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Of outcrops and narrow seams: Geology, tribute agreements, and co-operative chromite mining along Zimbabwe's Great Dyke, 1985-2022

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Abstract

This article argues that the development of co-operative chromite mining in post-colonial Zimbabwe was largely shaped by geological factors, particularly the geotechnical challenges of extracting the narrow (thin) and frequently faulted chromite seams in the northern section of the Great Dyke geological formation. It examines co-operative miners' geological knowledge and mining skills, and the roles of government departments, the Institute of Mining Research (IMR) at the University of Zimbabwe, and chromite mining companies in supporting miners in developing their mining operations and tackling geotechnical challenges. The article draws on oral interviews, contemporary newspaper reports, annual reports from the Zimbabwe Mining Development Corporation (ZMDC), the Secretary for Mines, and research reports produced by the IMR.

Keywords: chromite, co-operative mining, geology, Great Dyke, narrow seams,

Introduction

Soon after independence in 1980, the Zimbabwean government began supporting the establishment and growth of mining co-operatives as part of its drive to encourage the black majority population's participation in the economy. It created a supportive regulatory framework and provided financial and technical support through the Ministry of Mines, the Zimbabwe Mining Development Corporation (ZMDC), and the Small Enterprises Development Corporation (SEDCO), established in 1982 and 1983, respectively. Although co-operatives were established to mine gold, tin, lithium, copper, tantalite, and chromite, chromite mining co-operatives proved the most successful in both output and number. They expanded rapidly from 1985 to the late 1990s due to the availability of near-surface, narrow (thin) seam chromite deposits. Mining companies deemed these deposits too costly to extract.[1] The challenges mining companies faced in extracting the narrow chromite seams led mining companies to lease their underperforming operations and undeveloped claims to mining co-operatives using tribute mining contracts. Co-operative chromite mining operations, however, faced geotechnical challenges related to the thickness of chromite seams and faulting, and were severely underfunded—reliant on financial and technical assistance from the government, mining companies, and international development agencies to procure mining machinery and develop underground mining practices.

The article contributes to the growing, albeit still limited, scholarship on mineral resource extraction that foregrounds the centrality of geology and miners' geological knowledge in the development of mining operations and in shaping miners' everyday working practices. While most studies of artisanal and small-scale mining focus on political economy, environmental impacts and the relationship between mining and farming livelihoods, far less attention has been paid to the geological dimensions of mining. This lacuna has prompted calls for resource extraction scholars to consider the 'geology of mining', miners' geological knowledge, and the materiality of the minerals extracted.[2] This article responds to this call by placing the geology of chromite within the Great Dyke geological formation at the centre of the analysis of the development of co-operative chromite mining in Zimbabwe.

Co-operative chromite mining in Zimbabwe began in the 1980s, when Zimasco Private Limited (ZIMASCO) and ZimAlloys Private Limited (ZimAlloys), the chromite mining and ferrochrome smelting subsidiaries of Union Carbide and Anglo-American, respectively, began closing down their unprofitable mining operations in

[1] The terms 'narrow seams' and 'thin seams' are used interchangeably.
[2] See I. S. Jiyane, ' "Black Gold" and Verticality: Geology, Labour and Mining Operations in the Territorial Construction of the Witbank Labour District', *Journal of Southern African Studies*, 50, 1 (2024), pp.9-28; R. D'Avignon, *A Ritual Geology: Gold and Subterranean Knowledge in Savanna West Africa*, (Durham, Duke University Press, 2022); T. Richardson and G. Weszkalnys , 'Introduction: Resource Materialities', *Anthropological Quarterly*, 87, 1 (2014), pp.5-30; P. Alexander, 'Challenging Cheap-Labour Theory: Natal and Transvaal Coal Miners, ca. 1890-1950', *Labour History*, 49, 1 (2008), pp.47-70.

the middle and northern sections of the Great Dyke geological formation, and leasing them to mining co-operatives. This decision was driven primarily by the geotechnical challenges mining companies faced in extracting narrow chromite seams using large-scale mining operations, together with rising labour costs and falling global prices for chromite and ferrochrome, which threatened the long-term viability of their operations.[3] These challenges forced mining companies to lay off thousands of workers, shut down some operations, and lease narrow-seam deposits to mining co-operatives, while they focused on extracting from thicker seams in the Southern Dyke and from podiform deposits outside the Great Dyke.

There has been a recent upsurge in studies foregrounding geological factors and miners' geological knowledge, including how miners perceive the connection between the surface and the subterranean.[4] Luning and Pijpers describe a 'three-dimensional' approach to studying resource extraction, to be distinguished from an approach that focuses on surface mining activities, and examining how 'knowledge of specific subterranean structures' shaped interactions between miners over access to seams.[5] D'Avignon's seminal study on artisanal gold mining in West Africa clearly demonstrates how miners' knowledge shaped their practices.[6] D'Avignon deploys the concept of 'ritual geology', which she defines as 'the set of practices, prohibitions and cosmological entanglements with the earth and its spiritual inhabitants shared widely across a geological formation', to examine how artisanal miners in West Africa acquired and circulated knowledge of geology, metallurgy and the subterranean. They invite scholars to place geological structures and the relationship between humans and the spirit world at the centre of historical analysis of resource extraction.

In Southern Africa, Jiyane, whose work appears in this journal, recently demonstrated how coal mining in the Witbank District (now eMalahleni) was shaped

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[3] See H. Chiwawa, *Co-operatives and contract mining in the Zimbabwean chrome mining industry: the paradox of industrial democracy* (Harare, Zimbabwe Institute of Development Studies Monographs, Harare, 1990), O.Maponga and B. Ruzive, 'Tribute chromite mining and environmental management on the northern Great Dyke of Zimbabwe', *Natural Resources Forum*, 26, 2 (2002), pp. 113-126.

[4] See A. Marston, *Subterranean Matters: Co-operative mining and resource nationalism in a Plurinational Bolivia* (Durham, Duke University, 2024)., J. Jonkman, 'Extracting empirically: A ground's-Eye view of small-scale Mining in Colombia' *Anthropological Quarterly*, 95, 3 (2022), pp.649-680., S. Luning, and R. J. Pijpers. 'Governing access to gold in Ghana: In-depth geopolitics and mining concessions', *Africa* 87, 4 (2017), pp. 758-779., S. Geenen, 'Underground dreams: Uncertainty, risk and anticipation in the gold production network', *Geoforum*, 91 (2018), pp.30-38.

[5] Luning and Pijpers, 'Governing access to gold in Ghana', p.761.

[6] D'Avignon, *A Ritual Geology*.

by both the availability of labour and favourable geology, which made extraction less costly than in areas such as Natal.[7] Although Jiyane focuses on industrial mining, their insights are relevant to the analysis of co-operative chromite mining in Zimbabwe, as geological factors were central to the sector's development. Other scholars have analysed the extent to which gold mining in colonial Zimbabwe was influenced by government policies and the underlying geological factors.[8] Recently, some scholars have examined how alluvial diamond deposits in Chiadzwa influenced the diamond rush and the relationships between informal miners and mining companies.[9] This article contributes to this emerging scholarship by examining how geological knowledge affected co-operative chromite mining in post-colonial Zimbabwe.

Sources and Research Methodology

Research for this article was carried out between 2019 and 2022 as part of a larger project on co-operative chromite mining in Zimbabwe. Primary sources consulted include annual reports from the Chamber of Mines, the Secretary for Mines, the Zimbabwe Mining Development Corporation (ZMDC), and the Institute of Mining Research (IMR).[10] Additionally, I reviewed research reports on mechanised methods for extracting narrow chromite seams and on underground small-scale chromite mines support, conducted by IMR. The article also draws on newspaper reports and parliamentary committee reports.

Fieldwork was conducted intermittently between 2020 and 2021 in the Mapanzure, Lalapanzi, and Mutorashanga mining areas along the Great Dyke. Initially, participants were recruited through known mining co-operatives and small-scale mining operations. Subsequently, snowball sampling was used to identify and interview more participants. The oral interviews primarily focused on participants' mining experiences, involvement in mining co-operatives, and their knowledge of

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[7] Jiyane, ' "Black Gold" and Verticality.'

[8] See I. R. Phimister, 'The reconstruction of the Southern Rhodesian Gold Mining Industry, 1903-1910', *The Economic History Review*, 29, 3 (1976), pp.465-481.

[9] See T. Nyamunda and P. Mukwambo, 'The State and the Bloody Diamond Rush in Chiadzwa: unpacking the contesting interests in the development of illicit mining and trading, c.2006-2009', *Journal of Southern African Studies*, 38, 1 (2012), pp.145-166; P. Chadambuka, F. Tombindo and T. R. Bvirindi '"They are taking everything away from us": autochthonous claims and the moral contestations over Chiadzwa diamonds, eastern Zimbabwe', *Journal of Contemporary African Studies*, 42, 2 (2024), pp.263-279.

[10] Reports of the Secretary for Mines are annual reports prepared by the Permanent Secretary in the Ministry of Mines and presented to Parliament.

chromite geology. The research participants comprised men and women who were members of chromite mining co-operatives and syndicates, as well as individual artisanal and small-scale miners and local community members. All participants were anonymised, with pseudonyms used to protect their identities.

Figure 1. Map of Zimbabwe showing the Great Dyke geological formation (Map drawn by Russel Kapumha).

The rise of chromite mining co-operatives in post-colonial Zimbabwe

Chromite is the mineral ore containing chromium, a vital material used in the production of stainless steel, chrome plating, and pigments, among other applications. It exists in three forms: stratiform (seam), podiform, and eluvial deposits. The majority of the world's chromite resources are found in the stratiform deposits of South Africa's Bushveld Complex and Zimbabwe's Great Dyke geological formation. The Great Dyke is 550 kilometres long, stretching from the country's north-east to its south-west, and is four to twelve kilometres wide.[11] These deposits account for approximately 60 per cent of the chromite resources mined in Zimbabwe.[12] The stratiform deposits of the Great Dyke occur in eleven distinct seams, with thicknesses ranging from 8 cm to 40 centimetres. The North Dyke (the northern section of the Great Dyke) has predominantly narrow chromite seams, averaging 11 centimetres in thickness. These narrow and frequently faulted seams challenged ZIMASCO and ZimAlloys, affecting the viability of their operations.[13] To put this into perspective, chromite seams in the South African Bushveld Complex typically range from 76 to 102 centimetres in thickness, making their extraction economically viable.[14] Therefore, in addition to the effects of falling global prices and government minimum wage laws that raised production costs and challenged the viability of chromite mining companies, geological factors influenced the companies' decision to lease operations to mining co-operatives. Noetstaller notes how geological factors, including ore deposit type and

[11] R. F. Schulte, R. D. Taylor, N. M. Piatak, and R. R. Seal, 'Stratiform chromite deposit model' In *Mineral Deposit Models for Resource Assessment.* (Reston, US Geological Survey, 2012), p.2.
[12] *Ibid*
[13] Chiwawa, *Co-operatives and contract mining in the Zimbabwean chrome mining industry*, p.45.
[14] R. F. Ballen, 'The implications of South Africa and Zimbabwe on the American Ferrochrome industry' (PhD Thesis, Colorado School of Mines, 1981), p. 142.

size, host rock strength, mineralisation, and the presence of surface or near-surface deposits, played a crucial role in mining companies' decisions to close some of their operations and lease them to mining co-operatives.[15]

One of the ways the government of Zimbabwe sought to encourage the participation of the black majority in the mining sector was to promote the development of mining co-operatives. It did this by establishing parastatals such as ZMDC, whose mandate was to invest in the mining industry on behalf of the State and promote the development of mining co-operatives. The parastatal facilitated the registration of mining co-operatives with the Registrar of Co-operatives and ensured compliance with the Co-operative Societies Act (Chapter 193 of 1956) through its Department of Mining Co-operatives.[16] Along with helping mining co-operatives with registration and legal requirements, ZMDC offered technical support through its resident supervisors and organised training workshops. These initiatives were designed to improve the operational efficiency of co-operative members by equipping them with essential skills and supporting their efforts to buy or lease mining machinery.[17] ZMDC also deployed its field supervisors to provide technical assistance to co-operatives. This included selecting suitable mining machinery, assessing ore quality, designing both surface and underground mining operations and ensuring the operations adhered to mining regulations. According to Chiwawa, one of the key roles of ZMDC was to act as a 'recruiting, supervising, and training agency for co-operatives,' as well as to ensure that co-operatives complied with the terms of their three-year tribute mining agreements.[18] It is important to note that these services were not provided free of charge. In addition to plant-hire services, ore transportation, skills training, and other technical services, ZMDC also charged co-operatives for services provided by its field supervisors. In 1984, the fee for its field supervisor services was set at Z$3 per tonne of ore produced by co-operatives.[19]

[15] R. Noetstaller, 'Small-Scale Mining A Review of the Issues', World Bank Technical Paper, 75 (1987), p.42.
[16] The Act was amended in 1990 and 2001.
[17] ZMDC, Annual Report, 1990, p.12.
[18] Chiwawa, *Co-operatives and contract mining*, p.22.
[19] Report of the Secretary for Mines, 1983, p. 56.

The framework for the establishment and registration of co-operatives was laid out in the Co-operative Societies Act (Chapter 193, 1956).[20] Among other provisions, the Act stipulated that co-operatives must be composed of at least ten members. They were also to establish a management committee composed of a chairman, a vice-chairman, a secretary, a vice-secretary, a treasurer, and committee members. Membership was voluntary and open to individuals aged 18 or older, and new members could join established co-operatives by paying a predetermined joining fee. To facilitate the formation and registration of mining co-operatives, ZMDC provided a template of bylaws for the co-operatives to adopt. The objectives listed in the bylaws template included: 'to promote the economic interests of members in accordance with co-operative principles and to provide collective facilities,' 'to carry out operations on a co-operative basis, which include prospecting, processing and marketing,' 'to contract for mining work,' and 'to promote and stimulate the spirit of co-operation and collective effort among the members.'[21] The bylaws also included a clause authorising the co-operative committee to apply for loans to raise funds or enter into tribute mining agreements with mining companies that owned mining claims. Additionally, the bylaws set out how the co-operative would manage finances, distribute profits, conduct elections, resolve disputes, and manage its liquidation.[22]

Although mining co-operatives were established to extract a variety of minerals, those engaged in chromite mining expanded rapidly from 1985 onwards. This was because Zimasco and ZimAlloys, the leading chromite mining and ferrochrome-smelting companies, struggled to extract the narrow seams in the North Dyke, forcing them to seek government permission to shut down some operations and lay off thousands of employees to remain viable.[23] Government permission was granted in 1985 on the condition that the companies leased the closed mines and undeveloped claims to mining co-operatives under tribute mining contracts.[24] These arrangements contributed to the rapid rise in the number of chromite mining co-

[20] The Co-operative Societies Act (Chapter 193, 1956) was replaced by the Co-operative Societies Act (Chapter 24:05, 1990).
[21] 'Mining Co-operative Society By-laws', Template, ZMDC (no date)
[22] *Ibid.*
[23] See Chiwawa, *Co-operatives and contract mining*
[24] See O. Maponga and B. Ruzive, 'Tribute chromite mining and environmental management on the northern Great Dyke of Zimbabwe', *Natural Resources Forum*, 26, 2 (2002), pp. 113-126.

operatives, as former mine workers formed co-operatives and entered into three-year tribute mining agreements with mining corporations. The framework for tribute mining agreements was set out in the Mines and Minerals Act (Chapter 165, 1961) and its subsequent amendments. The Act also mandated that the Mining Affairs Board approve all tribute mining agreements. According to Maponga and Ruzive, 'under tribute arrangements, individual tributors or co-operatives work on claims and operate mines as though they were their own for a fee. Tributors also legally sublet claims to sub-tributors under similar arrangements.'[25]

Tribute agreements favoured companies, which controlled mineral rights and set the terms of the agreements. The companies established monthly production goals for the co-operatives, defined ore grades, and mandated that they sell all their ore to the companies. ZIMASCO required co-operatives to deliver only 'cleanly picked ore, free from dust, dirt sweepings, waste rock, and other foreign materials', with ore sizes ranging from half an inch to five inches.[26] Similarly, ZimAlloys stipulated that co-operatives should supply only hard, lumpy ore measuring between 19 and 150 millimetres in size.[27] Co-operatives were also required to pay royalty fees and an environmental rehabilitation levy to the mining companies. For example, in the 1980s and 1990s, ZIMASCO's tribute agreements required tributors to pay a royalty of 50 cents per tonne of ore produced, while ZimAlloys levied a 5 per cent royalty on gross earnings for ore extracted by tributors on its claims.[28] Mining co-operatives were fined for failing to meet their monthly production commitments or for repeatedly delivering more ore than their contractual obligations required. Although ZMDC negotiated ore prices on behalf of co-operatives, mining companies held greater power to determine the final price.

Some notable chromite mining co-operatives established in the 1980s and 1990s and operating in the North Dyke included Ngezi, Zacro, Nehanda, Kushinga Kukuru, Ntamoyatha, Nhamo, Power, Wakundwa, Chemakomo, Taisireva, and Tavakuenda.

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[25] Maponga and Ruzive, 'Tribute chromite mining', p. 117.

[26] O. Maponga, *Small-scale Mining Operations in Zimbabwe* (Ottawa: International Development Research Centre, 1993),p.26.

[27] *Ibid.*

[28] Chiwawa, *Co-operatives and contract mining,* p.25.

The Makomborero Co-operative, established in 1986, was one of the key co-operatives operating in the Lalapanzi mining area of the Middle Dyke.[29] The number of co-operators in each of the mining co-operatives ranged from the minimum ten members permitted by the Co-operative Societies Act to hundreds of members. Most of the co-operatives operated on mining claims or on established mining operations leased from ZIMASCO and ZimAlloys under three-year renewable tribute mining agreements. In 1985, ZimAlloys and ZIMASCO started leasing most of their operations in the North Dyke to mining co-operatives. ZimAlloys leased its Vanad and Sutton mines to five mining co-operatives. It also leased portions of its Caesar mine to three mining co-operatives.[30] Similarly, ZIMASCO leased parts of its Mutorashanga Mine operations to several mining co-operatives.[31] By closing their North Dyke operations and leasing them to mining co-operatives, the two companies successfully cut their North Dyke workforce by 37.12% and 25.5%, respectively, helping them reduce production costs.[32] The tribute mining arrangements also allowed them to retain ownership of the mineral rights and control over prices.

During the early years, mining co-operatives were able to exploit their lower overheads and labour-intensive methods to generate profits. Mining co-operatives could employ casual labour, paying them each month after selling their ore. Alternatively, each co-operative member could hire family members to mine ore individually, then combine their output with that of other members for sale. The earnings would then be distributed according to each member's tonnage. In 1986, ZMDC reported that the eighteen chromite-mining cooperatives in operation produced 37,000 tonnes of ore, generating gross revenue of $2,100,000.[33] It further noted that 'of this amount, $379 000 was the net operating surplus and $1 100 000, or an average of $126 per person per month, was distributed to members, which compared favourably with the mining industry's minimum wage during the year.'[34] The minimum for the industrial and mining sector for 1986 was $158, inclusive of all

[29] 'Viability woes rock co-operative', *The Sunday Mail*, 26 July 1998.
[30] *Ibid.*, p.21.
[31] *Ibid.*
[32] *Ibid*, p.25.
[33] ZMDC Annual Report, 1986, p.15
[34] *Ibid.*

benefits.[35] Although this was seldom consistent, co-operative miners in the 1980s claimed to earn more each month from the proceeds of their ore sales than from the wages they received while employed by the mining companies.[36] However, these positive statements were quickly replaced with complaints about deductions from their incomes by mining companies and the increasing costs of mining equipment and consumables, which impacted their net income.

Evidence from the five co-operatives with tribute agreements with ZimAlloys in the North Dyke between 1985 and 1987 indicates that, although these co-operatives consistently met their target production of 140 tonnes each per month, their total earnings were often reduced by deductions. These deductions included mining royalties and environmental levies imposed by mining companies with whom they signed tribute agreements. Furthermore, co-operatives were responsible for covering costs such as machinery rental, transporting ore from mining sites to smelters, electricity, explosives, and supervisory services supplied by mining companies and ZMDC.

In addition to mining royalties and environmental levies paid to mining companies, chromite mining co-operatives also saw their income reduced by deductions for machinery rental, transportation of ore from mining sites to smelters, and, in some cases, for supervisory services provided by mining companies and ZMDC. This caused considerable disquiet among co-operative miners, particularly as the cost of consumables continued to rise. In the North Dyke, the five co-operatives with tribute mining agreements with ZimAlloys from 1985 to 1987 consistently met their monthly target of 140 tonnes. However, their total earnings were often significantly reduced because of deductions. In 1987, each co-operative member of the five co-operatives contracted by ZimAlloys in the North Dyke earned '$211 after deducting stores utilised, tribute agreement payments [royalties] and ZMDC levy.'[37] This figure was further reduced when ZimAlloys decided to limit each co-operative's monthly ore production to only the agreed 140 tonnes per month and to stop accepting

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[35] P. R. Fallon, 'The labor market in Zimbabwe: Historical trends and an evaluation of recent policy' Unpublished Development Research Department Economics and Research Staff, World Bank Discussion Paper, May 1987, p.40.

[36] 'Picks, shovels keeps co-op on its feet', *The Sunday Mail*, 18 May 1986.

[37] 'Firm defends cuts in ore production', *The Sunday Mail*, 15 November 1987.

any excess ore.[38] Similarly, in May 1992, the Nhamo Mining Co-operative, comprising 51 members and also operating in the North Dyke, earned a gross income of $24,488.37, but their net income was $17,112,47 because of the deductions.[39] Although co-operatives generated substantial gross revenues, their net income was often heavily affected by several deductions made by mining companies from their gross earnings.

Despite miners' complaints about low prices, most co-operatives were unable to negotiate more favourable prices on the international market, especially to China and Japan, as the tribute agreements they had signed required them to sell their ore exclusively to the mining companies. Between 1995 and 1997, local companies purchased chrome from mining co-operatives at $150 per tonne, below the $450 per tonne obtainable in export markets such as China and Japan.[40] Only a few mining cooperatives and small-scale miners who had independently secured mining claims could access the international market directly. However, this opportunity also brought its own challenges, particularly intermittent government bans on the export of unprocessed ore, introduced in the 1990s to promote local beneficiation and value addition.[41] Some of these bans lasted for several months or even years, significantly affecting the production of the co-operatives.

Despite these challenges, chromite mining co-operatives expanded rapidly through the 1980s and 1990s owing to the lack of alternative employment as well as government support and support from mining companies. For instance, of the 38 mining co-operatives active in 1986, 23 were involved in chromite mining.[42] Two years later, there were a total of 28 chromite mining co-operatives out of the 44 registered mining co-operatives.[43] Co-operatives involved in chromite mining also played a major role in the yearly production. In 1988, chromite mining co-operatives accounted for 14.6 per cent of annual production, and by 1999 their average annual output had risen to 55 per cent, demonstrating their significant contribution to the sector.[44]

[38] *Ibid.*
[39] Tinaye Garande, 'Cooperators invade Great Dyke', *The Sunday Mail*, 4 June 1992. Official figures on the royalties deductions from ZIMASCO and ZimAlloys could not be sourced.
[40] "Chrome mining stopped, workers laid off", *The Sunday Mail*, 12 January 1997.
[41] *Ibid.*
[42] ZMDC Annual Report, 1986, 1988, 1990.
[43] ZMDC Annual Report 1988
[44] ZMDC Annual Report 1998, 1990, 1993, 1999.

Despite these positive statistics, mining co-operatives continued to face numerous geotechnical and financial challenges.

Outcropping seams and subsurface deposits

A significant aspect of co-operative chromite miners' operations since the 1980s has been their reliance on practical experience and interactions with experts from parastatals and mining companies to develop a robust corpus of geological knowledge and mining skills. This knowledge was often circulated using vernacular and colloquial terminology. When co-operative miners began their operations, they relied predominantly on visible outcrops to identify mineral deposits and determine where to establish their operations. Co-operative chromite miners described seams, in anthropogenic terms, as buried bodies with their backs sometimes visible on the surface as outcrops. They used the term *musana*, a ChiShona term for backbone, to refer to outcrops because they saw them as exposed backs of buried ore bodies. As one miner narrated, 'the outcrop is the surest indicator of the presence of a chromite ore body below the ground. Sometimes it is an even better indicator of the presence of an ore body than scientific surveys. The outcrop leads us to the seam underground, and we follow the seam (*kutevera bhande*).'[45] Initially, the miners worked with picks and shovels on exposed seams before expanding into deeper seams. However, as the pits became too deep and unsafe for manual labour, miners were often compelled to relocate to other sites or invest in underground mining equipment. As Maponga and Ruzive observed:

> Chromite outcrops are extracted using surface trenching up to depths of 10m using picks and shovels and sometimes explosives. It is thus not uncommon to encounter unfilled and 'orphaned' or abandoned trenches (some of them very deep) on the Great Dyke, as miners systematically abandon trenches and move to new mining sites in search of easier ore bodies to mine.[46]

This method resulted in significant environmental degradation, as miners left behind pits and trenches when they quickly relocated to new sites upon the exhaustion of surface deposits or when deeper mining became too hazardous.

[45] Interview with Andrew Ngwenya, Lalapanzi communal areas, 7 September 2021.
[46] Maponga and Ruzive, 'Tribute chromite mining', p. 119.

Figure 2: Seam outcrop mining by mining co-operatives Mutorashanga, North Dyke (Photograph by author).

While outcrops could generate expectations of large ore deposits, miners had to contend with uncertainties arising from variations in seam thickness. The narrow seams of the North Dyke were also known to be significantly faulted, adding another geotechnical challenge for miners.[47] Hanssen described faulting along the Great Dyke as ubiquitous and a significant challenge for chromite seams mining.[48] Faulting could displace seams by several metres or even kilometres, posing challenges for co-operative miners. Co-operative miners described chromite seams as appearing and disappearing, changing direction, and even becoming afflicted by maladies. Similar observations have been made among artisanal and small-scale gold miners, who are known to perceive gold veins as living creatures or ephemeral rivers that can unexpectedly appear, then disappear, only to reappear again.[49] According to Werthmann, gold-diggers in Burkina Faso imagined gold deposits as ʻa living creature that moves and can suddenly appear or disappear to the accompaniment of strange lights or sounds.'[50] In a recent study on gold mining in Peru, Melendez demonstrated how gold miners employed the metaphor of an ephemeral river—that can flow and then suddenly disappear, only to reappear later—to illustrate the behaviour of gold veins and how geological faulting can fracture and displace these veins.[51] In chromite geology, faulting can cause seam displacement, a geological phenomenon miners refer to as seam disappearance. Miners used the vernacular terms *kukata* (to split) and *kutiza* (to disappear) to describe faulting-induced displacement of seams.[52] Miners, especially those using manual methods, felt anxious about the possibility of encountering a displaced seam.

[47] M. G. Hanssen, 'The Geology of Great Dyke, Zimbabwe', Unpublished SAREC Project Interim Report, Institute of Mining Research, University of Zimbabwe, June 1990, p.10.
[48] *Ibid.*
[49] See K. Werthman, 'Cowries, Gold and 'Bitter Money' Gold-Mining and Notions of ill-gotten wealth in Burkina Faso" *Paideuma*, Vol. 49 (2003). Page ref needed?
[50] *Ibid*, p.110.
[51] See Luis Melendez, "Subterranean governance: The political work of artisanal miners in the northern Peruvian Andes" Unpublished PhD Thesis, Anthropology, University of Western Ontario, 2025.
[52] Interview with Tonderai Gumbo, Mutorashanga, 28 July 2020.

Faulting could also introduce intrusions into seams, leading to seam blanking that diminishes ore quality. Miners often described a blanked seam as having contracted a terminal illness (*kuita muzvezve*) or, more precisely, as a seam that would have contracted HIV/AIDS.[53] The metaphor of a human body afflicted by a terminal illness, which miners used to describe blanked seams, directly references miners' experiences with the HIV/AIDS epidemic and the suffering it generated before antiretroviral drugs became available. In essence, for co-operative chromite miners, ore bodies, much like human bodies, could be 'healthy' or 'unhealthy' and could contract various maladies, some incurable. Such metaphors highlight the effects that seam blanking could have on mining operations and the anxieties it caused among miners. Once miners diagnosed a seam as diseased, they usually had no option but to leave that section and go to a different area, hoping they had avoided the 'infected' part.[54] Some miners believed that seam displacement and seam blanking were caused by rival miners using charms (*mishonga*) to 'steal' their seams.[55] It was not uncommon for miners working on claims in close proximity to accuse each other of using evil charms to 'steal' seams and cause them to disappear. To tackle these problems, some chromite miners turned to traditional healers (*n'anga*) or prophets from apostolic church sects (*maporofita*) to perform rituals to protect their mining claims from such threats.[56] Similar practices have been documented by numerous scholars studying artisanal and small-scale gold, diamond, and gemstone mining. For example, in Sierra Leone, diamond diggers who seemed more successful than their peers were often suspected of using charms to steal their rivals' diamonds.[57]

Figure 3. Sketch showing faulting and seam displacement (Sketch by T. Masiya).

Figure 4. Sketch showing faulting and seam blanking (Sketch drawn by T. Masiya).

[53] Interview with Peter Ngwenya, Lalapanzi communal areas, 16 August 2021; Interview with Joseph Moyo, Lalapanzi communal areas, 7 September 2021.
[54] *Ibid.*
[55] Interview with Innocent Gumbo, Lalapanzi communal areas, 20 August 2021.
[56] *Ibid.*
[57] L. D'Angelo, "Who owns the diamonds? The occult economy of diamond mining in Sierra Leone." *Africa*, Vol. 84, No. 2 (2014), p.273.

Co-operative miners gained useful insights into seam thicknesses and their commercial value through their everyday mining practices and interactions with geologists. In Lalapanzi, in the Middle Dyke, seam three, which is only 5 centimetres thick, is considered too thin to be commercially viable, and, as a result, it is not mined.[58] Geologists refer to this seam, which occurs approximately 6 metres below seam two, as the *puppy seam*.[59] Geologist Hanssen states that although the seam was not mined because it was too thin, it served as a horizon marker during mining operations.[60] Similarly, co-operative miners recognised that this seam was too thin to be mined profitably and used it only as an indicator of the presence of a thicker seam (seam four) lying directly beneath. They described it as 'a step to seam four.'[61] One miner described the seam as follows:

> Seam three is very thin, so when we reach it, we usually say we have encountered a step to seam four (*simu rastepper*). We dig an additional one or two meters until we reach seam four, which is approximately 70 centimetres thick. So, seam three is usually an indicator that the seam beneath it is thicker and contains high-grade ore.[62]

Such vivid descriptions of the varying seam thicknesses offer valuable insights into the miners' geological knowledge and their understanding of the physical properties of the minerals they extracted. The miners, drawing on their practical geological expertise and that provided by mining companies, determined that seam four was considerably thicker and commercially viable compared with seam three, despite the potential challenges posed by faulting. Thus, the discovery of the puppy seam was not regarded as a cause for concern but as a sign of hope, as both practical mining experience and formal geological data confirmed that the seam lying beneath it, seam four, was thicker and commercially viable.

Co-operative miners also developed practice-based methods of assessing ore quality and estimating the amount of ore they extracted. For instance, miners could assess whether a chromite ore sample was high-grade by its weight, colour, and friability (its tendency to crumble under abrasive pressure). This knowledge was

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[58] M. G. Hanssen, 'The Geology of Great Dyke, Zimbabwe', p.27.
[59] *Ibid.*
[60] *Ibid.*
[61] Interview with Chipo Chirape, Lalapanzi communal areas, 16 August 2020.
[62] *Ibid.*

crucial because mining companies required co-operatives to supply only hard, lumpy ore, as friable ore could not be used in submerged electric arc furnaces without first being processed into pellets, which was a costly process. Co-operative miners typically tested the friability of ore by dropping lumps onto hard surfaces and observing how quickly they crumbled. If it crumbled easily, they concluded it was *sugar chrome*, a colloquial term they used for friable ore.[63] The term *sugar chrome* is derived from the ore's tendency to crumble into small granules resembling sugar granules. Additionally, miners used stacks (*zvitaga*) measuring 1 metre in width, 1 metre in length, and 30 centimetres in height, which were estimated to hold a tonne of ore to estimate ore quantity.[64] The measurements varied, particularly in height, with some miners estimating it using the height of a gumboot.[65] Although it is uncertain when the practice began and how it developed, these methods of measuring (*kupima/kuyera*) show how the miners drew on different regimes of knowledge in their everyday operations.

Mining companies, co-operatives and narrow-seam mining

Despite their notable advantages over large-scale mining companies in extracting marginal resources, co-operative miners still faced geotechnical challenges when extracting narrow seams, which affected the profitability and long-term viability of operations. To put this into perspective, co-operative miners who extracted the thinner seams of the North Dyke had significantly lower productivity than those who extracted the comparably thicker seams in the Middle Dyke. For instance, in 1990, reports on chromite mining co-operative production indicated that co-operative miners operating the Middle Dyke, with thicker seams, produced 8 tonnes per worker per month, whereas those in the North Dyke, with significantly thinner seams, averaged only 3 tonnes per worker per month.[66] This shows how the geotechnical challenges of extracting chromite seams affected not only the operational viability of mining companies but also the productivity of co-operative miners.[67]

[63] *Ibid*

[64] Chiwawa, *Co-operatives and contract mining*, p.33. I also benefited from conversations with Nyasha Bushu, Oswald Moyo and Ernest Takura, who have encountered these practices in their home areas.

[65] Nyasha Bushu, personal communication, 14 December 2025.

[66] Chiwawa, *Co-operatives and contract mining*, p. 45.

[67] 'Mine is barred from closing', *The Herald*, 5 August 1982.

Although chromite mining companies sought to transfer responsibility for extracting narrow seams to mining co-operatives, given their lower overheads and labour-intensive techniques, it soon became clear that co-operatives also struggled to mine these deposits sustainably without technical and financial assistance. To address this challenge, the government, mining companies, and international development agencies proposed numerous initiatives and funded research projects to develop mechanised methods for mining narrow seams. Most of the techniques and strategies were adaptations of methods originally developed for coal-seam mining. The pilot projects were carried out by IMR in collaboration with mining companies and international development agencies. One of the earliest such projects was a SIDA-funded project, initiated in 1983, to develop mechanised methods – notably the feasibility of using Plasma Arc mining technology - for the profitable extraction of narrow chromite seams.[68] It also examined methods to reduce the costs of ore smelting and production of ferrochrome.[69] This technology was expected to reduce extraction costs in narrow seams, increase production, and create new jobs if successful. However, it fell short of expectations and was discontinued in 1984.

After the Plasma Arc mining experiment failed, alternative techniques were investigated in the late 1980s and 1990s. However, these methods also failed on technical grounds, leaving the substantial narrow-seam deposits unexploited. In 1987, a study funded by the Swedish government advised the Ministry of Mines to conduct research on mechanised methods for mining narrow seams to boost production.[70] It was hoped that an appropriate mechanised mining technique would help unlock approximately 500 million tonnes of narrow-seam deposits in the North Dyke, which had largely remained untapped. In response, the Ministry of Mines, together with Zimasco and ZimAlloys, jointly funded a new research project, with renewed hope of developing mechanised mining of the narrow seams, which was launched in 1989. The project was led by a technical committee, chaired by the Minerals Development Unit of the Ministry of Mines and comprising representatives from the Department of Mining Engineering, the two chromite mining companies, and IMR.[71] After

[68] Report of the Secretary for Mines, 1983, p.6.
[69] *Ibid.*
[70] New chrome mine bid', *The Herald*, 5 March 1987.
[71] Chiwawa, *Co-operatives and contract mining*, p.56.

considering various methods and machines, the technical committee decided to purchase a roadheader from Atlas Copco-Eikhoff in West Germany, which was installed at the Mutorashanga Mine in the North Dyke, where mining co-operatives were extracting narrow seams under tribute mining agreements.[72] In May 1989, the IMR research team visiting the pilot project site observed that the machine could advance at a rate of one metre per hour but was limited to one eight-hour shift per day because of frequent dump truck breakdowns and other operational challenges caused by faulting.[73] However, despite its initial promise, the roadheader mining method was too costly to be rolled out across all chromite-mining operations along the Great Dyke, including those of co-operative miners. The roadheader used for the pilot project had been purchased for $ 2.2 million, with the government contributing $1.5 million and ZIMASCO and ZimAlloys each contributing $ 350,000.[74] The high cost of roadheaders made them unsuitable for the labour-intensive, low-technology methods employed by co-operative miners. Moreover, roadheaders proved unsuitable for the heavily faulted seams typical of the North Dyke, leading to the discontinuation of the experiment.[75]

Mining co-operatives and underground mining operations

Mining co-operatives seldom had start-up capital and were largely undercapitalised, limiting their ability to develop underground mining operations. As a result, without external financial and technical support, they resorted to open-cast mining with simple tools. To address this challenge, the Ministry of Mines established structures to provide co-operative miners and other small-scale miners with financial assistance and specialised services in geology, metallurgy, and engineering.[76] It also established the Mining Industry Loan Fund, to provide miners with access to capital to develop their operations, including prospecting, procurement of equipment and development

[72] 'New chrome mine bid', *The Herald*, 5 March 1987.
[73] A. E. Roberts, 'The Geological structure of the Great Dyke', (The Development of Chromite Mining and Ferrochrome Smelting in Zimbabwe, SAREC Project', Institute of Mining Research, Interim Report, June 1990), p.10.
[74] 'New chromite mining study', *The Herald,* 28 September 1989.
[75] Chiwawa, *Co-operatives and contract mining*, p. 56.
[76] 'Unify to gain aid, mines urged', *The Herald,* 5 February 1981.

of underground mining operations.[77] Additionally, the ministry offered plant-hire services for one to three years to mining co-operatives and small-scale miners, with monthly charges including interest at 10% per year.[78] While these initiatives showed government support for co-operatives, they also highlight the co-operatives' reliance on government assistance, without which they struggled to establish sustainable mining operations.

The undercapitalisation of mining co-operatives posed a major challenge, to the point that even large ones, such as Ngezi Chrome Mining Co-operative, frequently depended on government financial and technical assistance. In 1983, the Secretary for Mines in 1983 noted that Ngezi Chrome Mining Co-operative encountered considerable difficulties in its mining activities 'due to a lack of technical knowledge in mining, finance, maintenance of equipment and general management.'[79] In 1984, at the recommendation of the Secretary of Mines, the co-operative received a three-year loan of $39,236 from the Mining Industry Loan Fund and Plant Hire Scheme to purchase all the equipment it required to begin underground mining operations at its Mhondoro mine.[80] It also obtained an additional $15,000 loan from ZMDC, which also assigned a field supervisor to provide technical support.[81] These were quite substantial figures, considering that other co-operatives were unable to obtain similar loans due to a lack of capacity to repay them. The co-operative used the funds it received to pay workers' wages, equipment rental, cover expenses for ZMDC's field supervisor services, and handle other mining-related expenses.[82] With this financial and technical support, the co-operative commenced underground mining operations at its Mhondoro mine, where it employed adits (horizontal tunnels used in underground mining) to extract ore from chromite seams, leading to production nearly doubling, 1984 and 1986, from 1,289 to 2,467 tonnes.[83] The co-operative successfully repaid the loan in 1986, enhancing its reputation as one of the few co-operative thriving under challenging conditions. The co-operative also benefited from

[77] C. D. G. Chipato, 'Small Scale Chrome Mining Co-operatives in Zimbabwe and their relevance to the National Economy' (Unpublished MSc Minerals Economic Dissertation, Colorado School of Mines, 1988), p.26.
[78] Chipato, 'Small Scale Chrome Mining Co-operatives in Zimbabwe', p.26
[79] Report of the Secretary for Mines, 1983, p.5.
[80] *Ibid.*,p.45.
[81] *Ibid.*
[82] *Ibid*, p. 56.
[83] *Ibid*, p. 57.

more favourable geological conditions compared to those of others operating in the North Dyke.

Mining co-operatives were also drawn to underground mining because mining companies typically paid more for ore extracted by mechanised methods than for ore extracted with simple tools. For instance, ZimAlloys paid mining co-operatives under its tribute mining contracts for the chromite they produced, depending on the mining methods they employed, 'with higher payments for ore extracted through underground mining compared to surface mining.'[84] Specifically, ore extracted through handpicking, trenching and adit mining was paid for at lower rates than ore extracted undergrounding mining methods involving winze sinking and other underground mining techniques.[85] However, in an effort to address what they regarded as unfair practices by mining companies in assessing the quality of the ore, co-operative miners intentionally placed high-grade ore at strategic locations within the stockpiles to ensure it appeared to meet the minimum standards, and moved rejected stockpiled ore to new locations or mixed high-grade ore with low-quality ore to mislead mining companies into making purchases.[86]

Although the government continued to provide financial and technical assistance to mining co-operatives for developing underground mining operations, this support was often inadequate. As a result, co-operatives often depended on surface mining, which was labour-intensive and limited their ability to meet monthly production targets under their tribute mining agreements, unlike what they could achieve with mechanised underground mining methods. In July 1989, in an interview with *The Herald* newspaper, Jeffrey Nguruve, the secretary of the Tavakuenda Mining Co-operative Society, a prominent chromite mining co-operative in the Darwendale region of the North Dyke, expressed frustration at the co-operative's financial difficulties in acquiring essential mining machinery and developing underground mining operations.[87] He pointed out that these challenges were weakening the co-operative's capacity to meet its contractual monthly production targets, prompting

[84] Chiwawa, *Co-operatives and contract mining*, p. 34.
[85] *Ibid.*
[86] *Ibid.*, p.33
[87] 'Mine co-op hit by lack of equipment', *The Herald*, 31 July 1989.

the co-operative to request government financial support.[88] The co-operative signed a tribute mining contract with ZIMASCO to supply 500 tonnes of ore per month, but was able to produce only 300 tonnes due to a lack of funds to purchase machinery, mechanise operations, and establish underground mining operations to ensure they met their production targets.[89] Aside from resulting in lower monthly earnings than projected when the co-operative met its target, the failure to meet production targets put the co-operative at risk of fines or the mining company's cancellation of the tribute agreements for non-compliance. 'There is too much chrome around here, but our major problem is the lack of proper machinery to reach the chrome, which is deep down to a depth of 30m. We are presently using shovels, picks, and a few wheelbarrows', Jeffrey Nguruve explained.[90] Due to these challenges, most co-operatives could typically mine only two or three seams, abandoning the pits once the depth posed significant risks to miners using rudimentary mining methods.[91] Nguruve illuminated a general problem arising from co-operatives being largely undercapitalised and reliant on government financial and technical support.

While co-operative miners were expected to establish underground mining operations, they frequently lacked the technical expertise needed to ensure compliance with mining regulations, particularly in safety and strata support. As a result, they often relied on technical support from mining supervisors at mining companies and ZMDC. In addition, IMR conducted research projects to assist co-operatives and other small-scale chromite miners in acquiring the skills to develop standard underground mining operations. For instance, in 1989, it obtained a three-year grant from Canada's International Development Research Centre (IDRC) in 1989 to conduct research on geology and rock mechanics in small-scale underground chromite mines. The primary objective of the project was to develop a rock mechanics database for small-scale chromite mines and guidelines for installing underground mine support systems (timbering) to reinforce the roofs and walls of the mines. The research project, which was entitled 'Support of Underground Excavations in Small Mines in Zimbabwe', was conducted in collaboration with the Department of Civil

[88] *Ibid.*
[89] *Ibid.*
[90] *Ibid.*
[91] Chiwawa, *Co-operatives and contract mining*, p.17.

Engineering at the University of Toronto.[92] The research project focused on geotechnical mapping and data analysis of small-scale underground chromite mines to identify failure modes and mechanisms, and on rock mass characterisation required to design guidelines for underground strata support.[93] Although the project later expanded to other mining areas, its main focus remained on underground mining by chromite co-operatives in the North Dyke, particularly at Mutorashanga, Caesar, and Sutton Mines.

As part of the study, the research team initially gathered and classified 'case histories of ground failure in order to identify common mechanisms leading to failures around underground openings in various geological and mining environments in Zimbabwe.'[94] Additionally, it assessed the mechanical properties of the timber used by co-operative miners to evaluate its suitability for strata support, and they concluded that, despite being untreated eucalyptus, the timber was generally strong enough and suitable for use as props to support adits and tunnels.[95] The research team also conducted demonstrations for selected mining co-operatives.[96] The project team also produced training manuals and illustrated handbooks for installing mine support in small-scale underground mines, which they distributed among small-scale miners across the country.[97]

Despite government support and IMR's efforts, co-operative miners continued to struggle to establish standard and safe underground mining operations. Even the Ngezi Chrome Mining Co-operative, a model co-operative, resorted to surface mining and unsafe underground mining operations. In 1994, an IMR researcher visiting one of the co-operative's mines in Mhondoro noted:

> Three major seams are currently being worked on, and there are a few secondary seams as well. Mining is mainly by pit trenching along seams and is concentrated on selected areas of the 6 km stretch. The average size of the pits

[92] A. E. Roberts, 'Summary of Progress in 1993' in A. E. Roberts (ed.), 'Twenty-Fifth Annual Report for the Year 1993', Institute of Mining Research, Report No.151, February 1994, p.3.
[93] M. S. Lipalile, 'Overview of Rock Mechanics' in A. E. Roberts (ed.), 'Twenty-Fifth Annual Report for the Year 1993', Institute of Mining Research, Report No.151, February 1994, p.84.
[94] *Ibid.*
[95] J. S. Chihota, 'Evaluation of Mechanical Characteristics of Timber used for support by underground small-scale chromite mines,' in A. E. Roberts (ed.), 'Twenty-Fifth Annual Report for the Year 1993', Institute of Mining Research, Report No.151, February 1994, p. 87
[96] Lipalile, 'Overview of Rock Mechanics', p.84.
[97] A. E. Roberts, 'Summary of Progress in 1993', p.3.

> is 3x3x50m, and mining is done using the pick-and-shovel method. Blasting is normally done on the more competent rock.[98]

These challenges show that, despite their best efforts, co-operatives' efforts to develop underground operations were hindered by a lack of funding and machinery.

To maintain a reliable ore supply, especially during peak demand, mining companies often offered loans to co-operatives with which they had tribute mining agreements, to purchase mining machinery, establish underground mining operations, and pay workers' wages. This became increasingly critical from the 1990s onwards, when reduced government financial support forced mining co-operatives to limit their operations to surface mining, despite the associated safety hazards.[99] Mining companies provided services such as plant hire, geological and metallurgical expertise, and loans to support co-operatives in increasing their production through a transition to underground mining. It was in this context that ZIMASCO launched a $30 million capital assistance programme in 1996 to help co-operatives develop underground operations.[100] It used the fund to finance the merger of the Nehanda, Kushinga, Nhongo, and Zacro chromite mining co-operatives to accelerate their transition to underground mining operations.[101] The merged co-operatives took on the name NKNZ Co-operative. Under this arrangement, ZIMASCO signed three-year-renewable tribute agreements with the co-operative, financed mining development, and provided technical support, training, and management assistance. The cooperative obtained a $5 million loan to purchase mining equipment and supplies, cover wages, hire a mining supervisor for technical support, and develop underground mining operations at the Mhondoro Mine in the Middle Dyke, with the goal of producing 1,000 tonnes of ore per month.[102] In an interview with *The Herald* newspaper, Gabriel Kapfunde, who was the resident mining supervisor appointed by ZIMASCO to offer technical support to the co-operative, described the mechanised underground mining operations the co-operative had established as follows:

> We are working two seams at the moment, one of which has been worked before. Mining is planned to a depth of 200 metres, and we have some 17km of

[98] J. Nyagumbo, 'Ngezi co-operative chromite mine', (Institute of Mining Research, SAREC Funded Project, June 1994), p.1.
[99] 'Mining project to benefit thousands', *The Herald*, 24 October 1996.
[100] '220 programme to train chrome miners', *The Herald*, 31 October 1996.
[101] *Ibid.*
[102] '$5 million underground mine soon in Mhondoro', *The Herald*, 2 February 1996

> strike of both 1 and 2 seams…This gives us some 6,7 million tonnes of inferred resource, which we initially intend to mine at a rate of 40 tonnes a day…We are using advance longhaul (sic) stoping with some up-dig stoping from the top adits and using backfill to minimise the ugly waste dumps and strengthen the mine as a whole… Production from three of the adits is hand-trammed and uses conventional cocopans, but we have selected trackless mining techniques, using skidsteers, small front-end loaders, which we are using to sink the declines and develop new stope drives.[103]

This description shows how merging the four co-operatives, along with the tribute mining agreements and the funding scheme with ZIMASCO, had transformed the new co-operative's operations and boosted its production capacity. Although figures of its earnings could not be obtained, the fact that co-operative employed 400 people and was able to make savings of $90,000 in its first year, demonstrates that it was highly successful.[104] This showed that co-operative mining could create livelihoods for former miners and rural communities, if sufficiently funded.

Mining companies mainly used their funding schemes to secure long-term ore supplies from mining co-operatives for their smelters at minimal cost.[105] The fact that government financial support from the Mining Industry Loan Fund was often inadequate or unavailable further exacerbated the challenges faced by small-scale miners. In 1996, Giles Munyoro, then president of the National Miners Association of Zimbabwe (formerly the Small-scale Miners Association of Zimbabwe), expressed concern that the Mining Industry Loan Fund rarely had sufficient funds to lend to offer small-scale miners to buy machinery and expand their operations.[106] "If you manage to get even a spade from that fund, then you are lucky," he lamented.[107] In the absence of support from the government or mining companies, co-operative miners typically employed the ' "pig-rooting" method—digging shallow trenches along visible chromite seams on the surface using basic tools—and rarely advanced to substantial underground mining operations.'[108] Although this practice was often discouraged for its potential to sterilise mining deposits, it remained popular among

[103] *Ibid.*
[104] *Ibid.*
[105] 'Mining project to benefit thousands', *The Herald*, 24 October 1996.
[106] Cephas Chitsaka, "Chrome to be dumped in the sea" *The Herald*, 12 December 1996
[107] Ibid.
[108] O. Maponga, *Small-Scale Mining Operations in Zimbabwe* (Ottawa, International Development Research Centre,1993), p.21

miners because it enabled them to earn a living when they lacked the machinery and financial wherewithal to establish underground mining operations.[109]

From the late 1990s onwards, government and mining companies' financial and technical support for mining co-operatives declined sharply due to the country's economic crisis, which resulted in hyperinflation. This led Chromite mining companies to shut down large parts of their operations and cancel numerous tribute mining agreements, greatly impacting mining cooperatives. In 1998, it was reported that 10 mining co-operatives operating in the North Dyke had ceased operations due to financial and technical support challenges. This affected more than 200 families, most of whom were descendants of former Malawian and Zambian mine workers. *The Herald* newspaper reported that members of the mining co-operatives had gone for at least 10 months without earning anything, as the co-operatives were failing to break even due to the high cost of mining equipment and supplies, as well as a lack of government funding to shift from shallow open-cast mining to underground operations.[110] In an interview with *The Herald* newspaper, a chairman of one of the mining co-operatives illustrated the viability challenges faced by co-operatives by highlighting that 'a pack of dynamite, which is normally exhausted in a day, costs $10 000, and a co-operative would require about 30 packs every month. It is also common to exhaust the whole pack and mine less than a tonne of chrome, which, when sold, would generate only $1 600.'[111] As a result, miners abandoned their operations and moved to the villages. A few who continued mining later ceased rehabilitating the open pits, arguing they were prioritising buying food for their families. One miner put it as follows:

> No one can talk of reclaiming when we cannot even get money to buy food. You can only reclaim when you have food, and when you know you will be staying with the co-operative. Right now I got a job as a gardener. I could not remain with my co-operative because I last got my pay in November. Even then, I got less than half of what I had worked for.[112]

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[109] Chiwawa, *Co-operatives and contract mining*, p.46.
[110] 'Viability problems hit ten mining co-operatives', *The Herald*, 11 May 1998
[111] *Ibid.*
[112] *Ibid.*

Therefore, the viability issues faced by chromite miners not only affected their livelihoods and those of their workers but also hindered efforts to restore the environment, leaving a landscape scarred by open pits.

The environmental impact of chromite mining along the Great Dyke increased after 2000, as the economic downturn led mining companies to downsize operations further and cut back on tribute agreements with co-operatives. This compelled cooperative miners to shift to artisanal mining, greatly affecting the environment. A 2002 study by the UK-based Intermediate Technology Development Group (ITDG) reported that most of the more than 3,000 small-scale chromite miners operating on the Great Dyke faced financial challenges and relied on rudimentary tools.[113] Similarly, a 2013 report by the Parliamentary Portfolio Committee on Mines and Energy noted that artisanal and small-scale chromite miners were compelled to adopt open-cast methods, resulting in significant environmental degradation due to a lack of financial support for mechanisation and the development of underground mining operations.[114] Highlighting the government's desire to discourage open-cast artisanal mining methods due to their substantial environmental impact, the report stated that 'the thrust is to encourage more of conventional mining that will include mine planning for underground operations and thereby exploit the chrome seams to much deeper depths and hence more production for the country.'[115] Despite this, Zimbabwe's economic crisis contributed to the undercapitalisation of mining co-operatives and of individual artisanal and small-scale chromite miners, hindering their ability to establish sustainable underground mining operations.

Figure 5: A mine tunnel dug by artisanal miners in Mapanzure communal areas (Photograph by Ernest Muvunzi).

Conclusion

[113] 'Chrome miners need to adopt new business skills', *The Sunday Mail*, 28 April 2002.
[114] 'Chrome mining sector in Zimbabwe' Portfolio Committee on Mines and Energy Report, Parliament of Zimbabwe, 2013.
[115] *Ibid.*

While political economy approaches have continued to dominate resource extraction studies, an expanding body of historical and anthropological scholarship is increasingly examining how geology shapes mining operations and the economic and spatial interactions between small-scale miners and large-scale mining companies. This article contributes to the growing scholarship by arguing that although economic factors, government support, and regulatory conditions affected co-operative chromite mining in Zimbabwe, the geology of chromite within the Great Dyke had a stronger effect. Geological constraints, particularly the geotechnical challenges associated with extracting the narrow and frequently faulted chromite seams within the Great Dyke, posed viability challenges for mining companies, compelling them to close some operations and lease them to mining co-operatives under tribute mining agreements.

The article has shown the invaluable insights that can be obtained by paying closer attention to geology in reconstructing histories of co-operative mining and the interactions between co-operative miners and mining companies. It has also demonstrated the influence of geological knowledge and the development of appropriate mining approaches in the rise of the co-operative chromite mining sector in Zimbabwe. In particular, it examined different regimes of geological and mining knowledge that co-operative miners drew on to tackle the geotechnical challenges they encountered and to understand the physical properties of the minerals they extracted. This rich blend of tacit and scientific knowledge is most evident in the vernacular geological and mining vocabularies the miners used in everyday interactions.

The article highlights how, despite their geological knowledge and innovative mining techniques, co-operative miners struggled to establish sustainable operations without continued financial and technical support from the government and mining companies to develop safe underground mining operations. Overall, the article has demonstrated how geology and access to funding influenced miners' working practices. When co-operatives gained access to finance and technical support, their practices changed, and they were often able to mechanise their operations, transition to underground mining, and boost production.

List of Figures

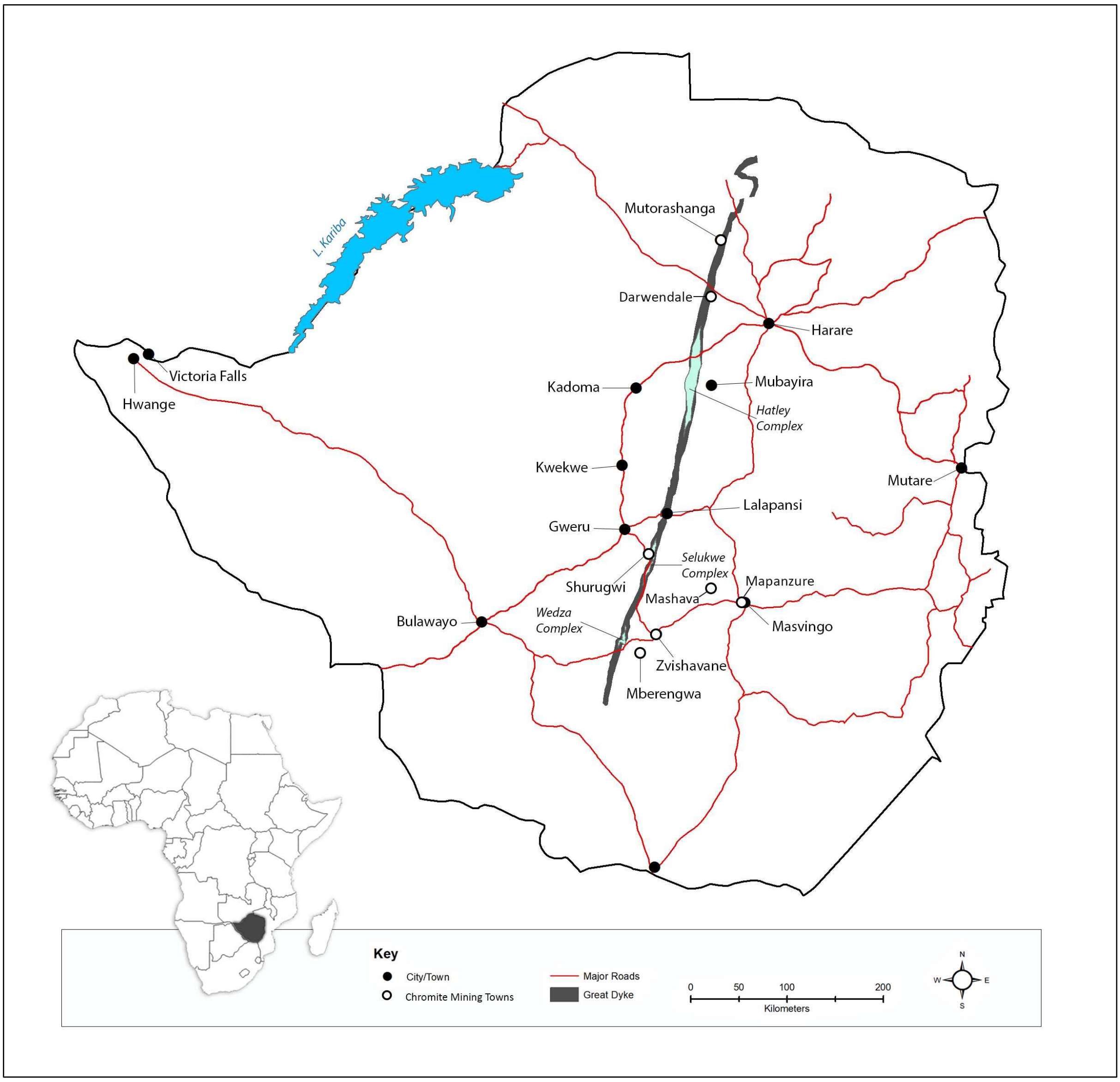

Figure 1. Map of Zimbabwe showing the Great Dyke geological formation (Map drawn by Russel Kapumha).

Figure 2: Seam outcrop mining by mining co-operatives Mutorashanga, North Dyke (Photograph by author).

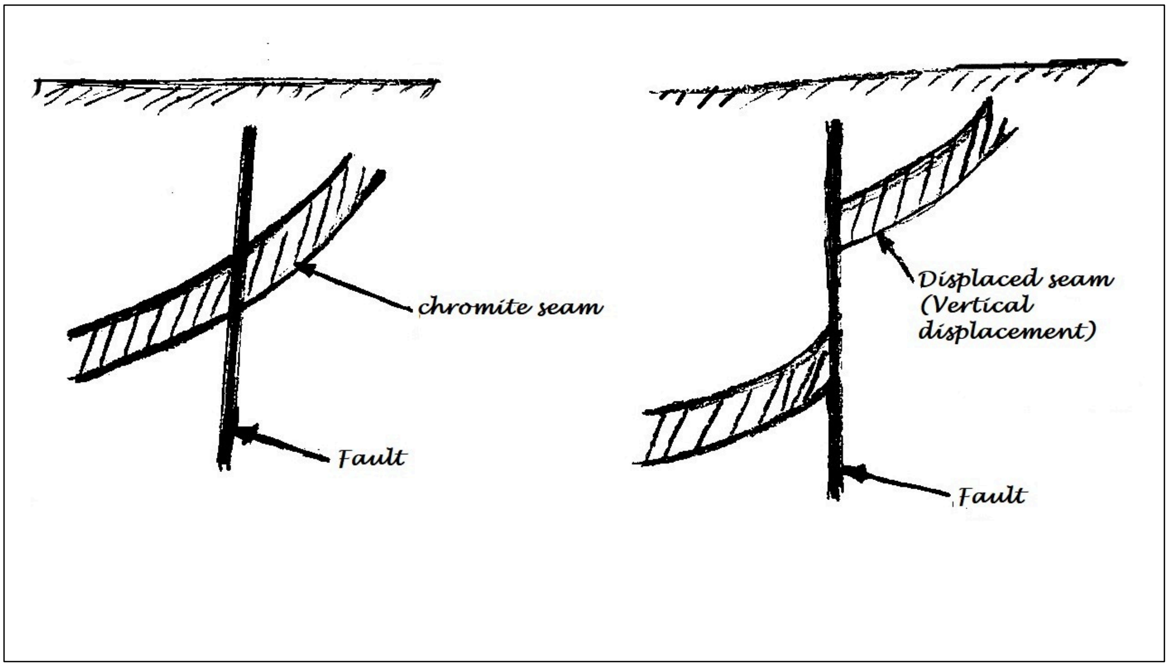

Figure 3. Sketch showing faulting and seam displacement (Sketch by T. Masiya).

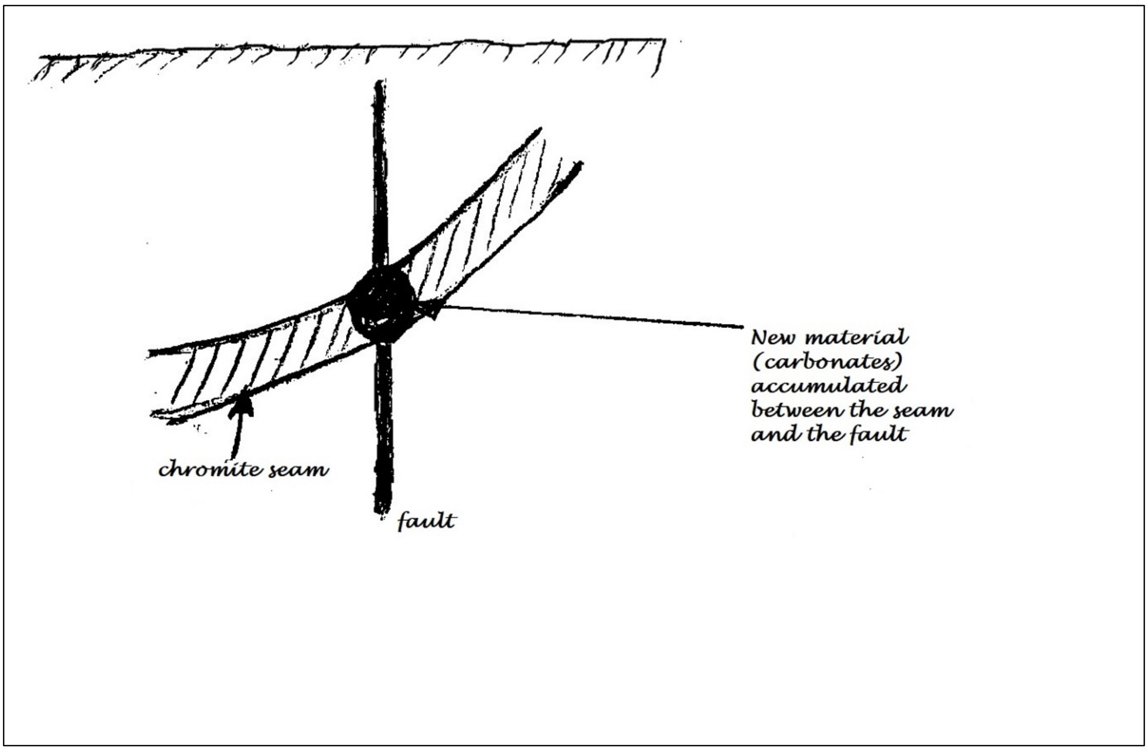

Figure 4. Sketch showing faulting and seam blanking (Sketch drawn by T. Masiya).

Figure 5: An adit dug by artisanal miners in Mapanzure communal areas (Photograph by Ernest Muvunzi).

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