Report R65/2007

NEPHELINE MINERAL PRODUCTION IN THE REPUBLIC OF SOUTH AFRICA 2007

DIRECTORATE: MINERAL ECONOMICS

Nepheline crystal. ***Photo:*** http://en .wikipedia

mineral resources

Department:
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TABLE OF CONTENTS - NEPHELINE SYENITE

ADDENDUM TABLES

TABLE OF FIGURES

DIAGRAMS

1. INTRODUCTION

Nepheline syenite is a source for nepheline. It is a [1]felsic, [2]leucocratic, silica-undersaturated and generally coarse-grained intrusive igneous rock, typically consisting of feldspar, nepheline and smaller amounts of [3]mafic constituents such as biotite, pyroxene and amphibole. It is white to greyish in colour and is distinguished in colour from the parent rock of feldspar.

In commercial industry, nepheline competes with feldspar as a source of alkalis and alumina for the glass and ceramics industries. In glass and ceramics manufacturing, nepheline, like feldspar, provides alkalis that can act as flux to lower the temperature of the [4]matte in blast furnaces. Nepheline syenite is extremely rich in alkalis and alumina, hence the abundance of feldspathoids and alkalis feldspars.

Since the mineral nepheline syenite is 75-80% pure feldspar, there are a number of projects in the United States currently researching the possibility of replacing steel rail coal cars with a molded feldspar body which is a third of the total weight.

The researchers at the University of Toronto and Hanford Washington are working on nepheline syenite use in the manufacturing of steel, and the transportation of nuclear waste.

Nepheline syenite deposits are commonly large uniform bodies. The preference is for medium to coarse-grained, preferably massive or gneissic where mafic component should constitute less than 5% of the rock, and become liberated by magnetic separation methods when ground to 30 mesh.

Apart from nepheline syenite, other sources of nepheline are the white and grey foyaite which are non-pophyritic, containing nepheline and large feldspar crystals, and the tinguaite, which is a porphyritic, green to grey in colour, also consisting of potash feldspar.

[1]Rock consisting of high percentage of iron and silica

[2]Rock predominantly consisting of white coloured minerals

[3]Rock that has high percentage of iron and magnesium

[4]Matte- reduced solids in a liquid form in a blast furnace

1.1 Occurrences

Although these are relatively rare deposits, their occurrence is spread throughout the world. Larger deposit intrusions are found in the United States (Texas, Arkansas and Massachusetts), Canada (Ontario, British Columbia), Brazil, Norway and in Russia. Few occurrences are also found in France and Portugal, as well as South Africa, Madagascar, India, Mozambique and Tasmania. Size is an important criterion for commercial consideration, whilst purity and location of deposit are also of vital importance (***Addendum Table 1***).

In South Africa, nepheline syenite is found in the Pilanesberg area on the Pilanesberg Alkaline Complex, which is an intrusion of the Bushveld Complex. Pilanesberg Alkaline Complex is located 50km north of north-west of Rustenburg, 10km south-west of Sun City on the farm Zonderivierspoort 210 JP.

1.1.1 Red Syenite

Red syenite is prominent in the south-east and north-west forming the outer wall of the Pilanesberg. It forms a complete ring of red syenite on the farms Palmiesfontein, Zandrivierspoort and Koedoesfontein, and it is developed within the white foyaite ring. In this area the red syenite deposit forms a distinguished hill along the road and it is known as the Burgwan's Kop.

1.1.2 The Red Foyaite

The core of the Pilanesberg Complex is made up of coarse grained red foyaite that has also two outlaying lobes of red syenite (***Figure 1***). One body forms a red hill in the southern part of the farm Buffelspan. The second body forms a big round hill in the eastern part of Welgeval, both south and north of the Rhenoster Spruit (Shand, 1932)

In this type of rock, the feldspar is mainly perthite and albite, while dark minerals are biotite, aegerine and iron ore. Accessory minerals include fluorite and zircon, while the common decomposition product is chlorite.

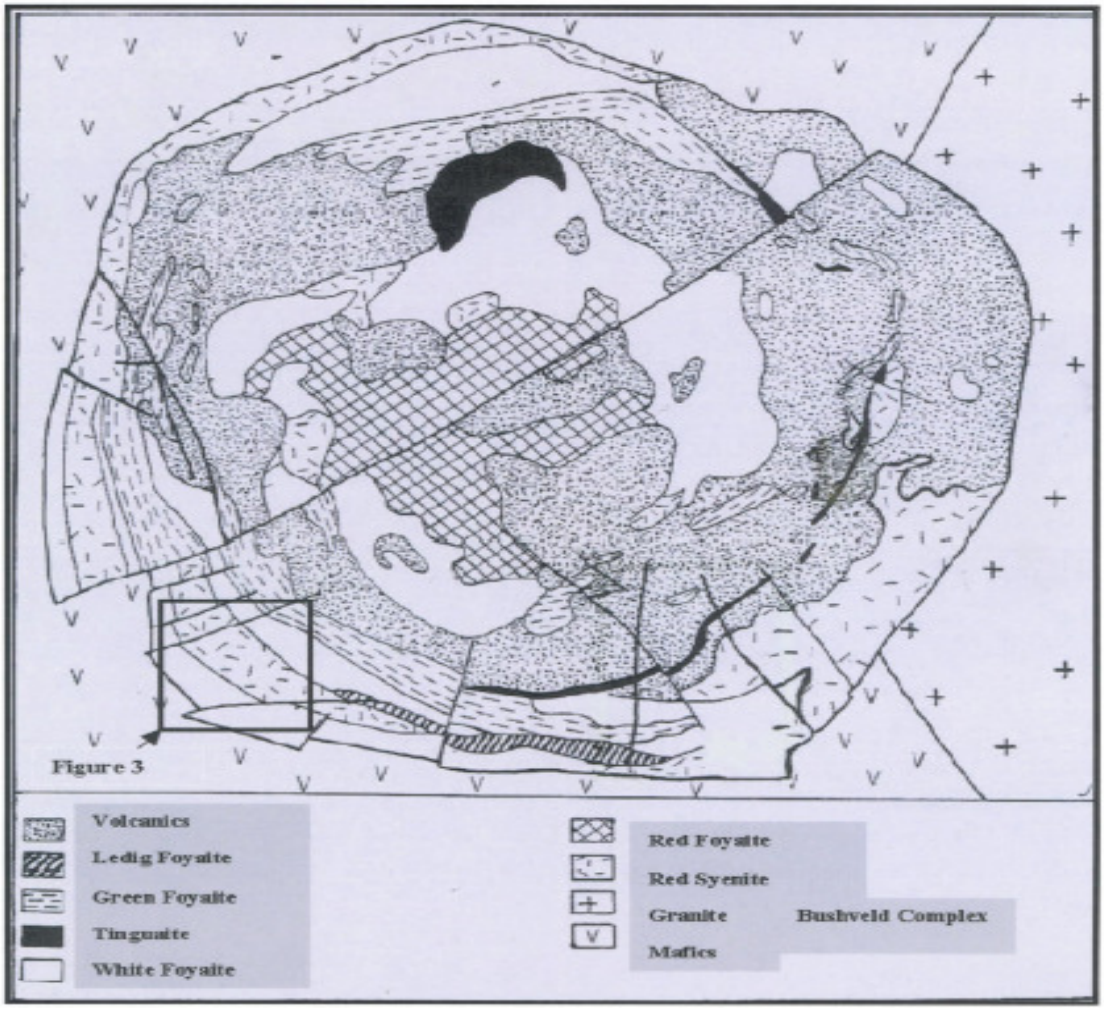

Figure 1. Geology of the Pilanesberg Complex. *Source: Jos Lurie, 1986*

1.1.3 White and Grey Foyaite

The core of the complex is succeeded by a complete ring of white foyaite which is sometimes referred to as grey foyaite. The white foyaite surrounds the red foyaite core and has the largest outcrop of all intrusives (***Figure 1***). The white foyaite is identified by its white or grey colour which is due to the predominance of minerals such as feldspar (Lurie, 1986).

1.1.4 Green Foyaite

Green foyaite lies between second and third white foyaite rings. It forms sharp-crested hills on Vaalsboschlaagte (***Figure 1***). This foyaite tends to be porphyritic in texture. The main minerals in the green foyaite are microcline and pyroxene. Accessory minerals include zeolite, sodalite, lamprophyllite, lovchorite, zircon, sphene, calcite, fluorite and magnetite. Lujaunite is a variety of nepheline syenite containing aegerine and eudialyte. The green foyaite has been observed to vary in grain size from medium to coarse-grained and even fine-grained in some localities.

1.1.5 Tinguite

Tinguite foyaite is located in Pilanesberg and it can be found in three forms namely, as a half ring, a large sheet capping the Pilanesberg and as thin dykes mainly concentrated in the north-western sector of the Complex. Tinguite can be traced within the green foyaite between the farms Ledig and Kaffirskraal. (***Figure 1***).

1.1.6 The Bulls Run Syenite Complex

This complex is located in the Natal Thrust Belt, 180km east-north-east of Durban (Scorgings and Foster, 1989). It is bounded in the south by Halambu Granitoid Gneiss and by Woshane amphiboles in the north (Germquet, 1986). From north to south, the complex shows extensive plastic deformation.

This zone is succeeded by a zone of fine-grained nepheline syenite, which has been identified to be rich in biotite and muscovite. The texture of nepheline syenite changes gradually towards the centre of the complex. It was identified that from the north nepheline syenite is fine grained and rich in both muscovite and biotite.

1.1.7 The Mamelodi Quarries Deposit

The Mamelodi Quarries Deposit, outside Pretoria, has over the past few years been producing small quantities of nepheline syenite. The product is locally used for

glazing and in ceramics. Although the grade is of low quality, it is sold to customers who are not stringent on the iron content.

2. Industry Flowchart

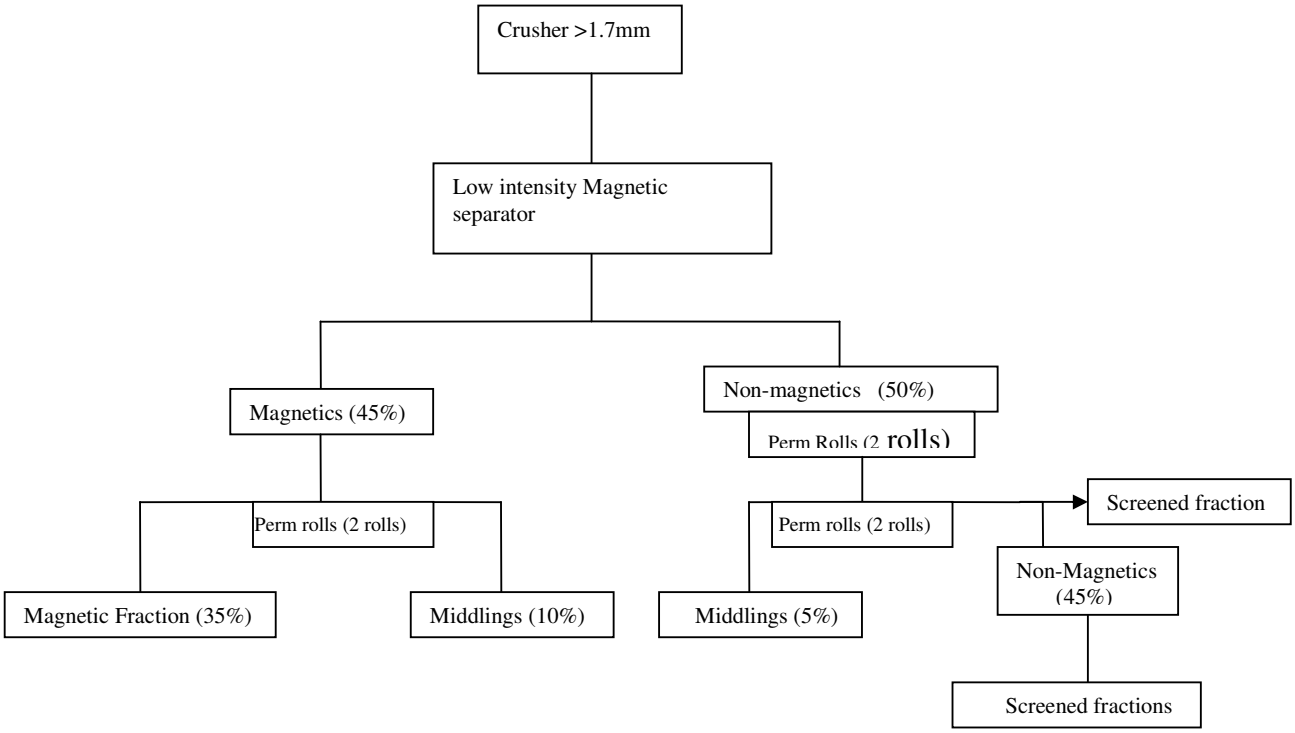

Diagram 1. *Beneficiation process of Nepheline Syenite (Germiquet, 1986)*

3. Uses

Nepheline syenite and feldspar can largely be substituted for each other in most applications. The choice is determined by factors such as purity, consistency and transport costs. Feldspar is generally preferred to nepheline syenite in the manufacture of flat glass as it is quicker to dissolve and easier to disperse evenly.

Nepheline syenite may be preferred in high volume ceramic manufacture because of lower firing temperature and shorter firing time needed, and is a better flux due to its higher alumina/alkali ratio. However, it is generally more expensive than feldspar. It is also used as filler as well as an abrasive.

4. Supply and Demand

Worldwide ceramic industry consumes around 7.7Mt of feldspar and nepheline syenite each year, accounting for around 55% of total world demand and over 70% of European demand.

The second largest market for feldspar and nepheline syenite is the glass industry, accounting for 35% of world demand. The market for glass grades of feldspar and nepheline syenite is being weakened by the increased use of cullet in preference to raw mineral material and in the case of container glass, by the use of alternative packaging materials. The glass industry is therefore expected to show relatively slow rates of growth in feldspar and nepheline demand.

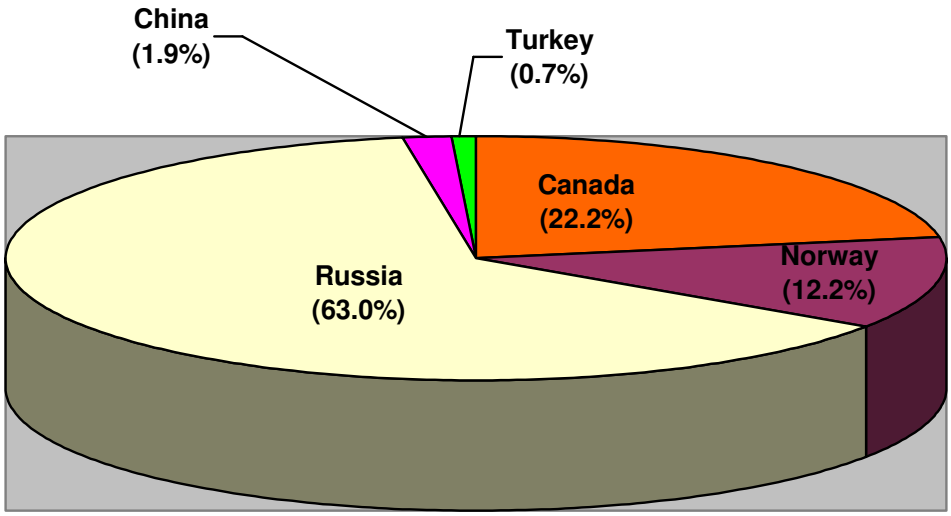

Figure 2. Percentage World Production of Nepheline, 2003.
Source: Tasmania Development and Resources, J.L. EVERARD.

Until recently, almost all the production of nepheline syenite outside Russia, who is the major and leading producer, has been sourced from three mines, all owned by the US-based Unimim Corporation, in Canada and Norway. World production, in percentage, is displayed in ***Figure 2,*** above.

The positive trend in the economic cycle of the building industry has an influence on the production of feldspar and nepheline in South Africa. In 2002 and 2003 production declined due to the economic recession in the US building industry which had an impact on other countries Gross Domestic Product (GDP).

In South Africa, there is no known supplier of glass grade nepheline. There is also no producer who is willing to import the product since South African manufacturers expect to pay less than R150/kg for the delivered product (Pirez, 2003).

5. Local Market

There is a concern about the grade of nepheline produced in South Africa. The iron content is too high for use in the manufacturing of glass and ceramics. The consistency in quality and supply are limiting factors. Owing to such reasons some manufacturers do not prefer using nepheline because it is much more expensive to process than other substitutes.

However, there were some producers in South Africa who are willing and who have shown interest in using this material as is, as it is deemed suitable for their specific requirements other than glass and ceramic.

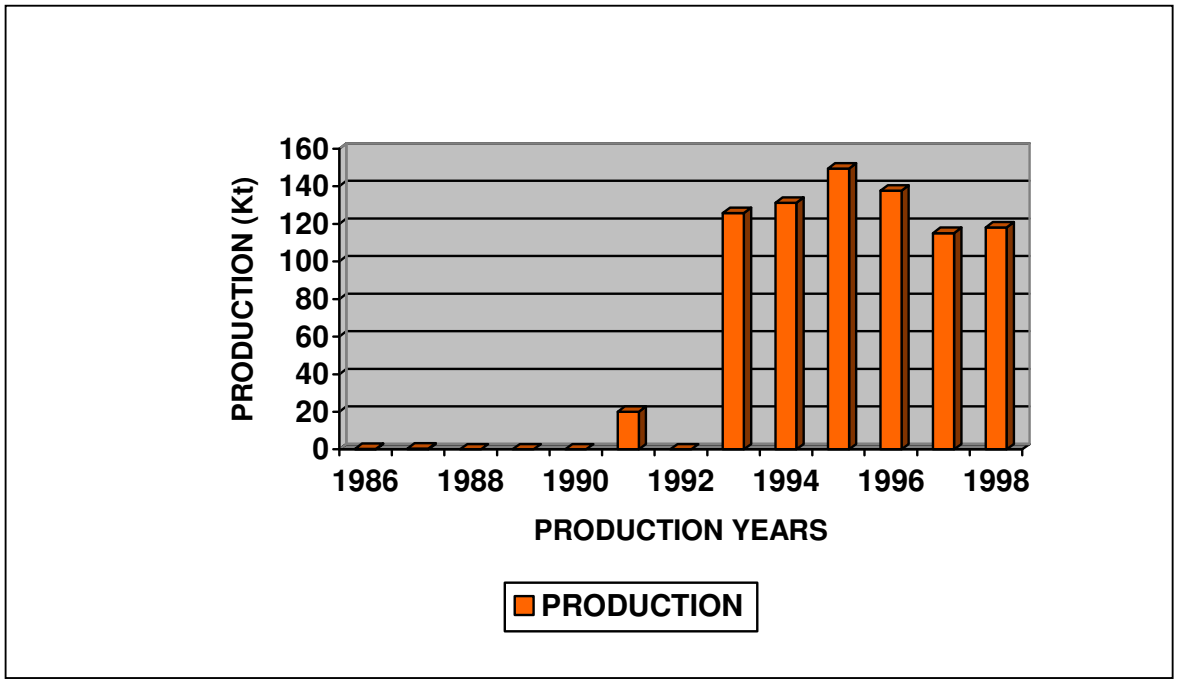

Figure 3. Local Production of Nepheline Syenite. *Source: Agnello, 2003*

It is extrapolated that the resultant opening of the Chinese large feldspar operations in 1999 had a negative impact on South Africa's nepheline production. Between 1999 and 2000 no nepheline syenite, was produced in South Africa.

6. International Markets

In 2004, nepheline syenite production was mainly from Canada and Norway and they are the sole commercial major producers and exporters of nepheline syenite each from single operations owned by the same US producer (Unimim Corporation).

Prior to 2004, 60% of the global nepheline product was exported to the US, 20% to the Canadian market, and the rest to other countries. In North America, about 80% of feldspar and nepheline is used in glass manufacturing, about 15% in ceramics, and less than 5% in fillers.

Growth in consumption of nepheline in glass containers has been affected by competition from metals and plastic containers. The use of nepheline in bathrooms fixtures, tiles and fiber glass insulation depends on the housing construction and remodelling markets.

Canada and Norway produce nepheline mainly for glass and ceramic use while in Russia it is produced for alumina, sodium and potassium carbonates uses.

Leading recipients of nepheline syenite from Canada (at a production of 710 Mt and an export of 476 Mt) include the US (350 Mt), Italy (54 Mt), Netherlands (39 Mt) and Spain (24 Mt). Countries importing from Norway (at a production of 340 Mt and export of 336 Mt) include Poland (65 Mt), Germany (58 Mt), UK (55 Mt), Netherlands (38 Mt), France (32 Mt) and Spain (24 Mt).

7. Industrial Use and Substitution

In industry, nepheline is substituted by other minerals in the following uses:

7.1 ***Abrasive*** - bauxite and alumina (fused alumina), corundum/emery, diamonds, diatomite, feldspar, garnet, ilmenite, iron oxide (magnetite), olivine, perlite, pumice, silica sand, staurolite, silicon carbide and tripoli.

7.2 ***Ceramics*** – aplite and feldspar

7.3 ***Fillers*** – aluminium trihydrate (ATH), barite, calcium carbonate, feldspar, kaolin, perlite, talc, mica, pyrophylite, microcrystalline silica, ground silica flour and synthetic silica and wollastonite.

7.4 ***Glass*** – aplite, steel mill slag, cullet, feldspar (container glass and fibreglass), kaolin (textile grade fibreglass), kaolin (textile grade fibreglass), calcined alumina or alumina hydrate (speciality glass).

8. Environmental Health and Safety

Occupational Safety and Health Administration Hazard communication standards or similar organisations require a cancer warning label on any mineral product with crystalline silica content above 0.1%. In nepheline and feldspar, to prevent the environmental dust pollution and silicosis related diseases, permitted dust particles released to the atmosphere should not exceed 0.01 ppm.

9. Logistics

Glass grade nepheline syenite is generally sold to a number of plants each requiring significant quantities on a regular basis thus allowing delivery in bulk via truck or rail in hopper cars.
The major concern is contamination which needs hopper cars to be leased exclusively for the transportation of nepheline syenite. Finely ground ceramic and filler grades are usually bagged and shipped by boxcar or truck, with exports transported in container loads via rail or cargo ship.

10. Threats, Problems and Risks in the Industry

Three trends are expected to have a negative impact on feldspar and nepheline syenite over the coming years:

- The increasing use of plastic rather than glass containers;
- The growing use of recycled glass in glass manufacturing;
- Substitution by other cheaper minerals;
- Increase in demand of aluminium containers; and
- Illegal operators

Some of the small to medium scale operators in this industry operate outside the required regulations of Health and Safety. The conditions under which employees work in some of the quarries are appalling.

11. Opportunities

Opportunities are abundant in feldspar production compared to nepheline at present. The demand for feldspar is higher than that of nepheline because nepheline is a rare mineral.

The increased use of nepheline may be stimulated by Occupation Safety & Health legislation discouraging the use of silica which causes silicosis.

OUTLOOK

The strong competition between producers for the major ceramics markets of Italy and Spain is likely to keep European feldspar prices low, probably negatively impacting on European prices. The development of the very large Chinese feldspar industry to support domestic demand and exports will exert a downward pressure on markets in the Far East and might put pressure on local producers.

In South Africa, the Mamelodi Quarries Deposits sells its produce irrespective of the amount of impurities in the material. Processed material is sold at R800/t whilst unprocessed material is sold at R400/t.

A market that should not be overlooked is that of granite where the dimension stone prices are slowly picking up. In countries like the USA, India, Pakistan and Italy there is a demand for dimension stones for building monuments, shrines and furniture.

South African nepheline market is dwindling due to the fact that it is expensive to process nepheline to required specification hence most producers of glass, ceramic, paint and earthenware prefer feldspar over nepheline. Ore deposits are not potentially feasible because of the high content of impurities.

It is expected that in the five coming years, the price of nepheline in South Africa will pick up together with other commodities used in the construction industry since South Africa is experiencing a huge infrastructural uplifment.

ADDENDUM TABLES

Table 1. Chemical analysis of nepheline from various deposits.

CHEMICAL COMPOSITION	[1]PILANESBERG RED SYENITE	[2]BULLS RUN	[3]CANADA	NORWAY	USA Maine Litchifield	CONGO
SiO_2	56.82	52.61	58.8	52.37	60.39	55.44
Al_2O_3	22.56	23.86	23.00	23.22	22.51	23.59
Fe_2O_3	0.81	0.22	0.80	1.10	0.42	0.44
MgO	0.70	0.11	0.04	0.25	0.13	0.14
CaO	1.44	1.19	0.82	3.11	0.32	1.56
MnO	0.29	0.02	0.05	0.09	0.08	0.15
P_2O_5	0.19	0.32	0.01	0.09	-	0.18
K_2O	5.01	6.92	5.20	8.30	4.77	6.26
Na_2O	8.92	8.53	9.40	6.87	8.44	10.20
L.O.I	1.59	8.53	9.40	6.87	8.44	10.2
Total	**98.33**	**95.08**	**98.12**	**95.4**	**97.06**	**99.58**

Sources: [1]Moruo Services, 2004; [2]Germiquet, 1986; [3]Minnes, 1975

Table 2. Chemical Comparison between TYPE I and TYPEII of white foyaite (Shand, 1932).

ELEMENT	TYPE I	TYPE II
SiO_2	49.88	55.5
Al_2O_3	21.70	19.87
Fe_2O_3	1.3	3.34
FeO	0.53	0.76
MgO	0.07	0.28
CaO	3.29	1.63
Na_2O	11.80	9.91
K_2O	4.66	5.41
MnO	-	0.60
P_2O_5	traces	absent
TOTAL	**93.23**	**97.3**

Table 3. Chemical Analysis of Major Countries vs. South Africa (Pirez, 2003)

Element(%)	South Africa	Canada	Norway	USSR
Al_2O_3	22.40	23.50	24.50	24
SiO_2	54.60	60.0	58.0	40
Fe_2O_3	0.51	0.09	0.09	2.86
Na_2O	7.64	10.40	8.00	10.65
MgO	0.38	-	-	-
K_2O	7.83	5.04	8.50	5.25
CaO	2.83	0.30	1.55	6
L.O.I	2.45	0.50	-	-

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