Urban Forum (2013) 24:463–483
DOI 10.1007/s12132-013-9198-9

The Political Life of Rising Acid Mine Water

Lindsay Bremner

Published online: 11 June 2013

Abstract The discovery of gold on the Witwatersrand in 1886 that gave rise to the exploitation of the world's largest gold reserves inaugurated new associations of air and earth, science and politics, humans and nonhumans. Very rapidly, these were organised into two apparently distinct realms—an aboveground world of capital, commerce, culture and politics and a belowground world of labour, minerals, rocks and science. Yet the two realms were deeply interconnected, and the threshold between them was always, literally and figuratively, in danger of collapsing. In this paper, I explore the use of legislation and cartography to stabilise this section and keep the two realms apart, and the aesthetic practices that portrayed their interrelatedness. I then chronicle the incursion of acid mine water, a geological by-product of mining operations, from the mining voids into the above-ground world of human affairs. This not only made the invisible processes of its commodification visible but also became a proposition around which new forms of political life have been assembled.

Keywords Johannesburg · Rising acid mine water · Legislation · Cartography · Aesthetics · Politics

Introduction

"Here in Johannesburg, it is the mines, he said, everything is the mines. These high buildings, this wonderful City Hall, this beautiful Parktown with its beautiful houses, all this built with the gold from the mines … built on our backs, our sweat, on our labour. Every factory, every theatre, every beautiful house, they are built by us" (Paton 2003, p.33).

L. Bremner (✉)
Architecture and the Built Environment, University of Westminster, 35 Marylebone Road
NW1 5LS London, UK
e-mail: bremnel@westminster.ac.uk

In their introduction to *Johannesburg The Elusive Metropolis*, Mbembe and Nuttall (2008) propose that Johannesburg's section, the relationship between its underground world of mineshafts, stopes, tunnels and manual labour and aboveground world of towers, commerce and capital, holds the secrets to its modernity. They challenge spatial readings of the city that remain locked into the plan, despite it being the primary instrument of apartheid's spatial politics, arguing that, in Johannesburg, it was in depth that the "calculus of capital and dispossession, technology, labour and the unequal distribution of wealth," operated (Mbembe and Nuttall 2008, p.17). In this paper, I explore this idea by analysing ways in which, historically, legislation, cartography and aesthetic practice managed the relationship between surface and depth. I then investigate the decanting of acid mine water from underground mining voids in Johannesburg in 2002, arguing that this geological incursion into the aboveground world of human affairs upturned the politics of verticality in which it had been produced, disrupted the order of the sensible and made new modes of political life possible. I theorise this using Ranciere's notion of politics (Ranciere 1999, 2004), as occasions when those who previously had no rights to be counted as speaking beings make themselves of some account. I align this, some may argue contentiously, with Latour's notion of a proposition (Latour 1999, 2004), an occasion when entities, human or nonhuman, bring about conditions of uncertainty and assemble collectives in search of their articulation.

Ranciere (1999) identifies the foundation of politics as the staging of conflict over the distribution of bodies, or the sensible, into two categories—"those that one sees and those that one does not see, those who have a logos—memorial speech, an account to be kept up—and those who have no logos, those who really speak and those whose voice merely mimics the articulate voice to express pleasure or pain" (Ranciere 1999, p.22). Politics arises when the distinction between who speaks and who does not speak is uncertain, "creating a stage around any specific conflict on which the equality or inequality as speaking beings of the partners in the conflict can be played out" (Ranciere 1999, p.51). He illustrates this by the story by Livy, retold by Pierre-Simon Ballanche, of the secession of the Roman plebeians on Aventine Hill. Faced with a situation in which they were denied symbolic enrolment in the city, the plebeians established another parallel order by conducting themselves as speaking beings, sharing the same properties as those who denied them those. In doing so, they found that they too were endowed with intelligent speech and the equals of those who had denied them this equality. This violated the symbolic order of the city and gave them a place as speaking beings (Ranciere 1999).

"Politics exists when those who have no right to be counted as speaking beings make themselves of some account, setting up a community by the fact of placing in common a wrong that is nothing more than this very confrontation, the contradiction of two worlds in a single world: the world where they are and the world where they are not, the world where there is something between them and those who do not acknowledge them as speaking beings" (Ranciere 1999, p.27).

For Ranciere, politics belongs, by definition, to humans. Nonhuman entities do not qualify to participate in the demos, for the disruption of a symbolic order must be accompanied by engagement in reasoned discourse. Bennett (2010) challenges this view, arguing that Ranciere's model suggests possibilities for a more vital materialist account of democracy. Nonhumans, she argues, are able to act or argue against the

partitioning of the sensible and catalyse a public able to engage, on their behalf, in reasoned discourse. Ranciere seems to hint at this in his discussion of questions of identification and representivity, of who speaks for whom and how this is interpreted in political discourse (Ranciere 1999). The third person is essential to these logics. Politics is never a simple dialogue between two equal parties but rather a situation where their very equality as speaking beings is at stake.

For Latour (1999, 2004), politics is a process of assembling collectives that incorporate human and non-human political agents working towards the "progressive composition of a common world" (Latour 2004, p.59). Collectives replace the oppositional unity of nature, with its mute objects, and the multiplicities of society, with its speaking subjects, with assemblies of human and nonhuman propositions. "Propositions," Latour argues, "are not positions, things, substances or essences, made up of mute objects facing a talkative human mind, but occasions given to different entities to enter into contact" (Latour 1999, p.141). They are associations of humans and non-humans before they are fully articulated or fully constituted as members of a collective. Through contact over the course of an event, propositions perform in certain ways, their definitions are modified and their attributes and competencies in relation to one another are played out. While expressly denying equivalence between human and non-human propositions ("Inanimate things, do you then have a soul? Perhaps not; but a politics, surely" (Latour 2004, p.87)), this opens the door for nature to enter the political arena and for political life to be reformulated.

It is these conceptions of politics that acid mine water, by decanting, has staged. It made the geological social, became a vibrant actor in the political life of the city, mobilised heterogeneous publics to speak on its behalf, catalysed debate and laid out new political and aesthetic agendas. While it was underground, its politics were only immanent; by dissenting from this spatial disposition, by gaining visibility and materially entering the world of human affairs, it became a proposition, or a "scandal at the heart of an assembly that (has) carrie(d) on a discussion requiring a judgment brought in common" (Latour 2004, p.54). It is the life of this political agent that this paper will give account of.

Origins

Great uncertainty surrounds the formation of the Witwatersrand basin, the world's richest source of gold (Frimmel 2005; Frimmel and Minter 2002). It remains the most controversial issue in the history of economic geology (Frimmel 2005; Davidson 1965). A number of models have been proposed to explain its origins. The epigenetic or hydrothermal model, advanced in the 1950s (Miholic 1954) proposed that gold was a marine deposit of the late Archean age (between 2.5 and 3.5 billion years ago), when gold was introduced into gravel conglomerates by hydro-thermal or metamorphic fluids derived from the upper continental crust. More recent findings using isotype analysis advocate an alternative sedimentary placer model, suggesting that gold was not deposited by hydrothermal fluids at all but was carried by rivers from source rocks to the north and deposited in alluvial fans spreading into the waters of the epicontinental Witwatersrand sea (Frimmel 2002; Frimmel and Minter 2002; Kirk et al. 2002). Still another theory, the modified paleoplacer model (Frimmel 2005)

suggests that it was a combination of the two that led to the formation of the goldfields: detrital deposits plus a repositioning by hydrothermal fluids, possibly as a result of meteoric impact. All that is agreed by scientists is that since around three billion years ago, at least five tectonothermal events have mobilised gold, along with uranium, carbon and pyrite in a fractured, dense geology of layers, seams and faults and that the gold is found as veinlets, specks or grains in the cracks and cavities of layers of carbonaceous conglomerate (Frimmel 2005; Kirk et al. 2002). This layer can be anything from a centimeter to over a meter thick and slopes at an angle of 20° or more towards the south to depths of at least 5,000 m (Grove and Harris 2010). It stretches from 65 km east of Johannesburg to 145 km west of the city and then circles to the southwest into the Orange Free State, 320 km away.

In 1886, George Harrison, a builder by trade, discovered this gold in an outcrop of conglomerate close to the surface on the farm Langlaagte, to the west of Johannesburg. This opened up the Witwatersrand Goldfields for extraction and laid the foundations for the future city (Beavon 2004). Within a matter of days, nine farms were declared public diggings, prospectors flocked to the site and mining began (Beavon 2004). Early miners found gold ore close to the surface in long outcrops known as reefs running east to west along the valley floor. Mined in shallow trenches, these were soon exhausted. It became necessary to access the deeper strata of conglomerate that fell away sharply to the southwest (Van Onselen 1982a). Prospecting gave way to geology. The subterranean landscape was surveyed; its cracks, fissures and fault lines were mapped. Shafts were sunk and new mines opened. Unexpected difficulties were encountered. Deep-level mining was risky and accident-prone. Transforming the underground into value needed enormous quantities of capital, machinery, water, electricity and labour (Winde et al. 2010; Beavon 2004; Van Onselen 1982a). These factors rapidly gave rise, not only the city of Johannesburg, but also the modern political economy of Southern Africa (Mbembe 2008; Chamber of Mines of South Africa 2008; Yudelman 1983; Van Onselen 1982a; De Kiewiet 1996 et al.). Soon, the early contours of the city of gold took shape (Beavon 2004). Mining headgear, battery stamps, reduction works, ore dumps, slimes dams and railways distributed the underground across the surface of the earth. Ridges and valleys were transformed into a churning metallurgical landscape (Bremner 2005). The city was laid out. Technologies of surveying, lifting, blasting, crushing, constructing, reticulating, organizing, etc. pioneered in mining were imported into the city (cf. Bridge 2009). Mining houses, mining mansions, legal frameworks, utility companies, institutions of civic life (municipal councils, schools, universities, art galleries, museums, libraries) and their underneath—mining compounds, municipal locations, beer halls, prisons and informal labour camps—sprang up. Fortunes rose and fell. Syndicates, consolidations and new financial institutions were floated to bankroll mining operations (Van Onselen 1982a, 1982b). The city soon became one of the world's richest and most rapidly growing centres, inscribed within global networks of transaction and exchange (Mbembe 2008; Chipkin 1993; De Kiewiet 1996).

Below- and Above-Ground

The underground is an invisible, geological world, a "deep-time process beyond human control" (Bridge 2009, p.45). Its transformation into a frontier for capital accumulation is both an unimaginable technological feat and an unprecedented debasement of humans and nonhumans alike. "The act of wresting minerals form the earth has historically required the

subjugation and the demeaning of both nature and humankind, as faceless pairs of hands and unseen labouring backs descend into the dark, inhuman hell of tunnels to strip away the organs of nature" (Mumford 1934 in Bridge 2009, p.45). The deep level gold mine is one of the most extreme forms of this exploitation of nature, a ruthless socio-political machine for the extraction of value. It comprises a vast infrastructural network of shafts, tunnels, dams, pumping stations, conduits, vents, ropes and cables that hoist, lower and distribute water, air, electricity, dynamite, equipment, ore and people between surface and depth (Gumede and Stacey 2007; Pogue 2006; Diering 1997). It mobilises instruments, laboratories, calculations, predictions, drawings and reports of innumerable scientists—geologists, seismologists, hydrologists, engineers—to overcome the effects of high rock pressure and great heat encountered at depth (e.g. Gumede and Stacey 2007; Richardson and Jordan 2002; Stephenson 1983). Within its voids, human bodies exposed to heat, vulnerability, silica dust and other toxins drill holes into rock in narrow, inclined stopes with hand held machines; rock faces are drilled and blasted; broken ore is gathered, dropped down ore-passes, hauled by rail or truck to shafts and hoisted to the surface (Chamber of Mines of South Africa 2008). Here, it is crushed, milled to dust and dissolved in a solution of cyanide; either zinc or carbon is added to the solution to precipitate gold, which is then smelted and purified; the waste generated by this process is discharged onto slime dams, vast mountains of toxic sludge which leach into groundwater and emit radio-active contaminants into the air (Pogue 2006).

Mineshafts mark the threshold between above and below ground as discrete points, wormholes that only permit access to the underground if elaborate rituals of identification, un- and redressing, health, safety and security checks, and so on are adhered to. For the broad public, the underground and extraction processes are invisible, except for the mine shafts and slimes dams that mark them on the surface, or in the inverted, commodity forms through which they circulate: gold bullion, gold jewellery, shareholder's reports, etc. In Johannesburg, this invisibility was enhanced by two mechanisms—one that had to do with the allocation of rights, the law, and the other that had to do with the representation of space, cartography. Both of these epistemologies constructed surface and underground topographies as two apparently distinct realms (geology and society) and kept the underground out of sight.

Before the discovery of gold, the Zuid-Afrikaansche Republiek (ZAR) had only legislated about territory as surface topography. In terms of its pre-1870 *grontwet* (ground law), minerals under the earth belonged to the owner of a piece of land (Stott 2008; Kaplan 1985; Webb 1981). An owner was entitled to mine or lease his/her land to anyone else to mine without the permission of the state. However, by the time the Witwatersrand goldfields were discovered in 1886, a policy of state control over mining had been instituted. This required proclamation of land once precious metals were discovered. This divested the owner and invested the state, not with ownership, but with control over the surface of the land and its gold workings. Landowners were compensated in various ways for this loss of rights over their land, including a share of claim license fees (Stott 2008; Kaplan 1985). Licensing provisions then entitled it to grant mining title (a *mynpachtbrief*) to third parties, who could, in turn, sell or lease these rights on. The landowner retained ownership over the minerals until the mineral rights holder had severed them from the ground. In this way, the common-law rights of land ownership, mineral ownership and political loyalty were preserved, while those with the skills, expertise and capital to mine gold were given the rights and incentives to do so (Stott 2008). This meant that the act of extraction itself altered the

allocation of rights, severed surface and depth, geology and commodity, and transformed their threshold into politics.

These arrangements were retained, though modified, for more than 80 years, until the Mining Titles and Registration Act of 1967, which eliminated the *mynpacht* as a form of title.[1] Over this period, anomalies had arisen. For instance, the 1908 Precious and Base Metals Act (the so-called Gold Law) defined the term *mining title* as "documents of title which confer upon their holders the right to mine, as distinct from the ground upon which mining operations could be concluded" (Kaplan 1985, p.16 in Stott 2008, p.127). This gave the right to extract gold within the vertical limits of the surface area specified by a *mynpacht*. While the alignment of surface and depth made sense when gold was relatively close to the surface, as the gold reef dropped down at an angle to the south and mining levels deepened, surface area bore little relation to underground workings. Property and mining rights were now not only vertically severed but also horizontally sheared, affecting further disjunctions between surface and depth.

Johannesburg itself came into being in 1886 as a mining town on Randjeslaagte, a triangular piece of ground known as an *uitvalgrond* at the centre of the nine farms first proclaimed as public diggings (Beavon 2004). *Uitvalgrond,* meaning surplus ground (Malcomess 2012), was the definition given by the ZAR to land left over between farm portions, whose perimeters were determined by the distance a Boer farmer could ride in a day from his/her farmstead. By the time it was laid out, Randjeslaagte was a proclaimed goldfield and crossed by a line of mining claims. The city was considered by the ZAR to be a mining camp, controlled by Pretoria through a Mining Commissioner and a Diggers Committee. *Voorkeurrechte* or preferent rights for use of urban stands were granted in much the same way that *mynpachtbriefe* were granted (Beavon 2004). City and mine were part of a legal, institutional and spatial continuum. In December 1887, however, Johannesburg was given permission to elect a Sanitary Board, and in 1897, a limited form of municipal government was granted (Beavon 2004). Thus began experiential, socio-political and cartographic separation of town and mine, consolidated from 1900 onwards when the British occupied the city, and formal municipal government, including the formalisation, and expansion of municipal boundaries began (Pogue 2006; Beavon 2004; Mabin and Smit 1997; Maud 1938). The city was subjected to one legislative regime and mining to another.

[1] This is an over-simplification of the complexity of the development of mineral rights policy, legislation and practice in South Africa over the course of the twentieth century but sufficient for the purposes of this paper. The 1908 Precious and Base Metals Act introduced a new system of mining title—the mining lease. Its primary objective was to give the State greater control over and stake in mining operations that the *mynpacht* system allowed. It meant that proclaimed areas were retained by the State, that mining companies were forced to compete with each other for leases on them, that conditions for lease could stipulated, e.g. that the lessee provide all the capital to develop the mine, and that the State would receive a share of the profits (Stott 2008; Sander 2000). This system only began to be accepted in 1916, when deep-level mining rendered *mynpacht* portions unworkable. The 1934 Mining Leases Act specified that if the holder of a *mynpacht* required a lease over an additional area of land, such an extension would be called a 'joint area' subject to state profit sharing, at the discretion of the Mining Leases Board. Despite such attempts by the State to gain further control over mining and a share in its profits, the *mynpacht* system was only completely replaced in the 1967 Mining Rights and Titles Act (Stott 2008; Kaplan 1985). For a more detailed account of this history, see Stott (2008); Sander (2000); Cawood and Minnitt (1998) and Kaplan (1985).

This schism is evident in two maps, both dating from 1897. In the first, *Plan of Johannesburg City and Suburbs* (Fig. 1), one of best-known maps of early Johannesburg, street grids, railway lines, townships and surface landscape features clearly designate a city in the making. One can read the faint register of the original *uitvalgrond* triangle, but the city has already exceeded this boundary, spreading east and west along a valley and northwards over the Witwatersrand ridge. Early signs of the future racialisation of urban space are evident in names like 'Coolie Location,' 'Kaffir Location' and 'Native Location,' though, at this time, the city was still a site of racial co-habitation (Bremner 2005). South of the city, mines are named and drawn as surface areas, with no registration of their underground topography or even of the location of their shafts or surface workings. A locational map on the bottom left hand corner of the map omits the mining properties altogether, simply overlaying township portions on farm portions. The only indication that this was a mining town is a table in the bottom right hand corner indicating quantities of gold produced between 1887 and 1897.

The second map, *Johannesburg, Z.A.R.* (Fig. 2) is a relatively unknown map found un-catalogued in the basement of the Johannesburg Public Library. It is a sectional drawing, a cut through the earth, showing two inclined gold reefs, a geological fault, a mineshaft and eight underground mining tunnels. No indication of the identity or location of the mining operation is given, other than that it is approaching its southern property boundary delineated by the words 'wire fence' on the left hand side of the

Fig. 1 Plan of Johannesburg and suburbs, 1897. Credit: William Cullen Library, University of the Witwatersrand, Johannesburg

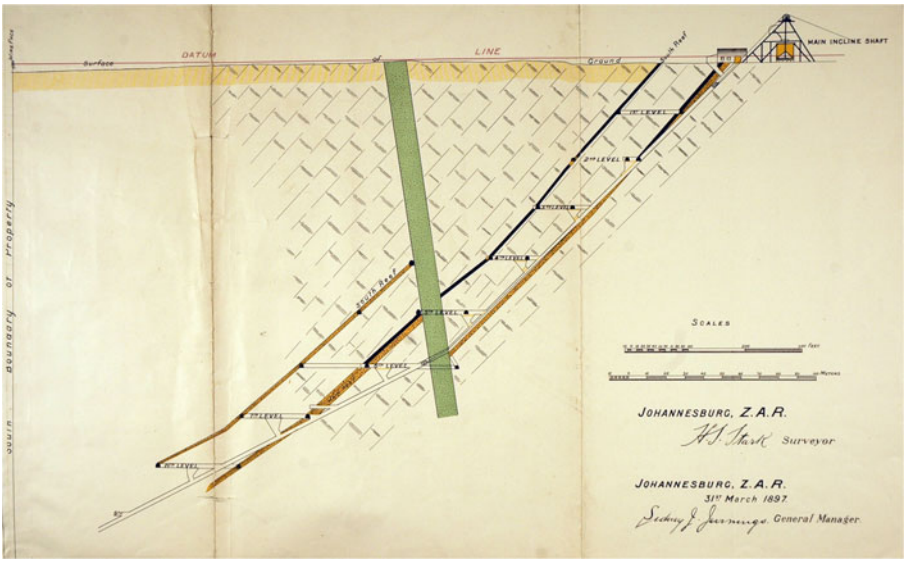

Fig. 2 Johannesburg Z.A.R, 31 March 1897. Credit: Johannesburg Public Library

map. The ground surface is a wavy line subsumed by a firm, level datum from which subterranean levels are plotted.

Whereas on the first map the city was only drawn in plan, on the second, the mine is only drawn in section. Where mining maps do make use of the plan, as in *A Map of the Witwatersrand Goldfields* published for the South African Mining Engineering Year Book (1927), also found in the Johannesburg Public Library's archive (Fig. 3), cities and towns vanish, appearing only as underlined names, (Johannesburg, Benoni, Roodepoort, etc.) subsumed by the patchwork of mining claims.

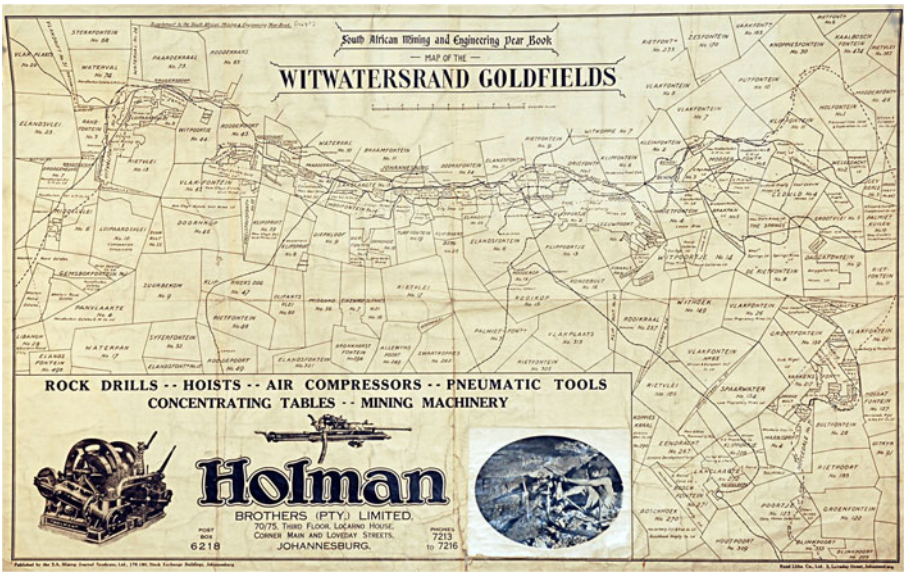

Fig. 3 Map of the Witwatersrand goldfields, 1927. Credit: Johannesburg Public Library

These examples reveal that cartographic representations of city and mine privileged different views and offered different readings of space that bore little if any relation to one another. The underground, though extensively surveyed and mapped was kept firmly out of sight on urban maps. Urban maps portrayed the city as an abstract, flat surface of civic elements (street grids, public squares, railway lines, natural features, etc.), giving no indication of underground workings or their extent. Evidence that the two realms existed in sets of relations "in which each relie(d) on the existence of the other, in which they (were) entwined or enfolded, suggestive of the other, interpenetrating, (though) separating out at different points" (Nuttall 2009, p.83), was eradicated.

It was in the forms of visibility of aesthetic practices (painting, film, fiction, architecture) that cracks appeared in this rigid separation of above and below and surface and depth were shown to be interpenetrating, overlapping and folded into one another. Aesthetic modes of representation gave the underground a presence in above-ground civic and cultural life. Following Ranciere, this disrupted the "distribution of the sensible" (Ranciere 2004, p.12) portrayed by cartographic representations, thereby presenting other possibilities to experience. Aesthetic space and practice served as precursor to the experiential space and politics that contaminated underground mine water would erupt in many years later.

In the work of Jeannette Unite, an artist who has worked on the mining industry for two decades for instance, the threshold between above and below ground is often portrayed as unstable and potent. In her *Above Below* series of photomontages (2011–2012), two separate photographic images of mining landscapes are stacked vertically one above the other (Lamprecht and Powell 2012). These juxtapose above-ground mining elements (mine head gear, mine plant, mine dumps, etc.) with underground ones (rock, tunnels, pipes, shafts, etc.). Unite works over the area of transition between the two with swirling lines, such that "if you block off the bottom half of the image, the zone of indeterminacy … belongs to the upper image of mining headgear … (but if) you block off the top half, the area in between the two reproduced images reads as the ceiling of the mining tunnel" (Powell 2012, p.48). This zone of dynamic uncertainty becomes a site of expressionistic dissent against the mechanistic, industrial ordering of experience portrayed in the individual photographs.

In William Kentridge's animated film *Mine* (1991), Soho Eckstein, a mining magnate, prepares his morning coffee by pushing down the plunger of a French coffee press. Instead of stopping at the bottom of the pot, it bores through the table and the floor and drills a deep shaft through the stopes of a mine below. These are crowded with human and non-human artefacts, which metamorphose into ore to be collected and refined. The plunge of the coffee press unites the world of mine owner and that of mineworkers and alludes to Kentridge's own autobiography through the personal pronoun, mine. This lays out a new narrative terrain for figuring out the city and personal history as entanglements of surface and depth and in which accounts that only acknowledge surface incidents and accidents are shown to be inadequate. (The Arts Fuse 2012; Nuttall 2009).

In a third example, a speculative building designed by architect Ivan Kadey in 1986, 100 years after the discovery of gold, the street grid of Johannesburg's original *uitvalgrond* and the mining land to its south are traced and folded through 90°. The plan of the city, as seen in the 1897 In *Plan of Johannesburg City and Suburbs* map, is folded into the section of a building that resembles both the shape of a mine's headgear and a yacht's sail. Primary streets in the city plan are translated into pilotis, which extend into a subterranean network of mining tunnels. This structure floats in a

pool of water whose edge is delineated by the city's southern freeway, marking the ancient inland ocean shoreline where gold sediment had settled. Kadey speaks of this as "revealing the city's underbelly and exposing its secrets" (personal communication). In one rendering of the building from below, a rust-coloured patina crept up its structure, foretelling of the acidic mine water that would rise under the city and disrupt its politics nearly 20 years later (Fig. 4).

Mine Water

Johannesburg is located at a height of 1,800 m above sea level in the headwaters of two major international river basins. It straddles the Witwatersrand, the watershed that divides the continent into rivers that flow east to the Indian Ocean via the Limpopo River and west to the Atlantic via the Orange River (Winde et al. 2010). These two river basins form the strategic backbone of the regional hydro-political complex of four of southern Africa's most economically developed countries, South Africa, Botswana, Namibia and Zambia (Turton et al. 2006).

The discovery of gold on the Witwatersrand necessitated the rearrangement of the geography and flow of this water, through an extensive socio-spatial network of dams, barrages, wells, reservoirs, pumping stations, Water Companies, Water Boards and Acts of Parliament. For a short period after gold was discovered, water drawn locally from streams, natural springs and dolomitic cavities below the ground was sufficient to supply the water required for mining and urban use (Turton et al. 2006). Mines were shallow enough to be ventilated through airshafts directly from the earth's surface. Water's primary use underground was for dust suppression after blasting (Stephenson 1983). By 1890, however, an increasingly voracious thirst for water outstripped supply, largely due to the introduction of a process to extract gold particles from ore using cyanide, which required large volumes of water and produced contaminated effluent (Pogue 2006). As mines became deeper, air circulation had very little cooling effect, so water was introduced as a coolant. A private concession for the supply of water, granted by the Z.A.R Government a year after the discovery of gold, was bought up by mining magnate Barney Barnato, coupling the commodification of water directly to the social relations of

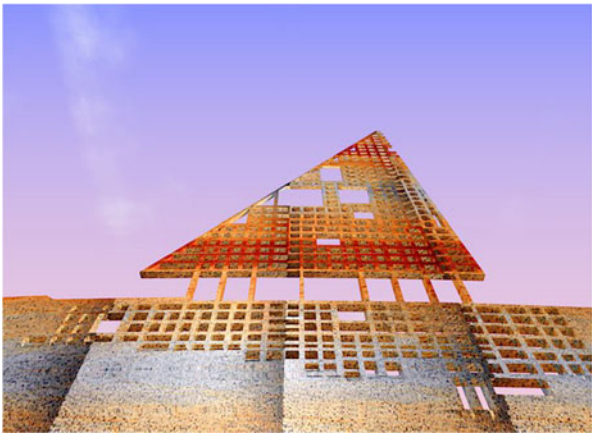

Fig. 4 City press building, 1986. Credit: Ivan Kadey

mining (Turton et al. 2006; Turton 2000). Water's material infrastructure—dams, pipes, pumping stations, treatment plants—were built by mining companies, and control over a scheme to stabilise supply by pumping water from the Vaal River, 60 km away, was bought up by Barnato's Johannesburg Waterworks and Exploration Company. Water and access to it were rapidly mediated by increasingly complex social and material relations, driven and umpired by Water Boards (representative bodies of Town Councils and the Chamber of Mines) and Acts of Parliament. Keeping the mines watered relied on mobilising increasingly vast resources across great distance. Material, social and discursive technologies (barrages, dams, outfalls, purification works, pumping stations; ideas about water and its association with ideas of cleanliness, class and race, negotiations over who should have access to what kinds of water and how much they should pay for it) transported, channelled, reassembled and recalibrated water, people, ideas and territory on a vast, sub-continental scale (Turton et al. 2006). Ongoing shortages and increasing demands from oil-from-coal developments on the Far East Rand from the 1960s onwards meant that, in 1974, the first inter-basin transfer from a water basin outside the Vaal River catchment system, the Thukela Basin, launched the Thukela-Vaal Augmentation Scheme, and investigations began into piping water from the highlands of Lesotho, 300 km away. This was eventually implemented and gave rise to the Lesotho Highlands Water Project, which delivered its first into the Vaal Dam in 1998 (Turton et al. 2006).

In the mines themselves, a complex network of discourses, practices, technologies, skills, trades and materials were deployed to re-engineer water and alter its relationships to space (Stephenson 1983). It was evaluated, modelled, tested; scientific laboratories, associations and journals were set up to study it, discuss the problems associated with its behaviour, evaluate new technologies and propose more effective ways of engineering it. Because water dropped down a shaft reaches high pressures, complex systems of dams and pressure-reducing valves were required underground (Stephenson 1983). Water was refrigerated on the surface, dropped down a shaft, circulated through cooling coils, sprayed onto the rock face, purified through settling at the base of the mine and then pumped up again. Water pressure was used to generate energy, drive turbines, power mining machinery and move ore. Different types of water—that contaminated by sulphides and other minerals in the ore, and better, less contaminated water required to drive machinery—travelled on their journeys through the mine in separate pipes (Stephenson 1983).

In this metamorphosis, water was chemically transformed. Mining introduces oxygen to deep geological environments where it has not been before, leading to the oxidation of the minerals inside the earth (Banks et al. 1997). The most common of these is pyrite, commonly known as fool's gold. As it oxidizes, pyrite produces acids and releases heavy metals and sulphates. Water in mine voids leaches these out, producing a highly acidic, saline solution (Akcil and Koldas 2006; Banks et al. 1997). On the Witwatersrand, this was compounded by the intrusion of toxic metals (arsenic, cadmium, copper cobalt, uranium and zinc) into mining voids, which are mobilised in acidic water, but drop out when its acidity is neutralised (Akcil and Koldas 2006; Pulles et al. 1996; Werdmüller 1986). While mines are operational and water levels are stabilised by pumping, little pyrite oxidation occurs below them and few metals are leached from above. When mines close and pumps are turned off, however, water levels rise and the contaminants are leached out (McCarthy 2010; Johnson and Hallberg 2005). This is what has occurred on the Witwatersrand goldfields since 2002. Mine closures and a number of socio-

environmental, legislative and political recalibrations created the conditions for water to seek its pre-mining piezometric surface, rainwater to fill abandoned mine shafts and underground water reticulation systems to leak (Johnson and Hallburg 2005). The toxic underground water rose and eventually decanted. This brought the underground to the surface and with it, not only the opportunity to reflect on the political ecology which polluted the earth and was kept out of sight in the first place, but also the possibility of doing things differently.

The Political Life of Rising Acid Mine Water

When acid mine water first decanted in 2002, it received very little attention.[2] It emanated from abandoned mine shafts (the Black Reef Incline, 17 Winze, 18 Winze and the North East Shaft), sunk in the early twentieth century by the Randfontein Estates Gold Mine (Coetzee and van Tonder 2008). From here, it flowed northwards into the Tweelopiesspruit and southwards into the Wonderfonteinspruit (Hobbs and Cobbing 2007; Coetzee et al. 2005, 2002). The first sign of its decant was when the hippo dam in the Krugersdorp Game Reserve was full all year round and turned a yellow colour. This killed all aquatic life, impacted on the drinking water of game in the reserve and caused a number of animal mortalities (Brink 2008; Du Toit 2006; Stoch 2005). In 2005, media reports claimed that the Cradle of Humankind, a World Heritage Site just downstream from the game reserve was under threat of acidic water pollution and accused scientists, mining companies and the South African government of not being prepared to act on an issue that would impact health and the environment for generations to come (Oelofse et al. 2007; Fourie 2005 et al.). Soon after, Robinson Lake, a mine-waste site that had been sold by the mining company to a developer with plans to create a shopping centre, private residences and a hotel, was found to have water nearing a pH of 2.0 that contained elevated levels of uranium and heavy metals. It was declared a radiation hotspot and fenced off (Adler et al. 2007). Amberfield, a luxury retirement village built nearby was deserted when it was shown to be exposed to radioactive airborne dust (National Nuclear Regulator 2010). It remains unoccupied, despite attempts by its developers to auction it for industrial use (Mathews 2011). Residents of Tudor Shaft, an informal settlement of 5,000 people on a neighbouring tailings dam, were found to have inhaled or ingested dangerous amounts of radioactive material (Hervieu 2012; Mathews 2011; National Nuclear Regulator 2010 et al.). In the other two Witwatersrand Basins, water had not reached the surface but was rising fast. In 2008, East Rand Propriety Mines Ltd., the last

[2] This despite the fact that the possibility and potential risks of its eruption had been long known to those who previously assessed these matters. As far back as 1976, scientific research found that sediment and water samples from gold and platinum mines had low pH levels and that acid leaching of iron, manganese, nickel, cobalt, copper and zinc had effected a 1,000–10,000-fold increase of metal concentrations compared with that of unpolluted river water (Forstner and Wittmann 1976). In 1996, scientists had predicted a decant in 2002 and proposed an integrated approach between the state, mines, water suppliers and water users to address it (Fourie 1996). It had also long been known to be invisibly active. Rainwater falling on mine dumps, tailings or slimes dams, of which there are more than 270 on the Witwatersrand, covering an area of approximately 400 km^2 (AngloGold Ashanti 2004), most of which are unlined and not vegetated, oxidizes pyrite and other sulphides in the dumps, which seeps into ground water and contaminates streams (Durkin and Herrmann 1994; Marsden 1986).

working mine in the Central Basin ceased pumping, and, in 2009, the liquidation of Pamodzi Gold Mine on the East Rand led to the closure of mining activities and the threat of acid mine water discharge (McCarthy 2010; Esterhuyse et al. 2008; Strachan et al. 2008).

Scientific debates on radioactivity, heavy metal contamination, water availability and quality, mine-water treatment technologies, archeological impact, aquatic monitoring, health risks of polluted drinking water, communities at risk from radiation and toxicity, etc. began to emanate from research councils, mining houses and independent scientists (Oelofse et al. 2007; Dugard et al. 2011; Winde 2009; Adler and Rascher 2007; Grandjean and Murata 2007; Coetzee and Winde 2006; Coetzee et al. 2005). Environmental activists and interest groups, most vocally, Mariette Liefferink of the Federation for a Sustainable Environment, began to call public meetings, petition parliament and mining houses and speak out in the media (Funke et al. 2012). Newspaper articles and television programs, some investigative, some sensationalist, fuelled the controversy, warning of the toxicity of the water, exploring its effects on health, crops and livestock, slamming the National Nuclear Regulator as a liar, reporting ministerial denial and exposing the crisis at Aurora Empowerment Systems' mine (AMD in SA n.d.). A venture capital company, *Watermark Global plc*, was floated in the British Virgin Islands to exploit the commercial opportunities of acid mine drainage in South Africa and began courting the government for contracts (Prinsloo 2009; Watermark Global plc n.d.). Artists and architects visualised and developed future scenarios on the impact of its salts, heavy metals and uranium on aquifers, dams, crops and human health (Kritzinger 2012; *litnet* 2012; Coetser 2012). Parties evaluated threats and took sides on their consequences. While few disputed evidence of contaminated wetlands, streams and dams and elevated levels of airborne toxicity, little progress was made on what to do about this or who should pay for it (Winde and Stoch 2010; Newmarch 2010).

What had occurred was that, after the water surfaced, it had gained in reality by circulating in expanding networks with a multiplicity of other entities—streams, hippos, fish, farmers, the media, tour operators, scientists, mining companies, property developers, radioactive monitors, shack dwellers, venture capitalists, artists, architects and others. Uncertainty about its status abounded: Was it about mining, about waste, about water resource management, about air quality, about human health, about economic development, about land values, about legal liability or about ecological rehabilitation? To whom or what was it a matter of concern—the government, current mining companies, former mining companies, tax payers, municipal authorities, shack dwellers, developers, farmers, people who live far downstream, people not yet born? If it was of concern to all of these (and more), how did one put together an assembly that spoke a common language to discuss it, account for it, call it to order, assess its contradictory scenarios and make decisions about how to deal with its consequences? Should this be in parliament, in appointed committees, in public gatherings, in scientific journals, in art galleries, in the media or all of the above, or more? In other words, acid mine water had become a proposition (Latour 2004), an association of humans and non-humans before it is fully articulated or fully constituted as a member of the collective. Through contact over the course of events, its performance was being staged, its definitions modified and its attributes and competencies in relation to others played out.

A group of scientists working on its chemistry stated this thus: "As a result of polluted mine water spilling out into the environment and the strong sentiments about the relationship between the mining industry and government, AMD became a very visible and highly political issue" (Oelofse et al. 2007, p.6). Its regime of visibility—its yellow and black metallic coating, white salt scum, acid taste—and its practices—the dead aquatic life it left behind, the pipes it corroded, the itchy skin it produced, its radioactive sludge—mustered a riotous assembly of "policy entrepreneurs" (Turton n.d., p. 13) or what Latour calls spokespeople or witnesses (Latour 2004), operating in the spaces opened up in South Africa's post-1994 constitutional, legal, moral and political environments to articulate the acid mine water across multiple registers.

By 2010, the water had become a national political crisis. Towards the end of that year, a Parliamentary Portfolio Committee visited the contaminated sites (Van Der Merwe 2010). A team of scientists was appointed by a national inter-ministerial committee to appraise, assess and report on the situation. Their report *Mine Water Management in the Witwatersrand Goldfields With Special Emphasis in Acid Mine Drainage* (South African Council for Geoscience 2010) acknowledged the toxicity of the water and recommended immediate steps to neutralise the water already decanting from the West Rand Basin, short-term interventions to pump water from the Western, Central and Eastern Basins to prevent surface decant and a long-term strategy to include the neutralization of acidity and the removal of salts (Digby Wells Environmental 2011). On 02 August 2011, a state-owned entity, the Trans-Caledon Tunnel Authority, established in 1986 and responsible for a number of apartheid era water infrastructure projects, was issued a directive by the Department of Water Affairs to undertake the pumping, neutralisation and discharge of acid mine water into the Tweelopiesspruit and to dispose of its residual heavy metal sludge into an existing deep surface excavation, the West Wits Pit (South African Department of Water Affairs 2011a, 2011b). Given that the water to be discharged into the Tweelopiesspruit would still have elevated levels of sulphate, manganese, iron and uranium, some up to 1,000 % of the South African operational limits (Oelofse et al. 2007), and the heavy metals would leach into aquifers, this was viewed as far from adequate by scientists, farmers, environmental activists and others. They voiced dissent at the public meetings conducted as part of an environmental impact assessment in July 2012, protesting that solutions should be deferred until all the entities impacted by the water were gathered into a coherent whole (personal attendance at a public meeting).

The government's proposal to address the environmental and political problems raised by the acid mine water did not attempt to hold its many associations together in an all-encompassing forum or collective. Instead, it curtailed the water's trajectories and re-articulated it by "amicable agreement" (c.f. Adler et al. 2007, p.34) between three players: the central government, government-employed scientists and state-owned companies. The water's multiplicity of clamorous attendants and associations were silenced, and its propositions were translated into technical processes of partial treatment, piping and discharge, to be conducted in private by government officials, engineers, scientists and company employees. This shedding of its wider gamut of collaborators and associations divested the water of its politics and made it less real (Latour 1999). What it had brought to the surface was channelled into treatment plants, engineering works and pipes and made to disappear.

This is the former way of doing business in South Africa, a collaboration between State and Industry. In the same West Rand basin in the 1960s, for instance, permission was given by the South African government to the West Driefontein Goldmine to dewater dolomitic rock in order to mine deep ore bodies (Winde and Stoch 2010). As the water table was lowered, springs and boreholes dried up and sinkholes appeared, resulting in ongoing calamities such as drinking water contamination, ground surface collapse and human fatalities. Two institutions were set up to deal with these: a Technical Committee and a Dolomitic Water Association, both comprising representatives of the central government, government scientists and the mining industry (Winde and Stoch 2010; Adler et al. 2007). Those whose boreholes dried up, farms disappeared, drinking water was contaminated, in whose municipalities sinkholes occurred etc. were either silent or rendered silent by compensation (Winde and Stoch 2010). When the dolomite itself resisted and spoke up by collapsing seven story buildings and killing whole families (Gold Fields Ltd 2005), it was mute, its voice designated by the distribution of powers to being mere background noise (Ranciere 1999).

This is what Ranciere (1999) calls policing, not politics.

> "The police is thus first an order of bodies that defines the allocation of ways of doing, ways of being, and ways of saying, and sees that those bodies are assigned by name to a particular place and task; it is an order of the visible and the say able that sees that a particular activity is visible and another is not, that this speech is understood as discourse and another as noise" (Ranciere 1999, p.29).

Politics, on the other hand, is when the very question of who speaks and who does not is raised, when uncertainty prevails over whose opinions matter and whose do not, and where the line that divides the two is redrawn to encompass a sphere of public intelligibility. This stage is always paradoxical, uncertain and experimental, aesthetic if you like; it brings together what was formerly legitimate with what was not, what was seen with what was invisible, the community with the non-community, and provides a space in which these relations can be debated, tested and recomposed (Ranciere 1999, 2004).

In South Africa, the shift from policing to politics was marked by the Constitution, a document drawn up collaboratively by parties who had previously held in dispute each others' right to speak or even exist (Republic of South Africa 1996; Turton n.d.). Who or what might be considered subjects, who or what had rights, who or what was entitled to speak and be heard on what, and how these agents might assemble a common world was questioned and recomposed.

As a result, the legislation governing natural resources underwent major reform (Hobbs et al. 2008). The Constitution made natural resources, including minerals, the collective property of the people of South Africa under the custodianship of the state (Funke et al. 2012). The National Water Act (Act 36 of 1998), administered by the Department of Water Affairs and Forestry, required that those responsible for producing, allowing or causing water pollution should be held liable for it according to a "polluter pays" principle (Taviv et al. 1999). The National Environmental Management Act (Act 107 of 1998), administered by the Department of Environmental Affairs and Tourism governed environmental management and required that pollution or degradation of the environment be prevented

or rectified through the instruments of Environmental Impact Assessments and Environmental Management Programs. The Minerals and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002), administered by the Department of Minerals and Energy, regulated mining and promoted equitable access to the mineral resources of the country and sustainable development of the mining industry (Hobbs et al. 2008). Further to this, the socio-economic Empowerment Charter of 2004 called for historically disadvantaged South Africans to control 15 % of mines (Mwape et al. 2005).

Between these legislative instruments and administrating departments, there are gaps and anomalies (Adler et al. 2007; Turton n.d.). The Mine Health and Safety Act (Act 29) (1996) administered by the Department of Minerals and Energy, which regulates the human environment underground and the MPRDA, which regulates mining, define mining waste as mineral residue, a potential future source of minerals, and therefore not waste (Godfrey et al. 2007). Similarly, the National Environmental Management Act (Act 107) (1998), while requiring remediation of environmental damage, supports the re-use of mineral waste, similarly nullifying its classification as waste. While the Hazardous Substances Act (Act 15) (1998) and the Nuclear Energy Act (Act 46) (1999), leave a grey area around radioactivity produced from mining activities, both the National Nuclear Regulator and the Nuclear Energy Act (Act 46) (1999) recognize that mineral waste from gold and uranium mines might be radioactive (Godfrey et al. 2007).

This is the complex legislative framework that rising acid mine water decanted into, exposing not only its contradictions and anomalies, but also, supported by other constitutional rights and responsibilities, insisting that vexing questions about its status, on who and how to think, speak and act on its behalf be addressed (Adler et al. 2007).

Conclusion

What this truncated account of the ongoing political life of rising acid mine water reveals is that, in re-distributing the underground across the surface of the earth, into the air, and into the metabolisms of plants, animals and humans, acid mine water transformed geology into politics. It made geology visible and knowable, not as a hidden abstraction or scientific fact, but as a form of above ground experience and matter of concern (Latour 2004). It reorganised surface and depth into a sludgy, contested, fluid continuum, making it impossible to act as if what had formerly been two distinct realms—above and below, science and politics, humans and nonhumans, the visible and the invisible, those who know and those who do not, those who deliberate and those who do not—do not belong to the same sphere. It insisted that this socio-temporal matrix was not singular or homogeneous, but an assembly of heterogeneous agents, with differing matters of concern and points of view, engaged in collective experimentation towards the construction of a common world (Latour 2004). The incursion of geology into the aboveground world of human affairs upturned the politics of verticality that had structured its commodification and created a horizontal political space of what Ranciere calls “community” (Ranciere 1999, p. 27) or Latour calls a “collective” (Latour 2004, p.59), a contradictory space of two worlds in one—“the world where they are and the world where they are not, the world where there is something between them and those who do not acknowledge

them as speaking beings" (Ranciere 1999, p.27). The mine water redefined what was available to politics in a common space where "the equality or inequality as speaking beings of the partners in the conflict (could) be played out" (Ranciere 1999, p.51).

This is a scandalous, paradoxical space, and likely, as I have shown, to have been short-lived. But it demonstrates that a common world does exist, that combinations between many systems are thinkable and that a topography that does not presuppose a position of mastery is possible. Whether its experimental logics will prevail or whether the politics of verticality will be reasserted will require ongoing vigilance to ensure that the equality or inequality as speaking beings of the partners in the conflict continue to be played out until the stability of an inclusive socio-natural assemblage gains ground.

Acknowledgements I would like to thank Susie Hall and Sarah Nuttall for comments on earlier versions of this paper; Francois Durand, Jozua Ellis, Alan Fine, May Hermanus, Steven Lenahan, Marietta Liefferink and Terence McCarthy for interviews; Ivan Kadey and Louise Kritzinger for access to their artwork; Ngozi Mokwe-Ozonzeadi for laboratory analysis of water samples and Nabil Ahmed for encouraging me to do this in the first place. A version of the paper was presented at 'Architecture and the Paradox of Dissidence,' an international conference at London Metropolitan University on 16 November 2012.

References

Adler, R., & Rascher, J. (2007). *A Strategy for the Management of Acid Mine Drainage from Gold Mines in Gauteng. Council for Scientific and Industrial Research Report No. CSIR/NRE/PW/ER/2007/0053/C*. Pretoria: Council for Scientific and Industrial Research.

Adler, R., Claassen, M., Godfrey, L., & Turton, A. R. (2007). Water, mining and waste: A historical and economic perspective on conflict management in South Africa. *The Economics of Peace and Security Journal, 2*(2), 32–41.

Akcil, A., & Koldas, S. (2006). Acid mine drainage (AMD): Causes, treatment and case studies. *Journal of Cleaner Production, 14*, 1139–1145.

AMD in SA. (no date). http://acidminedrainage.wordpress.com/. Accessed 10 October 2011.

AngloGold Ashanti. (2004). *AngloGold Ashanti Report to Society.* http://www.anglogold.com/subwebs/informationforinvestors/reporttosociety04/pdf/environment.pdf. Accessed 12 August 2012.

Banks, D., Younger, P. L., Arneson, R.-T., Iversen, E. R., & Banks, S. B. (1997). Mine-water chemistry: The good, the bad and the ugly. *Environmental Geology, 32*(3), 157–174.

Beavon, K. (2004). *Johannesburg, The Making and Shaping of the City.* Pretoria: University of South Africa Press.

Bennett, J. (2010). *Vibrant Matter, a Political Ecology of Things*. Durham and London: Duke University Press.

Bremner, L. (2005). Remaking Johannesburg. In S. Read, J. Rosemann, & J. van Eldijk (Eds.), *Future City* (pp. 32–47). London: Spon.

Bridge, G. (2009). The hole world, scales and spaces of extraction. *New Geographies, 2*, 43–49.

Brink, D. (2008). Crisis Situation in the Krugersdorp Game Reserve. Minutes of an urgent meeting at the Percy Stewart Waste Water Works, West Rand District Municipality, 26 August. Copy from Mariette Liefferink.

Cawood, F. T. & Minnitt, R. C. A. (1998). A historical perspective on the economics of the ownership of mineral rights ownership. *The Journal of the South African Institute of Mining and Metallurgy*, Nov/Dec, 369–376.

Chamber of Mines of South Africa. (2008). Working together for a sustainable future since 1889. http://www.bullion.org.za/content/?pid=84&pagename=Gold. Accessed 10 August 2012.

Chipkin, C. M. (1993). *Johannesburg Style. Architecture and Society 1880's–1960's*. Cape Town: David Philip.

Coetser, D. A. (2012). *Remining Johannesburg: Urban redevelopment through the treatment of acid mine drainage*. Masters in Technology Thesis, University of Johannesburg, Johannesburg, SA.

Coetzee, H., & van Tonder, D. (2008). *Draft Regional Closure for Strategy for the West Rand Goldfield. Council for Geoscience Report No: 2008–0175*. Pretoria: Department of Minerals and Energy.

Coetzee, H., Croukamp, L. & Ntsume, G. (2002). Report on visit to the West Wits Gold Mine and environs, 10 Oct and 7 Nov, 2002. *Report by the Council for Geoscience to the Department of Minerals and Energy.* Pretoria: Council for Geoscience.

Coetzee, H., Erasmus, E., van Wyk, N., Kwata, G., & Horstmann, U. (2005). *Preliminary investigation of a suspected ingress point into the Western Basin—Intersection of the Wonderfonteinspruit with the Witpoortjie Fault. Council for Geoscience Report No: 2005–0147*. Pretoria: Department of Minerals and Energy.

Coetzee, H. & Winde, F. (2006). *An Assessment of Sources, Pathways, Mechanisms and Risks of Current and Potential Future Pollution of Water and Sediments in Gold-Mining Areas of the Wonderfonteinspruit Catchment: Water Research Commission Report No. 1214/1/06*. Pretoria: Water Research Commission.

Davidson, C. F. (1965). The mode and origin of banket orebodies. *London Institute of Mining and Metallurgy Transcripts, 74*, 319–338.

De Kiewiet, C. W. (1996). *A History of South Africa, Social and Economic*. Oxford: Oxford University Press.

Diering, D. H. (1997). Ultra-deep level mining—Future requirements. Journal of the South African Institute of Mining and Metallurgy 97:249-255. October, 249–256.

Digby Wells Environmental. (2011). Background information document for the activities associated with the immediate and short term interventions regarding acid mine drainage in the Western, Central and Eastern Witwatersrand Basins. http://www.amdshort.co.za/documents/BID%20Rev%2011%2023-02-2012%20for%20website.pdf. Accessed 02 July 2012.

Du Toit, J. S. (2006). Practical applications—Effects of mine water drainage on the Krugersdorp Game Reserve. Proceedings of the Mine Water Drainage (South African Perspective) Conference, 19–20 October, 2006. Randfontein Estates Gold Mine Sports Club. Randfontein. http://www.dwaf.gov.za/Documents/ACIDReport.pdf. Accessed 4 March, 2012.

Dugard, J. MacLeod, J. and Alcaro, A. (2011). Rights mobilization in South Africa in the context of acute environmental harm: The case of acid mine drainage on the Witwatersrand Basin. *Human Rights and the Global Economy Conference*. Center for Public Scholarship, The New School New York 10 Nov. Copy from Mariette Liefferink.

Durkin, T. V., & Herrmann, J. G. (1994). *Focusing on the Problem of Mining Wastes: An Introduction to Acid Mine Drainage. Managing Environmental Problems at Inactive and Abandoned Mine Sites. Sem. Publ. EPA/625/R-95/007*. Washington: Environmental Protection Agency.

Esterhuyse, S., Van Tonder, D. M., Coetzee, H., & Mafanya, T. (2008). *Draft Regional Gold Mining Strategy for the East Rand Goldfield. Council for Geoscience Report No. 2008–0176*. Pretoria: Department of Minerals and Energy.

Forstner, U., & Wittmann, G. T. W. (1976). Metal accumulation in acidic waters from gold mines in South Africa. *Geoforum, 7*(1), 41–49.

Fourie, J. (1996). An integrated strategic water management plan for the Witwatersrand Gold Mines. Unpublished report.

Fourie, M, (2005). A rising acid tide. *Mail and Guardian*, 12 April. http://acidminedrainage.wordpress.com/2005/04/12/a-rising-acid-tide/. Accessed 20 October 2011.

Frimmel, H. E. (2002). Genesis of the world's largest gold deposits. *Science, 297*, 1815–1816.

Frimmel, H. E. (2005). Archaean atmosphere evolution: Evidence from the Witwatersrand goldfields, South Africa. *Earth-Science Reviews, 70*, 1–46.

Frimmel, H. E. & Minter, W. E. L. (2002). Recent developments concerning the geological history and genesis of the Witwatersrand gold deposits, South Africa. In R. J. Goldfarb & R. L. Nielsen (Eds.), *Integrated Methods for Discovery: Global Exploration in the Twenty-first Century* (pp. 17–45). Special Publication V 9. Littleton: Society of Economic Geologists.

Funke, N. Nienaber, S. & Gioia, C. (2012). An interest group at work: Environmental activism and the case of Acid Mine Drainage on Johannesburg's West Rand. http://hdl.handle.net/10204/5841. Accessed 20 July 2012.

Godfrey, L., Oelofse, S., Phiri, A., Nahman, A. & Hall, J. (2007). Mineral Waste: The required governance environment to enable reuse. *Council of Scientific and Industrial Research Report No. CSIR/NRE/PW/2007/0080/C.* Pretoria: Council of Scientific and Industrial Research.

Gold Fields Ltd. (2005). Salute this special mine. *Ngonyama News* 27, October.

Grandjean, P. & Murata, K. (2007). Developmental arsenic neurotoxicity toxicity in retrospect. *Epidemiology, 18*(1), 25–26.

Grove, D., & Harris, C. (2010). O- and h-isotope study of the carbon leader reef at the Tautona and Savuka mines (Western Deep Levels), South Africa: Implications for the origin and evolution of Witwatersrand basin fluids. *Geological Society of South Africa, 113*, 1–14.

Gumede, H., & Stacey, T. R. (2007). Measurement of typical joint characteristics in South African gold mines and the use of these characteristics in the prediction of rock falls. *The Southern African Institute of Mining and Metallurgy, 335–344*.

Hervieu, H. (2012). Poor South Africans living on toxic remains of defunct gold mines. *World Crunch,* 15 November. http://www.worldcrunch.com/culture-society/poor-south-africans-living-on-toxic-remains-of-defunct-gold-mines/tudor-shaft-radioactive-spoil-tips/c3s9958/#.ULUHvuOTv88. Accessed 20 November 2012.

Hobbs, P. J., & Cobbing, J. E. (2007). *A hydrogeological assessment of acid mine drainage impacts in the West Rand Basin, Gauteng Province. Council for Scientific and Industrial Research Report No. CSIR/THRIP/CSIR/NRE/WR/ER/2007/0097/C*. Pretoria: Council for Scientific and Industrial Research.

Hobbs, P., Oelofse, S. H. H. & Rascher, J. (2008). Management of Environmental Impacts from Coal Mining in the Upper Olifants Catchment as a Function of Age and Scale. *International Journal of Water Resources Development, 24*(3), 417–431.

Johnson, D. B., & Hallberg, K. B. (2005). Acid mine drainage remediation options: A review. *Science of the Total Environment, 338*, 3–14.

Kaplan, L. V. (1985) *The Development of Various Aspects of the Gold Mining Laws in South Africa from 1871 until 1967*. Unpublished PHD thesis. Faculty of Law, University of the Witwatersrand, Johannesburg.

Kirk, J., Ruiz, J., Chesley, J., Walshe, J., & England, G. (2002). A major Archean, gold and crust forming event in the Kaapval Craton, South Africa. *Science, 297*, 1856–1858.

Kritzinger, L. (2012). *Insidious Waters. Masters in Fine Arts, University of Pretoria Exhibition, 29 Sept–21 Oct*. Pretoria: Van Wouw House.

Lamprecht, A., & Powell, I. (2012). *Jeanette Unite Terra*. Cape Town: SoSo Press.

Latour, B. (1999). *Pandora's Hope. Essays on the Reality of Science Studies*. Cambridge, MA and London: Harvard University Press.

Latour, B. (2004). *Politics of Nature. How to Bring the Sciences into Democracy. Trans. C. Porter*. Cambridge, MA and London: Harvard University Press.

litnet, (2012). Louise Kritzinger Art Exhibition. 26 September. http://www.litnet.co.za/Article/louise-kritzinger-art-exhibition. Accessed 10 October 2012.

Mabin, A., & Smit, D. (1997). Reconstructing South Africa's cities? The making of urban planning 1900–2000. *Planning Perspectives, 12*(2), 193–233.

Malcomess, B. (2012). Uitvalgrond - Surplus Ground. *JWTC Blog*. http://jhbwtc.blogspot.co.uk/2012/06/uitvalgrond-surplus-ground.html. Accessed 8 August 2012.

Marsden, D. D. (1986). The current limited impact of the Witwatersrand gold mine residues on water pollution in the Vaal River System. *Journal of the South African Institute of Mining and Metallurgy, 86*, 481–504.

Mathews, C. (2011). Pouring poison. *PEA Public Environmental Arbiters*, 29 August. http://www.pea.org.za/latestnews/news.php?n_id=438. Accessed 10 October 2012.

Maud, J. P. R. (1938). *City Government: The Johannesburg Experiment*. Oxford: Clarendon Press.

Mbembe, A. (2008). Aesthetics of superfluidity. In S. Nuttall & A. Mbembe (Eds.), *Johannesburg, The Elusive Metropolis* (pp. 37–67). Durham and London: Duke University Press.

Mbembe, A., & Nuttall, S. (2008). Introduction: Afropolis. In S. Nuttall & A. Mbembe (Eds.), *Johannesburg, The Elusive Metropolis* (pp. 1–33). Durham and London: Duke University Press.

McCarthy, T. (2010). *The decanting of acid mine water in the Gauteng city-region: Analysis, prognosis and solutions*. Gauteng City-Region Observatory: Provocations Series. Johannesburg.

Miholic, S. (1954). Genesis of the Witwatersrand gold-uranium deposits. *Economic Geology, 49*, 537–540.

Mumford, L. (1934). *Technics and Civilization*. New York: Harper.

Mwape, P., Roberts, M. J., Mokwena, E., Tjatjie, T., & Phale, M. (2005). *Part One: South Africa's mineral industry general review. South Africa's Mineral Industry 2004/2005*. Pretoria: Department of Minerals and Energy.

National Nuclear Regulator. (2010). *Surveillance Report of the Upper Wonderfonteinspruit Catchment Area. Report No: TR-NNR-10-0001*. Pretoria: National Nuclear Regulator.

Newmarch, J. (2010). South Africa: Rising Toxic Tide Fuels Urgent Debate. *Business Day*, 11 August. http://acidminedrainage.wordpress.com/2010/08/11/south-africa-rising-toxic-tide-fuels-urgent-debate/. Accessed 15 August 2012.

Nuttall, S. (2009). *Entanglement. Literary and Cultural Reflections on Post-Apartheid*. Johannesburg: Witwatersrand University Press.

Oelofse, S. H. H., Hobbs, P. J., Rascher, J. & Cobbing, J. E. (2007). The pollution and destruction threat of gold mining waste on the Witwatersrand—A West Rand case study. http://www.anthonyturton.com/admin/my_documents/my_files/983_SWEMP.pdf. Accessed 15 February 2012.

Paton, A. (2003). *Cry, the Beloved Country*. New York: Scribner.

Pogue, T. E. (2006). *The Evolution of Research Collaboration in South African Gold Mining, 1886–1933. Proefschrift ter verkrijging van de grad van doctor aan de Universiteit*. Johannesburg: Maastricht.

Powell, I. (2012). Note: Parallax. In A. Lamprecht & I. Powell (Eds.), *Jeanette Unite, Terra* (pp. 46–48). Cape Town: SoSo Press.

Prinsloo, L. (2009). WUC advancing towards implementation of planned acid mine drainage project. *Mining Weekly*, 4 December. http://www.miningweekly.com/article/wuc-project-still-battling-to-get-the-go-ahead-2009-12-04. Accessed 19 August 2012.

Pulles, W., Howie, D., Otto, D. & Easton, J. (1996). A manual on mine-water treatment and management practices in South Africa, Vol. 1. *Water Research Commission Report No. 527/1/96*. Pretoria: Water Research Commission

Ranciere, J. (1999). *Disagreement. Politics and Philosophy. Trans. J. Rose*. Minneapolis, MN: University of Minnesota Press.

Ranciere, J. (2004). *The Politics of Aesthetics*. Trans. G. Rockhill. New York; Continuum.

Republic of South Africa. (1996). *Constitution of the Republic of South Africa: Act No. 108 of 1996*. Pretoria: Government Printers.

Richardson, E., & Jordan, T. H. (2002). Seismicity in deep gold mines of South Africa: Implications for tectonic earthquakes. *Bulletin of the Seismological Society of America, 92*(5), 1766–1782.

Sander, I. (2000). *Development, diamonds, gold and platinum: The story of the Johannesburg Investment Company 1889–1995*. Cape Town: Struik.

South African Council for Geoscience. (2010). *Mine Water Management on the Witwatersrand Goldfields with Special Emphasis on Acid Mine Drainage. Report to the Inter-ministerial Committee on Acid Mine Drainage*. Pretoria: Council for Geoscience.

South African Department of Water Affairs. (2011a). TCTA_Western Basin Immediate Solution_Treated AMD discharge [pdf]. *Digby Wells Environmental*. http://www.amdshort.co.za/appendices/category/appendix-b-directives.html. Accessed 02 July 2012.

South African Department of Water Affairs. (2011b). TCTA_Western Basin Immediate Solution_Sludge disposal. *Digby Wells Environmental*. http://www.amdshort.co.za/appendices/category/appendix-b-directives.html. Accessed 02 July 2012.

Stephenson, D. (1983). Distribution of water in deep gold mines in South Africa. *International Journal of Minewater, 2*(2), 21–30.

Stoch, L. (2005). *Memorandum Krugersdorp Game Reserve Animal Mortality V2*. Pretoria: Council for GeoSciences.

Stott, J. (2008). *Preservation or Exploitation? A Study of the development of the Mining Rights Legislation on the Witwatersand Goldfields from 1886 to 2008*. Grahamstown: Master of Economics thesis, Rhodes University.

Strachan, L. K. C., Ndengu, S. N., Mafanya, T., Coetee, H., Wade, P. W., Msezane, N., Kwata, M., & Mengistu, H. (2008). *Regional Gold Mining Strategy for the Central Rand Goldfield. Council for Geoscience Report No. 2008–0174*. Pretoria: Department of Minerals and Energy.

Taviv, I., Herold, C., Forster, S., Roth, J., & Clement, K. (1999). *A Philosophy and Methodology for the Implementation of the Polluter Pays Principle. Water Research Commission Report No. 793/1/99*. Pretoria: Water Research Commission.

The Arts Fuse. (2012). Fuse feature: Vertical and contingent—A dispatch from William Kentridge's Norton lectures. 6 April. http://artsfuse.org/55494/vertical-and-contingent-a-dispatch-from-william-kentridges-norton-lectures/. Accessed 01 March 2012.

Turton, A. R. (no date). South African water and mining policy: A study of strategies for transition management. http://www.anthonyturton.com/admin/my_documents/my_files/The_Evolution_of_SA_Mine_Policy.pdf. Accessed 10 July 2012.

Turton, A. R. (2000). Precipitation, people, pipelines and power: towards a political ecology discourse of water in Southern Africa. In P. Stott and S. Sullivan (Eds.), *Political Ecology: Science, Myth and Power*. London: Edward Arnold.

Turton, A. R., Schultz, C., Buckle, H., Kgomongoe, M. Malungani, T. & Drackner, M. (2006). Gold, Scorched Earth and Water: The Hydropolitics of Johannesburg. *Water Resources Development, 22*(2), 313–335.

Van der Merwe, C. (2010). Parliament committee visits AMD sites in Witwatersand Basin. *Miningweekly.com*. 27 July. http://acidminedrainage.wordpress.com/. Accessed 12 February 2012.

Van Onselen, C. (1982a). *Studies in the Social and Economic History of the Witwatersrand 1886–1914* (Vol. 1 New Babylon). Johannesburg: Ravan Press.

Van Onselen, C. (1982b). *Studies in the Social and Economic History of the Witwatersrand 1886–1914* (Vol. 2 New Nineveh). Johannesburg: Ravan Press.

Webb, A. C. M. (1981). Witwatersrand genesis: A comparative study of some early gold mining companies 1886–1894. Unpublished PHD thesis. Department of Economics, Rhodes University, Grahamstown.

Werdmüller, V. W. (1986). The Central Rand. In E. S. A. Antrobus (Ed.), *Witwatersrand Gold—100 Years* (pp. 7–48). Johannesburg: Geological Society of South Africa.

Winde, F. (2009). Uranium pollution of water resources in mined-out and active goldfields of South Africa—A case study in the Wonderfonteinspruit catchment on extent and sources of U contamination and associated health risks. http://www.imwa.info/docs/imwa_2009/IMWA2009_Winde.pdf. Accessed 20 July 2012.

Winde, F. & Stoch, E. J. (2010). Threats and opportunities for post-closure development in dolomitic gold mining areas of the West Rand and Far West Rand (South Africa)—A hydraulic view. Part 1: Mining legacy and future threats. *Water SA,* 36 (1) Jan. http://www.scielo.org.za/scielo.php?pid=S1816-79502010000100008&script=sci_arttext. Accessed 20 July 2012.

Yudelman, D. (1983). *The Emergence of Modern South Africa: State, Capital and the Incorporation of Organized Labour on the South African Gold Fields, 1902–1939*. Westport, CT: Greenwood Press.