B.E. CORNISH & ASSOCIATES

ANNUAL REPORT

EXPLORATION LICENCE

EL 3239 N.T.

Which Includes

THE BARITE RESOURCES OF

THE KIRRKIMBIE YARD AREA, INVERWAY STATION

NORTHERN TERRITORY

LOCALITY: INVERWAY, LIMBUNYA DISTRICT

FOR

NIBAR MINING PTY LTD

(EL3239 and the associated ML's are under option to
Antrim Barites Corporation Pty Limited)

Consulting Geologist: B.E. Cornish & Associates

April, 1985

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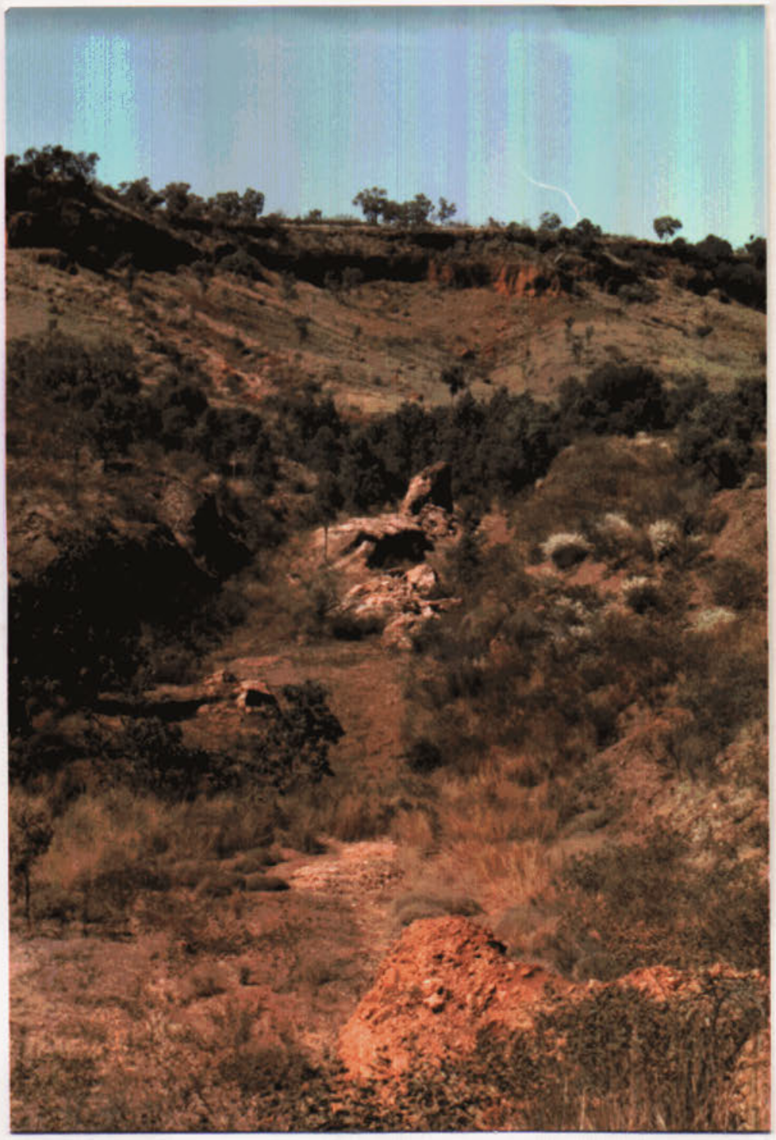

GENERAL VIEW LOOKING SOUTH OF THE MAIN LODE

I INTRODUCTION

a. General

The 3rd anniversary of EL 3239 occurred on March 15, 1985. Since that date B.E. Cornish and Associates on behalf of Nibar Mining Pty Ltd has lodged an application in writing to the Secretary reapplying for 9 blocks as shown in the enclosed block diagram. A cheque for $180 in support of the application for the 9 blocks was paid on April 2, 1985. Details of the areas reapplied for are shown in the accompanying figures.

During the period from the last renewal of EL 3239 on the 15th March, 1984 the writer visited the locality and conducted further geological and logistical assessment of the commercial viability of a large scale barites mining and milling project at Kirrkimbie Yard, Inverway Station and using some ore mined from the Bingy Bingy Springs area of EL3144.

The last assessment in the early 1970's resulted in an attempt by the company, South Australian Barytes Pty Ltd to establish a viable mining operation on site to supply ore to a milling plant in Wyndham Western Australia.

For reasons primarily relating to overriding political and economic factors, the project was abandoned in 1973.

These factors are improving slowly, primarily due to the increase in oil exploration activity in the Bonaparte Gulf and Timor Sea areas immediately to the north and the Canning Basin to the South West. Market studies are now continuing in this more favourable climate and also with the view to studying the possibility of exporting large tonnages of crude ore to Singapore.

A further geological and ore reserve assessment of the area is being made and the attached report 'up-dates' these figures and provides a basis for further mine cost evaluation studies.

b. Geological Consultants

For the exploration licence tenure period to March 1985 the company Nibar Mining Pty Ltd acquired the services of B.E. Cornish and Associates to continue further detailed geological marketing and mining and milling feasibility studies to determine the likelihood of developing a commercially viable project in the near future. Details of these studies are outlined in the following exploration and development report for 1984/85.

II LOCATION AND REGIONAL GEOLOGY

Exploration Licence EL3239 was granted on March 15, 1982 for five years to Nibar Mining Pty. Ltd. It covered an area of 124 square kilometres and is situated 30 kilometres N.N.W. of Inverway Homestead on the road between Inverway and Mistake Creek. This area is covered by the Limbunya 1:250,000 sheet (SE.52-7).

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The regional geology of the locality is discussed by D.M. Traves (1955) in 'The Geology of the Ord-Victoria Region, Northern Australia' (B.M.R. Bull. No. 27).

The oldest rocks in the area are the Upper Proterozoic Victoria River Group, consisting of sandstone, shales and limestones. These were strongly dissected prior to deposition of the Antrim Plateau Volcanics, at the base of the Cambrian.

The Antrim Plateau Volcanics, in which all the known outcrops of barite occur, represent at least six phases of volcanism. Lava flows varying from olivine to quartz basalts are separated by agglomerates and ash. At Inverway the volcanics have a maximum thickness of 80 metres, while 100km west, at Turner Homestead, a thickness of 1000 metres is recorded.

Conformably overlying the volcanics are the Negri Group limestones and shales. These occur in basins within the volcanics and have a maximum thickness of 600 metres in the Hardman Basin, west of Inverway. Conformably overlying the Negri Group is the Upper Cambrian Elder Sandstone.

Laterization of a pre-existing erosion surface, which is now dissected to form mesa-topography, has resulted in 3 to 6 metres of nodular laterite on the tops of most hills in the area. Tertiary alluvial soils are present in the valleys.

Apart from the Antrim Plateau Volcanics, the only evidence of igneous activity in the region are Proterozoic gabbros to the west, and Proterozoic granophyres 80km to the south.

SUMMARY OF EXPLORATION ACTIVITIES

Six steeply dipping barite veins occur in the Kirrkimbie Yard Area, near Inverway Station, Northern Territory, two of which were mined by South Australian Barytes Pty Ltd in 1971-72. The widest and most continuous segments of these veins are held beneficially under lease by Nibar Mining Pty Ltd. An estimate of the Barite resources in the lease areas has been made. This is based on previous ore reserve calculations of the Main and West lodes which were mined previously, and measurement of the surface outcrops of the other veins during a field inspection of the area.

Approximately 3200 metres of vein occurs in outcrop within the leases with an average width of between 0.8 and 2.1 metres. A conservative estimate of barite resources in the Kirrkimbie Yard lease areas to a depth of 20 metres is as follows:

	Tonnes	
Main and West Lodes		227000
Main Lode South	26000	
Bellchambers Lode	21000	
Coates No.1 Lode	45000	
Coates Nos.2,3 Lode	79000	
Bowering Lode	77000	248000
	TOTAL	475000

This estimate is not in the proven category. Further potential exists within the leases in areas covered by overburden. To quantify this potential and accurately assess ore reserves outside the Main and West Lodes, an exploration programme of percussion drilling and trenching is required.

History

The Kirrkimbi Yard barite deposits, Northern Territory, were mined on a small scale in the period April, 1971 to November, 1972 by South Australian Barytes Ltd. Since this operation ceased additional barite deposits have been discovered in the same area and these, together with the remainder of the original deposits, are currently under consideration for further production by Nibar Mining Pty Ltd of Adelaide, South Australia.

This report gives the results of my assessment of the barite resources of the Kirrkimbie area.

Location

The Kirrkimbie area is located 33 kilometres north-north-west of Inverway Station, Northern Territory, near the Western Australian border, 300km south-south-east of Kunnanurra.

Tenure

The Barite deposits are held under 19, 20 acre Mineral Leases, Nos. (O.P.F.) 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 155, 156, 157, 158, 159, 160, 161 in the name of A.J. Turner. These leases are currently held by Nibar Mining Pty Ltd and under option to Antrim Barites Corp Pty Ltd.

Geology

a. Regional

The Kirrkimbie Yard area is underlain by flat lying mafic flows, pyroclastics and volcanoclastics of the Lower Cambrian Antrim Plateau Volcanics. These volcanics are covered by a 3 to 5 metres thick layer of pisolitic Tertiary laterite. The laterite has been dissected and presently forms mesa-type topography in the area of the barite lodes.

b. Barite Lodes

The barite lodes consist of seven steeply dipping veins, striking north and north-west. They are traceable over distances of several kilometres as shown in Figure 1. The six largest and most continuous sectors of these veins are held within the current leases. These are the West and Main lodes which were mined by South Australian Barytes Ltd., and the Coates, Bellchambers and Bowering Lodes.

The veins vary from less than 20 cm to over 5 metres in width and are composed of coarse and fine laminated barite, white in outcrop, but occasionally with a slight pink or brown stain. The veins are sinuous in outcrop and may vary rapidly in thickness over short strike lengths. Dips are predominantly subvertical but may be as low as 75 degrees in either direction.

CR85/126

ANTRIM BARITE CORP. PTY. LTD
EL 3239 MINING LEASES
BARITE LODES
Nº 1
Nº 2
Nº 3
Nº 4
Nº 5
Nº 6
Nº 7
Nº 8
Nº 9
Nº 10
Nº 11
Nº 12
ML34
ML35
ML36
ML37
ML38
ML39
ML40
ML41
ML42
ML43
ML44
ML45
ML158
TRACK
ROAD
ALLUVIAL
CAMP
TO ROAD
BARITE FLOATERS
MAG NORTH
500m
BARITE LODE

c. Lode Material

The veins in outcrop are virtually 100% barite with occasional inclusions of quartz. The lode material is 95% to 98% $BaSO_4$, the only significant dilutant being 1% to 4% $SrSO_4$ (Campbell, 1972).

Reid (1970) reports the following results for specific gravity and chemical analysis of the coarse grained and fine grained layers.

	Coarse Grained	Fine Grained
Specific Gravity	4.32	4.35
$BaSO_4$	95.1%	98.2%
$SrSO_4$	4.15	0.71
SiO_2	0.18	0.30
	99.43%	99.21%

Bulk samples from the Main Lode and West Lode give the following results (Reid, 1970).

	Main Lode	West Lode
Specific Gravity	4.28	4.54
$BaSO_4$	97.3%	96.9%
$SrSO_4$	2.05	2.40
SiO_2	0.33	0.33
	99.68%	99.63%

Barite Resources

a. Main and West Lodes

Campbell (1972) carried out an assessment of barite "ore reserves" on the Main and West Lodes. The estimated amounts of ore available over a vein length of 1400 metres were as follows:

	0-10m	0-15m	0-20m
Probable Ore, Tons	115000	201000	288000
Possible Ore, Tons	47000	82000	117000
TOTAL TONS	162000	283000	405000

Campbell (1972) based his estimates on data from :-

1. the Western Mining Corporation percussion drilling.
2. the Western Mining Corporation measurement of surface lode widths at their drilling sites.
3. South Australian Barytes Ltd. measurements of surface lode widths in the north of the Main Lode.

Campbell estimated the yield of saleable product as likely to be:-

0-10m 130000 tons; 0-15m 226000 tons; 0-20m 324000 tons.

The assumptions in these calculations were:-

* specific gravity 4.35
* mining recovery 90%
* mill recovery 90%

Estimates of possible ore were derived from vein measurements in the central poorly exposed portion of the Main Lode. Campbell suggested further potential for possible ore may exist at the south end of the Main Lode.

In the opinion of the writer, after field inspection of the Main and West Lodes, the assumptions and calculations of Campbell are a reasonable estimation of the barite resources in these two veins at the time. Information provided by Mr. M. Nickels of Nibar Mining Pty Ltd indicates about 30000 tons of ore was removed from the Main and the West Lodes by South Australian Barytes Ltd. subsequently. However, the amount of product produced is not known, although could probably be found in the company reports of the time. Also no mill reconciliation is available to check the assumptions of dilution and recovery. The present barite resources therefore are likely to be somewhat less than Campbell's estimates, but they do define the order of magnitude of the deposits mined to date.

An accurate reassessment of the barite resources can only be made if the exploration and production data are made available. However, taking Campbell's assumptions of 90% recovery in the mining operations, his estimates will fall by 45000 tonnes. To a depth of 20 metres therefore, the recalculated barite resources will be 227000 tonnes. This is the equivalent figure of Campbell's estimates to a depth of 70 feet, the depth of open cut mining.

b. <u>Other Lodes</u>

Campbell (1972) made no estimates of barite resources for the other lodes in the area, nor for the southern end of the Main Lode, the former because they were discovered after his assessment, the latter because of lack of access at the time.

These other lodes were measured by the writer during the field inspection in order to establish the order of magnitude of the barite resources outside those established by Campbell (1972). This was accomplished by chaining the barite exposures within the leases and measuring the widths at 20 metre intervals. The basis for the calculations is as follows:-

* Only those segments of the veins which outcrop, or where continuity can reasonably be inferred in areas of partial cover are included.

* The width of split veins are added if the width of intervening rock is less then 2 metres.

* A specific gravity of 4.35 is assumed.

(i) Main Lode South

This extension of the Main Lode occurs within ML 41. It is separated from the Main Lode by a laterite capping. The vein has been partially stripped but probably not mined by South Australian Barytes Ltd.

Total length	260 metres
Length exposed	260 metres
Average Width	1.15 metres
Resource Potential	1300 tonnes/vertical metre
Resource to 20 m depth	26000 tonnes

(ii) Bellchambers Lode

This lode is most likely an extension of the West Lode. The lode is split at its central and western end and partially covered with scree.

Total length	280 metres
Exposed length	180 metres
Average width	1.33 metres
Resource potential	1040 tonnes/vertical metre
Resource to 20 m depth	20800 tonnes

(iii) Coates No. 1 Lode

This lode is separated from Coates No. 2 and 3 by about 3 kilometres but has been interpreted as an extension of the same structure (Figure 1). The lode forms zones up to 6 metres in width comprising two or three veins.

Total length	360 metres
Exposed length	260 metres
Average width	2.00 metres
Resource potential	2250 tonnes/vertical metre
Resource to 20 m depth	45000 tonnes

(iv) Coates No. 2, 3

This lode occurs in two leases separated from each other along strike by about 300 metres, striking west-north-west. An overall strike length of over 1200 metres is indicated, the widest and most continuous segments occurring within the leases.

In Coates No. 3 lease the lode is divided by a laterite covered mesa, as follows:-

Western End

Total length	160 metres
Exposed length	100 metres
Average width	0.84 metres
Resource potential	365 tonnes/vertical metre
Resource to 20 m depth	7300 tonnes

Eastern End

Two veins separated by about 10 metres occur at the western end of this exposure. The veins lengths are added to calculate the exposed length and average width:-

Total length of vein system	280 metres
Exposed length	250 metres
Average width	0.90 metres
Resource potential	975 tonnes/vertical metre
Resource to 20 m depth	19500 tonnes

In Coates No. 2, a wide well exposed lode is present, consisting in part, of two or more veins occurring in a zone up to 7 metres in width.

Total length	400 metres
Exposed length	280 metres
Average width	2.15 metres
Resource Potential	2600 tonnes/vertical metre
Resource to 20 m depth	52000 tonnes

(v) Bowering Lode

This lode occurs over three leases with an overall strike length of about 1300 metres.

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No. 1 Lease

The lode here is thin and discontinuous, covered in part by black soil.

Total length	100 metres
Exposed length	60 metres
Average width	1.00 metre
Resource potential	260 tonnes/vertical metre
Resource to 20 m depth	5200 tonnes

No. 2 and No. 3 Leases

The lode here is long and well exposed, covered partially at the north end by a laterite mesa.

Total length	700 metres
Exposed length	440 metres
Average width	1.90 metres
Resource potential	36000 tonnes/vertical metre
Resource to 20 m depth	72000 tonnes

c. Ore Reserve Estimate

Total barite resources over a total exposed lode/vein length of approximately 3200 metres to a depth of 20 metres for each of the lodes described above (to the nearest one thousand tonnes) are as follows:-

	Tonnes	
Main and West Lodes		227000
Main Lode South	26000	
Bellchambers Lode	21000	
Coates No. 1 Lode	45000	
Coates Nos. 2, 3 Lodes	79000	
Bowering Lode	77000	248000
	TOTAL	475000

It is emphasized that, apart from the estimates of the Main and West Lodes, which are recalculated from the figures of Campbell (1972), the total figure does not constitute an ore reserve and should not be quoted as such. Further exploratory work in the form of drilling and trenching to provide accurate data on the width of the lodes outside the Main and West Lodes is required before an ore reserve estimate can be made. Any estimate of ore reserves will also require consideration of the mining method and accurate estimates of mill recoveries.

If mining of the lodes is planned, then an exploration programme involving percussion drilling and trenching should be carried out to establish the ore reserves accurately.

d. Potential Reserves

In a number of areas within the leases further potential exists where the barite lodes are partially or totally covered with overburden. A further 700 metres of poorly exposed vein occurs in the areas measured for the calculations above, and extensions of all veins can be reasonably expected. No tonnage estimate is made, since an exploration programme would be required to quantify these resources.

e. Conclusion

Total barite resources in six steeply dipping veins in nineteen leases held beneficially by Nibar Mining Pty Ltd in the Kirrkimbie area are 475000 tonnes in approximately 3200 metres of outcropping lode to 20 m in depth.

If mining of these lodes is contemplated, a programme of percussion drilling and trenching outside the Main and West Lodes is required to accurately assess the ore reserves.

Further potential exists within the leases in areas of the veins covered by overburden.

IV MARKETING STRATEGY

At the present stage of the assessment and feasibility studies on the barite deposits in the Inverway, Limbunya district of the Northern Territory. It has been ascertained that there exists within this region reserves of barite of oil drilling mud grade meeting the necessary API specifications of the order of, in excess of 1,000,000 tons, of recoverable reserves. This reserve has sufficient to establish and sustain a viable mining extraction and possible milling operation for 10 to 20 years at the rate of 50,000-100,000 tons per annum provided markets can be contracted.

It may be possible to sell crude ore in tonnages of a lesser in the early years to markets primarily in South East Asia, however, it is the prime aim of the groups to, wherever possible, provide milled product to specification from a mill either located on site or in Wyndham.

Antrim Barites Corporation Pty. Limited has entered into agreement with Nibar Mining Pty Ltd and A.J. and C.E. Turner respectively to acquire and develop mining leases in EL 3239 and rights to further mining leases proposed from EL 3144.

Antrim Barites Corporation Pty. Limited under the management of B.E. Cornish and Associates is seeking various marketing arrangements with Australian and worldwide suppliers to the oil industry. Currently these suppliers are being made aware of the availability of the ore both in tonnage and specification with the intent to supplying industry with initial trial shipments in the coming year to June, 1986.

V COMMERCIAL DEVELOPMENT AND FEASIBILITY STUDIES

The development of barites resources at Kirrkimbie Yard and Bingy Bingy Springs is currently under study by several engineering and Industrial Mineral groups to determine the logical and most efficient method and sequence of mining these deposits. Feasibility studies are being carried out with the view to extracting the ore under contract and either milling on site or trucking crude to Wyndham or Darwin for milling. In either situation it is envisaged that crude ore and milled barites will be shipped ex Wyndham to Australian and overseas consumers.

Sufficient ore exists in both deposits to sustain a substantial mining and milling operation provided stable markets remain open.

VI PROPOSED 1985/86 PROGRAMME

The proposed programme for 1985/86 is to conduct a costeaning programme at regular intervals along the ore bodies where those extensions of the ore body are covered by alluvium in order to accurately plan a mining programme and to establish additional proven reserves.

Additional detailed sampling programmes will be conducted to determine whether quantities of filler grade barites may be available for the development of several high grade lines or product.

It is also planned to obtain estimates of the costs of construction of additional road works necessary to link EL 3144 to the Duncan Highway and to the cost of up grading sections of the connecting road from EL 3239 to the Duncan Highway where it crosses the Negri River into Western Australia.

VII PROPOSED EXPLORATION PROGRAMME BUDGET FOR 1985/86

		$
1. Costeaning and sampling programme over alluvium covered areas.		10,000
2. Mining cost feasibility study (shared with EL 3144)		5,000
3. Marketing Study. (shared with EL 3144)		7,500
4. General field service costs and travel. (shared with EL 3144)		8,000
	TOTAL	$30,500

VIII CONCLUSION

The company Antrim Barites Corporation Pty Limited has been formed by Cornwall Resources Corporation Ltd, the founding company of Plymouth Petroleum Resources N.L. and the controller Permian Petroleum Corporation Pty Limited and Laurel Bay Pty Ltd all with extensive oil exploration and production interests in Australia. Members of these above groups are joint venture partners in the Blina and Sundown Oil Fields of the Canning Basin of Western Australia, the Tintaburra

VIII CONCLUSION (CONT)

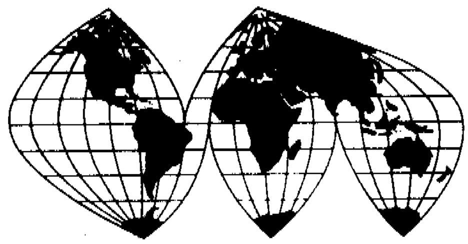
Oil Field in the Eromanga Basin of South West Queensland and the Petrel Gas Field in permit NTP28 in the Northern Territory.

The group is in partnership in various capacities with the majority of the major companies in the Australian exploration industry and foresees a growing market, particularly in northern Australia for oil drilling grade barites.

Through agreements with Nibar Mining Pty Ltd and A.J. and C.E. Turner lodged with the Department of Mines and Energy, Darwin, it intends to obtain contracts for the supply of crude barite ore initially to the Australian Oil Exploration Industry and to markets in South East Asia. To warrant developing the Inverway district barites deposits covered by exploration licences EL 3144 and EL 3239 initial crude ore markets need to be established. During the year mineral leases will be taken out over all those areas of Exploration Licence EL 3144 where future mining is planned and application will be lodged for such during the dry season of 1985.

Yours sincerely,

B.E. CORNISH & ASSOCIATES



Estimation of barytes consumption during oilwell drilling

*by Chris Drawater**

When examining potential markets, be it a new area, field, or country, barytes traders and producers with little or no access to drilling fluid (mud) engineering expertise often experience difficulty in determining or cross checking actual up to date market sizes. This article intends to provide two methods of estimating the approximate quantity (magnitude) of API/OCMA grade barytes powder consumed for a given well. Although such calculations will of course not be as accurate as perhaps those presented in mud engineering well proposals they will still be found to be of considerable use. Careful extrapolations of tonnage per foot, average well sizes, costs etc. can be utilised to cover required market areas. However, care must be taken that when extrapolating from the estimation of single well consumption to that of an area to cover only similar geological areas, hydrocarbon types, formation pressures, trap types, etc. For example, consideration of one well cannot provide data applicable to all US markets (eg. Louisiana is around 1.5m. short tpa but onshore California perhaps 30,000 short tpa.).

Table 1 — Hole Capacity

Hole Size (in.)	*bbl/ft.*
36	1.259
26	0.6567
17½	0.2975
12¼	0.1458
10⅝	0.1097
8¾	0.0744
8½	0.0702
7⅞	0.0602
6	0.0350

Table 2 — Casing Capacity

Casing Size (in.)	*bbl/ft.*
30	0.7616
20	0.3552
18⅝	0.3062
16	0.2222
13⅜	0.1497
11¾	0.1175
10¾	0.0942
9⅝	0.0732
8⅝	0.0594
7⅝	0.0459
7	0.0371
5½	0.0232
4½	0.0155

Table 3 — Mud Systems and Weights

Type	*Approx. original weight (ppg)*
High-viscosity bentonite	8.7
CMC polymer/bentonite	8.5
KCL/polymer	9.0
Lignosulfonate	8.6
Gypsum lignosulfonate	8.6
Oil mud	10
NaCL/polymer	10
Relaxed filtrate invert emulsion	7.8

Method 1

By examining back issues of journals such as the *Oil and Gas Journal*, *World Oil*, etc. it is often possible to locate special features on certain wells within the area(s) of interest which can provide detailed information on the drilling of those wells — casing and hole sizes and depths, mud systems, and weights. From this data, it is possible to estimate barytes consumption of the wells in question. The method is based around old, but simple mud engineering principles, whereby the quantity of barytes (required to increase a fixed volume of mud from the original to the required mud weight), is calculated interval by interval utilising the following equation:

$$V_B = \frac{V_1 (W_2 - W_1)}{(W_B - W_2)} \quad (1)$$

where: V_1 = Volume of mud before weighting (bbl)
V_B = Volume of barytes added (bbl)
W_1 = Initial mud density (ppg)
W_2 = Final mud density (ppg)
W_B = Barytes density (35.4 ppg)

ppg = pounds per gallon *bbl = barrels (US)*

Table 4 — Example barytes consumption estimation

Location:	US Gulf (Offshore Texas)
Well:	Oil
Type:	Exploration
Target depth (ft.):	17,000 (Deep Miocene)
Water depth (ft):	150
Rig height above sea level (ft.):	100
Riser diameter (in.):	24
Surface mud (bbl):	600
Constant mud vol. (bbl):	730

Interval	*Casing*	*C-depth*	*C-bbl/ft.*	*Hole*	*H.depth*	*H-bbl/ft.*	*Mud vol.*	*Mud code*	*Mud wt.*	*Req. wt.*	*Bar-bbl*	*Barytes*
1.	0	0	0	36	400	1.259	—	—	—	—	0	0
2.	30	400	0.7616	26	1,000	0.6567	—	—	—	—	0	0
3.	20	1,000	0.3552	17.5	4,500	0.2975	—	—	—	—	0	0
4.	13.375	4,500	0.1497	12.25	10,000	0.1458	2,205.55	4	8.6	12.5	375.6	253.8
5.	11.75	10,000	0.1175	10.625	13,500	0.1097	2,288.95	4	8.6	16	873.1	590.0
6.	9.625	13,500	0.0732	8.5	17,000	0.0702	1,963.7	7	7.8	18	1,151.1	777.8

Total barytes requirement: 1,621.6
Footage per tonne: 10.48

Note: *Hole sizes hypothetical to accommodate required casing sizes.*
Data source: *World Oil May 1982 p. 124.*
Mud Types: *4 = Lignosulfonate, 7 = Relaxed Filtrate Invert Emulsion.*

**Chris Drawater is presently working as an independent geologist.*

From the required volume of barytes, the barytes tonnages (metric tonnes) can be calculated using **equation (2)**.

$$T = V_B \times 0.159 \times 4.25 \qquad (2)$$

where: T = Barytes tonnage (tonnes)
V_B = Volume of barytes (bbl)
0.159 is bbl to cubic metres conversion factor
4.25 = SG of barytes

First of all, however, the actual volume of mud being circulated within the well for a given interval must be determined. For example, consider a 12¼in. hole being drilled to 8,800ft. T.D. through 13⅜in. casing set from the surface to 5,000ft.

bbl Capacity of casing = 5,000 × 0.1497 (see Table 2)
= 748.50
bbl Capacity of hole = (8,800 − 5,000) × 0.1458 (see Table 1)
= 554.04
Total volume = 1,302.54 bbl

However this calculation does not take into consideration the volume displacement of the drill pipe metal, collar, and bit. These will decrease the circulating mud volume by around 10–15%. Thus,

Down hole mud volume = Casing volume capacity + hole volume capacity — (volume displacement of drill pipe, collar, and bit).

But, because of the following factors this simple method does not take pipe etc. displacement into account.

- we are only interested in magnitude size
- drill collar size data etc. probably will not be available
- that volume can probably be partially offset or accounted for in the mud tank volume, surface pipes, etc.

As for the surface mud volume, all of which requires weighting since the fluid is continually circulating between surface and drill bit, a volume of 400–600 bbl is utilised. However this can vary from rig to rig. For example, a drill ship might have an active mud volume of 190 cubic metres (1,195 bbl) with a total mud volume of 490 cubic metres (3,081 bbl). Our 600 bbl would derive from 600 bbl active mud/200 bbl reserve.

This 600 bbl will be constant for any interval and should the rig be of an offshore variety then a riser (between the sea floor and rig) will also be present with an additional mud filled volume which is again constant for any interval. The riser volume will be:

internal volume capacity per ft. × (sea water depth + height of rig above sea level).

One can assume a 24in. riser (0.52 bbl/ft.) with a rig height 100ft. above sea level.

Riser volume = (sea water depth + 100) × 0.52 bbl/ft.

So our final volume of mud requiring an increase in mud weight by the addition of barytes using **equation (1)** is:

Table 5 — Selected examples of world mud weights and depths

Location	*Mud weight (ppg)*	*Depth (ft.)*
Offshore Angola	16.5	13,888
Offshore Cameroon	17	12,532
Benin: Seme Oilfield	12.8	9,022
Southern California: San Joaquin Valley	9.2	1,100
Offshore California	?10.5–10.8	?9–10,000
Offshore Texas	18	17,000
US Permian Basin: Maljamar Field	12.8	4,148
US Illinois Basin: Rosiclare Porosity Zone	9.2	3,050
Offshore China: S. China Sea	?11.0	?7,000
Indonesia: North Sumatra Arun Gas Field	13.6	10,000

Final volume = Surface volume (600 bbl) + riser volume (if applicable) + casing volume + hole volume.

Consider a complete interval example:
Aim — Increase weight of KCL/Polymer mud to 10.5 ppg from its original weight of 9.0 (see Table 3). As before consider a 12¼in. hole to 8,800ft. through 13⅜in. casing set to 5,000ft., with 600 bbl surface volume, sea depth of 150ft. and rig height of 100ft.

Riser volume = (150 + 100) x 0.5 = 130 bbl
Casing volume = 5,000 x 0.1497 = 748.5 bbl
Hole volume = (8,800 − 5,000) x 0.1458 = 554.04 bbl
Total mud system volume = 600 + 130 + 748.5 + 554.04 = 2,032.54 bbl

Volume of barytes required $= 2{,}032.54 \dfrac{(11.1 - 9.0)}{(35.4 - 11.1)}$ ≈ 175.65 bbl

From **equation (2)** barytes required = 175.65 x 0.159 x 4.25 = 118.7 tonnes

Please note that (a) should the initial mud system not be known, it would not be too far off the mark to assume a mud weight of 8.5 ppg, (b) if the mud weight is not given but instead a bottom hole pressure or formation pressure is known, then the conversion equation is:

Pressure (psi) = 0.052 x mud weight (ppg) x depth (ft.)

This system is easily computerised, and by utilising the initial mud weights for given mud systems as listed in **Table 3**, complete well barytes requirements, interval by interval, can be ascertained. A hypothetical example is set out in **Table 4**. **Table 5** presents example mud weights for given depths in named areas.

One final word, this method so far assumes that the casing is always cemented to the surface. Should this not be the case then a simple modification to the casing/hole volume calculations can be implemented, eg. for a 10¾in. casing to 12,300ft. from the surface, a 7in. casing from 12,300ft. to 18,860ft. then a 6in. hole to 21,325ft. would give a hole volume of (21,325 − 18,860) x 0.0350 + (18,860 − 12,300) x 0.0459 + (12,300) x 0.0942.

Once again, please note that although this is an over-simplification of a specialistic pursuit, these calculations do provide good quantification of magnitude of barytes requirement.

Method 2

Finally, one may estimate barytes consumption via total well cost or total mud cost by utilising the following relationships:

- Mud costs comprise approximately 10% of the total well cost.
- Barytes costs comprise approximately 40% of mud costs.
- Barytes tonnage (tonnes) $= \dfrac{\text{Barytes cost}}{\text{Average cost per tonne barytes}}$

This method works equally well for a simple well through to a whole field or area.

APPENDIX

Physical and Chemical requirements for oilwell drilling grade barytes:

Requirement	*API*	*OCMA*
(a) SG	4.2 min.	4.2 min.
(b) Soluble alkaline Earth metals as calcium	250 ppm max.	250 ppm
(c) Wet screen analysis		
(i) Residue on US sieve no. 200	3.0% max.	3.0% max.
(ii) Residue on US sieve no. 325	5.0% min.	10 ±5%

Source: API spec. 13A, 9th Edition. March 1983. API RP 13B contains performance test details.
OCMA spec. DFCP-3 (includes performance tests).

Barytes: non-drilling applications

by Joyce Griffiths, Deputy Editor

It is very difficult to accurately assess the quantity of barytes which is produced and used for non-drilling applications. Estimates of 0.6–0.65m. tonnes of chemical grade material and 0.5m. tonnes of filler grade barytes have been made. The main areas of consumption are — fillers and extenders, chemicals, glass, and ceramics. In the UK filler market the automotive industry is estimated to be the biggest consumer of barytes and barium salts in brakes, foams, paint primers, and sound deadening materials, with the paint industry running a close second, whilst the US filler market is dominated by the paint industry (including automotive paints and primers). The market for filler and extender grades of barytes is generally improving after a decline caused by the economic recession.

The chemical sector has experienced changes largely as a result of intense competition from, and subsequent replacement by, strontium chemicals. This has caused a number of barium chemical producers to retire from the field leaving only one manufacturer in the USA and two in Japan consequently placing increasing importance on European and Chinese supplies. Substitution of barium chemicals by strontium equivalents has now virtually ceased with each chemical group having secured its own area of the market thus ensuring a future steady, if reduced, demand for barium chemicals. That there appear to be no new applications for barium chemicals on the horizon underlines the maturity of the market.

Chemicals

It has been estimated that of the 1982 total world barytes production of 7.4m. tonnes about 0.6–0.65m. tonnes (8–9%) was used for the production of barium chemicals. The barium chemicals industry has experienced changes both in production and in the market over recent years. In the USA the number of barium chemical producers has been reduced from seven to leave only one in operation — *Chemical Products Corporation* of Cartersville in Georgia. A similar situation exists in Japan where only two producers now remain. These changes have occurred as a result of intense foreign competition, a decline in the use of barium chemicals following their partial replacement with strontium chemicals, and environmental problems at plant sites.

In September 1983 *FMC Corporation* announced its decision to close its barium and strontium production facilities at Modesto in California by mid-1984. At the time of announcement FMC accounted for about two-thirds of the 22,500 tpa US production capacity. US production has fallen drastically from about 75–80,000 tonnes in 1968 to about 20,000 tonnes today. The bulk of US production is for domestic use with less than 1% going in exports to Japan.

Competition has been strong from West German and Chinese imports of barium carbonate and barium chloride. This situation in the USA has given rise to allegations of dumping. The leading sources of barium chloride imports in the first nine months of 1983 were China (81%), West Germany (6%), and Italy (5%), whilst the main import sources for barium carbonate were West Germany, China, and Japan. On 6 April the United States International Trade Commission (USITC) instituted a final dumping investigation following a preliminary affirmative determination by the US Department of Commerce that barium chloride imported from China is being sold at less than fair value. A public hearing will be held on 26 June at the USITC and the commission will make its final injury decision on or before 6 August 1984. It was also determined at the preliminary investigation that barium carbonate is not being sold at less than fair value although at an earlier investigation it was unanimously decided that under section 733(a) of the Tariff Act of 1930 there is reasonable indication of material injury to US industry.

Because of their high density, high brightness, inertness, and radiation absorption characteristics barium chemicals find application in a variety of industries. The production of the most important of these chemicals is outlined in the following section whilst the specific properties which make them suitable for particular applications are discussed under the appropriate application headings.

Barium sulphide

Barium sulphide (black ash) derived from barytes forms the starting point for most barium chemicals. Barium sulphide is produced by the reduction of barium sulphate (barytes) with finely powdered coal in a rotary kiln at a temperature of 1100°C–1250°C. The end product contains about 80–85% BaS depending on the impurity content of the starting materials. Further impurities are removed by counter-current leaching of the furnace clinker with water and filtration to produce a barium sulphide solution and a leach residue containing most of the impurities.

Barium carbonate

Quantitatively the most important of all the barium chemicals, barium carbonate, finds applications in a number of industries including — glass, chemicals, ceramics, ferrites/titanates, and others. It is produced by two methods in which the starting material is barium sulphide (black ash) in each case. The methods can be summarised by the following equations:—

$$BaS + CO_2 \rightarrow BaCO_3 + H_2S$$
$$BaS + Na_2CO_3 \rightarrow BaCO_3 + Na_2S$$

Barium carbonate is used in some applications to enhance the quality of the finished product for example in the manufacture of glass, enamels, and permanent magnets. In other industries it finds application because of its ability to convert soluble sulphates into insoluble barium sulphate. The third sphere of application is in the production of barium chemicals.

UK imports of barium chemicals *('000 tonnes)*

	1976	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*
Barium carbonate	na	na	na	na	na	na	4.5
Barium chloride	3.2	2.3	2.9	2.9	3.1	0.9	1.3
Barium sulphate	na	na	5.6	6.4	5.2	4.8	4.4
Lithopone	1.8	2.1	1.8	1.9	1.4	1.3	1.3

Source: British Geological Survey, United Kingdom Mineral Statistics 1983.

Barium carbonate consumption by end-use

	Europe	*Japan*	*USA*	
	1982	*1982*	*1975*	*1983*
Glass	35%	60%	45%	30%
Chemicals	27%	20%	—	—
Ceramics	25%	—	25%	25%
Ferrites/titanates	8%	20%	7%	15%
Miscellaneous	5%	—	23%	30%

The market for barium carbonate has decreased markedly over the last few years because of several factors, not least of which has been the partial substitution by strontium carbonate in the glass industry (colour television tubes) and the manufacture of ferrites and titanates. In the chlor-alkali industry new technology has caused a reduction in barium carbonate usage since the replacement of graphite anodes by titanium in mercury cells means that higher sulphate levels can be tolerated. In contrast the introduction of membrane cell technology necessitates very low sulphate levels and a subsequent increase in barium carbonate use. Within the structural ceramics industry the use of barium carbonate remains unchallenged with demand being dependent on the fortunes of the construction industry. To summarise, it would appear that the decline in demand has now levelled out; barium and strontium have secured their own share of the market and increasing usage of ferrites and titanates has negated the fall in demand so that the barium carbonate market is now relatively stable.

Blanc fixe

Blanc fixe is chemically precipitated barium sulphate which can be prepared by a number of different routes according to the end-use. The main preparatory techniques can be summarised in the following equations:—

$$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$$
$$BaCO_3 + H_2SO_4 \rightarrow BaSO_4 + H_2O + CO_2$$
$$BaS + H_2SO_4 \rightarrow BaSO_4 + H_2S$$
$$BaS + Na_2SO_4 \rightarrow BaSO_4 + Na_2S$$

European production of blanc fixe in 1981 was about 76,500 tonnes of which approximately 80% was manufactured in West Germany by the leading producers — *Sachtleben Chemie GmbH* and *Kali-Chemie AG*. Blanc fixe is used predominantly as a filler and extender in the following industries — paint 70%, paper 10%, plastics and battery manufacture 10%. In addition about 10% finds an outlet in the medical field.

The market for filler grade blanc fixe in the paint industry has suffered in recent years from replacement by titanium dioxide and other less expensive fillers although as the price of titanium dioxide rose a degree of balance in the market has been achieved. The picture is similar in the paper industry where calcium carbonate and talc are used as fillers whilst the use of blanc fixe is restricted to paper coating and the manufacture of photographic paper.

Lithopone

Lithopone can be prepared by the reaction of barium sulphide with zinc sulphate to form a precipitate of barium sulphate and zinc sulphide as demonstrated in the equation:—

$$BaS + ZnSO_4 \rightarrow BaSO_4.ZnS$$

Lithopone was originally used as a pigment in the paper and paint manufacturing industries but over the years has been replaced to a considerable extent by titanium dioxide pigments. It is now used almost exclusively in paints with minor amounts going into artists' colours.

Barium chloride

Barium chloride can be produced directly from barium sulphide by reaction with hydrochloric acid or chlorine gas or through the reaction of barium carbonate with hydrochloric acid. Two types of chloride are used in industry — anhydrous ($BaCl_2$) or crystal ($BaCl_2.2H_2O$). The former is used entirely in the production of heat treatment salts whilst three-quarters of dihydrate production is used for the removal of sulphate impurities from various systems and the remainder is used in miscellaneous applications including the manufacture of molecular sieves.

The barium chloride market is small — about 1,000 tpa in the UK — and is likely to decline still further as its usage in the purification of brine, and as additives to steel hardening salts and welding flux compounds decreases.

Barium hydroxide

Barium hydroxide is produced by the oxidation of a hot barium sulphide solution in air and can be represented by the following equation:—

$$3BaS + O_2 + 2H_2O \rightarrow 2Ba(OH)_2 + BaS_3$$

On cooling, barium hydroxide octahydrate crystals form which can be calcined to produce the monohydrate. The barium sulphide which is formed during the oxidation process can be used as a starter material in the preparation of barium chloride.

$$BaS_3 + 2HCl \rightarrow BaCl_2 + H_2S + 2S$$

The barium hydroxide market is very small — about 500–600 tpa in the UK — and its usage is not expected to grow. It is used in the production of lubricating oil additives, the manufacture of PVC stabilisers, and as an alternative to barium carbonate in the ceramics industry for the fixing of soluble salts.

Fillers and extenders recovering

One of the most important non-drilling applications for barytes is as a filler and extender. The total world barytes filler market has been variously estimated between 0.3 and 0.5m. tonnes (based on a total world barytes production of about 8.3m. tonnes). Approximately 59,000 tonnes of US barytes production and 19,000 tonnes of UK barytes production in 1983 is used in this field. As the effects of the recession begin to recede it has been estimated that barytes consumption as a filler should experience a real growth of about 6% per annum. The US market for barytes as a filler can be broken down as follows — paint 60%, plastics 25%, rubber and others 15% — with the majority of these materials supplying the automotive industry. The UK filler market for barytes which includes an additional 5–6,000 tpa of imported white filler again supplies the automotive industry with about 33% whilst the remainder is allocated as follows — paint 27%, rubber 10%, radiation shielding 10%, plastics 6%, and others 14%.

Barytes, blanc fixe (precipitated barium sulphate), and lithopone ($BaSO_4$.ZnS) because of their density, brightness, low abrasiveness, inertness, resistance to weathering, and radiation absorption find important applications as fillers and extenders. Approximately 90% of blanc fixe production is used as a filler in the following categories — paint 70%, paper 10%, plastics and battery manufacture 10%. World production of lithopone amounted to about 0.2m. tonnes in 1981 nearly all of which was consumed by the paint industry. EEC countries contributed about 45,000 tonnes to the world total with the remainder origination in Eastern Europe and China.

Paints

The paint industry is by far the largest consumer of filler grade barytes and its derived barium salts. However, their usage in domestic paints has decreased considerably since the introduction of paint sales on a volume basis which resulted in replacement by cheaper and less dense fillers such as calcium carbonate and dolomite. High grade barytes which has been acid washed to remove impurities is suitable for use in the paint industry although neither it, nor blanc fixe, possess any pigmentary properties. Instead their function is to optimise the optical properties of the pigment in the system by ensuring complete distribution of the pigment particles so that their optical properties are maximised. The size distribution of the filler is therefore critical and it is predominantly this factor which governs the grade of filler chosen. The grain size and shape and the refractive index of filler and pigment determine the optical efficiency of the system. In the paint industry (cf. the paper industry in the next section) barytes and blanc fixe constitute high whiteness fillers but not pigments with the primary function of providing an opaque coat.

As fillers in varnishes, water-carried paints, and anti-rust primers barytes and blanc fixe produce a high degree of impermeability and durability through their close packing density. They are particularly useful in undercoats preventing the absorption of top coats, filling scratches, and being resistant to sanding marks. They do not contain water soluble materials (unlike calcium carbonate) and are thus not prone to blistering in the presence of moisture. Blanc fixe can be used to replace opaque white pigments without affecting the opaque properties of the paint and, because of its low oil index, the quantity of binder can be reduced. Blanc fixe increases the brightness of the paint system so that the quantity of coloured pigment can be reduced thereby improving the dispersion of the pigments which ensures more economic application of the paint.

Barytes, blanc fixe, and lithopone are also used in artists colours in small quantities particularly in the lower range students' colours. Blanc fixe is used in preference to barytes because of its better colour and closer grain size distribution. Artists' colours require a size range between 1 and 5 microns. In some of the cheaper student colours blanc fixe may constitute up to 25% of the product. Different grades of lithopone are used according to the zinc sulphide content (standard lithopone contains 30% ZnS) but titanium dioxide is used to provide a better white colour in the higher quality colours. High quality barytes is imported from China and India for use in artist colours. A rough break down of filler consumption in the UK for artists' colours is as follows — calcium carbonate 100–200 tpa, barytes 10 tpa, blanc fixe less than 100 tpa.

Optical performance of blanc fixe in paint and paper

Refractive index blanc fixe	1.65
Refractive index pulp	1.06
Relative refractive index blanc fixe/pulp	1.56
Intensity of reflected light	0.048
Refractive index paint binder	1.5
Relative refractive index blanc fixe/binder	1.1
Intensity of reflected light	0.0025

Paper

Barytes is used only infrequently as a filler in the paper industry since it cannot achieve the uniform whiteness of blanc fixe. As a filler blanc fixe imparts a high degree of opacity to paper and is consequently used in lightweight bond paper where good opacity is required to prevent characters from showing through. It also adds to the brightness of paper thereby reducing the amount of printing ink required. However the price of blanc fixe is fairly prohibitive and its use is restricted to heavy weight thin papers and paper coating to provide a smooth surface finish. The paper coating pigment should possess the following properties — uniform particle distribution, non-hygroscopic, low abrasiveness, good rheological properties, appropriate refractive index, and good dispersion in water.

Typical blanc fixe paper-coating grade

Density	4.0–4.2
Brightness	95–99
Mean particle size (microns)	0.5–4.0
Specific surface (sq. metre/g)	4.0–4.5
Hardness	3–4
Binder requirement (g casein/100 g pigment)	9–14
Oil Index (g oil/100 g pigment)	12–22
Water index (g water/100 g pigment)	16–23
Zeta potential (mv)	−20 to −35

An important use of blanc fixe paste is in the manufacture of photographic paper for black and white prints. The paper is coated with "baryta", a mixture of 70% blanc fixe and gelatine, prior to coating with a layer of silver halide emulsion. The baryta layer provides an inert base which will not react with the applied silver halide. It is opaque and provides a good mat reflective layer to give good definition. Varying the composition can result in mat, semi-mat, or glossy finish to the photographic papers. The paper can additionally be coated, embossed, or calendered for a high gloss. The manufacture of photographic paper consumes annually a few hundred tonnes of blanc fixe in the UK.

Plastics and rubber

The filler market for barytes is on the upturn particularly in those applications related to the automotive industry which is showing signs of recovery. The plastics and rubber industries utilise barytes in the following components — fan belts, hoses, mats, gaskets, and sound proofing. The latter can use up to 80% barytes. The properties of barytes which make it particularly suitable for these applications are its density which reduces the quantity of materials required, its low abrasiveness which makes it easy to grind and reduces wear, its inertness where resistance to heat and corrosion are necessary, and its ability to absorb radiation.

In a number of filler applications barytes is used simply as a weighting agent, for example in the manufacture of sports goods. The rubber core of tennis balls may contain up to 10% barytes of a moderate grade. In these applications the selection of grades is governed predominantly by cost whereby, provided the barytes is not too dirty, a cheaper grade will suffice. The manufacture of tennis balls consumes somewhere in the region of 4–5 tonnes of barytes per week. Barytes is also used as a weighting filler in a number of miscellaneous products including — playing cards, ropes, rubber mats, and tiles.

Friction materials

Barytes is used as an inert filler in friction materials including brake and clutch facings. Brakes consume varying amounts of barytes according to the end-use, whether it be industrial machinery, trucks, or saloon cars. Quantities can vary from 10% to 40%. Again the grade of filler used is essentially a compromise between the grade and price.

Typical brake lining grades

Specific gravity		4.34	4.34
Oil absorption		10.5	12.0
Particle size distribution %			
(microns)	<75	99	—
	<50	85	99.5
	<40	67	99.0
	<30	44	92
	<20	23	72
	<10	8	39
	< 5	3	19
	< 2	1	8

The market for barytes as a filler in friction materials is fairly stable being dependent on the fortunes of the automotive industry rather than suffering from competition from other materials.

Glass

The largest end-use for barium carbonate is in the manufacture of glass which accounts for 35% of usage in Europe, 60% in Japan, and about 30% in the USA. In this application barium carbonate acts as the principal source of barium oxide which improves the quality of glass in a number of ways — providing a higher refractive index, imparting greater hardness and scratch resistance, improved gloss, better flow properties to the molten glass, greater resistance to attack from aggressive media, and acting as a radiation filter in television cathode ray tubes. The development of television in the 1950s produced a large demand for barium carbonate in the manufacture of glass tubes but the advent of colour television necessitated the replacement of barium by strontium carbonate which can absorb the increased amount of gamma radiation produced by the higher cathode potentials utilised in colour televisions to improve picture brightness. Some manufacturers however, have continued to make TV tubes using only barium carbonate though in higher proportions — 12% BaO compared with the 3–4% BaO and 5–7% SrO used in the USA and Japan. A potential growth area for the use of barium carbonate in TV tubes is in China where a large market for monochrome sets is expected to materialise over the next few years. Otherwise a degree of stability has been achieved in the market now that the substitution of barium by strontium is virtually complete.

Barium oxide is an important constituent of crystal glassware imparting a higher refractive index and low dispersion and at the same time increasing the hardness whilst replacing potentially harmful lead. Less expensive components have replaced barium carbonate which was used in the manufacture of glass fibres. Another small application for barium carbonate is in the manufacture of reflective glass beads for use in road-marking paints.

Ceramics

The ceramics industry is a traditional market for barium carbonate accounting for about 25% of consumption. In structural ceramics barium carbonate serves to bind the soluble sulphates (gypsum) in the ceramic raw material and the formation of insoluble barium sulphate prevents discolouration of bricks and tiles and inhibits the formation of efflorescence on the surface of fired bodies. Barium chloride and hydroxide can be used as alternatives to the carbonate in this application. Barium carbonate is also added to glaze mixes and on melting is converted to barium oxide which improves the hardness and lustre of the glaze consequently improving its resistance to abrasion and leaching. Similarly the addition of barium carbonate to enamels improves their resistance to corrosion and weathering.

A reasonable growth area for barium carbonate is in the electro-ceramics field ie. the manufacture of barium titanates and ferrites. In the USA about 15% of barium carbonate is consumed in this application whilst Japanese consumption is about 20%. Barium titanates ($BaTiO_3$) are produced in two forms — disc or monolithic. The former are pill-shaped titanates formed from a mixture of ceramic and electrode which is fired and then anodised whilst the latter is formed by sandwiching layers of ceramic and electrode. Intense competition from Japan is causing the US disc market to shrink but in the USA the monolithic market is showing a healthy growth of about 20–30% per annum. Barium titanates possess a high dielectric constant which renders them suitable for the manufacture of small condensors for use in computers, telecommunications, and the automotive industry. Whilst the market for titanates is growing there is a potential threat from relaxer body materials such as lead-iron and lead-niobium. Total barium carbonate consumed in electro-ceramics amounts to about 900–2,700 tpa (2–6m. lbs).

Barium carbonate is added to a steatite base to produce a non-conducting steatite ceramic suitable for use as electrical components. The $BaCO_3$ addition results in enhanced electrical resistance, greater mechanical strength, and reduced dielectric loss.

Barium carbonate is also used in the manufacture of magnetic ferrite materials which are produced by sintering 1 mole barium carbonate with 6 moles iron oxide at a temperature between 1100°C and 1350°C. The material is then ground and fired. The reactions of formation can be summarised in the following equations:—

$$BaCO_3 + Fe_2O_3 \longrightarrow BaFe_2O_4 + CO_2$$
$$BaFe_2O_4 + 5Fe_2O_3 \longrightarrow BaFe_{12}O_{19}$$

Because the raw material cost is low compared with that of newer rare-earth-cobalt, or neodymium-iron-boron permanent magnets ferrites are able to retain their own sector of the magnet market. Competition is more intense from strontium ferrites which have a higher coercive field strength. The market for ferrites is still growing and finds use particularly in the automotive industry. Ferrite applications include — motors, reed switches, dynamic speakers, earphones, telephones, and microphones.

Radiation shielding

A number of factors are worthy of consideration when selecting a material for use in radiation shields:

- Density — closely packed light elements attenuate neutrons whilst heavy elements are better for gamma ray attenuation.
- Fabricability — the material must be capable of being used as an aggregate in concrete.
- Durability — the material must not lose its attenuation properties or be susceptible to cracking.
- Heat transfer properties — the heat generated by radiation must be easily removed.

Barytes is an excellent concrete aggregate for use in reactor shields but its use is based in part on its availability close to an installation site. Generally ordinary concrete would be the cheapest shield material to use but where limited space is a consideration special high density concretes can reduce the width of the shield. Barytes concrete with a density of 3.5–3.6 g/sq. cm is such a suitable shield material.

Composition of barytes aggregate

	Tennessee	*Nevada*
Composition % $BaSO_4$	>92	>90
Density course pieces	4.20	4.28
Density fine sand	4.24	4.31
% iron content	1–10	< 1
Fixed water wt.%	0	0

The mean volumetric weight of barytes concrete is about 50% higher than that of ordinary concrete and is an effective shield for gamma radiation. The high neutron cross section capture of barium ensures higher efficiency of barytes concrete against a neutron flux of medium and low energies but it has no advantage over ordinary concrete at high neutron energies.

Radiation shielding represents a steady source of demand for barytes both for use in aggregates and in plaster to meet the demands of new buildings and running repair work.

Purification

An important application of barium carbonate is the purification of brine for chlor-alkali electrolysis by the removal of sulphate. Generally the sulphate content of brine is controlled by the solubility product of calcium sulphate but periodically barium carbonate needs to be added to further reduce the sulphate content. Barium carbonate combines with the sulphate impurity to form insoluble barium sulphate which precipitates. New cell technology is a major influence on barium carbonate consumption in two respects. Firstly in mercury cells graphite anodes are being replaced by titanium anodes which can tolerate higher sulphate levels but, on the other hand, membrane cells which are coming more commonly into use are more sensitive to sulphate impurities and should lead to a small increase in barium carbonate consumption. On balance however, barium carbonate consumption for this application is expected to continue to decline particularly where a low sulphate-containing evaporated salt rather than rock salt, is used.

Barium carbonate is also utilised in the purification of factory effluence by the removal of sulphuric acid, dissolved sulphates, and chromic compounds. The removal of sulphates from ortho-phosphoric acid manufactured by the wet process provides another example of the carbonate's purification potential.

Miscellaneous

In the preparation of metallic sodium, barium chloride acts as a fluxing agent in a molten bath along with calcium chloride and sodium chloride. The barium chloride constitutes about 40% of the bath and, at the outset, large tonnages are required. However, as the barium chloride is not consumed by the process it requires only occasional topping up. This application therefore represents just a small outlet for the material.

It is known that barytes is used in explosives but although the manufacturers are unwilling to reveal the reasons for its use it is assumed that because of its density barytes helps to pack the explosive. Additionally, because of its inertness barytes, like graphite, may serve to coat explosive particles and prevent friction between them prior to firing.

Blanc fixe can also be prepared by precipitating and spray-drying to conform to international pharmaceutical specifications for use as contrast media for radiological applications. A number of grades are produced of different grain size and density for different applications. In addition these very pure and expensive grades are used for specialised plastics.

Typical blanc fixe specification for contrast media

Density	4.4 g/cm^3
Average particle size — fine	0.9–1.1 microns
Average particle size — coarse	9–11 microns

Typical blanc fixe paste for contrast media

$BaSO_4$:water	70–30
pH value	5–8
Iron	<10 ppm (dry)
Arsenic	<10 ppm (dry)
Heavy metals	<10 ppm (dry)
Salts soluble in acetic acid	<0.375% (dry)
Average particle size	0.8–1.1 microns

Producers

The production of non-drilling grades of barytes amounts to only a small percentage, averaging about 10%, of total barytes production. Actual end-use breakdown figures are not available and the producers themselves are generally reluctant to release what they consider to be proprietary information in a highly competitive market. In particular the chemical market is now fairly stable and unless new applications are developed sales of chemical grade barytes are unlikely to grow significantly. By contrast the market for fillers and extenders is recovering after a poor couple of years and the producers are in lively competition to meet the increase in demand.

Production figures for the major barytes producers has been estimated as follows for filler grade barytes — China 70,000 tpa, France 60,000 tpa, the USA 59,000 tpa, West Germany 50,000 tpa, India 36,000 tpa, Eastern European countries 30,000 tpa, and the UK 19,000 tpa.

The following country sections outline the major producers of non-drilling grade barytes but the list is by no means exhaustive since production of these grades is often controlled by the production of barytes for oilwell drilling. Many barytes producers along with their output of drilling grades also supply small quantities of filler or chemical grades.

Europe

France — bleached fillers source

The largest producer of barytes in France is *Barytine de Chaillac*, a subsidiary of Kali-Chemie AG of West Germany, with a total annual production of about 118,000 tonnes which is consumed as follows — 100,000 tonnes for the production of barium chemicals, 5,000 tonnes for oilwell drilling, 3,000 tonnes of aggregate for heavy concrete, and 10,000 tonnes for fillers. The mine and plant are situated at Chaillac and the deposit, which is Mesozoic in age, rests directly on the basement gneiss of the Massif Central. Three distinct horizons are worked — a complex surface layer of iron-barytes of minimum 8 metres in thickness containing 45–50% $BaSO_4$, at the bottom a layer of grey barytes (40% $BaSO_4$) of minimum 4 metres in thickness, and between the two a 4 metre thick layer of intermediate composition of intercalated barytes, iron oxides, silica sand, and clay. The ore is extracted by quarrying and is treated by flotation after an initial three-stage preparation to obtain an optimum size for release by flotation (160 microns for Chaillac material). The ore is crushed in two stages (jaw crusher and roll crusher), ground in a rod mill followed by a ball mill, and subsequently the fines are removed by hydrocyclones. The material is then subjected to flotation to produce concentrates for the glass, chemical, filler, and drilling industries. Barytine currently has no micronising facility but has plans to establish a mill in the future.

A second major French producer of filler grade barytes, *Sté des Couleurs Zinciques (SCZ)*, has gone into liquidation but its operation has been taken over by *Société de la Vieille Montagne (SVM)* which was formed in October 1983 on the site of *Société des Produits Chimiques de Viviez* at Aveyron. Barytes ore is extracted at Lacan near Rodez where it is beneficiated by mechanical treatment and subsequently enriched by flotation at Viviez for a $BaSO_4$-rich grade. A bleached grade barytes formerly produced by SCZ is still produced and marketed under the name Rutenia. At Viviez three product lines are operated — the first is produced by flotation and acid treatment, the second by flotation only, and the third by jigging. The bleached grade barytes is employed as a filler of very high whiteness in paints, corrosion resistant coatings, plastics, and PVC. Chemical treatment renders the barytes chemically inert so these grades are also particularly suitable for use in aggressive media in packing joints, coatings, tanks, and paints. The applications of the flotation grades are the same as those for the bleached grades except that the lower brightness restricts their usage to clear rather than white products.

Specifications for bleached barytes fillers

		Rutenia		
	G	*F*	*FF*	*FFF*
$BaSO_4$ % min	98	98	98	98
SiO_2 % max	2	2	2	2
Brightness CIE	94	95	95	95
Size distribution (microns)	0–50	0–40	0–20	0–15

Specifications for flotation grades

	Lacanyte	
	30 FB	*20 FB*
$BaSO_4$ % min	97	97
SiO_2 % max	2	2
Brightness CIE	93.5	93.5
Size distribution (microns)	0–40	0–20

The third grade produced by SVM, an off-colour material which is only graded according to size, finds application in anti-corrosion paints, glass, and friction products. Of SVM's total barytes production of 40,000 tpa about 25,000 is consumed in the paint industry.

Also operating in France is *Mines de Garrot* based at Porres in Var, with a production of 15,000 tpa for surface coating applications and nuclear shield aggregates.

West Germany — downstream chemicals

Two companies are involved in barytes production *Deutsche Baryt-Industrie Dr. Rudolf Alberti & Co.*, which is jointly owned by Kali-Chemie AG and *Metallgesellschaft AG*, and *Sachtleben Bergbau GmbH* which is owned by Metallgesellschaft. Deutsche Baryt has a mine and plant at Bad Lauterberg with capacity for the production of 50,000 tpa filler grade material and 5,000 tpa chemical grade barytes. Processing techniques include heavy media separation, flotation, and chemical bleaching to produce a variety of filler grades suitable for paints, pigment preparations, plastics, rubbers, sealing compositions, and floor coatings resistant to chemicals. Sachtleben has a mine and plant at Wolfach in the Black Forest with capacity to produce 60,000 tpa of filler grade barytes. The grades are, on average, coarser and less bright than the Deutsche Baryt grades thus rendering them more suitable for use as fillers in sound insulation materials, friction linings, plastering compositions, and coating compositions.

The chemical producers Kali-Chemie and Sachtleben Chemie GmbH (the latter is an associate company of Sachtleben Bergbau) obtain chemical grade barytes largely from their respective subsidiary or associate companies.

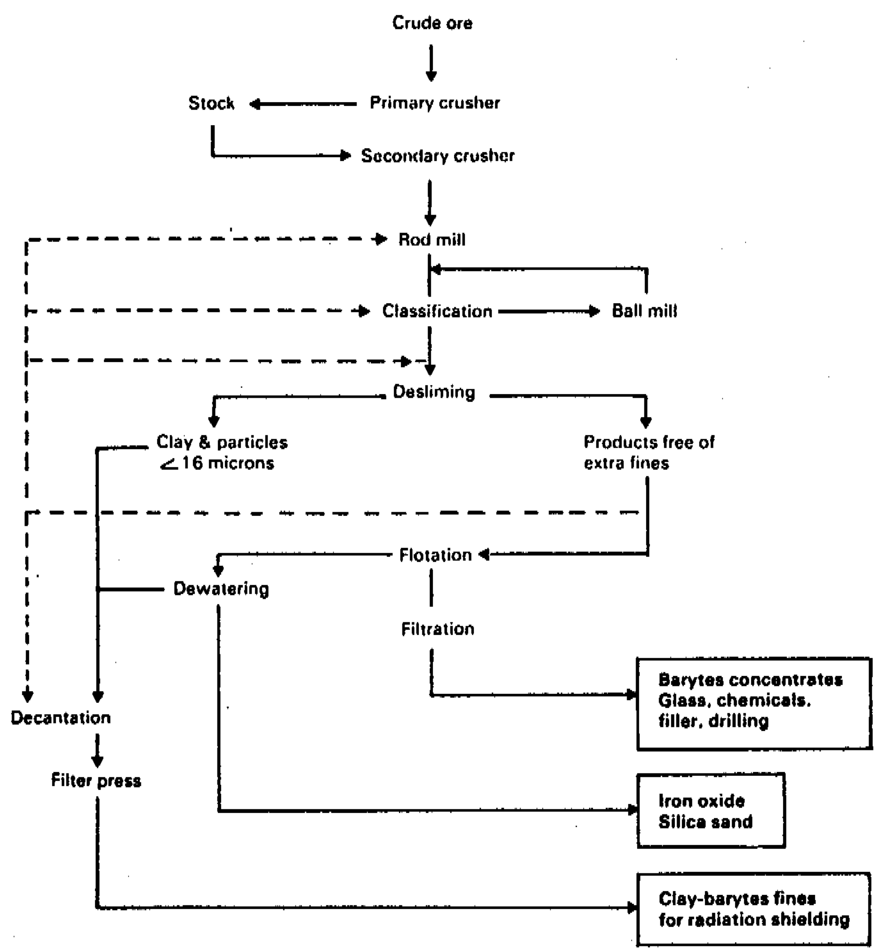
Greece — production on Milos

Silver & Baryte Ores Mining Co., a member of the Eliopoulos-Kyriacopoulos group, has an annual production of 5,000 tonnes of filler grade barytes for use predominantly in the domestic paint and rubber industries. Barytes ore, of average head grade 58% $BaSO_4$, is mined on the island of Milos near Voudia Bay in the Kavos area. The barytes mineralisation is believed to be a result of hydrothermal alteration of volcanic tuffs and lavas. Ore reserves are estimated to be about 2.8m. tonnes. Filler grade barytes is recovered by selective quarrying followed by dry classification using a hammer mill and Raymond mill classifier system at the company's Voudia plant where there are also loading facilities. The run of mine material contains about 80% $BaSO_4$ and has a specific gravity of 3.9. The plant capacity is about 2 tph.

Italy

Bariosarda SpA, a subsidiary of *Ente Minerario Sarda*, has two operations in Sardinia with the capacity to produce 40,000 tpa ground barytes for chemicals and oil-well drilling and 10,000 tpa flotation filtercake for chemicals from Barega and 20,000 tpa filtercake for chemicals from Mount Ega. A Kali-Chemie subsidiary, *Stà Bario e Derivati SpA* (Sabed), produces chemical grade barytes at Massa.

Chaillac plant flowsheet



Adapted from Barytine de Chaillac flowsheet

Total world barytes production (*tonnes*)

	1978	*1979*	*1980*	*1981*	*1982*
France	210,000	220,000	225,000	172,000	143,000
West Germany	168,586	161,661	175,380	165,189	361,762
Greece	110,841	109,344	98,529	116,773	119,747
Italy	236,832	214,630	203,038	174,057	180,022
Spain	71,457	74,700	59,827	52,695	50,000*
Turkey	100,904	100,005	128,352	185,555	107,393
United Kingdom	54,409	45,000	54,000	63,308	81,000
Yugoslavia	42,800	46,073	47,818	44,179	45,000*
Canada	99,339	67,035	95,000*	80,000*	30,000*
Mexico	231,485	151,162	269,322	317,738	323,753
USA	1,969,000	1,916,000	2,037,000	2,585,000	1,674,000
China	400,000*	500,000*	680,000*	800,000*	900,000*
India	388,582	490,699	442,326	399,000	325,679
Pakistan	16,303	32,433	14,054	26,985	23,600*
Thailand	274,564	378,654	305,057	307,046	330,948
Brazil	107,492	108,042	104,752	116,340	120,000*
Kenya	303	363	6,647	2,591	—
Morocco	176,813	286,467	320,585	463,869	418,200
Total	6,900,000	7,300,000	7,500,000	8,300,000	7,400,000

Source: British Geological Survey, World Mineral Statistics 1978–82, in press.
** Estimate.*

This table represents barytes production for all uses including about 0.6–0.65m. tonnes for chemical production and about 0.5m. tonnes for fillers and aggregates.

Mineraria Silius SpA produces about 5,000 tpa barytes as a by-product of its fluorspar mining operations at Genna Tres Montis, Muscadroxiu, and S'Acqua Frida in Sardinia. About 60% of production is supplied dried and bagged to the domestic glass industry whilst the remainder is sold, also domestically, for the preparation of barium salts.

Spain

The largest barytes producer in Spain is *Minas de Baritina SA*, another Kali-Chemie subsidiary, which operates mines in the Córdoba region at Espiel-Alcaracejos, Villaviciosa, and Belmez. The barytes from these mines is processed at Guillermin and undergoes crushing, hydrogravimetric pre-concentration, milling, and flotation to provide two barytes end-products along with by-product galena:—

- jigged barytes from the pre-concentration process for use primarily in drilling muds with some for use in fillers and the paint industry;
- flotation barytes for the chemical industry (1980 production was 35,000 tonnes).

Other Spanish producers include *José Andreu SA* which produces about 5,000 tpa filler grade barytes from its plant at Fuentes de Ebro. *Minera Arregui SA* operates a mine at Almogía in Malaga for the production of barytes (>96% $BaSO_4$) for paper and oil-well drilling. The company has recently commissioned two grinding mills at Haza de la Cruz which would be suitable for micronising barytes.

Turkey

Amongst Turkey's leading barytes producers is *Bastaş Barytes Industry & Trading Co. Inc.* which, in addition to drilling grade barytes, also supplies about 3–4,000 tpa of a grade similar to the French "Rutenia G" or "F" grades with the following specifications — minimum 97% $BaSO_4$ content, specific gravity 4.4, whiteness 95% minimum, and 99% less than 40 microns. Bastaş can also meet the requirements of the plastics industry. *Başer Maden Sanayii ve Ticaret AS* has the capacity to produce 3–5,000 tpa chemical grade, 7–10,000 tpa paint grade, and 5–7,000 tpa filler grade barytes although the actual 1980 production figures were between one-half and one-third of these levels. At the Eskişehir processing plant of *Dolsan Dolgu Maddelari AS* about 400,000 tpa of filler and coating grade barytes is produced for the plastics, rubber, filler, paint, and drilling industries. In addition to drilling grade barytes *Kimtes Kimya Tesisleri Sanayi ve Ticaret AS* produces some barytes for atomic shielding and water purification.

United Kingdom — fillers and aggregate

Of a total 1982 barytes production of 81,000 tonnes an estimated 19,000 tonnes was produced for the filler and radiation shield market. In 1981 *Fordamin*, a subsidiary of *English China Clays*, acquired the mineral interests of *Athole G. Allen Ltd.* which includes the mine at Closehouse, Middleton in Teesdale and a milling complex at Stockton on Tees. Fordamin has placed considerable expenditure in a modernisation programme at both mine and plant which yielded more than 20,000 tonnes in 1982. About one third of the barytes is destined for the oil-well drilling market. The remaining barytes is sold as aggregate for radiation shielding, general high density aggregate, and fillers for paints, rubber, and plastics. The barytes aggregate is processed at the Closehouse plant whilst oil-well and filler grades are produced at Stockton. Large scale geological exploration of the area has recently been completed and results are expected to confirm considerable reserves of barytes.

Horace Taylor (Minerals) Ltd. continues to operate the Silverband mine at Knock in Cumbria for the production of about 9–10,000 tpa of barytes for fillers and about 2,000 tpa for radiation aggregate. Filler grade material is processed at Dunsley Mills in Derbyshire for the paint and rubber industries each of which consumes about 20% of the production with the remainder being consumed in plastics and friction materials. *Laporte Industries Ltd.* recovers barytes as a by-product from its Glebe mines fluorspar operation in Derbyshire. The barytes, which amounts to about 10–15,000 tpa, is separated from the associated fluorspar and lead by flotation to produce a medium-low brightness filler grade suitable for plastics and rubber but lacking a sufficient degree of whiteness for use in paints.

Other Derbyshire-based producers include *Clay Cross (Iron & Foundries) Ltd.*, a subsidiary of *The Clay Cross Group*, which has increased its production of barytes from 100 tpw to 170–175 tpw and is eventually looking to double production to 200 tpw. Originally barytes was a mineral of secondary consideration for Clay Cross but it has now become the company's main interest. The company's current production of washed aggregate (size 1½–19mm) is distributed equally between drilling and filler applications but higher production will probably increasingly serve the drilling market. *Mineral Industries Ltd.*, through its subsidiary *Bleaklow Mining Co. Ltd.*, occasionally produces small tonnages of additionally ground drilling grades for use in brake linings.

Hopton Mining Co. Ltd. operates a processing plant at Brassington near Wirksworth in Derbyshire for the custom grinding of barytes for filler applications. Meanwhile *Braithwaite Mining Ltd.* which formerly produced about 1,200 tpa of white grade barytes for the paint industry has gone into liquidation.

Typical Derbyshire specifications for flotation grades

Grade	5	1	17m	MB/1A	LH415
Specific gravity			4.34		
Oil absorption	10.5	12	14	16	17
Dispersion	—	—	6.5	7	7.25
Particle size (microns)	97% < 75	99.5% < 53	100% < 15	100% < 12	100% < 10

The UK filler market is supplemented by imports of about 5–6,000 tonnes of white barytes grades. *Baker Sillavan Ltd.*, a company jointly owned by *Richard Baker Harrison Ltd.* and *Colin Stewart Minerals Ltd.*, imports acid-washed grades from France and natural whites from China and the Far East.

Yugoslavia

'Rudar' Zagreb at its TKP Ričice plant can, in addition to producing drilling grade barytes, supply barytes to the following specification — 99% below 0.02mm, 92–93% $BaSO_4$ (95–96% $BaSO_4$ on demand), and whiteness 75%. The barytes is suitable for use in the ceramics, glass, and chemical industries as well as for the production of friction materials.

North America

In **Canada**, *Extender Minerals of Canada Ltd.* produces filler grade barytes from its mine at Matachewan in Ontario. The company has the capacity to produce about 15,000 tpa. *Mountain Minerals Co. Ltd.* supplies barytes for fillers and chemicals from its mines at Parson and Brisco in British Columbia. The processing plant at Lethbridge in Alberta is able to produce 140,000 tpa of which about 5–10% is consumed in the paint and chemical industries. *Nystone Chemicals Ltd.* based at Brookfield, Nova Scotia has a production capacity for 15,000 tpa pharmaceutical grade barytes.

The main production area for non-drilling grades of barytes in the USA is Georgia. *New Riverside Ochre Co. (NRO)*, an associate company of Chemical Products Corp. (CPC) the sole surviving barium chemicals producer in the USA, produces chemical grade barytes and some aggregate from its operation at Cartersville in Georgia. The ore is extracted after removal of 20–40ft of overburden, by conventional open pit methods using a 5 yard dragline, elevating scrapers, trucks, dumpers, bulldozers, and front-end loaders. The deposit consists of a 20–40ft thickness of ore-bearing matrix. Beneficiation includes the following operations:—

- creation of a slurry of ore-containing matrix;
- separation of clay from rock in a log washer;
- concentration of barium sulphate from log overflow slimes by froth flotation;
- hydrogravimetric (jig) concentration of rock discharge from log washer;
- magnetic separation to upgrade jig concentrate.

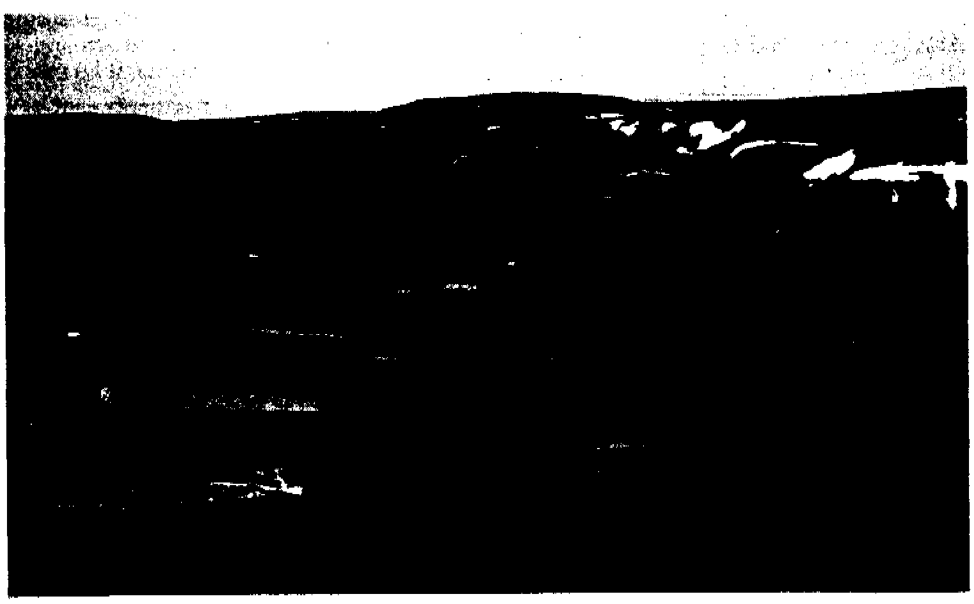
NRO's chemical grade barytes is supplied to CPC.

Thompson, Weinman & Co., a subsidiary of *Cyprus Industrial Minerals*, produces three filler grades of barytes from its mine and plant at Cartersville in Georgia. The company has a production capacity of about 25,000 tpa for supply to the domestic paint, plastics, paper, and rubber industries.

Typical Thompson, Weinman specifications

	Barimite XF	*Barimite*	*#22 Barytes*
Size distribution (microns)	0–15	0–25	0–60
Mean particle size (microns)	2.5	4.0	12.0
Oil absorption	9.0	8.0	6.0
Specific gravity	4.3	4.3	4.3
Hegman fineness	6.0	4.0	2.0

Imco Services, which is a subsidiary of *Halliburton Co.*, produces various grades of barytes fillers from its current production facilities particularly in the USA. *Chromalloy American Mining & Milling Co. Divn.* is another producer of non-drilling grade barytes. *Dresser Minerals* is the only major



A view of Fordamin's Closehouse mine showing the open pit and processing plant in the middle distance. In the foreground are the settling ponds where water is cleaned before release to a reservoir.

barytes producer in Nevada supplying small quantities of barytes to the glass industry.

Asia

China — exporting chemicals

Details of Chinese barytes production are not readily available but estimates suggest that the total production from five sources amounts to about 32,000 tonnes of material for export. White grade barytes is exported from China for use in the paint and filler industries. China is also engaged in exporting large quantities of barium chemicals to the USA. In 1983 Japan imported 43,083 tonnes of barytes from China probably in the form of lumps suitable for use in the chemical industry.

India — producing white grades

Most of barytes production in **India** comes from the Cuddapah district, Andhra Pradesh State where there are estimated reserves of 7.8m. tonnes. *Tiffins Barytes, Asbestos & Paints Ltd.* operates a 5,000 tpa grinding plant at Cuddapah for the production of snowy white filler grade barytes. *Indian Barytes & Chemicals (IBC)* produces two non-drilling grades of barytes — 15,000 tpa of white barytes with the following specification: 96% min. $BaSO_4$, whiteness 95%, fineness 98% less than 325 mesh, and 100,000 tpa red barytes for use as an aggregate with the following specification: 75–85% $BaSO_4$, 10–15% Fe_2O_3, specific gravity 4.35. The white grade is consumed domestically mainly by the paint industry with the remainder being used in explosives, and brake linings. The company also has plans to produce micronised barytes. IBC uses the white grade barytes with a 96% minimum $BaSO_4$ content for the manufacture of barium carbonate and to supply Indian chemical producers. The red barytes is used as a high density aggregate for undersea pipeline coatings. Also operating in the Cuddapah district is *The Krishnappa Asbestos & Barytes Pvt. Ltd.* which extracts barytes from four underground mines. Krishnappa is currently producing about 40–50 tpd (about one-half capacity) of white grades. The barytes ore is manually graded at the mine head and about one-third is washed to improve the whiteness. The barytes is mainly sold to the domestic market under three brand names:

- Super snow white: whiteness 96%, 97% $BaSO_4$, 1% greater than 63 microns.
- Snow white: whiteness 92–95%, 94–97% $BaSO_4$, 1% greater than 63 microns.
- White: whiteness 90–92%, 92–94% $BaSO_4$, 1% greater than 63 microns.

Some of Krishnappa's barytes has been exported to the USSR and Bangladesh and the company is hoping to break into the international market. *Gimpex Minerals Pvt. Ltd.* expects to be able to produce white barytes from its newly acquired mine at Pocharam Village near Yellandu.

Pakistan — new development

The *Baluchistan Development Authority* is implementing a project for the production of 5,000 tpa barytes in the Lasbella District, Hab Chowki which is due for completion in June 1985. The plant will produce barium carbonate and other barium compounds along with lithopone paint and zinc compounds for the domestic market.

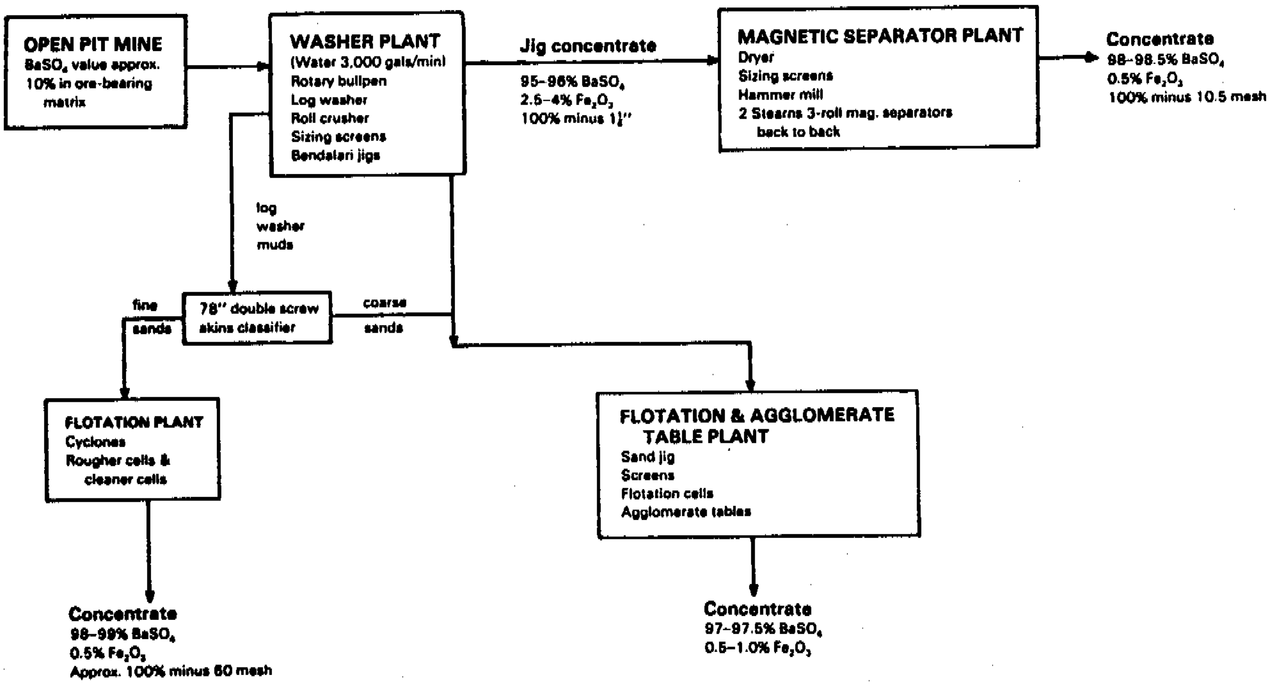
Thailand — small involvement

Total annual Thai production of non-drilling grades of baryte is probably about 10–15,000 tpa. The main producers are *Sohbu (Thailand) Ltd.* with a capacity of 1,000 tonnes per month and *Chemtrade International* — a miller in the Saraburi area. *NL American Thai Barite Ltd.* has only a very limite[d] involvement in this field but is encouraged to further investigate the sales of its crude for non-drilling uses.

. . . elsewhere

In **Kenya** *Athi River Mining Ltd.* has discovered a deposit a[t] Goshi in Kilifi District, Coast Province about 100kms from th[e]

Chemical grade barytes flowsheet



Source: New Riverside Ochre Company

Port of Mombasa. An exploration programme in 1983 established probable ore reserves of 1m. tonnes in two veins of hydrothermal origin which are 5kms and 8kms in length. Small scale commercial mining was undertaken during this period to produce about 50 tonnes per month of a white hand-picked grade suitable for a pigment or chemical grade with the following specification: 96–98.5% $BaSO_4$, 1–2.5% $SrSO_4$, less than 0.1% Fe_2O_3, less than 0.1% SiO_2, traces of Mn and TiO_2, less than 0.1% CaO, and less than 0.1% MgO. This material was supplied to local glass and paint industries whilst small quantities were also exported to neighbouring Rwanda, Burundi, and Uganda. Mining started on a larger scale in March 1984 and current production of the hand-picked grade is about 1,000 tonnes per month with potential outlets being in Europe and North America. A second exploration stage is due to start this month to conduct a feasibility study into the processing of the crude barytes. Ultimately the company hopes to produce up to 20,000 tpa of chemical, filler, and pigment grades for international markets.

In **Mexico**, *Corporacion Minera del Golfo SA de CV* is producing 15,000 tpa of barytes with a specific gravity of 4.1 from its mine at Gomez Farias in the state of Tamaulipas. The barytes is extracted by quarrying using track drills, bulldozers, and mechanical scoops. The product is sold to the domestic market.

In **Brazil** *Engeminas-Emp. Geral de Mineração e Indústria Ltda.* has a production capacity of 24–30,000 tpa of barytes of which 60% is destined for the chemical industry and 15% for use as fillers. *Empresa Industrial Lucaia Ltda.* has the capacity to produce 12,000 tpa barytes for the paint industry from its plant at Camaçari in Bahia State, but is currently only producing drilling grades. The paint grade material has a $BaSO_4$ content of more than 82% and a maximum Fe_2O_3 content of 0.5%.

Another producer not currently active in this field is *SA Chérifienne d'Etudes Minières (Sacem)* in **Morocco.** Sacem holds a stockpile of non-drilling grade material which is produced by hand sorting. Few Moroccan producers are able to meet the specifications for non-drilling barytes grades.

Department of Mines and Energy

HEAD OFFICE MINERALS HOUSE, ESPLANADE, DARWIN, N.T. 5790.
G.P.O. BOX 2901, DARWIN, N.T. 5794.
TELEPHONE (089) 81 5844, TELEX AA85473, VOCADEX (089) 81 4806

TITLE REGISTRATION BRANCH

IN REPLY PLEASE QUOTE: EL 3239

WG/LH:64
FEB7:3B

Managing Director
Nibar Mining Pty Ltd
PO Box 15
BURNSIDE SA 5006

Dear Sir

Exploration Licence Anniversary Notice

The third anniversary of EL 3239 occurs on 15 March 1985.

A mandatory requirement of the Mining Act is that you notify this Department not later than 15 February 1985 the blocks you wish to retain for the ensuing twelve months. To date notification has not been received.

Should you seek deferral of reduction, an application in writing to the Secretary must be lodged immediately..

Rent in respect of the blocks to be retained in the licence area is due and payable by 14 March 1985.

The Annual Report for this licence is due 15 April 1985.

Please attend to these requirements without delay.

Yours faithfully

Don L Woolfenden 7/3/85

D L WOOLFENDEN
Titles Manager

WG/LH:64
FEB7:3B

B. E. Cornish & Associates
Consulting Geologists

Brian E. Cornish
B.Sc.(Adel.)
Assoc. A.I.M.M., A.A.P.G., A.P.E.A.

17th Floor, AMP Centre
50 Bridge Street, Sydney 2000
Telephone: (02) 223 1766
Telex: PLYPET 74369

2nd April, 1985

Mr D.L. Woolfenden
Titles Manager
Title Registration Branch
Department of Mines & Energy
GPO Box 2901
DARWIN NT 5794

Dear Sir,

EXPLORATION LICENCE EL 3239

This firm is acting on behalf of Nibar Mining Pty Ltd, P.O. Box 15, Burnside, South Australia 5006.

The Company, Nibar Mining Pty Ltd hereby re-applies for nine (9) Blocks commencing March 1985 and the diagram identifying these Blocks is attached. This firm will be submitting the proposed exploration programme and estimated expenditure for the year ending March 1986 as well as the annual report for the year ending March 1985. This report will be submitted to the Department in the next two weeks while we are collating information.

A cheque for $180.00 in support of the application of the nine (9) Blocks is enclosed.

Yours faithfully,

#503 110 3/4/85

B.E. CORNISH

*Enclosure

TELEX

GA
85473
MINDAR AA85473
PLYPET AA74369

TO: DEPT OF MINES AND ENERGY / NORTHERN TERRITORY.

ATTN: D. L. WOOLFENDEN.

RE: EL 3239 - NIBAR MINING PTY LTD.

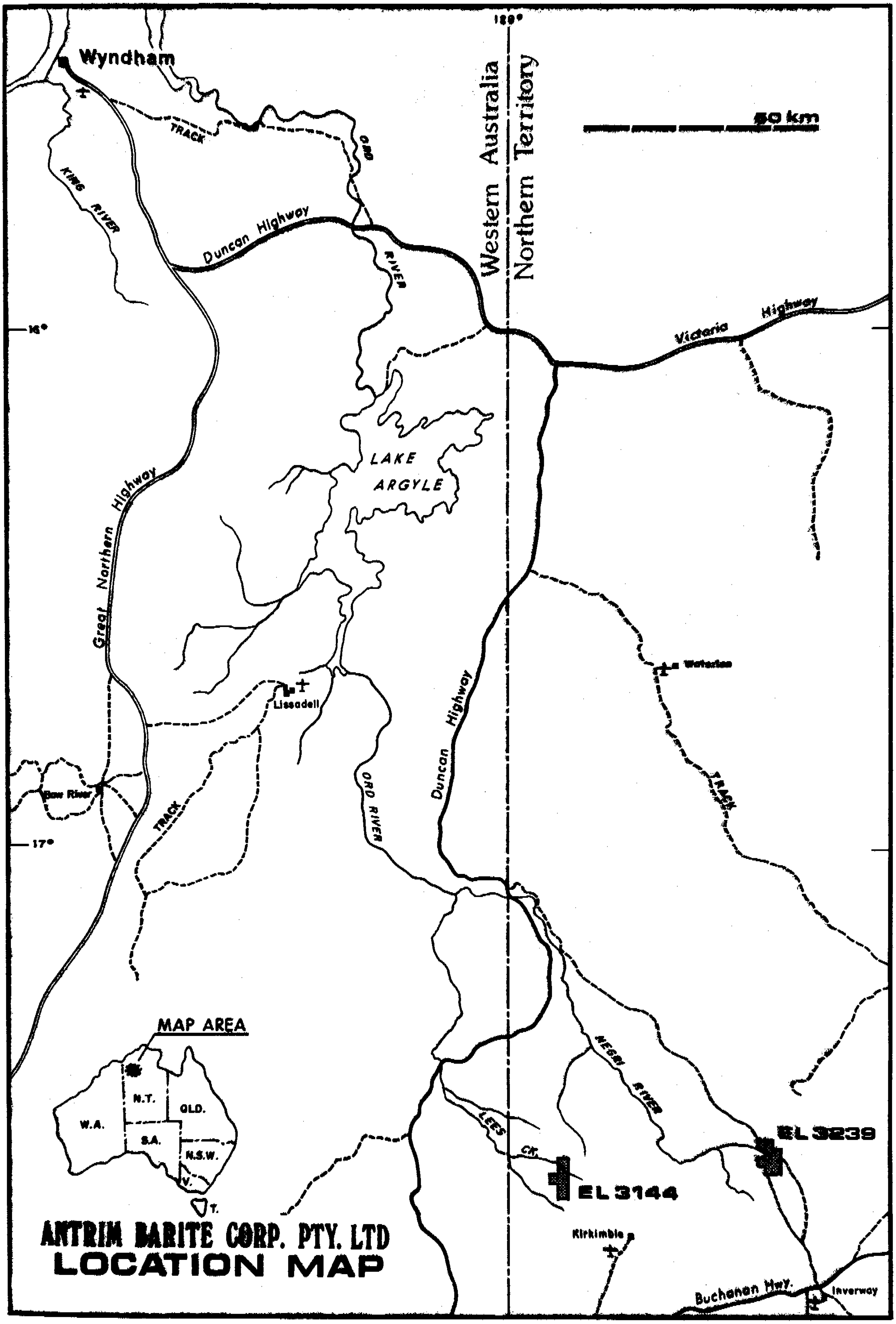
DATE: 4TH APRIL, 1985.

PLEASE BE ADVISED RENT FOR BLOCKS TO BE RETAINED EL 3239 MAILED APRIL 2, 1985 DUE TO DELAY IN RECEIPT OF CORRESPONDENCE FROM NIBAR MINING PTY LTD. THE ANNUAL REPORT FOR BOTH EL 3239 AND EL 3144 WILL BE SUBMITTED BY MYSELF ON BEHALF OF NIBAR MINING PTY LTD AND A J AND C E TURNER BY 15TH APRIL, 1985.

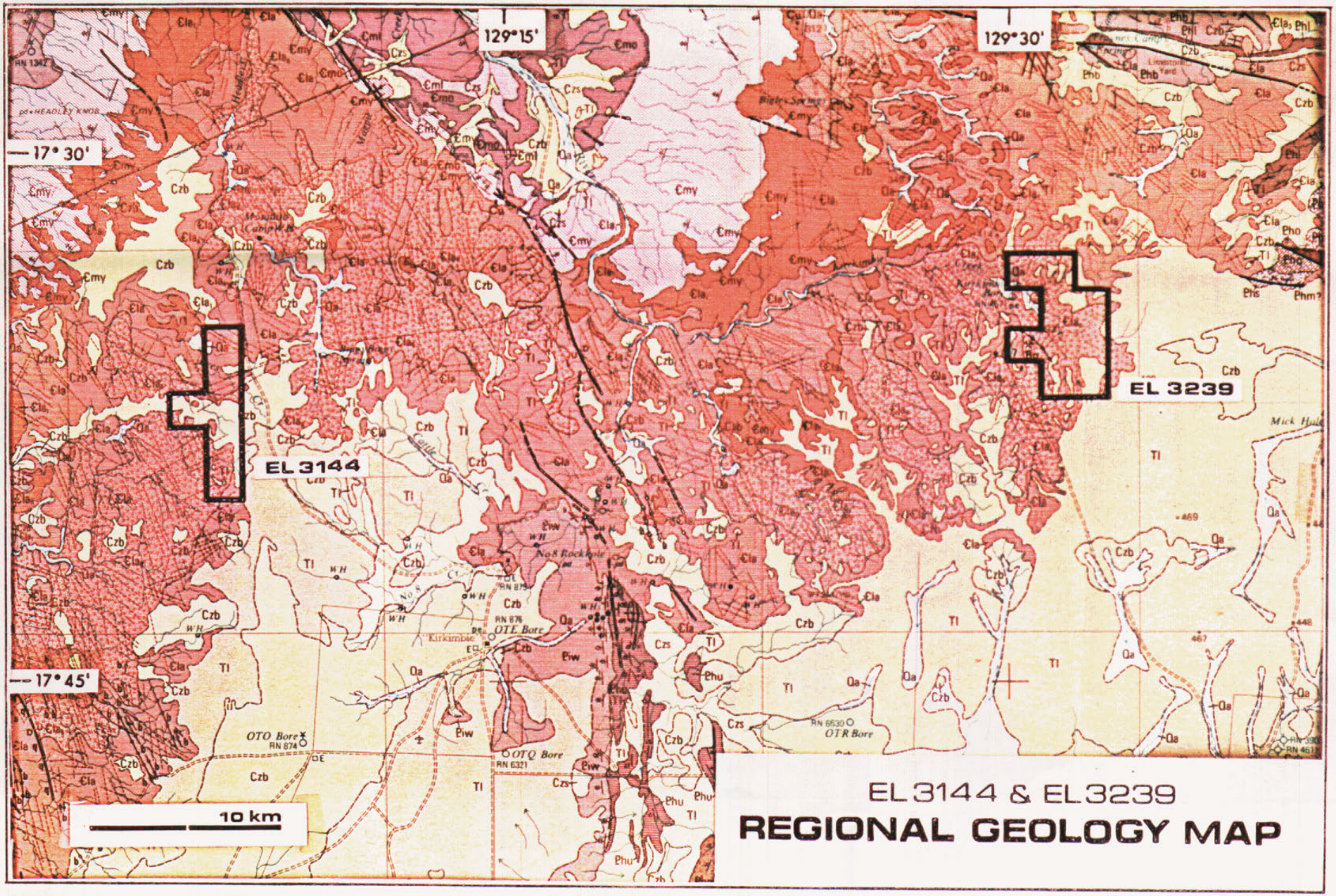
APOLOGIES FOR DELAY.

YOURS SINCERELY,
B.E. CORNISH AND ASSOCIATES. - CONSULTING GEOLOGISTS.

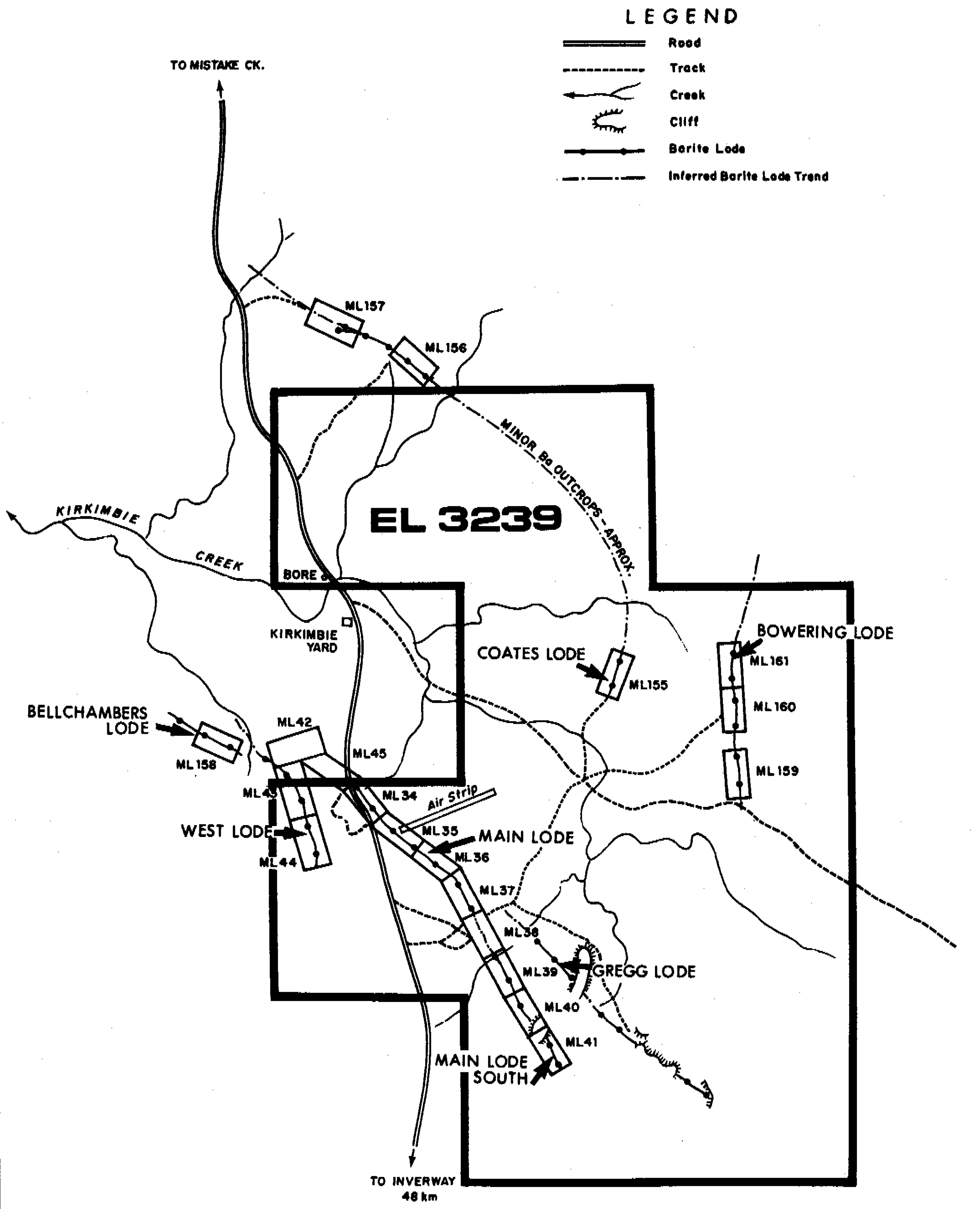
*
MINDAR AA85473
PLYPET AA74369



Wyndham
129°
Western Australia
Northern Territory
50 km
TRACK
ORD
KING RIVER
Duncan Highway
RIVER
16°
Victoria Highway
LAKE ARGYLE
Great Northern Highway
Waterloo
Lissadell
Duncan Highway
TRACK
Bow River
TRACK
ORD RIVER
17°
MAP AREA
N.T.
QLD.
W.A.
S.A.
N.S.W.
V.
T.
NEGRI RIVER
LEES CK.
EL 3239
EL 3144
Kirkimbie
Buchanan Hwy.
Inverway
ANTRIM BARITE CORP. PTY. LTD
LOCATION MAP



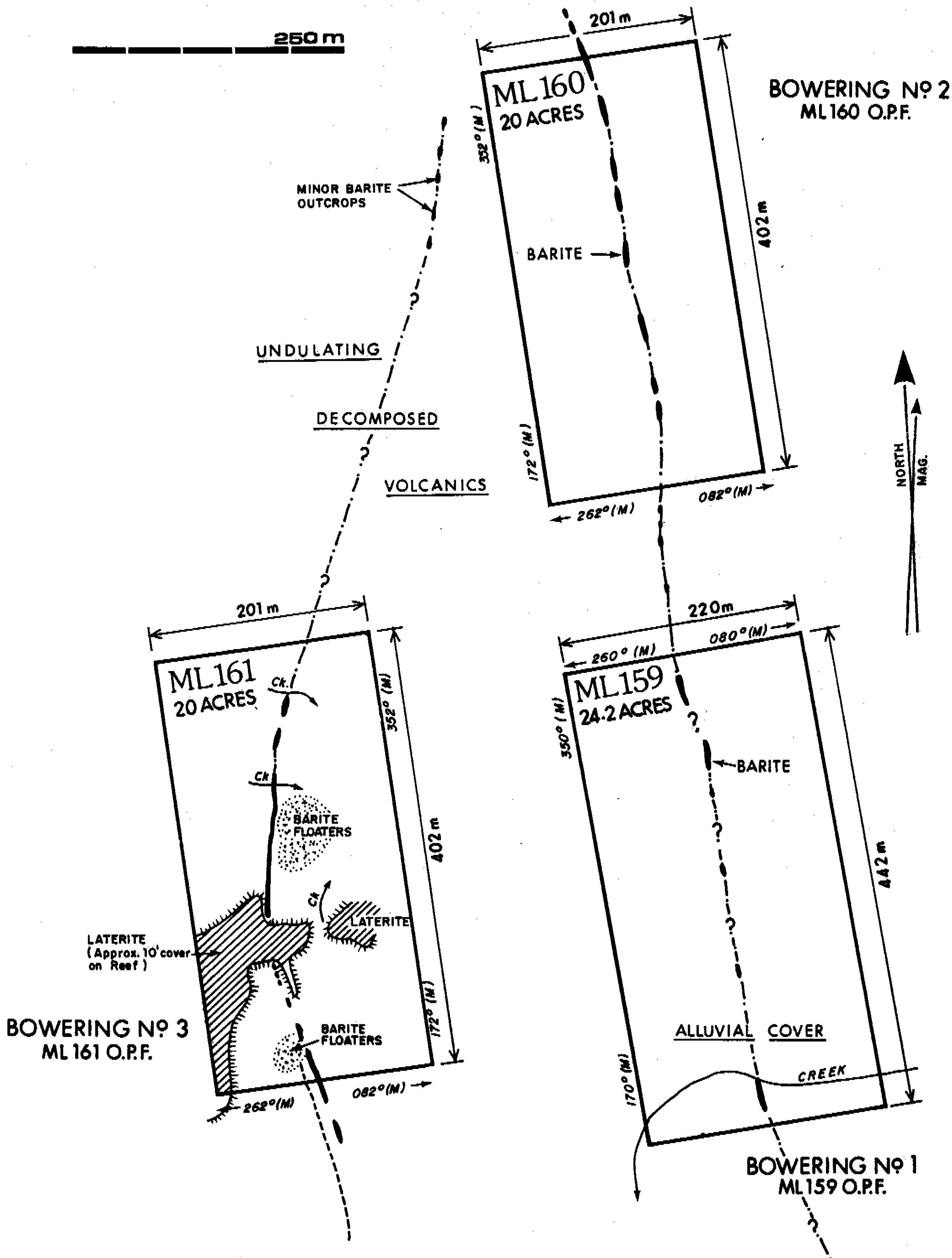
EL 3144 & EL 3239
REGIONAL GEOLOGY MAP



ANTRIM BARITE CORP. PTY. LTD

EL 3239 MINING LEASES

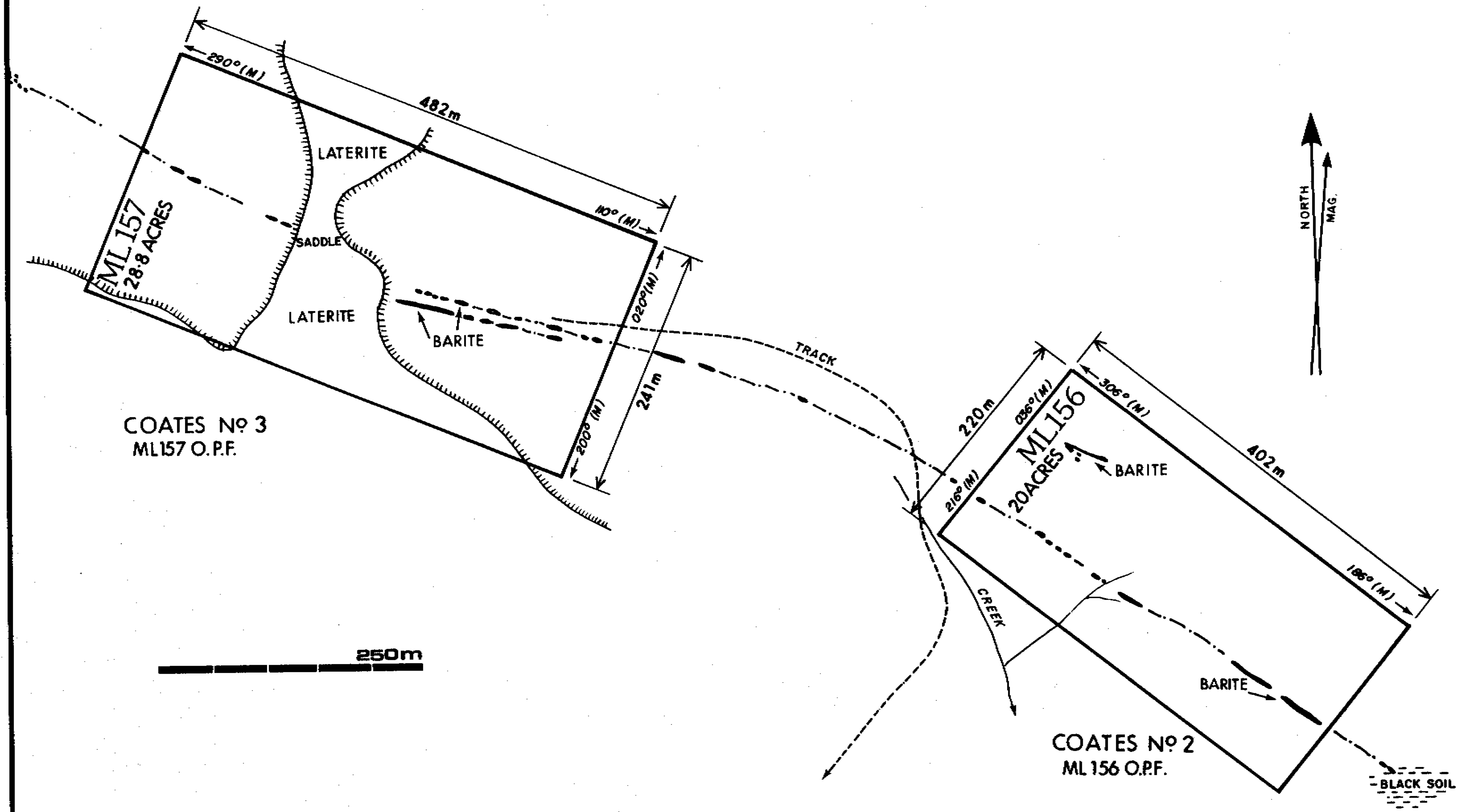
BARITE



ANTRIM BARITE CORP. PTY. LTD

EL 3239 MINING LEASES

BOWERING LODE – BARITE



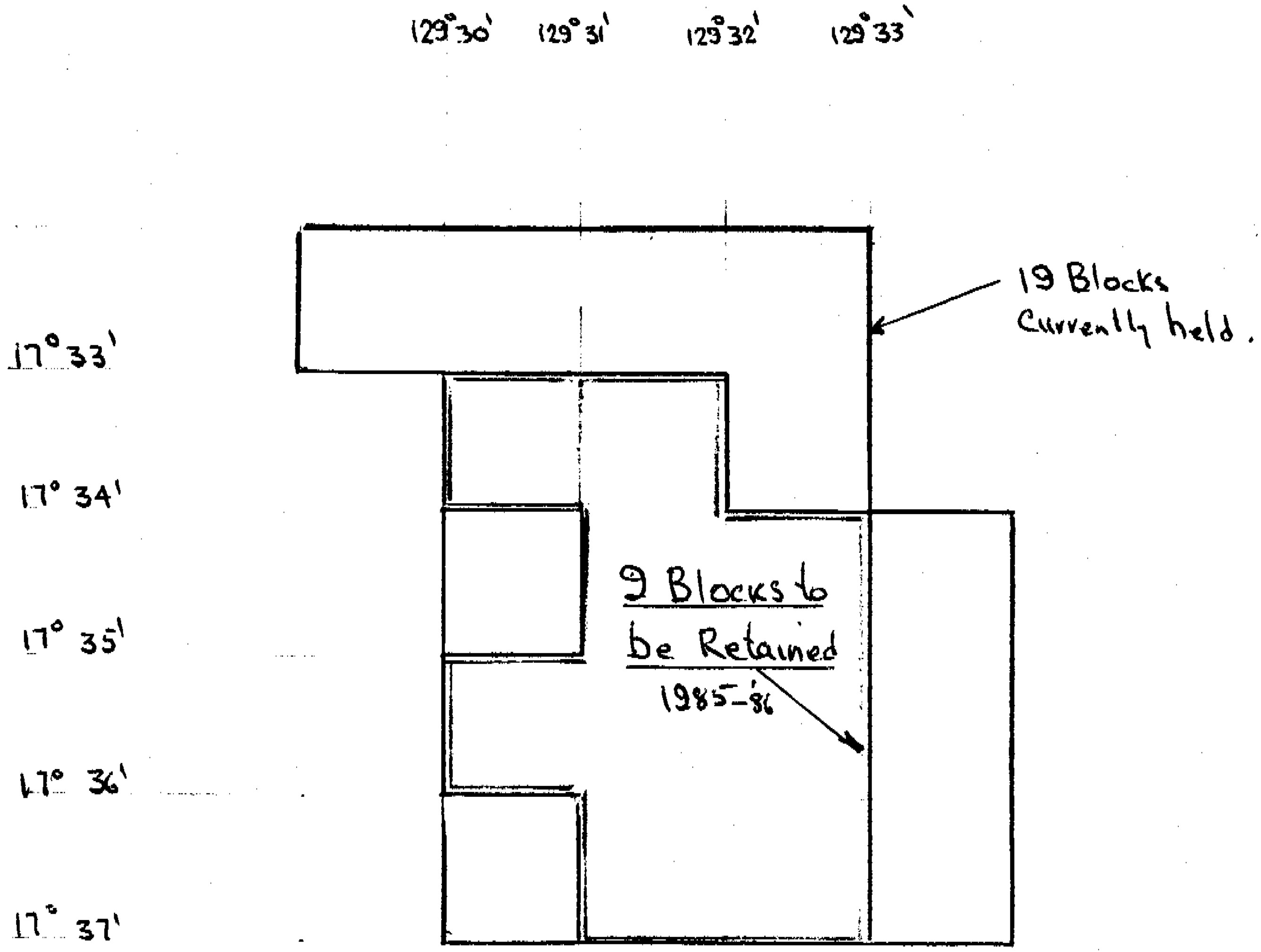
ANTRIM BARITE CORP. PTY. LTD

EL 3239 MINING LEASES

COATES LODE – BARITE

EL 3239

1982 (granted.)



Suggested Block Retention for Year 1985–'86

[signature] 25.3.85