. In a prescient 1984 essay ecophilosopher David Abram at once took inspiration from the idea of mutually implicated biological and inorganic processes – and offered a cautionary note about assuming planetary perspectives. As he reflected: "one's senses are … interwoven within a single specific region of the planet. … Gaia reveals herself to us only locally, though particular places."[5] In a similar vein, science studies scholar Donna Haraway admonished those who performed "the god trick of seeing everything from nowhere" in favour of acknowledging the location and the partiality of all knowledge claims.[6]

While Haraway's intent seems not to have been the preclusion of any particular scale or field of research, her singling out of the problematic planetary gaze of militaristic science projects and her pointed question about "who speaks for the earth?"[7] seemed to instil a suspicion of planet-oriented thought in many readers – which helped set the scene for the later reception of the Anthropocene concept in the humanities and social sciences. Consequently, many social thinkers reacted to the hypothesis of a novel human-induced geological epoch by asking who is making the claim and which humans they have in mind. When political scientist Eva Lövbrand and her colleagues inquire "Who speaks for the future of Earth?" in the Anthropocene context, the unsurprising answer is a resistance to "unified accounts of 'the human',"

[4] Wallace S. Broeker, "Unpleasant surprises in the greenhouse?" *Nature*, 328 (1987): 123–6.
[5] David Abram, "The perceptual implications of Gaia" (1984). Available at: https://wildethics.org/essay/the-perceptual-implications-of-gaia/ (accessed 13 August 2023). Unpag.
[6] Donna Haraway, "Situated knowledges: The science question in feminism and the privilege of partial perspective." *Feminist Studies* 14: 3 (1988): 575–599, p 581.
[7] Donna Haraway, "The promises of monsters: a regenerative politics for inappropriate/d others," in Lawrence Grossberg, Cary Nelson and Paula Treichler (eds*) Cultural Studies*, (New York: Routledge, 1992) 295–336, p 318.

and an exhortation to reckon with cultural and historical diversity.[8] As Lövbrand and her co-authors conclude: "Numerous studies have illustrated how global representations of environmental problems such as climate change are complicated and challenged when they meet the local and every-day life of particular people and places."[9]

One would be hard-pressed to find social thinkers in any discipline who do not affirm the importance of daily life and the wider social, historical and cultural worlding processes that give meaning to such experience. But when we are speaking of the Earth, its formations and dynamics, the question of situatedness is hardly resolved by returning to social categories, even when the social or the human is permitted to mix its forces with nature. This is where the idea of Gondwanaland – "the largest unit of continental crust for more than two hundred million years"[10]– offers its provocation, in ways that are more easily evaded when the main issue is human influence on Earth and life processes. For there is no lived experience of the remains of the ancient mega-continent that does not sooner-or-later find itself confronting the decidedly unlived dimensions of planetary existence, no present and place-based inhabitation that does not grate against Gondwana's unfathomably vast spatio-temporal displacements. Or at least that is the case if we take our bearings from the geosciences.

In western thought, such confrontation with an inhuman Earth has of course been some time in the making, lurching from the eighteenth-century opening up of deep geological time, through nineteenth-century evolutionary theory, to early twentieth century continental drift hypotheses and the later confirmation of plate tectonics. The current conjuncture is complicated. The mainstreaming of anthropogenic climate change and the idea of a human-triggered geological epoch in the opening decades of the twenty-first century has both focused attention on the ubiquity of the human footprint and seen the matter of a prehuman Earth get ever more enmeshed with the threat of a post-human planet. But something else important

[8] E Lövbrand, S Beck, J Chilvers, T Forsyth, J Hedrén, M Hulme, R Lidskog and E Vasileiadou. "Who speaks for the future of Earth? How critical social science can extend the conversation on the Anthropocene." *Global Environmental Change*, 32 (Supp. C): 211–18, p 216.
[9] Lövbrand, op cit, 214.
[10] T Torsvik and L R Cocks, "Gondwana from top to base in space and time", *Gondwana Research* 24 (2013): 999-1030, p.1000.

has been unfolding, if perhaps overshadowed by the prioritization of Earth processes in which human and extra-human forces are problematically mixed.

Over the last fifteen years or so geoscientists have made significant advances in integrating the dynamics of the inner and outer Earth. This is partly a matter of improved techniques for studying the composition and dynamics of the subcrustal Earth, but it's also about taking advantage of growing computational power and novel data-sharing practices. As geophysicist Sabin Zahirovic and his colleagues explain:

> time evolving 4D Earth models have … provided insights on the evolution of the plate-mantle system over supercontinent cycles, as well as shed important insights into the role of the churning planetary interior in vertical motion of tectonic plates and the continents they carry.[11]

Reference to "vertical" motion here is crucial. Whereas the idea of horizontally mobile blocks of crust is entrenched in scientific and popular imaginations, the new reconstructions direct attention to both the processes through which crustal material is recycled in the Earth's interior and to ongoing interactions of the mantle layer with the lid of hardened rock that rafts upon it.

Clearly, novel insights into supercontinent cycles and the dynamics of the inner Earth have potential implications for the way we envision Gondwanaland and set it to work. But as *Ghosts of Gondwana* and other recent evocations of the mega-continent remind us, it matters who speaks and from where. What becomes of mandates to apprehend the Earth "locally, though particular places" when significant aspects of the shaping of the planet defy practical or sensual engagement? At the same time, what does "cultural" and "historical" specificity mean when Indigenous peoples, often amongst the most vocal critics of Western epistemic global dominance, are themselves engaged in world-making activity "on an increasingly planetary scale."[12]

Rather than seeking to resolve these questions, I want to take some excursions through the Gondwana story that approach them obliquely. Whereas much critical

[11] S Zahirovic, T Salles T, R D Müller et al, "From Paleogeographic maps to evolving deep-time digital Earth models". *Acta Geologica Sinica.* 93: supp.1 (2019): 73–75, p.73.
[12] Mary Louise Pratt, *Planetary Longings*. (Durham: Duke University Press, 2022) p. 113.

and policy-oriented framing of the planetary predicament assumes that there are multiple human voices jostling on a single planet, my approach – developed in collaboration with Bronislaw Szerszynski – takes off from the idea that human multiplicity expresses and channels a multiplicity proper to the planet itself.[13] Taking inspiration from Gayatri Chakravorty Spivak's notion of planetarity – which insightfully positioned human alterity within the unassimilable forces of the Earth,[14] we build on a subsequent quarter century of geoscience exploration of the capacity of the Earth to systematically self-transform.

The following section reviews the new capabilities for 4D modelling of Gondwana and other crustal formations. I then return to Craw and Hubbard's notion of a hybrid Aotearoa and look more closely at the way Craw and fellow New Zealand biologists sought to deconstruct the binary of rock and life by weaving together insights from Jacques Derrida and biogeographer Leon Croizat. From there we change hemispheres and engage with Giles Deleuze and Félix Guattari's reflections on the philosophy of Ancient Greece. Taking their more general proposition that "thinking takes place in the relationship between territory and the Earth"[15] as an incitement, I dig deeper into the matter of how a thinking being arose on Earth, bringing us to the possible Gondwanan origins of primates. The final section draws together the idea of Gondwana and the changes signalled by the Anthropocene hypothesis, raising questions about what kind of guidance and mediation we might look for as we confront the possibility of passing over thresholds in the Earth system – limits beyond which lie new and threatening "other worlds".

Gondwana in 4D

Problems like climate change, biodiversity loss and altered geochemical cycles – the threats collated by the Anthropocene concept – draw attention to mutual relations between humans and Earth processes. We might see the human-Earth system interface, however, as one aspect of a broader thematic of putting the Earth in contact

[13] Nigel Clark and Bronislaw Szerszynski. *Planetary social thought: the Anthropocene challenge to the social sciences* (Cambridge: Polity, 2021).

[14] Gayatri Charavorty Spivak, "Planetarity", in *Death of a Discipline*, (New York: Columbia University Press, 2003): 71-102.

[15] Giles Deleuze and Félix Guattari, *What Is Philosophy?* (New York: Columbia University Press, 1994) p. 85.

with itself, in which deepening scientific understanding of the interaction between different components of the Earth system opened the way to understanding of the planet as having multiple possible operating states. Perhaps of more lasting significance than its pronouncement on human impacts, Anthropocene science has foregrounded exchanges between the lithic crust and the more fluid envelope of the outer Earth system.[16] Whereas the notion of an Earth system built on the Gaia hypothesis and its merger of biological life and atmospheric process into a single system, the plate tectonic hypothesis – confirmed in the late 1960s-early 1970s – was even more pivotal for envisioning the Earth as a unified and dynamic whole.

Its worth recalling that before attention shifted to the flows and circulations of the outer Earth system, plate tectonics had already begun to integrate the geodynamics of the crustal and subcrustal Earth. Whereas early twentieth-century theories of continental drift struggled to explain the mobility of the Earth's crust, it was the theory of mantle convection – proposed by geologist Arthur Holmes in 1919 and bolstered by harder evidence in the post-war period – that eventually provided a convincing mechanism.[17] Current theories contend that at a certain point in the Earth's history flowing mantle rock self-organized into convection cycles driven from the bottom up – as hot, buoyant subcrustal material ascended, and from the top down – as dense tectonic plate slabs sank or "subducted" beneath the crust.[18] New research indicates that not all changes occur at the interminably slow pace previously thought to characterise mantle-crust relations. While increasingly complex models help explain the immensely long-term cycles of supercontinent accretion and break-up, they also point toward faster changes – "sudden and perhaps catastrophic movements of material and heat."[19] Possible chaotic behaviour of the deep Earth include avalanches in the lower mantle; rapid collapses that are under consideration as possible triggers for the upwellings of superheated rock known as mantle plumes.[20]

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[16] Will Steffen, Reinhold Leinfelder, Jan Zalasiewicz, Colin Waters, Mark Williams, Colin Summerhayes, Anthony Barnosky, Alejandro Cearreta, Paul Crutzen et al. (2016) 'Stratigraphic and Earth System approaches to defining the Anthropocene,", *Earth's Future,* 4:8(2016): 324–45.
[17] N Coltice, M Gérault and M Ulvrová, "A mantle convection perspective on global tectonics," *Earth-Science Reviews* 165 (2017): 120-150.
[18] W Ernst, "Earth's thermal evolution, mantle convection, and Hadean onset of plate tectonics," *Journal of Asian Earth Sciences.* 145 (2017): 334-348.
[19] G Schubert, D Turcotte and P Olson P (2001) *Mantle Convection in the Earth and Planets.* (Cambridge: Cambridge University Press, 2001) p.626.
[20] R Muller, "Avalanches at the core-mantle boundary," *Geophysical Research Letters*. 29: 19 (2002): 41: 1-4.

With growing degrees of confidence, researchers are making connections between dynamic inner Earth processes and specific events in outer Earth history. A combination of techniques including seismic tomography (a form of remote sensing of subsurface "inconsistencies" that involves tracking the signals generated by natural Earth tremors), geological reconstruction of past and present configurations of tectonic plates, and powerful computational modelling is being used to generate the long-term time-evolving simulations of the 4D Earth that we encountered in the introduction. Open access digital data covering the last billion years of "the entire Earth system" now has enough resolution to link inner Earth dynamics not only to the evolution of continents or supercontinents but to the most tectonically complex areas such as the Caribbean and Southeast Asia.[21] By modelling feedbacks between tectonic plate motion and the evolving deep interior of the Earth, these data sets further cast light on outer Earth processes such as rising and falling sea levels, long term climate and ocean circulation change, and the evolutionary pathways and dispersals of biological life.[22]

By the 1920s Alfred Wegener and his contemporaries were using evidence of the distribution of life as a vital supplement to the interlocking jigsaw of adjacent landmasses. But as some biogeographers were already arguing in 1980s, Wegener and many subsequent researchers largely treated continents as permanent masses which maintained their integrity and basic contours as they shifted around the planet.[23] Recent reconstructions reveal much more complexity, complicating the idea of basic reconfiguration of landmasses with evidence of more composite formations and drawing out connections with a richer array of Earth and life processes. In this regard, paleobiologist Stephen McLoughline's depiction of the disintegration of Gondwana resonates with Craw and Hubbard's account of the geodynamics of Aotearoa New Zealand:

> From a biogeographic perspective the Jurassic–Holocene history of Gondwana has commonly been viewed as a simple sequence of

[21] RD Müller, J Cannon, X Qin et al, "GPlates: Building a virtual Earth through deep time," *Geochemistry, Geophysics, Geosystems.* 19 (2018): 2243–2261. https://doi.org/10.1029/2018GC007584
[22] Zahirovic et al, "From Paleogeographic maps"
[23] JR Grehan, "Panbiogeography and Evolution," *Rivista di Biologia Biology Forum* 81: 4 (1988) 469-498.

> diverging terranes, hosting progressively more isolated and distinctive biotas through time. However, the breakup history of Gondwana should be considered as a reticulate and multidimensional pattern of separating and amalgamating landmasses, fluctuating climates, emergence of terrane-linking island arcs, intermittent orogenesis, sporadic marine transgressions and regressions and a changing mosaic of soil substrates.[24]

Likewise, field studies suggest that as the Indian plate drifted north toward its momentous collision with Asia, it encountered – if not quite the mythical lost continent of Lemuria[25] – then certainly more than empty ocean. According to geologist Jonathan Aitchison and his co-authors: "It is now apparent that Neo-Tethys was like large oceans present today in which intraoceanic island arcs, plateaus, seamounts and other bathymetrically positive features exist."[26] Material from some of these formations was swept up and incorporated in the suture zone, which helps explain its observed stratigraphic complexity.

While plate tectonics propelled by the coupled lithic-convective mantle system is credited with being the predominant force shaping outer Earth, mantle flow exerts its own influence on the crust above it – resulting in deformations such as uplift, stretching, rifting and subsidence as well as occasional extrusions of molten mantle material.[27] There is also growing evidence that, just as upwelling melted mantle material contributes directly to the shaping of surface topography, so too do "conveyor belts" pull both organic and inorganic matter deep into the subcrustal Earth.[28] In the words of geologists Terry Plank and Craig Manning "subduction links surface biological processes with the deep Earth, creating a planet suffused with the signature of life".[29]

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[24] S McLoughlin, "The breakup history of Gondwana and its impact on pre-Cenozoic floristic provincialism," *Australian Journal of Botany*. 49 (2001): 271-300, p 283-4.
[25] Sumathi Ramaswamy, *The Lost Land of Lemuria: Fabulous Geographies, Catastrophic Histories* (Berkeley CA: University of California Press, 2004)
[26] J Aitchison, J Ali and A Davis, "When and where did India and Asia collide?" *Journal of Geophysical Research*. 112 (2007) B05423, doi:10.1029/2006JB004706, p.6.
[27] D Davies, A Valentine, S Kramer, N Rawlinson, M Hoggard, C Eakin and C Wilson "Earth's multi-scale topographic response to global mantle flow," *Nature Geoscience* 12 (2019): 845-50.
[28] RD Müller, B Mather, A Dutkiewicz et al, "Evolution of Earth's tectonic carbon conveyor belt," *Nature* 605 (2022): 629-639.
[29]T Plank and C Manning (2019) "Subducting carbon," *Nature* 574 (2019): 343-352, p. 343.

Recognising that sedimented, lithified remains of once living creatures are drawn deep into the subcrustal Earth is not the same thing as asserting the entire planet is alive – though it is a further step in the conceptual integration of the outer and inner Earth. But what difference does this growing detail, complexity and nuance, and the addition of deep verticality to an already abyssal temporal depth, make for those of us who find ourselves rafting on or near remnant fragments of Gondwana? What might it mean for thinking more generally about life – human and otherwise? This brings us back to Craw and Hubbard's attempt to carve out a social and culturally relevant storyline for the composite formation Aotearoa, and to the biogeographic and philosophical thinking that informed this project.

Originary complications of Earth and life

While South African statesman and polymath Jan Smuts drew on the work of compatriot geologist Alex du Toit to position South African at the core of Gondwanaland,[30] successive New Zealand commentators seem to have been content to view their islands as eccentric breakaways from the southern mega-continent. The intention, however, looks to be similar: furnishing a credible origin story with an epicentre underived from the metropoles of Europe or the North Atlantic. It is the afterlife of this imaginary that Craw and Hubbard were contesting with their narrative of a composite and hybrid Aotearoa. As Craw made clear elsewhere, science is by no means immune from such longings. In a critical intervention into nationalist themes in New Zealand natural science, he noted that, as early as the 1870s, researchers in the dominion were intent on countering the Victorian notion that evolution's worthiest creations had sprung from a northern soil:

> local geologist T.H Cockburn-Hood developed the notion of a great ancient bird-inhabited Pacific continent from whence New Zealand's native life originated. He named this lost Pacifica APTERYXIA

[30] Saul Dubow, "Adventures in Gondwana: Science in the South," *RCC Perspectives: 1, The Edges of Environmental History: Honouring Jane Carruthers* (2014): 87-92.

(after Apteryx, the generic name of the kiwi) with an "equal right to be delineated" as any European theoretical construct.[31]

But Craw's chief target was less phantasmal. His own research came out of a tradition of biogeography and evolutionary thinking that explicitly contested the enduring Darwinian idea of unitary centres of origin.[32] As Darwin wrote in *On the Origin of Species*: "the simplicity of the view that each species was first produced within a single region captivates the mind"[33] – from which followed his basic principle that "descent with modification" occurred as organisms subsequently dispersed across the Earth's surface.[34] In the Cross Pollination essay, as we have seen, Craw and Hubbard present an alternative view of the landmass and biota of Aotearoa converging from multiple origins which they extend to include the island arc's human populations. Subsequent research connecting the now largely submerged Te Riu-a-Māui/Zealandia continent to Gondwana raises questions about the geological thinking informing this vision, although evidence from the 4D mapping of geodynamics lends support to other aspects of Craw's biogeography.

The essay also encapsulated a cosmopolitan current in cultural thought in which ideas of stable identity were subjected to interrogation and notions of mixity, fluidity and hybridity proliferated.[35] This was reflected in Hubbard's curatorial practice which involved mostly younger Māori artists working in non-traditional media often in collaborations with Pākehā artists, and in his work with the band Upper Hutt Posse who musically fused Māori and Black American radicalism.[36] For Craw and a group of largely New Zealand based biologists, this was also a moment which French post-structural thought offered new intellectual resources for confronting the centres of origin narrative that they believed still dominated mainstream Neo-Darwinist evolutionary thought.

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[31] Robin Craw, "Visible Difference: Nationalist Repertoires and the Semiotics of Place in New Zealand Science," *Antic* 8 (1990):4-7, p.6.

[32] Craw and Heads, "Reading Croizat", Robin Craw, "Foreword," *New Zealand Journal of Zoology* 16: 4 (1989): i-iv 528; Leon Croizat, *Space, Time, Form: The Biological Synthesis*. (Caracas: Self Published, 1962): 56.

[33] Charles Darwin, *The Origin of Species* (Oxford: Oxford University Press, 1959) p. 382; see also J Grehan, "Panbiogeography and evolution," *Rivista di Biologia Biology Forum* 81: 4 (1988): 469-498.

[34] Craw and Heads, "Reading Croizat."

[35] Cf Dubow, "Adventures in Gondwana."

[36] Anne-Marie White and Robert Leonard "George Hubbard: The hand that rocked the cradle," *Reading Room* 8 (2018): 30-54.

Derrida featured, but for most of the youngish cohort of New Zealand biologists the main influence was the "panbiogeographical" approach of the maverick Italian-Venezuelan botanist Leon Croizat, who Craw once referred to as "our fellow Gondwanan."[37] As Croizat summed up his perspective on evolution in one of his self-published tomes: "Form-making is by its very essence diffusive … not a miracle of nature brightly flaring out at some particular spot of the earth."[38] In place of unitary origins, he proposed that ancestral organisms were widely dispersed and diverse, or what is referred to in biogeography as vicariance. Although life's own mobilism was certainly a factor, Croizat insisted that geological processes played the primary role in severing ancestral populations from one another and setting them on different evolutionary trajectories – which also meant that very different taxa followed similar geologically predicated pathways. As he put it: *"Earth and life evolved together: dispersal forever repeats because geology forever does the same."*[39] Although writing prior to the confirmation of plate tectonics, Croizat chastised other biogeographers and evolutionary thinkers for assuming a "background of a geology like the present one,"[40] his alternative view constantly stressing the impact of fracture and suture zones, uplift, marine incursion and other geodynamic processes on life, in what he referred to as "the incredible tangle of tectonics and life."[41]

For the New Zealand panbiogeographers, writing from the late 1970s, emergent reconstructions of plate tectonics and related geodynamics appeared to support Croizat's basic premises about the co-construction of Earth and life, which they felt were supported by evidence of the distribution taxa from the field. As Craw elaborated:

> most, if not all, of the world's continent landmasses are not permanent and stable, but rather composite formations that have been formed by the accretion of crustal blocks since the Permian. The geological and

[37] Robin Craw, "Essay Review: How to be a Good Biogeographer in 1979," *Tuatara* 24: 1 (1979) :81-87, p.81.

[38] Croizat, *Space, Time, Form* 200.
[39] Croizat, op cit 338.
[40] Croizat op cit 292.
[41] Croizat op cit 68.

> geophysical findings of the 1980s promise to corroborate Croizat's biogeographic work, in novel and exciting ways.[42]

In spite of Wegener's linking of biogeography and continental drift and some of Darwin's own geological speculations, Craw and his co-authors noted, most mid-twentieth century evolutionary thinkers remained convinced that relatively recent events, notably Pleistocene glaciations, were the primary influence on plant and animal distribution.[43] Even after the acceptance of plate tectonics, argued Craw and his colleagues, evolutionary theorists stayed focused on timescales too restricted to encompass major events like the breakup of Gondwana. Neo-Darwinians continued to view chance dispersal, including the 'sweepstake" of ocean crossing, as the best explanation for the observable distribution of life, rather than contemplating a deeper temporal schema of life rafting on mobile blocks or fragments of crust.

But even the acceptance of the evolutionary implications of Gondwana and its disintegration – more common amongst Southern hemisphere biologists – did not go far enough if it merely translocated the idea of a unitary centre of origin to a great southern continent. As Craw summed up the work of New Zealand's preeminent biogeographer: "Fleming accepts that here have been massive changes in the past in the geography of the globe but to this mobilist past geography he transfers dispersal routes tailored to fit a stabilist geography of the past."[44] The importance of geodynamics for evolution, in short, was more than a matter of laterally drifting landmasses. What Craw and his compatriots took from Croizat was the insistence on a much more complex and dynamic interplay of life and tectonic geology, vertical as well as horizontal, the present and the past implicated in ways other than simple stratigraphic superposition. Organisms themselves may have phases of mobility, they insisted, but a big part of their survival and form-making was a matter of riding out geological upheavals, which often meant staying more-or-less in place. Especially during bursts of tectonic activity, flora and fauna frequently move from older to newer geological surfaces, and in this way, they effectively traversed geological

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[42] Robin Craw, "Croizat's biogeographical work: a personal appreciation" in R Craw and G W Gibbs (eds) *Croizat's Panbiogeography and Principia Botanica* (Wellington: Victoria University, 1984) 8-13, p. 11.
[43] Robin Craw, John Grehan and Michael Heads, *Panbiogeography: Tracking the History of Life* (New York: Oxford University Press, 1999) pp. 31, & 148.
[44] Craw, "Essay review" 85.

strata. Consequently, as Croizat observed, "*very new stratigraphy may harbour very ancient life*."[45] As Craw and his co-authors elaborate:

> Despite all these geological upheavals, organisms may survive in the general vicinity by moving between these changing surfaces—effectively a biological layer or living stratum. As a result, descendants of ancient Mesozoic life forms can exist more or less in situ and move onto much younger Tertiary strata. Life evolves biogeographically as if it were another geological stratum.[46]

Crucial to this narrative is that the interplay of Earth and life involves an always already diverse ancestral matrix: it is a matter of "evolution on a broad front."[47] It is in this sense, for Craw and Heads that Croizat's refusal of the Darwinian enthrallment with points of origin anticipates Derrida's later troubling of the idea of simple, discernable origins. But Croizat's "deconstruction of European biological philosophy" went further than this.[48] Observing how organisms moved across strata, Croizat reflects "the life of the present is virtually fossil and living at the same time,"[49] again, as Craw and Heads suggest, resonating with Derrida's later work on memory and the trace structure of the past in the present.

The panbiogeographic approach was and is controversial, and Croizat remains a fringe figure in evolutionary theory. Whether its appeal to a cohort of biologist reflects specificities of New Zealand geology and biogeography is also up for debate. As one reviewer remarked: "The panbiogeographic approach may be stimulating in archaic and insular New Zealand, but it has limited relevance in continents that have been subject to massive climatic changes, range shifts, and extinctions.[50] This critique might be turned around, however. For there is much in the notion of an interplay of life and geology – the idea of life "as a geological layer of the earth"[51] that anticipates the Anthropocene hypothesis. Moreover, in their foregrounding of composite tectonic

[45] Croizat, *Space, Time, Form* 259.
[46] Craw et al *Panbiogeography* 45.
[47] Craw and Heads "Reading Croizat" 502.
[48] Craw and Heads op cit 511.
[49] cited in Craw and Heads, op cit 507.
[50] A Keast, "Commentary: Panbiogeography: then and now," *Quarterly Review of Biology*, 66: 4 (1991): 467-472, p. 471.
[51] Croizat *Space, Time, Form* 90.

landscapes and finely detailed interactions of life with geodynamics, the New Zealand panbiogeographers seem prescient in the light of subsequent advances in 4D modelling.[52]

But the question remains where does this leave "us" as observers and contemporary dwellers on or near Gondwana's fragments? Where is thought itself - the thinking subject - positioned when it grapples with shifting, uplifting, down-warping landmasses, both past and present? This is a question I want to track back to the European heartland of a certain tradition of thought. Or rather, as we will see, back to the composite, convoluted fringes of the other end of the former Gondwana.

Earthly origins of thought

Craw and Hubbard's Cross Pollination essay appeared in the same year as Derrida's *L'autre Cap – The Other Heading* – an engagement with the question of European identity that explored the differences dividing Europe from within. Here Derrida described himself as one who, "not quite European, since I come from the southern coast of the Mediterranean, considers himself … to be a sort of over-culturated, over-colonized European hybrid."[53] Or as we might say, he had a foot in both ancient Laurasia and Gondwanaland. Craw had earlier suggested something along these lines, as he reflected on the fact that Derrida, who had recently shifted to the USA, shared with Croizat - who had moved from Italy to Venezuela via the USA - a similar traversal of the planet's great geophysical divides: "Thus the respective biography/biogeography of the two can be oriented on an Atlantic-Mediterranean baseline."[54] The idea that Derrida's troubling of identity through a groundless self-differentiating structural logic could be pushed all the way through life to the Earth and cosmos would re-emerge as a theme in Australian materialist feminist thought.[55] But Craw and his collaborators were prescient in seizing the opportunity to literalize the "abyssal" deferral of the origin to the opening of ocean basins, the play of tectonic

[52] See Craw et al *Panbiogeography* 40.
[53] Jacques Derrida, *The Other Heading: Reflections on Today's Europe* (Bloomington IN: Indiana University Press, 1992) 7.
[54]Craw and Heads "Reading Croizat" 505.
[55] See esp. Vicki Kirby *Quantum Anthropologies: Life at Large* (Durham, NC: Duke University Press, 2011) 34.

forces and the co-implication of rock and life – in the process teasing out certain 'geophilosophical' possibilities that Derrida himself barely hinted at.

This is, of course, terrain more explicitly tilled by Deleuze and Guattari. Deeply evocative, the discussion of geophilosophy in their final collaborative work *What is Philosophy?* can also feel perplexing and counterintuitive. Like many other continental philosophers, Derrida among them, Deleuze and Guattari return to the question of the "miraculous" emergence of philosophy in ancient Greece. This was a matter tied up with broader questions about the "national characteristics" of European philosophy, issues that had taken on new and disturbing connotations after the rise of Nazi Germany.[56] Eschewing both older claims for the foundation of philosophy in Greek "soil" and more recent refusals of any real connection between thought and a terrestrial substrate, Deleuze and Guattari offer another option. Becoming grounded in a particular territory was something the Greeks had to creatively work towards, they proposed, while the physical Earth the Greek people dwelled upon was itself constantly shifting and changeable.[57] And somehow – contingently or non-deterministically – from the experience of strangers forging a shared homeland out of rugged and tumultuous terrain, those who became Greeks generated ways of thinking that were more able to break free of their social and physical context than any previous thought.

The argument may be clearer if we consider the details. As Deleuze and Guattari note, following Nietzsche, key founders of Greek philosophy were immigrants. They were landless, deracinated "strangers" who came to Greece seeking "a freedom and mobility denied to them" by older, more rigidified empires to the East.[58] What helped make Greece an inviting milieu, add Deleuze and Guattari, was its physical geography. Greece presented itself to those on the move as a "fractal structure" of peninsulas,[59] in Rudolphe Gasché's elaboration, as "a land divided from within by its coastline, a land without interiority."[60] As with much of the Eastern Mediterranean, what had shaped Greece was a dynamic and turbulent geology. The region was earthquake prone, relationships between land and sea subject to sudden,

[56] Deleuze and Guattari, *What Is Philosophy?* 102-7.
[57] Op cit 101-2.
[58] Op cit 87.
[59] Op cit 87.
[60] Rodolphe Gasché *Geophilosophy* (Evanston, IL: Northwestern University Press, 2014) 87.

chaotic reconfiguration. Or in Deleuze and Guattari's formulation, it was an Earth that "constantly carries out a movement of deterritorialization on the spot." [61]

The irony that Deleuze and Guattari were underlining was that Europeans looked to a Greek homeland as the originary ground of philosophy that in actuality was both peopled by strangers and prone to the further estrangement of geological upheaval. But if this situation happened to have sparked a certain kind of philosophical thought, their broader point was that Greece was far from unique. All philosophical thought, as Deleuze and Guattari would have it, is ultimately open to and animated by the dynamism of the Earth and cosmos – even as it devotes itself to trying to construct a coherent, liveable world out of this predicament. "Philosophy is a geophilosophy", they insist, "in precisely the same way that history is a geohistory from Braudel's point of view."[62]

All this may not be as distant from Gondwanaland as it first appears. For a start, we should keep in mind that geologically speaking, Europe – the home of "continental philosophers" - is far from a coherent entity. Much of the Eastern Mediterranean, including Greece, is a "peri-Gondwanan mosaic" in the words of geologist Olga Zlatkin and her colleagues: an assemblage of fragments from a terrane (a distinctive crustal block) that drifted across the long-lost Iapetus Ocean before docking with the continental mass then being formed from the collision of the cratons (large, coherent, extremely long-lived slabs of crust) of Laurentia and Baltica.[63] But this occurred some 400 million years ago, deep in the Paleozoic and early in the colonization of land by plants and animals, so we are still a long way from implicating the evolutionary developments that eventuated in a thinking being in the geodynamics of Gondwanaland.

To put it another way, humans are offshoots of the mammalian order of primates, and the prevalent reading of the fossil record is that primates evolved too recently to have been impacted by major tectonic events. This view has always faced a major problem, however. It needs to explain how primates came to be distributed across Africa and South America – for which the best explanation has been wildly

[61] Deleuze and Guattari, *What Is Philosophy?* 85.
[62] Op cit 95.
[63] O Zlatkin, D Avigad and A Gerdes, "The Pelagonian terrane of Greece in the peri-Gondwanan mosaic of the Eastern Mediterranean: Implications for the geological evolution of Avalonia," *Precambrian Research* 290 (2017): 163–183.

improbable trans-oceanic rafting events.[64] An alternative view is advanced by Michael Heads, Craw's collaborator and fellow deconstructivist. Rejecting the assumption of a single localized primate centre of origin – which still accepted by many primatologists, Heads proposes a widespread polymorphous primate ancestor distributed across Africa, Madagascar, Southeast Asia and South America.[65] Whereas the dominant view takes the earliest recovered fossil, dated 56 million years ago, as the time of primate emergence, Heads combines evidence from nuclear DNA studies and radiometrically dated plate tectonics to push back primate emergence to the early Jurassic, some 185 million years ago. This admittedly "radical step" dispenses with any need for 'sweepstake" oceanic rafting – because it reaches back to still largely intact Gondwana.[66] Indeed, in Heads' view, it is the Pangea-Gondwana breakup and associated geodynamic processes that separates ancestral primates, resulting in their evolutionary divergence.[67]

Recalibrating the primate story so that it "fits easily with the chronological sequence of great rifting events which broke up Pangea and Gondwana"[68] does not seamlessly connect the big picture of plate tectonics with emergence of our own species or genus. But it does offer a backstory for subsequent primate evolution in which geodynamics are a key variable. More than this, it taps into and draws support from the increasingly integrated and complex 4D models of earth processes we looked at earlier. At numerous junctures in Heads' account, what matters are not simply the broad contours of continental drift but the finer-grained details now available. Divergence of primate populations is keyed to moments of marine incursion and regression, episodes of uplift and mountain-building, the jostling of continental fragments and the presence of particular ecosystems.[69] What was formerly viewed as empty ocean – such as the sea that lay between India and pre-collision Asia – is now seen to be punctuated by island arcs, continental fragments

[64] Michael Heads, "Evolution and biogeography of primates: A new model based on plate tectonics, molecular phylogenetics and vicariance," *Zoologica Scripta*, 39 (2010): 1–21; Michael Heads, *Molecular Panbiogeography of the Tropics*. (Berkeley: University of California Press, 2012): pp 129 & 229.
[65] Heads, "Evolution and biogeography" 15.
[66] Heads, op cit 14
[67] Heads, *Molecular Panbiogeography* 201.
[68] Heads "Evolution and biogeography" 13.
[69] Heads, *Molecular Panbiogeography* ch 4-5.

and plateaus that may have been home to early or -proto-primates.[70] The connection with inner Earth process too is significant, particularly as major extrusions of magma can at once divide populations of organisms and erase the evidence of their earlier inhabitation, as Heads suggests may have been the case with the bursts of volcanism in the Karoo basin southern Africa that have been linked to the beginning of the Gondwana breakup.[71]

While there is little doubt that the continents were very nearly in their current locations when the primate genus *Homo* appeared, we shouldn't forget that the underlying geodynamic processes were and are still in play. As geologists note, the East African rift is currently the largest and longest lasting example of the extensional faulting that occurs when the pressure of rising magma stretches and cracks the rigid Earth's crust, and recent work has explored the role of this tectonic activity in shaping the landscape in which humans and their hominin ancestors look to have evolved.[72] While nobody is linking it directly to the trajectory of human evolution, a ghostly fragment of Gondwana's breakup has also entered the picture. Geophysicists have identified a huge slab of subducted rock from the Tethys Ocean, which they believe has been slowly drifting through the Earth's mantle layers since the late Jurassic.[73] Most likely composed in part from the sedimented skeletons of Mesozoic marine creatures, the slab appears to have intercepted and modified plume activity in this region and in this way would have helped shape the physical environment in which our own distant ancestors emerged.

We are far from joining all the dots, and the connections I have drawn between Gondwanan geodynamics and the emergence of our species are both speculative and contentious. But the point of Deleuze and Guattari's reflections on Greek philosophy is not simply to situate a particular turn in human thought in a specific physical milieu. It is also to open the question of how our planet self-transforms, how it probes its own limits and explores its own possibilities – which in

[70] Heads, "Evolution and biogeography" 10; see also Aitchison et al, "When and where did India and Asia collide?"
[71] Heads, *Molecular Panbiogeography* 206, 222.
[72] Geoffrey King and Geoff Bailey, "Tectonics and human evolution," *Antiquity,* 80: 308 (2006) 265–86.
[73] SJ Chang, E Kendall, A Davaille and A Ferreira, "The evolution of mantle plumes in East Africa," *Journal of Geophysical Research: Solid Earth* (2020) 10.1029/2020JB019929

turn has profound implications for how we, as terrestrial beings, experience and negotiate these changes.

Negotiating Planetary Thresholds

Understandably, social thinkers have insisted that the reception of the intellectual labours of Anthropocene science – as with any knowledge claim – must account for the context from which it emerged. But we need to be careful of the way this is done. If our framing of location is too restrictive, we run the risk of tracking thought back to focal points or originary centres – which is much the same manoeuvre that deconstructive biogeographers have called into question in mainstream explanations of species divergence. As literary theorist Alberto Moreiras reminds us, 'no thinking exhausts itself in its conditions of enunciation.'[74] In other words, while holding onto the promise of situating knowledge, we need to leave room for what is excessive or unassimilable in thought – including the very forces that incite and make possible our thinking processes.

One of the provocations of the Anthropocene, then, is to consider how our current location might include the predicament of finding ourselves at the threshold or juncture between two different operating states of the Earth system – however much that locus defies precise identification. In a related way, geologically informed narratives about Gondwana suggest to many of us that we 'positioned' on blocks or fragments of dispersed mega-continent. In this concluding section, informed by the various modes of 4D planetary thinking we have looked at, I want to ask what it might mean to think, together and simultaneously, a Gondwanan positioning and the experience of passing into a novel Earth system.

While no one is suggesting that climate change is going to reconfigure tectonic plates, major climate change and more generalized Earth system transitions offer greatly accelerated versions of some of the major impacts of continental reorganization. Anthropogenic combustion of fossil fuels has similar effects to release of mantle-derived CO_2 during supercontinent break-up, melting icecaps result in sea level increases as does supercontinent dispersal and the formation of new ocean

[74] Alberto Moreiras, *The Exhaustion of Difference: The Politics of Latin American Cultural Studies* (Durham: Duke University Press, 2001) p.24.

floor, and climate-driven redistribution of the loading of water and ice on the Earth's crust can trigger volcanic and seismic activity along plate boundary fault lines – although not on the scale associated with the making and breaking of supercontinents.[75]

While the vastly different timescales involved hinder meaningful comparison between the impact of rapid Earth system change and supercontinent cycles on the trajectory of organic evolution, it's interesting to note researchers conceding, relatively recently, that "whether the individual stages of organic evolution and extinction on the planet are closely linked to Solid Earth processes remains to be investigated."[76] But read in concert with recent generation 4D Earth system modelling, earlier panbiogeographical approaches foregrounding "the incredible tangle of tectonics and life" 'would seem to be applicable in cases of both rapid and gradual change. In particular, we might consider the principle that key evolutionary developments occur along broad fronts of geophysical transformation including marine incursion, the claim that certain patterns in the distribution of taxa recur where geodynamical processes are shared, and the idea that flora and fauna can more-or-less stay in place by migrating between older and newer geological formations. Just as some biogeographers direct our attention to active geological junctures as sites of form-making, so too should we recall Deleuze and Guattari's thesis that significant developments in human thought or sense-making take place along extensive zones of geographical complexity and geophysical instability – and their more general point that interesting new things often come about when humans or other actors move across different strata or compositional layers of the Earth.

None of this implies that we should expect to see the same reactions to climatic and Earth system change across all the dispersed fragments of the former Gondwana, or across Laurasia for that matter. What it might encourage us to do, however, is to look for emergent responses – both human and other-than-human – to accelerating change across broad fronts, and to seek patterns where populations encounter similar geophysical challenges. This may mean that, in certain cases, there

[75] See RD Nance, JB Murphy and M Santosh, "The supercontinent cycle: A retrospective essay," Gondwana Research 24 (2014): 4-29; Bill McGuire, "Hazardous responses of the solid Earth to a changing climate," in Bill McGuire and Mark Maslin (eds) *Climate Forcing of Geological Hazards* (Oxford: Royal Society and Wiley-Blackwell, 2013) p. 15.

[76] M. Santosh, "Supercontinent tectonics and biogeochemical cycle: A matter of 'life and death'," *Geoscience Frontiers* 1 (2010) 21-30, p.27.

will be commonalities that reach back, beyond the current configuration of landmasses, to earlier geohistorical associations. It could involve looking to formerly contiguous cratons or terranes, but so too might it direct our attention to common geodynamic evolution, such as asking what Aotearoa New Zealand shares with other composite peri-Gondwanan assemblages like the Eastern Mediterranean or the Eastern Tethys-Southeast Asian region.[77] This might also entail identifying shared inner Earth processes, such as plume activity and subducted slab transport.

We should be wary of the way narratives of human climate-induced migration echo the prioritizing of lateral movement in Western evolutionary thought and the way they seem to recapitulate notions of 'centres of origin' when it comes to identifying that which most under threat from mass displacement. Without ruling out horizontal mobilism as an active force, the work we have been looking at – in various ways – attunes us to more complex negotiations: the kind of crosscutting and often vertical movements from older to newer formations that trouble simple notions of linear temporality. Though we shouldn't push the analogy too far, there are resonances between Croizat's precept that "very new stratigraphy may harbour very ancient life" and Deleuze and Guattari's suggestion that migrants from adjacent, older civilizations established themselves in the physically unstable and socially formative milieu of Greece.

But no complication of matters of vertical and horizontal mobility should detract from the fact that most of the former Gondwana is peopled both by those with relatively long-term affiliations with place and those who are more recent arrivals: differences most often accompanied by profound power differentials. If this brings us resolutely back to the question of who speaks for the past and future of the Earth – I want to make a case for simultaneously accounting for powers, forces and formations that exceed the socio-historical conditioning of our utterances and the actions they inform. Which is to say that, whether we are confronting geological extremity, making contact with previously unencountered regions of the Earth or passing over a threshold into a novel planetary operating system, we are in a situation that defies precise identification and definition.

While sciences that are still predominantly western have brought the thematic of multiplicity or non-self-identity into the structure and workings of the Earth itself,

[77] See Zahirovic et al "Tectonic evolution".

providing meaningful guidance for the movement between known and unknown worlds is not their forte. Neither is this the strength of most critical social thought, where the preference is most often to be able to identify the contours of power and the capacity to make meaning in advance of any upheaval. In both cases, it is the constitutive exposure to forces that overflow contextual limits that Derrida is getting at when he speaks of a "hazardous abyssal generativity."[78] But it is telling that in many parts of the world where knowledge formations and ecologies of practice irreducible to Eurocentric modernity have endured, there is a formidable presence of figures or entities whose task is to help negotiate between ordinary and extraordinary domains.

As Hirini Melbourne recounted in the Ghosts of Gondwana, Māori conceive of certain forest creatures as mediators between day-to-day existence and the underworld. Fictionally gesturing towards Gondwanaland, the revenant pterosaur in Mahasweta Devi's novella *Pterodactyl, Puran Sahay, and Pirtha* does another version of intermediation by bridging the gulf between prehistoric time and the catastrophic present experienced by the India's contemporary tribal peoples.[79] Or as Croizat might say, it is "fossil and living at the same time." Such figures - spirits, deities, ancestors, agential animals, animated landforms – or what anthropologist Marisol de la Cadena, refers to as "Earth-beings" in the Andean context – may be called forth in situations where people confront physical challenges that cannot always be assimilated and overcome, and to help mediate environmentally or socially fraught predicaments.[80]

With analogies to the panbiogeographical account of the way evolutionary form building takes place along fault lines, sutures and other geological junctures, Earth-beings appear to gather around seismic and volcanic hotspots and other geodynamically active zones – including zones of devastation resulting from incursive colonial and capitalist social forces. Comparable powers and strategies can be observed at geographically distant locations where there are common physical and existential challenges. One such power is the ability to shift between human and nonhuman viewpoints. As geographer Adam Bobbette observes of Javanese animist

[78] Jacques Derrida, *Politics of Friendship* (London: Verso, 1997) p.208.
[79] Mahasweta Devi, "Pterodactyl, Puran Sahay, and Pirtha" in Imaginary Maps (Kolkata: Thema, 2015); see also Spivak, *Death of a Discipline*: pp.66-70, 80.
[80] Marisol de la Cadena, *Earth Beings: Ecologies of Practice across Andean Worlds*, (Durham, NC: Duke University Press, 2015); see also Clark and Szerszynski, *Planetary Social Thought* Ch 7.

communities living around active volcanoes: "Because perspectives can circulate amongst this world of forms, humans can be possessed by other perspectives while maintaining their unique bodily form."[81] While such "multi-perpectivalism" or "multi-naturalism" is often contrasted with the singular universal vantage point of western science, we should also note that it likewise exceeds the demands of critical social thinking to locate thought and practice within pre-existing socio-historical categorizations – and that it constitutively overspills the bounds of lived or everyday experience. Analogous to the Eastern Mediterranean philosophers celebrated by Deleuze and Guattari, those peoples who are capable of identifications beyond their human form might be seen as setting out from a particular terrestrial location while succeeding in freeing thought from its given milieu and taking it into another domain.

By the same logic, we might see Deleuze and Guattari's "strangers" – their soon-to-be Greek philosophers – as a kind of Earth-being: figures who negotiate between different cultural worlds and between the realm of the human and the dynamic Earth. So too, Craw and Hubbard's "hybrids" – figures who emerge from the geological, ecological and socio-cultural rifts and sutures of Aotearoa – might be viewed as counterpoints to the those other "Earth-beings" who rival evolutionary theorists summon to bolster the idea of centres of origin. Perhaps we could see Gondwana itself as a sort of southern meta-Earth-being around which proliferates a host of other agential entities – forest guardian creatures, fossil and living relics, subterranean energy reserves, mantle plumes and carbon conveyor belts, sunken continents and wandering terranes, ancestors, spirits, divinities – some of which have crossed geohistorical time or geographical distance to enter into communication with each other. If such figures may have formerly been called upon to address issues of belonging in new worlds or the clash between inhabitants of old and new worlds, they now find themselves confronting an Earth that is in the process of becoming other to itself. And where scientific disciplines may once have pitted themselves against 'otherworldly' threats to reason, increasingly it is the sciences themselves who speak of thresholds between knowable and unknowable worlds – while leaving matters of guidance or intermediation between these domains an unanswered question.

[81] Adam Bobbette, "Cosmological reason on a volcano'" in Adam Bobbette and Amy Donovan (eds) *Political Geology: Active Stratigraphies and the Making of Life*, (London: Palgrave Macmillan, 2019): 169–199, p.188.

Gondwana, then, might be viewed as a broad and deep front where figures are being summoned to help guide us across thresholds between abyssally different worlds.