POSSIBLE USE OF –3 mm ULEXITE TAILINGS AS MARKETABLE PRODUCT

H. Ipek & H. Gursoy

Osmangazi University
Mining Engineering Department, Eskisehir, TURKEY
hipek@ogu.edu.tr hgursoy@ogu.tr

ABSTRACT

Ulexite is one of the major boron minerals. It is widely used in many areas. In Turkey, it is produced in a single mine. Up to date approximately 190.000 tones of uneconomic product have been stored in stock area.

In this study, marketable products containing 36.75 % B_2O_3 with %44.91 recovery and 34.54 % B_2O_3 with %46.88 recovery were obtained using mechanical dispersion, ultrasonic sound waves, water absorption and magnetic separation.

INTRODUCTION

Turkey has more than 60 % of the world's boron deposits and is the second boron producer in the world preceded by the U.S. These deposits are located four different regions which are Eskisehir (Kırka), Kutahya (Emet), Bursa (Kestelek) and Balıkesir (Bigadic) at the east of Turkey. In Eskisehir, tinkal is produced, in Bursa and Kütahya, colemanite is produced and in Balıkesir, colemanite and ulexite are produced. Ulexite ($Na_2O.2CaO.5B_2O_3.16H_2O$) is the third major boron mineral after tinkal ($Na_2O.2B_2O_3.10H_2O$) and colemanite. ($2CaO.3B_2O_3.5H_2O$)

Boron minerals are widely used in many industries such as glass, agriculture, textile, chemical, metallurgical, nuclear, cosmetic. Generally ulexite is used in metallurgical, nuclear, glass fibers and cellulose industries as a insulator (Will et al. 1990).

Concentration of colemanite and ulexite are carried out by sieving and washing or dispersing and washing to remove clay from surfaces(Aytekin and Sönmez, 1991). These concentrating processes lead to the production of considerable amount of tailings. Many studies have been conducted in order to extract values from these tailings (Ayok and Tolun, 1979; Doğan et al., 1997; Özdağ et al., 1988; Sönmez and Savaş, 1994; Delice et al, 1998; Sönmez et al, 1996; Ipek and Bozkurt, 2000) Concentrated products are separated in two different screen sizes which are -125+3 mm and -3+0.2 mm. -0.2 mm is discarded to tailing ponds. -3+0.2 mm containing 22-25% B_2O_3 is stored in two different areas according to its B_2O_3 content. Ore containing 25 % B_2O_3 is sold for approximately 45-50$/ton. Ore lower than 25% B_2O_3 content can not be sold but it is stored in stock area. -125+3 mm containing 34-36% B_2O_3 is sold approximately 150$/ton. Up to now, 190.000 tones of uneconomic ore have been stored and every day approximately 100 tones have been added to this.

The aim of this study is to obtain an economic concentrate from those low grade ulexite concentrates.

MATERIAL AND METHODS

Material

20 kg of -3+0.2 mm low grade ulexite concentrate is sampled from Bigadic Colemanite and Ulexite Mine. After drying all samples in natural conditions, the sample was reduced by coning and quartering and riffling for screen and chemical analyses.

At the all tests approximately 250 grams sample was used. The result of screening is given in Table I

Table I. Wet screen analysis and B_2O_3 distribution of the sample

Particle size (μm)	Weight (%)	Σ U. size (%)	B_2O_3 (%)	Distrib. B_2O_3 %
- 4750 +3350	13.8	100.0	31.04	19.34
- 3350 +1700	34.2	86.2	29.19	45.22
- 1700 +1180	14.5	52.1	26.04	17.05
- 1180 + 850	8.7	37.5	20.07	7.88
- 850 + 600	5.6	28.8	20.51	5.19
- 600 + 425	4.2	23.8	12.78	2.42
- 425 + 300	2.8	19.1	9.13	1.15
- 300 + 212	2.2	16.2	4.56	0.45
- 212 + 150	1.5	14.0	4.56	0.31
- 150 + 106	1.8	12.5	3.65	0.29
- 106 + 75	1.0	10.7	1.82	0.08
- 75 + 53	1.0	9.7	1.60	0.07
- 53 + 45	0.6	8.7	1.60	0.04
- 45	8.1	8.1	1.37	0.50
Total	100.0		22.15	100.0

Method

In this study, ulexite concentrates were tried to be upgraded separetly by using ultrasonic waves, mechanical dispersion, water absorption and magnetic separation.. After that the sample which had been treated by ultrasonic waves, mechanical dispersion and water absorption, was passed through 300 microns screen. Deslimed and dried sample was separated by PERMROLL® high intensity, permanent magnetic separator.

EXPERIMENTAL STUDIES

Mechanical dispersion

Mechanical dispersion was applied to remove clay. Experimental conditions are summarized below and results are given in Table II and Figure 1.

Experimental Conditions:

Sample size	: -3 mm
Sample weight	: 250 g.
Feed grade	: 22.12 % B_2O_3
Pulp density	: 20, 50 % w solid
Agitation time	: 15, 30, 60, 90 min.
Agitation speed	: 670 rpm

Table II. Mechanical dispersion results :

15 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	79.22	26.12	93.55	70.22	26.87	85.30
-300	20.78	6.87	6.45	29.78	10.92	14.70
Feed	100.00	22.12	100.00	100.00	22.12	100.00

30 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	74.25	26.89	90.26	60.48	29.05	79.43
-300	25.75	8.37	9.74	39.52	11.51	20.57
Feed	100.00	22.12	100.00	100.00	22.12	100.00

60 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	69.58	28.00	88.08	53.66	31.00	75.20
-300	30.42	8.67	11.92	46.34	11.84	24.80
Feed	100.00	22.12	100.00	100.00	22.12	100.00

90 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	61.23	30.47	84.34	48.58	32.89	72.23
-300	38.77	8.93	15.66	51.42	11.94	27.77
Feed	100.00	22.12	100.00	100.00	22.12	100.00

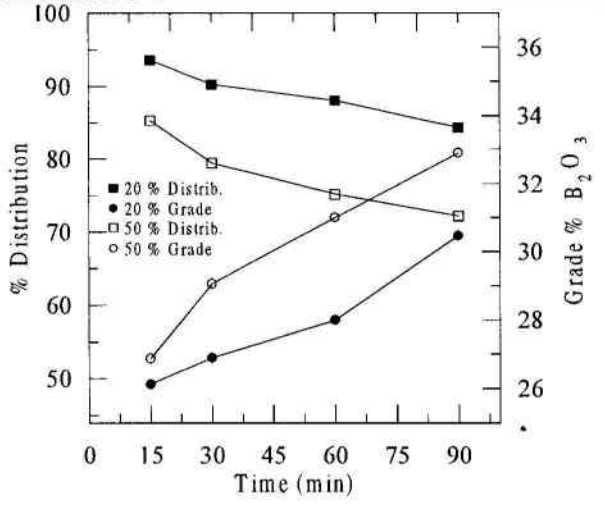

Figure 1. The variation of mechanical treatment results versus time

When Table II and Figure 1 are examined, it can be seen that mechanical dispersion has been effective on the disintegration of clay. In addition, when the agitation time and pulp density are increased, the B_2O_3 grade gets higher while the recovery gets lower.

Ultrasonic bath treatment

Sounds over the audio-frequency called ultrasound (13-100kHz). Ultrasound waves have been used in industry for cleaning metal surfaces. Fine clay particles on ore grains were removed by the pull a part effect of ultrasonic sound waves (Ipek and Bozkurt, 2000). Bath experiments which were used ultrasonic sound waves were carry out in a stainless steal tank with 12 transducers in 400x300x450 mm dimensions and power supply was 500 W. Basically in the ultrasonic bath an electrical current produced with high frequency an voltage by applying to crystals with piezoelectric properties, it is obtained that high frequency vibrations. In the experiments the tank was filled up to the determined level and it was run for 10 minutes to reduce the amount of solvent air and then the sample was added. Experimental conditions and results are summarized below and results are given in Table III and Figure 2.

Experimental Conditions:

Sample size : -3 mm

Sample weight : 250 g.

Feed grade : 22.12 % B_2O_3

Pulp density : 20, 50 % w solid

Ultrasonic times : 15, 30, 60, 90 min.

Table III. Ultrasonic bath treatment results :

15 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	76.96	27.02	94.01	80.01	26.85	97.12
-300	23.04	5.75	5.99	19.99	3.19	2.88
Feed	100.00	22.12	100.00	100.00	22.12	100.00

30 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	64.14	29.99	86.96	77.11	27.35	95.34
-300	35.86	8.04	13.04	22.89	4.50	4.66
Feed	100.00	22.12	100.00	100.00	22.12	100.00

60 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	52.36	32.08	75.94	69.78	29.29	92.40
-300	47.74	11.17	24.06	30.22	5.56	7.60
Feed	100.00	22.12	100.00	100.00	22.12	100.00

90 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	51.09	32.23	74.44	62.41	30.98	87.41
-300	48.91	11.56	25.56	37.59	7.41	12.59
Feed	100.00	22.12	100.00	100.00	22.12	100.00

From above results, it can see that ultrasonic treatment is also as effective as mechanical dispersion. When the results are examined, ultrasonic effect is not as strong at the high pulp densities, comparing to low pulp densities.

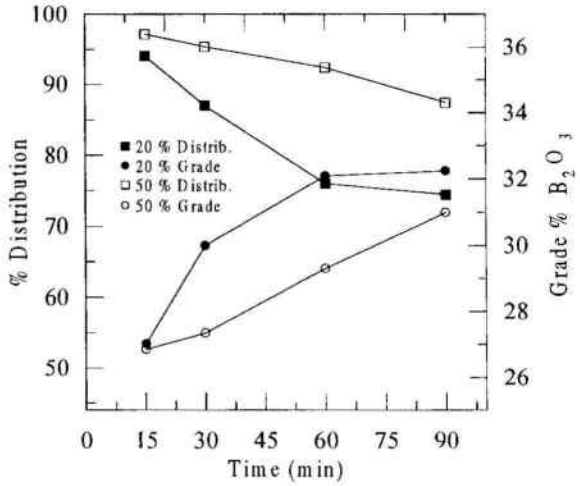

Figure 2.The variation of ultrasonic sound waves results versus time

Water absorption treatments

The purpose of this group of experiments is to determine the effect of water temperatures on the disintegration of clay from the surfaces..

Experimental conditions and results are summarized below and results are given in Table IV, V, VI and Figure 3,4,5..

Experimental Conditions:

Sample size : -3 mm

Sample weight : 250 g.

Feed grade : 22.12 % B_2O_3

Pulp density : 20, 50 % w solid

Water temperatures : 30, 45, 60° C

Treatment times : 15, 30, 60, 90 min.

Table IV. Water absorption results :30 °C

15 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	83.40	25.91	97.69	83.44	26.02	98.15
-300	16.60	3.08	2.31	16.56	2.47	1.85
Feed	100.00	22.12	100.00	100.00	22.12	100.00

Table IV. Water absorption results (*cont.*): 30 °C

30 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	82.49	26.00	96.96	81.37	26.48	97.41
-300	17.51	3.84	3.04	18.63	3.08	2.59
Feed	100.00	22.12	100.00	100.00	22.12	100.00

60 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	81.00	26.38	96.60	80.59	26.35	96.00
-300	19.00	3.96	3.40	19.41	4.56	4.00
Feed	100.00	22.12	100.00	100.00	22.12	100.00

90 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	78.17	27.15	95.95	78.00	27.00	95.21
-300	21.83	4.11	4.05	22.00	4.82	4.79
Feed	100.00	22.12	100.00	100.00	22.12	100.00

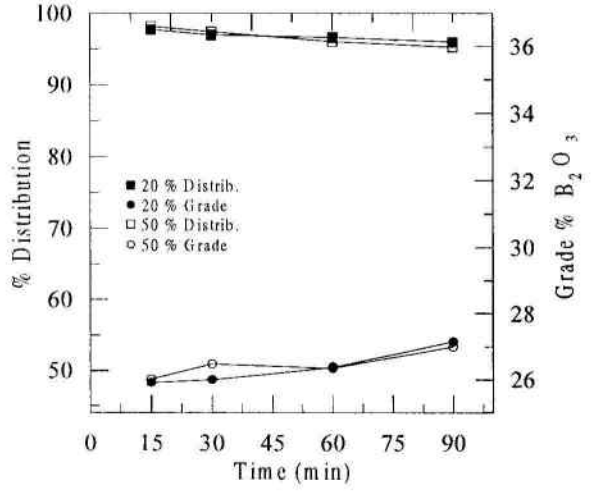

Figure 3. The variation of water absorption results for 30°C versus time

Table V. Water absorption results: 45 °C

15 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	82.30	26.10	97.11	82.14	26.20	97.29
-300	17.70	3.61	2.89	17.86	3.36	2.71
Feed	100.00	22.12	100.00	100.00	22.12	100.00

30 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	79.00	26.90	96.07	78.45	27.00	95.76
-300	21.00	4.14	3.93	21.55	4.35	4.24
Feed	100.00	22.12	100.00	100.00	22.12	100.00

60 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	77.15	27.41	95.60	76.86	27.38	95.14
-300	22.85	4.26	4.40	23.14	4.65	4.86
Feed	100.00	22.12	100.00	100.00	22.12	100.00

90 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	75.15	27.99	95.09	74.00	28.17	94.24
-300	24.85	4.37	4.91	26.00	4.90	5.76
Feed	100.00	22.12	100.00	100.00	22.12	100.00

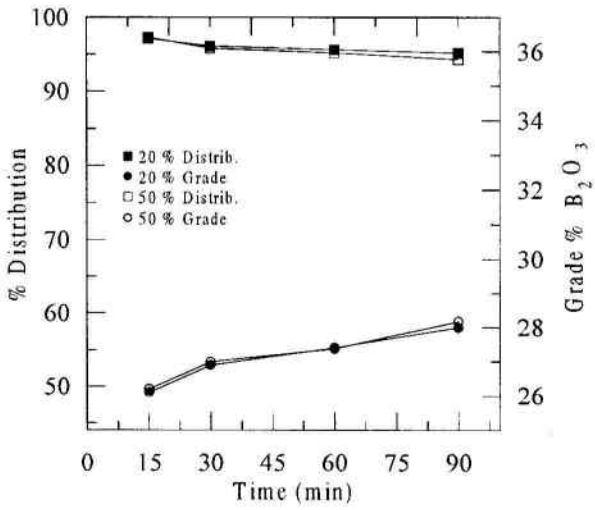

Figure 4. The variation of water absorption results for 45°C versus time

Table VI. Water absorption results: 60 °C

15 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	80.39	26.24	95.36	78.26	26.48	93.69
-300	19.61	5.23	4.64	21.74	6.42	6.31
Feed	100.00	22.12	100.00	100.00	22.12	100.00

30 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	75.89	27.12	93.04	75.18	27.20	92.45
-300	24.11	6.38	6.96	24.82	6.73	7.55
Feed	100.00	22.12	100.00	100.00	22.12	100.00

60 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	74.23	27.23	91.38	71.56	27.10	87.67
-300	25.77	7.40	8.62	28.44	9.59	12.33
Feed	100.00	22.12	100.00	100.00	22.12	100.00

90 minutes

	20 % w solid			50 % w solid		
Prod. microns	Wt %	B_2O_3	Distrb.	Wt %	B_2O_3 %	Distrb.
+300	72.98	26.94	88.88	69.14	26.90	84.08
-300	27.02	9.10	11.12	30.86	11.41	15.92
Feed	100.00	22.12	100.00	100.00	22.12	100.00

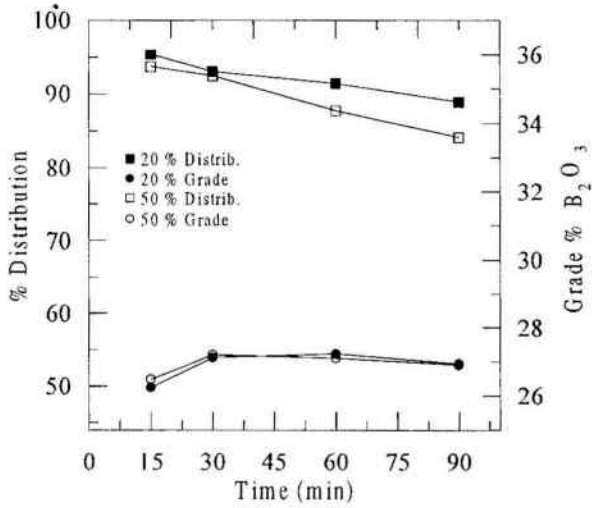

Figure 5. The variation of water absorption results for 60°C versus time

As it is seen above, the grades of B_2O_3 did not change considerably in water at lower temperatures and as the temperature of water increases, ulexite ores start to dissolve.

Magnetic separation tests

In these tests, the two of the best grade concentrates from the mechanical dispersion and ultrasonic waves treatments, 60, 90 minutes for 50% pulp density and 60, 90 minutes 20% pulp density, respectively, were used as feed to magnetic separator. The other were not enough in quality to concentrate by magnetic separation.

In these tests, a high field intensity permanent magnetic separator (PERMOLL®) was used and samples were passed three times. At the all tests belt speed was constant at 80 rpm.

Experimental conditions and results are summarized below in Table VII

Experimental Conditions:

Sample size	: -3 +0.3 mm
Sample weights	: 123,110,120,116 g.
Feed grades	: 31,00, 32.89 % B_2O_3
	32.08, 32.23 % B_2O_3
Belt speed	: 80 rpm (3 stage)

Table VII. magnetic separations results :

60 m. mechanical dispersion 50 % pulp density

Products	Weight %	B_2O_3 %	Distrib.
Concentrate	49,19	32,94	50,10
Tailing	4,63	12,78	3,56
Pre Concentrate (Feed)	53,66	31,00	53,66

90 m. mechanical dispersion 50 % pulp density

Products	Weight %	B_2O_3 %	Distrib.
Concentrate	44,11	36,75	44,91
Tailing	4,53	12,94	3,67
Pre Concentrate (Feed)	48,58	32,89	48,58

60 m. ultrasonic treatment 20 % pulp density

Products	Weight %	B_2O_3 %	Distrib.
Concentrate	47,89	33,82	48,78
Tailing	4,47	13,45	3,58
Pre Concentrate (Feed)	52,36	32,08	52,36

Table VII. magnetic separations results (cont.):

90 m. Ultrasonic treatment 20 % pulp density

Products	Weight %	B_2O_3 %	Distrib.
Concentrate	46,62	34,54	46,88
Tailing	5,15	13,47	4,21
Pre Concentrate (Feed)	51,09	32,23	51,09

As seen in above results, concentrates containing 36.75 % B_2O_3 and 34.54 % B_2O_3 are marketable products, the others can be marketable by mixing them with the –125 +3 mm products.

CONCLUSIONS

This study was done to see whether –3 mm low grade ulexite concentrates were able to be upgraded or not.

The following results can be drawn from the study:

1. Pre-concentrates were obtained by the mechanical dispersions and ultrasonic bath treatments containing 31.00% B_2O_3 with 53.66% recovery at 50% pulp density and 60 minutes treatment, 32.98% B_2O_3 with %48.58 recovery at 50% pulp density and 90 minutes treatment, 32.08% B_2O_3 with %52.36 recovery at 20% pulp density and 60 minutes treatment, 32.23% B_2O_3 with %51.09 recovery at 20% pulp density and 90 minutes treatment respectively.
2. Pre-concentrates obtained were fed to magnetic separator and a marketable product containing 36.75% B_2O_3 with %44.91 recovery %50 pulp density and 60 minutes by mechanical dispersion and a marketable product containing 34.54% B_2O_3 with %46.88 recovery at %20 pulp density and 90 minutes by mechanical dispersion were obtained.
3. The other pre-concentrates except for water absorption tests can be used as a marketable product by mixing with the –125 + 3 mm concentrates.
4. Pre-concentrates which were obtained from the water absorption tests were not good enough in quality to be used in the magnetic separation but these pre-concentrates could be used as a feed to the mechanical dispersion and ultrasonic bath treatments.

REFERENCES

Ayok, T. and Tolun, R. Concentration of low grade colemanite tailings by flotation. TÜBİTAK Project No. 0713017403. Gebze, Turkey, 1979, (Turkish Text)

Aytekin, Y. and Sönmez, E. The investigation of concentration possibilities of Kırka Tincal ore and concentrates. PhD Thesis. Dokuz Eylül University. Izmir, Turkey, 1991.(Turkish Text)

Delice, S., Gündüz, M and Özkan, Ş. Recovery studiesof ulexite ores from Eti-Holding Bigadiç mine. Proceeding of the 7th Int. Mineral Proc Symposium, p 291, İstanbul, Turkey, 1998

Doğan, Z., Kaytaz, Y., Önal, G.and Perek, K.T. Bigadic ve kestelek bor atıklarının ısıl işlem, elektrostatik ayırma ve flotasyon ile zenginleştirme olanaklarının araştırılması. 2th Industrial Minerals Symposium, p 76, İzmir, Turkey, 1997 (Turkish Text)

Ipek, H. And Bozkurt, V., Benefication of Emet tailings by ultrasonic sound waves. Proc of the 6th Conference on Enviromental Issues and Management of Waste in Energy and Mineral Production p 431, Calgary, Alberta, Canada, 2000

Özdağ, H., Bozkurt, R. And Uçar, A. The recovery of boron from Kestelek boron washing tailings. Proceeding of the 1th Int. Mineral Processing Symposium, p 282, İzmir, Turkey, 1988 (Turkish Text)

Sönmez, E. and Savaş, M. Benefications of Ement colemenite dam tailings. M.S. thesis. Osmangazi University Eskisehir, Turkey, 1994

Sönmez, E. Özdağ, H. and Savaş, M. Benefications of Emet tailings by water absorption + mechanical attrition + magnetic separations. Proc. 6th Int. Mineral Processing Symposium, p 143, İzmir, Turkey, 1996

Will, R., Mori, S. and Willhalm, R., Boron minerals and chemistry, Marketing research report , 1997