

THE IMPORTANCE OF STATE-FUNDED DATA GATHERING IN THE GENERATION OF EXPLORATION TARGETS

**A Case Study of the Bushveld Mineral's Mokopane Fe-V-Ti Project in the
Upper Zone of the Bushveld Complex's Northern Limb**

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ABSTRACT

This research report discusses the importance of state-funded geoscientific data sets (also known as pre-competitive data) in the initial generation of mineral exploration targets. These are data sets that any country may and need to have in their geoscientific database to provide either freely or at a minimal fee to the public or prospective investors. Such data sets may include geochemical data, geophysical data, geological data, maps, technical reports, imagery and are usually made available through the state's Geological Survey Organisations (GSO's) or any state – run geoscientific institutions like the Council of Geosciences (CGS) in the Republic of South Africa.

The availability or unavailability of such data sets during the initial stages of a particular mineral exploration project for a particular exploration destination has a very important effect in the establishment of any mineral exploration project, and subsequently on the success and benefits of such projects, both to the investors and the state.

A case study of the Bushveld Minerals Ltd Mokopane Iron-Vanadium-Titanium Project in Limpopo Province, South Africa is used to demonstrate the importance of pre-competitive data sets. This project acquired data from the Council of Geosciences and such data included regional geochemical data, regional geological data (geological logs, historic drill core and assay data), regional aeromagnetic and radiometric data, geological maps and some technical reports. The data was processed, integrated and was used to establish the initial exploration targets. Any follow up exploration activities were based on this initial data. This project now prides itself with JORC compliant resources and reserves of 298Mt of vanadium ore across three parallel overlying magnetite layers – the MML (Main Magnetite Layer), the MML Hanging Wall and the AB Zone, with grades ranging from 1.6% to over 2% V₂O₅.

Secondly, examples from other parts of the world including Northern Ireland, Canada, Burkina Faso, Namibia, have been discussed to complement the Case Study.

In the end, the research report shows that exploration jurisdictions that have pre-competitive data freely available have high inward investment rate as compared to those without any data. It also shows that the availability of such data sets helps to reduce the exploration expenses incurred by the prospective investors in their operations but at the same time boosting returns for the state because of the high number of inward coming investment.

Following the concluding statements, the report also emphasizes implementation of procedures that have been used by countries that have been successful in increasing their inward exploration

investment. Such procedures as relinquishing of all data to the state by companies that have ceased their operations, and also continual data collection exercises by the state. This means continuation of geological mapping in unmapped areas, continuation of soil geochemical sampling in areas that have not been sampled, and conducting of additional regional geophysical surveys.

The conclusion of this research report simply agrees with Hronsky, 2016 who states “Give them data and they will come”.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO RESEARCH

According to Duke (2010), mineral exploration may be characterized as a multistage information gathering process. The goal of each stage is to discriminate between areas of greater and lesser mineral potential, thereby reducing the area to be explored in the subsequent more expensive stage. Although terminology varies, five stages are generally recognized: planning, reconnaissance exploration, detailed exploration, discovery, and deposit appraisal.

Such mineral exploration activities are conducted by exploration companies, which may either be local or foreign to a particular jurisdiction. Mineral potential jurisdictions or destinations have the potential to attract foreign investment through such exploration companies in search of economically viable mineral deposits.

The Fraser Institute's Annual Survey for Mining Companies, (2016) states that there are mainly two factors that will determine investment decision making on a particular jurisdiction by an exploration company, and these are the mineral potential of the area and the policy factors (these could be political, economic, and other regulatory policies for the industry). The same factors are also mentioned by Otto (2006), where it is noted that the decision on where to explore is based on the evaluation of a variety of risk factors, which may be grouped into three main categories:

- Political or Country Risk – This includes not only the political stability of the jurisdiction in question but also the existence of a stable and reasonable regulatory framework governing mineral title, taxation, environmental protection, labor, and so on.
- Economic Risk – The greatest economic risk derives from uncertainty about commodity prices, especially in relation to the cost of inputs to production. However, many economic factors are dependent on location. These include the availability of labor and infrastructure, physical geography, climate and other factors that will determine the costs of exploration, development and production.
- Discovery Risk – The greatest risk in exploration is that it will not succeed in finding an economic mineral deposit. This comprises two components: the probability that a deposit having the desired characteristics exists in the area in question and the probability that it can be discovered.

The latter depends on the availability of both reliable geoscience information and appropriate exploration technologies for the target deposit type in the particular area.

The last factor mentioned by Otto (2006) emphasizes the importance of geoscience information and data for a target deposit type in a particular jurisdiction. And as such, to attract exploration investment into a country, the government needs to play a role in the provision of regional data that may be used to generate exploration targets. Such data would assist in de-risking the exploration projects and would also assist prospective explorationists into the particular jurisdiction.

Jon Hronsky, principal of Western Mining Services, spoke on the future of exploration in his keynote address at the 2016 PDAC convention in Canada, and stated that “geoscience data is to exploration what road systems are to transport: a pre-competitive asset that jurisdictions must provide if they hope to foster a viable and sustainable mining industry”.

The talk “Give them data and they will come” (Hronsky, 2016) summarised how important geoscientific pre-competitive data sets can be in attracting exploration and mining investment into any potential exploration destination zone, apart from other equally important factors such as mineral potential and policies.

The geoscientific datasets that may be useful in the initial generation of exploration targets include geochemical data, geophysical data (which includes aeromagnetic, gravity survey, ground penetrating radar, and electromagnetic data), geological data (cores, cuttings, paper geological logs, and rocks), technical reports and many more.

Geoscientific data sets are critical to mining exploration’s efficiency, success, and also to provide a steady stream of new projects which is essential to maintaining a strong minerals industry and healthy economy in any part of the world. In a competitive world, the challenge is to continue to attract the investment needed to sustain the sector. Due to this reason, exploration companies are therefore finding ways to maximize the value of their existing data, and technology, to prioritize opportunities and select the best exploration targets.

Maximizing the value of data and the use of technology has had a far-reaching impact on new discoveries in mineral exploration in the 21st century compared to the decades of discoveries in the mid-20th century. A major part of the new discoveries has resulted from the integration of huge volumes of geological, geochemical, geophysical and GIS / satellite imagery datasets to generate the best exploration targets.

This data may either be freely or cheaply sourced out using state-funded data banks or repositories (pre-competitive data) while some of the data may have to be generated on a project specific local scale using a project's own funding (competitive data). Some datasets are financed entirely by a country's government while others are industry-funded. Other datasets in different countries are hybrid systems, funded in part by industry and government. These data banks typically charge fees for data requests and for data loading and the cost differs significantly between countries.

Different countries have different levels of pre-competitive geoscientific data provision and access to the public domain, and this factor in turn has an effect on the ability of a country to attract inward investment through exploration and mining.

State-funded data usually covers regional extents and is used by initial exploration target generation, and such data may eventually need to be verified or supplemented using localised project specific data generation techniques. However, project specific data generation, for instance airborne geophysical studies, comes at a very high price.

Due to the high price in generating project specific geoscientific data, some low capital exploration and mining companies tend to find it difficult to venture into exploration projects in countries with little or no pre-competitive data available. Many countries with weak economies are potentially rich in natural resources but lack pre-competitive data to attract inward investment to effectively develop this sector.

This study focusses on countries in Africa as one of the major mining exploration destinations in the world with particular attention to a South African exploration project case study where pre-competitive data was used.

Africa is richly endowed with a number of metals and material, and around 85% of the world's platinum is produced by South Africa and Zimbabwe, 50% of chromium is from South Africa and Zimbabwe, 53% of cobalt and 10% of copper is from the Central African Copper belt in the DRC and Zambia, 47% of manganese is from South Africa, 40% of phosphate rock is produced by Morocco and Algeria, and just less than 10% of the world's gold is produced in Africa, mainly by Ghana and South Africa (Kinnaird and Durrheim, 2017). These are just a few of the commodities that Africa is producing

at the moment, however Africa with its large extent of the continent under explored (Kinnaird and Durrheim, 2017) has a potential to produce more than it is currently.

Exploration destination countries in Africa face challenges in a number of areas including political stability and security, legal systems in place, taxation regimes being implemented, socio-economic problems and unavailability or difficulty in accessing of pre-competitive data to the general public.

Figure 1.1. shows some exploration destination African countries differentiated on the basis of their total exploration and mining permit areas.

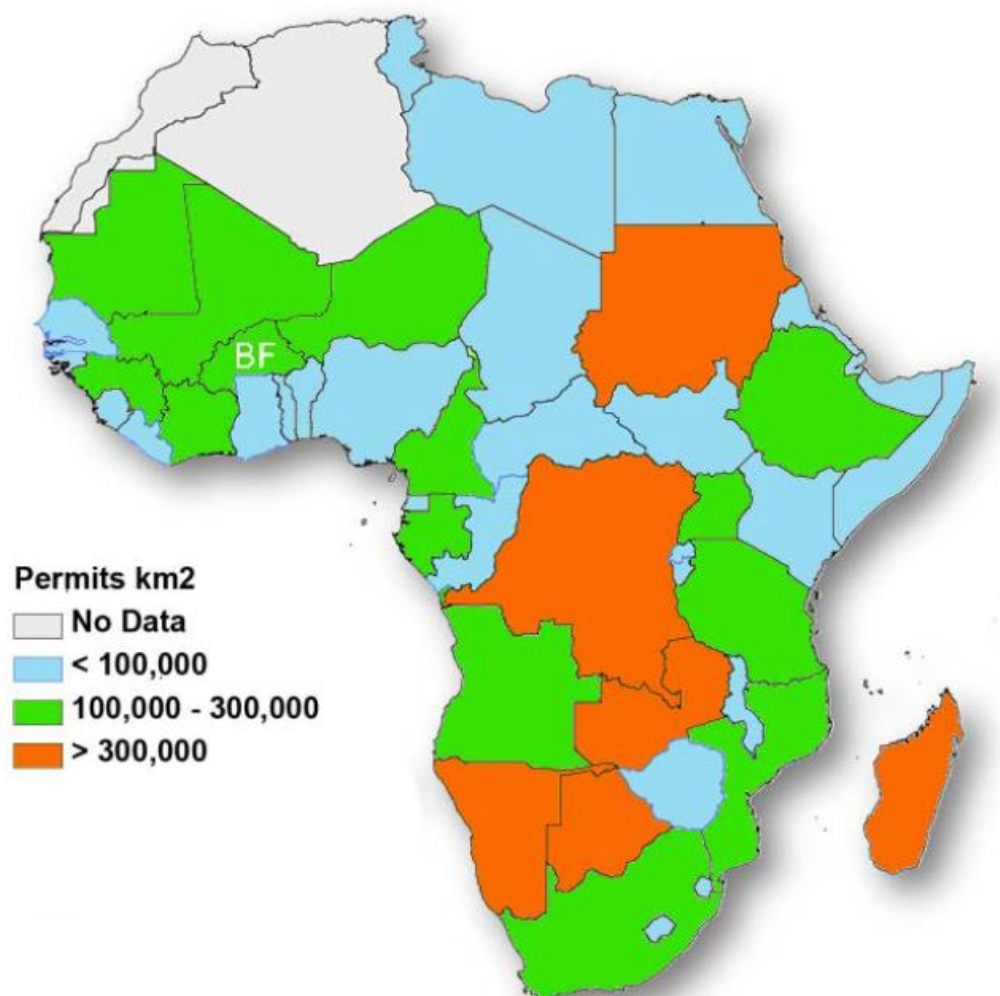


Figure 1.1: Total exploration and mining permit areas for selected African countries. Raw data sourced from publicly available mining cadastre data, country-level permit maps provided by Ministries as well as estimates based on reports on company activity (Harris & Miller, 2015)

This study looks at the importance of state-funded datasets (pre-competitive data) in the generation of initial exploration targets on a regional scale. Additionally, it also looks at how such datasets are integrated efficiently in the process of generating the exploration targets (a case study of the Bushveld Mineral's Ltd Mokopane Fe-V-Ti Project in Limpopo Province, South Africa was used to demonstrate effective data integration).

The case study was further used to provide an insight of accessibility to pre-competitive data in South Africa, how such data may be used in generating exploration targets at a regional scale, how important such data is in terms of risk and cost reduction, and how the same technique may be applied in similar projects.

This South African case study will be compared against other countries in Africa in terms of ease of accessibility to pre-competitive geoscientific data sets and assess the effect of this data in those different countries.

Countries to be comparatively assessed against South Africa will include Botswana, Democratic Republic of Congo (DRC), Kenya, Lesotho, Malawi, Mozambique, Namibia, Nigeria, South Sudan, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe.

These countries were selected based on a number of factors that includes: political stability and security, taxation regimes available and in use, legal systems and regulations (applicable to exploration and mining, access to geoscientific data sets and availability of exploration / mining skills in the country.

1.2 RESEARCH AIMS AND OBJECTIVES

The main objective of this study was to assess and demonstrate the importance of using state funded geoscientific data sets (pre-competitive data sets) in the generation of exploration targets at a regional scale.

The research is aimed at:

- Demonstrating the possibility of using state-funded geoscientific data sets which may be freely accessible or accessible at a relatively low cost for initial mineral exploration targeting.
- Demonstrating how various geoscientific datasets may be efficiently integrated for effective exploration targeting
- The overall importance of data integration in ore deposit identification and evaluation.

1.3 LITERATURE REVIEW

1.3.1 Importance of pre-competitive geoscientific data

Lane (2010) points out that the exploration and mining industry faces a decrease in the rate of important discoveries of resources paralleled with the record costs of exploration. As such, measures to cushion exploration expenditure need to be made available by different exploration destination countries to ensure that inward exploration investment may be attracted. One of those measures could be the use of state-funded pre-competitive data which the state could provide to prospective exploration companies at a reasonable fee or freely.

Mineral exploration can be a costly, laborious and mostly a win or lose exercise if explorers do not get sufficient data for the specific area being explored. It has been observed that in the absence of geoscientific data, it is often the case that economically viable deposits will only be discovered or proven by the fourth or fifth company investigating a particular area (Scott, *et al*, 2014). Consequently, the availability of and access to a country's geoscientific data is absolutely fundamental in the process of proving a mineral resource.

In a recent article in the Mining Weekly magazine titled "Political risk, poor infrastructure and lack of geodata stymying African exploration", University of Witwatersrand Honorary Professor Richard Viljoen states that until quite recently, there has been a general lack of understanding among many African administrations of the benefits of creating geoscience databases for use in exploration and mining. "Many governments are only now beginning to realize what is required in the chain of events from exploration and acquisition of prospecting licenses to the granting of a mining license and the establishment of a new mine."

Several African Governments have implemented Government Mining Cadastre Portals for companies wanting online access to information about exploration and mining licenses. These portals allow registered parties to submit new applications for mineral exploration, make online payments, renew permits, or to upload statutory reports (Table 1.1). These countries include Botswana, Burkina Faso, Cameroon, Democratic Republic of Congo, Guinea, Cote d'Ivoire, Ethiopia, Ghana, Guinea, Kenya, Liberia, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Sierra Leone, South Africa, South Sudan, Tanzania, Uganda, Zambia and Zimbabwe (Kinnaird and Durrheim, 2017).

Table 2.1: Availability of geoscience data repositories in Africa (Kinnaird, et al 2017)

Country	Commodities mined	On-line portal
Botswana	Diamonds, coal, cobalt, copper, gold, nickel, platinum-group metals, salt, aggregate, semi-precious gemstones, silver.	http://geoscienceportal.geosoft.com/Botswana/search
Burkina Faso	Gold, zinc, phosphate, manganese, copper.	In preparation, Contact details. http://www.burkina-emine.com/?p=3747
Cameroon	Cement, petroleum, sand and gravel. Artisanal recovery of minor diamond and gold.	Launched in 2016 http://www.spatialdimension.com/News
DR Congo	Cobalt, tantalum, diamonds copper, tin, gold.	http://portals.flexicadastre.com/drc/en/
Cote d'Ivoire	Petroleum, gas, gold, manganese, silver, diamonds, industrial minerals.	Launched in 2016 http://www.spatialdimension.com/News
Ethiopia	Tantalite, gold, gemstones, cement, soda ash, kaolin, dimension stone.	http://www.mom.gov.et
Ghana	Gold, petroleum, diamonds, bauxite, cement, lead, manganese, salt, silver, construction materials.	Launched in 2016 www.ghana-mining.org
Guinea	Bauxite, diamonds, alumina, cement, gold, iron ore, graphite, manganese, nickel.	Launched 2015 http://www.spatialdimension.com/News
Kenya	Soda ash, coloured gemstones, gold, columbite, titanium and zircon.	https://portal.miningcadastre.go.ke/
Liberia	Iron ore, barite, cement, diamonds and gold, aggregate.	http://portals.flexicadastre.com/liberia/
Malawi	Uranium, cement, coal, aggregate, limestone, colored gemstones & others	Launched in 2017 http://portals.flexicadastre.com/malawi/
Mozambique	Ilmenite, zircon, aluminium, beryl, tantalum, cement, coal, natural gas.	http://portals.flexicadastre.com/mozambique/en/

Namibia	Uranium, diamonds, arsenic, copper, gold, lead, manganese, silver, zinc, cement, dolomite, fluorspar, granite, marble, salt, semi-precious stones, wollastonite.	http://portals.flexicadastre.com/Namibia/
Nigeria	Oil and gas, tin, coltan, iron ore, coal, limestone, barite, gemstones, gold, salt, lead, zinc. Oil and gas 13% GDP.	http://www.miningcadastre.gov.ng/
Rwanda	Tantalum, tin, tungsten, gas, niobium, gold.	http://portals.flexicadastre.com/rwanda/
Sierra Leone	Diamonds, rutile, bauxite, iron ore, cement, gold, ilmenite and zircon.	http://www.nma.gov.sl/home/licence-application-process/
South Africa	Platinum, rhodium, chromium, kyanite/andalusite, palladium, vermiculite, vanadium, manganese, gold, coal, fluorspar, cobalt, nickel, iron ore, diamonds, uranium, ilmenite, rutile and zircon.	Limited http://www.gov.za/services/mining-and-water/apply-mining-right portal.samradonline.co.za
South Sudan	Oil, gold	http://portals.flexicadastre.com/southsudan/
Tanzania	Gold, cement, coloured gemstones, tanzanite, coal, diamonds.	http://portal.mem.go.tz/map
Uganda	Pumice, aggregates, cement, cobalt, gold, iron ore, kaolin, lead, coltan, tin, tungsten, salt, vermiculite.	http://portals.flexicadastre.com/uganda/
Zambia	Copper, cobalt, coloured gemstones.	http://portals.flexicadastre.com/zambia/
Zimbabwe	Diamonds, platinum, palladium, gold, nickel, copper, chromite, cobalt, graphite, coal.	Launched in 2016 http://www.spatialdimension.com/News

The countries listed in Table 1.1, however are not the only countries in Africa with a potential for mineral resources. Other countries in Africa have mineral potential, for instance Lesotho has diamond resources (both kimberlitic and alluvial), and mining activities do exist. For example, De Beers has been operating the Letseng Diamond Mine in the Maluti mountains of Lesotho since 1977. The mine closed in 1982 and was reopened by in 2004 and it is still in operation (Corporate profile, <http://www.letsengdiamonds.co.ls/about/default.php>). However, the country attracts minimal exploration investment partly due to lack of pre-competitive geoscientific data that potential exploration investors can use to make informed decisions and de-risk expensive exploration procedures that would follow.

According to Mineral Industry Advisors, Behre Dolbear's 'Where to Invest in Mining Report (2015), the following countries: Botswana, Democratic Republic of Congo, Ghana, Mozambique, Namibia, South Africa and Zambia have been rated in the top 25 countries in the world as top exploration investment countries for three consecutive years (Table 1.2). Behre Dolbear's ratings are based on political system, economic system, currency stability, social license issues, and permitting, competitive taxation and corruption levels. The same countries are also rated by the Fraser Institute Annual Survey of Mining companies 2016 on their Investment Attractiveness Index in the top 18 countries in Africa (Figure 1..2) (Jackson, et al, 2017).

Table 1.3: Ranking of Countries for Mining Investment (Behre Dolbear, 2015)

2015		2014	2013	
1	Canada	Canada	Australia	1
2	Australia	Australia	Canada	2
3	United States	United States	Chile	3
4	Chile	Chile	Brazil	4
5	Mexico	Mexico	Mexico	5
6	Peru	Brazil	United States	6
7	Namibia	Peru	Colombia	7
8	Botswana	Botswana	Botswana	8
9	Colombia	Namibia	Peru	9
10	Ghana	Ghana	Ghana	10
11	Brazil	Colombia	Mongolia	11
12	Zambia	Zambia	Tanzania	12
13	South Africa	Tanzania	China	13
14	India	South Africa	Namibia	14
15	Indonesia	Philippines	Argentina	15
16	Philippines	China	India	16
17	Mozambique	India	Philippines	17
18	Kazakhstan	Indonesia	Indonesia	18
19	Mongolia	Kazakhstan	Zambia	19
20	Tanzania	Argentina	South Africa	20
21	China	Papua New Guinea	Kazakhstan	21
22	Argentina	Mozambique	Papua New Guinea	22
23	Russia	Mongolia	D.R. Congo	23
24	Papua New Guinea	Russia	Mozambique	24
25	D.R. Congo	D.R. Congo	Russia	25

Due to the reason above, these countries have seen much more inward investment in exploration and mining as compared to countries like Malawi.

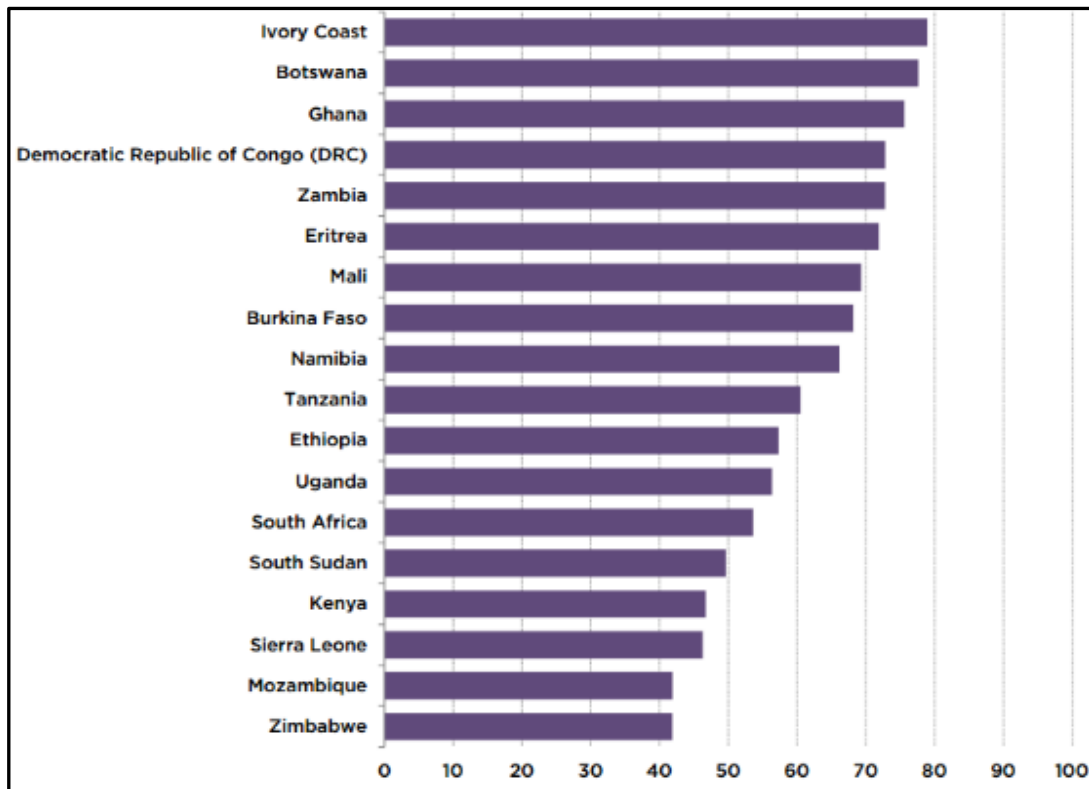


Figure 1.2: Investment Attractiveness Index – Africa (Fraser Institute Annual Survey, 2016)

A number of successful exploration projects do exist in South Africa as one of the top investment countries as shown in Table 1.2 and Figure 1.2. Apart from other factors, notable projects in South Africa have succeeded because pre-competitive geoscience data sets that were available during the initial exploration targeting phase. Such projects include the Waterberg Platinum Project and the Mokopane iron-vanadium-titanium project in the Limpopo Province.

1.3.1.1 The Waterberg Platinum Project Example

This is a famous new discovery on the northern limb of the Bushveld complex in South Africa, the Waterberg Platinum Project owned by Platinum Group Metals Ltd. The layered ore deposit for this project area underlies the Waterberg sediment cover, and had been unexplored until 2009.

In the recently updated mineral resource report for the Waterberg Project, Muller (2016) states that topographical and aerial maps for Waterberg were used for initial surface mapping. And these were coupled with surface maps and public aeromagnetic and gravity maps. However not much information was seen from the mapping due to the sediment cover, however the use of the public geophysical maps allowed for preliminary generation of exploration targets.

To get more detailed data for the project area, a soil geochemical sampling was conducted, followed by a Falcon airborne and a ground gravity surveys.

The soil geochemical sampling showed elevated PGMs and this increased exploration interest in the area. The geophysical data showed a good correlation, and showed that a denser mafic intrusive rock may occur beneath the Waterberg Group sediment cover.

The geophysical data was integrated with the geochemical data and the mapping information to establish drilling targets. According to the recent mineral resource update (October, 2016), the Waterberg project has a NI 43-101 compliant estimated indicated resource of 24.9 Million Ounces (4E) and an estimated inferred mineral resource of 10.8 Million Ounces (4E).

The initial data used in this project was sourced out from the Council of Geosciences, which is a state-owned institution responsible for custody and dissemination of geoscientific data to the general public.

1.3.1.2 The Mokopane iron-vanadium-titanium Project

The case study project, Bushveld Minerals Ltd.'s Mokopane iron-vanadium-titanium project in Limpopo Province is another good example.

The first phase of the of the project involved development of a geological and mineralization model using published and unpublished geological, geochemical, geophysical, remote sensing and exploration data that was acquired from the Council of Geosciences (Figures 1.2), other academic institutions, publications and private companies (Cheshire, 2011).

The data in Figure 1.3 was part of the pre-competitive data that was obtained from the Council of Geosciences and other sources. It is this data that was fundamental in the generation of exploration targets for this successful project.

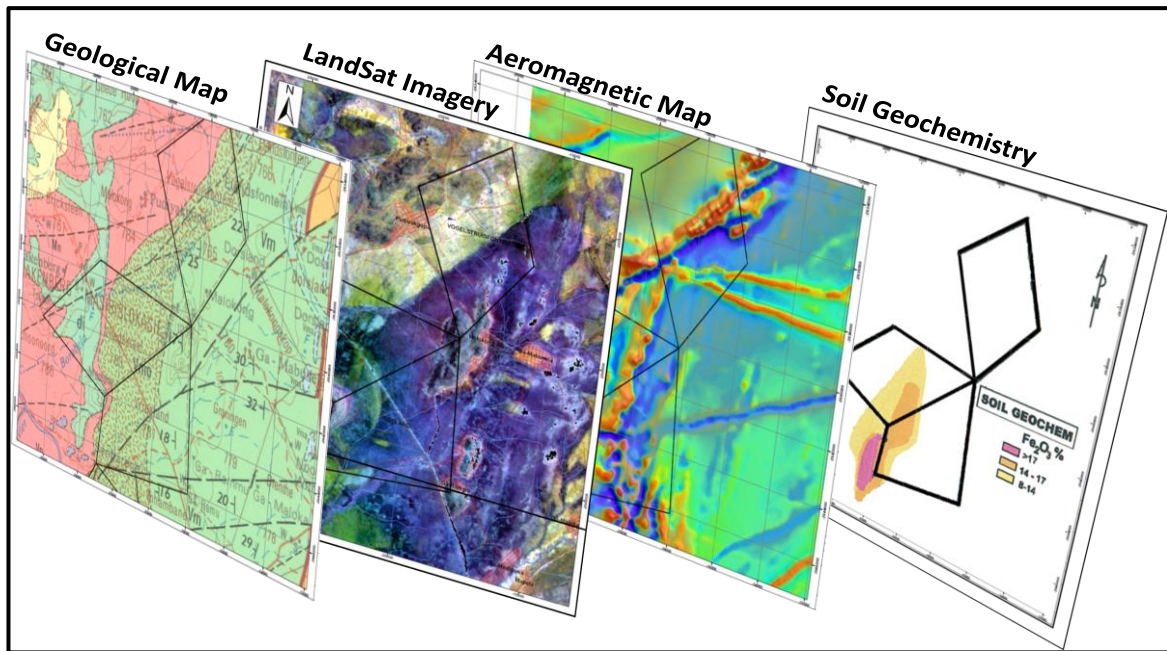


Figure 1.3: Pre-competitive data sets used in the Mokopane Project (from Cheshire, 2011)

The two South African examples show the role that governments need to play in provision of geoscientific data. Governments through their state funded Geological institutions have a mandate to de-risk exploration (as shown in the examples) so that more inward investment into the industry may be attracted. De-risking of the exploration exercise may only be achieved by providing potential investors with pre-competitive geoscientific data which is necessary to reduce exploration costs.

Figure 1.4 generally serves to explain the use of the state funded data sets (Government pre-competitive data) in the initial exploration stages of any exploration project and later supplemented with project specific data (Industry – competitive data) to increase geological certainty and confidence.

In addition, governments have to provide a conducive environment for potential investors in exploration by providing flexible and fast licensing / permitting processes, competitive taxation policies, viable economic stability environments and very low corruption levels.

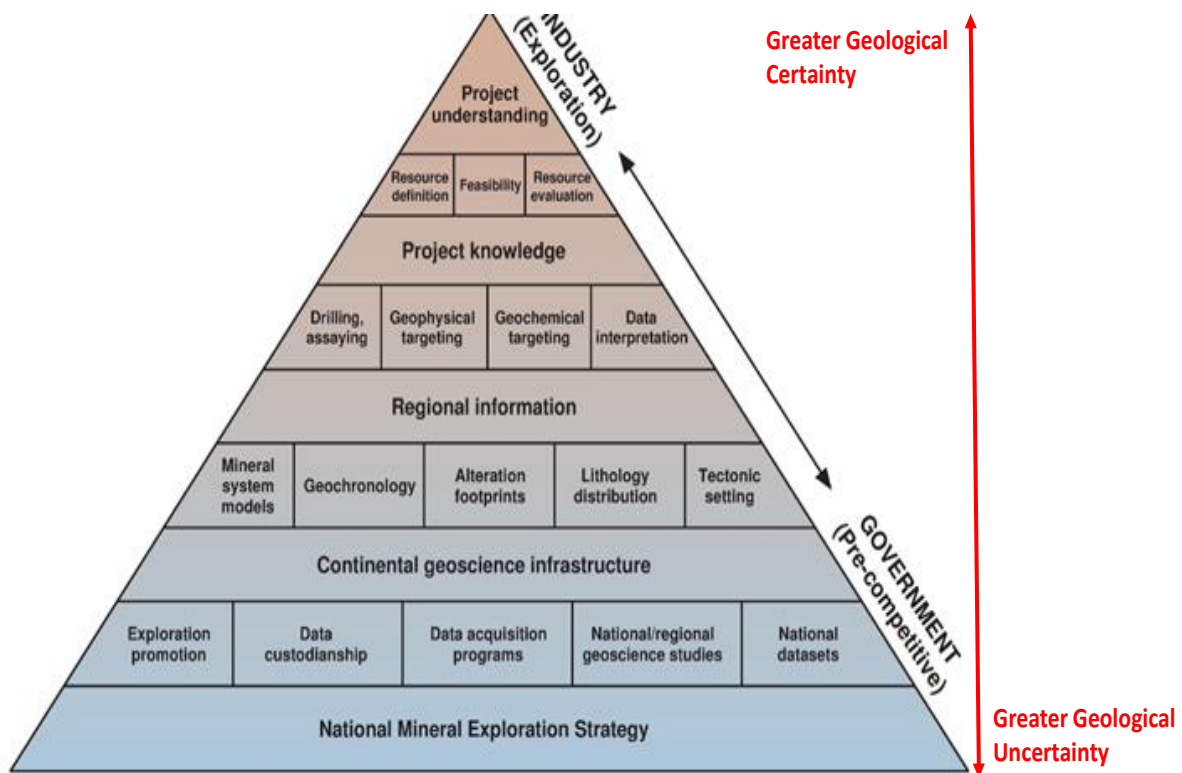


Figure 1.4: Government and industry roles in mineral exploration (from BP, 2006)

1.3.1.3 The Northern Ireland Case

In support of the notion on the government's role in provision of such data, Young, et al. (2013) gives an example of Northern Ireland where the Geological Survey of Northern Ireland (GSNI) conducted a government-funded initiative between 2004 and 2007 for soil and stream geochemical sampling and a low-level airborne geophysical survey of Northern Ireland. Within 12 months of the data launch in 2007 the area of Northern Ireland licensed for exploration increased from 15 per cent to 70 per cent. Targets include gold, platinum group elements and base metals.

Northern Ireland is therefore a good example of how countries with freely or cheaply accessed data may attract more investment opportunities for exploration to mining as compared to those that do not have any of such data repositories.

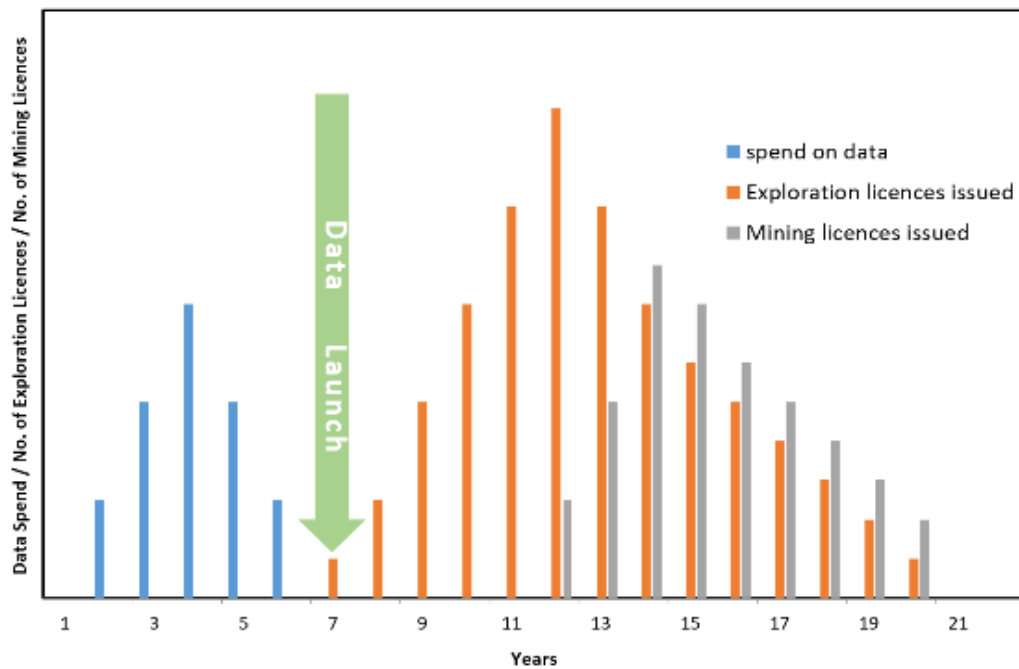


Figure 1.5: Typical geodata investment / return profile showing the effect of investing in pre-competitive data
(Source: <http://slideplayer.com/slide/7682700/>)

The Northern Ireland example fits well with Figure 1.5’s “geodata investment / return profile against data spend / number of exploration licenses / number of mining licenses” graph. It can be seen from this graphical representation that after a few years of investing in collecting and putting together a geodata repository, the number of exploration licenses issued increases because exploration investors were able to access and use available data as one of the factors necessary for investment decision making regarding the economic potential of the area.

1.3.1.4 The Burkina Faso Example

Burkina Faso implemented a system around 2006 and 2007 where the government keeps all the data from companies that have surrendered their permits ensuring that all the data they have acquired during exploration activity doesn’t leave the country with them (Harris and Miller, 2015).

This system has boosted the government database for geoscientific data which is then made available to new explorationists to make use in trying to reduce cost and de-risk their projects. Burkina Faso experienced a boom to bust exploration cycle between 2007 and 2014 due to this system of geoscience data acquisition for the government (Figure 1.6).

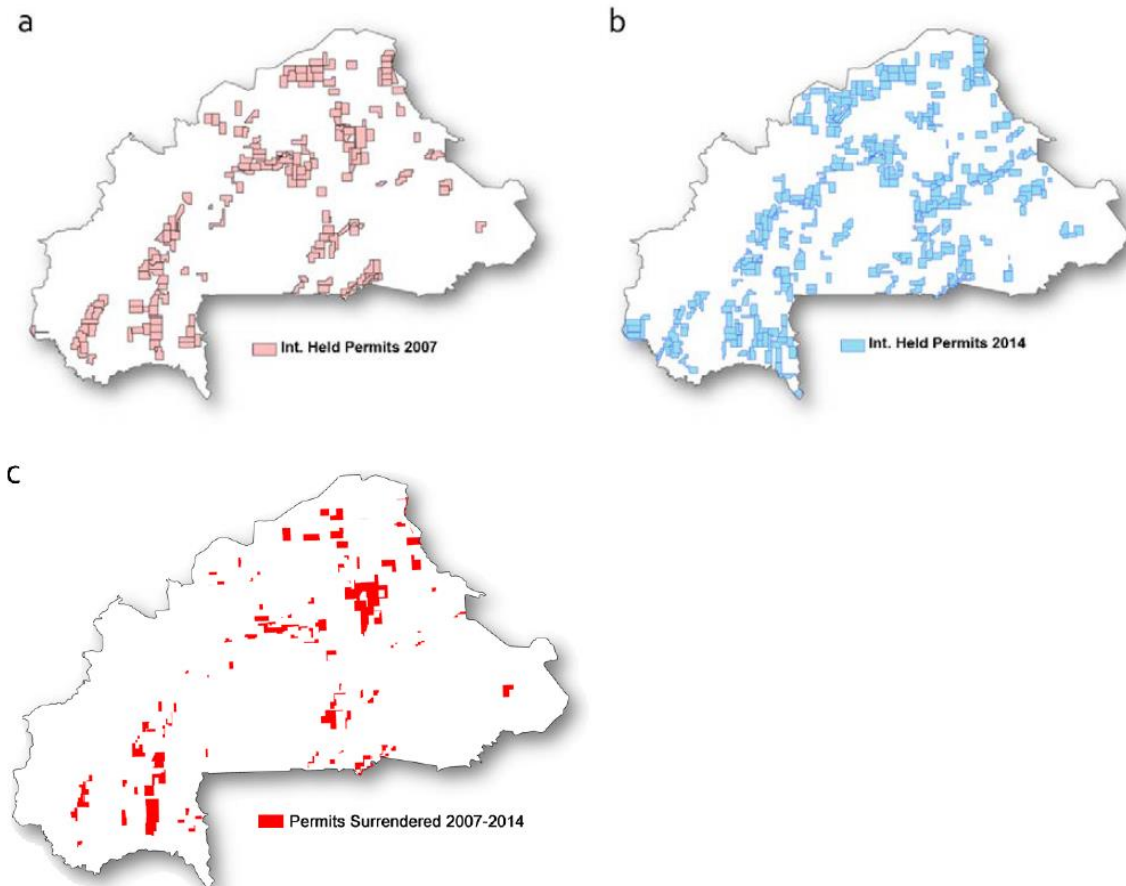


Figure 1.6: Evolution of exploration and mining permits held by International Companies 2007-2014 for Burkina Faso. a) Permits held by international mining companies in 2007. b) Permits held by international mining companies in 2014. c) Ground that was held by international mining companies in 2007 but was vacant ground in 2014. Source of cadastre maps: Ministry of Mines, Quarries and Energy, Department of Geology and Mining Cadastre, Burkina Faso (Harris & Miller, 2015).

It can be noted from the Figure 1.6.b that the total number of exploration and mining permits almost doubled during the period from 2007 to 2014, and this was due to the increased availability of the pre-competitive data sets and its accessibility to prospective explorationists.

1.3.1.5 The Namibian Case

Namibia is one of the countries in Africa that has benefited from the provision of geoscientific pre-competitive data to the exploration industry. The Fraser Institute has rated Namibia at 53 out of 104 countries in the world on the Investment Attractiveness Index, and 9 out of the 18 African countries rated on the index in the Annual Survey of Mining Companies, 2016 (Figure 1.1).

Hutchins, et al, (1997) stated that the Namibian government commitment to the mining sector is demonstrated by recent initiatives to promote exploration. These include the compilation of a regional aeromagnetic data base, the commencement of a programme of high-resolution airborne geophysical surveys and the initiation of a regional geochemical mapping programme.

Magnetic data from forty-one regional airborne geophysical surveys, flown between 1962 and 1992 and covering a large proportion of Namibia (approx. 700 000 line-km), were compiled as part of a German-Namibian cooperation project to produce an integrated digital countrywide magnetic data set.

Radiometric data from surveys conducted over selected areas of Namibia were similarly compiled to produce compatible data sets.

To enhance the regional magnetic data set the Geological Survey of Namibia has recently embarked on a programme of high-resolution airborne geophysical surveys to provide non-exclusive data for the exploration industry.

The first phase, funded by the European Union SYSMIN programme, was completed during 1996 and surveyed approximately 135 000 km² (nearly 750 000 line-km).

The programmes implemented as discussed above have led to increased exploration acreage, licence applications (both exploration and mining) and the diversification of exploration companies in Namibia demonstrates the importance of this new data to exploration.

1.3.1.6 The Canadian Open Public Geoscience Data Example

Mining is a very significant industry in the Canadian economy, and according to a presentation at the Canadian Natural Resources by Kostylev, et al (2017), Canada has 200 active mines and 7000 sand and gravel pits and produces up to 60 metals from these mines. The value of Canadian mineral production in 2016 was \$40.8 billion, and the industry supports 563 000 jobs. As such, the industry is a pillar to the Canadian economy and in 2015 it accounted for 19% of Canada's total domestic exports.

In order to sustain the mining industry, new deposits need to be discovered through exploration of non-explored and under-explored areas. Such exploration activities are made easier if geoscience data for a specific jurisdiction is freely available to the public.

Canada has had a success story of mining because it is supported by a high quality public geoscience data system which is available and provided free of charge to the public.

The Geosciences data in Canada is provided through coordinated and collaborated mechanisms and policies that have been set up by:

- Federal, provincial and territorial governments
- Industry and industry associations and professional bodies
- Academia and academic institutions

The set up as shown in Figure 1.7 ensures that latest public geoscience knowledge and methodologies relevant to the discovery of new mineral resources are used in the industry (Kostylev, et al, 2017).

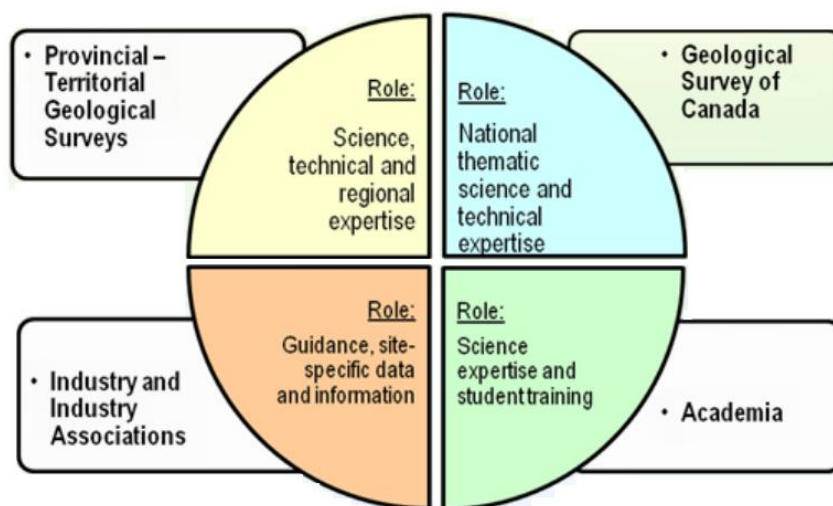


Figure 1.7: The Intergovernmental Geoscience Accord (IGA) in Canada that defines complementary roles and mechanisms for cooperation and collaboration for provision of public geoscience data (Kostylev, et al, 2017)

1.3.2 Integration of pre-competitive geoscientific data

Effective data interpretation and integration procedures are key to realizing the usefulness of pre-competitive data sets. Although government funded pre-competitive data sets are mostly regional, it does become useful if well interpreted and integrated.

Minton, et al (2008) stated that the problem in this “data- and information- rich” environment lies in implementing efficient approaches for verifying and integrating all available data and information. Effective integration leads directly to increased success potential and reduced exploration risk. This

emphasizes on how important efficient and effective integration may be and can give positive results as long as the data is verified and efficiently integrated.

Data verification is also particularly important with historical data where data origins and quality can vary significantly, and additional information helps increase the accuracy and completeness of interpretation.

The success in the use of pre-competitive data sets for target generation on both the Waterberg Platinum project and the Mokopane iron-vanadium-titanium projects discussed earlier may be attributed to effective data integration and data interpretation techniques.

Another successful project where effective data interpretation and integration yielded successful results is the new Sishen – South iron ore deposit at the northern tip of the Maremane anticline, and situated near Kathu in the Northern Cape Province of the Republic of South Africa. On this project, as stated by Mouton (*date unknown*), geological data and interpreted Landsat 5 imagery (Figure 1.8) were integrated and later combined with a project – specific gravity survey results to delineate the new deposit.

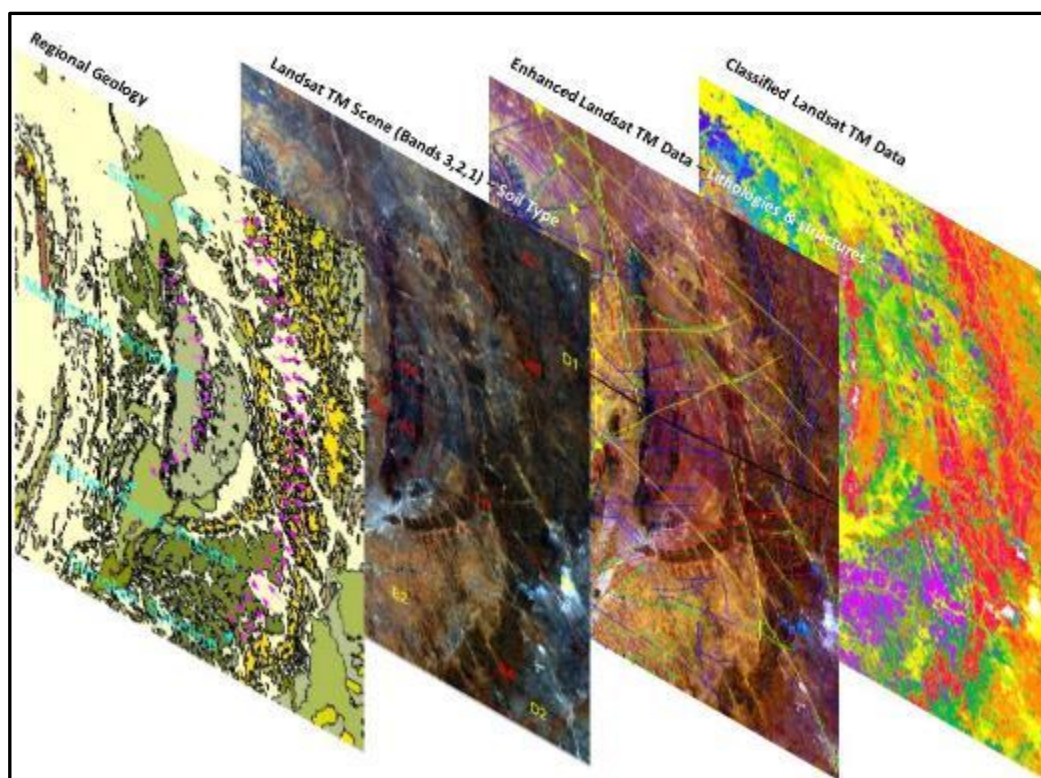


Figure 1.8: Sishen iron ore deposit - Geology & Interpreted Landsat Imagery Integration (Mouton, *date unknown*)

Mouton also states that a regional approach was followed starting with the interpretation of Landsat 5 data over the area. Known hematite outcrops served to “calibrate” the TM data and identify possible targets for geophysical and geological follow-up surveys. Other uses for the TM data included the studying of drainage patterns and delineation of structures. Airborne magnetic data were added to delineate structures and to verify the optically mapped geology.

Targets for iron ore were identified along the north-south striking thrust zones using this data after interpretation and integration thereby saving on the exploration costs.

1.3.3 Other applications for geoscientific data sets

State funded pre-competitive geoscientific data sets may also be fundamentally useful in other applications other than exploration. Duke (2010) points out that the importance of government funded datasets is not only to the investor, but governments also need geoscience information to formulate and implement public policies in such areas as resource development, environmental protection, public health and safety, land use, and infrastructure planning.

A practical example of the use of geoscientific data used in a crisis is provided using a natural gas explosion in downtown Hutchinson, a city of 40,000 in Central Kansas, USA on January 17, 2001. (Allison, 2001). A natural gas burst from the ground under Woody’s Appliance Store and the adjacent Décor Shop, blew out windows in nearby buildings. Within minutes, the two businesses were ablaze. That evening, geyser-like fountains of natural gas and brine, some reaching heights of 30 feet, began bubbling up 3 miles east of the downtown fires. The next day, natural gas, migrating up a long-forgotten brine well, exploded under a mobile home and killed two people. The city ordered hundreds of residents to evacuate homes and businesses, many of whom were not able to return until the end of March.

The Kansas Geological Survey (KGS) stepped into a situation where demand for answers was great, but information was in short supply. Fortunately, the KGS had cores preserved in its repository from a project the Atomic Energy Commission had conducted in the 1960s to investigate the geology of localities being considered for nuclear storage. Practically unused for more than 30 years, these cores contained information that could be obtained rapidly, and without the time or risk of drilling into another unknown gas pocket. Geologists examined these and other cores and samples from wells drilled in the area to get a sense of the potential paths for gas flow through the rock.

Armed with this information, obtained using geoscience data and collections, the KGS gathered new seismic data around the city, from which two anomalous zones of potential high gas pressure were identified. The gas had migrated 8 miles from a leaking salt cavern used as an underground natural gas storage facility. This gas was then safely vented. Over the next two months the Kansas Gas Service consulted with the KGS about possible vent-well locations and additional vent wells were drilled to release pressure. Hutchinson was safe from further gas geysers and gas explosions, and the displaced residents finally could return safely to their homes (Committee on the Preservation of Geoscience Data and Collections, 2002).

Understanding of the situation was initiated through the KGS's fast action that began with cores that had been collected for another purpose many years earlier. Having immediate access to critical geoscience data and information played a crucial role in facilitating rapid response to a local crisis.

Reedman, et al., (2002), summarised some of the most important applications for geoscientific data sets in Table 1.3.

The table therefore does show that apart from the primary benefits of geoscientific data to the exploration industry, the government and the private sector may also find the same data very useful in other applications e.g. in the construction industry, waste management, agriculture, environmental assessment, road building and many more.

Table 1.3: Geological Information: users and applications (Reedman, et al., 2002)

SECTOR	Examples of broad decision-areas that might be sensitive to availability of geological information
Minerals – metallic	- mineral exploration - regional resource assessment and extraction planning
Minerals – aggregates and other industrial	- minerals extraction planning - identification of new resource areas
Waste management	- location of waste disposal sites
Environmental assessment	- assessment of pollution potential/risk from anthropogenic contaminants (e.g. heavy metals) - assessment of pollution potential/risk from naturally occurring elements (e.g. radon)
Local and regional planning	- geohazard identification and land use planning
Coastal management	- coastal defence against flooding and erosion - shoreline management - identification of aggregate resources
Water management – resources	- information for siting and designing boreholes - information for predicting surface water/groundwater interactions
Water management – protection	- regional data for catchment management plans - delineation of groundwater protection areas
Construction industry, excluding roads	- site surveys - site investigation planning and interpretation - excavation conditions
Road building	- as above
Insurance, re-insurance, conveyance	- swell-shrink clay distribution - general geohazard data
Education	- study maps - intellectual basis for understanding UK geology
Academic research	- as above
Hydrocarbons – offshore	- framework of regional geology
Hydrocarbons – onshore	- as above and background 3D geology
Coal	- exploration - detailed 3D geology and ground conditions for mining
Conservation	- data for protection of valuable cultural sites
Tourism and recreation	- basis for guides and information at interpretative centres
Agriculture	- pollution risk from pesticides - basic information for soil categorisation
Forestry	- basic information for soil categorisation

1.4 METHODOLOGY

In an effort to establish the importance of state funded data in initial exploration targeting, and how the different data sets would be effectively interpreted and integrated, two methods were used.

These were:

1.4.1 Case study of Bushveld Minerals Ltd.'s Mokopane iron-vanadium-titanium project in Limpopo Province

Data for this case study was mainly collected from Bushveld Mineral's Ltd internal company unpublished reports, while some was also sourced out from the company's website from their Competent Person's Reports (CPRs) which have been made public since the company is listed on the London Stock Exchange.

1.4.2 Questionnaires administered to different exploration companies and State Geological Survey Organizations (GSOs) in selected African countries.

The contact email addresses for sending out the questionnaires were sourced out from the internet on the company's / GSO's websites, personal contacts and referrals.

CHAPTER 2

CASE STUDY: MOKOPANE IRON - VANADIUM – TITANIUM PROJECT

2.1 INTRODUCTION

The Mokopane iron-vanadium-titanium project is located approximately 45km NNW of Mokopane, Mokopane District, Limpopo Province in the Republic of South Africa, and consists of the farms Vliegekraal 783LR, Vogelstruisfontein 765LR and Vriesland 781LR in the Mokopane district (Figure 2.1).

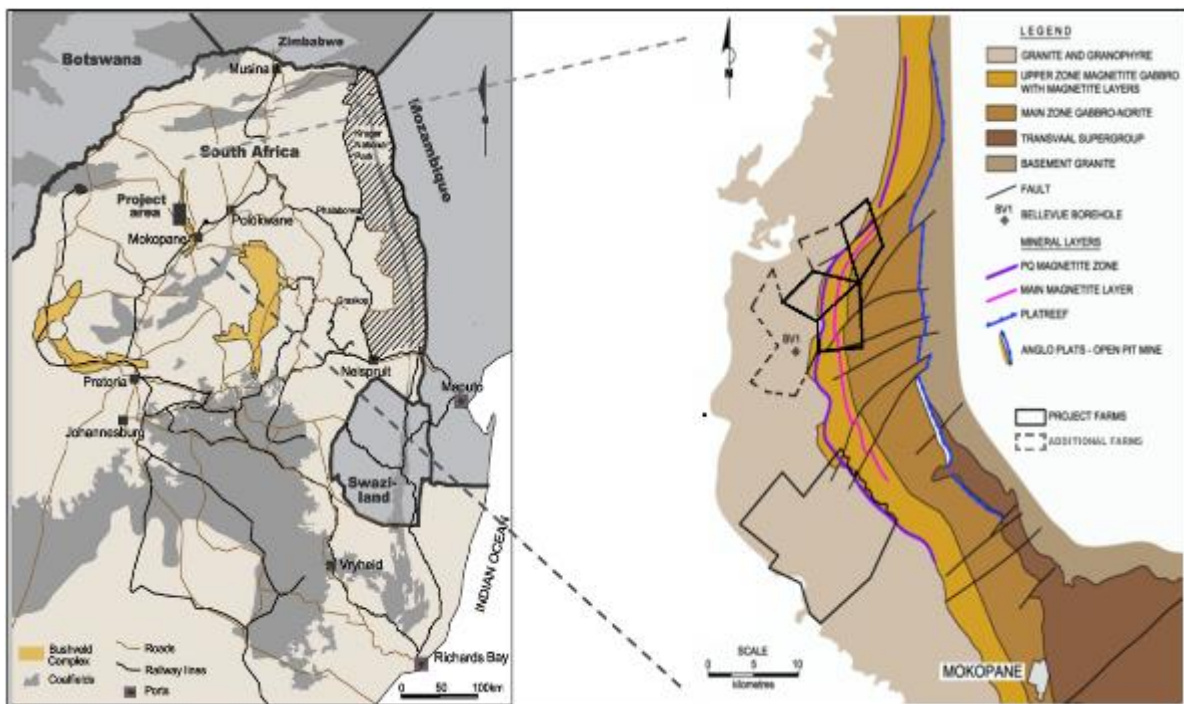


Figure 2.1: Location of the Mokopane Fe-V-Ti Project in relation to the Northern Limb of the Bushveld Complex. (a) shows the location of the northern limb of the Bushveld Complex in relation to the entire Bushveld Igneous Complex, (b) shows the northern limb of the Bushveld Complex with the project farms

This project was used as a case study to test the importance of state funded data. The focus on this case study was on the pre-competitive data sets that the company acquired from the Council of Geosciences (CGS), which is a state-owned institution responsible for collection, assessment, dissemination and curation of all geo-scientific data. This initial data used on the project was acquired from the CGS and was used in the initial stages of the project to generate potential exploration targets. The case study was also used to determine on how the different data sets were integrated to generate the exploration targets.

2.2 GEOLOGICAL SETTING FOR THE PROJECT

The project area is located in the Bushveld Igneous Complex which is situated in northern part of the Republic of South Africa (Figure 2.2). The Bushveld Complex is a layered mafic-ultramafic intrusion with a surface exposure over an area of 90 000 km² (Finn et al, 2004) and geographically, the Bushveld Complex is divided into the Western Limb, Eastern Limb, Northern Limb, the Far Western Limb and the buried Southeastern Limb (Figure 2.2).

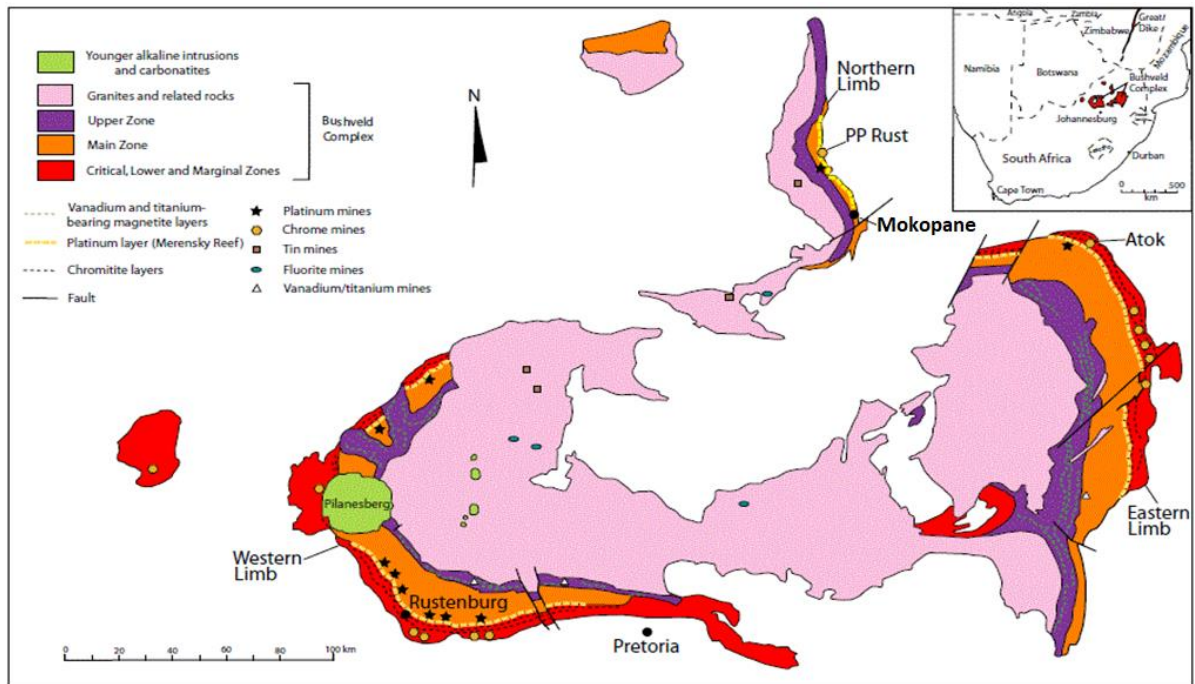


Figure 2.2: Geology and Stratigraphy Map of the Bushveld Complex showing its location in South Africa and the subdivisions (Western, Eastern, Northern and Far Western Limbs) and also showing locations of some of the more important chromium and PGM mines (Modified from Viljoen and Schurmann (1998))

The Complex consists of three suites of plutonic rocks, namely the mafic-ultramafic Rustenburg Layered Suite (South African Committee for Stratigraphy, 1980), the Raseop Granophyre Suite and the Lebowa Granite Suite (Von Gruenewaldt et al., 1985) (Figure 2.2).

The Rustenburg Layered Suite is subdivided into five zones from bottom to top (Hall, 1932): the basal Marginal Zone (gabbro-norite), the Lower Zone (peridotites and pyroxenites), the Critical Zone (pyroxenites and chromitites), the Main Zone (gabbro-norites), and the Upper Zone (anorthosites, diorites and magnetites) (Table 2.1 and Figure 2.2). The lithologic characteristics of the various zones are described in detail by Eales and Cawthorn (1996).

The licence area overlies part of the north trending northern limb of the Bushveld Complex, which dips gently (15-25°) to the west (Cheshire, 2011). In this section of the northern limb, the ultramafic and mafic rocks of the Rustenburg Layered Suite lie on a floor of Archaean basement granites (Rashoop Suite) and is overlain by Bushveld granite sills (Lebowa Granite Suite) and younger post Bushveld Waterberg Group and Quaternary cover rocks to the west. The generalized sequence of the Bushveld Complex in the northern limb and regional geology is shown in Table 2.1 and Figure 2.2.

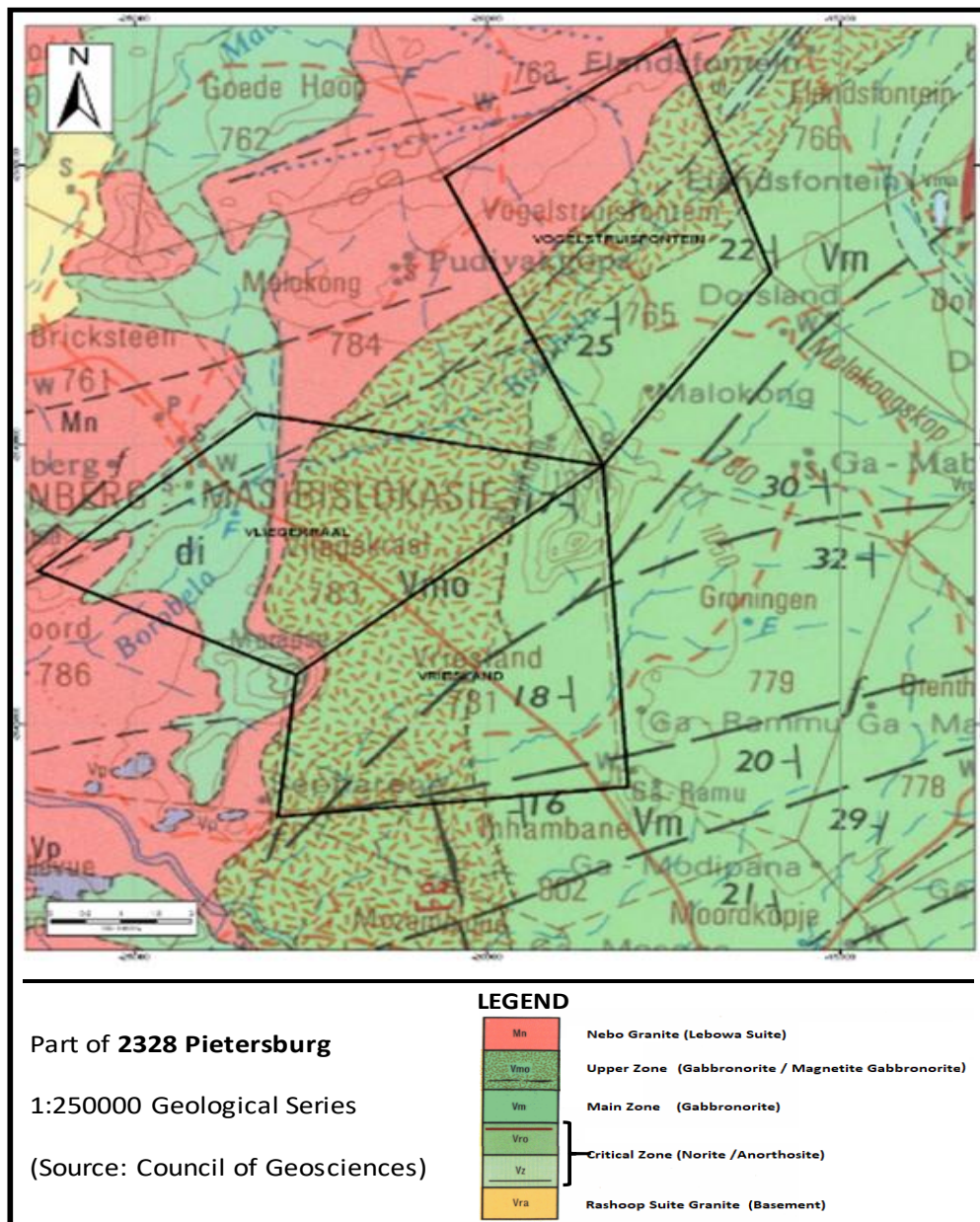


Figure 2.3: Project Area Regional Geology – Part of 2328 Pietersburg 1:250000 Geological Series showing farm boundaries for the Mokopane iron-vanadium-titanium Project (Source: Council of Geosciences)

Stratigraphically, from west to east (younger to older), rocks of the Nebo granite, intruded by a late Waterberg age diabase sill, underlie the high ground of the western parts of Vliegekraal and Vogelstruisfontein farms (Figure 2.3). The Molendraai Magnetite Gabbro of the Upper Zone of the Rustenburg Layered Suite (RLS) dominates the thick soil covered central portion of the licence area. The eastern portion of the licence area is underlain by the upper part of the Mapela Gabbronorite of the Main Zone. The Lower Main Zone and underlying units (including the Platreef) do not sub-outcrop in the licence area but dip below the sub-outcropping Main and Upper Zone (Cheshire, 2011)

Table 2.1: Generalised Lithographic Sequence, Bushveld Complex (after SACS, 1980 and 2328 Pietersburg, 1:250000 Geological Series)

Lebowa Granite Suite			Nebo Granite (Mn)
Rustenburg Layered Suite	Upper Zone	Subzone C	Molendraai Magnetite Gabbro (Vmo)
		Subzone B	
		Subzone A	
	Main Zone	Upper Subzone	Mapela Gabbronorite (Vm)
		Lower Subzone	
	Critical Zone	Upper Subzone	Grasvally Norite-Anorthosite (Rooipoort Norite-Anorthosite) (Vro)
		Lower Subzone	
	Lower Zone	Upper Pyroxenite Subzone	Zoetveld Subsuite (Vz)
		Harzburgite Subzone	
		Lower Pyroxenite Subzone	

A series of NNE-SSW to ENE-WSW striking regional faults, with a right lateral sense of horizontal displacement of up to 2.6km, transect the Rustenburg Layered Suite sequence in the licence area.

Two diabase dyke sets have intruded the licence area, an earlier E-W trending positive magnetic dyke set crosscut by a later ENE-WSW trending negative dyke set.

2.3 MINERALISATION

Based on recorded information and known styles of mineralization in the northern limb of the Bushveld Complex, mineralization in the licence can be expected to occur in the following geological settings:

1. Rustenburg Layered Suite (RLS) Upper Zone – Vanadium-titanium-magnetite (VTM) mineralization associated with the titaniferous and vanadiferous magnetite layers and magnetite rich units of the Upper Zone which sub-outcrop in the licence area

2. Rustenburg Layered Suite (RLS) Main/Upper Zone – Platinum group element, copper-nickel (PGE-Cu-Ni) mineralization sporadically recorded in Main and lower part of Upper Zone rocks which sub-outcrop in the licence area
3. Rustenburg Layered Suite (RLS) Basal Contact Zone – Platinum group element, copper-nickel (PGE-Cu-Ni) mineralization associated with the basal contact of Rustenburg Layered Suite and basement floor rocks, known as the Platreef ore zone. The Platreef would be expected to occur underlying the licence area at depths in excess of 1000m.

This report focuses on VTM mineralization associated with titaniferous and vanadiferous magnetite layers and magnetite rich units of the Upper Zone of the Northern Limb of the Bushveld Complex.

2.4 THE PROSPECTING WORK PROGRAMME

The prospecting work programme for the project was started in August 2009 and in order to evaluate the mineral potential of the prospecting area cost effectively, the programme was divided into the following phases (Cheshire, 2011):

- **Phase 1 – Desktop Information Review (August 2009 – January 2010)**

The objective of this phase was to develop a geological and mineralization model using available geological, geochemical, geophysical and exploration data from the Council for Geoscience (CGS), other geological institutions, published papers, and private companies.

- **Phase 2 – Surface Field Investigation (September 2009 – April 2010)**

The main objective of the field investigation was to locate indications of surface mineralization, establish its geological setting and identify targets for further testing. The following field surveys were completed: Geological mapping and air photo interpretation, rock chip sampling, soil sampling, data analysis and review.

- **Phase 3 – Target Drill Testing (May 2010 – November 2010)**

Shallow diamond drilling was undertaken to establish the presence of mineralization at shallow depths, identify host rock and provide an indication of mineralization grade and width where present. The programme consisted of shallow diamond drilling on selected soil geochemical anomalies and favorable geological units, core logging, sampling & analysis, review and analysis of drill information, and reporting.

2.4.1 Regional Exploration Phase

The first detailed historical investigations on the project site were carried out in the 1970s and included mapping, ground geophysics, trenching and limited drilling south of the Mokopane project. This work focused mainly on the MML (Main Magnetite Layer) because of its high vanadium content. The project area has not been previously explored for its Ti-magnetite potential but was covered by a regional geochemical soil sampling and mapping programme by the Council for Geoscience (“CGS”).

During 1979 and 1980, the Mining Corporation Ltd (“MCL”), a South African government company, completed geological mapping, magnetic surveys, and drilling over the five contiguous farms to the south of the Mokopane project. The main focus was the vanadium potential of the MML layer and a non-JORC-compliant mineral resource along a 16km strike of 419Mt of VTM-rich material containing 6.5Mt of V_2O_5 was reported (Bushveld Minerals, March 2013).

This pre-competitive data (available from the CGS) was a starting point for further investigation on this project when the prospecting right was first awarded to the company.

During the initial exploration phases of this project, phase 1 of the project involved mainly desktop review of data that was available for the license area at the time. The main purpose of this phase was to develop a geological and mineralization model based on the available data.

Additional data sourced out from the CGS as pre-competitive geoscientific data sets included geological, geochemical, and geophysical data.

Landsat satellite imagery data for the license area was downloaded freely from USGS EROS (United States Geological Survey - Earth Resources Observation and Science) website, <https://landsat.usgs.gov/landsat-data-access>.

All the data sets were interpreted, and integrated to build a geological and mineralization model and ultimately used to generate the exploration targets.

2.4.2 Pre-competitive Data used

The data sets discussed below acquired from the CGS were used to build a geological and mineralization model which ultimately led to the generation of the exploration targets. The data included:

- **Regional geology** – the regional geology of this part of the northern limb of the Bushveld Complex which has been mapped by the Council for Geoscience (CGS) and published at 1:250000 scale as the 2328 Pietersburg Geological Series map (Figure 2.3).

1:50 000 scanned geological printed maps in TIFF format are sold as a set of two (one with a legend and one clipped in WGS84 datum) at the cost of R1100 (Appendix 5).

- **Regional Geophysical Surveys Data** - the CGS has also flown regional aeromagnetic and radiometric surveys and this processed data is available electronically (Figures 2.4 & 2.5). This data costed R1000 per 1:50000 scale georeferenced map image (see price schedule in Appendix 5).
- **Regional Geochemical Data** – the CGS has undertaken soil geochemical sampling in the area as part of the Regional Geochemical Mapping Programme. Sampling was conducted at 1km intervals and XRF and ICP-MS analyses included Fe₂O₃, V, TiO₂, Cu, and Ni (Figures 2.7 to 2.11). Significant V and TiO₂ soil anomalies occur over Upper Zone rocks. This data was acquired at R3 per element per sample.
- **Historical Boreholes** – Data for 5 historical boreholes namely: BV1, M7, M8, P56 and P57 were acquired from the CGS. Borehole BV1 was drilled by the CGS in the 1970's, boreholes M7 and M8 were drilled by General Mining Drilling Company while P56 and P57 were drilled by MSA.

The most important of the five boreholes is BV1 where a typed hard copy geological log for the borehole was obtained from the CGS. The CGS drilled this 2450m stratigraphic borehole, BV1, located on Bellevue farm 808LR (Figure 2.12).

The borehole was re-logged and sampled on all the magnetite mineralized zones by Bushveld Minerals.

Additionally, **Landsat satellite imagery** (Figure 2.6) was freely accessed from USGS EROS (United States Geological Survey - Earth Resources Observation and Science) website and was used to identify soil types and lithological boundaries in the project area.

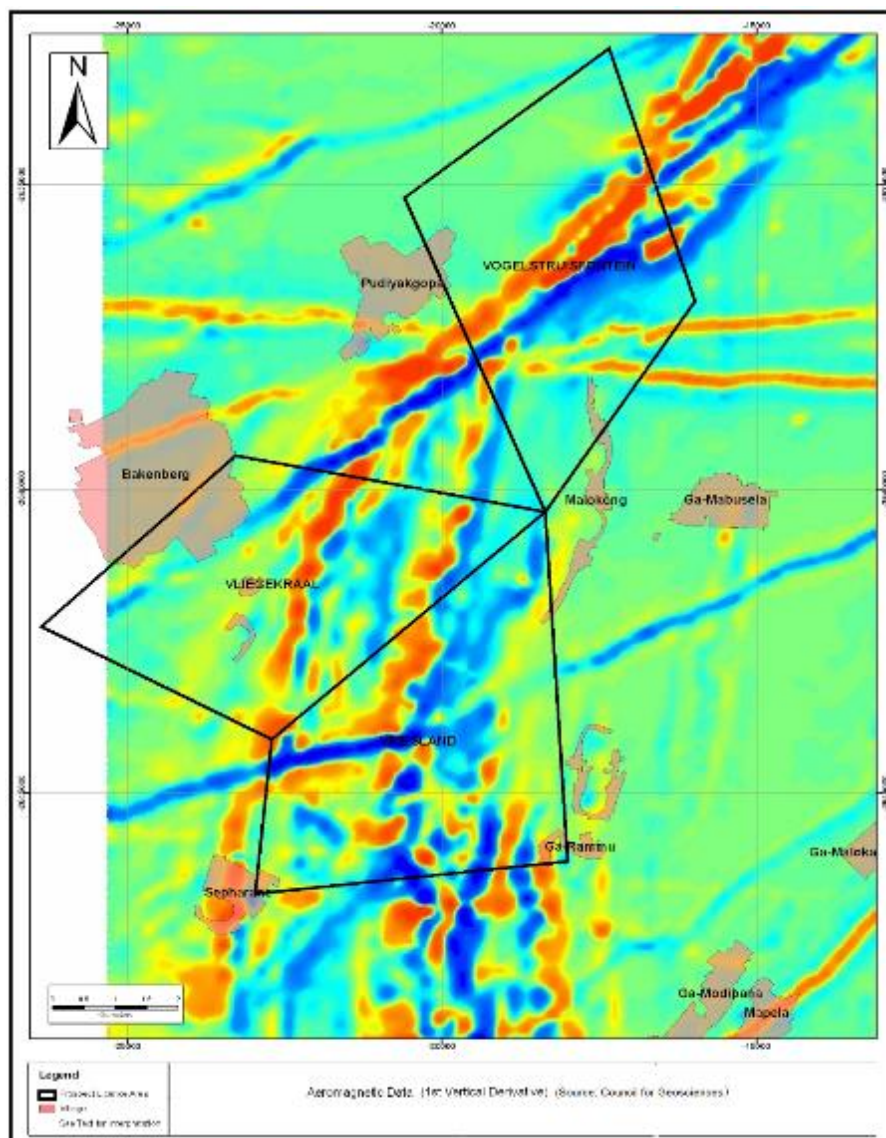


Figure 2.4: Project Area Aeromagnetic Data (1st Derivative)

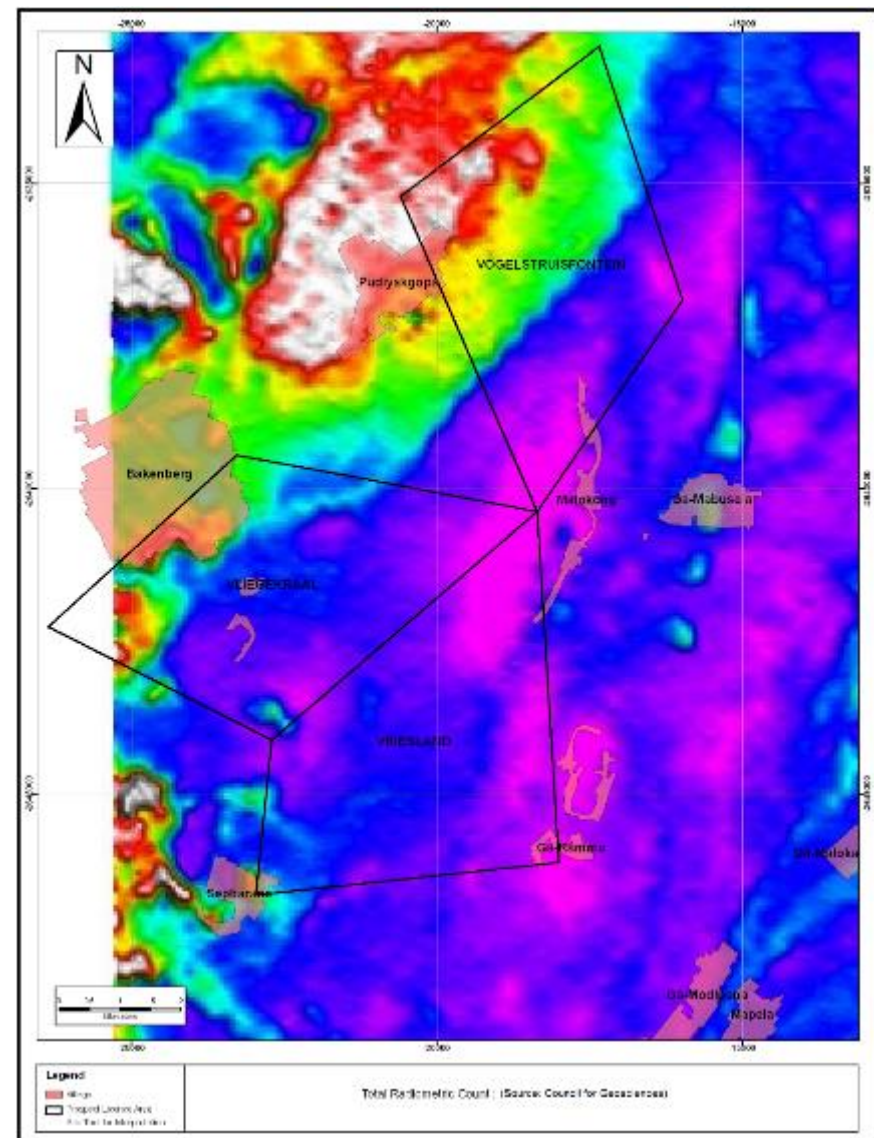


Figure 2.5: Project Area Total Radiometric Count

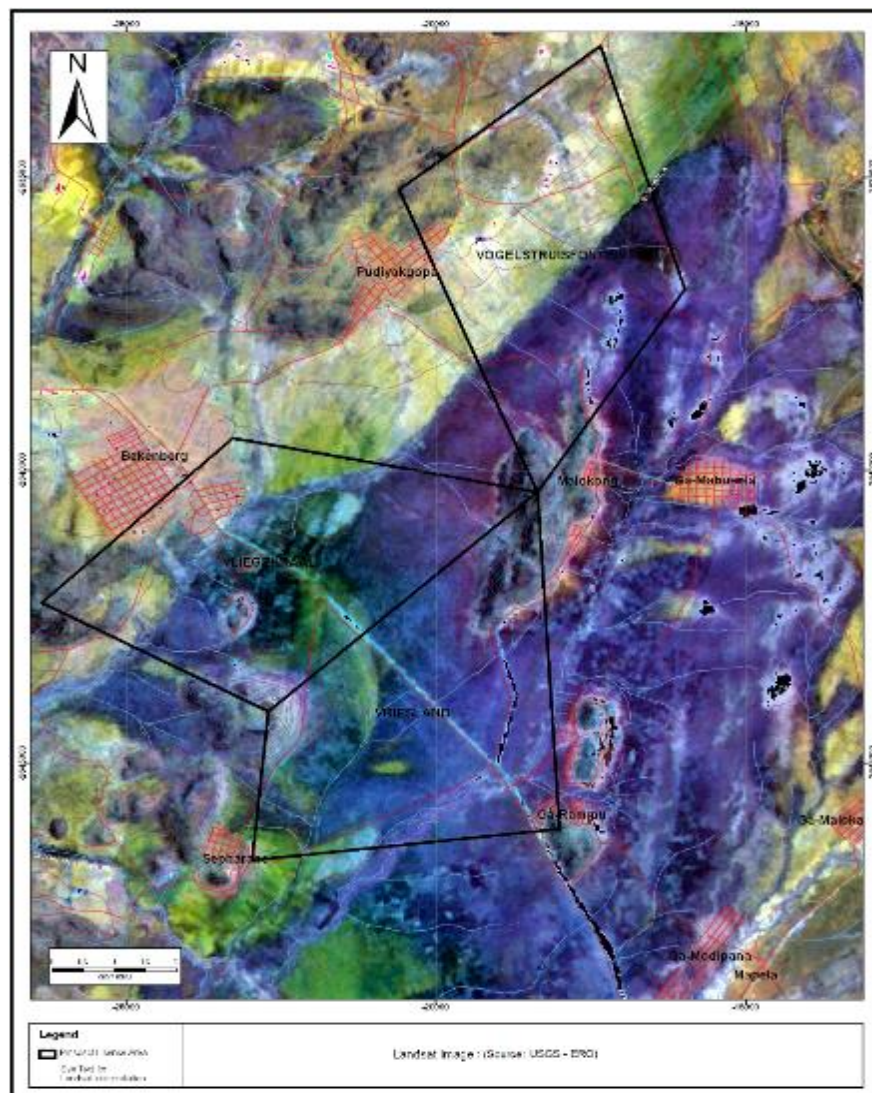


Figure 2.6: Project Area Landsat Imagery showing lithological and soil type contacts (Source: USGS EROS)

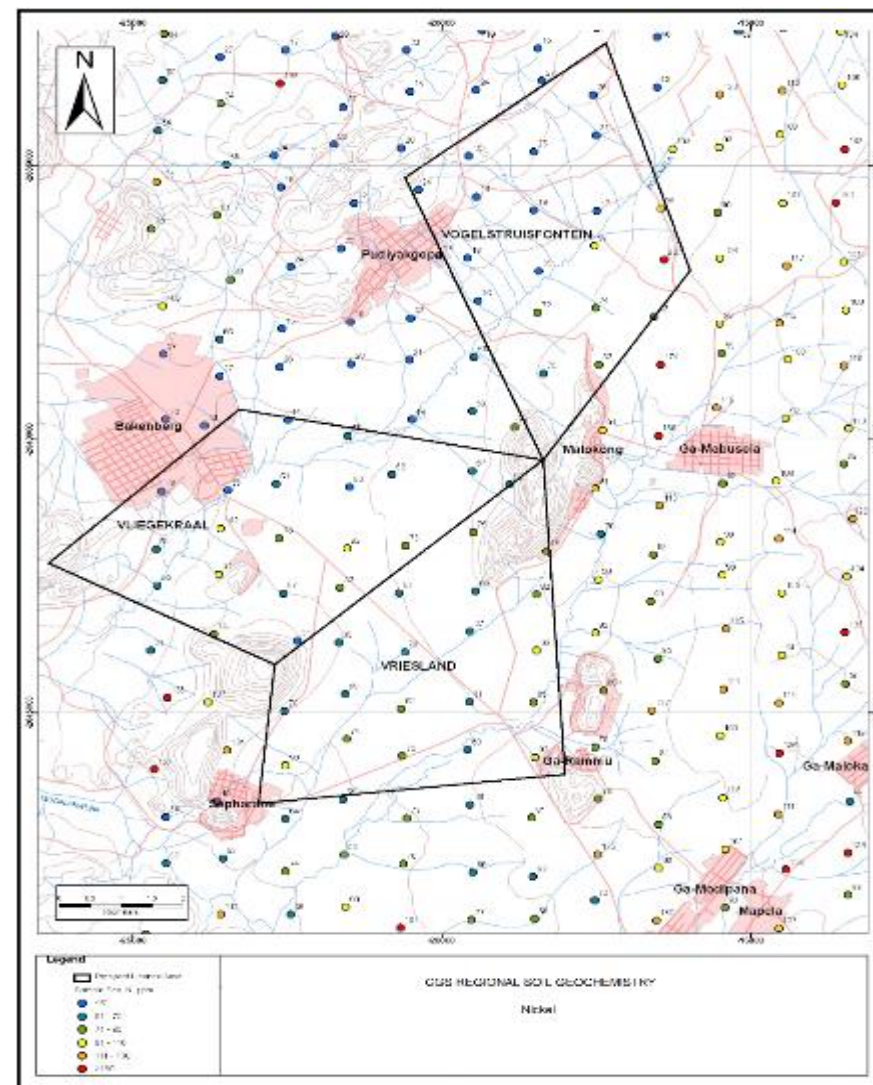


Figure 2.7: Project Area Regional Soil Geochemistry showing nickel sample points and assay results (Source: CGS).

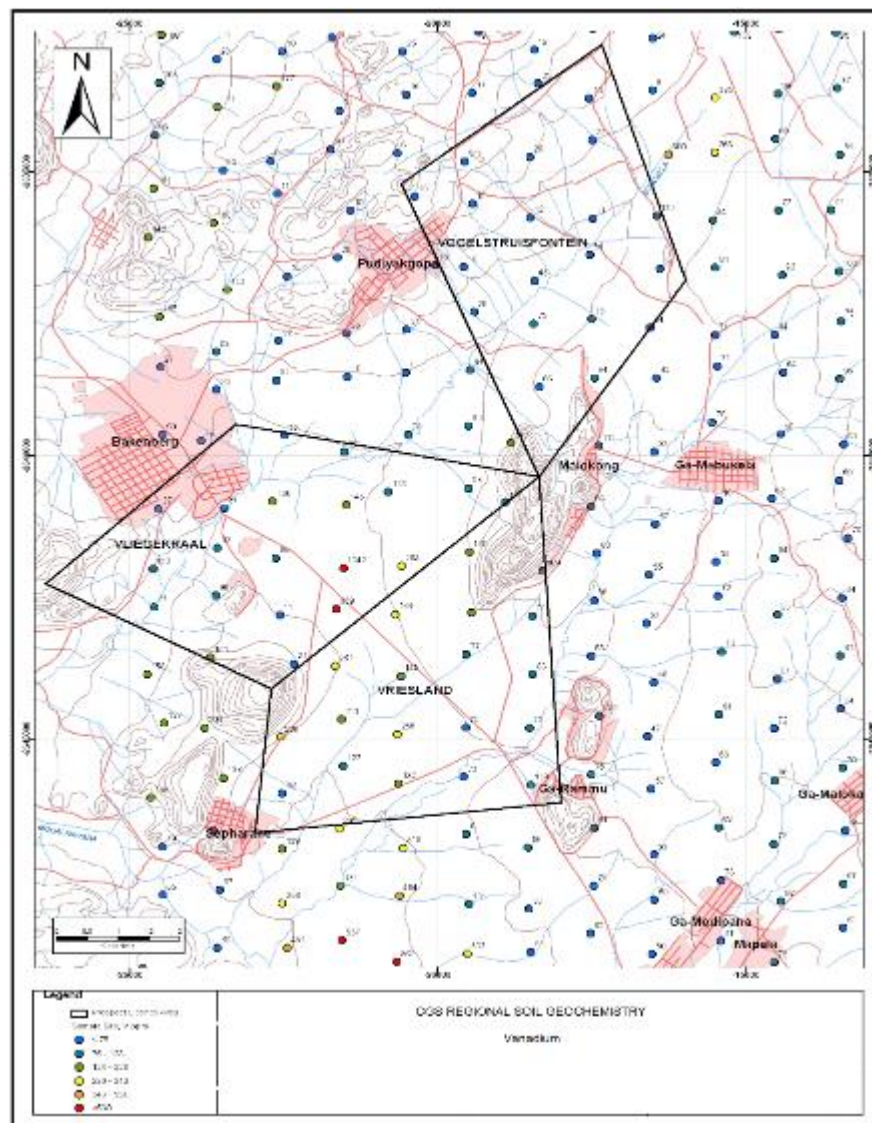


Figure 2.8: Project Area Regional Soil Geochemistry showing vanadium sample points and assay results (Source: CGS)

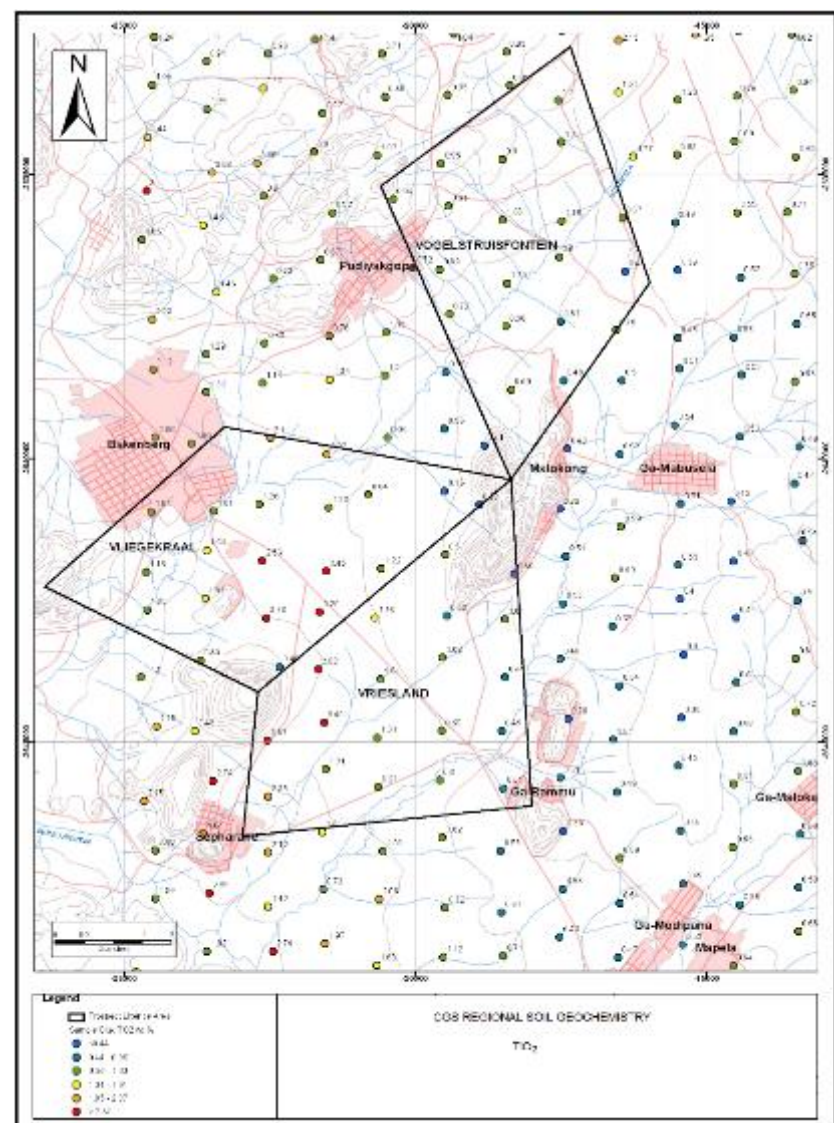


Figure 2.9: Project Area Regional Soil Geochemistry showing titanium sample points and assay results (Source: CGS)

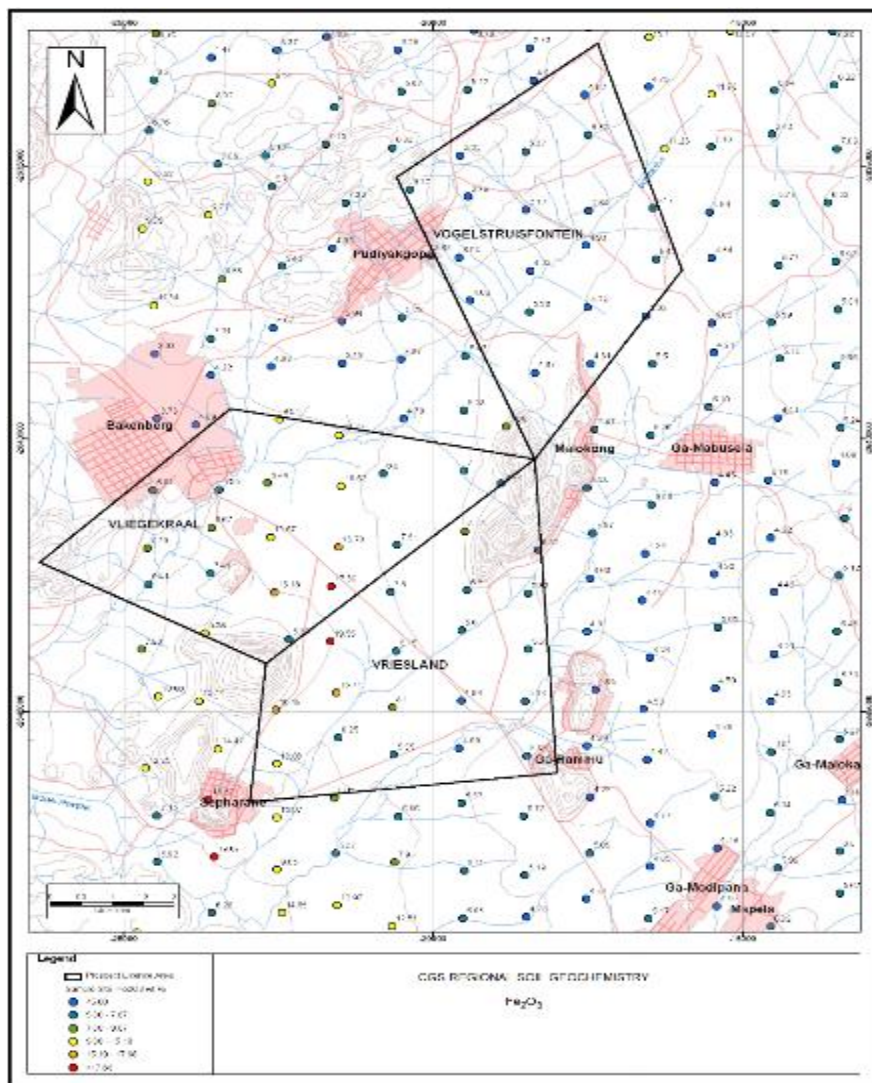


Figure 2.10: Project Area Regional Soil Geochemistry showing Fe_2O_3 sample points and assay results (Source: CGS)

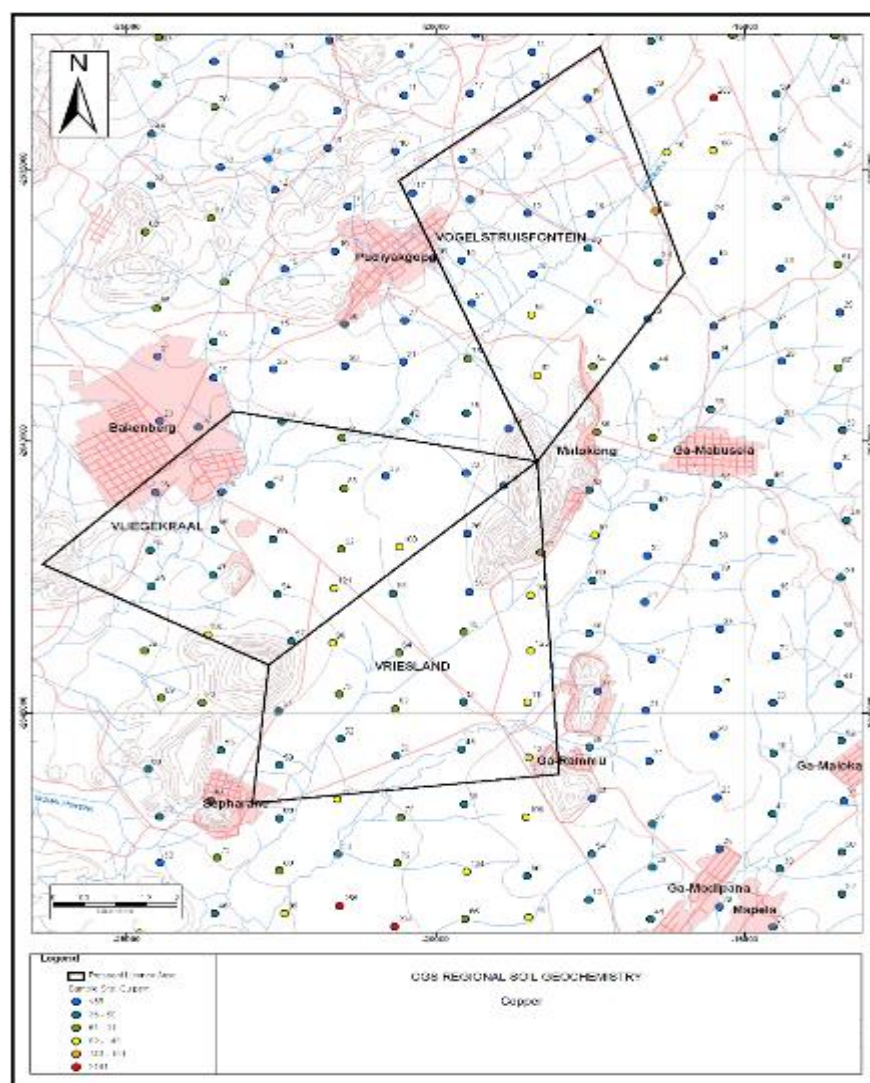


Figure 2.11: Project Area Regional Soil Geochemistry showing Copper sample points and assay results (Source: CGS)

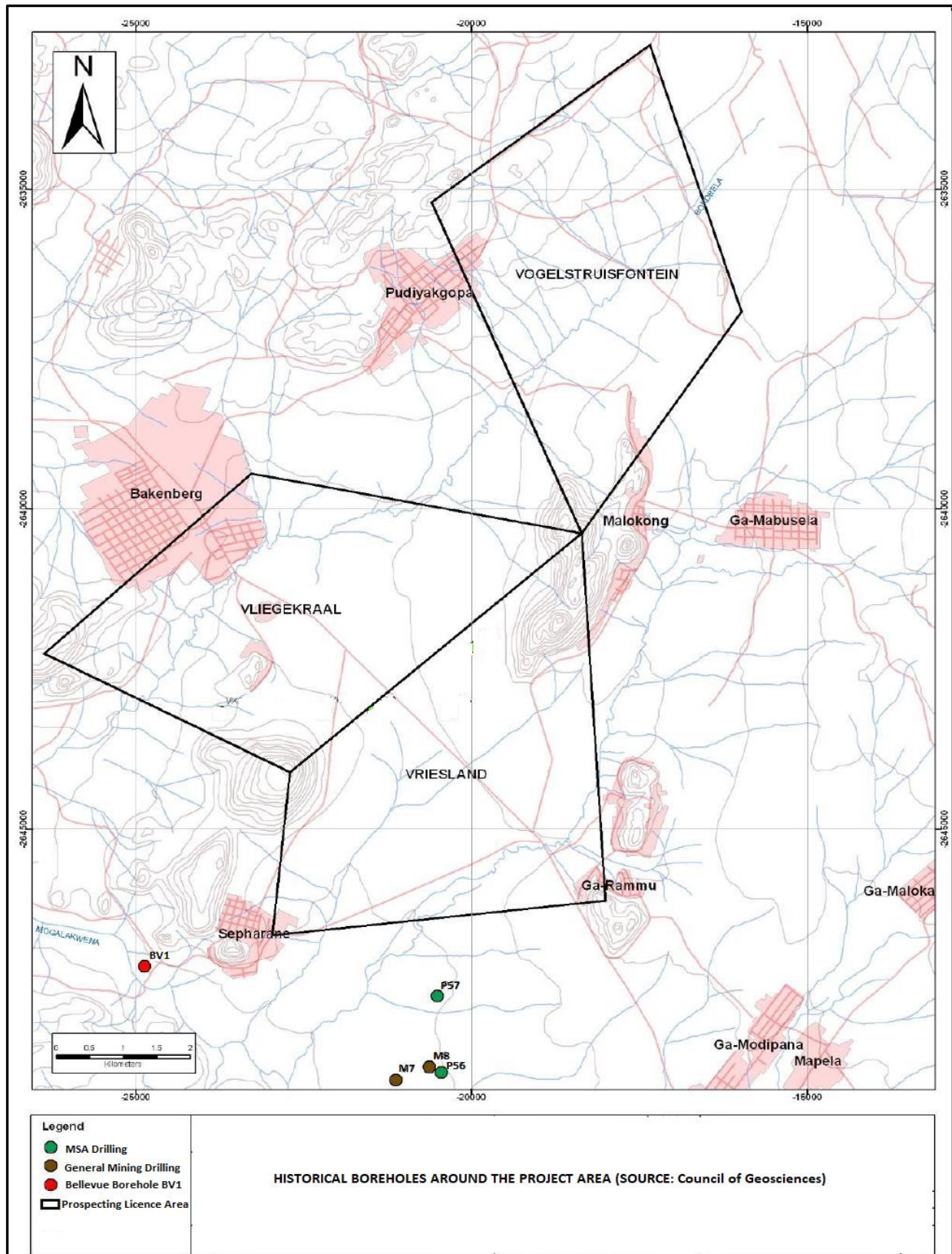


Figure 2.12: Historical Boreholes in proximity to the Project Area (Source: CGS)

2.4.3 Processing and Analysis of the data

- **Geochemical Data Sets** – the geochemical element maps in Figures 2.8, 2.9 and 2.10 were hand – contoured for the elements vanadium (v), titanium (Ti) and Iron (Fe) respectively. In the case of Fe_2O_3 the contours showed the anomalous areas as shown in Figure 2.13. The anomalies indicated the presence of two magnetite - rich orebodies, representing the Upper Magnetite Zone (also known as the PQ Zone) and the Main Magnetite Layer (MML).

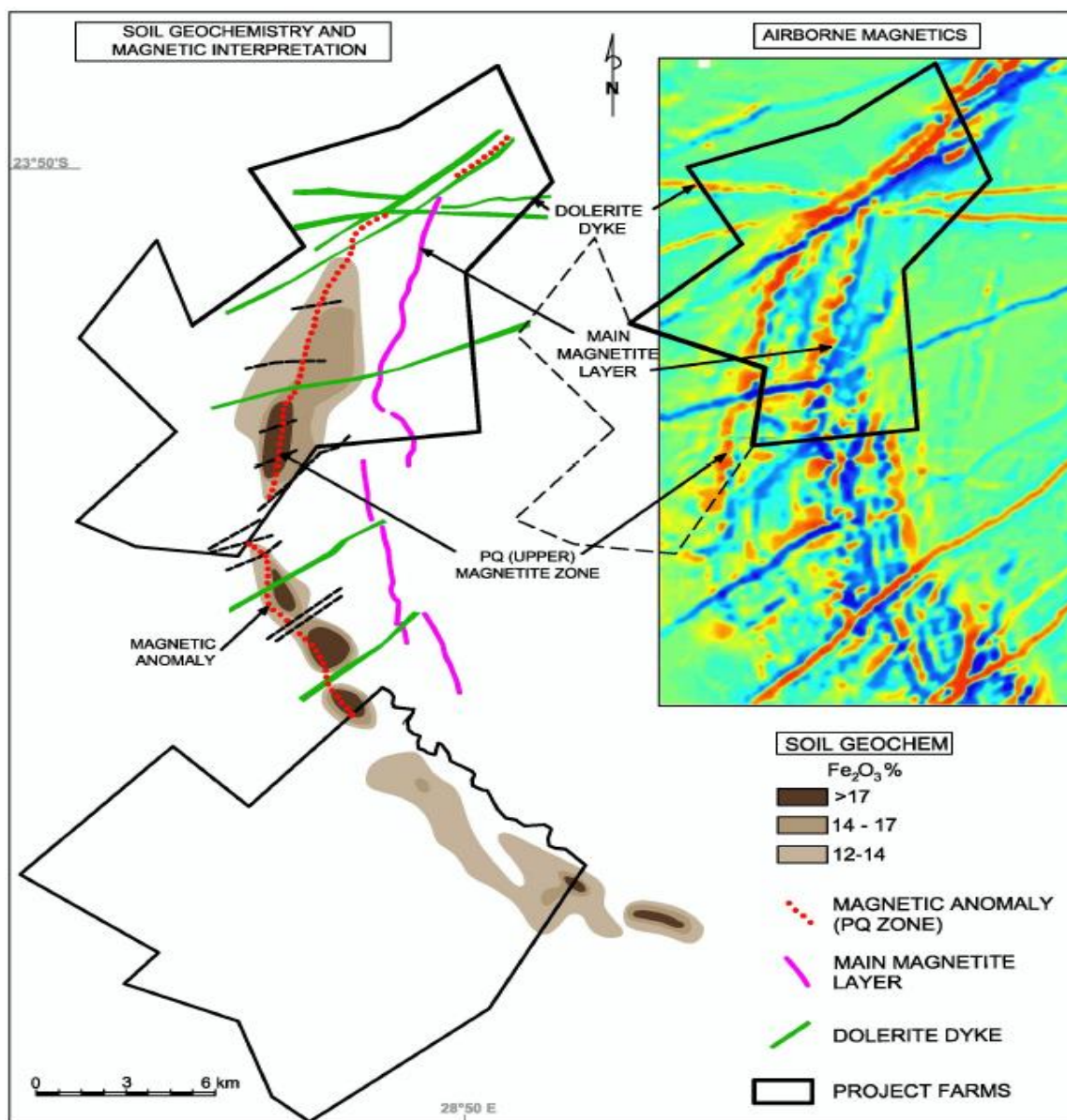


Figure 2.13 - Soil geochemistry and airborne magnetite data covering the project area. The regional setting of the P-Q Zone and MML as well as the anomalies that defined these layers are portrayed (Bushveld Minerals Scoping Study, 2013)

The anomalies identified through the geochemical sampling contours were later integrated with Geophysical data interpretation (Figure 2.13 – top right) and the two data sets showed a close correlation in their anomalies.

- **Geophysical Data Sets** – aeromagnetic (1st derivative) and the total radiometric count data sets (Figures 2.4 and 2.5) were obtained in already processed electronic format, and georeferenced electronic images ready for use in ArcGIS.

The aeromagnetic data picked up structures (faults and dykes) and was also able to show the anomalous portions of the property resulting from the magnetite – rich portions of the stratigraphy, thus the Main Magnetite Layer (MML) and the overlying two closely associated, magnetite leucogabbro-hosted, Ti-magnetite-rich layers known as the P-Q Zone (Figure 2.13).

The MML occurs near the base of the Upper Zone of the Bushveld Complex and consists of a lower vanadium rich Ti-magnetite interval (known as MAG3 on the project) which is separated from an upper vanadium-rich Ti-magnetite interval (known as MAG4 on the project) by a leucogabbro parting with disseminated Ti-magnetite. The MML ranges in down-hole thickness from 7.9 m to 11.3 m but the average true thickness of the MML is 9.8 m (including a 1.8 m parting) after correcting for a dip of 20°.

The P-Q Zone occurs near the top of the Upper Zone of the Bushveld Complex. The entire P-Q Zone, including the P and Q Layers has an average true width of approximately 50 m (Table 2.2).

Table 2.2 – Stratigraphic Units in the P-Q Zone Based on Borehole BV1 (Bushveld Minerals Scoping Study, 2013)

		Stratigraphic Unit	Average Thickness	Description
Q layer Ti-magnetite units		Q3	13 m	Upper, generally disseminated or semi-massive stringer Ti-magnetite mineralisation
		Q2	12 m	Largely massive Ti-magnetite mineralisation
		Q1	3.5 m	Lower disseminated Ti-magnetite mineralisation
		PQPART	4 m	Barren zone with no grade separating the P and Q Ti-magnetite layers
P layer Ti-magnetite units		PMAG	3 m	Generally massive Ti-magnetite mineralisation with internal waste and often containing more sulphides than the Q-horizon
		PFWDISS	15 m	Disseminated Ti-magnetite mineralisation below the more massive P-Ti-Magnetite, lower grade but nonetheless significant

- **Geological Map** –prominent structures e.g. faults, dykes and other features were identified and hand - traced on the geological map of the project area. The hand – traced map was scanned and saved in TIFF format, then georeferenced in ArcGIS.

The geological map was also integrated with the geochemical and geophysical data sets. The result of this integration showed that the magnetite-rich orebodies are all lying within the Upper Zone of the Bushveld Complex (Figure 2.14) which is consistent with previous knowledge.

- **Landsat Satellite Imagery** – the processed false color Landsat TM image (Figure 2.6) shows a number of clear and well defined reflective responses and these responses were used to delineate the soil types and lithological boundaries in the project area. The soil types were ground – truthed by a geological mapping exercise of which one of the focus points was to take a record of the different soil types in the project area.
- **Stratigraphic Diamond Drill hole** – the typed borehole geological log for borehole BV1 was studied in detail in order to identify the magnetite layers of the upper zone corresponding to the geology of the study area.

Mineralogical, geochemical and geophysical work undertaken by Barnes et al (2004) and Ashwal et al (2005) has contributed significantly to establishing the Upper and Main Zone stratigraphy in the borehole.

Specifically, with regard to the Upper Zone, Ashwal, et al (2005) concluded that:

- Bushveld Complex granite (Nebo granite), metasedimentary and hybrid rocks, and post Bushveld diabase sill intrusions were logged between surface and 234.14m
- The Upper Zone was defined by the appearance of modal magnetite in the gabbros, gabbro-norites and anorthosites.
- The Upper Zone was subdivided into 3 subzones based on the presence of modal olivine in rocks of subzone B and modal apatite in subzone C
- 18 magnetite layers were recorded; from the bottom of the Upper Zone upwards they were labelled the A-Magnetite Layer to R-Magnetite Layer. They have been used as stratigraphic markers and assisted with the geological interpretation of the Upper Zone stratigraphy
- The magnetite layers can be broadly identified based on their TiO_2 and vanadium (V) ratios. The magnetite layers show increasing TiO_2 and decreasing V content from the base to the top of the Upper Zone.

2.4.4 Integration of the Data Sets and Information

All the processed data (geological maps, geochemical maps, geophysical data maps and Landsat Images) were georeferenced and integrated using ArcGIS software.

After integration of the data, anomalies were correlated across all the maps (Figure 2.14), and these anomalies were further investigated by:

- Field geological mapping, and
- Additional soil geochemical sampling exercise

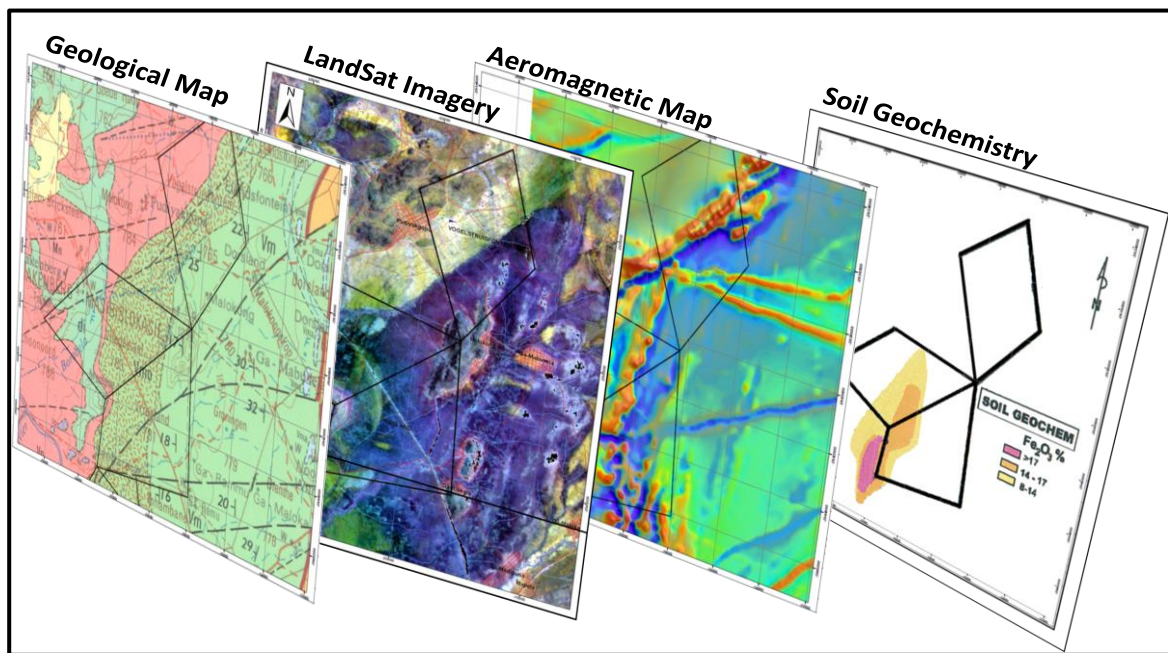


Figure 2.14: Data sets correlated in ArcGIS to identify structures, geochemical and geophysical anomalies, different soil cover and possible underlying geology.

2.4.5 Generation of Exploration Targets

Test borehole positions were created and the first five boreholes were drilled on an east- west cross section. The boreholes were planned to test the anomalies identified through the geochemical, geophysical and geological data sets that were processed, analyzed and integrated in the first phase. These boreholes were planned to be drilled on a cross section to cover a large portion of the Upper Zone stratigraphy (Figure 2.15 A, B &C).

This case study focused on Phase 1 (Desktop Review) because this was the phase that pre-competitive geoscientific data sets were used and attention was given to:

- Type of pre-competitive data that was used (geological, geochemical, geophysical, exploration data and other related data sets)
- Source of the data sets and costing
- Data processing and analysis
- Integration of all data sets
- Geological interpretation
- Identification of exploration targets

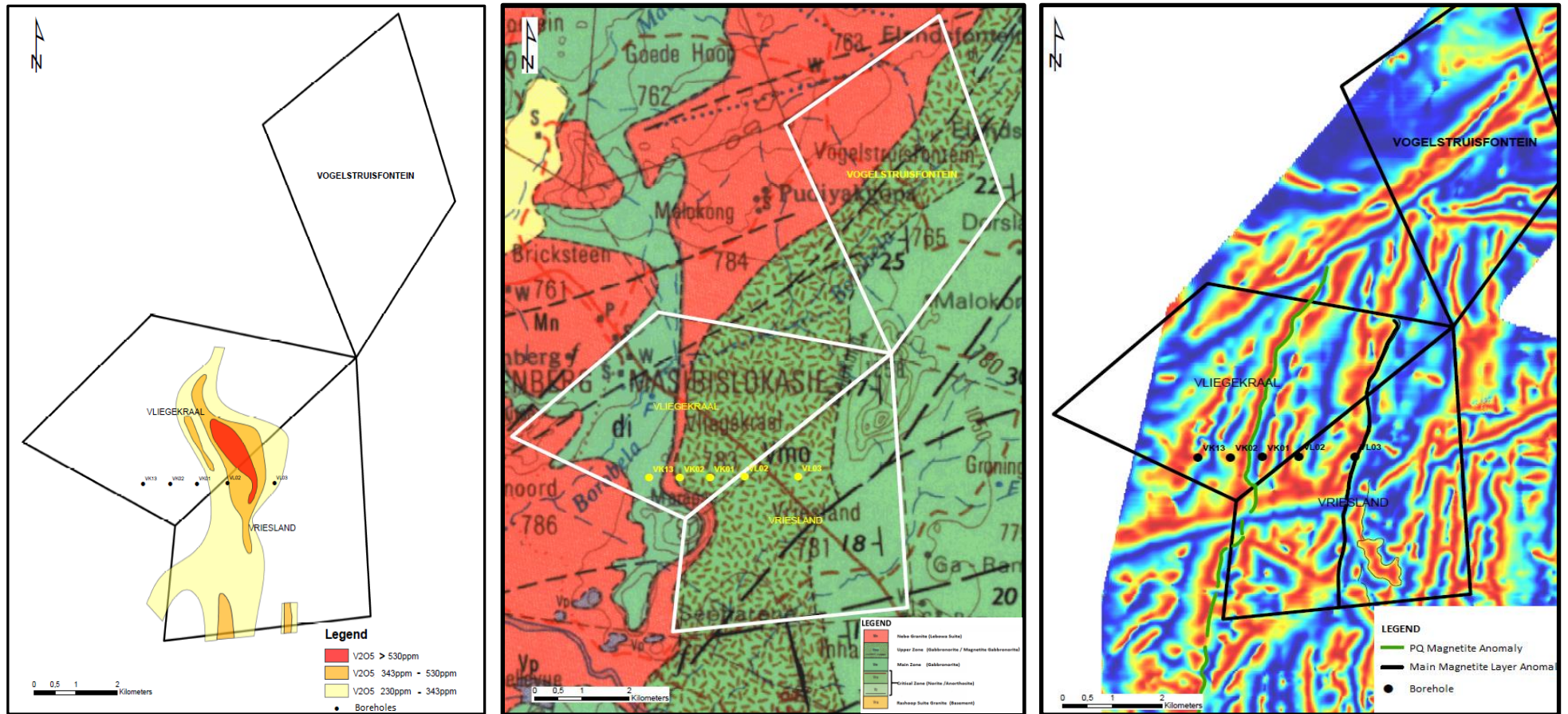


Figure 2.15: Exploration target maps: A – Geochemical map showing the first boreholes drilled against the geochemical anomalies, B – Geology map showing the first boreholes drilled against the known geology, C – Magnetics Map: showing the positions of the first 5 boreholes drilled on an east – west section line to test the geochemical and geophysical anomalies and a traverse of the geological stratigraphy

2.4 PROSPECTING COST ANALYSIS

A cost breakdown is presented in Table 2.3 for the expenses incurred during the first phase of the exploration programme. These expenses relate to pre-competitive data sets that were acquired from the Council of Geosciences (CGS) for the initial exploration targeting.

Table 2.3: Expense Sheet for the Mokopane Vanadium Project Pre-competitive data sets

EXPENSES FOR MOKOPANE VANADIUM PRE-COMPETITIVE DATA SETS			
ITEM	SOURCE	UNIT PRICE	TOTAL
Geological Maps:	CGS		
2228 Alldays		R11 290,80	
2230 Messina		R10 131,60	
2326 Ellisras		R4 095,60	
2328 Pietersburg		R8 932,80	
2330 Tzaneen		R6 706,80	
2426 Thabazimbi		R6 585,60	
2428 Nylstroom		R4 770,00	
			R52 513,20
Geophysical Data	CGS		
Magnetics Line Data (1:250000 Regional Map Sheet)		R2 500,00	
Gravity Point Data (1:250000 Regional Map Sheet)		R2 500,00	
2 x Georeferenced Aeromagnetic Image		R2 000,00	
			R7 000,00
Satellite Imagery	Landsat	Free	
Geochemical Data:	CGS		
100 samples @ R3 per element per sample		R1 500,00	
Each sample with 5 elements			
Unit Price per sample: 3x5 = R15 / sample			
			R1 500,00
BV1 Borehole			
Borehole, Coordinates, and all metadata	CGS	R300,00	
Lithology + Assays		R300,00	
Geological Log		R100,00	
			R700,00
TOTAL EXPENSES FOR DATA SETS			R61 713,20

With the acquisition of the data mentioned in Table 2.3, it was possible to carry out an initial assessment of the potential of the project area, and at the same time this data was also used to establish initial exploration targets after processing and integration. Anomalies arising from geochemical and geophysical and geological data were correlatable. All this was obtained from pre-competitive data acquired at a cost of **R61 713.20**

Comparatively, if this area had no pre-competitive data available from the Council of Geosciences, or any other cheaper sources, the company would have had to privately source out the data by:

- conducting its own geochemical sampling and sending soil samples to the laboratory (e.g. Setpoint Labs) for analysis
- conducting its own geophysical surveys e.g. aeromagnetic survey from a private company
- engaging an experienced geologist to map the area to report on lithologies, structures, stratigraphy, etc.
- drilling its own stratigraphic borehole, which would have been very deep considering the vast thickness of the upper zone stratigraphy.

If the company were to carry out the above for the purpose of initial target generation, then the expenses amounting to **R3 796 596,00** shown in Table 2.4, would have been incurred.

Table 2.4: Expense Sheet for the Mokopane Vanadium Project initial exploration data

EXPENSES FOR MOKOPANE VANADIUM ADDITIONAL PROJECT LEVEL DATA SETS			
ITEM	SOURCE	AMOUNT	TOTAL
Geological Maps			
Through Mapping exercise (Only Project Area)		R171 200,00	
20 days x 8 hrs a day @ R1070 /hour (SACNASP)			
			R171 200,00
Geophysical Data			
Aeromagnetic Data Survey		R945 000,00	
\$15 (R180) / km line with 50m line spacing			
5250 lines			
			R945 000,00
Satellite Imagery	Landsat	Free	
Geochemical Data:			
100 samples @ R670,78 per sample		R670,78	
(Analysis at Setpoint Labs)			
			R67 078,00
Stratigraphical Borehole Drilling (2900m)			
Drilling (see rates below)		R2 546 240,00	
Core Sample Analysis (100 samples)		R67 078,00	
			R2 613 318,00
TOTAL EXPENSES FOR DATA SETS			R3 796 596,00

Drilling Rates (Source: Discovery Drilling)	
0 - 40.00m NQ	R645,00
0.00 - 800.00m BQ	R534,00
800.00 - 1000.00m BQ	R570,00
1000.00 - 1200.00m BQ	R825,00
1200.00 - 1400.00m BQ	R1 082,00

The cost comparison shown Tables 2.3 and 2.4 clearly shows how expensive prospecting activities can be if no pre-competitive data sets are not available for a particular exploration jurisdiction.

CHAPTER 3

QUESTIONNAIRE ADMINISTRATION

3.1 INTRODUCTION

To support some of the points established through the case study of the Mokopane Fe-V-Ti Project, questionnaires were used to gather information on the importance of pre-competitive data.

The questionnaires were administered to heads of exploration companies in and outside South Africa, and a different set of questionnaires to heads of geoscientific government or state – run institutions, such as State Geological Surveys in different countries.

The industry questionnaire (Appendix 1) was intended to gather data from Project or Exploration Managers of various companies on the following:

- Company's projects and countries of operation
- Commodities targeted by the company
- Use of any pre-competitive data sets in the company's initial exploration stages
- What type of pre-competitive data was acquired
- How the data was accessed and the quality of the data.
- Expenditure on the pre-competitive data acquired
- How useful was the data in the initial exploration targeting?

The main purpose of this questionnaire was to understand the importance of pre-competitive data sets from an industry's perspective focusing on the industry's views on the quality of the data, ease of access, the data price, the density of the data and its appropriateness / usefulness.

The Geological Survey questionnaire (Appendix 2) was administered to Chief Geologists / Heads of state-funded geological institutions and was focusing on the following:

- Whether the country has a pre-competitive geoscientific data set or repository for public access
- Type of data available and in what format is the data available
- Sources of these data sets
- Access procedures to the data by the general public and the cost structure (if not free)
- Impact of the data repository to the number of exploration / mining licenses issued

The main purpose of this questionnaire was to understand the importance and benefits of pre-competitive data from a particular government's perspective. The responses were to provide understanding on the type of platform that the state is using in providing data (if there is any). to the

general public, for instance, as just a database or a GIS based cadastral system. What are the sources of the data, and how is the data made available to the public (at a fee or free).

A total of 20 industry questionnaires were sent out via emails to different companies in and outside South Africa (Appendix 3), while 24 questionnaires were emailed to Chief Geologists / Heads of state geological institutions in the following countries: Angola, Algeria, Benin, Burkina Faso, Burundi, Botswana, Cameroon, Democratic Republic of Congo (DRC), Egypt, Ghana, Guinea Conakry, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Nigeria, South Africa, South Sudan, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe (Appendix 4).

Most of the contacts for the Geological Surveys in different countries were sourced out from the OAGS (Organisation of African Geological Surveys) website, www.oagsafrica.org

Out of the 20 industry questionnaires, 12 responses were received from the companies listed in Table 3.1 while only 5 Geological Survey questionnaire responses were received out of the 14 targeted countries. The countries that responded are Burkina Faso, Cameroon, Namibia, Swaziland and South Africa.

3.2 Analysis of the Industry Questionnaire Data

Due to the low response rate of the Geological Questionnaires, minimal information was gathered for interpretation.

Table 3.1 is based on Questions 1 and 2 of the Industry Questionnaire which asked about general information for the company and the sector(s) of the industry that the particular company is involved in, and based on the table 3.1, there are 12 companies that responded to the industry questionnaire, and out of those respondents, there are groups below:

- Both Mining and Exploration: 6
- Mining Only: 1
- Exploration Only: 3
- Mining / Exploration Consultancy: 1

Based on this relatively small set of companies, it is evident that most companies running mining operations have either on-the-mine exploration activities or new exploration activities on new licenses to ensure that mining is sustained.

Table 3.1: Showing Questionnaire Respondent Companies and their associated sector of business

COMPANY NAME	COUNTRY	COMPANY'S SECTOR			
		MINING	GAS & EXPLORATION	MINERAL EXPLORATION	MINING / EXPLORATION CONSULTANCY
Bushveld Vametco	RSA	1	-	-	-
Ivanplats	RSA	1	-	1	-
Khoemacau	Botswana		-	1	-
Kilo Goldmines	DRC	1	-	1	-
Lemur Resources	Madagascar		-	1	-
Mkango Resources	Malawi		-	1	-
New Kush Exploration & Mining (NKEM)	South Sudan	1	-	1	-
Orex Exploration	RSA		-		1
Paladin Resources	Malawi	1	-	1	-
Platinum Group Metals (PTM)	RSA	1	-	1	-
Umbono	RSA		-	1	-
United Manganese of Kalahari (UMK)	RSA	1	-	1	-

Note that in the table above, the number “1” represents a *positive* or “Yes” in any column while a “-” represents “No”.

Table 3.2: Showing Use of Pre-Competitive Data (Public Data) on Specific Projects and Associated Comparative Percentage of Public and Company data used

		PRE-COMPETITIVE DATA (PUBLIC DATA)		TOTAL DATA USED ON PROJECT (%)	
COMPANY NAME	COUNTRY	YES	NO	PUBLIC	COMPANY
Bushveld Vametco	RSA	N/A	N/A	N/A	N/A
Ivanplats	RSA	1	-	20	80
Umbono	Canada	1	-	40	60
	RSA	1	-	5	95
	Rwanda	1	-	2	98
	USA	1	-	2	98
Khoemacau	Botswana	1	-	30	70
Kilo Gold Mines	DRC	1	-	4	96
Lemur Resources	Madagascar	1	-	10	90
New Kush Mining & Exploration	South Sudan	1	-	10	90
Orex Exploration	RSA	1	-	10	90
Paladin Resources	Malawi	1	-	5	95
Platinum Group Metals	RSA	1	-	15	85
UMK	RSA	1	-	5	95

Note that the number “1” represents a *positive* or “Yes” in any column while a “-” represents “No”.

Table 3.2 is based on Questions 3, 4, 5 and 10 of the Industry Questionnaire which generally finds out if the company ever did use Pre-competitive (Public) data and what percentage of public and company generated data was used.

Based on the table 3.2, all the respondent companies in their respective countries used public data in their exploration phases with differences in percentage of public data used against company generated data.

Figure 3.1 shows a comparison chart for Public data (Pre-Competitive Data) against company generated data for the respondent companies in different countries. Based on the relatively small number of companies that responded, Canada ranks high in having a relatively high percentage of public data used compared to the rest, while South Sudan ranks the lowest. It should be noted that this is not representative of the actual situation because the number of companies used in the questionnaire exercise is very low. However, the result may not be too far from the truth especially with Canada ranking high on this list.

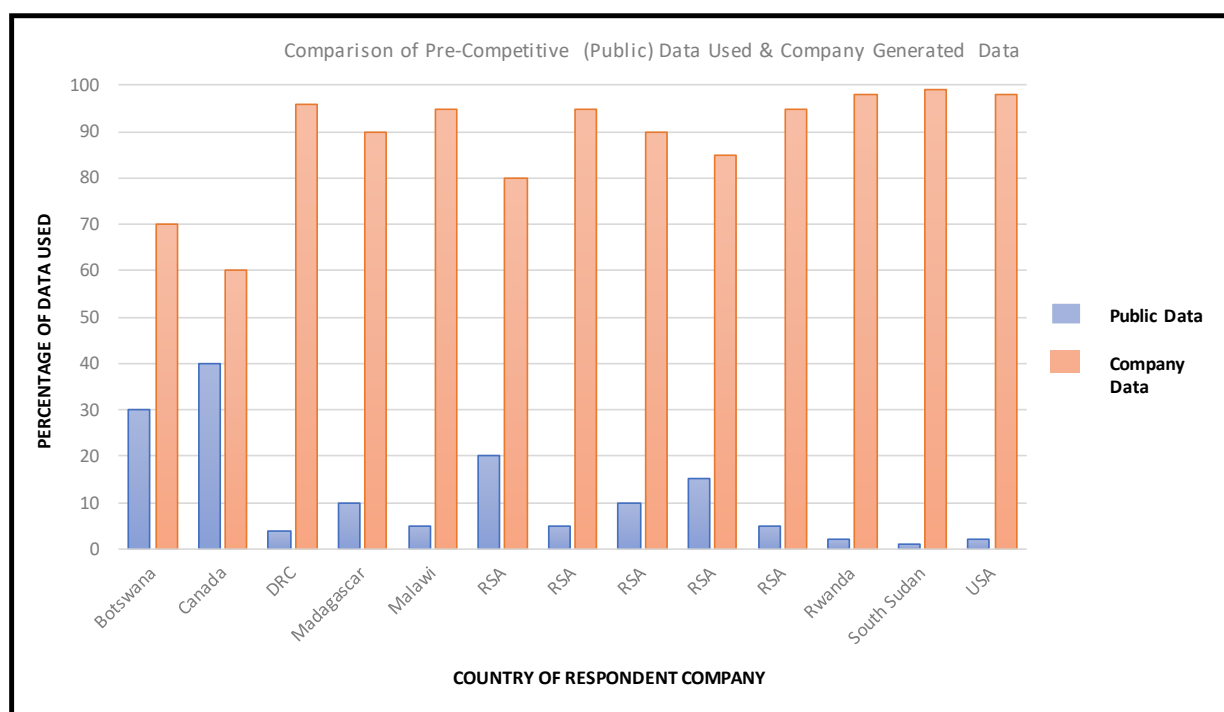


Figure 3.1: Comparison Chart for pre-competitive (public) data against company generated data for different companies in different Countries

3.3 Analysis of the Geological Survey (GS) Questionnaire Data

Very minimal data was also received based on the Geological Surveys Questionnaire, and out of the 14 countries requested for data, only 5 responded.

Because of the few responses received, the GS questionnaire has not been processed as it was thought and interpretations might not be representative of the situation.

RESULTS, DISCUSSION & CONCLUSION

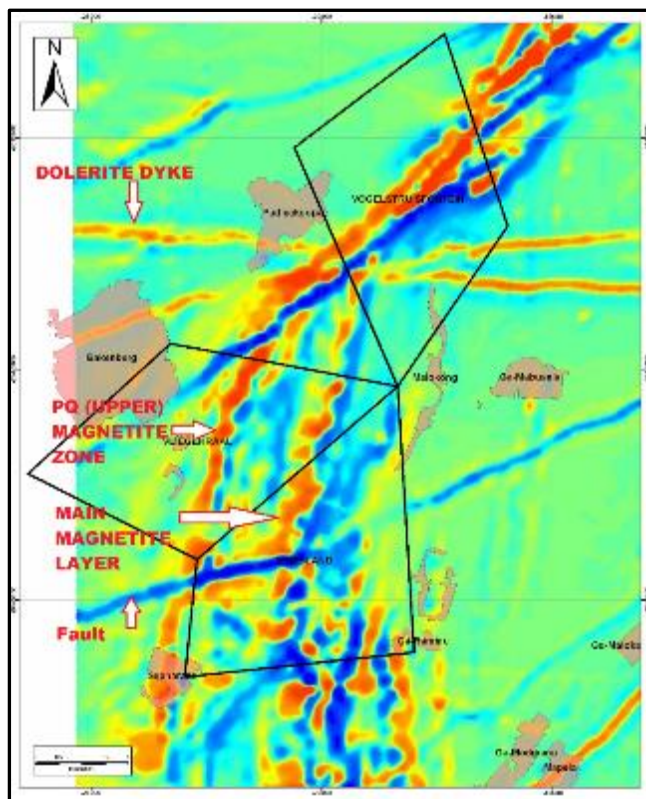
4.1 Case Study Results and Discussion

Case study results and discussions are structured into two categories: the results of the exercise of using pre-competitive data for exploration targets and secondly, the cost benefit in using pre-competitive data.

4.1.1 Results of using pre-competitive data sets on the project

Each of the different data sets produced very useful results leading to the generation of the exploration targets on the project

- **Geophysical Data Sets** –The aeromagnetic data picked up structures (faults and dykes) and was also able to show the magnetite-rich orebodies, thus the Main Magnetite layer (MML) and the PQ Layer overlying the MML were identified (Figure 4.1).



East west trending dolerite dykes in orange to yellowish warm colors were picked up by the interpretation of the aeromag image (figure 4.1).

Dark blue cold colors were interpreted as faults on the property. The major faults are generally trending east west and others north east to south west.

Two main magnetic orebodies were also picked up: the overlying iron rich PQ Zone and the underlying Main Magnetite Layer (MML).

Figure 4.1: Aeromagnetic Data showing interpreted structures and orebodies

- **Geochemical Data Sets** – each of the element maps was contoured based on the concentration of each of the elements per sample point. The contours would show the general distribution of each of the elements on the project area.

Figure 4.2 shows the distribution of Fe_2O_3 after contouring and the resulting geochemical anomalies were then correlated to the airborne magnetics.

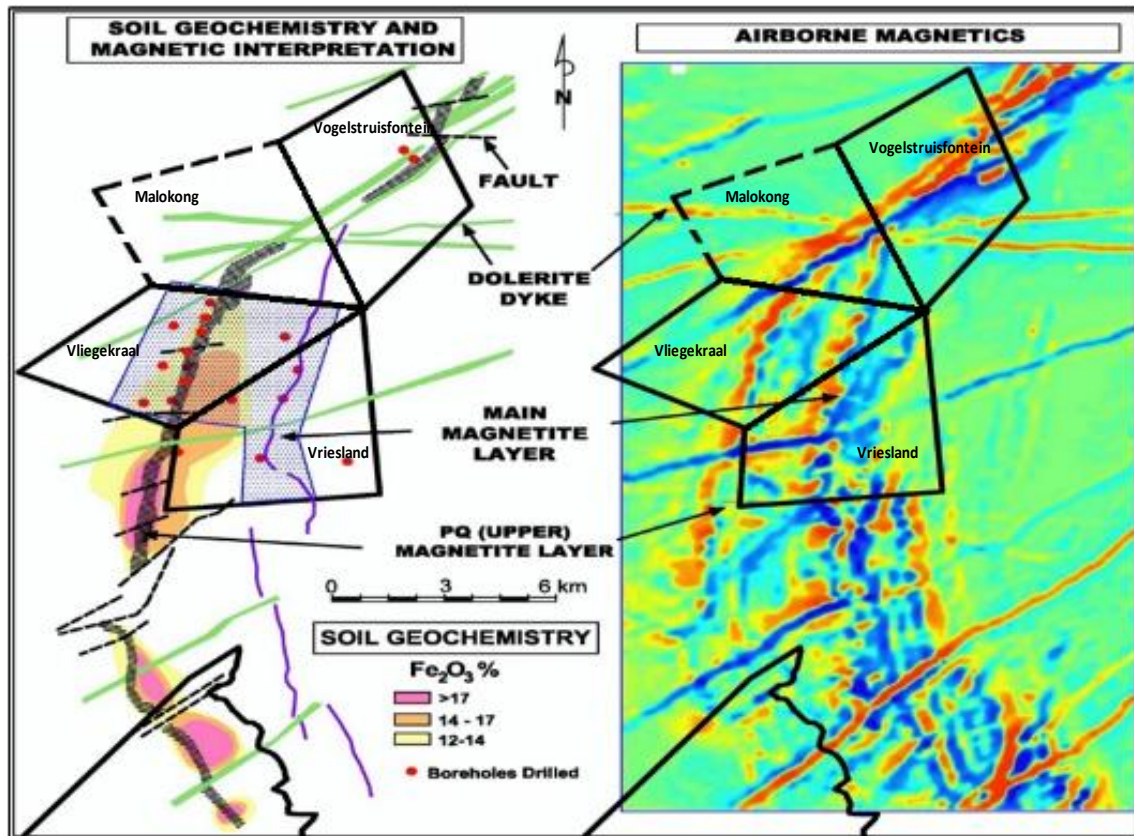


Figure 4.2: Soil Geochemical map correlated to aeromagnetics map showing Fe_2O_3 anomalies, trace of magnetite layers (PQ and MML) and planned boreholes as generated exploration targets.

In summary, the data indicated the following after analyses:

- V – high values ($V > 100\text{ppm}$) in the central part of Vliegkraal and western part of Vriesland farms over the RLS Upper Zone
- TiO_2 - high values ($\text{TiO}_2 > 1.5\text{wt}\%$) in the central and northern part of Vliegkraal and western part of Vriesland farms over the RLS Upper Zone
- Fe_2O_3 - high values ($\text{Fe}_2\text{O}_3 > 10\text{wt}\%$) in the central and northern part of Vliegkraal and western part of Vriesland farms over the RLS Upper Zone
- Cu - high values ($\text{Cu} > 100\text{ppm}$) along:
 - the eastern boundary of Vriesland (RLS Main Zone)
 - southeast boundary of Vliegkraal (RLS Upper Zone)

- an isolated value along the central east boundary of Vogelstruisfontein farm (RLS Main Zone – troctolite unit)
- Ni - high values (Ni > 90ppm) along:
 - ✓ the eastern boundary of Vogelstruisfontein (RLS Main Zone – troctolite unit)
 - ✓ central west part of Vliegekraal (post-Bushveld diabase sill)
 - ✓ an isolated value along the east boundary of Vriesland (RLS Main Zone)
 - ✓ an isolated value in the southwest corner of Vriesland (RLS Upper Zone)
 - ✓ an isolated value in the central part of Vliegekraal (RLS Upper Zone)
- **Geological Map** – prominent structures e.g. faults and dykes that were identified and traced on the geological map of the project area (Figure 2.1) were then correlated to the interpretation from the aeromagnetics map (Figure 2.2). These two correlated well especially on the presence of faults, however the geological map wasn't able to show the presence of the dykes.

Another limiting factor on the mapping was that a major part of the project area is covered by sands and clay soil material (black turf), and because of that the faults and dykes could not be fully ground-truthed.

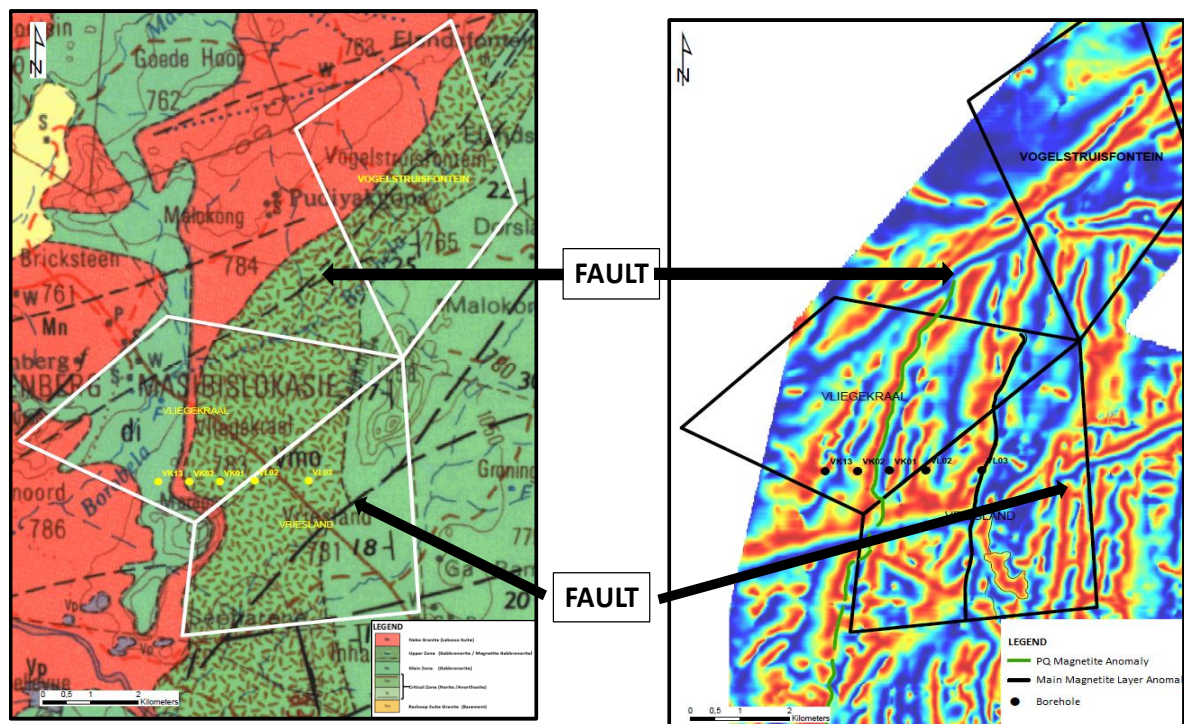


Figure 4.3: A geological map and an aeromagnetics map of the project area showing the correlation of structures

- **Stratigraphic Diamond Drill hole** – the typed borehole geological log for borehole BV1 was studied in detail in order to identify the magnetite layers of the upper zone corresponding to the geology of the study area.

Mineralogical, geochemical and geophysical work undertaken by Barnes et al (2004) and Ashwal et al (2005) has contributed significantly to establishing the Upper and Main Zone stratigraphy in the borehole.

Specifically, with regard to the Upper Zone, they concluded:

- Bushveld Complex granite (Nebo granite), metasedimentary and hybrid rocks, and post Bushveld diabase sill intrusions were logged between surface and 234.14m
 - The Upper Zone was defined by the appearance of modal magnetite in the gabbros, gabbronorites and anorthosites recorded between 234.14-1575.80m
 - The Upper Zone was subdivided into 3 subzones based on the presence of modal olivine in rocks of subzone B and modal apatite in subzone C
 - 18 magnetite layers were recorded; from the bottom of the Upper Zone upwards they were labelled the A-Magnetite Layer to R-Magnetite Layer. They have been used as stratigraphic markers and assisted with the geological interpretation of the Upper Zone stratigraphy
 - The magnetite layers can be broadly identified based on their TiO_2 and vanadium (V) ratios. The magnetite layers show increasing TiO_2 and decreasing V content from the base to the top of the Upper Zone.
- **Landsat Satellite Imagery** – the processed false color Landsat TM image (Figure 2.6) shows a number of clear and well defined reflective responses and these responses were used to delineate the soil types and lithological boundaries in the project area.

The main features (based on Figure 2.6) are described below:

- Yellow-green reflectivity in the northern part of Vogelstruisfontein and extending between Pudiyaqopa and Bakenberg villages. This is a response to transported hill wash sand derived from granite hill areas north of Pudiyaqopa. The strikingly sharp NE-SW trending contact with a reddish purple reflective area to the south coincides with the course of the Borobela River.
- The reddish purple reflective area through the southern part of Vogelstruisfontein, east part of Vliegekraal and central-east part of Vriesland corresponds to a deep (>5m) cover of “dark grey to black turf” in the broad shallow valleys of the Borobela River and unnamed tributary which overlies much of the lower subzones of the RLS Upper Zone and upper part of the RLS Main Zone.

- The green reflective areas in the west portion of Vriesland and southern central part of Vliegekraal corresponds to an oxidised iron rich red brown residual soil cover overlying the magnetite rich gabbroic rocks and more massive magnetite seams of the RLS Upper Zone.
 - Northerly trending, strongly contrasting areas of medium to dark grey, at the corner of Vogelstruisfontein, Vliegekraal and Vriesland farms and east of the SE corner of Vriesland farm, reflect hill areas dominated by RLS Main Zone rock outcrop (gabbro-norite and anorthosite)
 - Light coloured areas adjacent to the hill features, particularly in the SE corner of Vogelstruisfontein (north of Malokongskop) as well as scattered within the reddish purple areas east and south of Malokongskop reflect shallow light grey brown residual soils with outcrop of RLS Main Zone gabbro-norite and anorthosite.
- **First Target Drilling** – As mentioned with Figure 2.11, the first 5 boreholes were drilled on an east west section intended to test the anomalies identified using geochemical and geophysics data, the stratigraphic section interpreted from borehole BV1.

Figure 4.4 shows the positions of the first test borehole drilled and the resultant cross – section after the drilling and logging of the boreholes.

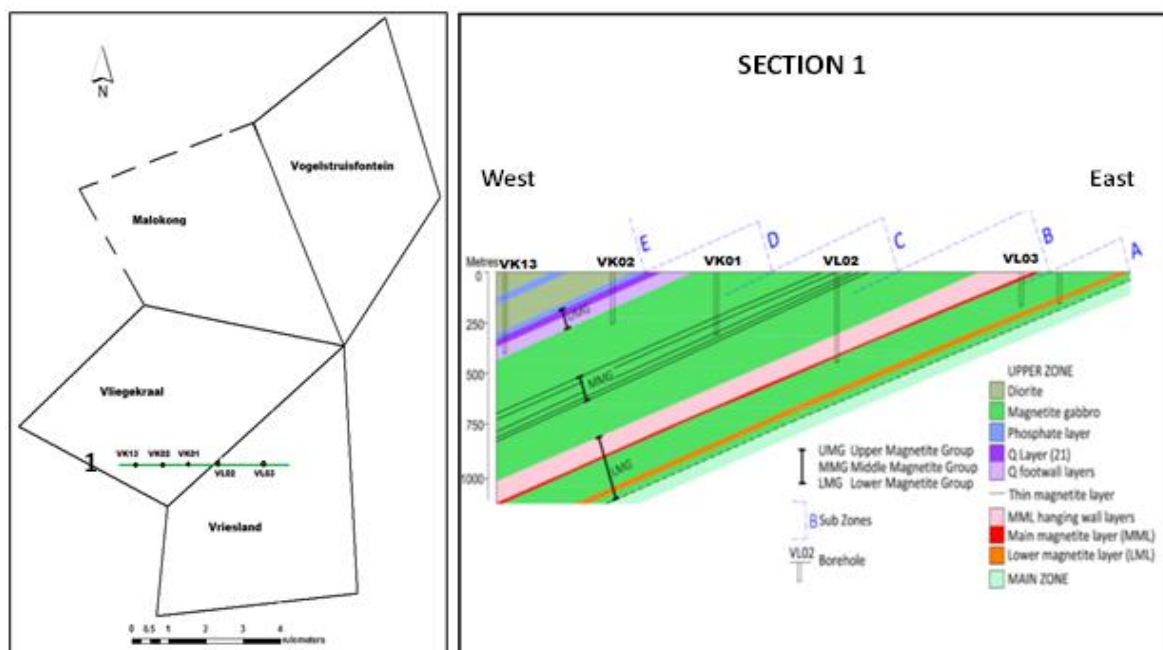


Figure 4.4: First Test Boreholes Drilled and a Cross Section from the Drilling Section Line 1 showing subzones A, B, C, D and E of the Upper Zone of the Bushveld Complex which are subdivided on the basis of the cumulus mineralogy and whole-rock geochemistry.

The test boreholes confirmed the occurrence of the two magnetite layers: PQ (Layer 21 and 22) and the Main Magnetite Layer (MML).

- Further drilling followed in different phases, until indicated and measured resource estimates of both iron ore (in the PQ) and vanadium (in the MML) were declared for the property. Today, the project holds 300 Mt of a vanadium resource at an average grade of 1.48% V₂O₅ in situ and in-concentrate 2.01% V₂O₅ in the MML with a thickness of 10m and an iron resource of 939 Mt of 33% Fe, 11% TiO₂ and 0.19% V₂O₅ contained in a layered ore body of average 45 m thickness, along a strike of ~8 km and dipping at 18-22° to the west.

This case study clearly supports the importance of using pre-competitive data sets in the initial exploration stages. In 2016, at the PDAC in Toronto, Canada, Steve Hill pointed out in a presentation that the role of government is to attract, stimulate and partner with exploration companies, and that may be done in part by providing quality and reliable public geoscientific data sets. This is because such data sets reduce expensive re-acquisition of data, thus focusing expenditure on acquiring new data and using funds for subsequent exploration activities (Scott, et al, 2014).

4.1.2 Cost Benefit Result for using pre-competitive data sets on the project

The Mokopane Fe – Ti – V project was budgeted at **R 3 796 596.00** (Table 2.3) for the initial exploration programme without any consideration that pre-competitive data sets would be existing for the license area. This amount was budgeted for the following exploration activities:

- Mapping (geological and structural)
- Geophysical surveys (magnetics and gravity)
- Geochemical soil sampling
- Drilling of the first deep stratigraphic borehole that would represent the local stratigraphy.

However, the availability of various data sets at the Council of Geosciences which is available to the public at a relatively small fee allowed the budget indicated to be reduced by a very wide margin. The total amount spent on acquiring the various data sets was **R 61 713.20** (Table 2.2). Comparative summary of the individual costs for each set of data is outlined in Table 4.1.

Table 4.1: Comparative Summary of Expenditure between Own Data Collection (without availability of Pre-Competitive Data) and CGS Pre-Competitive Data

EXPENDITURE (in SA Rand)			
Exploration Activity / Requirement	Own Data Collection		Pre-competitive Data
Geological Mapping / Maps	R	171 200,00	R 52 513,20
Geochemical Data / sampling & Assaying	R	67 078,00	R 1 500,00
Geophysical Data / Surveys	R	945 000,00	R 7 000,00
Stratigraphical Borehole Drilling / Borehole Data	R	2 613 318,00	R 700,00
TOTAL	R	3 796 596,00	R 61 713,20

The scenario summarily presented in table 4.1 represents an actual expenditure of approximately 1.6 % of the original budget. It should be noted, however, that the percentage saving of initial capital in this project may not apply to all projects, and that may be due to a number of factors, including:

- The pricing structure of pre-competitive data in different exploration destination countries.
- The quantity and quality of data available in a particular exploration jurisdiction.
- Availability or non – availability of technical skills to effectively interpret, integrate and use the available data.

Assuming that there was no pre-competitive data available for this project area, the company was going to spend approximately R3.8 million just to have usable data for a project that they would not be sure of its potential for Fe-Ti-V.

It should be noted, however that the scenario presented in Table 4.1 is typical of the South African case, but in other countries, for instance in Canada where geoscientific data is freely available (Kostylev, et al, 2017), pre-competitive data cost would be zero. However, such investment in free geoscientific data sets by the state has enormous benefit to a country as a whole as mentioned by Kostylev, et al (2017) in their presentation that every \$1 million of government investment to enhance the geoscience knowledge base will likely stimulate \$5 million of private sector exploration expenditures, which, in turn, will result in discovery of new resources with an average in situ value of \$125 million (Figure 4.5).

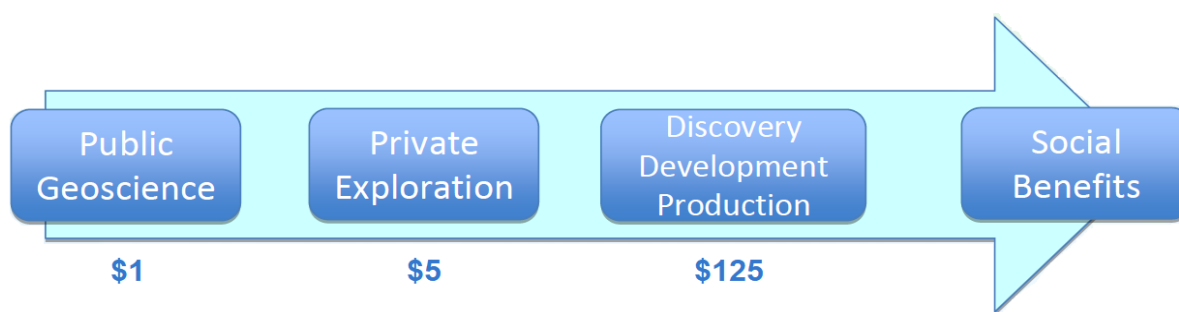


Figure 4.5: Showing the benefits of investment in Public Geoscience data in Canada (Kostylev, et al, 2017)

This cost saving is important for both the exploration company and the country in general. The funds saved would be useful for later phases of the exploration programme if the project proves to have economical potential, and the country would be in a better competitive space to attract more exploration investment from foreign companies and investors.

4.2 Questionnaire Results and Discussion

4.2.1 Industry Questionnaire

Though minimal responses were received from the Industry, a general picture of the setup of these companies may be deduced from those results (Figure 4.6).

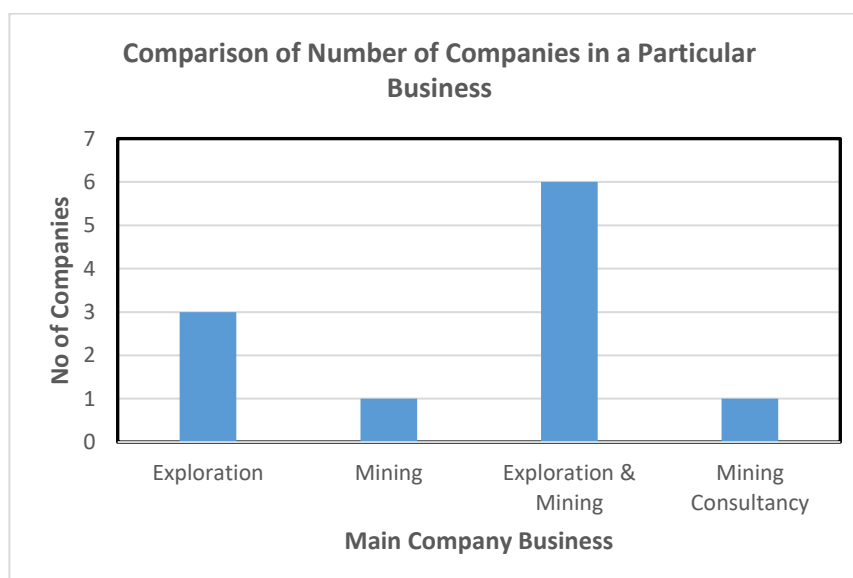


Figure 4.6: Chart showing proportion of companies in particular business areas

The chart in Figure 4.6 shows that most mining companies that have operating mines will also have an exploration component that will be used to ensure a prolonged Life of Mine for the current operations

or opening of new mines. This means exploration is not only for those companies that are intending to find their first new mines but also for companies that are already hold operating mines. This being the case, there is always need therefore for more data to be available to facilitate these exploration activities. Pre-competitive data sets will be of importance in such circumstances.

Secondly, the most important part of the questionnaire was to find out how much data a company had used on a project? In this case, a comparison of public (pre-competitive) data and private (company generated data) was done.

Figure 4.7 is a chart summarizing data received from the few companies that responded to the questionnaire request.

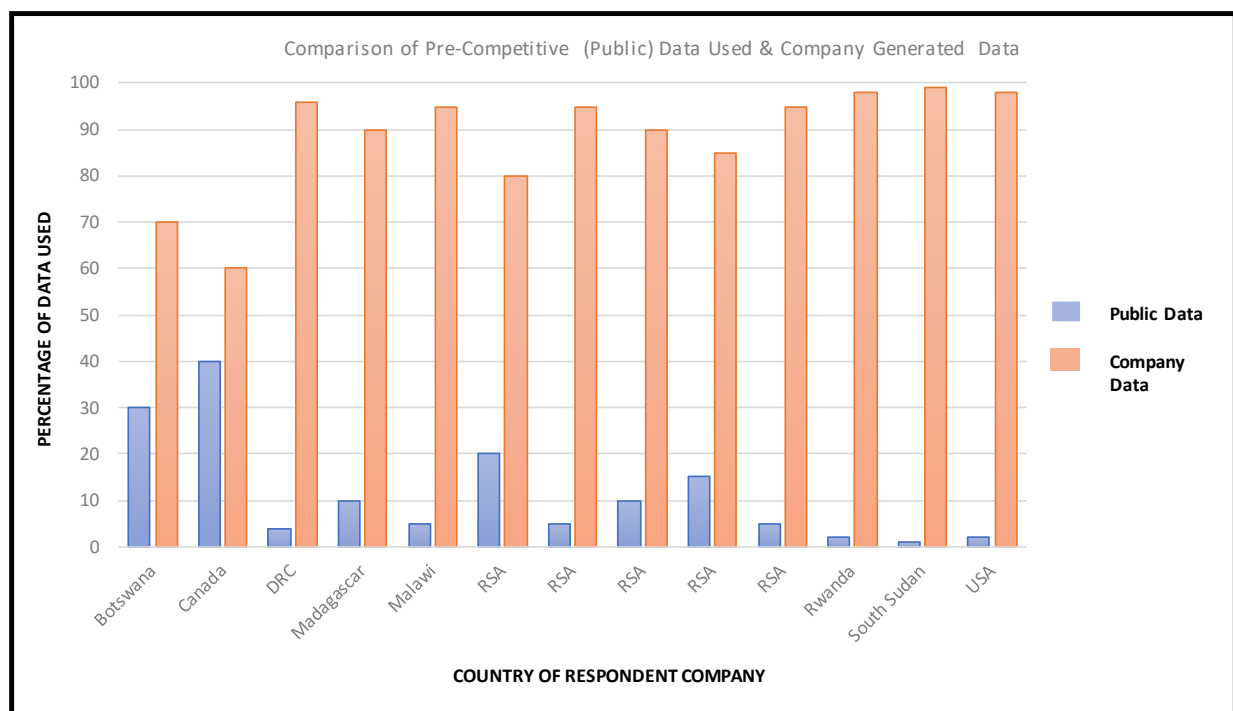


Figure 4.7: Chart showing a comparison between public (pre-competitive) data and private (company generated) data on specific projects in different countries

Figure 4.7 shows that each and every company that goes into any exploration jurisdiction always searches for any public data that may be available in the area for a specific commodity being targeted. The percentages of such data used by the different projects in this case indicate 5 – 30% may be used before the company starts spending huge amounts of funding to generate its own data.

The percentages for countries such Botswana and Republic of South Africa (according to Figure 4.7) indicate that they hold reasonable data repositories that explorationists may use as initial data for their projects hence cutting on exploration expenditures.

Investors will therefore prefer to invest in a country like Botswana as compared to a country like South Sudan for reasons of saving on their exploration budgets.

It should be noted however, that there is always a consideration of several factors for investors to make a decision on where to invest apart from availability of pre-competitive data sets. For instance, some countries may not have much public data available, may not be politically stable but may have potential for known huge mineral resources, for instance the DRC (Democratic Republic of Congo). Today, there is a lot more interest for mineral exploration in DRC than other countries with equal public data sets.

4.3 CONCLUSION

Based on the case study, it is evident that use of pre-competitive (state-funded) data sets has a number of positive factors that such data may bring to an exploration destination. If an exploration jurisdiction possesses such data, investors will find it easier to invest and work in such an environment because projects get de-risked by the use of such data. A prospective investor will have basic information required to make a decision on an exploration project e.g. potential of the area for a specific commodity before spending large amounts of money, and in that way such data sets helps to reduce exploration expenditure for exploration companies.

Countries need to put measures in place to ensure that they attract foreign investment into their exploration potential areas. This should be done by growing national geoscientific data sets through establishment of policies to allow transfer or relinquishing of all corporate geoscientific data to government after operations have ceased.

Governments should implement or improve on their Cadastral Portals, which allows explorationists to check availability of land for prospecting and mining, amongst other things.

Governments also need to continually map all the unmapped areas geologically, carry out regional geochemical sampling, and conduct regional geophysical surveys to add to the existing geoscientific data sets so as to enable potential investors to have access to such data freely or at a reasonable fee. Such would attract a lot of inward investment into a particular exploration jurisdiction.

If a particular exploration destination can provide data freely or at a reasonable fee, indeed explorers will flock to such a destination.

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APPENDIX

Appendix 1: Industry Questionnaire

QUESTIONNAIRE

1. Please tell us about your Company (this information is kept confidential)

Name :
Company :
Address 1 :
Address 2 :
City :
Country :
Email Address :

2. Please indicate your company's main projects or business (mark all that apply)

- ☐ Mining
 - ☐ Oil and gas exploration
 - ☐ Mineral Exploration
 - ☐ Mining consultancy
 - ☐ Other (please specify)
-

3. Please indicate in which countries in Africa your company is operating (State 'N/A' if none)

4. Please indicate in which other countries outside Africa your company is operating (State 'N/A' if none)

5. If your company has been / is involved in Mineral Exploration, please indicate if the company ever made use / is using data obtained from the national geological surveys or other national data repositories of the countries in which you operate for the projects in place.

- ☐ Yes
- ☐ No

6. If 'Yes' to Question (5), how would you generally rate the data obtained from the national geological surveys or national data repositories in each of the countries that you operate (Please mark with a Tick ✓ in the table below) :

(NB: If there are more than 4 countries you operate in, please respond for your top 4)

NAME OF COUNTRY 1: _____

	Unacceptable	Poor	Reasonable	Good	Excellent	N/A
Data Quality						
Data Price						
Ease of Access						
Data Appropriate to needs						
Density of Data Coverage						

NAME OF COUNTRY 2: _____

	Unacceptable	Poor	Reasonable	Good	Excellent	N/A
Data Quality						
Data Price						
Ease of Access						
Data Appropriate to needs						
Density of Data Coverage						

NAME OF COUNTRY 3: _____

	Unacceptable	Poor	Reasonable	Good	Excellent	N/A
Data Quality						
Data Price						
Ease of Access						
Data Appropriate to needs						
Density of Data Coverage						

NAME OF COUNTRY 4: _____

7. In general, how would you rate the data obtained from the national geological surveys or national data repositories in the different countries in its usefulness on initial target generation of your exploration project (please mark one option):

- ☐ Not useful
☐ Partially useful
☐ Useful
☐ Very useful

8. In addition to the public geodata, did the company conduct own additional data generating exercises for initial target generation on any of the company's projects:

- ☐ Yes
☐ No

9. If 'Yes' to Question 8, what would be the reason(s) for generating additional data.

10. Please indicate as a Percentage (approximately) the amount of expenditure on Public Geodata and Company's additional data used for initial target generation of each of the projects in each of the countries you are operating in.

(If no additional data was used, please indicate 100% under Public Geodata).

COUNTRY NAME	PUBLIC GEODATA USED (%)	ADDITIONAL COMPANY DATA (%)

11. What's your general comment on how important Public Geodata is in initial target generation on your projects?

Appendix 2: Geological Survey Questionnaire

QUESTIONNAIRE

12. Please tell us about your National Geological Survey (GS) / NATIONAL Data Repository (NDR):

Name :
Country :
Website :

13. Does your GS have a geoscientific data repository which is accessible to the public?

- ☐ Yes
☐ No

14. If 'Yes' to Question 2, please indicate the year when the geodata repository was first established for access to the public.

15. How does the GS acquire this geodata (mark all that apply):

- ☐ Historical Geoscientific Data from previous mining / exploration / survey companies
☐ Geological Data from Government Surveys Geological Mapping
☐ Geophysical Data from Government Geophysical Surveys
☐ Data from Government Sponsored University Research Work
☐ Geochemical Data
☐ Other (Please Specify)

16. If 'Yes' to Question 2, please indicate the type of geoscientific data that has been made accessible to the public (mark all that apply)

- ☐ Geological Maps (hard copies)
☐ Geological Maps (vector digital format)
☐ Regional Airborne Geophysical Data (Magnetism, Radiometric) & Gravity
☐ Regional Geochemical Data
☐ Regional Scale Metallogenic Maps
☐ Cadastral Maps
☐ Topographical Maps & Data
☐ Technical Reports & Published Papers
☐ Hydrological Maps
☐ Interpreted Satellite Imagery
☐ Physical Samples
☐ Physical Borehole Core & its associated data (e.g. geological logs)
☐ Other (Please Specify) _____

17. In what format is data made available to the public? (mark all that apply)

- ☐ Electronic
- ☐ Hard copies
- ☐ Both

18. As a percentage (%), how much of the available data is in:

- ☐ Electronic format: _____
- ☐ Hard copy format: _____

19. Please indicate how the available geodata is made available to the public:

- ☐ At a fee
- ☐ Free

20. If data is made accessible to public at a fee, please indicate the pricing schedule for each of the data set listed:

- ☐ Geological Maps (hard copies)
- ☐ Geological Maps (vector digital format)
- ☐ Regional Airborne Geophysical Data (Magnetism, Radiometric) & Gravity
- ☐ Regional Geochemical Data
- ☐ Regional Scale Metallogenic Maps
- ☐ Cadastral Maps
- ☐ Topographical Maps & Data
- ☐ Technical Reports & Published Papers
- ☐ Hydrological Maps
- ☐ Interpreted Satellite Imagery
- ☐ Physical Samples
- ☐ Physical Borehole Core & its associated data (e.g. geological logs)
- ☐ Other (Please Specify) _____

21. Since the inception of the country's data repository and open access to public, what has been the effect on the number of exploration licences or tenements issued? (Please state number of licences before open data access and number of licences after two years of geodata availability to the public)

- ☐ Number of Exploration Tenements before Geodata Availability: _____
- ☐ Number of Exploration Tenements 2 years after Geodata Availability: _____

22. Please indicate any 5 mining / exploration projects that might have benefitted from the geodata available in the public domain since its establishment:

23. Do you currently have a Mining / exploration cadastre system or portal in use for the public in your country?

- ☐ Yes
- ☐ No
- ☐ In Progress

24. If 'yes' to Question 11, please indicate the online web address that may be used to access your country's cadastre system or portal:

25. If 'yes' to Question 11, what type of data is currently accessible from the cadastre system or portal (Mark all that apply)

- ☐ Active Mining licences
- ☐ Active Prospecting / Exploration licences
- ☐ Pending Mining / Prospecting licences
- ☐ Satellite Imagery
- ☐ Geology
- ☐ Farms
- ☐ Mineral Occurrences
- ☐ Geology
- ☐ Administrative Environmentally Sensitive Areas
- ☐ Protected Areas
- ☐ Others (Please Specify)

26. What's your general comment on how important publicly available geodata and cadastre systems are to the country as a whole?

Appendix 3: List of Companies for Questionnaire I

NAME OF COMPANY	NAME OF PROJECT	CONTACT PERSON & CONTACT DETAILS	COMMODITY	PROJECT COUNTRY
IvanPlats	Platreef Project	Sello Kekana Transformation Manager / Geologist selloK@ivanplats.com	PGE's	RSA
Paladin Resources	Kayelekera Mine Exploration	Ignatius Kamwanje Exploration / Mine Geologist igkamzy@yahoo.com	Uranium	Malawi
Umbono Capital Partners (Pty) Ltd	Waterberg Coal	Richard Montjoie Director - South Africa rmontjoie@umbono.co.za	Coal & PGEs	RSA
Pangolin Diamonds Corp	Diamond Projects (Botswana) - Jwaneng South Project - Machaneng South Project	Leon Daniels Director / info@pangolindiamonds.com	Diamonds	Botswana
Mkango Resources	Songwe Hill REE Project & Thambani Uranium Projects	Andre Mhango Project Manager - Malawi amhango@mkango.ca	Uranium & REEs	Malawi
Platinum Group Metals (PTM) Ltd	Waterberg Platinum Project	Thys Botha Project Manager tbotha@platinumgroupmetals.co.za	PGE's	RSA
KILO GOLDMINES LTD	Imbo Gold Project	Phillip Gibbs Geologist / Director philip.gibbs@kilogoldmines.com	Gold	DRC
United Manganese of Kalahari (UMK)	Manganese Mining	Stephan Laubscher Chief Geologist Stephan.Laubscher@umk.co.za	Manganese	RSA
Orex Exploration Geological Services	Manganese	Hannes Van Der Merwe Exploration Geologist sol4@xsinet.co.za	Manganese	RSA
Khoemacau Copper Mining (PTY) Ltd	Copper Project	Sipho Tshabalala Database Geologist sipho@geodatasolutions.co.za	Copper	Botswana

Appendix 4: List of Geological Surveys for Questionnaire II

COUNTRY NAME	GEOLOGICAL INSTITUTION	CONTACT PERSON & CONTACT DETAILS
Botswana	Geological Survey of Botswana	Dr. G. Tshoso Chief Geologist gtshoso@gov.bw
Nigeria	Nigeria Geological Survey Agency (NGSA)	Dr. A . Garba Director - Economic Geology razoggarba@yahoo.com
Namibia	Geological Survey - Namibia	Dr K.K. Mhopjeni Chief Geologist Kombada.Mhopjeni@mme.gov.na
Malawi	Department of Mining	Akimu Wona Deputy Director chechanda@gmail.com
Zambia	Geological Survey - Zambia	Dezderious Chapewa Senior Geologist
Tanzania	Geological Survey of Tanzania	Yokbeth Myumbilwa Director Database and Information Services yokbeth.myumbilwa@gst.go.tz
South Africa	Council of Geosciences	Mashudu Matshivha Database Manager mmatshivha@geoscience.org.za
Kenya	Still looking for contacts	
South Sudan	Ministry of Commerce, Investments, Industry & Mining	Hon. Lorika Stella Minister s_lorika@yahoo.com
Lesotho	Ministry of Mining	Tseliso Ntabe Commissioner of Mines ntabetseliso@gmail.com
Zimbabwe	Geological Survey	The Director (Name not provided) zimgeosurvey@mines.gov.zw
Swaziland	Geological Survey - Swaziland	Director (No name provided) geo.director@swazi.net

Appendix 5: Geoscientific Data Price Schedule (Council for Geosciences – RSA)

Geophysical Data Prices

Item	Description	Product	Unit	Price
High res airborne	Magnetic	line data	1:50,000 sheet	R 49 500.00
		grids		R 24 750.00
	Radiometric	line data	1:50,000 sheet	R 19 968.00
		grids		R 9 984.00
Regional data	Magnetic	line data	1:250,000 sheet	R 2 500.00
		grids	Whole SA	Free
	Radiometric - Total Count Only	line data	1:250,000 sheet	R 2 500.00
		grids	Whole SA	Free
	Gravity	point data	1:250,000 sheet	R 2 500.00
		grids	whole SA	Free
Seismic data		line data	100km	R 650 000.00
Maps	At 50K or 250K scale	paper map	A0	R 1 000.00
		georeferenced image	ea	R 1 000.00
	At 1000K (whole SA)	paper map	A0 x 4	R 1 000.00
		georeferenced image	ea	R 1 000.00
Reports		Printed	ea	R 27 100.00
		PDF	ea	R 27 100.00

Geochemical Data Cost

MAPS, ANALYSES AND PRODUCTS	SCALE	PRICE PER SAMPLE/ELEMENT
Digital SXRF data set (23 elements)	Any	R6 per sample per element
Color contoured map	Any	R3 per sample per element plus hour compilation fee
Proportional (bubble) plots	Any	R6 per sample per element plus hour compilation fee
Published geochemical map series	1: 1 000 000	R1000 (Available at the Bookshop at the Council for Geoscience)

Geochemical Data Cost

Price for 1:250 000 Map sheet digital data:

Map name	Map number	Number of samples	Elements	Price/element/sample	Cost per element	Total cost (23 elements)
Ellisras	2326	7759	23	R 6.00	R 46,554.00	R 1,070,742.00
Pietersburg	2328	22562	23	R 6.00	R 135,372.00	R 3,113,556.00
Tzaneen	2330	2776	23	R 6.00	R 16,656.00	R 383,088.00
Thabazimbi	2426	17412	23	R 6.00	R 104,472.00	R 2,402,856.00
Nylstroom	2428	22955	23	R 6.00	R 137,730.00	R 3,167,790.00
Pilgrim's rest	2430	3368	23	R 6.00	R 20,208.00	R 464,784.00
Mafikeng	2524	8379	23	R 6.00	R 50,274.00	R 1,156,302.00
Rustenburg	2526	22264	23	R 6.00	R 133,584.00	R 3,072,432.00
Pretoria	2528	21921	23	R 6.00	R 131,526.00	R 3,025,098.00
Barberton	2530	1284	23	R 6.00	R 7,704.00	R 177,192.00
Vryburg	2624	22760	23	R 6.00	R 136,560.00	R 3,140,880.00
Kuruman	2722	5515	23	R 6.00	R 33,090.00	R 761,070.00
Christiana	2724	8228	23	R 6.00	R 49,368.00	R 1,135,464.00
Alexander Bay	2816	7181	23	R 6.00	R 43,086.00	R 990,978.00
Onseepkans	2818	4124	23	R 6.00	R 24,744.00	R 569,112.00
Upington	2820	21092	23	R 6.00	R 126,552.00	R 2,910,696.00
Springbok	2916	8377	23	R 6.00	R 50,262.00	R 1,156,026.00

Geological Map Data Cost

- Geological Map Data is supplied in 2 formats: **Vector** and **Raster Data** on **1:250000 Scale** (Limited data sets are available on 1:50000 Scale)
- Price for Raster Data is R 1 000 per map
- Prices for Vector data sets vary according to the number of polygons, arc segments and labels
- **VECTOR DATA** are separate polygons, lines and points, which can be edited. The data is provided in ESRI shapefile format, the coordinate system is Geographic and the datum is Hartebeesthoek.

The layers included in each data set, consist of:

- Structure lines
- Stratigraphic / lithologic polygons
- Geological and tectonic contacts
- Structural points measurements
- Stratigraphic / lithologic Lines
- Stratigraphic / Lithologic Points

VECTOR DATA PRICES on 1:250 000 Scale

						2228 Alldays R11 290.80	2230 Messina R10 131.60		
						2326 Ellisras R4 095.60	2328 Pietersburg R8 932.80	2330 Tzaneen R7 410.00	
						2426 Thabazimbi R6 585.60	2428 Nylstroom R4 770.00	2430 Pilgrim's Rest R6 706.80	
		2520 Nossob R1 213.20	2522 Bray R1 646.40	2524 Mafikeng R3 236.40	2526 Rustenburg R11 029.20	2528 Pretoria R6 595.20	2530 Barberton R10 594.80		
		2620 Twee Rivieren R3 222.00	2622 Morokweng R2 164.80	2624 Vryburg R2 538.00	2626 West Rand R8 430.00	2628 East Rand R8 200.80	2630 Mbabane R3 567.6	2632 Mkuze R2 325.60	
		2720 Noenieput R4 222.80	2722 Kuruman R6 505.20	2724 Christiana R4 477.20	2726 Kroonstad R6 032.40	2728 Frankfort R7 188.00	2730 Vryheid R9 540.00		
2816 Alexander Bay Not Available	2818 Onseepkans R6 181.20	2820 Upington R11 248.80	2822 Postmasburg R8 086.80	2824 Kimberley R7 572.00	2826 Winburg R4 980.00	2828 Harrismith R7 440.00	2830 Richards Bay R15 396.00		
2916 Springbok R15 396.00	2918 Pofadder R10 842.00	2920 Kenhardt R11 553.60	2922 Prieska R14 793.60	2924 Koffiefontein R7 347.80	2926 Bloemfontein R5 596.80	2928 Drakensberg R3 103.20	2930 Durban R8 234.40		
3017 Garies NOT Avail	3018 Loeriesfontein R14 368.20	3020 Sakrivier R7 405.20	3022 Briststown R8 948.40	3024 Colesberg R9 660.00	3026 Aliwal North R11 379.60	3028 Kokstad R5 601.60	3030 Port Shep = stone R5145.60		
	3118 Calvinia R8 739.60	3120 Williston R3 744.00	3122 Victoria West R9 878.40	3124 Middelburg R12 447.60	3126 Queenstown R9 631.20	3128 Umtata R8 274.00			
3218 Clanwilliam R6 154.80		3220 Sutherland R3 996.00	3222 Beaufort West R6 237.60	3224 Graaff-Reinet R5 696.40	3226 King William's Town R5 386.80	3228 Kei Mouth R3 043.20			
3318 Cape Town R6 163.20	3319 Wor = cester R13 171.20	3320 Ladismith R9 439.20	3322 Oudtshoorn R7 946.40	3324 Port Elizabeth R6 775.20	3326 Grahamstown R3 759.60				
		3420 Riversdale R5 547.60							

- **RASTER DATA** are TIFF, JPEG and PDF images of the original published 1:250 000 maps. The data cannot be edited or queried.

It is supplied with the complete legend as on the published maps. A second map is supplied as a clipped map and georeferenced to CAPE DATUM while a third map is georeferenced in WGS84 and can be used as back drop for other data sets.

The labelled map block below shows all the geological map blocks available at the Council of Geosciences at 1: 250 000 Scale and all the blocks are costed at R 1000 per map.

RASTER DATA PRICES on 1:250 000 Scale

						2228 Alldays R1 000		2230 Messina R1 000			
						2326 Ellisras R1 000		2328 Pietersburg R1 000		2330 Tzaneen R1 000	
						2426 Thabazimbi R1 000		2428 Nylstroom R1 000		2430 Pilgrim's Rest R1 000	
						2520 Nossob R1 000		2522 Bray R1 000		2524 Mafikeng R1 000	
						2526 Rustenburg R1 000		2528 Pretoria R1 000		2530 Barberton R1 000	
						2620 Twee Rivieren R1 000		2622 Morokweng R1 000		2624 Vryburg R1 000	
						2626 West Rand R1 000		2628 East Rand R1 000		2630 Mbabane R1 000	
						2720 Noenieput R1 000		2722 Kuruman R1 000		2724 Christiana R1 000	
						2726 Kroonstad R1 000		2728 Frankfort R1 000		2730 Vryheid R1 000	
						2820 Upington R1 000		2822 Postmasburg R1 000		2824 Kimberley R1 000	
						2826 Winburg R1 000		2828 Harrismith R1 000		2830 Richards Bay R1 000	
						2916 Springbok R1 000		2918 Pofadder R1 000		2920 Kenhardt R1 000	
						2922 Prieska R1 000		2924 Koffiefontein R1 000		2926 Bloemfontein R1 000	
						2928 Drakensberg R1 000		2930 Durban R1 000			
						3017 Garies R1 000		3018 Loeriesfontein R1 000		3020 Sakrivier R1 000	
						3022 Bristown R1 000		3024 Colesberg R1 000		3026 Aliwal North R1 000	
						3028 Kokstad R1 000		3030 Port Shep = stone R1 000			
						3118 Calvinia R1 000		3120 Williston R1 000		3122 Victoria West R1 000	
						3124 Middelburg R1 000		3126 Queenstown R1 000		3128 Umtata R1 000	
						3218 Clanwilliam R1 000		3220 Sutherland R1 000		3222 Beaufort West R1 000	
						3224 Graaff-Reinet R1 000		3226 King William's Town R1 000		3228 Kei Mouth R1 000	
						3318 Cape Town R1 000		3319 Worcester R1 000		3320 Ladismith R1 000	
						3322 Oudtshoorn R1 000		3324 Port Elizabeth R1 000		3326 Grahamstown R1 000	
						3420 Riversdale R1 000					

Core & Borehole Data Cost

ITEM / PRODUCT	PRICE	ADDITIONAL PRICE
Farm Name, Coordinates, Depth of Borehole, Drill Date, Company, Intersections	R 300 for a search of 10 farms and maximum of 100 boreholes	R1.00 per borehole extra borehole
Lithology & Assay Data	R300 per borehole	N/A
Lithology Data only	R100 per borehole	N/A
Scanned Geological Logs with Assay Data	R300 per borehole log	N/A
Scanned Geological Logs without Assay Data	R100 per borehole log	N/A