Apartheid’s Anthropocene: The (Under)mining of a South African Company Town

Stephen Sparks (University of Johannesburg)

A vast body of literature over four decades detailed the political, economic and social (especially labour) history of mining on the Witwatersrand, the mineral-bearing plateau at the core of southern Africa’s economic life since the late nineteenth century.¹ Occupational health has been a key area for investigation and one of the main sites for the recent injection of creative STS approaches.² As part of this STS turn and a shift away from production centered histories towards an interest in waste, scholars like Gabrielle Hecht have begun to think about how the Witwatersrand mines (and their poisonous afterlives e.g. acid mine drainage) might be fruitfully thought of in terms of an explicit theoretical engagement with the concept of the ‘Anthropocene’.³ If, as Hecht puts it, the Anthropocene has entailed ‘exponential increases in the rearrangement of earthly materials’, then South Africa’s mineral

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revolution, beginning with the discovery of diamonds and gold in the late nineteenth century, and accelerating over the course of the twentieth century, surely counts as one of the most significant episodes of this history.  

My concern here is a small, but important slice of the South African Anthropocene: the undermining, by coal mining, of the sub-surface of Sasolburg, the South African company town set up in the 1950s by the apartheid state. I suggest that the story of the undermining of Sasolburg quite fundamentally changes the way we think about the shaping of South Africa’s apartheid and post-apartheid urban geography. Well-worn historical themes such as the development of the Verwoerdian white supremacist spatial fix and the ratio of single male migrants to families in Sasolburg’s township, Zamdela, are shown to have been shaped by hollowed ground in unexpected ways. The second section of the paper focuses on the paradoxical role of minerals-energy research complex (the Chamber of Mines, the Council for Scientific and Industrial Research and the engineering faculties of the major local universities) and, in particular, the field of subsidence engineering in producing and mitigating the crisis of Sasolburg’s present and past: the revenge of the voids. I conclude with some reflections on the perils of ‘anthropocene’ as metanarrative.  

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Sasolburg was established by SASOL, a parastatal tasked (by a state increasingly preoccupied with autarky in defiance of anti-apartheid boycotts) with producing oil from coal, via the synthetic Fischer-Tropsch process of coal liquification. Though anti-apartheid mythology has it that SASOL inherited coal liquification directly from the Nazis, the technology took a much earlier, circuitous route to South Africa, where there had long been interest in using it to turn the country’s vast coal deposits into fuel: water

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into wine.\(^5\) Renfrew Christie long ago demonstrated that the artificially suppressed cost of black labour in twentieth century South Africa made the cost of coal mining and electricity generation supplying the power-hungry deep-level gold mines at the heart of the political economy extraordinarily cheap.\(^6\) Cheap, plentiful coal was an important condition of possibility for South Africa’s autarkic oil-from-coal experiment. Seemingly inexhaustible coalfields prompted boasts in parliament in the 1950s of limitless ‘oil-potential’, which ‘cannot be touched by boycott or any other type of unfriendly action’; enough to meet South Africa’s requirements ‘for the next 500 years’.\(^7\)

Getting coal to the pithead in 1950s South Africa cost 5 shillings per ton, as compared to 5-7 pounds per ton in the United Kingdom. SASOL’s oil-from-coal factory, its coal mine, Sigma, and company town lay on coalfields in close proximity to much needed infrastructure for water supply: the Vaal dam, lying on the Vaal river. SASOL purchased mineral rights for 1625 hectares of land containing an upper coal seam of 11 feet thickness at a depth of 370 feet; a 24 feet thick middle seam at 420 feet, and a bottom seam immediately below this, 10 feet wide. An estimated 650 million tons of coal, 300 million tons of which was thought to be extractable, 140 years worth at a ‘reasonable’ rate of extraction. What constituted an optimal rate of coal seam extraction? The answer to this question depended on whether it was asked from the perspective of the production imperatives of SASOL’s oil-from-coal factory or with safety in mind. This tension lies at the heart of the story of the undermining of Sasolburg and of the history of subsidence engineering in South Africa.

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\(^6\) Renfrew Christie. *Electricity, industry, and class in South Africa* (London and Basingstoke: Macmillan, 1984)

\(^7\) Hansard, 10th April, 1951: Minister of Economic Affairs comments; ‘Oil Boycott not real threat, says SASOL chief’ *Natal Witness*, 7th April 1964.
From the very beginning of the SASOL project, undermining helped determine the shape of Sasolburg and its accompanying African township, Zam德拉. Farmland where borehole tests indicated higher quality coal would be ‘undermined’ quite severely and would be put to Verwoerdian use, making ideal ‘buffers’ between the white town and black township. As had long been the case by national law and mine regulations, SASOL had to request permission from the government mining engineer to undermine land. By the end of the 1950s, at precisely the point when the oil-from-coal plant’s severe operational teething problems begun to ease – and as David Noble’s *Forces of Production* has taught us to expect – the pressure to feed an increasing volume of coal into the continually operating petrochemical process, began to make itself felt. The pressure to increase the coal extraction rate lay behind SASOL’s request to undermine the area beneath the mine compound used to house its mine-workers, mostly migrant laborers from Lesotho and Mozambique. As per the mining regulations requests made to the government mine engineer to undermine existing buildings were met with a reminder not to encroach within 300 foot (vertically, rather than horizontally) of existing buildings, and the stipulation that any construction on undermined ground be limited to single storey buildings, with walls of no higher than 17 feet above the surface.

The ‘throughput pressure’ unique to 24 hour/7 day a week petrochemical production made the percentage rate of coal extraction a matter of ongoing debate among technical and managerial staff at Sigma. Concern about ‘safe roof conditions’ genuinely operated as a restraint on the company pushing the upper limit of extraction. Sigma’s initial extraction rate, when blasting and drilling were the primary method of mining, was just 15%, but the introduction of continuous miners pushed it to 60% at the close of the 1960s, while maintaining what SASOL’s managing director Etienne Rousseau, called ‘safe roof

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8 National Archives of South Africa (NASA) NTS 6134: 481/313N; Stigting van lokasies. SASOLBURG. Verslag: Hinterland vir Sasolburglokasie, 30 Jan, 1954
10 NASA, BAO 481/313 Sasolburg. Stigting van lokasies, JP Malan to Sec, Natural Resources, 3 Jan 1958
conditions’. Rousseau made it clear he didn’t think they could push any higher. At 80 per cent ‘you soon would have no mine at all; the whole mine would collapse. It was inconceivable that in our mine total extraction would not result in surface damage.’ Rousseau and mine manager Wantenaar both agreed that the bottom of the three coal seams in Sigma’s coalfield should be ‘left to posterity.’ It would be ideal to ‘work [the] mine to highest economy’ [i.e. maximum extraction], this would be ‘in Sasol's but not necessarily in the national interest.’ For once the two were not synonymous.

![Aerial view of Sasolburg town and Zamdela township in relation to SASOL’s factory and the Sigma mine.](image)

Then, on the evening of 21 January 1960 at the Coalbrook colliery, situated in an adjacent coalfield not owned by SASOL, approximately 900 supporting pillars over an area of 324 hectares (1.25 sq. miles) gave

12 SASOL 1 Archive, 303/2, Notes on Overseas Trips, ‘Summary of Conclusions to date’ 21 May, 1959.
way in a catastrophic mine collapse that buried 435 miners (five white South Africans, a Hungarian; the balance were migrants from Lesotho and Mozambique) alive, their bodies never to be recovered.

Because of its proximity, Sigma emergency personnel were part of the immediate rescue mission, and the disaster undoubtedly shocked many employees, managers and Sasolburg residents. Because of Coalbrook and Sigma’s shared geology, official scrutiny of SASOL’s mine was immediate and intensive. Investigations suggested that the disaster at Coalbrook happened because the mine had attacked (‘rubbed out’ or ‘robbed’, in industry parlance) supporting pillars in a scramble to meet contractual coal supply for newly established state-owned electrical power station nearby.

By contrast, a ministerial report by the government’s mine engineer praised the notably more ‘conservative’ approach to mining at Sigma, describing the mine as ‘magnificently planned, particularly from the angle of providing proper and adequate support for the superincumbent strata.’ The mine engineer had expressed concern in one area of the mine about decreased pillar size, but was otherwise ‘quite confident [that] the strength of the mine, the stability of the mine - its capacity to hold up all the rock above, that is right up to the surface – was quite in order.’

Coalbrook colliery had taken the lead with the introduction of ‘continuous miners’ in the late 1950s. SASOL had also begun to experiment with these ‘mighty monsters’, with their large rotating steel drums equipped with tungsten carbide teeth that scraped coal from the seam which was then loaded onto a built-in conveyer, connected to the colliery conveyer-belt system. Continuous miners were

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13 SASOL 1 archive, 4/3/21 Progress Reports, 26 March 1960 SASOL Progress Report
14 Free State Archives, Bloemfontein, Sasolburg Magistrate Court Case No 3411/65. The State vs Cornelis Johannes Wantenaar
massive boons for mine productivity and they opened up tempting avenues for the attainment of higher levels of extraction. Much of the area beneath and around Sasolburg was mined by the ‘bord-and-pillar’ approach customarily employed in South Africa, whereby ‘rooms’ of coal were cut away, with pillars left behind for roof support. Coalbrook showed that aggressive bord-and-pillar mining, greedily attacking supporting pillars with the assistance of the new ‘continuous miners’ courted disaster, as Etienne Rousseau clearly knew.

However, there was no escaping the throughput pressure of continuous petrochemical production. In the late 1960s, under a new mine manager, Ben Leach, SASOL began experimenting with a new hybrid high extraction method, combining aspects of strip and longwall mining: removing 600-foot-wide strips of coalface, which would cause the ground to ‘slump’ 4 or 5 feet. A decade before, requests to undermine the edges of Zamdela township had been granted by the government mining engineer so long as ‘the building of Bantu houses wasn’t in danger’. Now SASOL was warning that land reserved for township expansion (i.e. not yet built on) would be undermined to the point where it would be ‘impossible to build’ and getting impatient with officials pointing out that the company had effectively violated a previous agreement that it would not encroach further on Zamdela’s ‘hinterland’. Minutes from a meeting with officials notes that SASOL had ‘acquired the right to mine the coal and definitely has the claim on it, with the support of the state’, and, ‘will certainly not give it up for a few Bantu houses’. In order for SASOL to proceed with its new, higher extraction experiment (an experiment ‘supported by the state’, the official minutes note) a ‘relatively small encroachment’ of additional undermined ground would be necessary.

17 NASA, BAO 481/313N Stedelike Bantoewoongebiede Sasolburg. W. Sharp to Min BAO, 3 Feb 1969
18 NASA, BAO 481/313N Stedelike Bantoewoongebiede Sasolburg. G.H. Meiring to Sec, BAO, 26 March 1968
There were tensions between officials in the Department of Bantu Administration and Development and SASOL over what undermining encroachments meant for the plans laid down for Zamdela’s development by Hendrik Verwoerd in the early 1950s. SASOL’s new company town was designed by Max Kirchhofer, a fastidious Swiss émigré architect, strongly influenced by post-war ‘new town’ planning in Britain. Kirchhofer put great care and attention into designing a (white) worker’s utopia of sorts. Racial segregation between the white town and black township of Zamdela was *sine qua non*. Though his own sensibility was closer to a ‘middling modernism’, Kirchhofer’s plans for the township ultimately had to conform strictly to Hendrik Verwoerd’s notoriously rigid and segregatory ‘authoritarian high modernism’. Native Affairs Department minutes from meetings with Kirchhofer confirm that Verwoerd double checked the finer detail of Kirchhofer’s plans, quarrelling about the precise positioning and size of roads, buffers and hinterlands.

During these early apartheid years, before his ascent to the highest office in the land, Verwoerd closely supervised plans for the mass construction of new black townships in response to the crisis precipitated by massive war-time urbanization of Africans and the associated chronic housing shortage. As he poured over sketch maps with planning consultants like Kirchhofer, Verwoerd insisted upon conformity to his ironclad segregationist formula for a spatial fix to allegedly chaotic, miscegenated pre-apartheid development, his answer to the problem of securing a white supremacist future. In the case of new areas of urban development, white town and black township were to be placed an adequate distance apart, be separated by buffer zones and transportation infrastructure had to channel Africans between town and township without permitting their concentrated movement through white residential areas. Plans for townships had to specify the existence of a ‘hinterland’; space for their

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controlled expansion, away from white residential areas. These hinterlands were key to the spatial life of Verwoerd’s project of securing orderly racial segregation over the longer term.

SASOL’s undermining of the edges of Zamdela (see arrow bottom right corner of map; second arrow shows undermining of the white town) compromised these Verwoerdian prescriptions. By eating away at Zamdela’s subsurface, SASOL’s mine rendered sections of Verwoerd’s hinterlands unusable for township expansion. Verwoerd had been assassinated a few years before, but his successors in the Department of Bantu Administration and Development were bound by his covenants and committed to defending them. Undermining meant ‘the expansion of the Bantu residential area must be curtailed’

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20 Evans, Bureaucracy and Race, p 128
because ‘it may be dangerous’. A more immediate concern than safety was the fact that the fracturing of Zamdela’s ‘hinterland’ by undermining might necessitate the development of a second township in the vicinity of Sasolburg, a prospect that Verwoerd had personally vetoed in the early 1950s when it had been on the cards, and which, after all, his hinterland was designed to prevent. Deputy Minister of Bantu Administration, Piet Koornhof, made it very clear that the department refused to be ‘forced into the creation of a second township.’ SASOL’s undermining of this additional section of Zamdela’s hinterland was permitted. What, then, of Zamdela’s expansion? ‘They must concentrate only on hostels, so far as is practically possible’, an official instructed. The building of family accommodation for Africans would be frozen and limited to approximately 4% of the total African population in Zamdela going forward.

The dilemma provoked by the unavailability of portions of land intended for Zamdela’s expansion was resolved, in other words, by recourse to residential densification in remaining portions of the townships which were not undermined. Verwoerdian spatial strategies were coupled with a racial arithmetic preoccupied with holding down the number of Africans living in urban areas, even while his department pursued the stabilization of the African working class through the new township build. For its part, SASOL and its planner Kirchhofer had initially imagined a significant proportion of Zamdela residents would be living in family accommodation, much higher than the 3% norm on the Witwatersrand gold mines. With its much-hyped mechanized mine and sophisticated factory, SASOL employed a high

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21 NASA BAO 481/313N Stedelike Bantoowoongebiede Sasolburg. Memo, Onderhoud met stadsraad van Sasolburg: Ondermyning van Bantooweongebied, 6 June 1969
22 NASA BAO 481/313 Sasolburg. Stigting van lokasies. Proposed Native Location and Village, Coalbrook, O.F.S, Sec Native Affairs to Construction Manager, Sasol, 30 August, 1951
23 NASA BAO 481/313N Stedelike Bantoowoongebiede Sasolburg, P. Koornhof to Sec, BAO (Bantu Administrasie en Ontwikkeling), 17 Feb, 1969;
24 NASA BAO 481/313N Stedelike Bantoowoongebiede Sasolburg. Memo, Onderhoud met stadsraad van Sasolburg: Ondermyning van Bantooweongebied, 6 June 1969
number of ‘skilled’ African workers, who it expected to be more ‘contented’ and likely to stay in its employ if accompanied by their families. This was not to come to pass.

In the mid 1960s, just a few years before the latest undermining encroachment, Kirchhofer complained bitterly that his understanding of the original intention of creating a “balanced community” with significant family housing had not materialized: Zamdela was scarred by the “mass housing of men” in “mass accommodation devoid of privacy, rife with pilfering and incapable of fulfilling the most modest human endeavors.” Hostels continued to dominate Zamdela through to the end of apartheid.

The conventional explanation for how this happened elsewhere in South Africa focuses, correctly, on Verwoerd belligerent insistence on holding down the number of African families in urban areas and later turning the old ‘native reserves’ into Bantustans, which meant that the long established pattern (which in fact partly owed its origins to African resistance to proletarianization) skewing urban African presence towards single migrant laborers was further entrenched. This paper has suggested an additional, subterranean source of momentum behind the aborted family housing project in Zamdela.

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In 1999, Sigma mine was finally closed after four decades of mining. The mine was flooded with water, a common strategy intended to remove oxygen from the mine in order to slow the emergence of Acid Mine Drainage. The entrance shafts were demolished and sealed with cement caps, as required by law. SASOL continued to monitor water conditions and surface stability, with the assistance of the Institute

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26 SASOL 1 Archive, 8/2/4, Housing, Steyn van der Spuy to Sec of Native Affairs, 21 November, 1955.
27 Sasolburg Town Clerk Files (STCF), 2/9/69, Planning of Sasolburg, Max Kirchhofer to Town Clerk, Sasolburg, 30 July, 1965.
28 SASOL 1 Archive, 8/2/5/3, Housing Black Personnel, Revd, Douglas Wessels (St Michael and All Angels Church, Sasolburg) to Mr F.J. Botha, 26 Nov 1985.
of Groundwater Studies at the University of Free State, Bloemfontein and private consultants. Because of intermittent issues with subsidence in the old mine, in 2012, the company instructed consultants to produce a 'Potential Failure Report' on the threat posed by undermined ground in the vicinity. The report identified a significant spread (see map) of the undermined area as ‘high risk’, likely to collapse ‘at any time’, with the ‘potential to cause fatalities’.

Map showing sections of Sigma mine at risk of pillar failure.

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Local nearby white-owned commercial farms where SASOL had originally acquired mining rights had been undermined and lost access to groundwater because of the ‘dewatering’ necessary to prevent the mine from flooding while in operation. SASOL had long provided these farmers with a replacement water supply. Now, SASOL’s consultants warned, subsidence threatened the structural integrity of these farms.

Likely pillar collapses would have what the consultant report described as ‘catastrophic impacts’ on the Leeuspruit and Rietspruit running above the mine, tributaries of the nearby Vaal River, the third largest river in the country and one of the main sources of water for the Vaal Triangle and Gauteng province. With subsidence, the emergence of cracks at the surface would result in surface water entering the underground mine workings and groundwater, causing the Mean Annual Runoff of water flowing into the Vaal River to cease, with implications for vegetation and habitat functionality: ‘a complete sever, in the hydrological links’ of the Vaal River system. In addition, ‘the merging of surface and groundwater in the mine would result in ‘contamination of the wetland and freshwater systems’.

The consultant report did not mince words: subsidence cannot be stopped because the coal is gone. Mitigation of impact – of risk – is all that’s left. Infrastructure would be demolished in areas where pillar failure was most likely to occur but two additional main strategies were to be used: river diversion and the ‘backfilling’ of mine voids with ash slurry in order to increase pillar support. The Leeuspruit and Rietspruit rivers would be diverted, using canal and flood protection berms, away from areas where subsidence was most likely to occur, in order to ‘preserve the surface water resources for future generations.’ Boreholes will be drilled to inject approximately 10 million cubic meters of ash slurry (20% fine ash, 80% water), carried by pipeline from the nearby Sasol plant, where coal from a recently opened nearby mine is burnt to produce steam for the conversion of natural gas (piped from Mozambique) into petrochemicals.
Ash backfilling shallow coal voids had been pioneered at Koornfontein colliery, where bord-and-pillar workings started collapsing in the early 1960s. As SASOL grew concerned in the late 1980s and early 1990s about the ‘slow ongoing collapse of old bord & pillar workings’ and potential damage to ‘surface structures over large areas’, Nielen Van der Merwe, SASOL’s strata specialist proposes using ash backfilling in mitigation. The company first employed ash backfilling for stabilization of mine works in 1999, with the permission of the Department of Water Affairs (DWAF), beneath the severely undermined Sasolburg-Parys Road (R26). By this stage the company had realized ash backfilling had the added benefit of disposing of material which otherwise would have to be placed on the surface in ash dams, a method which environmentalists had become increasingly critical of. A consulting firm employed, as per the DWAF license, to monitor water quality in the voids reported no deterioration in water quality over a two year period, though when backfilling was first initiated ‘decant’ had occurred, which led to the realization that backfilling flooded mines required simultaneously pumping void water out and injecting ash slurry at equal speed and volume.

The feedback forms from the statutory public participation process for the EIAs indicate understandable anxiety among local farmers and residents about the possible deleterious effects of ash backfilling, on top of what is widely assumed to be tainted groundwater, no longer ‘dewatered’, but replenished by contaminated void water. The EIA report admits – in strange, hedging language – that ash slurry ‘will and has in the past potentially impacted’ groundwater quality while insisting that this is

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32 CSIR Library, J A Ryder 'Determination of the Quantity of Ashfill required to stabilize and prevent undue subsidence of old workings', Oct 1992
33 Lize Wessels ‘Decant of Sigma Colliery’ M.A. Thesis, Institute for Groundwater Studies, University of Free State, Bloemfontein, June 2013
34 The consultant reports confirm that the void water will need to be treated, upon removal from the mine.
the most efficient method for urgently required mitigation of subsidence risks. The report also points out that in voids where the highest levels of coal extraction had occurred, ash backfilling would make no difference, because, in a chilling phrase, ‘no pillars currently exist to improve the strength of’. **

The missing pillars had collapsed. Explaining why requires an excursion into the history of the regulation of undermining and of mining-related subsidence engineering in South Africa. The field of subsidence engineering i.e. the prediction, assessment and management of subsidence and its effects – first emerged in the late nineteenth century in British and European coal mining districts. It did so in response to the need for ‘realistic and meaningful allocation of compensation costs’ in cases where damage resulted from the undermining activities of mining companies. Since late nineteenth century, mineral and surface rights have been severed from one another in South Africa, with the law giving mineral exploitation precedence, within certain limits. Mineral rights holders typically negotiate contractual agreements that stipulate damages in the event of subsidence.

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J. N. van der Merwe ‘Handling the effects of subsidence on structures: a comparison of the approaches adopted in the USA, Australia and South Africa’ in COMA: Symposium on construction over mined areas, Pretoria, 1992
Gold mining in Johannesburg in the late nineteenth and early twentieth century was plagued by subsidence problems: the annual reports of the Transvaal Mining Engineer between 1903 and 1927 make frequent reference to subsidence-related problems, only decreasingly significantly after exhausted shallow mines nearer the urban core are surpassed by the regions deep level mines. Regulation happened on a case by case basis and was marked by a degree of what later generations would come to view as conservatism. Official approval had to be secured for any undermining within 240 meters of the surface, a depth contour apparently settled upon by the observation that mining at deeper levels than this tended not to have visible surface effects in the same way.\(^{39}\) It is some measure of the success of the undermining regulations that a belt of largely derelict surface area extended, for much of the twentieth century, in a 50 km belt from Roodepoort in the West of Johannesburg, beyond Daveyton and Springs in the east. Because of where seams are located, coal mining in South Africa happens at shallow levels which has made undermining and subsidence an ongoing source of difficulty. Singer shows that in the immediate aftermath of the Boer War, the Witbank colliery encountered pushback from the Transvaal Mining Engineers Dept for its undermining of the town.\(^{40}\)

From the late nineteenth century until after Coalbrook, the design of collieries proceeded by trial and error, drawing on inherited traditions from British collieries and accumulated practical engineering experience. While SASOL managers privately worried about regulatory overreach in the aftermath of Coalbrook, they conceded the episode had ‘underlined how little research there was on coal mining methods’ in South Africa. This now changed thanks to a special levy on coal sold by collieries, which was matched rand for rand by state funds, together with monies contributed by the

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\(^{39}\) See p 8 of ‘Report by the Working Group on Undermining Guidelines’, Annexure in Dirk Bakker, ‘Factors affecting the undermining of surface structures above hard rock mines in the Central Witwatersrand and the Western Bushveld Igneous Complex’ MSc, Wits, 1991

Chamber of Mines. Coal pillar strength became a major new research area, within the larger minerals-energy research complex that emerged out of mutually-reinforcing relationships between the Chamber of Mines, the Council for Scientific and Industrial Research (C.S.I.R) and the engineering faculties of the major local universities. Established in 1965, the Chamber of Mines Research Organisation (COMRO) became the locus of this research.

The most important South African study of coal pillar strength, which went on to enjoy international influence, was published by COMRO researchers (and European emigres) Salamon and Munro in 1967. Employing a statistical approach, they sent out a questionnaire to local collieries that would ‘rationalize the past experience of mining engineers’, requesting the physical dimensions of ‘current workings and areas where collapse of pillars had taken place’. Generating two data sets from the questionnaires: the dimensions of failed pillar cases and stable pillars, Salamon and Munro proposed that the safety factor of coal pillars in South Africa could be defined as:

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\text{safety factor} = \frac{\text{strength}}{\text{load}}
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Thinking it reasonable to presume that the majority of local coal mining engineers settled on a compromise between safety and economic considerations, Salamon and Munro suggested that the optimum safety factor for pillars lay in the range where 50 per cent of the ‘stable’ pillar cases were most densely concentrated i.e. between a safety factor of 1.3 and 1.9 - with the mean being 1.6. Though

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never written into law, this safety factor value and the strength formula that generated it was enforced by the government mine inspectorate as the ruling pillar geometry of the country from the late 1960s.

Other coal pillar researchers adopted an experimental approach, conducting extended laboratory tests, but these were a poor substitute for an actual pit. Another émigré COMRO researcher, Z.T. Bieniawski, conducted in situ tests (see below) involving carving large coal specimens from existing coal pillars in underground workings, cutting them horizontally while retaining their attachment to the floor of the mine shaft. To simulate the effects of the roof on the coal pillar, a reinforced concrete cap was placed on the top of the specimen, together with hydraulic jacks used to apply pressure to the pillar, measuring their strength to the point of collapse. These in situ tests encountered the abiding difficulty that coal pillars tend in fact to be very stable, the unpredictability of their collapse was the very problem researchers were grappling with.\textsuperscript{43}

\textsuperscript{43} Email communication with J.N van der Merwe. For a sense of the ‘experimental difficulties’ involved, see Z. T. Bieniawski ‘Note on in situ testing of the strength of coal pillars’ \textit{Journal of the South African Institute of Mining and Metallurgy} (May, 1968)
In-situ experimentation: testing strength and deformation of large coal specimens underground
In situ experimental work and chemical analysis of coal by the Fuel Research Institute at the C.S.I.R encouraged appreciation among COMRO researchers of the subtle differences between the geology of the different South African coalfields. One of the difficulties with Salamon and Munro’s formula, from SASOL’s perspective, was the fact that only three of the pillar cases in their dataset were from the Vaal basin where Sigma was located. Over the three decades after the formula began to be enforced by inspectors, a pattern of a disproportionate number of pillar failures at Sigma emerged, suggesting that Salamon and Munro’s safety factor was not the neatest fit on the Vaal basin. No massive collapse to compare with Coalbrook happened at Sigma, certainly – a track record which was an important source of the Salamon and Munro formula’s authority – but a significant statistical anomaly had emerged, which demanded further research. Drawing on an expanded database of pillar failures, the original
formula was revised in 1993, by the in-house strata specialist at SASOL Mining, Nielen van der Merwe. Now the leading expert on subsidence and South African coal mining, van der Merwe demonstrated that coal in the Vaal Basin was significantly weaker than in the coalfields which made up the bulk of Salamon and Munro’s dataset.  

Van der Merwe adjustment to the Salamon and Munro formula increased the size of pillars carved out in the last few years of Sigma’s operation, but this was too late for the missing pillars noted in the consultant report.

Salamon and Munro’s original formula had largely been welcomed by coal interests in 1967 because it effectively legitimized the middle ground of existing bord-and-pillar mining practice. From the late 1960s, with a new export market on the horizon, and especially after the 1973 Oil Shock, a new consensus began to emerge within the coal industry that the nationally dominant method of bord-and-pillar mining was extracting coal at ‘wastefully’ low levels. Coupled with this, the old regulatory approach of ‘sterilising’ undermined ground came to be seen by subsidence engineers and regulators (a revolving door between the relevant government ministry, the mines and the CSIR meant these were often the same people) as archaic and too conservative. The older approach to undermining needed to be supplanted by what Van der Merwe called ‘an engineering approach’.

The main thrust of subsistence engineering research over the last three decades of the twentieth century was the facilitation of significantly higher rates of coal extraction via newer methods of mining and generally pushing the envelope on the kinds of infrastructure that could be undermined.

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47 D. Bakker (Gov Mining Engineers Office) ‘The undermining of surface structures and construction/erection over undermined ground: coal mines’ COMA
48 J. N. van der Merwe ‘Handling the effects of subsidence on structures: a comparison of the approaches adopted in the USA, Australia and South Africa’ in *COMA: Symposium on construction over mined areas*, Pretoria, 1992
without undue damage or disruption. This entailed a shift from predicting, minimizing or preventing subsidence to the active inducement of subsidence via more voracious forms of extraction and the management of the resulting effects. Roads; power pylons; houses; surface dams; pipelines; farmland: all were subject to undermining via experimental study. (see image below)

Van der Merwe’s own doctoral research at Wits set out to show that the historically cautious regulation of high extraction undermining had unnecessarily ‘sterilised’ coal reserves in Sasolburg and Secunda, SASOL’s second company town. Van der Merwe used experimental studies to investigate the effect of high extraction coal mining on different kinds of roads; on a conveyor belt carrying coal, a water pipeline and farmland near SASOL’s towns. Van der Merwe found that even where structures had been designed without subsidence in mind, they withstood its effects ‘with only minor and relatively inexpensive precautionary and repair measures’. Caution had been understandable in the past but science had moved on, and though he wasn’t calling for ‘blanket undermining’ to be permitted, he believed the restrictions could be relaxed.49 Presenting his own research on undermining at a 1992 symposium on ‘construction over mined areas’, the assistant government mining engineer was in broad agreement with Van der Merwe’s position: the state must of course intervene ‘to protect life, limb and property’ but, ‘it is to nobody’s advantage to have a rigid attitude’.50 Van der Merwe hoped that his findings would ‘relax the sociological strains’ provoked – especially among local farmers – by the prospect of high-extraction mining.51 Less reassuringly, Van der Merwe conceded that the effect of high extraction mining on groundwater could be ‘very serious’.52

49 J.N. Van der Merwe, ‘Subsidence caused by high extraction coal mining in the Sasolburg and Secunda areas: prediction thereof and the mitigation of its effects.’ DPhil, Faculty of Engineering, Wits University, 1991, iii-iv and chap 12, p22
50 D. Bakker (Gov Mining Engineers Office) ‘The undermining of surface structures and construction/erection over undermined ground: coal mines’ COMA
51 Ibid, Chap 1, p 8-9
52 Van der Merwe ‘Subsidence’ chap 11, p 15.
Studying the effect of experimental undermining of a road near Sasolburg
Whatever the weaknesses of the concept of ‘the Anthropocene’, the fact that the activity of (some) humans (more than others) have indelibly altered the geology and ecosystems of Earth in the last few centuries in unprecedented ways is beyond dispute. We finally appear to have found the metanarrative to end all metanarratives. The call for precision contained in critiques of the Anthropocene remind us of the usual analytical perils that still need our attention.

The different shape economies and states take matter to the way the ‘Anthropocene’ looks on (and below) the ground. Sasolburg has, as yet, not seen the kind of catastrophic pillar collapse which occurred at Coalbrook. Nor, during the working life of Sigma mine, did it reach the extremes of Brian Butte, Montana (‘the city that ate itself’). There were important constraints on SASOL’s extractions. The prospect of a repeat of the mass pillar collapse in the next door mine; government inspectors keeping a close eye on pillar thickness; Etienne Rousseau’s recognition that SASOL’s financial imperatives and the national interest (even if only the white nation) were not synonymous. A government department preoccupied with defending Hendrik Verwoerd’s vision of the racial ordering of space also set limits. And yet, unremitting production pressures, the introduction of new technologies of extraction and the push within the minerals-energy research complex for higher levels of coal extraction have left their mark on the Vaal’s vulnerable hydro-ecology.

In order for SASOL to receive a certificate of closure for its underground mine from the South African state, the post-apartheid state requires it to undertake mitigatory measures to diminish the negative effects of its operations. Of course, in one sense this is too little, too late. As SASOL managers readily admit, backfilling voids with ash slurry is a less than perfect attempt at stabilizing irredeemably unstable, contaminated ground. It is also economically and otherwise expedient. The primary reason I

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have been able to describe the severity of the void crisis in Sasolburg is because of the statutory requirement in that major projects in South Africa provide heritage and environmental impact assessments before receiving planning approval. In order to get government approval to backfill mine voids with ash slurry, SASOL provided documents (which are now freely available on the internet) detailing the proposed intervention, its likely effects, and the historical and contemporary reasons that make such an intervention necessary. There is, I think, a lesson here – and in the longer history of Sasolburg’s undermining – about the importance of regulation and of transparency, but also a warning, in the ongoing revenge of the voids, that leaving the last seam to posterity may not be anywhere near enough.