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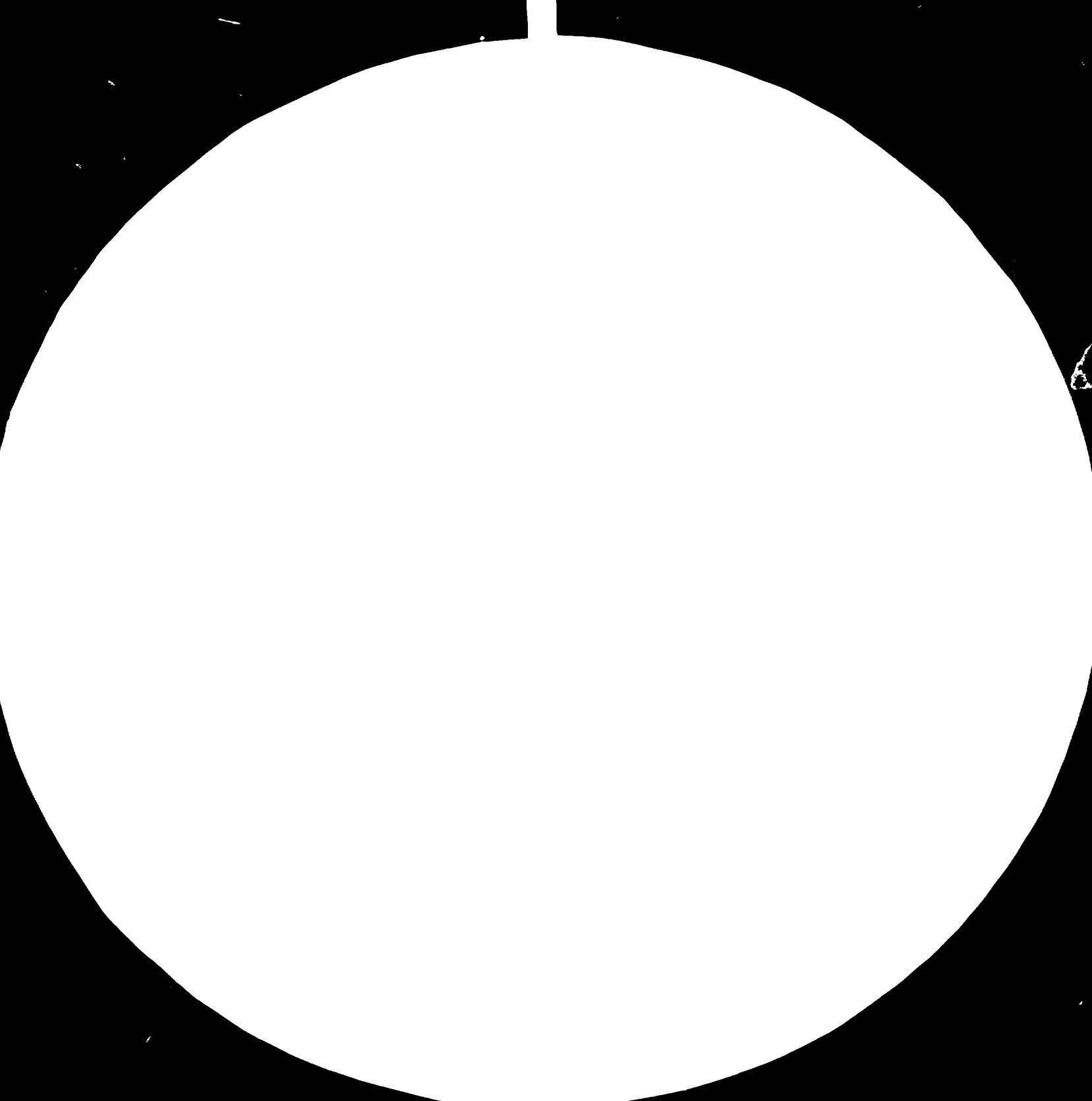
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## MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS  
TANG AND DEWEY REFERENCE MATERIAL DIVISION  
ASTM, 1983 EDITION, TEST METHOD E 294-77

13347

RESTRICTED

March 11, 1983  
English

Zimbabwe.

PRODUCTION OF LITHIUM CHEMICALS

SI/ZIM/82/801/11-01/31.8.A

ZIMBABWE

Terminal Report

Prepared for the Government of Zimbabwe  
by the United Nations Industrial Development  
Organization, executing agency for the  
United Nations Development Programme

Based on the work of Dr. P.Hadzeriga  
adviser on lithium chemical processing.

United Nations Industrial Development Organization  
Vienna

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INTRODUCTION

According to the U.S.A. Bureau of Mines statistics, Zimbabwe in 1981, ranks as the fourth largest producer of lithium mineral in the world. Thus, the study of mission SI/ZIM/82/801/11-01/31.8.A from the United Nations Industrial Development Organization, has sufficient justification for the approval of an evaluation of the production of lithium chemicals in Zimbabwe rather than just export the concentrates minerals. As it may be realized, if this project, under proper economical circumstances, may result in a better revenue for the country.

This report covers a brief review of lithium chemicals production under the present circumstances and present status in Zimbabwe, and of course, the economical aspects, on world basis, of this venture.

Special emphasis was given at the potential of lithium chemicals production from low grade sources, as it can be found in the tailings of the Kamativi tin operation.

SUMMARY AND CONCLUSIONS

Reviews of reports were made on only few of the many lithium deposits encountered in the country. Starting with the Bikita, the richest deposit in Zimbabwe, the Kamativi tails from their tin operation and the Green Mamba geological report.

A three days visit was paid to the Bikita works in order to get acquainted with the only producer-exporting lithium minerals concentrates of the country.

A report on a pre-feasibility, dated May 1981, on the Kamativi tin tailings (containing relatively small amounts of spodumene) prepared by the Industrial Development Corporation of Zimbabwe Limited was thoroughly studied. Finally, a report, dated February 1982, prepared by Mr. P.J. Best of the Geotechnical Services (Pvt) Limited, on the Green Mamba lithium deposit was reviewed.

Some tentative conclusions were arrived to as a result of this work:

1. With the depressed market of practically all minerals and metals commodities around the world (except for gold, some precious metals and few others), the production of lithium chemicals in Zimbabwe is at the present an economical impossibility.

2. The above is true including the Bikita deposit, in spite of its high grade ores (around 4%  $\text{Li}_2\text{O}$  run-of-mine) because the high cost of fuel and the prevailing price of the chemicals needed to convert the concentrates into lithium chemicals. The same can be say about the Kamativi tails, with a content of only 0.7%  $\text{Li}_2\text{O}$  and the Green Mamba pegmatites, which has a calculated reserves of over 15 millions tons averaging about 1.55%  $\text{Li}_2\text{O}$  and has not been exploited yet.

3. However, needless to point out, that the present economical circumstances are bound to change for the better at sometime in the foreseeable future. In that case, the possibilities of producing lithium chemicals in Zimbabwe should be reviewed again according the market conditions that may exist then. In spite of the vast reserves of lithium ores in the country, one should not forget the cost of the chemicals needed, which should be considerable below of what are at the present in order to pro-

duce lithium chemicals that will on a competitive basis in the world, and specially in the Far East and Europe.

4. Under the worst of the circumstances, in the future, Zimbabwe should be looking at domestic market and some of the close-by neighborly countries in Africa.

5. Zimbabwe also should look, in the future, for new technology that may be the most economically processing of lithium ores into lithium chemicals using raw or manufactured chemicals which may be found in the country. Research work presently carried out in the U.S.A. and other many countries in the world should be followed.



A BRIEF BACKGROUND ON THE PRODUCTION OF LITHIUM  
CHEMICALS IN ZIMBABWE

The idea of production of lithium chemicals in Zimbabwe is very old.

In reviewing the technical files on lithium at the Geological Survey Department in Harare, a letter was found dated November 10th., 1941, (File L I, Reference No. 7) from Mr. Sydney J. Johnstone (Principal: Mineral Resources Department) addressed to Mr. Robertson of the Imperial Institute. In that letter, Mr. Johnstone said textually:

"The matter of obtaining lithium salts from the Souther  
Rhodesia, has been before us on several previous occasions  
during the last six years ... It was raised by Mr. Billing-  
hurst in 1935 ..."

Apparently Mr. Billinghurst run a pilot plant experimentation tests in the middle of the third decade with not much success. He used lepidolite concentrate running 3.34%  $\text{Li}_2\text{O}$  (letter from the Chief Government Engineers of Salisbury, Geological Survey File L, Reference No. 8 c) making a mixture of the lithium mineral with gypsum, calcinated at  $1000^\circ\text{C}$  for two hours. The product from the calcination was boiled with water to obtained a solution of  $\text{Li}_2\text{SO}_4$ ,  $\text{K}_2\text{SO}_4$  and  $\text{Na}_2\text{SO}_4$  with small amounts of  $\text{CaSO}_4$ . In the opinion of the writer, this route has its merits at that time and perhaps should be fully reinvestigated and make an appraisal under the current economical situation of the merit of such process as may be applicable to Zimbabwe.

No further information of value for this mission was found at the Geological Survey Library.

The basic conclusion that could be made was that the production of lithium chemicals from the country's ores have been in mind of the technical people for almost half century.

KAMATIVI LITHIUM TAILINGS PROCESSING

Extensive studies were made in the early of 1980, edited in May 1981, about the extraction of lithium chemicals from the tailings of the recovery of tin concentrate produced at the Kamativi ore deposit. The work was done in West Germany, Netherlands and the United States of America. The Secretary of the Industrial Development Corporation of Zimbabwe Limited, Mr. B. McCurdy, was kind enough to supplied the writer with a report prepared from the three above mentioned countries and assembled in one voluminous hard bounded book.

The writer reviewed that report("Pre-feasibility study for producing Lithium Chemical from Kamativi ores", prepared for the Industrial Development Corporation of Zimbabwe Limited", May, 1981) in its lenght. The following information was extracted from it.

1. The chemical analyses of the main tailings pile from the tin ore processing is as follow:

Li <sub>2</sub> O	0.70%
Fe <sub>2</sub> O <sub>3</sub>	0.54%
K <sub>2</sub> O	2.52%
Na <sub>2</sub> O	5.12%
Al <sub>2</sub> O <sub>3</sub>	15.7 %
SiO <sub>2</sub>	72.7 %
MgO	0.51%
L.O.I.	1.21%

The estimated quatities of mineral species are distributed approximately as following:

Muscovite	10.8%
Spodumene	10.8%
Soda Feldspar	43.4%
Potash Feldspar	7.3%
Quartz and others	27.7%

The above analyses were obtained from a composite of 360 pounds sample.

The calculated reserves in the tailings stock-pile, containing Li<sub>2</sub>O values, in Kamativi as of July 1980, were reported as following:

Section	Class	Tonnes of Ore***	%Li <sub>2</sub> O	Tonnes Li <sub>2</sub> O	Tonnes Li <sub>2</sub> CO <sub>3</sub> equivalent
7	I	1,432,613	0.65	9,350	23,126
	II	1,998,204	0.71	14,113	34,906
	III	638,107	0.70	4,479	11,078
	IV	<u>4,415,196</u>	<u>0.68</u>	<u>29,952</u>	<u>74,081</u>
Subtotal		<u>8,484,120</u>	<u>0.68</u>	<u>57,894</u>	<u>143,191</u>
6	III	430,663	0.23	990	2,448
	IV	<u>5,494,400</u>	<u>0.26</u>	<u>14,258</u>	<u>35,265</u>
Subtotal		<u>5,925,063</u>	<u>0.25</u>	<u>15,248</u>	<u>37,713</u>
<u>GRAND TOTAL</u>		<u>14,409,183</u>	<u>0.51</u>	<u>73,142</u>	<u>160,904</u>

Class I: Developed ore reserve blocks sampled on 3 sides  
 Class II: Developed ore reserve blocks sampled on 2 sides  
 Class III: Developed ore reserve blocks sampled on 1 side  
 Class IV: Indicated ore reserves from boreholes

\*\*\* These ore reserves figures are for ore associated with economic tin values and no account has been taken of the which may be available for Li extraction but has values of tin below the current cut-off grade.

2. The report assumes that there will be a short over-supply of Li<sub>2</sub>CO<sub>3</sub> in the short term that will persist until the use of lithium in batteries become wide spread, possible in ten years. Thereafter, demand will increase considerably. Further the demand will accelerate by its use in fusion reactor for power generation. Forecast that it will be a 5% per year accompanied by similar increase in price.

3. The Kamativi deposit has reserves which permit a production of lithium carbonate to continue for 25-30 years at a production rate of 12 million pounds per year. The volume of sales that can be achieved on world market in short term is vital is assessing the viability of lithium chemical at Kamativi. This should consider other factors as corporate structure(a separate company); financial arrangement; choice of plant site and process to be use and more data on engineering aspects and plant cost. This only can be done by a detailed feasibility study and financial analysis.

4. Kamativi Tin Mines Limited is 91% owned by the Industrial Development Corporation, operating a tin mine in a pegmatite belt in North-West of Zimbabwe. Tantalite is a by-product of the mine smelter slags.

5. The ore body contains spodumene, amounting to an average of 10% by weight of the ore.

6. Over the years a considerable amount of investigations has been done by Kamativi with the prospect of producing lithium chemicals. But no detailed has been undertaken to demonstrate that either Li minerals or chemicals can be produced and sold to the world market or a firm decision made to which process can be used to accomplish this.

7. It can be seen that (in the above figures), at the current rate of mining of 65,000 TPY, the higher grade section seven reserves will be exhausted in six-seven years. If Class IV reserves become proven, the life of Section 7 is extended for twelve years. After this, lithium content of the mill feed will drop to 0.25%. To maintain a production of twelve million lb/year, recourse will have to be made to the existing tailing dump which has reserves of 8 million tonnes at a content of 0.7%  $\text{Li}_2\text{O}$  or equivalent to 138,500 tonnes of  $\text{Li}_2\text{CO}_3$ .

8. It may be feasible to mine and mill ore purely for lithium products but more information is required on its reserves which are not associated with economic tin values.

9. Maximum potential production from Kamativi, through detailed investigations has shown that recovery of spodumene from the ore can best achieved desliming and flotation of the plant discard or tailings. Recovery of  $\text{Li}_2\text{O}$  obtained was 58%. The spodumene produced is, however, high in tin (0.3%) and iron (0.19%) to be acceptable to the ceramic industry and must therefore be converted to lithium chemicals.

10. Of the two proven processes for the production of lithium chemicals the most potentially applicable to Kamativi is the lime process which will give a recovery of 70% of the  $\text{Li}_2\text{O}$  content in the spodumene. This, not counting the used of tailings already at hand, may result in the production of 12.1 million lb. of  $\text{Li}_2\text{CO}_3$  per year.

11. Total non-Communist of lithium carbonate in 1979 was estimated to be 23,000 tonnes. The U.S.S.R. consumption for the same year was estimated to be between 3,400 and 5,200 tonnes.

12. Longer terms forecast for the year 2,000 was estimated in Li equivalent as:

USEM	100,000 tonnes
Dr.I.A. Kunass(Foote Min.)	500,000 tonnes

Taking the USEM figure, it can be seen that Kamativi's potential production will amount of 1% of world demand in the year 2,000 as against 20% at the present.

13. Maximum specification for iron in the ceramic producer is 0.1% iron in the spodumene concentrate (Bikita concentrates run a typical 0.07% iron). Microprobe analysis showed that Kamativi contains 0.14% Fe in the crystal lattice of its spodumene. The iron content, therefore can not be reduced below this level without expensive chemical treatment.

14. Market potential in South Africa appears very limited, being to possible use in the Alusaf Aluminum Smelter at Richard Bay and as a swimming pool chemical. Maximum demand is put at 500 tonnes per year of  $\text{Li}_2\text{CO}_3$  equivalent.

15. Several processes have been investigated for the extraction of  $\text{Li}_2\text{O}$  values from the Kamativi ores. But fundamentally heavy media separation and flotation. By heavy media, one test on the tin plant tailings gave a recovery of only 50% of the lithium values at a grade of 2.5%  $\text{Li}_2\text{O}$ . This poor result was probably due to the finess of the feed material.

16. Extensive tests have been done by Mr. Billiton, IDC staff and the faculty of the North Carolina State University on beneficiation by flotation methods. These tests, after desliming, prior to flotation, gave a recovery of 58% of the  $\text{Li}_2\text{O}$  values, but it is mention that probably in practice should be closer to 70%.

OUTLOOK OF PRODUCTION AND CONSUMPTION OF  
LITHIUM MINERALS AND CHEMICALS

Lithium minerals are produced in a number of countries around the world. It is also produced, as a chemical, usually lithium carbonate, from saline deposits or brines. These countries are: Argentina, Brazil, Canada, China \*, Mozambique, Namibia, Portugal, Rwanda, U.S.S.R. \*, U.S.A. \*, and Zimbabwe \*. (The asterisk following the name of the country are the major producers).

In addition, it will be not a surprise that Zaire, with very much extended reserves of lithium ores than Zimbabwe, may become another large producer in the world in the future.

The list given above does not include a country like Chile, where Foote Mineral Co. together with Sociedad Chilena de Litio, Ltda., will start in 1984, the production of lithium carbonate from brines found in the southern section of the Salar de Atacama, at a rate of 12 million tons of the salt per year after a total investment of US\$ 61 million, which after recent revision will be reduced to US\$ 55 million. The process will use solar evaporation to concentrate the brine. Brine pumping started in late 1982 and construction of the plant is well advance at the moment.

Bolivia is also not listed in the above, but Lithium Corporation of America (LITHCO) is making substantial efforts to make lithium carbonate from the Salar de Uyuni in south west of the country. Lithco also has the rights to extract lithium values from the northern section of the Salar de Atacama in Chile.

The United States continues to be the world's larger producer (over 45% of the total world production), consumer of lithium minerals and chemicals and the largest exporter.

The estimated production of lithium chemicals in the world during 1980, was slightly lower than in 1979, with about 50,000 tones expressed as lithium carbonate. Because the worldwide recession, the demand of lithium may still be suffering additional reductions during the coming year.

Thus, if this situation is to be improved in the future, will very much depends in the recovery of primary aluminum metal production. As a consequence, a potential increase or adoption of granular lithium carbonate addition to the electrolytic salts bath in the United States, Western Europe and elsewhere. Granular lithium carbonate added to the bath at a rate of 2.5 to 3.5% of the total salts allows to form a eutetic mixture with lower temperature of melting, reduces power consumption and reduces volatilization of fluoride, among other advantages. Primary aluminum metal production, as other basic metals for the metallurgical industry, is at a very low level. However, some analysts, predict that there are signs of recovery of metals production but very few are telling when normal production according capacity will be attained. In North America about 45% of all primary aluminum production are using lithium in their electrolic baths as compare with only 16-18% in Europe and 50% in Argentina, Brazil and Venezuela.

Of course, that, it will be helpful, with the increase of population, additional lithium consumption will be larger in the ceramics and glass industries, and perhaps also in the commercial production of batteries.

During 1978, the United States consumption of lithium chemicals were distributed as following:

Aluminum production	35.3%
Ceramic and glass	26.5%
Lubricant greases	14.7%
Others(pharmaceutical, synthetic rubber, thermoplastics, etc.)	23.5%

The forecast consumption in the United States for the year 2,000 varies over an extensive range: from a low of 32,000 tons to a high of 217,000 tons all expressed as lithium carbonate. The probable consumption has been set at 62,000 tons.

The distribution of total consumption of lithium in the world (except China and the U.S.S.R. whose statistics are not disclosed) in the year 1981 can be tabulated as following:

North America	47.1%
Western Europe	22.4%
Japan	10.7%
South America	9.5%
Other countries	<u>10.3%</u>
Total consumption	100.0%

At the present, production of lithium chemicals at the installed capacity is low because of decreased demand. Further, it is projected that if the future market will substantially improve, it could be met by the established plants and the new processing plants which will be on stream by mid-1984 and thereafter.

Another drawback for the production of lithium chemicals in Zimbabwe is the lack of chemical production, and specially those needed in most of the "simple" flowsheet that could be adopted. The other important factor, if chemicals derived from lithium are to be produced, is the expensive cost of transportation to the consumer market.

In respect of chemicals it found during the visit to the country, that there are not quantities of pure enough limestone, or if there is the reserves are not known at this time. The chemicals available for production are also very high in cost. Mr. Anderson, Economic Geologist at the Geological Survey Department, provided the price of some of the chemicals which may be needed if other routes (than the calcination of lithium minerals) may be used. Following are the prices given in Z\$ as compared with the prices of the same chemicals in the United States, all in bulk delivered :

	Z\$/metric tonne delivery Harare	US\$/short ton (*)
Sulfuric acid	212.00- 220.00	75.00-95.00
Sulfuric acid (from SO <sub>2</sub> )	N.A.	55.00-75.00
Sodium carbonate	170.00- 200.00	85.00 (**)
Sodium carbonate		120.00 (***)

(\*) F.O.B. plant.

(\*\*) F.O.B. Wyoming

(\*\*\*) Sodium carbonate by Solvay' process in Eastern U.S.A.

As can be seen, there is a wide difference in the price range in Zimbabwe in respect to the United States.



THE BIKITA OPERATION

Not much can be said about this operation after so much has been published in the world technical literature (see References). However, few remarks can be presented at this time.

The operation have now a sock-pile, bagged and ready to be shipped, of petalite concentrate containing 4%  $\text{Li}_2\text{O}$  with 0.07% of  $\text{Fe}_2\text{O}_3$  and small amounts of  $\text{Na}_2\text{O}$  and  $\text{K}_2\text{O}$ . This amounts to two years annual production.

Consequently, they had to reduce their working force from over 200 men to 130 and working one shift a day six days a week, rather than two shifts a day seven days a week in the past.

The flotation plant (for spodumene) is shut down since December, 1982, probably because technical or other difficulties.

They considered the production of lithium carbonate as far back as 1970, but found that they will have a limited world market, and they think in the same way at the present.

Figures 1, 2 and 3, diagramatically show the three main flowsheets involved in the Bikita operation.

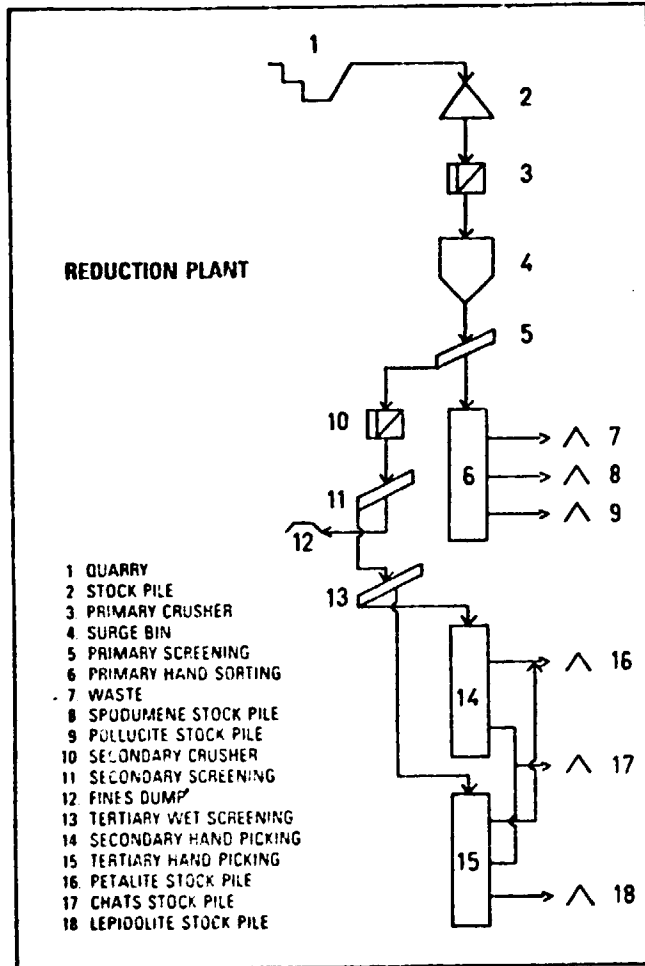


FIGURE 1: The Reduction Plant at Bikita works

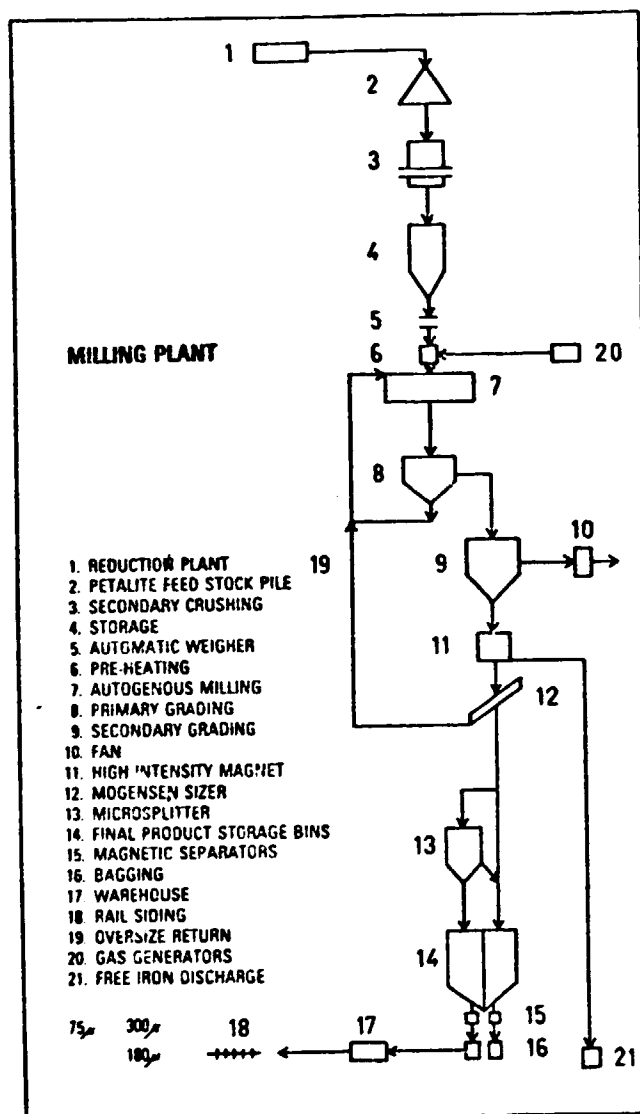


FIGURE 2: The Milling Plant at Bikita works

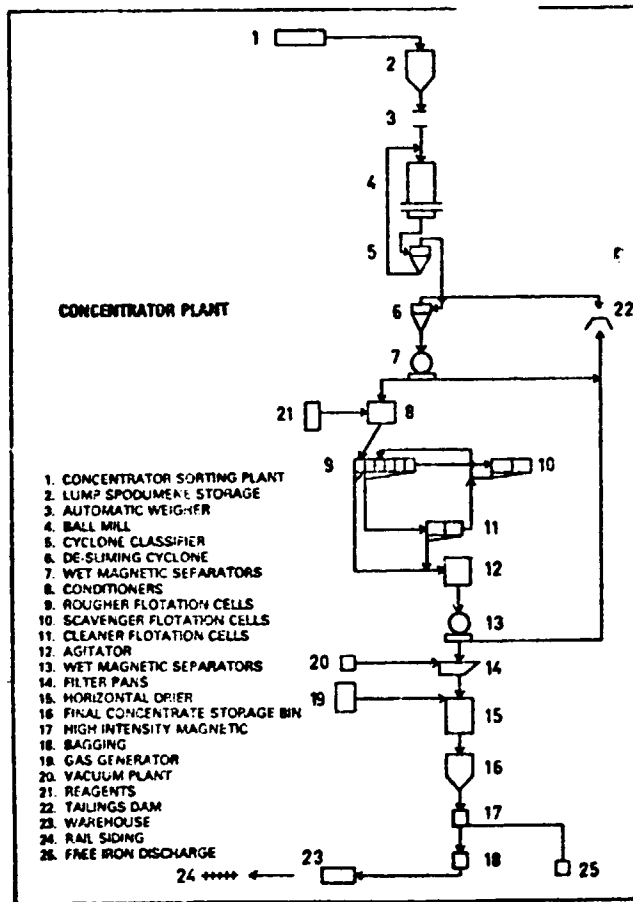


FIGURE 3: The Concentration Plant at Bikita works

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VISITS PAID DURING THE MISSION TO ZIMBABWE

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- J.C. Graylin, Managing Director, Bikita Minerals (Pvt.)Ltd.
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