CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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Arizona Testing Laboratories

817 West Madison · Phoenix, Arizona 85007 · Telephone 254-6181

For D. K. Martin & Associates
4728 North 21st Avenue
Phoenix, Arizona 85015

Date March 30, 1982

ASSAY CERTIFICATE

LAB NO.	IDENTIFICATION	OZ. PER TON		PERCENTAGES			
		GOLD	SILVER	COPPER	Silica	Alumina	Iron
	Diatomite						
5934	111 Ranch 1				71.6	9.5	1.4
	111 Ranch 2				73.0	12.1	1.3
	San Carlos 3				21.3	3.6	0.5
	San Carlos 4				28.1	2.8	0.7
Mammoth	~~San Carlos~~ 5				69.0	10.0	1.0
Mammoth	~~San Carlos~~ 6				72.5	8.0	0.8

Respectfully submitted,
ARIZONA TESTING LABORATORIES

Claude E. McLean, Jr.

Registered Assayer
CERTIFICATE NO. 6258
CLAUDE EUGENE McLEAN, JR.
Date Signed 3/30/82
ARIZONA, U.S.A.

Arizona Testing Laboratories

817 West Madison · Phoenix, Arizona 85007 · Telephone 254-6181

For D. K. Martin & Associates
4728 North 21st Avenue
Phoenix, Arizona 85015

Date March 30, 1982

ASSAY CERTIFICATE

LAB NO.	IDENTIFICATION	OZ. PER TON		PERCENTAGES			
		GOLD	SILVER	COPPER	Silica	Alumina	Iron
	Diatomite						
	Diatomite Samples						
5934	111 Ranch 1 (Whitlock)				71.6	9.5	1.4
	111 Ranch 2 (Whitlock)				73.0	12.1	1.3
	San Carlos 3 } Not Main deposite				21.3	3.6	0.5
	San Carlos 4 } Taken along Highway 70				28.1	2.8	0.7
	~~San Carlos~~ 5 (Whitecliffs)				69.0	10.0	1.0
	~~San Carlos~~ 6 (Whitecliffs)				72.5	8.0	0.8

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean, Jr.

Registered Assayer
CERTIFICATE NO. 6258
CLAUDE EUGENE MCLEAN, JR.
Date Signed 3/31/82
ARIZONA, U.S.A.

10:45
3-18-82

1. L. D. Phone Conference w/ Prof W. E. Elston Univ. of N.M.
Albuquerque, N.M. 505-277-4204

Duck Creek Valley – Buckhorn & Cliff deposits on US 180 NW of Silver City
Some old Dozer work has been done – but none recently as far as he knows.

He will send copy of thesis by Leopold w/ map
and also the thesis by Randy Albright – still incomplete.

Clay – Diamond Shamrock Mine

order from N.M. Bur. of Mines Socorro, N.M.
N.M Geol Society Special Publication #7 James Ratté

Sum: Check out N. Mexico Guidebooks to see if there is any thing
on the Lordsburg Basin

Statement

Expenditure Through March 12, 1982

Professional Service

Field Reconnaissance, research, etc	8 days @ 500/day	=	4000.00
Office:	3 days @ 350/day	=	1050.00
			5 [illegible]
Lodging & meals	434.67		434.67
Milage: 1370 @ .40/mile	548.00		548.00
Misc			
Topo Sheets, reproductions, maps, Xerox, filing & Phone calls.	Est.		70.00
			6102.67

Tom C

SiO_2 — 80% or better — Selective can get it
may be expensive mining

Low Alumina 3-4%

Sum ½%

Maybe 20 new deposits need 10,000,000 Tons

Check out San Carlos deposits
Sulphur Springs
Curtis

We will check status of Whitecliffs & Whitlock

and call him if its open or can be dealt with

Call Monday. or as soon as we know the status
of Whitecliffs & Whitlock.

To Discuss w/ Pollard

1. Best prospects are the Mammoth-White Cliffs & the 111 Ranch-Whitlock prospect.

Both have fairly large ores

	Whitlock
Silica	79.92%
Alumina	7.68
Iron Fe_2O_3	0.30
Calcium oxide	3.18
Magnesium oxide	0.38
Sodium oxide	0.15
Potassium oxide	0.24

Diamond Shamrock

Mammoth – (Whitecliffs) Area.

Best Diatomite is confined in SW 1/4 Sec 18 – T. 9 S. – R 18 E

and NW 1/4 + N 1/2 SE 1/4 Sec 19 – T 9 S – R 18 E Pinal Co. Ariz

Beds up to 30-40' thick of Good diatomite with only limited

Contaminants such as clay, silt & chert beds. The overburden

ranges from 5 to about 50' & is composed of mostly boulder

conglomerate. a fairly large cubic yardage could be mined but the

deposits are limited in aerial extent.

Away from the best outcrops, the diatomite thins

out to beds 2-4' thick with clay & silt beds interbedded

Mining these deposits would be a "poor-boy" type of operation

where each lense would be cleared of overburden & the diatomite

(over)

sorted from the contaminants. The deposits are really in lenses which may be as much as 100 to 200 feet wide. Some exposures in side canyons indicate the lenses extend into the hills of ± 100' & about 10,000 sq yds is minable. Several of these ots occur so 250,000 to 300,000 sq yds is readily minable and several million square yards are available.

Going away from the best deposits, the diatomite occurs in lenses in clay & marl & mining would be expensive & recoveries quite low & not recommended.

A plane-table survey would have to be made to determine the amount of minable diatomite available & the amount of overburden to be removed.

Some of the deposits consist of a good grade of diatomite & grades laterally into interbedded clays.

The reconnaissance indicate the deposit to cover an area about 2 miles long and from ~~less than~~ 1/2 to 1 mile wide. The possible the deposit extends eastward toward the mountains, however, the thickness of the overburden increases making it uneconomical to mine.

Considerable work had been done in years past but there is no evidence any mining has taken place in the past several years.

Write to Robeson, Purchasing Dept, N.A.A. Tucson to see if acreage is available, what they require as override

Location (General) opposite San Manuel community, Pinal Co. on the E. Side of the San Pedro River. in Parts of 6 section T 9 S R 17 E

Flat lying to 1 degree E. dip. Local faulting & some discontinuity. Numerous box canyons - Reported beds up to 100' thick but generally 20-40' in the best areas. 4' clay beds above & below diatomite

Well suited for open pit mining

County Seats

county	town
Cochise	Bisbee
Pinal	Florence
Graham	Safford
Gila	Globe
Greenlee	Clifton
Pima	Tucson

First: Check out M. Herrera property So. of Hannibal 9 mile
& upper Gila Valley in Ariz, near Clifton - Greenlee Co.

Heating and Cooling Supply, Inc.

HEATING &
AIR CONDITIONING
SUPPLIES

WHOLESALE ONLY

4449 SO. 38th PLACE PHOENIX, ARIZONA 85040
(602) 243-5231 (800) 352-5724 (Outside Phoenix)

Branches in California: San Diego (Main Office) — Escondido — El Monte
Orange — Van Nuys — Long Beach — Riverside

Proposed Program for Diamond Shamrock

1. Get balance of Topo Sheets 2-22-82
2. Research data at Fall-grounds 2-22-82
3. " " " Tucson
4. Mean survey of Known Deposits

day & night HEATING & AIR CONDITIONING

Heating and Cooling Supply, Inc.

HEATING &
AIR CONDITIONING
SUPPLIES

WHOLESALE ONLY

4449 SO. 38th PLACE PHOENIX, ARIZONA 85040
(602) 243-5231 (800) 352-5724 (Outside Phoenix)

Branches in California: San Diego (Main Office) — Escondido — El Monte
Orange — Van Nuys — Long Beach — Riverside

1-18-82

Tom Pollard - Diamond Shamrock Corp
Irving, Texas 214-659-7160

1. He wants to go ahead with the Project
2. We can start latter part of next week
3. We need letter authorizing us to do the work
4. He will send letter & Purchase order Tomorrow.

5. ask for a Retainer.

day & night HEATING & AIR CONDITIONING

Diamond Shamrock Prog.

ordered 8/22/82

Topo Sheets – To Order

15 min Quads

- 1. Bylas – San Carlos Deposit?
- 2. Ft Thomas
- 3 Bryce Mtn
- 4 Big Lue Mts
- 5 Redington
- 6 Clifton

Diatomaceous earth Studies

maybe
Jackson Mtn

7½ min Quads

- 7 ~~6~~ Dry Mtn.
- 8 ~~7~~ Whitlock Cienega
- 9 ~~8~~ Javeline Peak
- 10 ~~9~~ Kielberg Canyon
- 11 Artesia NE – Whitlock Deposit
- 12 San Carlos. } San Carlos Deposit
- 13 Mt. Triplet }

maybe
Jackson Mtn
Buford Hill
Tripp Canyon

Topo Sheets

(2-1-92) Diatomaceous earth Studies

(Ordered & Delivered 2-1-92)

15 min Quads

1 Thatcher
2 Safford
3 Guthrie
4 York Valley
5 San Carlos Reservoir
6 Duncan

7½ min Quads

7 Whitlock Mts NE
8 Peppersauce Wash
9 Campo Bonito
10 Mammoth.

10 x 2.50 = 25.00 + Tax

Order Topo Sheets

15 Min

1 Thatcher
2 Safford
3 Gutherie
4 York Valley
5 San Carlos Reservoir
6 Bylas
7 Ft Thomas
8 Duncan
9 Bryce Mtn
10 Big Lue Mts
11 Redington

7½ min

12 Dry Mtn
13 Whitlock Mts NE
14 Whitlock Cienega
15 Javelina Peak
16 Peppersauce Wash
17 Campo Bonito
18 Mammoth
19 Kielberg Canyon

Geological program

for

S.E. Arizona Only

Time -

5 days Research + check BLM & County Records

10 days to Reconnaissance (5 prospects)

15 days @ 500/day Geologist + Assistant 7500.00

6-8 days office, Geologist, Assembling data + preliminary Reports @ $350/day 2100.00 – 2800.00

Expenses

Miss'l office expenses, drafting, Secretarial, reproductions, etc 300.00

13 days Field + outy Turn Research (2 men) Food & Lodging (75-90/day) 975.00 – 1170.00

Est Milage: 1750 x .40 mi (4x4 mostly) 700.00

Sampling, handling & Assays 250 – 500.00

$11,825 to 12,970

Contingencies 10% 1183 to 1297

Total 13,008 14,267

(Rounded to Nearest $100) 13,000 – 14,300

Silas C. Brown

We always have a geologist and an assistant for plane-table contour & for safety reasons. Most of these prospects are remote & in mountainous terrain.

Only actual charges for time & expenses will be made.

We enjoyed meeting you & Mr. Ditmars and appreciate your confidence. If you need more information on this proposal, feel free to contact us.

Sincerely,

S. C. Brown

Mr. T. W. Pollard
Industrial Chemicals Unit
Diamond Shamrock Corp
P.O. Box 2300
Irving, Texas 75061

1-29-82

Dear Mr. Pollard:

The ~~above~~ enclosed estimate is approximate but believe we can do the research, check BLM & County records for ownership, make a reconnaissance & recommendations for work necessary to determine the quantity & quality of the material.

We expect to presently confine our activities to Pinal, Graham & Greenlee Counties in Arizona where we know Diatomite occurs and the estimate covers this phase of the work.

We believe the 10 days allotted to field reconnaissance is sufficient to check out the 5 prospects, however, if there is a material change due to weather, number & size of prospects, terrain, etc. we shall ask for your approval if any additional time is required. The contingency fund will probably cover all but the most unusual condition.

The estimated charges for food and lodging may be high but moreover rates are charged between Dec 1 & Apr. 1, in Arizona. On all field work

Phx 0900
1-28-82

Conference

W. Ditmars & Tom Pollard - Diamond Shamrock

Doug Martin & Buzz Brown - Martin & Assoc - Brown & Assoc

(SCB recommended by Trent Meacham of S.R.P.)

1 They are interested in Diatomaceous earth (Diatomite) in S.E. Arizona.

2. They want a proposal of costs to look for prospects
Research, Title Checks, reconnaissance & preliminary evaluation of various properties

3. Consulting fee, expenses such as food, lodging, mileage, etc.

A. Research data of Brown prospects - Tucson, Phx, etc
B. Make a Record check to see who is owner
C. Reconnaissance of property to set up an evaluation program
D. Evaluation program.

Off: 602-246-9573
Res: 602-966-7874

4728 N. 21st. Ave.
Phoenix, Ariz. 85015

January 18, 1982

Mr. W. C. Ditmars
Diamond Shamrock Corp.
1149 Ellsworth Drive
Pasadena, Texas 77501

Dear Mr. Ditmars:

I appreciated your call on 1-12-82 regarding the possibility of making a mineral evaluation on some 2025 acres in eastern Arizona.

In June 1981 I have set up an office at the above address with Mr. D. K. Martin and associates. Mr. Martin is a specialist in mining administration and development.

My associates and I are capable of handling a project of the magnitude you mentioned. We shall be happy to discuss procedures with your representative when he arrives in Phoenix.

~~Off: 602-246-9573~~
~~Res: 602-966-7874~~

Thank you for considering us on this project.

Sincerely,

S. C. Brown
Registered geologist

Encl: Business Cards
SCB/kb

E.C. DAPPLES
GEOLOGIST

Telephone
602-977-3388

13035 98th Drive
Sun City, Arizona 85351

Januar 6, 1982.

Mr. W.C. Ditmars
Diamond Shamrock Corporation
1149 Ellsworth Drive
Pasadena, Texas, 77501.

Dear Mr. Ditmars:

Following our telephone communication of yesterday I was in conversation with Dr. Joseph F. Rominger who mentioned that he had spoken to you earlier. Together, we thought that a well-known geologist of the Phoenix area, namely Mr. Silas C. Brown would prove to be the person who could carry-out the project of appraising the mineral deposit you have in mind. Rominger and I spoke with Brown who told us he would be interested in discussing your proposal further with you should you desire. Because it is his practice not to give the impression that he is soliciting business he asked that you be kind enough to communicate with him. I list below his address and telephone numbers:

Silas C. Brown
2401 W. Southern Ave. # B 78
Tempe, Arizona, 85282.
Telephone (602) 966-7874.

Yours sincerely,

E.C. Dapples

Cc.
✓Silas C. Brown
Joseph F. Rominger

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

Phone (602) 966-7874

~~2401 W. Southern Ave. B-78~~
~~Tempe, Arizona 85282~~
4728 N. 21st Ave.
Phx. Ariz. 85015

Mr. T. W. Pollard
Mgr, Business Development
Diamond Shamrock Corp.
P. O. Box 2300
Irving, Texas 75061

29 September 1982

Dear Mr. Pollard:

It has been four months since our last correspondence. As geological consultants and because it is our practice to retain all samples collected in the field for not longer than thirty days (due to storage problems) unless the project is on going or is to be continued at a later date.

As you requested in our last telephone conversation, an estimate of expenses for the next phase of exploration and development at Mammoth, Arizona, was produced in anticipation of your visit to Phoenix.

Please advise us whether or not to retain the field samples and if we may be of further service.

Very truly yours,

SCBrown

S. C. "Buzz" Brown
Geologist

SCB:dm

Diamond Shamrock

Diamond Shamrock Corporation
1100 Superior Avenue
Cleveland, Ohio 44114

CLEVELAND
MAY 19 '82
OHIO

US POSTAGE
.20
METER
8000107

Diamond Shamrock

Doug		Buzz	
Prof Sev	5837.50	Prof Sev.	5837.50
Expense Mileage 2643 @.40	1057.20	Expenses	1358.88
	$6894.70		$7196.38

7196.38 B
6894.70 D
$ 14,091.08 Total

1358.88
1057.20
2416.08 Exp

Doug Pd. Some extra
Scott Pd " extra Costs } Cancel/Out

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

(602) 246-9573

4728 N. 21st Avenue
Phoenix, Arizona 85015

Mr. T. W. Pollard
Manager, Business Development
Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

15 April 1982

Dear Mr. Pollard:

Please find enclosed our statement for professional services and expenses for the period from February 22, 1982, through April 15, 1982.

All of the receipts for lodging are enclosed and most of the meal tickets. Some camp food and a few restaurant receipts are not available. The receipt for the New Mexico topographical sheets , acquired in Silver City at Wilkins Map Co., has been misplaced.

I shall retain the original receipts for income tax purposes.

We trust the statement is sufficient for your Company's purpose and accounting procedures. Only the portion of the bills pertaining to Shamrock and this project were charged.

You will note many of the receipts are made out to D. K. Martin and Associates. This is because several accounts were set up originally in that manner and is most convenient to our operation.

Should you have any questions, please contact us.

Sincerely,

Silas C. Brown

Silas C. Brown

SCB:dm

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

(602) 246-9573

4728 N. 21st Avenue
Phoenix, Arizona 85015

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Should you have any questions, please contact us.

Sincerely,

Silas C. Brown

Silas C. Brown

SCB:dm

NATIONAL 45-602 EYE-EASE 45-702 20/20 BUFF Made in U.S.A.

Diamond Shamrock Corp
Diatomaceous Earth Project

Feb. 22 thru Apr. 15, 1982

		Professional Services		1	2
1	2-22	Research & check records	(2)	500 -	
2	2/25	Field - Tucson, Benson, Duncan, Safford, San Carlos	(2)	500 -	
3	26	" "	(2)	500 -	
4	27	" "	(2)	500 -	2000 -
5					
6	3-1	Office - Assemble data	(1)	350 -	2350 -
7	3-2	" - " " Weekly Report 1/2 day @ 350/day	(1)	175 -	2525 -
8	3-3	" - " " " "	(1)	175 -	2700 -
9					
10	3-5	Field - Mammoth Area (Whitecliffs mine & Sd) Areas	(2)	500 -	3200 -
11	3-6	"	(2)	500 -	3700 -
12					
13	3-9	" " " " "	(2)	500 -	4200 -
14	3-10	" " " " "	(2)	500 -	4700 -
15					
16	3-11	Office: Contact U.A.A, San Carlos Tribe re: status & Assemble Data 1/2 day	(1)	175 -	4875 -
17	3-12	" : Assemble data, research + Weekly Report 1/2 day	(1)	175 -	5050 -
18	3-15	" " " " Check Ownership in BLM Record 1 day	(1)	350 -	5400
19					
20	3/16-19	Field - Check out Sulphur Springs Valley, Cochise area &			
21		Recon of balance of San Pedro Valley. 4 days @ 500		2000 -	7400 -
22					
23	3-22-42	Office 1/2 day Compile data + Weekly report		175 -	7575 -
24					
25	3/28-31	Field: Recon of upper Gila in N.M & San Simon			
26		Valley for Whitlock deposits to San Simon & N of Rodeo N.M.			
27		4 days @ 500		2000 -	9575 -
28	4-5-82	office - chg 1 day		350 -	9925 -
29	4-6	" " 1/2 day		175 -	10100 -
30	4-8	" " 1/2 " Compilation of Data, Drafting Maps,		175 -	10275 -
31	4-12	" 1 day writing Report, etc.		350 -	10625 -
32	4-13	" " 1 day		350 -	10975 -
33	4-14	" " 1 day		350 -	11325 -
34	4-15	" " 1 day		350 -	11675 -
35		D.K. Martin - Prof. Services 5837.50			
36		S.C Brown - " " 5837.50			
37		11675.00			
38					
39					
40					

NATIONAL 45-602 EYE-EASE 45-702 20/20 BUFF Made in U.S.A.

(2)

Feb. 22, 1982 Thru

Diamond Shamrock Corp
Diatomaceous Earth project

				1	2
		Expenses			
		Lodging			
2	2-25 to 2-27	Safford - Sandia motel - Best Western	(3)	10712	10712
3	3/5-6	Tucson - Executive Inn - "	(2)	5597	16309
4	3/9-10	Kearney - Kearney Inn	(2)	4696	21005
5	3/16-19	Tombstone & Tucson	(2)	10905	31910
6	3/28-31	Silver City N.M., Lordsburg N.M., Duncan Ariz & Lowes San Simon	(2)	16879	48789
		Meals			
10	2/25-27	Meals	(2)	9817	9817
11	3/5-6	"	(2)	5597	15414
12	3/9-10	"	(2)	7048	22462
13	3/16-19	"	(2)	10758	332.20
14	3/28-31	"	(2)	18447	510.67
		Mileage			
23	2/25-27	651 x .40 = 260.40	Pd to D.K. Martin & Assoc $1057.20	260 40	260 40
24	3/5-6	341 x .40 = 136.40		136 40	396 80
25	3/9-10	378 x .40 = 151.20		151 20	548 00
26	3/16-19	591 x .40 = 236.40	[redacted]	236 40	784 40
27	3/28-31	682 x .40 = 272.80	2643 x .40	272 80	1057 20
		Misc			
33	2-22	Topo Sheets, Xerox 9		28 00	25 -
35	3/5-6	Topo Sheets (73)		25 20	50 20
36	3/9-10	Film		12 67	62 87
37	3-11	Phone calls - U.A. & San Carlos Tribe & BIA	(3)	7 13	70 00
38	3-12	Topo Sheets (6)		12 60	82 60
39	3-9	Phone calls from Kearney - (White cliffs field)	(2)	5 62	88 72
40	3-14	Photo Mounts - White cliffs area		6 07	94 29
	3-15	3 Topo Sheets		6 30	100 59

(over)

			1	2
		Miss'l		100.59
1	3-15	Reproduction BLM Records of Whitecliffs claims 4.00 1.75	5 75	106 34
2	3-18	Topo Sheets (14) SE. Ariz	29 40	135 74
3	3-23	Topo Sheets (2) Regional Topo Sheets (2) Gila Forest Sec. Map Ariz-N.M	13 65	149 39
4	3-29	" " N.M.	27 00	176 39
5	3/9-31	Phone calls, San Carlos, Free Bureau of Mines, etc	15 27	191 66
6	4-9-82	Maps Reproduction	3 15	194 81
7	4-12	" "	2 84	197 65
8	4-13			
9	3-30	6 Assays, Ariz Testing Labs, Bisbee Silica, Alumina & Iron	153 60	153 60
10				
11				
12				
13		Miss'l.		
14	4-14	BLM Reproduction of Whitlock area	7 15	204 80
15	4-15	Reproduction	2 52	207 32
16				
17				
18				
19		Sent Statement Apr 15, 1982		
20				
21		Total $14,091.08		
22				
23		Prof Services 11,675.00 Payment Rec'd 5-21-82		
24		Expenses 2416.08 Pd in full		
25		$14,091 08 SCB		
26				
27				
28				
29				
30				
31				
32				
33				
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36				
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38				
39				
40				

Diamond Shamrock Corp
Diatomaceous Earth Project

			1	2
	Feb. 22 thru Apr. 15, 1982			
	Professional Services			
2-22	Research & check records	(2)	500 -	
2/25	Field - Tucson, Benson, Duncan, Safford, San Carlos	(2)	500 -	
26	" "	(2)	500 -	
27	" "	(2)	500 -	2000 -
3-1	Office - assemble data	(1)	350 -	2350 -
3-2	" " " weekly Report ½ day @ 350/day	(1)	175 -	2525 -
3-3	" " " " " "	(1)	175 -	2700 -
3-5	Field - Mammoth Area (Willcox Playa & Sid) Areas	(2)	500 -	3200 -
3-6	"	(2)	500 -	3700 -
3-9	" " " " "	(2)	500 -	4200 -
3-10	" " " " "	(2)	500 -	4700 -
3-11	Office - Contact BLM, San Carlos, Tucson & States & assemble data ½ day	(1)	175 -	4875 -
3-12	" - Assemble data, research & Weekly Report ½ day	(1)	175 -	5050 -
3-15	" " " " " Check Ownership in BLM Record 1 day	(1)	350 -	5400
3/18-19	Field - Check out Sulphur Springs Valley, Cuchillo area & Area of Influence of San Pedro Valley. 4 days @ 500		2000 -	7400 -
3-22-26	Office ½ day, Compile data + weekly report		175 -	7575
3/29-31	Field: Recon of upper Gila in N.M. & San Simon Valley for Wholebark deposits to San Simon & Rio Rodeo N.M. 4 days @ 500		2000 -	9575 -
4-5-82	office - Chg 1 day		350 -	9925 -
4-6	" " ½ day		175 -	10100 -
4-8	" " ½ "	Compilation of Data, Drafting Maps,	175 -	10275 -
4-12	" 1 day	Writing Report, etc.	350 -	10625 -
4-13	" " 1 day		350 -	10975 -
4-14	" " 1 day		350 -	11325 -
4-15	" " 1 day		350 -	11675 -

D.L. Martin - Prof. Services 5837.50
S.C. Brown - " " 5837.50
11675.00

NATIONAL 45-502 EYE-EASE 45-702 20/20 BUFF

(2)

Feb. 22, 1982 thru

Diamond Shamrock Corp
Diatomaceous Earth project

			1	2
	Expenses			
	Lodging			
2-27 thru 2-27	Safford - Sandi Motel - Best Western	(2)	107.12	107.12
3/5-6	Tucson - Executive Inn - "	(2)	55.97	163.09
3/9-10	Kearney - Kearney Inn	(2)	44.96	210.05
3/16-19	Tombstone & Tucson	(2)	109.05	319.10
3/28-31	Silver City, N.M., Lordsburg N.M., Duncan Ariz & Lower San Simon	(2)	168.79	487.89
2/22-27	**Meals**	(2)	98.17	98.17
3/5-6	"	(2)	55.97	154.14
3/9-10	"	(2)	70.48	224.62
3/16-19	"	(2)	107.58	332.20
3/28-31	"	(2)	178.47	510.67
	Mileage			
2/22-27	651 x .40 = 260.40	Pd to D.K. Martin 1/1/82 $1057.20	260.40	260.40
3/5-6	341 x .40 = 136.40		136.40	396.80
3/9-10	378 x .40 = 151.20		151.20	548.00
3/16-19	591 x .40 = 236.40	[redacted]	236.40	784.40
3/28-31	682 x .40 = 272.80	2643 x .40	272.80	1057.20
	Misc.			
2-22	Topo Sheets, Xerox 9		25.00	25.-
3/5-6	Topo Sheets (22)		25.20	50.20
3/9-10	Film		12.67	62.87
3-11	Phone calls - U.A.A. & San Carlos Tribal BIA	(3)	7.13	70.00
3-13	Topo Sheets (6)		12.60	82.60
3-9	Phone calls from Kearney - Winterhaven (2)	(2)	5.62	88.22
3-10	Photo Reports - Winterhaven area		6.07	94.29
3-15	3 Topo Sheets		6.30	100.59

		1	2
	Missl		100.59
3-15	Reproduction BLM Records of Whitelitte Claim 4.00 1.75	5 75	106 34
3-18	Topo Sheets (1x) SE Ariz	29 40	135 74
3-23	Topo Sheets (2) Reprint Topo Sheets (2) Gila Forest Sec Way Ariz-N.M	13 65	149 39
3-29	" " N.M.	27 00	176 39
3/29-31	Phone calls, Sec contact, Tax Assr of Ariz, etc	15 27	191 66
4-9-[illegible]	Map Reproduction	3 15	194 81
4-12	" "	2 84	197 65
4-13			
3-30	6 Assays Ariz Tertary Lake, Ore Silica, Alumina & Iron	153 60	153 60
	Missl.		
4-14	BLM Reproduction of Whitlock area	7 15	204 80
4-15	Reproduction	2 52	207 32

Sent Statement Apr 15, 1982

Total $14,091.08

Prod Services 11,675.00
Expenses 2416.08
$14,091 08

Payment Rec'd 5-21-82
Pd in full
SCB

Diamond Shamrock Expenses

		1	2	3	4	5	6	7
			SERVICES	SUPPLIES	FOOD	Lodge	mileage	OTHER
1		2/22	500.00					
2				27.30				
3				21.00				phone 3.71
4		2/23		63.35				
5				credit (50.00)				
6		2/25	500.00					
7					Sn 1.15			
8					Sn 1.79			
9					B 7.19			
10					L 11.72			
11					D 22.45			
12					Sn 14.10			
13		2/26			B 5.83			
14								
15					L 9.22*			
16					D 28.27*			
17		2/25-26	500.00			107.12		
18		2/27	500.00					
19					B 6.45*			
20					L 11.36*			
21					D 15.25*			
22		2/25-27					260.40	
23		2/28			6.45			
24								
25								
26								
27		3/1	350.00					
28		3/2	175.00					
29		3/3	175.00					
30		3/5	500.00					
31					B 14.79			
32					L 5.86			
33					B 7.42*			
34						55.64		
35		3/6	500.00		B 7.35*			
36		3/5-6			D 13.63*		136.40	
37		7			L 6.89			
38								
39								
40								

© WILSON JONES COMPANY G7207 GREEN 7207 BUFF MADE IN U.S.A.

	1	2	3	4	5	6	7
		Service	Supplies	Food	LODGE	mileage	other
1	3/9	500.00					
2				L-D 42.62	~~44.72~~		phone 5.62
3				B	46.98		
4							
5	3/10	500.00					
6				B			
7				L			
8				D			
9	3/9-10					151.20	
10							
11	3/11	175.00					
12	3/12	175.00					
13	3/14						film 6.07
14	3/15	350.00	14.39				
15			1.75				
16			4.00				
17	3/16	500.00					
18				B	60.90		
19				L 6.64			
20				Sn 3.87			
21				D 25.03			
22	3/17	500.00					
23			12.60	B			
24				L 10.01			
25				D			
26	3/18	500.00			48.15		
27			29.40	B			
28				L			
29				D			
30	3/19	500.00		107.70			phone 24.31
31				B			
32				L			
33				D			
34	3/16-19					236.40	
35							
36							
37							
38							
39							
40							

© WILSON JONES COMPANY G7207 GREEN 7207 BUFF MADE IN U.S.A.

	1	2	3	4	5	6	7
		Services	Supplies	Food	Lodge	mileage	other
1	3/22	175.00					
2	TOTALS	7575.00	123.79	365.26	318.77	784.40	39.21
3	3/23		28.74	332.53			11.95
4			credit (15.09)	684.03		163.50	
5							
6	3/28	500.00					
7				D ~~35.61~~ 25.61*			
8				B 9.22*			
9				L 12.07			
10							
11	3/29	500.00					
12				B & Sm 15.63			
13				L-D 46.12	28/29 122.26		27.76
14							
15	3/30	500.00				arrow	153.60
16			27.00				
17					46.53		
18				B 9.09			
19				L-D 35.13			
20							
21	3/31	500.00		L 7.25			
22				B 15.06			
23	3/28-31			D 24.82*		272.80	
24				200.05	168.79		
25							
26							
27	4/5	350.00					
28	4/6	175.00					
29	4/8	175.00					
30	4/9		3.15				
31	4/12	350.00	2.84				
32		3050.00	46.64	200.05	168.79	272.80	181.36
33	4/13	350					
34	4/14	350					
35	4/15	350					
36		4100					
37			170.43	~~532.58~~	487.56	1057.20	193.31
38	Thru 4-15-82 =	11675 —	Asset 153 —	510.67	487.89		207.32
39		153 -					
40		510.67					
		487.89					
		1057.20					
		207.32					
		14091.08					

Incl. addendum

Statement sent 4-15-82 $14,091.08

© WILSON JONES COMPANY G7207 GREEN 7207 BUFF MADE IN U.S.A.

Diamond Shamrock

Diamond Shamrock Corporation
1100 Superior Avenue
Cleveland, Ohio 44114

64-1327
611

FN 543252

Check No.	Check Date.
FN543252	05/19/82

Pay Exactly *****14,091 Dollars and 08 Cents

in settlement of items listed on accompanying remittance statement

Dollars and Cents
*****14,091.08

The First National Bank of Atlanta
Augusta, Georgia

Pay to the order of

SILAS E BROWN & ASSOC
4728 N 21ST AVE
PHOENIX AZ 85015

Void

TREASURER

⑈0543252⑈ ⑆061113279⑆ 07 506 987⑈

Diamond Shamrock Corporation

Vendor No.	Check Date	Check No.
87032-01	05/19/82	FN543252

Loc.	Invoice No.	Amount	Discount	Net Amount
IRV	05/01/82	14,091.08	0.00	14,091.08
	DIATOMACEOUS EARTH PROJECT, EXPENDITUR			

Doug
Prof Ser 5837.50
Mileage 1057.20
$ 6894.70

pd 5-24-82

2643 @ .40

7196.38
6894.70
$ 14,091.08

Buzz
Prof. Ser. 5837.50
Exp 1358.88
$ 7196.38

D 1259-14

Remittance Statement
Please detach and retain before depositing check

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

(602) 246-9573

4728 N. 21st Avenue
Phoenix, Arizona 85015

Mr. T. W. Pollard
Manager, Business Development
Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

15 April 1982

Dear Mr. Pollard:

Please find enclosed the Reconnaissance Survey Report for southeastern Arizona and southwestern New Mexico.

Unless we are instructed to the contrary, we shall continue attempting to obtain the "Walk-On Permit from the San Carlos-Apache Indian Tribal Council to allow checking the San Carlos Deposits. We have been advised, no decision will be made until the newly elected Tribal Council becomes organized and have their first official meeting. This is expected to occur around the end of April at the earliest.

We are duplicating receipts for various expenditures and shall forward a statement under a separate cover.

If you need additional copies of the maps or have further questions, please call us.

Sincerely,

Silas C. Brown

Silas C. Brown

SCB:dm

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

DIATAMACEOUS EARTH RECONNAISSANCE

Southeastern Arizona
Southwestern New Mexico

by

Silas C. Brown

REGISTERED GEOLOGIST
CERTIFICATE NO
4702
SILAS C.
BROWN
Date Signed 4-15-82
ARIZONA, U.S.A.

15 April 1982

DIATAMACEOUS EARTH RECONNAISSANCE

INTRODUCTION

Diatomite is synonymous with diatomaceous earth, and in its natural state is a soft rocklike material consisting mainly of an accumulation of siliceous frustules (shells) or skeletons of diatoms that are microscopic single-celled plants of freshwater and saltwater origin. Chemically, diatomite is essentially amorphous hydrated or opaline silica with varying amounts of contaminants such as silica sand, clay minerals, metal salts, and organic matter. The apparent density of dry consolidated diotomite is 20 to 40 pounds per cubic foot and that for dry powdered diatomite is 5 to 16 pounds per cubic foot.

LOCATION

The diatomaceous earth reconnassiance survey included the San Pedro, Gila and San Simon Valleys in Southeastern Arizona and Southwestern New Mexico.

PURPOSE OF INVESTIGATION

Preliminary investigation was undertaken to evaluate the known diatomite deposits and locate any new deposits capable of producing ten million tons in one or more localities.

Approximately sixteen days were spent in the field. Considerable difficulties were encountered due to weather conditions, locked gates and impassable jeep trails and paths.

CONCLUSIONS

All diatomite deposits visited can be mined by open pit methods. They entail the usual associated environmental problems such as overburden disposal, dust control, and appropriate rehabilitation of abandoned quarry sites. Effective control of the silica dust can be obtained by employing enclosed circuits.

The White cliffs (Mammoth) Deposit in Pinal County, Arizona, appears to be the only deposit capable of producing the required tonnage. Based upon reports, the San Carlos Deposit will probably be the second choice. However, no field check has been accomplished because of Tribal Elections and the "Walk-On" Permit cannot be obtained until the end of April at the earliest.

CONCLUSIONS (continued)

The Whitlock (111 Ranch) Deposit in Graham County, Arizona has good large reserves, but on a much lesser scale when compared with the Whitecliffs Deposit.

The Stevens (Duncan) Deposit in Greenlee County, Arizona, has some fair deposits, but most are in a well settled and populated area. Many of the outcrops occur within the City Limits of Duncan, Arizona, and probably could not be economically acquired in a block large enough to mine.

The deposits listed below were checked and found to be inadequate because of the thin and lensing beds of poor quality and quantity. No further investigative work is recommended on the following areas:

Curtis	Cochise County, Arizona
BMS et.al.	Graham County, Arizona
Soloman	Graham County, Arizona
Sulphur Springs	Cochise County, Arizona
Buckhorn-Cliff	Grant County, New Mexico

Please refer to Exhibit I, the base map showing general locations of each diatomite deposit.

RECOMMENDATIONS

A more detailed survey of each area is needed to determine the reserves and quality of the deposits.

Phase Number 2

Contact owners of the Whitecliffs and Whitlock Deposits to determine availability and terms of acquisition.

Obtain permission from the San Carlos-Apache Tribe to conduct a preliminary survey of their deposit.

Phase Number 3

Map each deposit, calculate the amount in site, calculate amount of overburden and sample each area, project drilling locations to determine amount of reserves.

Drill with a rotary down-in-hole pneumatic hammer to sufficient depth and block out reserves plus determine amount of overburden to be removed.

RECOMMENDATIONS (continued)

Phase Number 4

Produce a feasibility study

Phase Number 5

Design and erect milling plant

Phase Number 6

Place deposits into production

GEOLOGY

The diatomite deposits are in fresh water lake beds, believed to be Pleistcene and/or Pliocene in age. The deposits occur in two levels and reminants of a third upper bench at Whitecliffs, and two beds at Whitlock. All are lensy and seldom form a continuous bed. The deposits are wide-spread however, and large quantities of diatomite can be mined economically.

Because of the lensing nature of the deposits, the high grade diatomite grades laterally into interbeds of clay and silt. Several cubic yards or tons of good quality diatomite can be mined using selective mining methods.

The diatomite beds contain varying amounts of clay, silt and minor chert. In some areas a clay bed occurs above and below the diatomite. Above the clay beds, a boulder conglomerate occurs which would have to be removed for open pit mining.

The San Pedro Valley narrows north and south of the Whitecliff Deposits and grades from lake beds to fanglomerates. The fanglomerates are composed primarily of sand, pebble and boulder conglomerate.

The Gila River Valley includes the San Carlos and Duncan (Stevens) Deposits. Going upward in the geologic section, and to the north, the deposits change to volcanic tuffs. The deposits observed in the Upper Gila Valley near Buckhorn-Cliff in New Mexico are thin and lensy and consist of air-fall ash rather than diatomite.

In the San Simon Valley, the Whitlock (111 Ranch) Deposits are the best developed. Small lenses of diatomite extend southward for several miles but seldom exceed three feet in thickness. The BMS et.al. Deposits north of the

the town of Bowie are the southern extension of the lake beds. The diatomite is in horizontal beds and ranges from 4 inches to 8 inches in thickness. These deposits are considered uneconomical to mine, although, some mining has been accomplished and the ore shipped from Bowie via railroad to California. It was not determined where it was shipped in California nor for what end use. There was no need to make further inquiry based upon the limited deposit.

No diatomite was found south of the BMS et.al. Deposits as most of the area is being farmed and the lake beds change to fanglomerates from the surrounding mountains.

WHITECLIFFS (MAMMOTH) DEPOSITS

LOCATION

The Whitecliffs Deposits occur about 8 miles south of the town of Mammoth on the east side of the San Pedro Valley. More specifically, the claims are located in Sections 13 and 24 ~~18~~, Township 9 South, Range 17 East, G&SRB&M, and Sections 18, 19, 20, 29, and 30, Township 9 South, Range 18 East, of the G&SRB&M, Pinal County, Arizona, containing 3120 acres more or less.

ACCESSIBILITY AND FACILITIES

These deposits lie to the east of the mining community of San Manuel. It is accessible from the town of Mammoth by crossing the San Pedro River to the east and traveling southward for a distance of approximately 8 miles.

The Southern Pacific Railroad at San Manuel connects with it's mainline at the Town of Bowie, about 25 miles to the south. The El Paso Natural Gas Company pipelines extend to the San Pedro River directly across from the diatomite deposits. An Arizona Public Service Company power line bisects the approximate center of the property. Water is available from wells in the San Pedro flood plain.

GENERAL

The reconnaissance survey gives only a general picture of the total diatomite deposits. A more exact figure of diatomite in these deposits are contingent on a more thorough

SHANE BROWN GEOLOGIST

investigation. This would include measurement of the diatomite beds for thickness and quality; amount of contaminent to be removed; quantity and type of overburden, and a drill hole program to determine the extent and thickness of the deposits below the overburden.

Based upon some data acquired in the field, it appears the ten million tons required are present in the Whitecliffs Deposits. It is estimated about 400 acres in Sections 18 and 19 would average 20 feet or more diatomite in two horizons and a limited amount in a third upper horizon. In some areas within the 400 acre block, the two beds exceed 50 feet of fair to good grade diatomite.

If the 400 acres will average 20 feet in thickness, the projected estimates are as follows:

43560 x 400 = 17.42 m sq ft x 20' = 348.4 m cu ft
Assuming 54 cubic feet per ton, then
348.4 ÷ 54 = 6.45 m tons

This is believed to be a conservative figure since some local areas would average 50 feet or more. It has been reported the diatomite is up to 100 feet in thickness in places, However, this was not observed during the preliminary investigation.

Based upon the cursory survey, the Whitecliffs Deposits are the most likely to contain the ten million tons of the quality of diatomite required. Phase 3 of the exploration should be instigated as outlined above and when an equitable arrangement can be made with Southwest Mining Company of Mesa, Arizona.

Exhibit II shows the approximate edge of the diatomite deposits, location of major outcrops and their general thickness. The eastern limits are governed by increased overburden and the eastward extension of the beds would have to be determined by drilling.

Exhibit III shows the individual claims with the major outcrops and approximate thickness. The Whitlock Claims (not related to the Whitlock [111 Ranch] Claims in Graham County) join the Whitecliffs on the east and south. These claims are also leased to Southwest Mining Company. A land check was not made of the Whitlock Claims as they appear to be beyond the main diatomite deposits and the overburden becomes excessive.

Photos #1 through #6 show the general terrain, thicknesses, lensing nature and overburden.

Two samples were taken for assay with the following results:

#5	Silica =	69.0%	Alumina =	10%	Iron =	1.0%
#6		72.5%		8%		0.8%

The samples were taken across the complete outcrop and some contamination may have come from the overburden through percolating water. By going deeper into the formation wall, the percentages may improve by eliminating some of the contaminates.

Wide spread samples taken for the Arizona Development Board, and the chemical analysis was reported as follows:

Silica = 87.92% Alumina = 3.9% Iron = 0.1%

WHITLOCK (111 Ranch) DEPOSIT

LOCATION

The Whitlock Deposits are located approximately 20 miles southeast of the town of Safford. The major deposits center in Sections 26 and 27, Township 8 South, Range 28 East, of the G&SRB&M, Graham County, Arizona. Please refer to Exhibit IV.

ACCESSIBILITY AND FACILITIES

The Deposits can be reached by traveling approximately 15 miles east from Safford on paved U.S. Highway 70, then southward about 5 miles on a good gravel road to the 111 Ranch. The road continues past the deposits approximately 8 miles to the community of Tanque, which is on the west side of the San Simon River. The river has no bridge and is dry except during stormy periods. Please refer to Exhibit V, showing land status and claim locations.

The Southern Pacific Railroad has a siding at Tanque. Electric power and gas lines are available along U.S. Highway 70, about 5 miles north of the deposits. Water is available in some of the larger washes and larger quantities may be be developed by drilling in the gravels of the San Simon drainage. These latter well locations may be 2 to 4 miles from the deposits.

WHITLOCK DEPOSIT (continued)

GENERAL

The diatomite deposits are lensy and some were observed to have thicknesses up to 30 feet. Please see Exhibit IV, indicating locations and thicknesses. The north portion of the deposit has been highly eroded to form small diatomite hills with up to 10 and 15 feet of overburden. The impurities include pumicite, clay and some calcium carbonate (lime).

The deposits lie around the north end of the Whitlock Mountains, as would be expected, the overburden increases toward the mountains.

Where erosion has exposed the deposits at the surface, an ideal open pit mining situation exists. A more detailed survey and drilling program are necessary to determine the lateral extent and the thickness of the deposits.

The reconnaissance survey indicates the probability of approximately a two million ton reserve. This estimate is assuming 300 acres having diatomite averaging 10 feet in thickness.

Because of the nature of the outcrops near the bottom of the dry washes, more diatomite may occur with depth. Therefore to try and deliniate the aerial extent of these deposits could prove to be very misleading. Each outcrop would have to be measured, sampled and drilled carefully for a more exact reserve figure.

This is a good back-up property to the Whitecliffs Deposits, even though the Whitecliffs should produce the tonnage required. Photos Numbers 7 through 10 show the general character of these deposits.

Respectfully submitted,

Silas C. Brown

Silas C. Brown

SCB:dm

REGISTERED GEOLOGIST
CERTIFICATE NO.
4702
SILAS C.
BROWN
Date Signed 4-15-82
ARIZONA, U.S.A.

SILAS C. BROWN GEOLOGIST

Diamond Shamrock

Diamond Shamrock Corporation
351 Phelps Court
P. O. Box 2300
Irving, Texas 75061
Phone: 214 659-7160

T. W. Pollard
Assistant to the President
Industrial Chemicals Unit

Diamond Shamrock

Diamond Shamrock Corporation
Industrial Chemicals & Plastics
1149 Ellsworth Drive
Pasadena, Texas 77501
Phone: 713 476-1303

W. C. (Bill) Ditmars
Engineering Manager

10:30 AM
5-6-82

Tom Pollard called SCB pm Diamond Shamrock, Irving, Tex.

He will call us next week to set up a meeting in Phx to go over report & will want an estimate of how long & cost to do phase II on Mammoth. (Maybe we should make an estimate on Whitlock too?)

Hold up on the San Carlos land inspection until we meet & make a decision.

Tom has been out of town a lot lately

Our statement is being processed & we should be paid soon.
(SCB to be out of town from May 26 thru June 8th)

Note Doug & SCB should set up an estimate to map, drill & sample Mammoth — also Whitlock if the decide to go there also.

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

Telephone:
(602) 246-9573

4728 North 21st Avenue
Phoenix, Arizona, 85015

May 5, 1982

Mr. T. W. Pollard, Manager
Business Development
Diamond Shamrock Corporation
P.O. Box 2300
Irving, Texas, 75061

Dear Mr. Pollard,

We have again contacted the Burear of Indian Affairs (BIA) at San Carlos. The Tribe still does not have a Chairman for the Resources section, so we have been unable to set up an appointment with them for the "walk-on" permit.

The procedure is to see the Resources Section Chairman who will take our proposal to the BIA and then to the Tribal Council.

Since we have not heard from you, we assume you intend us to follow through on the San Carlos deposits as it is reportedly the second best prospect after Mammoth.

Sincerely,

S.C. Brown

S. C. Brown

SCB/jeo

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

Phone (602) 966-7874

2401 W. Southern Ave. B-78
Tempe, Arizona 85282

28 January 1982

Mr. T. W. Pollard
Industrial Chemicals Unit
Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

RE: Diatomaceous Earth Preliminary Survey

Dear Mr. Pollard:

We are able to accomplish the required research; BLM, County and Owner record searches; geological reconnaissance of more than five known prospects; report our recommendations for the exploratory work necessary to positively ascertain the quantity and quality of the non-metallic ore. We believe a step by step planned approach is best for this type of survey.

Presently we expect to confine our activities to Pinal, Graham and Greenlee Counties in Arizona where we know diatomite occurs. The attached estimate covers this phase of the work.

The eight to ten days allotted to field reconnaissance should be sufficient for the preliminary evaluation of four to five of the prospects, however, if there is a material change due to weather, number and size of the prospects, terrain, etc., we shall seek your approval prior to affording additional time. The contingency fund should cover all but the most unusual conditions.

The estimated charges for subsistance may seem high, but maximum rates are charged between December 1st and April 1st in Arizona.

On all field work we always have a geologist and an assistant for surface control, sampling, mapping and safety requirements. Many of these prospects are remote and in mountainous terrain.

Only actual charges for time and expenses will be made.

We enjoyed meeting you and Mr. Ditmars and appreciate your confidence and the opportunity to submit our proposal. If you have any questions, feel free to contact us anytime.

Sincerely,

S C Brown

S. C. Brown

SB/dm
encl: 1

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

Phone (602) 966-7874

2401 W. Southern Ave. B-78
Tempe, Arizona 85282

28 January 1982

GEOLOGICAL PROGRAM PROPOSAL

FOR

SOUTHEASTERN ARIZONA

(Re: Diatomaceous Earth Preliminary Survey)

Professional Services:

4 - 5 days - Research & search BLM & County records of known deposits		
10 - 12 days - Reconnaissance of 4-5 prospects		
14 - 17 days @ $500/day. Geologist & assistant	$7000 - 8500	8000
6 - 8 days - Geologist, assemble data and preliminary reports @ $350/day	2100 - 2800	3675.00
	9100 - 11,300	11,675

Thru 4-13
16 day Field
10½ days Wpe

EXPENSES

10 - 13 days - Field and out of town research, 2 men, subsistance @ $75-90/day	750 - 1170	998.56
Est. mileage - 1500-1750 @ .40/mi. (4x4) 2643 * .40 = 1057.20	600 - 700	1057.20
Misc. office expenses, drafting, secretarial, reproductions, etc.	200 - 300	207.32
Sampling, handling, assay & Spec. 153 32 185	250 - 500	153.00
Contingencies - 10%	1090 - 1400	
Estimated Totals	$11,990 - 15,370	

Statement 11,675.00
Pay Sec 2416.08
EXP 14,091.08

Respectfully submitted,

Silas C Brown

Silas C. Brown
Registered Geologist

Apr. 5, 1982
12:35 PM

Pollard - Drummond Shamrock
Irving Tex
1-214-659-7160

1. We have Whitecliff & Whitlock deposits only
San Carlos may look good after Wallen survey.

2. Do not contact SW Mining Co but make a check
of ownership of 111 Ranch - Dory says its fee or ~~Hom~~ pat. land.

3. They will decide if we or they contact SW. Mining after seeing
our report.

4. Hold San Carlos Indian deposit in obeyance until we get
clearance to make Walk-on inspection.

5. Send receipts in that we have when submitting Statement
& Pollard will see that it gets paid.

Tom Pollard: 1-214-659-7160

L.D. Tom - out of office for a couple of hours will call back

upper 6.1's in N. M. - Thin beds of airfall ash - looks like Diatomite
Thin beds 6"-10" in San Simon S. of Whitlock

Only 2 prospective areas so far
Whitlock (111 Ranch) :-!-:-:
White cliffs (Mammoth) (SW. Mining Co. Mesa.)

The San Carlos deposit appears fairly large as observed from South of the river
The tribe is having an election Tomorrow & they said it would take them 2 weeks to organize & hold their 1st Council meeting

Next Step is to find out if the property is available

Second is to see how much Good Diatomite is available at each area - Very slow because each bed has to be measured for thickness & overburden & assayed very carefully because of the contaminants.

Statement - What receipts are required? Just in what we have
we have
Miss'l eff, lodging & Some Food meals

Sylvs c. Brown & Assoc
Geological Consultants

Off: (602) - 246 - 9573
Res. (602) - 966 - 7874

4728 N. 21st Ave
Phoenix, Ariz. 85105

April 15, 1982

STATEMENT

DIATOMACEOUS EARTH PROJECT

For: Diamond Shamrock Corporation
P.O. Box 2300
Irving, Texas, 75061

Expenditures From February 22 thru. April 15, 1982

Professional Services:

Field reconnaissance, research, etc. ~~fund check, etc~~ 16 days @ $500 = $8000

Office compilation, progress & final Reports
drafting, etc 10½ days @ $350 = 3675 ~~x x x x~~ 11675

Expenses:

Lodging ~~& meals~~	487.89
Subsistence	510.67
Mileage: 2643 x .40	1057.20
Assays: Ariz Testing Labs, Phoenix - Six Samples	153.00
Miss'l: Topo Sheets, maps, Reproduction, Film, Xerox, phone, etc	207.32 / 2416.08
Total	14,091.08

Thank you.

Sylvs Brown Reg. Geol.

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

(602)246-9573

4728 N. 21st Ave.
Phoenix, Ariz. 85015

April 20, 1982

File

Mr. T. W. pollard
Manager, Business Development
Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

Dear Mr. Pollard:

Enclosed ~~is~~ are the results of the assay from the BMS, et. al. claims in Graham County, Arizona. You will recall that these deposits were mentioned in our report as being 4 to 8 inches thick and not worthy of further investigation. The diatomite here is very hard and heavier than the diatomite at Whitlock to the north.

~~This assay sheet is~~ These data are for your information.

Sincerely,

SCB

Silas C. Brown

SCB:wm

INVOICE

0541

ARIZONA TESTING LABORATORIES

817 WEST MADISON STREET • PHOENIX, ARIZONA 85007 • 602/254-6181

ESTABLISHED MARCH 1, 1932

In Account With: D. K. Martin & Associates
4728 North 21st Avenue
Phoenix, Arizona 85015

PURCHASE ORDER •

DATE • April 15, 1982

LAB. NO. • 6173

PLEASE PAY FROM THIS INVOICE • STATEMENT UPON REQUEST

DATE	QUANTITY	ITEMS	UNIT PRICE	AMOUNT
		Sample of Diatomaceous Earth marked "BMS #7"		
	3	Chemical Analyses, Alumina, Silica & Iron plus sample preparation		$ 32.00

Pd #1053

Speediply ® MCP ® Patented

"One Test Is Worth A Thousand Expert Opinions"

Arizona Testing Laboratories

817 West Madison Street □ Phoenix, Arizona 85007 □ 602/254-6181

For: D. K. Martin & Associates
4728 North 21st Avenue
Phoenix, Arizona 85015

Date: April 15, 1982

Lab. No.: 6173

Sample: Diatomaceous Earth

Marked: DMS #7

Received: 4-14-82

Submitted by: D. K. Martin

REPORT OF LABORATORY TESTS

DMS #7

Alumina, Al_2O_3	16.5 %
Silica, SiO_2	53.2 %
Iron, Fe	2.1 %

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean, Jr.

Claude E. McLean, Jr.

Arizona Testing Laboratories

817 West Madison Street □ Phoenix, Arizona 85007 □ 602/254-6181

For: D. K. Martin & Associates
4728 North 21st Avenue
Phoenix, Arizona 85015

Date: April 15, 1982

Lab. No.: 6173

Sample: Diatomaceous Earth

Marked: DMS #7

Received: 4-14-82

Submitted by: D. K. Martin

REPORT OF LABORATORY TESTS

DMS #7

Alumina, Al_2O_3	16.5 %
Silica, SiO_2	53.2 %
Iron, Fe	2.1 %

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean, Jr.

Claude E. McLean, Jr.

D. K. MARTIN & ASSOCIATES
MINING ADMINISTRATION & DEVELOPMENT
OFFICE ACCOUNT
4720 NORTH 21ST AVENUE
PHOENIX, ARIZONA 85015
PHONE 246-9573

VALLEY NATIONAL BANK
PHOENIX, ARIZONA

NO. 1055

PAY THE SUM 31 DOLS 87 CTS

DATE 4/27/82

AMOUNT $ 31.87

THE ORDER OF Mountain Bell
Phoenix, Arizona

NOT NEGOTIABLE

246-9573

⑈001055⑈ ⑆122100024⑆ 658⑈7949⑈

CV Rocky Mountain Bank Note

PAYEE: DETACH THIS STATEMENT BEFORE DEPOSITING

D. K. MARTIN & ASSOCIATES
MINING ADMINISTRATION & DEVELOPMENT

DATE	INVOICE NO.	DESCRIPTION	AMOUNT	DISCOUNT OR DEDUCTION	NET AMOUNT
4/19/82	246-9573	Telephone Service & Calls			
		Diamond Shamrock	27.68		
		General	1.68		
		Clark Drilling	1.68		
		Lambert Project	.83		
					31.87

602 246-9573 APR 19 1982

ITEMIZED CALLS PAGE 4

NO.	DATE	TIME	TO PLACE	TO AREA - NO.	*	MIN	AMOUNT
33	418	850P	PAYSON AZ	602 474 5733	73	25	4.96
			CRDT CARD FROM PHOENX AZ	602 265 3373			
34	418	343P	E KINGMAN AZ	602 757 2321	3	7	.96
			TOTAL OF ITEMIZED CALLS EXCLUDING TAX				66.23

TAXES-U.S. .66 STATE 1.24
COUNTY .00 CITY .74 2.64

EXPLANATION OF *
IZ INTERZONE
1 DIAL STATION DAY RATE
2 DIAL STATION RATE INCL 35% EVE DISCOUNT
3 DIAL STATION RATE INCL 60% NITE/WKND DISCOUNT
15 OPERATOR STATION RATE

BK

-- 1 R 767 18 0519 0607 82

602 246-9573 APR 19 1982

SERVICE & EQUIPMENT - APR 19 THRU MAY 18 13.60
OTHER CHARGES & CREDITS-SEE DETAIL .33
ITEMIZED CALLS-SEE DETAIL 66.23
TAXES-U.S. .80 STATE 1.83
COUNTY .00 CITY 1.09 3.72
CURRENT CHARGES-INCLUDING TAX --DUE BY MAY 10-- 83.88

LAST BILL	ADJUSTMENTS	PAYMENTS	
56.55	.00	56.55	THANK YOU

TOTAL DUE 83.88

DS	21.70	33	27.68	1055	DKM	7 92	12	10 07	2084
GEN	1.45	02	1.68	1055	CLRK	1 42	02	1 68	1055
PAY	6.70	10	8.39	2084	LAW	.47	01	.83	1055
TRV	20.77	31	26.00	600	GAR	5 [illegible]	.05	[illegible]	016

BILLING INQUIRIES CALL 602-973-7911
TO PLACE AN ORDER CALL 602-255-2502
-- 1 R 767 18 0519 0607 82

602 246-9573 APR 19 1982 H

ITEMIZED CALLS PAGE 1

NO.	DATE	TIME	TO PLACE	TO AREA - NO.	* MIN	AMOUNT
1	318	1043A	PHOENIX AZ	602 246 9573	16 9	6.22 DS
	COLLECT FROM ALBQ NM 505 277 5339					
2	319	914A	COTTONWOODUT	801 943 2005	1 3	1.45 B
3	322	111P	PAYSON AZ	602 474 5733	1 1	.45 P
4	322	113P	IRVING TX	214 659 7160	1 1	.61 DS
5	323	922A	E KINGMAN AZ	602 757 2321	1 2	.82 TRV
6	324	938A	E KINGMAN AZ	602 757 2321	1 10	3.38 TRV
7	325	952A	PAYSON AZ	602 474 5733	1 4	1.29 P
8	326	138P	IRVING TX	214 659 7160	1 1	.61 DS
9	328	531P	PHOENIX AZ	602 265 3373	15 3	2.40 DS
	CRDT CARD FROM SL CTY NM 505 538 2916					
10	328	524P	TEMPE AZ	602 966 7874	17 4	2.65 DS
	CRDT CARD FROM SL CTY NM 505 538 2916					
11	328	617P	LORDSBURG NM	505 542 3444	73 8	1.12 DS
	CRDT CARD FROM SL CTY NM 505 538 2916					

602 246-9573 APR 19 1982 H

ITEMIZED CALLS PAGE 2

NO.	DATE	TIME	TO PLACE	TO AREA - NO.	* MIN	AMOUNT
	STATE TAX ON ABOVE CALL					.04 DS
12	329	1011P	LORDSBURG NM	505 542 3444	73 5	.83 DS
	CRDT CARD FROM SL CTY NM 505 538 2916					
	STATE TAX ON ABOVE CALL					.03 DS
13	330	659P	TEMPE AZ	602 966 7874	17 6	3.16 DS
	CRDT CARD FROM LDBG NM 505 542 3591					
14	330	715P	PHOENIX AZ	602 265 3373	17 7	3.41 DS
	CRDT CARD FROM LDBG NM 505 542 3591					
15	4 2	1118A	E KINGMAN AZ	602 757 2321	1 9	3.06 TRV
16	4 3	634P	CALIFON NJ	201 832 7556	21 1	1.34 LAND
	CRDT CARD FROM PAYSON AZ 602 474 5733					
17	4 5	417P	E KINGMAN AZ	602 757 2321	1 1	.50 TRV
18	4 5	931A	IRVING TX	214 659 7160	1 1	.62 DS
19	4 5	1139A	SPSTNAPJCTAZ	602 986 5681	IZ 1	.26 clark
20	4 5	227P	KINGMAN AZ	602 753 2198	1 1	.50 clark

-- 1 R 767 18 0519 0607 82 BK

602 246-9573 APR 19 1982 H

ITEMIZED CALLS PAGE 3

NO.	DATE	TIME	TO PLACE	TO AREA - NO.	* MIN	AMOUNT
21	4 5	502P	E KINGMAN AZ	602 757 2321	2 9	1.98 TRV
22	4 6	731A	KINGMAN AZ	602 753 2198	3 1	.20 clark
23	4 6	734A	KINGMAN AZ	602 753 6262	3 1	.20 clark
24	4 8	1006A	E KINGMAN AZ	602 757 2321	1 2	.82 TRV
25	4 8	148P	KINGMAN AZ	602 753 9141	1 4	1.46 TRV
26	4 8	221P	E KINGMAN AZ	602 757 2321	1 5	1.78 TRV
27	4 8	924A	E KINGMAN AZ	602 757 2321	1 16	5.30 TRV
28	415	857A	SPSTNAPJCTAZ	602 986 5681	IZ 1	.26 clark
29	415	755A	E KINGMAN AZ	602 757 4315	3 5	.71 TRV
30	417	215P	PHOENIX AZ	602 274 4000	74 1	.47 LAM
	CRDT CARD FROM GILA B AZ 602 683 9937					
31	418	806P	AURORA CO	303 341 0678	20 18	5.80 GAR
	CRDT CARD FROM PHOENX AZ 602 265 3373					
32	418	915P	ENGLEWOOD CO	303 761 3505	20 21	6.58 LAND
	CRDT CARD FROM PAYSON AZ 602 474 5733					

-- 1 R 767 18 0519 0607 82 BK

Statement

Expenditures Through March 22, 1982

Prof Service

Field	12 days @ 500	=	6000.00
Office	4½ " @ 350	=	1575.00

Expenses:

Food & Lodging		=	651.30
Mileage	@.40	=	
Misc: Reproduction, maps, filer, xerox Topo Sheets & Phone		=	135.74

11:45 3-22-82

10975
350
11325

Mr. Johnson: Prescott - 20 g ~~Gold~~ Silver -
Char
832-4195 Gold - Good.

192.65
7.15
204.80

4-7 mile S of Courthouse
1-1½ W Goldwater Lake Groom Creek Mining area

N-S Claim 6 claims in a block (on road)

Pat Patterson was in - Papers all signed
No money for about a month

Progress Reports

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

(602) 246-9573

4728 N. 21st Ave.
Phoenix, Arizona
85015

22 March 1982

RE: Diatomite

Mr. T. W. Pollard
Manager, Business Development
Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

Dear Mr. Pollard:

The reconnaissance of the San Pedro River Valley to the North and South of the Whitecliffs (Mammoth) deposits has been completed. It is apparent the Whitecliffs deposit is the only diatomite worthy of commercial development in this area.

Geologically, the fresh water lake beds phase out into fanglomerates which are not favorable for diatomite development.

The Whitecliffs claims of any value belong to the University of Arizona, Tucson, Arizona, and have been leased to Southwest Mining Company, Inc., of Mesa, Arizona. This company has not been contacted.

Minimal road work has been done to various deposits. Little or no mining has been accomplished for some time. The claims have been validated through 1981 and are therefore current with all governmental requirements.

The Sulphur Springs area in Cochise County has only limited indications of diatomite. There are no reliable outcrops in the predominately alkali flats. This area as a prospect should be eliminated for further exploration.

The Curtis Deposits near St. David and Curtis Flats in Cochise County are limited in extent. They are very lensy and occur in thin layers between the silts and clays on the average. These are near-shore deposits and contain mumerous bone fragments of fossil mammals. Further evaluation is not recommended.

Contact was established with the Bureau of Indian Affairs at the San Carlos-Apache Indian Agency. The BIA is to meet with the Tribal Council and present our request for a "Walk-On" permit. The Tribe generally wants a fee for this type of permit which we hope will be exempted, due to the nature of our request. In any case, we shall inform you as soon as we know their decision.

(continued)

To complete this phase of the project, a reconnaissance of the southern extension of the San Simon Valley and the upper part of the Gila River Valley extending into New Mexico must be made. If we obtain the permit from the Indians, all of this work should be completed in one final trip to the field.

We expect to complete the field work in four to six days. Our schedule is to leave Phoenix Sunday, March 28th, weather permitting.

Respectfully Submitted,

S.C. Brown

Silas C. Brown
Registered Geologist

REGISTERED GEOLOGIST
CERTIFICATE
4700
SILAS
BROWN
3-22-82
ARIZONA, U.S.A.

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

(602)246-9573

4728 N. 21st. Ave.
Phoenix, Arizona 85015

March 22, 1982

STATEMENT

DIATOMACEOUS EARTH PROJECT

For: Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

Expenditures from February 22 thru March 22, 1982

Professional Services:

Field reconnaissance, research, etc.	12 days @ $500 =	$6000.00
Office compilation, progress reports, research, etc.	4 1/2 " @ 350 =	1575.00

Expenses:

Lodging & meals	651.30
Milage: 1961 @ .40	784.40
Miss'l: Topo sheets, maps, reproduction, film, xerox, phone, etc.	135.74
Total	$9146.44

Thank you,

Silas C. Brown

Silas C. Brown
Registered geologist

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

(602)246-9573

4728 N. 21st. Ave.
Phoenix, Arizona 85015

March 22, 1982

STATEMENT

DIATOMACEOUS EARTH PROJECT

For: Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

Expenditures from February 22 thru March 22, 1982

Professional Services:

Field reconnaissance, research, etc. 12 days @ $500 = $6000.00

Office compilation, progress reports, research, etc. 4 1/2 " @ 350 = 1575.00

Expenses:

Lodging ~~& meals~~	651.30
Subsistence	
Milage: 1961 @ .40	784.40
Assays	
Miss'l: Topo sheets, maps, reproduction, film, xerox, phone, etc.	135.74
Total	$9146.44

Thank you,

Silas C Brown
Silas C. Brown
Registered geologist

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

(602)246-9573

4728 N. 21st. Ave.
Phoenix, Ariz. 85015

March 12, 1982

Mr. T. W. Pollard
Manager, Business Development
Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

Dear Mr. Pollard:

We are having some rain again which has interferred with our field work to some extent. If it clears this week end we shall attempt to check out the areas in Cochise County.

We have applied to the San Carlos Tribal Counsel and the Bureau of Indian Affairs for the necessary permits to check those deposits.

A written request has been made to the University of Arizona regarding the status of the Whitecliffs deposits.

Enclosed is the progress report and a statement for professional services and expenses to date. Also enclosed are analysis sheets for the Whitecliffs, Whitlock and San Carlos deposits made for the Arizona Development Board about 1954. The samples analysed represent grab samples from one or more outcrops in the designated area. The Silica and Iron contents are within the range you requested, but the alumina is high except for Whitecliffs.

When we receive the data requested from the University and after checking the ownership records and requirements, we shall phone you our opinion.

Sincerely,

Silas C. Brown

Silas C. Brown

Encl:

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

Mar 12, 1982

PROGRESS REPORT

DIATOMITE RECONNAISSANCE SURVEY

SOUTHEASTERN ARIZONA

Whitecliffs (Mammoth) deposits

March 5, 6, 9 & 10 was spent in the Whitecliffs area checking the better outcrops and determing the limits of the entire deposit. The best diatomite appears to be confined to the SW 1/4 Section 18 and the NW 1/4 & N 1/2 of theSE 1/4 Section 19, T. 9 S., R. 18 E., Pinal County, Arizona. Beds of better diatomite range from 20 to 40 feet thick with only limited contaminants such as clay, silt and thin chert beds. The overburden ranges from 5 to 50 feet thick and is composed mostly of boulder conglomerate. Clay beds averaging 4 feet in thickness occur above and below the diatomite where it had not been eroded.

The diatomite beds are somewhat discontinuous due to lensing and local faulting, however, 2 separate beds are present locally. Radiating from the best outcrops in the sections listed above, the diatomite thins into lenses interbedded with clay and silt. This would create mining problems and probably could not be mined economically, therefore, it would be advisable to open-pit the more massive deposits where the overburden is minimal.

In past years, some mining was accomplished in SW 1/4 Section 19 and from two separate terraces in SW 1/4 Section 18. The remnants of an old mill site were found in the south-central part of Section 13. It is likely the material milled was hauled from Section 18.

The next step is to check the status of these claims with the University of Arizona, the present owners. They have requested a letter outlining our interest and desires prior to their responding. All we want at the present time is the status of the claims and we are now awaiting their reply.

San Carlos deposits

We are still awaiting permission for a permit to check these deposits. When permission is granted, a ranger from the tribe must accompany us at all times. The Bureau

Diatomite recon.

of Indian Affairs are also involved so we cannot expect a speedy decision granting our request.

Other Prospects

As weather permits, we shall check out deposits in Sulphur Springs Valley and the Curtis prospect in Cochise County.

We shall extend our reconnaissance into New Mexico to determine the extent of deposits on the border between the states and look for new deposits.

Respectfully submitted,

SC Brown

Silas C. Brown
Registered geologist

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

(602)246-9573

4728 N. 21st. Ave.
Phoenix, Ariz. 85015

March 2, 1982

Mr. T. W. Pollard
Manager, Business Development
Diamond Shamrock Corp.
P. O. Box 2300
Irving, Texas 75061

Dear Mr. Pollard:

Please find enclosed a progress report of the diatomite reconnaissance survey in southeastern Arizona. The Whitlock prospect has the best potential of the areas inspected to date.

Our immediate plans are to check the Whitecliffs (Mammoth) deposits sometime during the latter part of this week. An attempt will be made to inspect the Sulphur Springs prospect in Cochise County, weather permitting. We have been plagued with rainy weather which is fairly normal this time of year. Some problems were encountered last week, but they did not prevent us covering a considerable area.

Upon receiving a permit from the San Carlos Tribal Council, we shall inspect the San Carlos and Triplet Peak prospects.

It would be helpful to know the quality and quantity of diatomite needed for your application. This information will allow us to determine whether small, medium or large deposits are required and enable us to save you time and money by a more rapid elimination of prospects which do not meet your needs. It will also give us more time researching those prospects which may meet with your approval.

Sincerely yours,

SCBrown

Silas C. Brown
Registered geologist

Encl:
SCB/wg

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

PROGRESS REPORT

DIATOMITE RECONNAISSANCE SURVEY

SOUTHEASTERN ARIZONA

Whitlock Prospect

The Whitlock prospect is situated in Sections 22 and 27, T. 8 S., R 28 E., Graham County.

This property has also been known as the Haralson, Flat Tire or 111 Ranch property. It was orginally staked as an uranium property and in 1976 the uranium deposits were sub-leased to Anaconda. The owner retained the diatomaceous earth on a reported 2540 acrea, about 4 sections of land.

The Whitlock prospect appears to have the most promise of the properties observed to date. The diatomite occurs in isolated small hills and fairly continuous, lensing ourcrops over a large area. Some interbeds of clay, marl and minor chert occur locally in the diatomite. Other areas of the deposit have been eroded away and only remnants are left to form small, isolated hills. The diatomite beds range from 8 to about 30 feet in thickness. The overburden is generally 30 feet or less and consists of mainly boulder conglomerate. Two samples were obtained for analysis.

Stevens Prospect

The Stevens prospect is located three miles north of Duncan, Arizona in Sections 2 & 11, T. 8 S., R. 31 E., Graham County. This prospect consists of a 170 acre lease on a patented homestead with minerals included. The diatomite occurs in lensing beds up to approximately 8 feet in thickness with 3 to 10 feet of gravel overburden. The deposit is small, contains thin clay and chert lenses which would have to be sorted out. No additional work is advised for the present.

Solomon Prospect

The Solomon prospect was reported to be located in Section 14 or 15, T.6 S., R 27 E., Graham County. We made a reconnaissance of more than two townships without observing any good diatomite outcrops. It has been reported that the deposits are diatomite and pearlite, however, it appears to

be of limited size and the overburden would be excessive for the most part. No additional work is advised for the present.

Curtis Prospect

An attempt was made to visit the Curtis prospect approximately 10 miles south of Benson, Arizona in Cochise County. Heavy rains had created wash-outs preventing a reconnaissance survey at that time.

San Carlos Deposits

These diatomite prospects are on the San Carlos Indian Reservation and the main deposits are reported to be in Section 18, T. 1 N., R. 18 E.,Graham County.

Some minor deposits were observed along the highway which were limited in extent and not over 3 feet thick. Clay lies above and below the layered deposits. Due to scheduling and the location of the better deposits only a brief survey was attempted and accomplished. A permit for tresspass and exploration from the Tribe is needed. When the permit is granted we shall make a more thorough survey.

Whitecliffs Deposits

Our next field reconnaissance will be made on the Whitecliffs deposits in T. 9 S., R. 17 & 18 E., Pinal County, Arizona. If the reconnaissance proves favorable, a record search will be made to determine ownership and availability.

Other prospects

We shall continue to check out other areas of interest and keep you posted.

Respectfully submitted,

SCBrown

Silas C. Brown
Registered geologist

REGISTERED GEOLOGIST
CERTIFICATE
SILAS C. BROWN
3-2-82
ARIZONA, U.S.A.

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

STATEMENT

EXPENDITURES THROUGH MARCH 12, 1982

Professional services:

Field Reconnaissance, research, etc. 8 days @ $500	=	$4000.00
Office compilation, progress reports, 3 days @ 350	=	1050.00
Lodging & meals	=	434.67
Milage: 1370 @ .40	=	548.00
Miss'l. Topo sheets, maps, reproduction, film, xerox, phone	=	70.00
Total		$6102.67

Thank you,

SCBrown

Silas C. Brown

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

EXPENDITURES THROUGH MARCH 1, 1982

These figures have been rounded off but will be made exact for final billing.

Professional Services:

Field reconnaissance, research, etc. 4 days @ $500	=	$2000.00
Office compilation of data 1 day @ $350.00	=	350.00
Milage: 651 @ .40 mile	=	260.00
Food and lodging	=	215.00
Miss'l expenditures, reproductions, maps, xerox	=	25.00
Total	=	$2850.00

S C Brown

S. C. Brown

Proposal w/ Est Cost

Letter of Authorization
from T. W. Pollard

Diamond Shamrock

February 19, 1982

Mr. Silas C. Brown
Registered Geologist
Silas C. Brown & Associates
2401 W. Southern Avenue B-78
Tempe, Arizona, 85282

Dear Mr. Brown:

As we discussed on the phone, will you please proceed with the Diatomaceous Earth project as outlined in your proposal dated January 28, 1982. I believe you indicated that you could get started early next week and that this project would take about a month to complete.

We would appreciate it if you would advise us on a weekly basis of the progress that is being made and also provide us with an estimate of the costs that have been incurred. Thank you.

Yours truly,

T W Pollard

T. W. Pollard
Manager
Business Development

jw

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

Phone (602) 966-7874

2401 W. Southern Ave. B-78
Tempe, Arizona 85282

28 January 1982

Mr. T. W. Pollard
Industrial Chemicals Unit
Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

RE: Diatomaceous Earth Preliminary Survey

Dear Mr. Pollard:

We are able to accomplish the required research; BLM, County and Owner record searches; geological reconnaissance of more than five known prospects; report our recommendations for the exploratory work necessary to positively ascertain the quantity and quality of the non-metallic ore. We believe a step by step planned approach is best for this type of survey.

Presently we expect to confine our activities to Pinal, Graham and Greenlee Counties in Arizona where we know diatomite occurs. The attached estimate covers this phase of the work.

The eight to ten days allotted to field reconnaissance should be sufficient for the preliminary evaluation of four to five of the prospects, however, if there is a material change due to weather, number and size of the prospects, terrain, etc., we shall seek your approval prior to affording additional time. The contingency fund should cover all but the most unusual conditions.

The estimated charges for subsistance may seem high, but maximum rates are charged between December 1st and April 1st in Arizona.

On all field work we always have a geologist and an assistant for surface control, sampling, mapping and safety requirements. Many of these prospects are remote and in mountainous terrain.

Only <u>actual</u> charges for time and expenses will be made.

We enjoyed meeting you and Mr. Ditmars and appreciate your confidence and the opportunity to submit our proposal. If you have any questions, feel free to contact us anytime.

Sincerely,

S C Brown

S. C. Brown

SB/dm
encl: 1

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

2401 W. Southern Ave. B-78
Tempe, Arizona 85282

Phone (602) 966-7874

28 January 1982

GEOLOGICAL PROGRAM PROPOSAL

FOR

SOUTHEASTERN ARIZONA

(Re: Diatomaceous Earth Preliminary Survey)

Professional Services:

4 - 5 days	- Research & search BLM & County records of known deposits	
10 - 12 days	- Reconnaissance of 4-5 prospects	
14 - 17 days	@ $500/day. Geologist & assistant	$7000 - 8500
6 - 8 days	- Geologist, assemble data and preliminary reports @ $350/day	2100 - 2800

EXPENSES

10 - 13 days - Field and out of town research, 2 men, subsistance @ $75-90/day	750 - 1170
Est. mileage - 1500-1750 @ .40/mi. (4x4)	600 - 700
Misc. office expenses, drafting, secretarial, reproductions, etc.	200 - 300
Sampling, handling, assay & Spec.	250 - 500
Contingencies - 10%	1090 - 1400
Estimated Totals	$11,990 - 15,370

Respectfully submitted,

Silas C. Brown

Silas C. Brown
Registered Geologist

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

(602) 246-9573

4728 N. 21st Avenue
Phoenix, Arizona 85015

Mr. T. W. Pollard
Manager, Business Development
Diamond Shamrock Corporation
P. O. Box 2300
Irving, Texas 75061

15 April 1982

Dear Mr. Pollard:

Please find enclosed the Reconnaissance Survey Report for southeastern Arizona and southwestern New Mexico.

Unless we are instructed to the contrary, we shall continue attempting to obtain the "Walk-On Permit from the San Carlos-Apache Indian Tribal Council to allow checking the San Carlos Deposits. We have been advised, no decision will be made until the newly elected Tribal Council becomes organized and have their first official meeting. This is expected to occur around the end of April at the earliest.

We are duplicating receipts for various expenditures and shall forward a statement under a separate cover.

If you need additional copies of the maps or have further questions, please call us.

Sincerely,

Silas C. Brown

Silas C. Brown

SCB:dm

SILAS C. BROWN & ASSOCIATES
GEOLOGICAL CONSULTANTS

DIATAMACEOUS EARTH RECONNAISSANCE

Southeastern Arizona
Southwestern New Mexico

by

Silas C. Brown

15 April 1982

DIATAMACEOUS EARTH RECONNAISSANCE

INTRODUCTION

Diatomite is synonymous with diatomaceous earth, and in its natural state is a soft rocklike material consisting mainly of an accumulation of siliceous frustules (shells) or skeletons of diatoms that are microscopic single-celled plants of freshwater and saltwater origin. Chemically, diatomite is essentially amorphous hydrated or opaline silica with varying amounts of contaminants such as silica sand, clay minerals, metal salts, and organic matter. The apparent density of dry consolidated diotomite is 20 to 40 pounds per cubic foot and that for dry powdered diatomite is 5 to 16 pounds per cubic foot.

LOCATION

The diatomaceous earth reconnassiance survey included the San Pedro, Gila and San Simon Valleys in Southeastern Arizona and Southwestern New Mexico.

PURPOSE OF INVESTIGATION

Preliminary investigation was undertaken to evaluate the known diatomite deposits and locate any new deposits capable of producing ten million tons in one or more localities.

Approximately sixteen days were spent in the field. Considerable difficulties were encountered due to weather conditions, locked gates and impassable jeep trails and paths.

CONCLUSIONS

All diatomite deposits visited can be mined by open pit methods. They entail the usual associated environmental problems such as overburden disposal, dust control, and appropriate rehabilitation of abandoned quarry sites. Effective control of the silica dust can be obtained by employing enclosed circuits.

The White cliffs (Mammoth) Deposit in Pinal County, Arizona, appears to be the only deposit capable of producing the required tonnage. Based upon reports, the San Carlos Deposit will probably be the second choice. However, no field check has been accomplished because of Tribal Elections and the "Walk-On" Permit cannot be obtained until the end of April at the earliest.

CONCLUSIONS (continued)

The Whitlock (111 Ranch) Deposit in Graham County, Arizona has good large reserves, but on a much lesser scale when compared with the Whitecliffs Deposit.

The Stevens (Duncan) Deposit in Greenlee County, Arizona, has some fair deposits, but most are in a well settled and populated area. Many of the outcrops occur within the City Limits of Duncan, Arizona, and probably could not be economically acquired in a block large enough to mine.

The deposits listed below were checked and found to be inadequate because of the thin and lensing beds of poor quality and quantity. No further investigative work is recommended on the following areas:

Curtis	Cochise County, Arizona
BMS et.al.	Graham County, Arizona
Soloman	Graham County, Arizona
Sulphur Springs	Cochise County, Arizona
Buckhorn-Cliff	Grant County, New Mexico

Please refer to Exhibit I, the base map showing general locations of each diatomite deposit.

RECOMMENDATIONS

A more detailed survey of each area is needed to determine the reserves and quality of the deposits.

Phase Number 2

Contact owners of the Whitecliffs and Whitlock Deposits to determine availability and terms of acquisition.

Obtain permission from the San Carlos-Apache Tribe to conduct a preliminary survey of their deposit.

Phase Number 3

Map each deposit, calculate the amount in site, calculate amount of overburden and sample each area, project drilling locations to determine amount of reserves.

Drill with a rotary down-in-hole pneumatic hammer to sufficient depth and block out reserves plus determine amount of overburden to be removed.

RECOMMENDATIONS (continued)

Phase Number 4

Produce a feasibility study

Phase Number 5

Design and erect milling plant

Phase Number 6

Place deposits into production

GEOLOGY

The diatomite deposits are in fresh water lake beds, believed to be Pleistcene and/or Pliocene in age. The deposits occur in two levels and reminants of a third upper bench at Whitecliffs, and two beds at Whitlock. All are lensy and seldom form a continuous bed. The deposits are wide-spread however, and large quantities of diatomite can be mined economically.

Because of the lensing nature of the deposits, the high grade diatomite grades laterally into interbeds of clay and silt. Several cubic yards or tons of good quality diatomite can be mined using selective mining methods.

The diatomite beds contain varying amounts of clay, silt and minor chert. In some areas a clay bed occurs above and below the diatomite. Above the clay beds, a boulder conglomerate occurs which would have to be removed for open pit mining.

The San Pedro Valley narrows north and south of the Whitecliff Deposits and grades from lake beds to fanglomerates. The fanglomerates are composed primarily of sand, pebble and boulder conglomerate.

The Gila River Valley includes the San Carlos and Duncan (Stevens) Deposits. Going upward in the geologic section, and to the north, the deposits change to volcanic tuffs. The deposits observed in the Upper Gila Valley near Buckhorn-Cliff in New Mexico are thin and lensy and consist of air-fall ash rather than diatomite.

In the San Simon Valley, the Whitlock (111 Ranch) Deposits are the best developed. Small lenses of diatomite extend southward for several miles but seldom exceed three feet in thickness. The BMS et.al. Deposits north of the

the town of Bowie are the southern extension of the lake beds. The diatomite is in horizontal beds and ranges from 4 inches to 8 inches in thickness. These deposits are considered uneconomical to mine, although, some mining has been accomplished and the ore shipped from Bowie via railroad to California. It was not determined where it was shipped in California nor for what end use. There was no need to make further inquiry based upon the limited deposit.

No diatomite was found south of the BMS et.al. Deposits as most of the area is being farmed and the lake beds change to fanglomerates from the surrounding mountains.

WHITECLIFFS (MAMMOTH) DEPOSITS

LOCATION

The Whitecliffs Deposits occur about 8 miles south of the town of Mammoth on the east side of the San Pedro Valley. More specifically, the claims are located in Sections 13 and 18, Township 9 South, Range 17 East, G&SRB&M, and Sections 18, 19, 20, 29, and 30, Township 9 South, Range 18 East, of the G&SRB&M, Pinal County, Arizona, containing 3120 acres more or less.

ACCESSIBILITY AND FACILITIES

These deposits lie to the east of the mining community of San Manuel. It is accessible from the town of Mammoth by crossing the San Pedro River to the east and traveling southward for a distance of approximately 8 miles.

The Southern Pacific Railroad at San Manuel connects with it's mainline at the Town of Bowie, about 25 miles to the south. The El Paso Natural Gas Company pipelines extend to the San Pedro River directly across from the diatomite deposits. An Arizona Public Service Company power line bisects the approximate center of the property. Water is available from wells in the San Pedro flood plain.

GENERAL

The reconnaissance survey gives only a general picture of the total diatomite deposits. A more exact figure of diatomite in these deposits are contingent on a more thorough

investigation. This would include measurement of the diatomite beds for thickness and quality; amount of contaminent to be removed; quantity and type of overburden, and a drill hole program to determine the extent and thickness of the deposits below the overburden.

Based upon some data acquired in the field, it appears the ten million tons required are present in the Whitecliffs Deposits. It is estimated about 400 acres in Sections 18 and 19 would average 20 feet or more diatomite in two horizons and a limited amount in a third upper horizon. In some areas within the 400 acre block, the two beds exceed 50 feet of fair to good grade diatomite.

If the 400 acres will average 20 feet in thickness, the projected estimates are as follows:

43560 x 400 = 17.42 m sq ft x 20' = 348.4 m cu ft
Assuming 54 cubic feet per ton, then
348.4 ÷ 54 = 6.45 m tons

This is believed to be a conservative figure since some local areas would average 50 feet or more. It has been reported the diatomite is up to 100 feet in thickness in places, However, this was not observed during the preliminary investigation.

Based upon the cursory survey, the Whitecliffs Deposits are the most likely to contain the ten million tons of the quality of diatomite required. Phase 3 of the exploration should be instigated as outlined above and when an equitable arrangement can be made with Southwest Mining Company of Mesa, Arizona.

Exhibit II shows the approximate edge of the diatomite deposits, location of major outcrops and their general thickness. The eastern limits are governed by increased overburden and the eastward extension of the beds would have to be determined by drilling.

Exhibit III shows the individual claims with the major outcrops and approximate thickness. The Whitlock Claims (not related to the Whitlock [111 Ranch] Claims in Graham County) join the Whitecliffs on the east and south. These claims are also leased to Southwest Mining Company. A land check was not made of the Whitlock Claims as they appear to be beyond the main diatomite deposits and the overburden becomes excessive.

Photos #1 through #6 show the general terrain, thicknesses, lensing nature and overburden.

Two samples were taken for assay with the following results:

#5	Silica =	69.0%	Alumina =	10%	Iron =	1.0%
#6		72.5%		8%		0.8%

The samples were taken across the complete outcrop and some contamination may have come from the overburden through percolating water. By going deeper into the formation wall, the percentages may improve by eliminating some of the contaminates.

Wide spread samples taken for the Arizona Development Board, and the chemical analysis was reported as follows:

Silica = 87.92% Alumina = 3.9% Iron = 0.1%

WHITLOCK (111 Ranch) DEPOSIT

LOCATION

The Whitlock Deposits are located approximately 20 miles southeast of the town of Safford. The major deposits center in Sections 26 and 27, Township 8 South, Range 28 East, of the G&SRB&M, Graham County, Arizona. Please refer to Exhibit IV.

ACCESSIBILITY AND FACILITIES

The Deposits can be reached by traveling approximately 15 miles east from Safford on paved U.S. Highway 70, then southward about 5 miles on a good gravel road to the 111 Ranch. The road continues past the deposits approximately 8 miles to the community of Tanque, which is on the west side of the San Simon River. The river has no bridge and is dry except during stormy periods. Please refer to Exhibit V, showing land status and claim locations.

The Southern Pacific Railroad has a siding at Tanque. Electric power and gas lines are available along U.S. Highway 70, about 5 miles north of the deposits. Water is available in some of the larger washes and larger quantities may be be developed by drilling in the gravels of the San Simon drainage. These latter well locations may be 2 to 4 miles from the deposits.

WHITLOCK DEPOSIT (continued)

GENERAL

The diatomite deposits are lensy and some were observed to have thicknesses up to 30 feet. Please see Exhibit IV, indicating locations and thicknesses. The north portion of the deposit has been highly eroded to form small diatomite hills with up to 10 and 15 feet of overburden. The impurities include pumicite, clay and some calcium carbonate (lime).

The deposits lie around the north end of the Whitlock Mountains, as would be expected, the overburden increases toward the mountains.

Where erosion has exposed the deposits at the surface, an ideal open pit mining situation exists. A more detailed survey and drilling program are necessary to determine the lateral extent and the thickness of the deposits.

The reconnaissance survey indicates the probability of approximately a two million ton reserve. This estimate is assuming 300 acres having diatomite averaging 10 feet in thickness.

Because of the nature of the outcrops near the bottom of the dry washes, more diatomite may occur with depth. Therefore to try and deliniate the aerial extent of these deposits could prove to be very misleading. Each outcrop would have to be measured, sampled and drilled carefully for a more exact reserve figure.

This is a good back-up property to the Whitecliffs Deposits, even though the Whitecliffs should produce the tonnage required. Photos Numbers 7 through 10 show the general character of these deposits.

Respectfully submitted,

Silas C. Brown

Silas C. Brown

SCB:dm

REGISTERED GEOLOGIST
CERTIFICATE NO.
4702
SILAS C.
BROWN
Date Signed 4-15-82
ARIZONA, U.S.A.

mm

Diatomite

1. How much do you need per month, annual?

2. 10 M Tons for 30 years = 3 MT per annum = 250,000 T per month = 10,000 T per Day

365 - 102 = 261 work days - 5 day week = Dail, Prod 11,494 25 or 11,500 Tons per day

3. Before considering Phase II we must have S.W. Mining agreement in hand.

4. We believe it is impossible to deal with the San Carlos Indians. Even if an agreement is made, it appears unlikely that we could do open Pit Mining on Indian lands

See Article in Republic re Magma Oil & Oil exploration 5-7-82

Phase II

1. Financing will have to be arranged in Adv on Ø program & justifiable statements for geol work.

2. Est. cost of phase II is approximate since each hole will decide the loc & depth of next.
Better estimate after Approx 2 weeks drilling

3. We may have underestimated the use of the Dozer - Approx right

4. 5000' of Ø may take 4-5 weeks - depending on conditions.

5. Maybe set up a Trust or Escrow fund of amount of $50,000 or 6 program

6. ~~4-10 months~~ 3-4 months to complete Phase II as now outlined. Maybe July 15 - Aug 15 - Normally.

7. Must pay assayers, Drilling & Dozer on spot

How do we set up the finance?

SILAS C. BROWN & ASSOCIATES

GEOLOGICAL CONSULTANTS

WHITECLIFFS (MAMMOTH) PHASE II ESTIMATE

Professional services:	Min.	Max.
Field: 25-30 days geologist @ $350/day 25-30 days 2 assistants @ $150 day each Total for geologist & assistants = $650/day	= $16,250	19,500
Office: 12-15 days @ $350/day	= 4,200	5,250
Expenses: 3 men		
25-30 days @ $120/day subsistence	3,000	3,600
Milage: 3000-3500 @ .40	1,200	1,400
Assays: 200-250 @ $16	3,200	4,000
Miss'l: Site office trailer, assays, reproduction, phone, etc.	750	1,000
	$28,600	34,750
15% contingency	4,290	5,113
	$32,890	39,863

Drilling program page 2.

Whitecliffs con't.

Drilling program:		Min.	Max.
Rig- moving in & out from Apache Jct.		600	650
Dozer for roads, drill locations,etc., 10 - 12 days @$75/hour		6,000	7,200
Dozer transport	200		
casing transport	100		
Water haulage	300		
Fuel haulage	40		
	640	640	640
Casing: 500-750 ft. @$3.00/ft.		1,500	2,250
Drilling: 4000-5000 ft @ $10.00/ft		40,000	50,000
Miss'l. Expenses: Dozer fuel & maintainance, Safety & dust control.		1,000	1,250
		$49,740	61,990
15% contingency		7,461	9,299
		$57,201	71,289

Totals	Min.	Max.
Professional Services & expenses	32,890	39,863
Drilling program	57,201	71,289
	$90,091	111,152

Silas C. Brown

Silas C. Brown

REGISTERED GEOLOGIST
CERTIFICATE NO.
4702
SILAS C.
BROWN
Date Signed.....
ARIZONA, U.S.A.

1925

DIATOMITE

By Arthur C. Meisinger [1]

Filtration (the separation of solids from liquids) is one of the most widely used operations in industrial processing, and diatomite, or diatomaceous earth, has been an indispensible filter aid material for more than 60 years.

The United States, the most important source of high-quality filter aid material, is the world's largest producer and consumer of diatomite and, in addition, exports significant quantities. In the past 11 years (1964–74), world production of diatomite has annually averaged over 1.62 million tons.[2] Domestic and world production increased in 1974 for the third consecutive year. Although preliminary estimates for 1975 indicate a decline in production from that of 1974, the upward trend is expected to continue through 1980.

Based on contingency assumptions for various end uses of diatomite, demand for the year 2000 has been forecast to range from 1.0 million to 2.1 million tons for the United States and from 3.2 million to 7.0 million tons for the rest of the world. The probable domestic demand in 2000 is nearly 1.8 million tons, or a 5.4 percent annual growth rate through the forecast period, 1973–2000. Domestic diatomite reserves (estimated to be 600 million tons), more than half of which are contained in current operating deposits in Western States, will furnish probable cumulative requirements of 26.5 million tons indicated in table 5.

Rest-of-world consumption is forecast to grow at a probable higher rate of 6.5 percent, primarily because of increasing need for filter media using diatomite. Expected cumulative demand of 72.3 million tons in the rest of the world by 2000 can be met in part by expanding presently developed deposits in producing countries and, in part, by an increase in imports from the United States. Development of inferred reserves of diatomite to increase supply availability in all producing countries would be more than adequate to supply remaining requirements throughout the forecast period.

Potential substitution by competitive materials is present for all major uses of diatomite; however, based on availability and technical and economic factors, the continued desirability of diatomite for its many applications seems assured.

INDUSTRY STRUCTURE

Background

Diatomite was first produced in the United States in 1884 on the east coast in Maryland. Deposits on the west coast were opened to mining in the late 1880's in California. California emerged as the dominant producing State, a position it has retained since about the time of World War I, owing in large part to the continuing development of the extensive diatomite deposits near Lompoc, Santa Barbara County. In 1975, Nevada was the second largest producing State with minor output from Kansas, Oregon, and Washington. Other States that have had recorded production of diatomite are Arizona, Connecticut, Florida, Idaho, Massachusetts, New Hampshire, New Jersey, New Mexico, New York, Utah, and Virginia.

Size, Organization, and Geographic Distribution

United States.—The United States is the world's largest producer and consumer of diatomite. In 1975, 11 companies actively mined and prepared diatomite from 17 operations in 5 States—California, Kansas, Nevada, Oregon, and Washington. The major producers are Johns-Manville Sales Corp. at Lompoc, Calif.; Grefco, Inc., with operations near Lompoc, Calif. and Mina, Nev.; Eagle-Picher Industries, Inc., with facilities near Sparks and Lovelock, Nev.; and Kenite Corp., Division of Witco Chemical Corp., at Quincy, Wash. The major firms have other mineral and manufacturing interests such as the production of asbestos products, roofing, floor tile, acoustic insulation, refractories, lead and zinc, plastics, thermal insulation, chemicals, and industrial fillers.

Other Countries.—World production of diatomite has annually average approximately 1.62 million tons in the past 11 years (1964–74), coming from some 30 countries on 6 continents. France, Italy, the U.S.S.R., and West Germany lead the other countries in diatomite production. In addition, Denmark annually produces a substantial tonnage of moler, an impure diatoma-

[1] Industry economist, Division of Nonmetallic Minerals.
[2] The quantities used throughout this chapter are short tons unless otherwise specified.

ceous earth, used mainly as insulating bricks. Some of the major European producers are Carbonisation et Charbons Actifs (CECA), a subsidiary of Pierrefitte-Auby in France; Vereinigte Deutsch Kieselgurwerke KG of West Germany; and Winkelmann Mineraria Spa., Diatom Spa., and Diatomite Italiane APES, Spa., Italy (*2*).[3] Johns-Manville Sales Corp., one of the leading producers and processors of diatomite in the United States, also has operations in France, Iceland, Mexico, and Spain.

World diatomite production and capacity in 1973 and projected capacities for 1974 and 1980 are shown in table 1.

Table 1.—World diatomite capacity and production, 1973, and capacity, 1974 and 1980

(Thousand short tons)

	1973		Capacity	
	Capacity	Production	1974	1980
North America:				
United States	1,000	609	1,000	1,150
Costa Rica	30	23	30	35
Mexico	35	17	35	40
Other	5	1	5	5
Total	1,070	650	1,070	1,230
Europe:				
Denmark	125	118	125	145
France	200	190	200	230
Iceland	30	24	30	35
Italy	75	65	75	90
Spain	30	22	30	35
U.S.S.R.	450	430	450	500
West Germany	125	51	125	145
Other	25	16	25	30
Total	1,060	916	1,060	1,210
Other:				
South America	25	17	25	30
Africa	10	3	10	10
Asia	10	4	10	10
Oceania	15	7	15	20
World total	2,190	1,597	2,190	2,510

Definitions, Grades, Specifications, and Uses

Diatomite is synonymous with diatomaceous earth and the lesser used German word, "kielselguhr." The terms "moler" and "moler earth" apply to an impure diatomite with a high clay content produced in Denmark. Diatomite in its natural state is a soft rocklike material consisting mainly of an accumulation of siliceous frustules (shells) or skeletons of diatoms that are microscopic single-celled plants of freshwater and saltwater origin. Chemically, diatomite is essentially amorphous hydrated or opaline silica with varying amounts of contaminants such as silica sand, clay minerals, metal salts, and organic matter. The silica content of diatomite will range from about 58 to 91 percent with a corresponding variation of accessory oxides and about 3.5 to 8.5 percent water of combination(*5*).

Diatoms occur in more than 10,000 species and vary in size from several micrometers to hundreds of micrometers in diameter. The apparent density of dry consolidated diatomite is 20 to 40 pounds per cubic foot and that for dry powdered diatomite is 5 to 16 pounds per cubic foot.

Although no standard-grade specifications exist for prepared diatomite, producers market diatomite in a range of grades through trade name designations such as "Celite," "Celatom," "Dicalite," and "Microsil." The separation of products into various grades is based principally on different test performance characteristics for each specific application. Based on production methods, processed diatomite powders are classified as "natural," "pink" or calcined, and "white" or flux-calcined, with a range of grades in each classification. Those process designations, however, do not maintain identity into the market classifications.

Filtration is the major end use of diatomite. Other important uses include soft abrasives, industrial fillers, and lightweight aggregates. Diatomite as a filler or extender is used in paint, asphalt products, paper, and plastics where bulk is needed with minimum weight; where economy of more expensive ingredients is a factor; and when anticaking, good absorbency, and mild abrasiveness are desired.

Other uses of diatomite include shaped forms as catalyst carriers utilized in petroleum refining, hydrogenation of oils, and acid manufacturing; carrier for insecticides; anticaking agents for fertilizers and explosives; soft abrasives; a source for highly reactive silica; and lightweight aggregates, pozzolans, and soil conditioners.

RESERVES-RESOURCES

Geology

Although actual fossil evidence is lacking, diatoms apparently lived abundantly in all geologic ages from Precambrian to and including Recent. However, for diatom colonies to accumulate and subsequently form sediments, proper environmental requirements are necessary to permit growth and deposition over an adequate time period. The more important requirements include cool, clear, well-lighted water, a supply of nutrients and dissolved silica, and relatively quiescent conditions (for example, protective marine coves or large inland lakes) to

[3] Italicized numbers in parentheses refer to items in the list of references at the end of this chapter.

prevent undue contamination and degradation. Rates of accumulation, degree of water temperature, salinity, and depth are also important in determining the abundance and species of diatoms found in a deposit (*6*).

Present economic deposits and other data indicate that appreciable diatom concentrations are restricted to relatively recent geologic ages. The important deposit types are—

1. Compact marine sediments, mostly Tertiary in age, that have accumulated near continental margins.
2. Nonmarine (freshwater) strata that formed adjacent to ancient rivers or in lakes of Miocene, Pliocene, or Pleistocene age.
3. Sediments formed in modern lakes, marshes, and bogs, usually of Quaternary or Recent age.

U.S. and World Resources

Diatomite deposits occur in many areas of the United States and are widely distributed on all continents, but known data are inconclusive for a tabular presentation of reserves on a worldwide basis.

Based largely on descriptions of operating properties and geologic evidence (*5*), domestic reserves are estimated to be 600 million tons—all located in Western States. The major quality-grade reserves are contained in the Lompoc, Santa Barbara County, Calif., deposit area, and are probably sufficient to continue present operations for at least 100 years. Identified reserves of diatomite in Nevada approximate 25 million tons (*1*). Although reserves in deposits in Oregon and Washington are not quantified, current economic operations indicate sufficient quantities are available to meet future demands. Large resources of diatomite also occur in undeveloped areas along the Atlantic coast from Maine to Florida.

Little information is available on diatomite reserves in other producing countries. Deposits of high-quality diatomite were discovered near Inca, Peru, in 1975. Reported indicated reserves were on the order of 67 million tons. Measured and indicated reserves in deposits in Brazil, France, Iceland, and New Zealand are each on the order of 2.5 million tons.

Total reserves, largely in the inferred category, for all countries are speculatively placed at 2 billion tons.

TECHNOLOGY

Mining

Most commercial diatomite deposits occur at or near the surface and can be mined by open pit methods. Dredging with dragline scrapers is the usual method employed for lake bottom deposits, such as at Lake Myvatn, Iceland, and Kentmere, England. In the Massif Central area of France, underground mining is used in conjunction with open pit operations. The particular method employed, however, will depend upon the deposit's thickness, stratification, attitude, areal topography, and nature of overburden.

Diatomite mining in the United States is all open pit, normally using some combination of bulldozers, scraper-carriers, powershovels, and trucks to remove overburden and the crude material. In most cases fragmentation by drilling and blasting is not necessary, although that procedure is followed in certain harder diatomite zones and in lenses of waste material.

Processing and Product Preparation

Processing of diatomite involves a series of basic steps developed and refined by the industry over the years, primarily to take advantage of the unique characteristics of the commodity for use as a filter aid and filler to meet industrial requirements. The major processed diatomite products are powders and aggregates of variable sizes and grades that have been uncalcined, straight-calcined, or flux-calcined.

Processing of uncalcined, or "natural" grade, diatomite initially comprises the drying and crushing of crude material to reduce the high moisture content (up to 60 percent water). Further size reduction and removal of water is usually accomplished by a blower-hammer mill combination with a pneumatic feed and discharge system to suspend the particles. The suspended particles and impurities are separated and removed through a series of cyclone classifiers. The various sized products are then collected in a baghouse for market preparation, principally for fillers and uses other than filter aids.

For filtration uses, "natural" grade diatomite is calcined by heat treatment in a rotary kiln—with or without a fluxing agent. The calcination process removes any organic matter or contained water and converts impurities into a fused slag that is later extracted by air classification. The resultant straight-calcined product is normally applied to filter uses where medium flow rates are required. For filtering that requires faster flow rates, the addition of a fluxing agent to the kiln feed sinters the diatomite particles and increases the particle size, thereby increasing the flow rate.

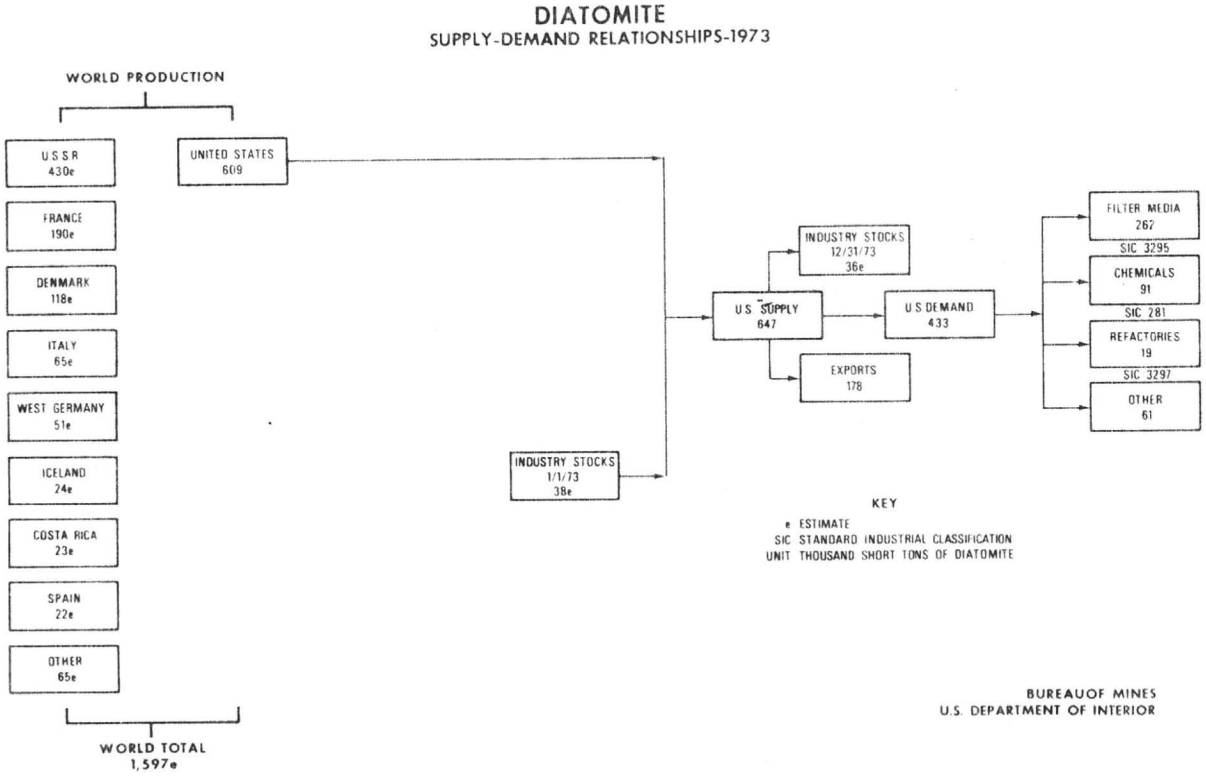

Figure 1.—Supply-demand relationships for diatomite, 1973.

Current Research and Applications

Research conducted by most of the large domestic diatomite producers has emphasized product development that has led to a number of new applications for the commodity. Some recent examples of new product applications are the following: A formulation of properly prepared diatomite to act as an antiblocking agent when incorporated in polyethylene manufacturing; removal of manganese from well water by adding diatomite with soda ash to the water, and then precipitating the oxidized manganese through diatomite vacuum filters; the removal of undesirable material from a dye operation incorporating diatomite filtration, followed by granular activated carbon adsorption; and use as a "sunburn lotion" on freeze-damaged citrus trees (*3-4*). In the last case, a finely particulate diatomite powder is applied as a whitewash on new tree growth to prevent further damage. The producers have also been active in process control research to maintain uniformity within various product grades.

SUPPLY-DEMAND RELATIONSHIPS

The supply-demand relationship for diatomite is shown in figure 1 for 1973, and in table 2 for the period 1964–74.

Components of Supply

The United States is self-sufficient in diatomite supply, and significant quantities are exported, mostly in the form of packaged consumer products. The quantity of diatomite imported by the United States is minor and is used primarily for test purposes.

Producer stocks of diatomite are not known but are believed to range from 5 to 10 percent of annual production.

U.S. and World Production

U.S. production of processed diatomite in 1974 was 664,300 short tons compared with nearly 1 million short tons for other producing countries. The United States has produced an average of 607,000 tons over the period 1964–74, or 37 percent of the world diatomite output.

U.S. and World Consumption Pattern

World consumption of diatomite totaled 1.5 million tons in 1974. The most important end

Table 2.—Diatomite supply-demand relationships, 1964-74

(Thousand short tons)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974 [e]
World production:											
United States	563	584	607	625	646	[r] 598	598	535	576	609	664
Rest of world	809	826	1,186	1,166	1,084	[r] 1,018	[r] 1,015	[r] 1,033	982	[r] 988	[e] 1,068
Total	1,372	1,410	1,793	1,791	1,730	[r] 1,616	[r] 1,613	[r] 1,568	1,558	[r] 1,597	[e] 1,732
Components of U.S. supply:											
U.S. production	563	584	607	625	646	[r] 598	598	535	576	609	664
Estimated industry stock, Jan. 1	50	50	50	50	33	37	37	37	40	38	36
Total U.S. supply	613	634	657	675	679	[r] 635	635	572	616	647	700
Distribution of U.S. supply:											
Estimated industry stock, Dec. 31	50	50	50	33	37	37	37	40	38	36	36
Exports	128	114	144	148	168	176	154	142	148	178	186
Demand	435	470	463	494	474	[r] 422	444	390	430	433	478
U.S. demand pattern:											
Filter media	205	207	213	237	237	[r] 245	258	230	250	262	255
Chemicals	104	94	93	89	95	[r] 84	84	74	80	91	110
Refractories	17	28	23	20	19	[r] 17	18	12	17	19	32
Other	109	141	134	148	123	[r] 76	84	74	83	61	81
Total U.S. primary demand	435	470	463	494	474	[r] 422	444	390	430	433	478

[p] Preliminary.
[r] Revised.
[e] Estimated.

use of diatomite—filter medium—has steadily increased throughout the past 11 years. Domestic use for diatomite as a filter medium comprised 53 percent of the 478,000 tons consumed in 1974. World consumption of diatomite for filter use in various industries such as food, pharmaceutical, beverage, and municipal water processing is estimated to be around 50 percent of annual production.

The quantity of processed diatomite used as a filler or extender in the preparation of various industrial chemicals and paints in the United States in 1974 was 110,000 tons, or 23 percent of total consumption.

Diatomite used for thermal insulation in 1974 was about 7 percent (32,000 tons) of domestic consumption. A kiln-fired molded brick is the primary form for insulation, although diatomite powders and aggregates are also used as a loose covering, filling, or binding.

Other uses totaled 81,000 tons or 17 percent of demand in 1974.

World Trade

The principal diatomite-producing countries are also the major exporters of diatomite products. Diatomite is used in nearly every country primarily for filtration purposes.

U.S. exports were 28 percent of domestic production in 1974, and diatomite products were exported principally to Canada, Japan, the United Kingdom, West Germany, Australia, and the Republic of South Africa. The United States is the largest producer and exporter of diatomite. The U.S.S.R. is the second largest producer, but data are not available on exports. France, the leading producer of filter-aid-quality diatomite in Europe, supplies most major European markets. Denmark exports about 40 percent of its diatomite production annually along with a large percentage of moler earth, primarily to the United Kingdom for use as moler brick in construction and as a fertilizer coating. The United Kingdom imports various grades of diatomite that average about 14,000 tons per year, mostly from the United States, Denmark, West Germany, and France.

Substitutes

Many alternate materials can be substituted in end uses for diatomite; however, the unique and desirable porperties of diatomite assure a continuing acceptance for many applications. Expanded perlite, asbestos, and silica sand compete for some filtration purposes although, in most instances, diatomite is a superior material. Alternate filler materials include talc, ground silica sand, ground mica, clay, perlite, vermiculite, and ground limestone. For thermal insulation purposes, a variety of materials such as high alumina brick, fire clay, asbestos, mineral wool, expanded perlite, and exfoliated vermiculite can be used.

STRATEGIC CONSIDERATIONS

Of the 18 nonmetallic mineral commodities requiring strategic attention, diatomite has the

Table 3—Time-price relationship for diatomite

Year	Average annual price, dollars per short ton	
	Actual price	Constant 1973 dollars
1954	39.21	67.49
1955	39.21	66.57
1956	39.21	64.38
1957	43.36	68.61
1958	46.18	71.26
1959	47.59	72.22
1960	49.50	73.99
1961	50.65	74.70
1962	50.06	72.97
1963	50.72	72.98
1964	50.62	71.80
1965	49.94	69.56
1966	52.44	71.06
1967	52.54	68.95
1968	57.98	73.11
1969	60.96	73.36
1970	54.63	62.37
1971	64.25	70.14
1972	65.19	68.84
1973	59.26	59.26
1974	76.31	69.19
1975 [1]	73.95	----

[1] Price data for 1975 is based on preliminary estimate.

lowest rating (16) within the medium priority category. The low rating was established primarily because reserves of diatomite are more than sufficient to meet cumulative domestic demand through 1985 and 2000.

ECONOMIC FACTORS AND PROBLEMS

Prices and Costs

The weighted average price (in constant 1973 dollars) of domestically prepared diatomite has ranged from a low of $59.26 per ton to a high of $74.70 per ton over the past 21 years (table 3). Prices of processed diatomite for a variety of end uses vary depending primarily upon grades, packaging, and shipping costs. In 1974, the average price for filter grades, the largest end use, was $87.40 per ton. Average prices per ton for other uses in 1974 were insulation, $55.59; fillers, $77.12; lightweight aggregate, $47.31; abrasives, $129.51; and miscellaneous uses, $46.25.

Transportation has always been an important cost factor in the price of diatomite to the ultimate consumer because the product is a high-bulk commodity, and thus has a high freight rate per ton. The cost of moving diatomite (bulk shipments) from western producing points to midwestern and east coast markets, for example, has ranged from $25 to $35 per ton. However, because of essential industry applications for diatomite, transportation costs have not seriously affected supply and demand in the past.

Taxes and Tariffs

No special taxes are imposed on the diatomite industry. Producers are currently granted a 14-percent depletion allowance on domestic and foreign production. Crude or processed diatomite is imported free of duty.

OPERATING FACTORS AND PROBLEMS

Environmental

All diatomite deposits in the United States are currently mined by open pit methods. They entail the usual associated environmental problems such as overburden disposal, dust control, and appropriate rehabilitation of abandoned quarry sites. The large moisture content of crude diatomite contributes to adequate control of dust in mining, and almost all processing is accomplished in enclosed circuits that permit effective control of silica dust.

Employment Productivity

Employment in the diatomite mining and processing sectors of the industry is estimated to be about 850 employees. Based on that number and the 1974 output, approximately 780 tons of processed diatomite was produced per production employee.

OUTLOOK

Demand

Domestic demand for diatomite is anticipated to increase to between 1.0 million and 2.1 million tons by the year 2000, with a probable demand of 1.8 million tons or a 5.4 percent annual growth rate.

The demand forecast was developed by an analysis of contingency factors influencing consumption for the major end-use categories. Diatomite demand for each end use was first projected to 1985 and then 2000 on the basis of a forecast growth rate for the gross national product (GNP), with the exception of the refractories category, which was projected by means of the Federal Reserve Board Index of Industrial Production (FRBIPI). The quantities of diatomite for each end use indicated by those projections constituted a forecast base that was then modified by contingency assumptions such as technological and economic factors to arrive at a forecast demand range. The overall demand range was obtained by a summation of the individual end use forecast ranges.

Table 4.—Projections and forecasts for U. S. diatomite demand by end use, 1973 and 2000

(Thousand short tons)

End use	1973	2000 Contingency forecasts for United States			
		Forecast base	Forecast range		Probable
			Low	High	
Filter media	262	670	585	1,275	1,100
Chemicals	91	230	200	390	300
Refractories	19	55	45	90	85
Other	61	155	120	330	300
Total	433	---	950	2,085	1,785

Table 5.—Summary of forecasts of U.S. and rest-of-world diatomite demand, 1973–2000

(Thousand short tons)

	1973	2000 Forecast range		Probable		Probable average annual growth rate, 1973–2000 (percent)
		Low	High	1985	2000	
United States:						
Primary demand	433	950	2,085	815	1,785	5.4
Cumulative	---	18,000	29,000	7,400	26,500	---
Rest of the world:						
Primary demand	988	3,200	7,000	2,100	5,400	6.5
Cumulative	---	52,300	85,600	18,300	72,300	---
World:						
Primary demand	1,421	4,150	9,085	2,915	7,185	6.2
Cumulative	---	70,300	114,600	25,700	98,800	---

The summarized diatomite demand forecasts for the United States and the rest of the world for 1985 and 2000 are shown in table 4. The contingency forecasts for the United States by end use are given in table 5.

End Use Trends

Filter media.—The projected demand for this end use, based on the forecast growth rate for the GNP, established a forecast base of 670,000 tons. Since increasing needs for water purification with removal of impurities in manufactured products and reusable process fluids are anticipated, the high demand forecast was set at 1.275 million tons. The low demand forecast of 585,000 tons was established near the forecast base because of the possible substitution of other filter media for diatomite during the forecast period. The probable demand is 1.1 million tons (slightly below the forecast high) because of anticipated increasing demand for diatomite to recycle industrial process fluids and municipal water supplies.

Chemicals.—Industrial chemical demand was related to the GNP to establish a forecast base of 230,000 tons. Some of the products containing diatomite, like plastics, paper, and paint, could have a higher growth rate than the GNP and cause projected demand to increase; however, by 2000, alternate materials could be substituted for some applications. Because of the foregoing assumptions, the low forecast demand was established at 200,000 tons and the high at 390,000 tons. The probable demand of 300,000 tons was placed nearer the midpoint of the forecast range because of an anticipated growth rate slightly below that of the GNP.

Refractories.—The demand forecast base of 55,000 tons for this end use category was related to the Federal Reserve Board Index of Industrial Production (FRBIPI). The forecast high is 90,000 tons because of a probable increase in use for diatomite in high-temperature equipment. Anticipated availability of competitive insulating materials suggests a demand of 45,000 tons for the low forecast, but the expected increase in use of diatomite during the forecast period places the most probable quantity of 85,000 tons nearer the forecast high.

Other Uses.—The variety of applications and broad spectrum of industries involved in this category was correlated with the GNP to establish a diatomite forecast base of 155,000 tons. Consideration of factors such as the development of new products requiring greater quantities of diatomite coupled with the possible use of alternate materials restricting consumption of diatomite resulted in a forecast of 330,000 tons for the high and 120,000 tons for the low. The

probable demand of 300,000 tons, slightly below the forecast high, was selected because of the existing aggressive industry research programs to develop new uses and expand markets for older products.

Cumulative Requirements to 2000

The probable cumulative U.S. demand of 26.5 million tons during the forecast period, 1973–2000, can be met from domestic supply at current prices. The rest-of-world probable cumulative demand of 72.3 million tons will be supplied by exports from the United States and production from other diatomite-producing countries.

Supply

United States and World Resources.—Deposits of diatomaceous earth are distributed throughout the world. However, deposits located in the Western United States, the U.S.S.R., France, and Denmark are currently supplying the major portion of world requirements.

Domestic reserves (estimated to be 600 million tons), more than half of which are contained in current operating deposits, can easily sustain domestic requirements through the forecast period, 1973–2000.

Demand for the rest of the world can be met in part by expanding presently developed operations in other producing countries and, in part, by an increase in imports from the United States. Development of inferred reserves to increase supply availability in all producing countries would be more than adequate to meet remaining requirements throughout the forecast period.

Production Forecast to 1985 and 2000

Domestic diatomite production was 609,000 tons in 1973 and 664,300 tons in 1974, compared with a demand of 433,000 tons in 1973 and 478,000 tons in 1974; therefore, production exceeded demand by about 40 percent. The probable domestic demand in 1985 and in 2000 is 815,000 tons and 1.785 million tons, respectively. If the current ratio of production to demand continues throughout the forecast period, domestic production would be 1.15 million tons in 1985 and 2.5 million tons in 2000.

For speculative purposes, however, a straight-line projection derived from historical production data (table 6) suggests that diatomite production in 1985 and in 2000 might be 824,000 tons and 1.033 million tons, respectively, if the historical trend continues. Based on analysis of contingency factors affecting domestic production, estimated diatomite production will be 1 million tons in 1985 and 2 million tons in 2000.

Table 6.—Comparison of domestic diatomite production and demand 1954–74, 1985, and 2000

(Thousand short tons)

Year	U.S. demand	Domestic production
1954	285	356
1955	302	377
1956	318	398
1957	335	419
1958	341	439
1959	368	460
1960	389	481
1961	406	501
1962	413	522
1963	431	543
1964	435	563
1965	470	584
1966	463	607
1967	494	625
1968	474	646
1969	491	667
1970	444	598
1971	390	535
1972	430	576
1973	433	609
1974 [1]	478	664
1985	[2] 815	[3] 824 [e] 1,000
2000	[2] 1,785	[3] 1,033 [e] 2,000

[e] Estimated.
[1] Preliminary, not used in forecasts.
[2] Probable forecasts from table 5.
[3] 20-year trend.

Possible Supply-Demand Changes

No significant supply-demand changes are anticipated during the forecast period for the domestic diatomite industry. It is expected, however, that changes in supply patterns will occur in areas outside the United States for the larger diatomite producers. Factors that could provide incentives for development of overseas deposits include the impact of inflation on costs, fluctuating freight markets, and the gradual expansion of industrial activity in developing countries. Increasing freight rates could also reduce U.S. exports in the future.

Possible Technological Progress

Production methods at currently operated deposits are relatively simple; therefore, no significant changes in technology are anticipated. The most likely area for change will be in the utilization of diatomite where the pressure of competitive materials will require progressive improvements in efficiency and applicability of products. An increase in population and spread of industrial activity will also require larger quantities of clean and potable water entailing

recycling of liquids through low-cost filter materials, such as diatomite. Some research has been done by industry (Johns-Manville Sales Corp. announced the availability of a diatomite recycling system in 1972) on recycling with diatomite filter aids.

Possible advances in development of beneficiation methods may be applicable to purifying low-grade, clay-contaminated diatomaceous earth which, in turn, could decrease final consumer costs by reducing shipping costs from more distant deposits to the market areas.

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DIATOMITE

By Benjamin Petkof

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DIATOMITE

By Benjamin Petkof [1]

MICROSCOPIC water plants called diatoms secreted silica from the prehistoric seas in which they lived. Upon their death their silicified remains settled to the bottom and formed sedimentary deposits of amorphous silica of great depth. This material, referred to as diatomite, possesses certain physical properties which make it valuable as a filter medium, as industrial filler, for thermal and accoustical insulation, and for many other purposes.

The United States leads the world in production, with primary production in California. Production during 1960–62 averaged more than 482,000 short tons per year, valued at about $24 million.

The principal problems confronting the industry concern the search for new uses, development of specialized processes and equipment for improvement of efficiency and product quality, health hazards, high transportation cost, and need for markets for low-quality diatomite and any coproducts developed during mining.

BACKGROUND

In A.D. 532, the Roman Emperor Justinian I used diatomite brick to lighten construction of a dome 107 feet in diameter in the church of St. Sophia in Constantinople. The first large-scale application of diatomite was as an absorbent for liquid nitroglycerine, developed by Alfred Nobel in 1886; this use is now obsolete. The first extensive use to survive was for filtration of raw cane sugar liquor. This application dates from 1876, when diatomite began to replace paper pulp, compressed cotton, and asbestos-cellulose filter pads (*2*, *6*).[2]

The most important developed domestic deposits were discovered about 1890 near Lompoc, Calif. Insulating brick cut from naturally consolidated diatomite was the first quantity product of the Lompoc mines. In 1906, the first mill was built at Lompoc to pulverize the diatomite. In 1912, new owners of the Lompoc quarries organized the Kieselguhr Co. of America and began a program to develop diatomite as a filter aid. Subsequently, the firm name was changed to Celite Co. This organization acquired extensive adjoining acreage in 1926, and 2 years later was sold to the Johns-Manville Corp. Great Lakes Carbon Corp. has since acquired and developed a large acreage in the Lompoc area (*11*).

SIZE AND GEOGRAPHIC DISTRIBUTION OF THE INDUSTRY

The United States is the largest world producer and user of diatomite. During 1963, 15 plants operated by 13 companies produced diatomite. In 1962, 12 companies operated 14 plants, producing an average of 482,000 short tons per year valued at about $24 million. California produced the bulk of domestic supply with smaller quantities from Nevada and Washington. Arizona, Maryland, and Oregon provided minor quantities.

The major producers during 1963 were Johns-Manville Corp. at Lompoc, Calif.; Great Lakes Carbon Corp., at Lompoc, Calif., and Basalt, Nev.; The Eagle-Picher Co. at Colado and Clarke Station, Nev.; and the Airox Co. at Santa Maria, Calif. The remaining nine producers, in Arizona, California, Maryland, Nevada, Oregon, and Washington, furnished about 7 percent of the total production.

Diatomite is mined in the U.S.S.R., Denmark, France, West Germany, Italy, the United Kingdom, and other countries.

[1] Commodity specialist.
[2] Italicized numbers in parentheses refer to items in the list of references at the end of this chapter.

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DEFINITION OF TERMS, GRADES, AND SPECIFICATIONS *(4, 8—10)*

The terms "diatomite", "diatomaceous earth", and "kieselguhr" are synonymous and currently preferred for this commodity. Erronenous nomenclature occasionally encountered includes infusorial earth, infusorial silica, tripolite, and other local designations.

Diatomite is largely a fossil accumulation of diatoms, usually with some radiolaria and smaller amounts of foraminifera. These are all microfossils, diatoms being planktonic siliceous plant organisms, while radiolaria are planktonic siliceous, single-cell animal organisms. Foraminifera are calcareous animal organisms. Diatomite is essentially amorphous, hydrated, or opaline silica with various contaminants, such as silica sand, clay minerals, iron, alkalies, and alkaline earths. The chemically combined water ranges from 3½ to 8½ percent. Apparent density of dry consolidated material varies from 20 to 40 pounds per cubic foot, and the dry powder from 5 to 16 pounds per cubic foot.

Unprocessed diatomite has a hardness between 4 and 6½ on Mohs' scale. It is softer than opal, and appears to be only slightly harder than brass, which is considered 3½ on Mohs' scale.

Qualities responsible for the wide use of diatomite include its structure, porosity, low apparent density, strength, elasticity, chemical inertness, low thermal conductivity, light color, high melting point, and large surface area per unit of weight.

Three general grades of prepared diatomite are based on heat treatment after the usual drying and reduction stages. These grades are called "natural," "calcined" or "pink," and "flux calcined" or "white." The natural is that material sold without heat treatment after drying, delumping, and air classification. The calcined grade is similarly processed and is heat-treated in direct-fired rotary kilns using gas or fuel oil without fluxes, while flux-calcined material is calcined with the addition of a fusible alkali salt.

The Great Lakes Carbon Corp. markets its processed diatomite under the trade name of Dicalite, Eagle-Picher Co. Celatom, and Johns-Manville as Celite. The various processed grades are also named or numbered by each company for designating material with certain standardized qualities, such as color, brightness, particle size range and distribution, chemical analyses, and filtering speed.

TABLE 1.—*Typical chemical analyses of processed diatomite (dry basis)*

	Natural (percent)	Calcined (percent)	White (percent)
SiO_2	86.8	91.0	87.9
Al_2O_3	4.1	4.6	5.9
Fe_2O_3	1.6	1.9	1.1
CaO	1.7	1.4	1.1
MgO	.4	.4	.3
Ignition loss	4.6	.3	.1
Undetermined	.8	.4	3.6

TECHNOLOGY

Geology *(2, 4, 6, 11)*

The principal commercially developed diatomite deposits were formed in the late Miocene to early Pliocene ages when volcanic activity furnished silica-rich waters combined with ideal sunlight conditions and plant food supply. Each diatom extracted silica from the waters, secreting it to form minute, siliceous, two-halved envelopes or frustules with various intricate and often symmetrical designs. The two halves are not hinged but fit together. A small diatom measures less than 10 microns, a large diatom 100 microns or more.

The fossil species involved are single-celled algae. More than 12,000 different frustule patterns have been identified. These are microporous structures, many containing substructures only visible under the electron microscope. Although fossil frustules are known to be more than 25 million years old, these shells are identical to those of their living descendants.

Some diatomite beds are of fresh water origin, while others accumulated in ocean waters. Both lake and marine varieties are mined commercially; the frustule patterns of the diatoms from the two sources differ considerably so that the sources of each can be determined with a microscope.

The porous structure of individual diatoms and their massed arrangement impart unusual filtering properties to diatomite. When used as a coating on filter cloth diatomite strains out microbes and colloids from liquids and still permits relatively rapid flow of the filtrate. The filter coating is about 90 percent voids.

Some authorities believe that the marine diatoms of the Pacific Coast propagated in the colder climates of the north Pacific during the Miocene and were carried south by ocean currents and trapped in protected coves of the California coast.

As zones of varying hardness are found in many deposits, particularly near the surface, sampling must be conducted to depth.

Mining *(2, 5–6, 9, 11)*

All current mining is by open pit. The first step is to remove the overburden with high-speed, power-driven scraper-carriers or bulldozers. Thickness of overburden ranges from 1 to 15 times the thickness of recoverable and usable diatomite. After exposing the diatomite, the mining is done either with the same carryalls used for stripping overburden or with power shovels, loading into trucks. The Johns-Manville Corp. hauls the crude to a series of glory-hole storage shafts at strategic points in the deposit and above a tunnel system. These tunnels terminate near central storage bins close to the mill where crudes of differing grades can be segregated for specification blending.

Mining is complicated by faulting, combined with interbedding of contaminated material which must be wasted. In the Lompoc, Calif., area, selective mining is done within a total vertical thickness of about 1,000 feet. The purest material lies in a series of beds stratified with thin layers of volcanic ash down to the 500-foot level. Stratification lines are seldom more than one-fourth inch thick. Below this zone is a conchoidally fracturing bed several hundred feet thick contaminated with argillaceous material up to 10 percent alumina. Under these two beds may be another series of varying purity, also interstratified with argillaceous diatomite and volcanic ash.

In some cases wet ore goes to a storage area at the quarry where air drying takes place. It is loaded into bottom-dump trailer trucks by bulldozer or slusher hoist and slackline cable drag-scraper for transporting to the mill.

Milling *(2, 5–6, 9, 11)*

The cost of a plant to process 50,000 tons of diatomite per year is about $2.8 million. Because of the climate, Western plants are of the outdoor type and house only the packing and storage departments and operating control room.

The process outlined diagrammatically in figure 1 covers the Great Lakes Carbon Corp. plant at Lompoc, Calif., which is typical of large-scale diatomite processing.

Diatomite freshly mined from the Lompoc area frequently carries 50-percent moisture by weight; in which case 1 ton of water must be evaporated for each ton of dry diatomite produced—an expensive step in the processing. Drying is accomplished in a hot pneumatic system embodying flash-drying, combination blower-hammer mill comminution, air cyclones, and dust collectors. The diatomite is transported through the system by moving hot gases.

The processing system has three general divisions—a wet-end circut, a calcining section, and a finishing circuit. Crude ore passes through a crusher to a storage bin, discharging to a combination miller-blower with simultaneous injection of a large volume of hot air from a direct-fired oil or gas furnace. The blower injects the ore and hot gases into a system of cyclones and dust collectors, which release air and moisture to the atmosphere, sludge waste to a settling pond, and dry diatomite to the calcining kiln. Impurities not eliminated in the wet-end circuit are usually removed in the finish-end separators.

When flux calcining takes place, 3 to 10 percent by weight of either soda ash, sodium chloride, or caustic soda is added at the crude ore storage bin. Calcination affects the filtering properties of diatomite by changing the surface texture, agglomerating fines, and converting clay minerals which were not removed in the wet-end circuit to aluminum silicate slag. These slag particles are then largely eliminated in the finish-end trapping circuit. Organic matter is removed by combustion during calcination.

Calcination with fusible alkali salts reduces the diatomite surface area per unit volume of the finished product. It also whitens the product, thus increasing its value as a filler where color is significant. Kiln feed temperature is 300° to 400° F; maximum discharge temperature is 2,200° F.

The calcine drops to a hammer mill in which lumps are broken and passes to a milling blower, further reducing the particle size and carrying the calcine to air separators. Any dense particles still in the circuit are trapped in one of these separators and eliminated as a final waste product discharge.

The last air classifier exhausts a fine finished product to a baghouse while discharging a coarser main product. Both of these finished products go to storage hoppers and bagging machines where they are packed in 50-pound paper or cloth bags.

Waste products comprise about 16 percent of total feed.

USES *(2, 4–6, 8–10, 12)*

The primary industrial application of diatomite is as an industrial filtration medium for liquids ranging from municipal water supplies to alcoholic beverages. Additional uses for diaomite are as fillers, as thermal and accoustic insulation, and for miscellaneous uses such as absorbents, abrasives, polishes, catalyst carriers, glazes, paints, pozzolan, anticaking agent, insecticides, fungicides, fabrication of synthetic silicates, and lightweight aggregate.

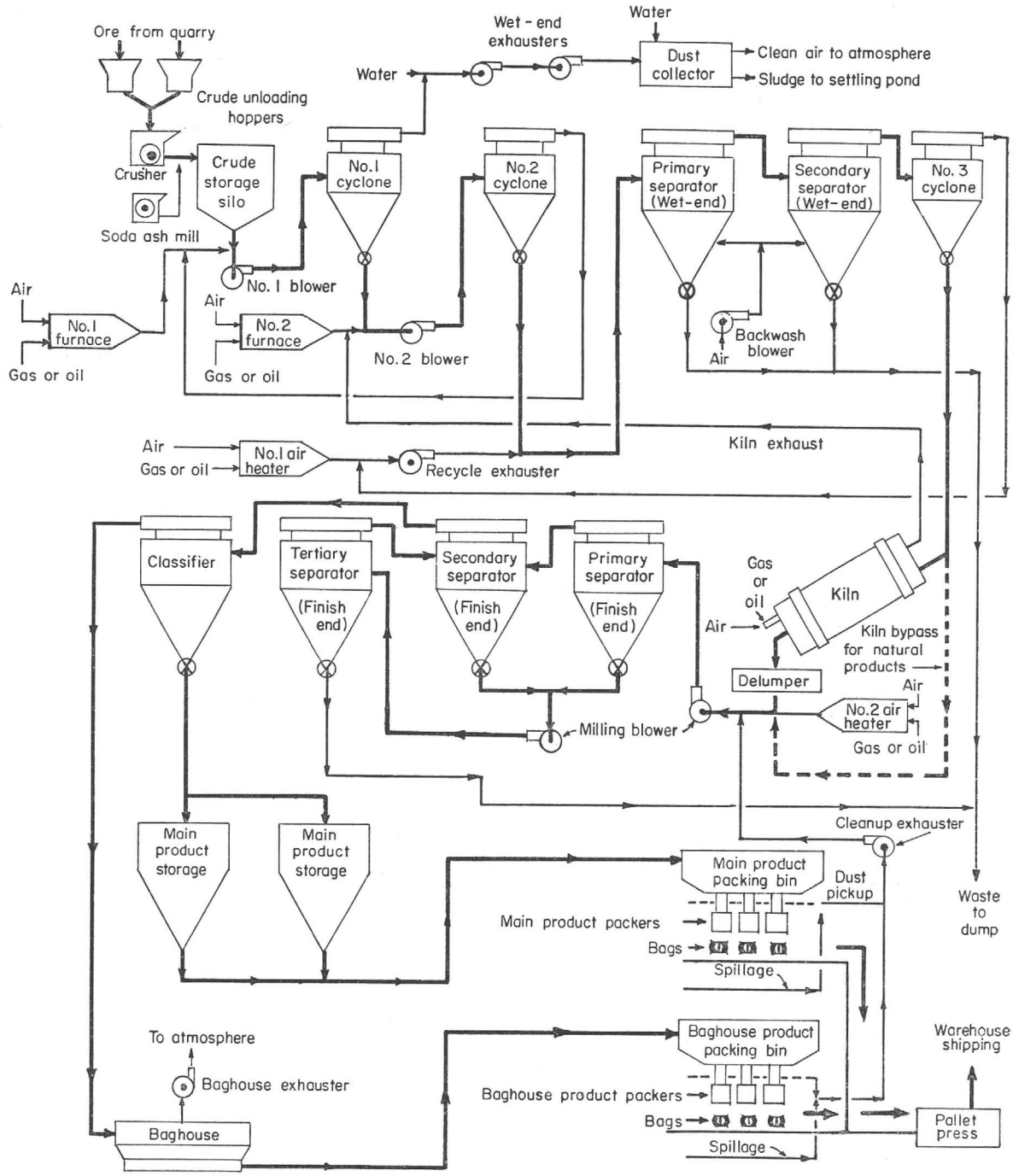

FIGURE 1.—Flowsheet for the Processing of Diatomaceous Earth at Great Lakes Carbon Corp., Lompoc, Calif.

Products filtered with the aid of diatomite include sugar liquor, alcoholic and nonalcoholic beverages, acids, water, petroleum compounds, varnishes, shellac, waxes, greases, resins, plating and dry-cleaning solutions, vegetable oils, gelatins, and antibiotics.

Industrial filters have frameworks supporting filter cloths or wire mesh on which a precoat or cake of porous filter-aid material, usually diatomite, is uniformly deposited. By a difference in pressure between the two sides of this septum, the liquid from the liquid-solids mixture is forced through the filter aid and filter cloth so that the solids to be filtered out are deposited on the precoat.

The continuous filter cycle is started by filling the circuit with a mixture of clear liquid and filter aid until a precoat 1 to 2 inches thick is deposited on the filter cloth. The pulp to be filtered is then introduced with periodic additions of filter aid so that a porous sludge is being constantly deposited on the precoat.

As a mineral filler or extender diatomite is low in cost and imparts such desirable physical properties as light unit weight, strength, elasticity, chemical inertness, low heat conductivity, light color, and reduces reflection of light (flatting agent). Its market as a filler is largely in paint, asphalt, rubber, paper, plastics, and insecticides.

As diatomite is composed of about 90 percent voids and has a relatively high melting point it is a good insulator against heat and sound. It consequently finds applications in furnaces, kilns, refrigerators, safes, and building construction as either brick, shapes, or loose fill.

ALTERNATE MATERIALS

Expanded perlite and silica sand can replace diatomite as a filtration medium. Talc, ground silica sand, barite, gypsum, wollastonite, clay, perlite, vermiculite, chalk, and ground limestone are filler substitutes for diatomite.

Vermiculite, perlite, cinders, expanded clay, shale, and slag can replace diatomite as material usable for lightweight aggregate. When used for insulation, diatomite competes with high-alumina brick, fire clay, asbestos, kyanite, synthetic mullite, mineral wool, expanded vermiculite, and perlite.

RESERVES

Domestic deposits are widely distributed throughout the country. The best known deposits and reserves occur in the West and the largest known reserve, currently being mined, lies near Lompoc, Calif. This deposit extends over many hundreds of acres with beds reaching 1,400 feet in thickness. Arizona, Nevada, Oregon, and Washington currently produce diatomite and have large undetermined reserves of material. The Western States are capable of meeting national requirements for many years. Deposits also occur in nearly all Atlantic coast States from Maine to Florida. However, these deposits have been unable to compete with western material (*4*).

Adequate published information on foreign reserves is not available, but diatomite deposits occur on every continent. Deposits capable of sustaining a processing plant have been confirmed in Iceland. A proved reserve of approximately 6 million tons is available in Kenya, Africa, with an additional 4 million tons estimated to be available. Additional deposits are known in numerous countries with undetermined reserves (*12*).

PRODUCTION, CONSUMPTION, AND TRADE (*12*)

Bureau of Mines statistics are collected on the basis of sales and use of mined diatomite by both producers and consumers. Therefore, the data shown in table 2 are representative of both production and of consumption plus exports.

Government records of imports or exports of diatomite are not available. Presumably very little material is imported because of high transportation costs from most foreign countries. U.S. producers export better quality prepared diatomite, but the quantity is believed to be small.

Crude or processed diatomite may be imported duty free.

World production of diatomite is shown by countries in table 3.

TABLE 2.—*Diatomite sold or used by producers in the United States, 3-year totals*

Years	Quantity, short tons	Average value per ton
1945–47	640, 764	$20. 17
1948–50	722, 670	25. 55
1951–53	908, 448	29. 97
1954–56	1, 105, 279	39. 21
1957–59	1, 349, 340	45. 73
1960–62	1, 446, 625	50. 08

PRICES AND COSTS

Prices vary according to purity of the diatomite, its particle size range, whether it is uncalcined, calcined, or flux calcined, whether it is in bulk or bagged, and the type of bag used.

Average prices of diatomite during 1963 are presented in table 4. These values were obtained from direct canvass of the industry by the Bureau of Mines.

TABLE 3.—*World production of diatomite, by countries* [1] [2]

[Short tons]

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	34	5	44	214	211	322
Costa Rica	2, 860	2, 425	2, 425	717	827	[3] 2,000
Guatemala	17, 576	----------	----------	----------	----------	----------
Nicaragua	----------	1, 887	2, 249	2, 976	1, 414	[3] 1, 400
United States	400, 968	[4] 449, 789	[5] 482, 202	[5] 482, 202	[5] 482, 202	[5] 482, 202
South America:						
Argentina	4, 233	4, 829	117	1, 286	180	[3] 1, 000
Chile	117.	----------	----------	----------	----------	----------
Colombia	187	330	440	330	150	[3] 150
Peru	39	254	1, 284	2, 048	1, 624	[3] 1, 600
Europe:						
Austria	4, 275	4, 492	4, 431	5, 993	4, 613	[3] 4, 500
Denmark:						
Diatomite	15, 895	18, 200	17, 600	21, 500	22, 000	[3] 22, 000
Moler [3] [6]	193, 500	205, 000	204, 300	212, 900	230, 800	220, 500
Finland	2, 030	1, 520	1, 457	805	1, 323	[3] 1, 300
France [7]	81, 216	112, 821	140, 468	118, 429	[3] 110, 000	[3] 110, 000
Germany, West [7] (marketable)	64, 796	55, 737	51, 138	72, 201	67, 792	[3] 66, 000
Italy	22, 196	57, 099	51, 888	[3] 55, 000	[3] 55, 000	[3] 55, 000
Portugal [7]	1, 853	2, 075	1, 172	847	1, 598	[3] 1, 600
Spain [7]	13, 138	11, 561	13, 840	19, 351	13, 352	[3] 13, 000
Sweden	1, 292	764	453	783	[3] 770	[3] 770
U.S.S.R.[3]	([8])	275, 000	300, 000	330, 000	330, 000	345, 000
United Kingdom	25, 409	[3] 19, 000	16, 553	24, 920	[3] 24, 900	[3] 24, 900
Yugoslavia	[3] 4, 400	[3] 5, 000	[3] 5, 000	[3] 5, 000	4, 500	[3] 4, 500
Asia: Korea, Republic of	2, 134	1, 865	2, 646	1, 989	758	2, 407
Africa:						
Algeria	29, 280	38, 087	24, 266	34, 315	30, 534	[3] 9, 000
Kenya	4, 200	4, 041	3, 791	3, 537	3, 207	[3] 3, 300
Mozambique	22	----------	103	397	----------	----------
Southern Rhodesia [7]	----------	148	164	409	423	301
South Africa, Republic of	700	397	346	137	647	[3] 250
United Arab Republic (Egypt)	364	440	805	332	55	[3] 55
Oceania:						
Australia	5, 988	5, 700	5, 218	6, 067	8, 189	[3] 4, 700
New Zealand	2, 167	8, 152	6, 992	3, 961	2, 099	[3] 2, 200
World total (estimate) [1] [2]	1, 235, 000	1, 480, 000	1, 550, 000	1, 635, 000	1, 630, 000	1, 610, 000

[1] Diatomaceous earth is produced in Brazil, Bulgaria, and Japan, but data on output are not available; estimates are included in total. Hungary and Rumania may produce diatomaceous earth, but data are not available and no estimates are included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Average annual production 1957–59.

[5] Average annual production 1960–62.

[6] A clay-contaminated diatomite used principally for lightweight building brick.

[7] Includes Tripoli.

[8] Data not available; estimate included in total.

TABLE 4.—*Average value per ton of diatomite in 1963*

Use	Value
Filtration	$62. 26
Insulation	49. 91
Abrasive	137. 00
Fillers	50. 07
Miscellaneous	30. 20

TAXES

Producers are accorded a 15-percent depletion allowance in computing Federal income tax on diatomite operations.

TRANSPORTATION

Transportation of diatomite is an important economic factor in the industry. This low-density, high-bulk material must be moved from western production areas in California and

Nevada to the highly industrialized East and Middle West where it is used.

RESEARCH

Several large producers maintain laboratory facilities and engage in research into new uses, improvements, and product standardization. Additional research is carried at the university level, especially in the area of filtration and filter aids. Recent Bureau work has been limited to the investigation of the diatomite-bearing strata of Choctaw and Clark Counties, Ala. (*7*).

OUTLOOK

Recent data indicate that diatomite production for various industrial uses has been steadily increasing at an average annual rate of about 5 percent. The demand for diatomite should continue, and a small but steady production increase can be expected.

Individual uses such as filtration, filter aid, industrial filters, insulation, and other miscellaneous uses have shown a steady or increasing demand since 1959. The abrasive use of diatomite is small and has steadily decreased; in time it may cease completely.

The increasing demand for diatomite may encourage exploration for new deposits and eventual exploitation of less desirable impure deposits.

Applied research by diatomite users and producers will continue to develop new applications for this nonmetallic mineral. Additional research and resource investigations may be carried out by the Bureau of Mines and the various agencies of diatomite-producing States.

Domestic reserves of diatomite are adequate for the forseeable future.

PROBLEMS

Shortage of high-grade diatomite deposits in the eastern and central sections of the country and lack of economical techniques to beneficiate low-grade diatomite are obstacles to the development of diatomite production closer to major consuming markets.

The high cost of transporting diatomite from the current major producing areas in the Western States to the principal markets in the highly industrialized Eastern and Central States remains a primary industry problem.

Potential newcomers in the industry are handicapped by the limited availability of information on methods of testing, beneficiation, and other technical data. Almost all research is sponsored by industry, and results are not published.

Processing problems occur in the industry which require the development of special techniques. The high ratio of water in some newly mined diatomites, the fragile character of the material, and the complex specifications required for the final product are examples of industry problems.

If rigid precautions are not observed, diatomite dust can cause pneumoconiosis among workers, especially in plant areas where dust from calcining operations is present (*1*, *3*).

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Amazing Arizona!

DIATOMACEOUS EARTH

ARIZONA
Development Board

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DIATOMACEOUS EARTH

IN ARIZONA

A FIELD AND LABORATORY REPORT

Prepared for

THE ARIZONA DEVELOPMENT BOARD

by

ARIZONA RESEARCH CONSULTANTS

John T. Long, Jr.
and
George G. Olson

FOREWORD

Among the many non-metallic minerals described in the Arizona Development Board's book on Natural Resources is diatomaceous earth.

Because of the apparent extent of the deposits in Arizona and the increasing demand for it in today's markets, the Board commissioned Arizona Research Consultants to explore the substance as found in the state in more detail.

This report, therefore, is a companion study. It is highly technical for the layman, but will find wide and understanding readership among those who now use diatomaceous earth in their products or fields of endeavor.

In general, this mineral is used wherever an inert bulking agent or filler is needed--as a filtration medium in cleaning liquids for repeated use; as an admixture for lightweight cement; as a pozzolanic material in massive concrete structures; as a filter in plastics; for insulation, sound-proofing and fire-proofing; for abrasives and polishes; as a flatting agent in paints; as a bulking agent for fertilizers.

It is the hope of the Arizona Development Board that this report will stimulate investment capital in commercial mining of the known deposits; that other deposits will be discovered and that it will contribute substantially to yet another facet of the industrial economy of Arizona.

INTRODUCTION

The diatomaceous earth deposits described in this report are readily accessible and of sufficient size to be economically important. Numerous other samples have been examined in the laboratory which are not reported here. Upon investigating the source of these samples, it was usually found that they represented small outcroppings or deposits too small to support a mining operation. In a few cases it was not possible to even definitely establish the source of the samples. These samples did serve to indicate how widespread the occurrence of the diatomaceous earth is in Arizona. It is possible that continued prospecting and field work will uncover still other large reserves of diatomite.

The data presented here was obtained from composite samples which were selected at random at a particular deposit. They do not completely describe all of the diatomite in a deposit, but should be indicative of the characteristic properties of the diatomite there. A more detailed study should be undertaken on each deposit to clearly define areas and strata containing the various grades of diatomite.

It is evident that Arizona has almost unlimited reserves of diatomaceous earth. Most of the deposits are situated reasonably close to the utilities and transportation facilities that are required by a modern industrial plant. The small Arizona communities in the vicinity of these deposits are actively seeking new industries and will be most cooperative with any new industrial development project. The rapidly expanding western markets and the growing yearly consumption of diatomaceous earth are creating an increasing amount of interest in Arizona deposits. No company utilizing diatomaceous earth or products derived from it should overlook an opportunity to further investigate these Arizona deposits.

DEFINITION

Diatomaceous earth is a general term applied to many types of sedimentary deposits containing the fossils of diatoms. It is usually contaminated with varying amounts of other materials. It is also known as infusorial earth, kieselguhr, tripolite, fossil flour, diatomite and incorrectly as tripoli. While deposits may have different physical properties all types of diatomaceous earth contain the highly siliceous frustules of diatoms which may be observed under the microscope. Common impurities are clay, sand, lime and pumicite and it is these impurities that give the great variety of appearance to diatomaceous earth.

Diatoms or bacillariales, are microscopic unicellular plants belonging to the algae family. They are distinguished by the complex structure of their cell-walls which consist chiefly of silica. They occur in both marine and fresh waters either singly or in great colonies. The individual diatom is extremely minute and seldom exceeds a length of 1/200 of an inch. Over 15,000 species of diatoms are known and have been described in the literature. Species which were known to have existed 25,000,000 years ago are still found in present day waters. The individual cells of diatoms are called frustules whose walls consist of 2 similar halves. One-half is slightly smaller than the other, the smaller fitting into the larger like a box fits into its cover.

The ordinary mode of reproduction is by cell division. The protoplasm divides into two masses and the halves of the shell or frustule begin to separate. Upon the completion of cell division each new diatom has a half shell from the parent cell and a half shell that it has formed itself. Cell division occurs every 8 to 24 hours depending on environmental conditions and a single diatom may give rise to as many as one billion new cells in a month.

The conditions necessary for the growth of diatoms are moisture and light. Diatoms can occur wherever these two conditions exist, in soil, on moist rocks, in ponds, pools and large bodies of water. Where conditions for the growth of diatoms remains ideal for long periods of time, large deposits of diatom shells may accumulate on the bottom of the sea or inland lake. Since the siliceous frustule is practically impervious to most of the forces of nature, the diatom fossils remain intact and identifiable for millions of years. Thus it is possible to classify the types of diatoms in a deposit that may be as much as 25 million years old.

The system of classification of diatoms usually followed is one put forth by Schutt in 1896, which separated them into two primary divisions; the Centricae and the Pennatae. The Centricae include diatoms in which the valve view (top or bottom of the box-like shell) possesses a radial symmetry around a central point and contains no raphe. The Pennatae comprise those in which the valve view is boat or needle shaped with striations or markings on each side of a median line. The Centricae are much more abundant in sea waters and serve to identify marine deposits.

ARIZONA OCCURRENCES

In Arizona extensive deposits of diatomaceous earth are found along the principle river systems, particularly in the Gila and San Pedro valleys. They occur as bedded deposits in Pleistocene and Pliocene sediments. The overburden consists of sediments and alluvium of recent and Quaternary origin except where erosion has exposed the diatomaceous earth strata. In places erosion has cut deep canyons into the diatomaceous earth and exposed layers of diatomite 100 feet or more in thickness. Other geological evidence indicates that marshes and extensive inland lakes and seas occupied this part of Arizona in the late Tertiary period. Fossils of various prehistoric animals are also found in the river valleys which contain deposits of diatomaceous earth. The supposition that these bodies of water were fresh-water inland seas and not intrusions of salt water from the ocean is supported by the fact that the majority of fossil frustules making up the diatomite belong to the Pennatae division.

The general areas in which diatomaceous earth is found in Arizona are shown on Figure 1. At the present time known occurrences are limited to the valleys of the Gila, San Pedro and Verde rivers. A deposit has been reported in the western part of the state along the Colorado River but it has not been possible for personnel from this laboratory to substantiate this claim. Each of the areas indicated contain numerous deposits of varying size and grade. Some beds which may be an integral part of a large deposit occur over a much greater area than the other beds making up the deposit and indicate that the inland seas may have varied considerably in size during their existence. This is particularly true in the San Pedro valley where a certain stratam may outcrop off and on for a distance of 30 miles. Characteristic bands of pumicite occur at the same relative elevation in many of the deposits and serve to indicate the position of the beds of diatomite which are known to occur above and below them. These bands are of considerable aid in determining the possible extent of the diatomite in a prospect. The areas indicated in Figure 1 might well contain large deposits which as yet are not known to exist either because erosion has not exposed any of the diatomite or they occur in inaccessible areas. In some places erosion has caused such extensive damage that little diatomite remains in a region that shows evidence of once having been covered with it.

The principle known deposits of diatomaceous earth are indicated in Figure 2. Only those deposits of sufficient size and quality to be of economic interest have been represented there.

Some of these deposits have been worked on a small scale but the majority of them have not been commercially developed. Diatomaceous earth was first reported in Arizona by Blake (1) in 1903. He described the deposit located across the San Pedro River from Mammouth and reported the possible existence of other deposits in the San Pedro River Valley. Several deposits along the San Pedro and one along the Gila River were reported by Trischka (2) in 1929. In spite of these early accounts of the occurrence of diatomaceous earth deposits in Arizona, they have attracted little or no attention until recently.

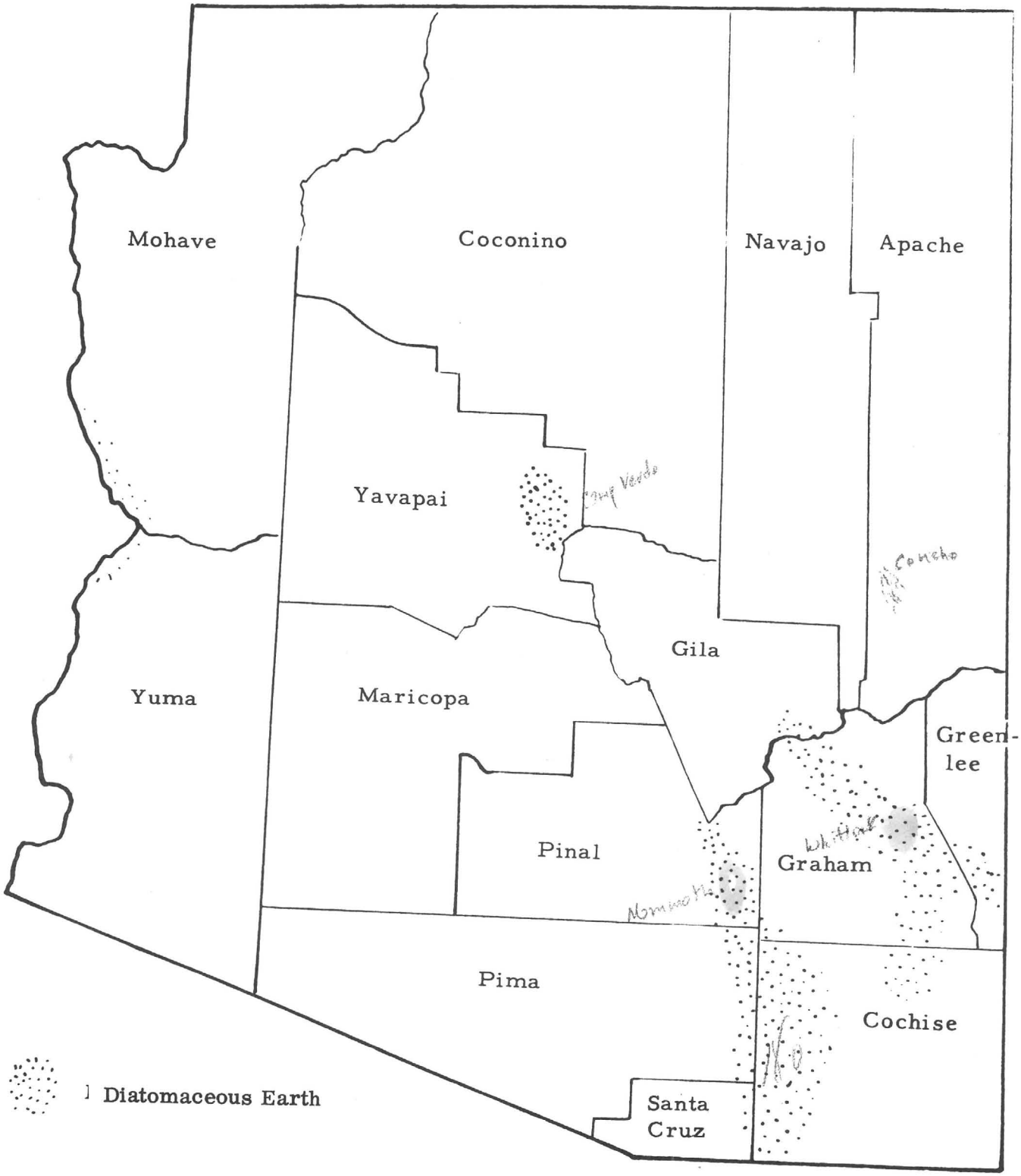


FIGURE 1

Counties and Areas where Diatomaceous Earth is Found in Arizona

The rapidly expanding market for diatomite products in the last 15-20 years has sparked a renewed interest in Arizona's diatomaceous earth. The average yearly production since 1930 in the United States as well as the average price per ton at the mine is plotted in Fig. 3. As the market increases the importance of Arizona's deposits to our national economy also increases. Most of the Arizona deposits are located in terrain suitable for open pit mining operations. They are all located reasonably close to a railroad and to one of our national highways. They are also closer to the bulk consumers which are the eastern markets than deposits currently being worked on the west coast. These factors all contribute to making an investigation of diatomaceous earth deposits in Arizona a worthwhile project.

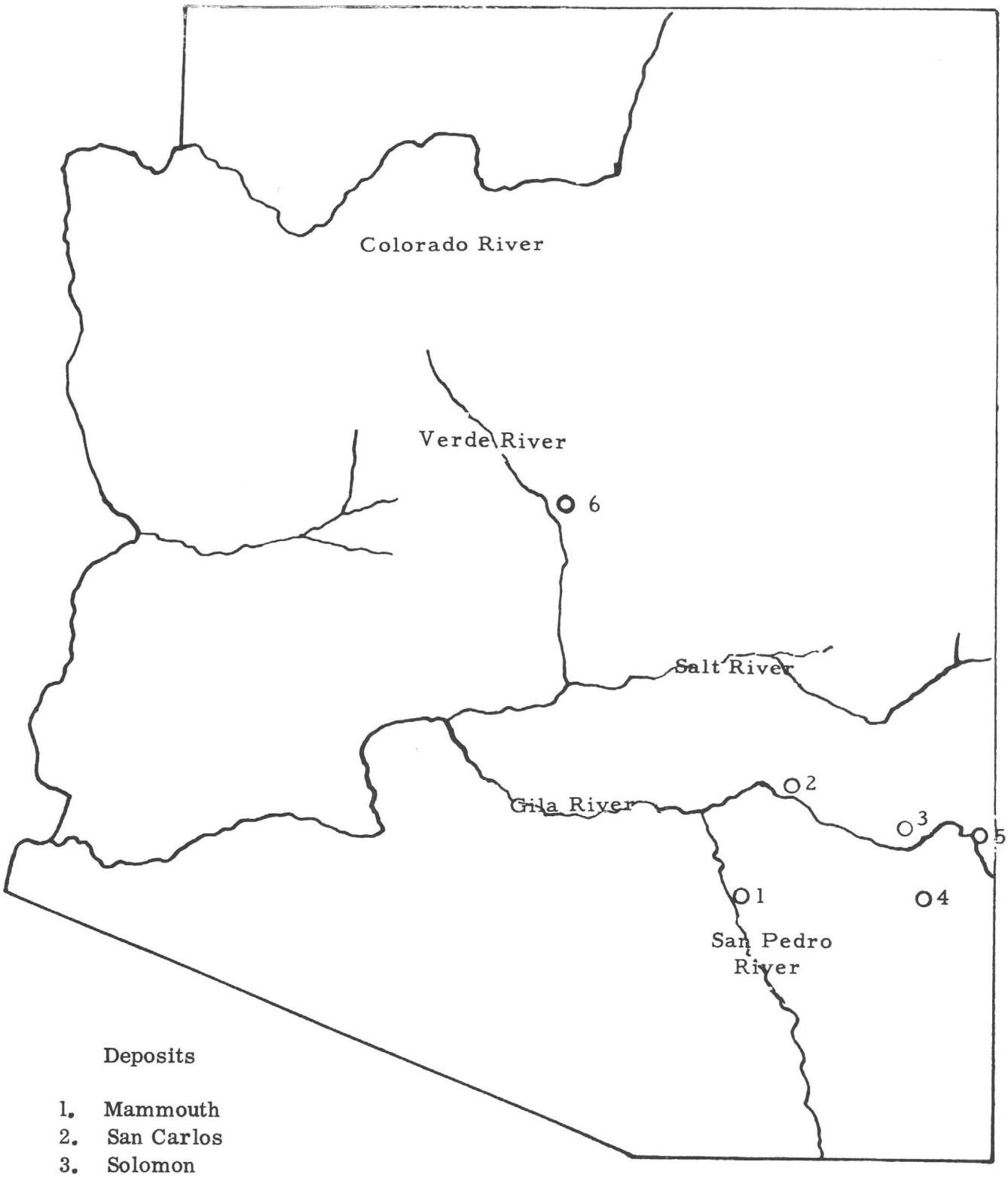
MAJOR DEPOSITS

1st choice

Mammouth deposit

Elev. Between 2600-2800'

The best known Arizona deposit lies on the east bank of the San Pedro River directly opposite the new mining community of San Manuel in Pinal County. It is commonly known either as the Mammouth deposit or the White Cliffs Mine and can be reached from the town of Mammouth by crossing the river and following the east bank of the San Pedro River south for a distance of eight miles on a graded county road. It can also be reached by driving east from San Manuel on a graded county road for a distance of 5 miles and crossing the river to the deposit. Rail service connecting with Southern Pacific is available at San Manuel. The El Paso Natural Gas Co. pipe line extends to the San Pedro River directly across from the deposit and electric power is available from the Arizona Public Service Company's lines which cross the deposit. The deposit covers about 6 sections located in T 17 E, R 9 S with respect to the Gila and Salt River Base Line and Meridian. The deposit lies nearly level with the beds dipping slightly to the east. Some faulting has occurred and in places the continuity of the bedding has been disturbed. A number of canyons transect the deposit from east to west and in places expose more than 100 feet of diatomite. Drainage is from east to west into the San Pedro River. The river is dry except during the rainy season in July and August. Surface run-off from the Galiuro Mountains to the east is diverted around the deposit by the Big Gust James Wash and flood waters are not a problem during the rainy season. Typical Sonoran desert conditions are found at the deposit. The sparse vegetation consists mainly of mesquite, catclaw and greasewood. In spite of the dry surface conditions abundant water is available from underground sources. An artesian well has been drilled on the western edge of the deposit and is used to irrigate farm land along the river bottom. Two well defined clay strata about four feet in thickness are found near the top and near the bottom of the deposit. Some diatomite occurs above and below them and approximately 100 feet of excellent white material lies between them. Over many acres of the deposit the upper clay band has been eroded away to expose the diatomite. In places where the diatomite is exposed it is possible to mine the material by ripping it loose with a bulldozer. A photomicrograph of a typical sample from the deposit is shown in Fig. 4. Most of the diatoms present are Navicula (canoe shaped) with 20%-30% Synedra. Also present are sponge spicules and volcanic glass. Some chemical and physical properties are presented in Table 2.



Deposits

1. Mammouth
2. San Carlos
3. Solomon
4. Whitlock
5. Duncan
6. Verde Valley

FIGURE 2

Principle Diatomaceous Earth Deposits in Arizona

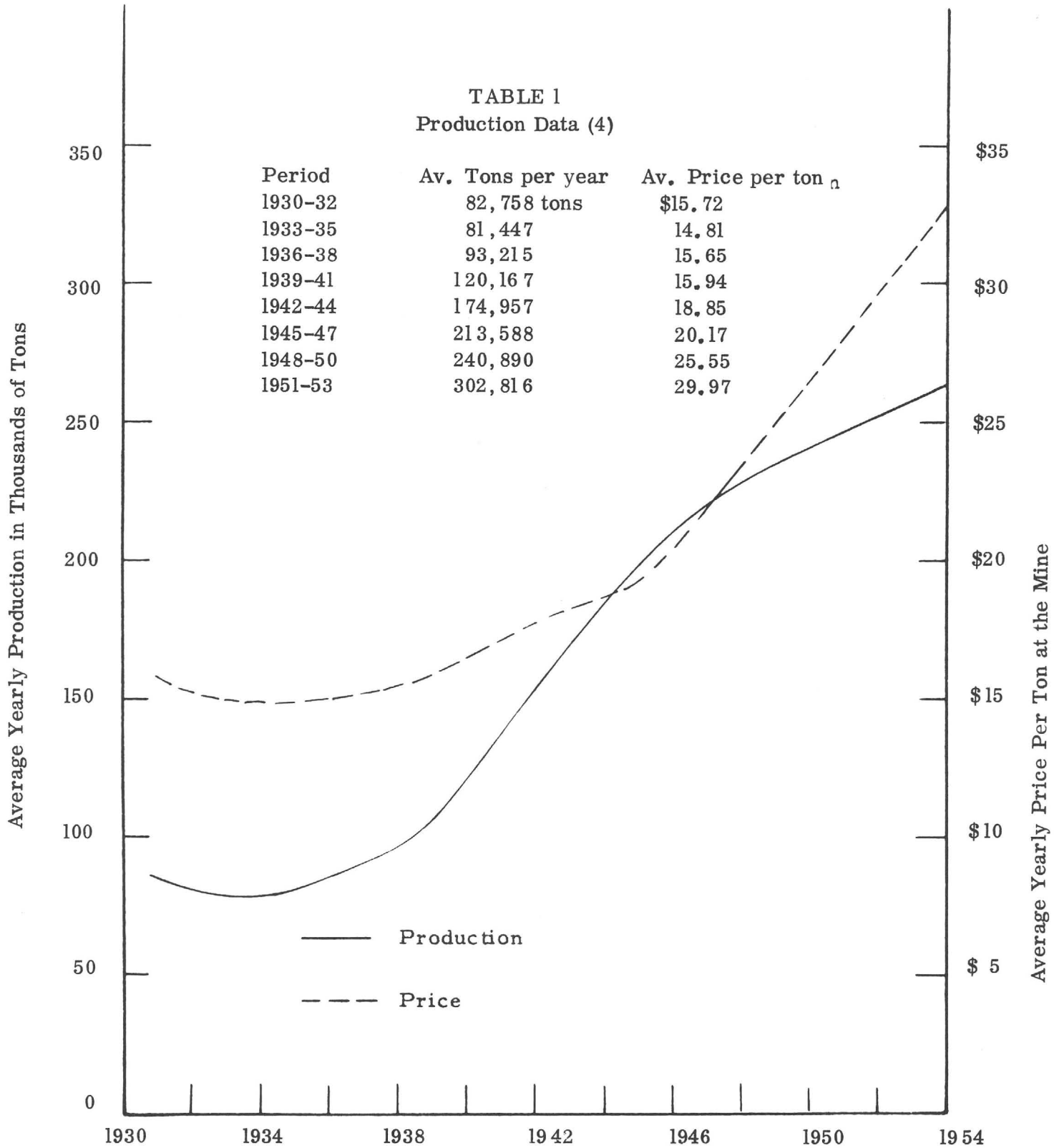


TABLE 1
Production Data (4)

Period	Av. Tons per year	Av. Price per ton
1930-32	82,758 tons	$15.72
1933-35	81,447	14.81
1936-38	93,215	15.65
1939-41	120,167	15.94
1942-44	174,957	18.85
1945-47	213,588	20.17
1948-50	240,890	25.55
1951-53	302,816	29.97

FIGURE 3

Increase in Production of Diatomaceous Earth in Recent Years.

Not recommended because of problems w/Indians

San Carlos Deposit

The largest deposit of diatomaceous earth in Arizona is found in Graham County on the San Carlos Indian Reservation. It lies on the north side of the Gila River a few miles from the present river bed and extends into the mountains to the north. This portion of Arizona has not been surveyed and it is not possible to locate the deposit with respect to section, range or township. This land is not open to mineral location and mining rights must be secured from the San Carlos Apache Tribal Council. The deposit was first described by Bromfield and Shride (3) of the U. S. Geological Survey.

This deposit is readily accessible and can be reached from the towns of Peridote or Bylas on the recently realigned section of Highway 70. In a number of places, highway cuts have exposed 20 to 30 feet of the material. Diatomaceous earth begins to appear along the highway about 6 miles east of Peridot and extends east for a distance of 6 to 8 miles.

The diatomaceous earth occurs in an area of gently rolling foothills which are cut with numerous dry washes. Drainage is from north to south into the Gila River. The Gila River flows throughout the year but the small washes crossing the deposit carry water only during periods of local thunderstorm activity. The deposit is covered with sparse desert vegetation. Diatomite is exposed at the surface of the ground over extensive areas covering as much as a section. The overburden increases near the mountains where the diatomite is covered with alluvium. Some faulting has disturbed the continuity of the bedding planes and in places block faulting has exposed sizeable faces of diatomaceous earth. The material lies in well defined strata of varying hardness, averaging 100 feet in thickness. The difference in hardness is more pronounced on the western side of the deposit. The chief impurity is calcium carbonate which varies in amount from one layer to another. Occasionally small lenses of chert are found as well as thin strata of pumicite. A photomicrograph of a typical sample from the deposit is shown in Fig. 5. Easily seen are Stephanodiscus astraea (discs), Synedra (rods), Melosira (ladders), and pumicite. Some of the chemical and physical properties are presented in Table 3.

The Solomon Deposit

This deposit lies approximately 10 miles north of Solomon in Graham County in township T8S, R27E, Gila and Salt River Base Line and Meridian. It lies on the north side of the Gila River approximately 2 miles from the present river bed. The deposit may be reached by driving north from U. S. Highway 70 on the San Jose road for 5 miles, then crossing the river at this point. The nearest siding of the Southern Pacific railroad is at Safford, a distance of 15 miles from the deposit. Electric power is available from the Graham County Electric Cooperative whose main substation is located at San Jose. Natural gas is available near Highway 70 from the El Paso Natural Gas Co. line.

This deposit is similar in appearance and properties to the larger deposit on the San Carlos Indian Reservation. Other outcroppings of diatomaceous earth could well

occur between Solomon and San Carlos. This area, however, has not been prospected for diatomaceous earth and none has been reported in the literature. Much of this deposit is covered with alluvium and the diatomite that is exposed has suffered from much erosion. In places, beds of diatomite 20 feet or more thick can be observed.

The Whitlock deposit

This deposit lies southeast of Solomon in Graham County on the east side of the San Simon Creek. It consists of a series of low rolling hills which make up the northwest foothills of the Whitlock Mountains. The deposit can be reached from Solomon by driving east on U. S. 70 for a distance of 8 miles and turning south onto an unimproved dirt road for a distance of 5 miles. There are no roads on the deposit itself at the present time. The road continues on past the deposit and across the San Simon Valley to Tanque, a siding on the Southern Pacific railroad. It is approximately 8 miles from the west side of the deposit to the railroad at Tanque. There is no electric power at the deposit but both electricity and gas are available along U. S. Highway 70.

Good backing property to Hawnoth

Much of the deposit is badly eroded but there are still several hundred acres of relatively undisturbed diatomite. Near the mountains the amount of overburden increases as would be expected. However, much of the deposit is exposed at the surface in terrain ideally suited for open-pit mining. Drainage is from east to west into the San Simon River which is a dry stream except during periods of local thunderstorm activity. The deposit is covered with typical sparse desert vegetation.

The diatomaceous earth occurs in a series of beds laying nearly horizontal. In places the beds are eroded to form a series of hills and small mesas. Some faulting has occurred but no major displacements of the diatomite have been observed. Field observations reveal some variation in the physical properties of several of the strata. This is due to a difference in the impurities which are pumicite, clay and occasionally calcium carbonate. The diatomite is very white in color. In places where erosion has cut the strata, faces of good diatomite 30 - 40 feet thick can be observed. Characteristic thin bands of chert and of pumicite are also found in this deposit. Some of the chemical and physical properties of a typical sample from the deposit are presented in Table 4. A photomicrograph of a representative sample is shown in Fig. 6. This photograph shows the presence of Cocconus placentula (ovals), Synedra (rods), Melosira (ladders) and other unidentified types.

The Duncan Deposit

A large deposit of diatomaceous earth is found just north of Duncan in Greenlee County, T8S, R31E, Gila and Salt River Base Line and Meridian. It lies on the north bank of the Gila River and extends over an area of several hundred acres. The deposit is readily accessible from Duncan on State Highway 75. It is about 1 mile northwest of town, immediately adjacent to the highway. In this area diatomite appears in numerous highway cuts and at the deposit beds 20 feet thick are exposed along the roadway. Electric power is available adjacent to the deposit and natural gas is available in Duncan. Duncan is also served by Highway 70 and the Southern Pacific railroad.

Good Diatomite but in Developed Area

FIGURE 4

Photomicrograph of Diatomaceous Earth from the Mammouth Deposit
X 450

FIGURE 7

Photomicrograph of Diatomaceous Earth from the Duncan Deposit
X 450

TABLE 5

DUNCAN DEPOSIT

Chemical Analysis	
Silica	65.96%
Alumina	12.52
Iron (Fe_2O_3)	1.12
Calcium oxide	7.16
Magnesium oxide	0.67
Sodium oxide	0.19
Potassium oxide	0.24
pH (50% slurry)	7.40
Oil Absorption (Gardner-Colman)	74.0 lbs./100 lbs.
Bulk density	16.18 lbs./cu. ft.
Color	Gray-White
Sintering temperature	ca 2000° F
Color of sintered crude	Tan-Brown
Color rating of 5 samples reported	5

WHITLOCK DEPOSIT

Chemical Analysis

Silica	79.92%
Alumina	7.68
Iron (Fe_2O_3)	0.30
Calcium oxide	3.18
Magnesium oxide	0.38
Sodium oxide	0.15
Potassium oxide	0.24
pH (50% slurry)	8.49
Oil absorption (Gardner-Colman)	82.0 lbs./100 lbs.
Bulk density	14.63 lbs./cu. ft.
Color	Off White
Sintering temperature	ca 2100° F
Color of sintered crude	Pink-Tan
Color rating of 5 samples reported	3

The deposit occurs as a series of low hills capped with clay and soil with very little rock. Erosion has been very severe and steep cliffs of diatomite and clay are found northeast of the highway. Drainage is from northeast into the Gila River. The surface runoff is confined to a series of narrow washes and would not seriously hamper mining operations. The diatomite occurs in beds 20 - 40 feet thick which lie almost horizontal. While there is much clay in the area, it is in distinct beds above and below the diatomite and does not contaminate it. The diatomite is exceptionally white and clean in this deposit. In places the upper strata of clay have been eroded away and the diatomite is exposed at the surface. Some chemical and physical properties of a representative sample are recorded in Table 5. A photomicrograph is shown in Fig. 7. This sample shows the presence of Cocconeis placentula (ovals), Melosira fragilaria (ladders), Synedra (rods) and volcanic glass.

Verde Valley Deposit

This deposit occurs over an extensive area south of the town of Camp Verde in Yavapai County. Samples have been obtained from both sides of the river from individuals owning mining claims in this section. On the east side of the river it outcrops along the valley at elevations above the gypsum deposits which are found there. The area lies south of Camp Verde on the road to Pine. A paved road connects the deposit with Clarkdale, a railhead for the Santa Fe railroad 30 miles to the north. Natural gas will soon be available in the valley and the Arizona Public Service Co. provides electric power there. Water is available from the Verde River and from wells.

While diatomaceous earth is widespread in the Verde Valley, thick beds of it are not found here as in the southern part of the state. The diatomite is found in a series of beds varying in thickness from a few inches to 8 feet. Many of the beds contain a considerable amount of calcium carbonate and it is not possible to identify the material as diatomite except by microscopic examination. The various strata are sometimes widely separated and it is difficult to trace the continuity of the material. The region has been inadequately prospected for diatomite and the true extent of the material in the valley is not known at this time. Some chemical and physical properties of a typical example from the area are reported in Table 8. A photomicrograph of this sample is presented in Fig. 8. This sample is composed mainly of Melosira and Synedra. The large segment near the center of Fig. 8 could be a fragment of Stephanodiscus type.

MAMMOUTH DEPOSIT

Chemical Analysis

Silica	87.92%
Alumina	3.90
Iron (Fe_2O_3)	0.10
Calcium oxide	0.84
Magnesium oxide	1.43
Sodium oxide	0.24
Potassium oxide	0.22
pH (50% slurry)	8.00
Oil absorption (Gardner-Colman)	94.7 lbs./100 lbs.
Bulk density	11.18 lbs./cu. ft.
Color	Off White
Sintering temperature	ca 1800° F
Color of sintered crude	Light Tan
Color rating of 5 samples reported	1

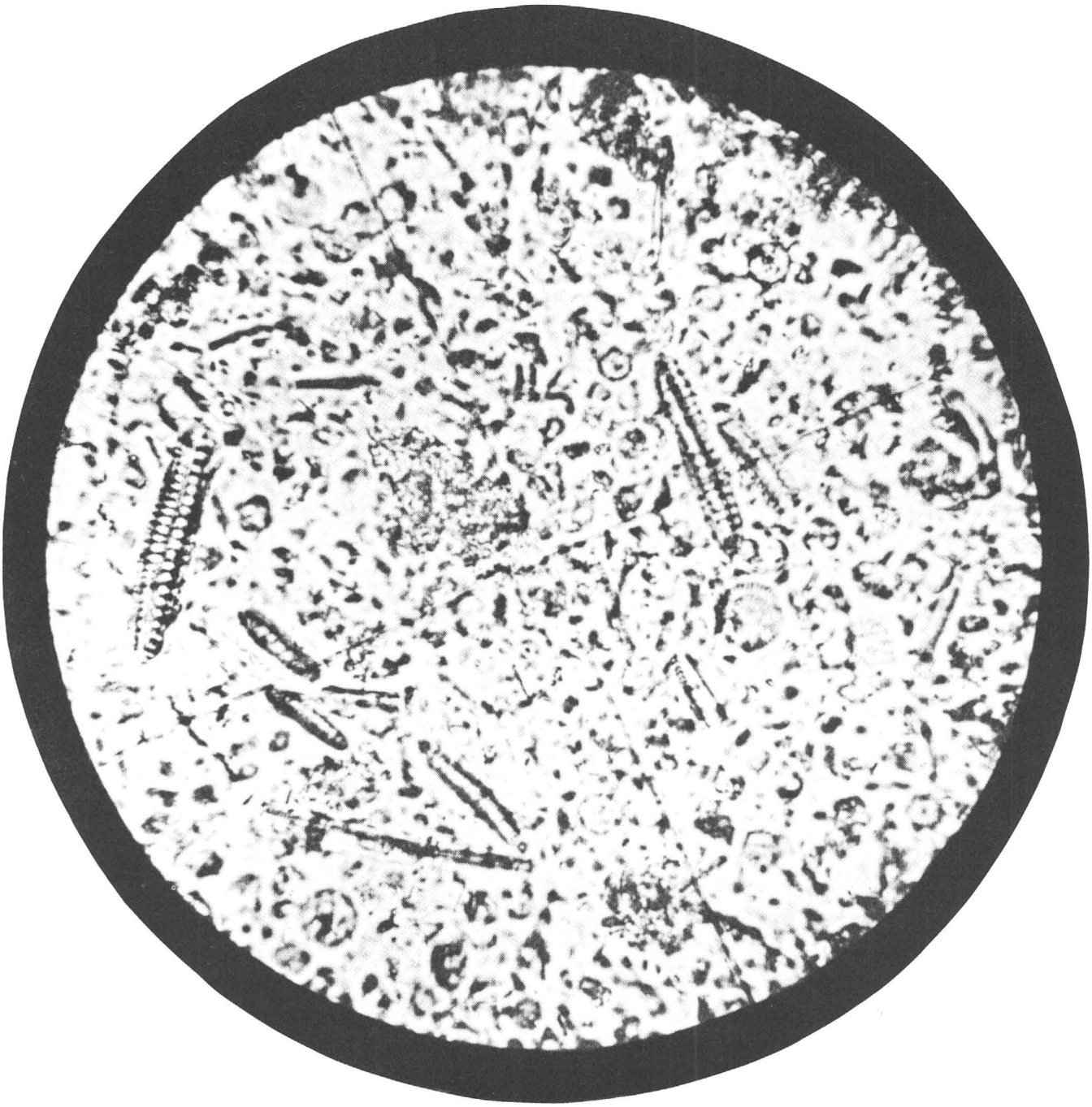


FIGURE 5

Photomicrograph of Diatomaceous Earth from the San Carlos Deposit
X 450

SAN CARLOS DEPOSIT

Chemical Analysis

Silica	77.96%
Alumina	6.76
Iron (Fe_2O_3)	0.23
Calcium oxide	3.69
Magnesium oxide	0.47
Sodium oxide	0.16
Potassium oxide	0.19
pH (50% slurry)	8.11
Oil absorption (Gardner-Colman)	82.0 lbs./100 lbs.
Bulk density	15.86 lbs./cu. ft.
Color	Off White
Sintering temperature	ca 2100° F
Color of sintered crude	Pink-Red
Color rating of 5 samples reported	4

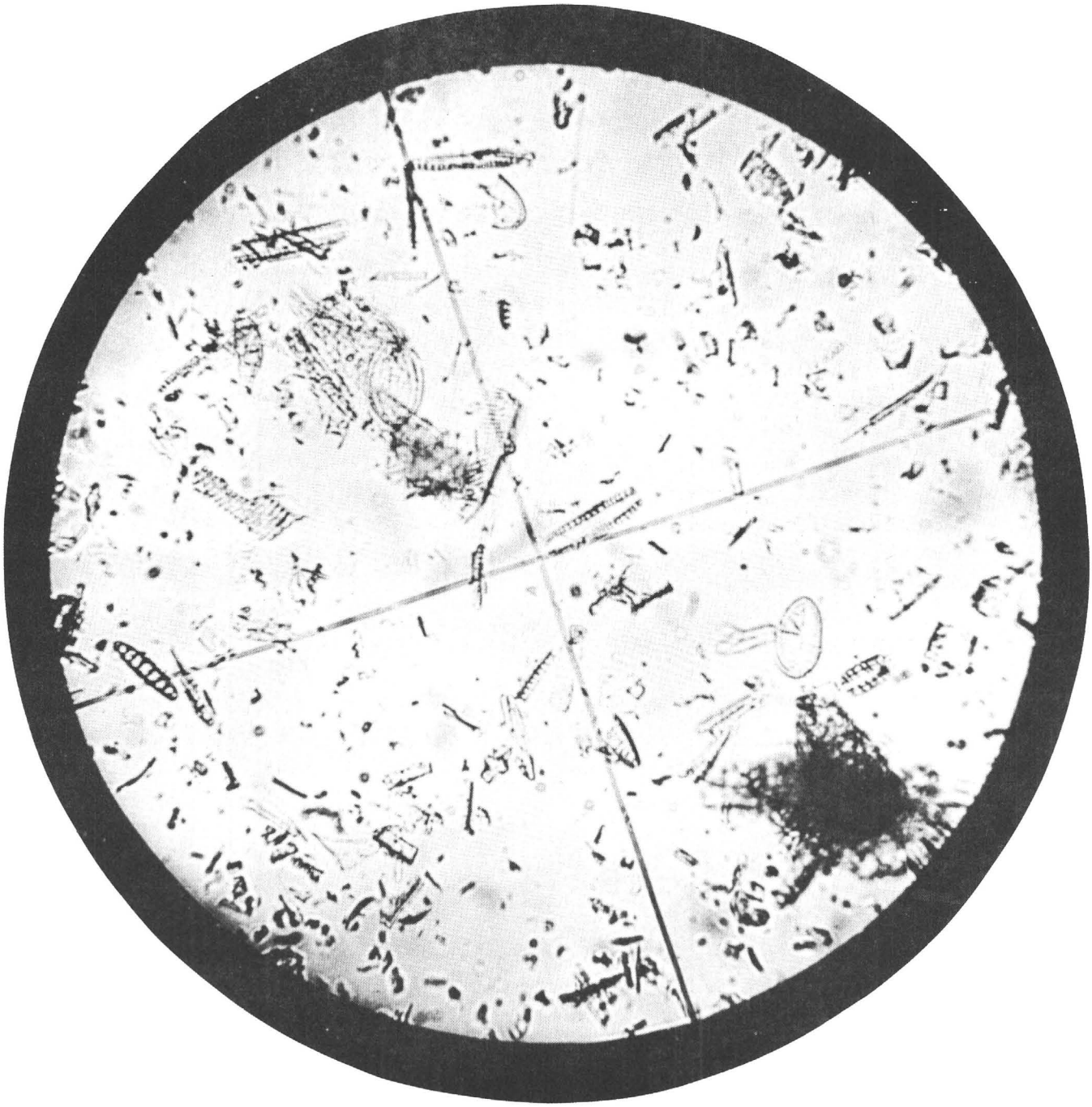


FIGURE 6

Photomicrograph of Diatomaceous Earth from the Whitlock Deposit
X 450

TABLE 6

VERDE VALLEY DEPOSIT

Chemical Analysis	
Silica	86.64%
Alumina	6.10
Iron (Fe_2O_3)	0.22
Calcium oxide	1.91
Magnesium oxide	0.08
Sodium oxide	0.11
Potassium oxide	0.12
pH (50% slurry)	8.1
Oil absorption (Gardner-Colman)	87.0 lbs./100 lbs.
Bulk density	13.2 lbs./cu. ft.
Color	Off White
Sintering temperature	ca 2100° F
Color of sintered crude	Light Pink
Color rating of 5 samples reported	2

FIGURE 8

Photomicrograph of Diatomaceous Earth from the Verde Valley Deposit
X 450

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THE UNIQUE PROPERTIES OF DIATOMITE AND NEW FILLER USES

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THE UNIQUE PROPERTIES OF DIATOMITE AND NEW FILLER USES

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THE UNIQUE PROPERTIES OF DIATOMITE AND NEW FILLER USES

Introduction

A discussion of fillers would not be complete without allotting adequate time to that unique and different mineral material, diatomaceous silica. Historical references to its use challenge the aesthetic aspect of man's curiosity; whereas modern scientific tools have provided a dimension of measurement that has motivated many of its more recent applications. A brief review of what is already known is in order. The diatom is a unicellular, plant-like, microscopic organism, related to the algae[1]. Its natural function appears to be that of a food for other marine or lacustrine organisms. The diatom's "claim to fame" from an industrial viewpoint is dependent on the fact that it secretes an opaline siliceous skeleton that must survive, chemically and structurally, the geologic processes that caused its formation in the first place; its subsequent demise, burial, consolidation, and alteration; and finally, its ultimate exploitation by man--in somewhat that order. In addition to its siliceous nature, the skeletal structure of the diatom possesses a variety of shapes, patterns, and sizes that have not only been the intrigue of microscopists for decades, but have served to set diatomite apart as an industrial mineral; and have reserved for it applications that cannot be satisfied by any other material. Its chemical inertness, its intricate structure, and its intrinsic hardness-coupled with fineness and friability--are generally known and have accounted for its application in a wide range of filtration and filler uses.

The increasing use of the electron microscope has considerably expanded our knowledge of heretofore unseen secondary and tertiary structure of submicron dimension in the diatom valve. The development of electro-sensing methods of particle size measurement which seem to supersede sedimentation and microscopic techniques has portrayed size distribution in a more realistic light. Interest in the surface chemistry of these silica structures has further strengthened our understanding for certain uses. Thus, new tools and ideas have made possible the introduction of diatomite into such sophisticated technologies as that of chromatographic supports, its improved utility in paint applications for the control of gloss and sheen, and its usefulness in the entirely new concept of "Dry Acid Concentrates." Each of these applications has been discussed elsewhere before people particularly interested in analytical chemistry, in paint, and in liquid handling, respectively, where the diatom has been a means to an end. The emphasis here, before the mining fraternity, however is on diatomite as a raw material with reference to the uses mentioned above. It is therefore toward an awareness and understanding of diatomite properties pertinent to these newer filler applications that this paper is directed.

Structure

One of the most distinctive characteristics of the diatom is its skeletal structure. Resolution of fine diatom structure is still a worthy test for any light microscope. Figure 1 is not new to those familiar with diatoms.

Nature of the Surface

[redacted]

Use of Diatomite in Paint

[redacted]

[redacted]

Conclusion

The uses of diatomite as a filler at one time grew from the efforts of product development to dispose of the fines created by the manufacture of filter aids. This "stepchild's role" has changed markedly in recent years. Now, diatomite filler applications demand more than simply a by-product for a source of material, or a "hand-me-down" approach in finding a market. As the foregoing discussion should have emphasized, there are filler applications for diatomite that exist only because of its unique properties. Furthermore, these applications have been made possible because of a concentrated research effort to know and to understand the properties of diatomite coupled with efforts to determine what is needed in the marketplace.

The uses discussed herein are representative of different aspects of filler development. "CELITE" 499 flatting pigment is the result of a basic study into the effect of particle size and shape in a paint film. A theoretical concept was developed and a product tailored to meet it. The dry acid concept involves taking advantage of a known property when it is recognized in a new deposit to be manifested to a degree beyond that found elsewhere. The development of chromatographic supports on the other hand is not only a new use that is dependent on diatomite's unique properties, but an example of the enhancement of diatomite in this application by the alteration of chemical characteristics of the surface.

It is fascinating to speculate on what new properties of diatomite will be discovered that can be capitalized on, or what well-known properties can be modified to fit new applications. Although the requirements for all fillers, including those applications served by diatomite, are becoming more demanding, the industry should remain confident that with thoughtful and intelligently directed research and development the challenge can be met.

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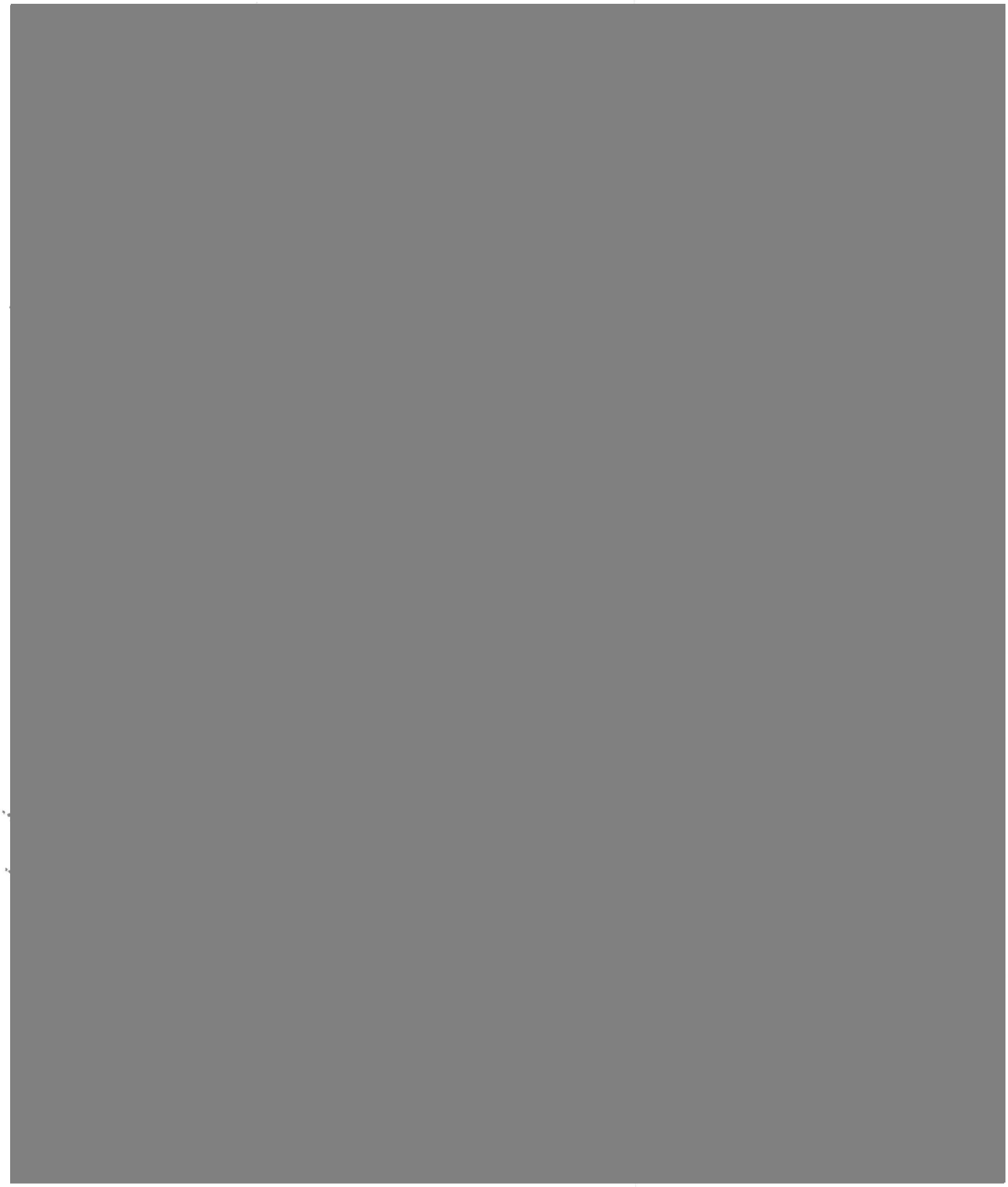

Fig.1 Typical diatom forms

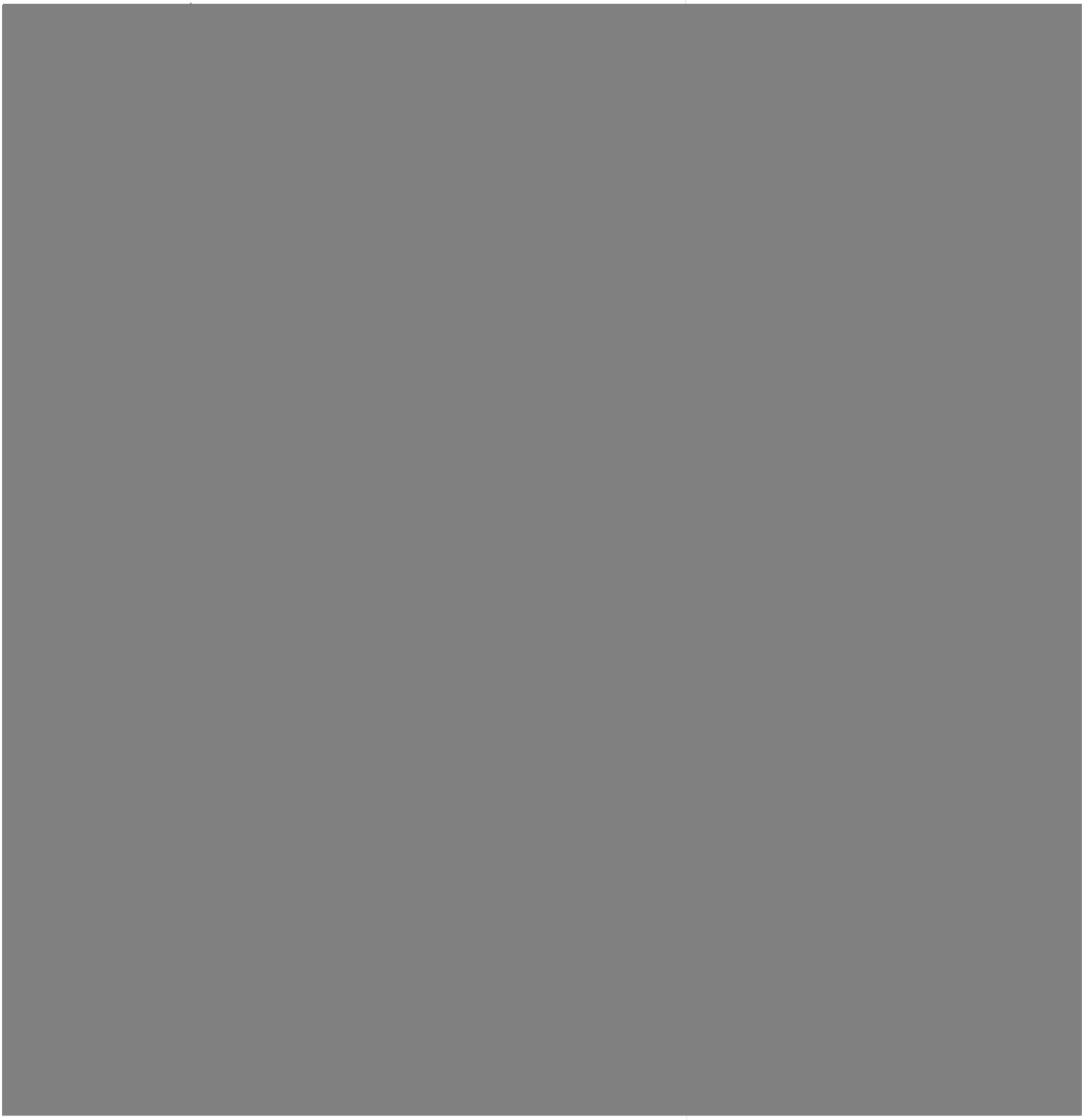

Fig.2 Coscinodiscus - typical marine diatom

Electron micrograph-valve view:

Fig.3 Structure of Coscinodiscus valve

Diameter, microns

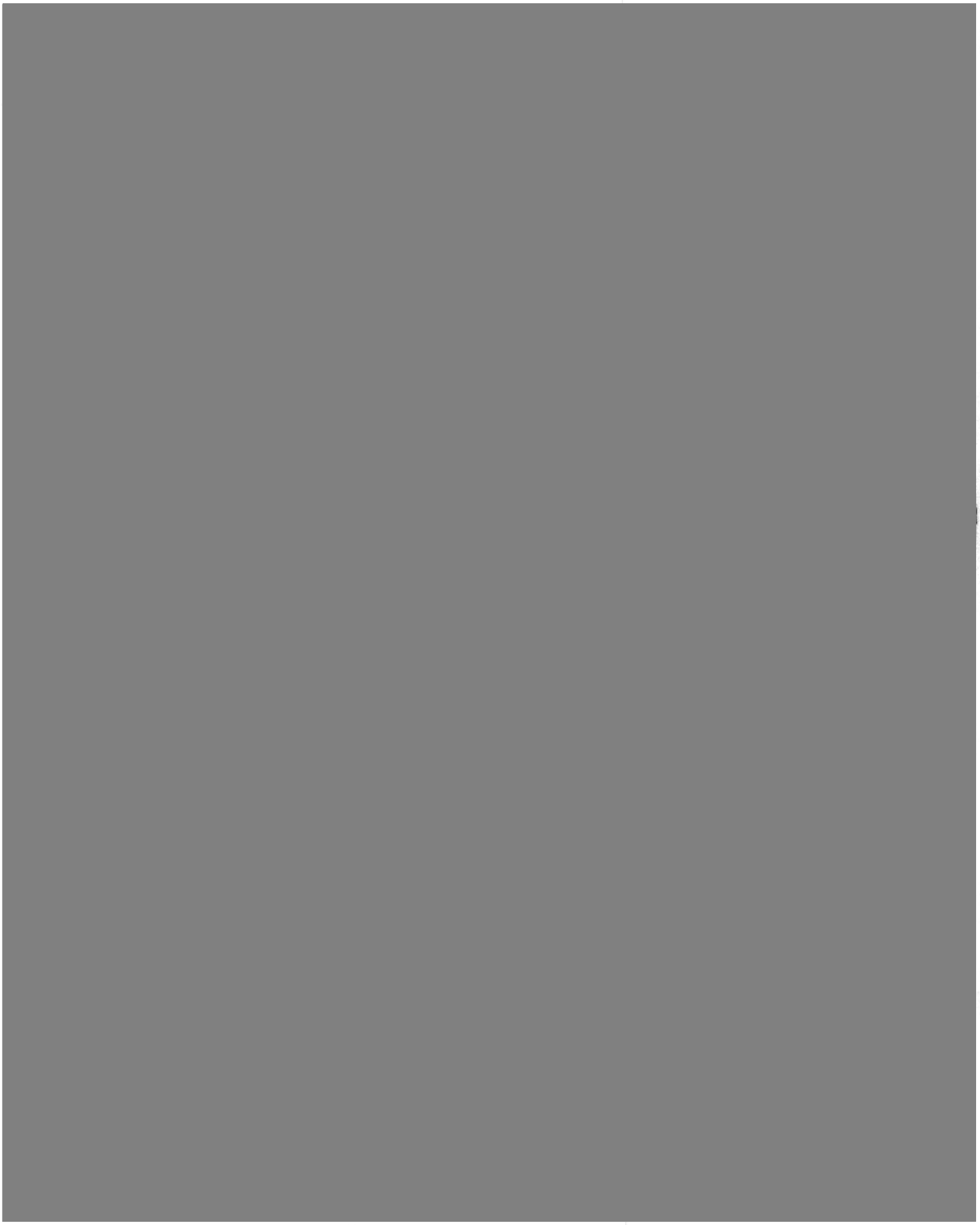

Fig. 5 Celite 499 Flatting Agent for Paint

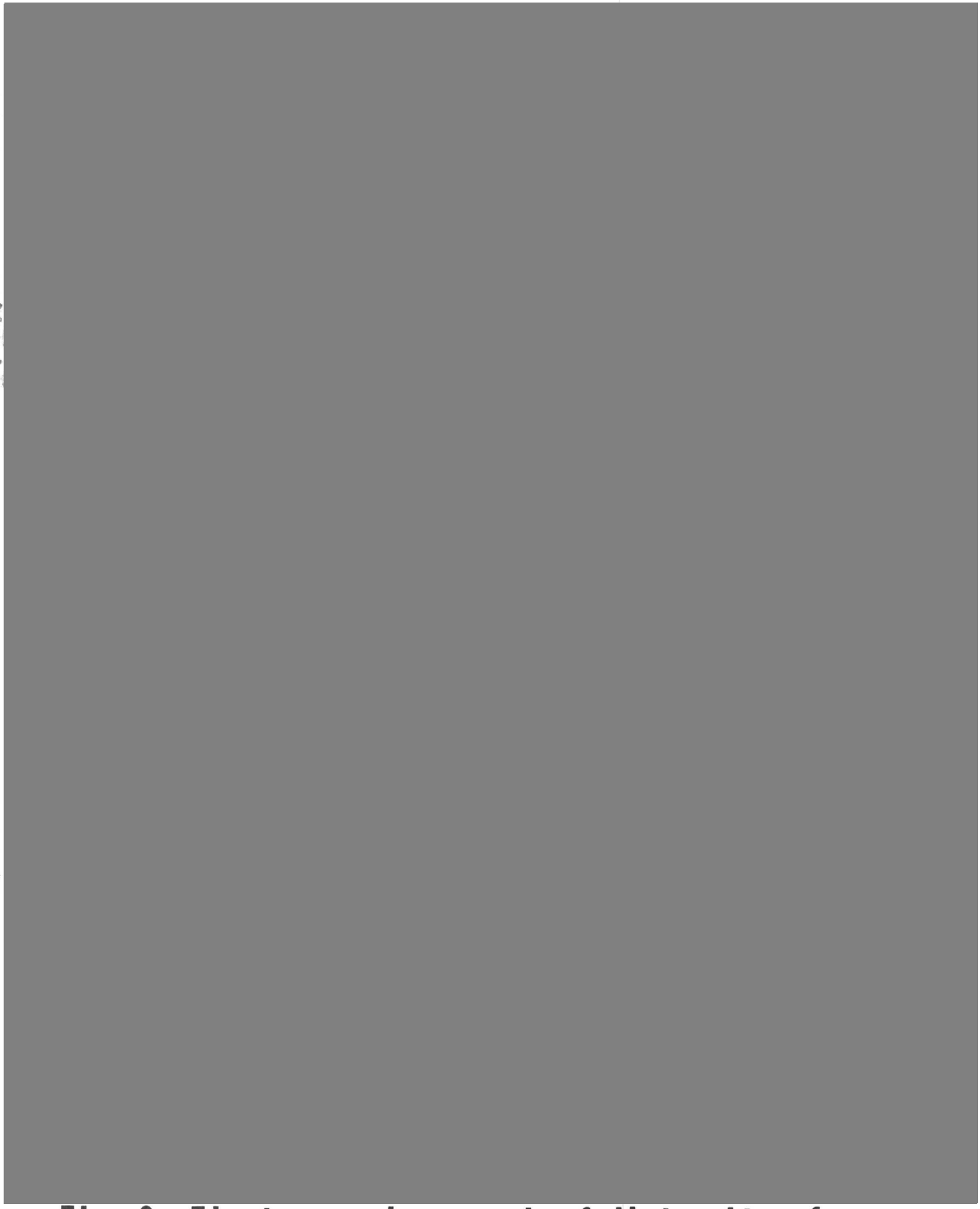

Fig. 6 Electron micrograph of diatomite from Jalisco, Mexico

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California

DIATOMITE

By P. W. Leppla

Origin

Diatomite is a soft sedimentary rock consisting of the siliceous remains of tiny unicellular aquatic plants. The plants are a type of algae. The silica part of a diatom consists of two halves, hinged together like an oyster shell. Biologically, diatoms are interesting because of their method of propagation. The diatom divides into two halves, each retaining one-half of the silica "shell." The newly formed individual then grows a new half "shell" and the process is repeated. The newer "shell" is usually smaller than the original, consequently the size decreases with successive generations. With many species, the cycle consists of five such steps, after which a different reproductive process intervenes.

Diatoms are very prolific when environmental conditions are right. Today they exist in almost every pond and in the sea. They are especially numerous in the Antarctic. They grow best when the dissolved silica content of the water is high, and many deposits are related in location and time of deposition to volcanic activity because of the high dissolved silica concentration developed from volcanic ash and lava flows.

Several thousands species are known, each with a characteristically different silica structure and size. The maximum dimension ranges from about one micron to several hundred. They exist in the shape of needles, discs, boats, bananas, ladders, and many others. One particular species looks almost exactly like a microscopic milling cutter. Each has fantastically complicated surface detail in the form of ridges, spines, holes, dimples. Some years ago when our laboratory obtained an electron microscope, our first pictures were taken of diatoms. Much to our surprise, each diatom was found to have additional detail far below the limit of resolution of the optical microscope.

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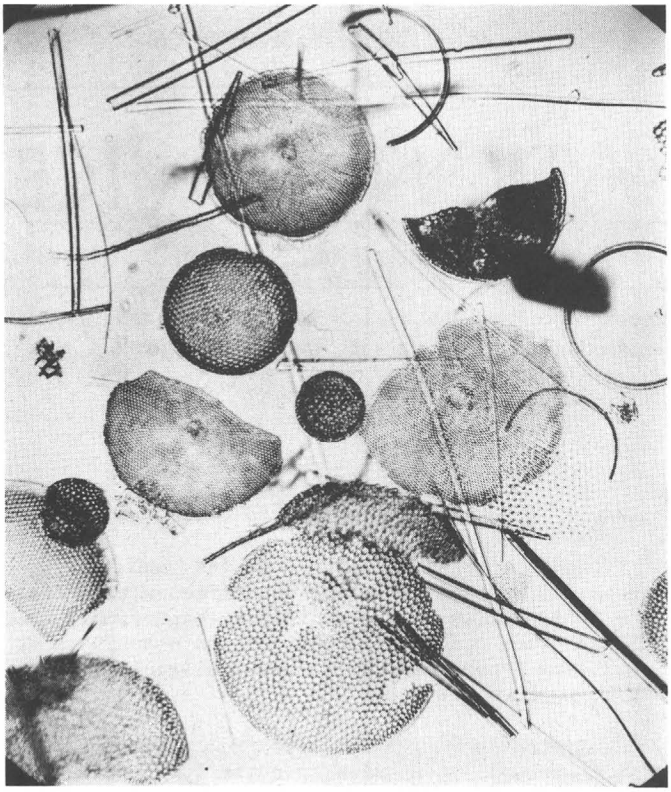
*Technical director, Dicalite Division, Great Lakes Carbon Corporation. Paper presented at meeting of American Institute of Mining and Metallurgical Engineers held Oct. 2, 1953 at Los Angeles. Published by permission of the Institute.

Diatoms grow in fresh, brackish, and salt water. Different species are identified with different degrees of salinity so that an experienced technician often can determine whether a deposit is of marine or fresh water origin by a single look through the microscope.

Diatomite ranges in color from white through tan to brown. It is usually quite soft and can be disintegrated between the fingers. The bed density on a dry basis ranges from 20 to 35 pounds per cubic foot.

The marine deposits have a characteristic lam-

Photomicrograph of species of diatoms common in freshwater deposits. Average diameter of the fossils is about .05 mm.



Photomicrograph of species of diatoms common in marine deposits. Average diameter of the fossils is about .15 mm.

inated structure with darker streaks 1/16 to 1/4 inch apart and parallel to the bedding plane. The fresh water deposits are massive in nature and almost invariably are free of such lamination. The better fresh water deposits are lighter in color than the marine deposits. Usually marine deposits are softer in texture and less firmly indurated.

Diatomite is commonly deposited in beds ranging from a few inches to a hundred feet in thickness. Most of the diatomite strata are separated by clay or clay-diatomite layers. In certain deposits portions of the deposit have been altered to chert or opal.

Carryall and bulldozer at work on diatomite beds. The thin overburden is pushed over the ridge. Carryalls transport diatomite to stock pile from which it is trucked to the processing plant.

Properties

Diatomaceous earth is amorphous, hydrous silica containing about 6% water of hydration. The most important single property and the one responsible for most of its commercial significance is the low bulk density of the material and its products. The densities of 20 to 30 pounds per cubic foot, with a real density of 2.05, correspond to a void volume of 75 to 85%. The voids in the bed are partially or completely filled with water. Crude diatomite ranges in moisture content from 15% in arid regions to 65% in localities of high rainfall.

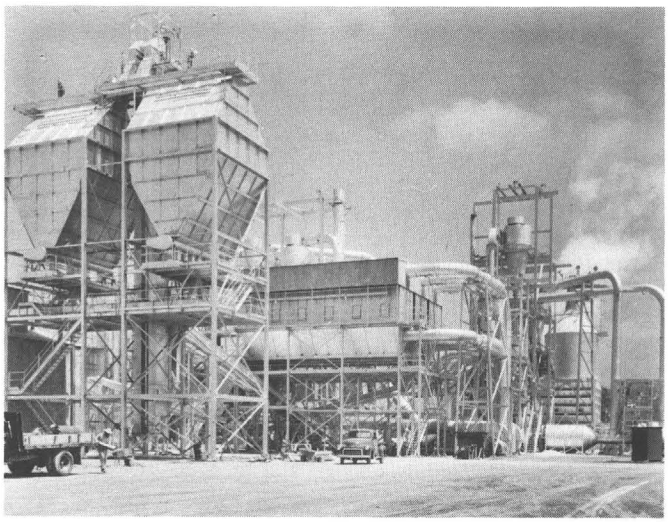
Chemical analyses of commercial grades of diatomite are as follows:

SiO_2	85 - 92%
Al_2O_3	4 - 10%
Fe_2O_3	0.8 - 2.0%
CaO	0.1 - 2.0%
MgO	0.1 - 2.0%
Alkalis	0.2 - 1.5%
Loss on ignition	5 - 8%
Organic	0 - 3%

The value of a diatomite deposit depends in large measure upon shape factors, density, and the physical state of aggregation, with chemical purity less important. The particle size range and the species of diatoms present are most important. A typical deposit will comprise several species in high percentages with many others present in lesser proportions. A few deposits of fresh water type are almost exclusively Melosira.

Occurrence and Quarrying

Diatomite occurrences are scattered over most of the earth. Deposits have been worked in Europe for many years and in this country for about thirty-



New diatomite processing plant of Dicalite Division at Lompoc. This very modern plant featuring push-button control center was built in 1952 to process diatomite from the company's Lompoc quarry.

five years. In the United States, deposits of minor commercial significance are known in New England, Maryland and Florida. The major deposits occur in the western states, specifically in California, Nevada, Oregon, Washington, Idaho, and Utah. Marine deposits are worked in California in the vicinity of Lompoc and Los Angeles. Fresh water deposits are being quarried in Nevada, Oregon, and Washington. Most of the California deposits occur in upper Miocene sediments. The fresh water crude diatomite of the western states are generally of more recent geologic age.

Quarrying, originally an underground operation, is now exclusively by surface workings. Depending upon the regularity and thickness of the strata, various types of equipment are used. Euclid loaders, scrapers, and shovels are employed as required. Quarrying is a highly specialized art. The individual strata are classified as to their suitability by actual product testing. Each stratum is quarried separately and rigorously segregated according to its intended use. In a complex quarry, over a hundred different strata may be recognized and handled separately. Off-grade material, and the intervening layers of clay or other extraneous material are quarried separately and transported to a dump. Overburden ratios are the most significant factor influencing mining costs, and strata having superior quality have been exploited when the total excavation exceeded 30 yards per ton of product.

Products and Processing

Processing is quite specialized, involving equipment designed and constructed by the processor. Design and operating "know-how" are rather closely held, although the industry is much less committed to a policy of secrecy than it was a few years ago.

The industry offers a bewildering variety of products under trade names that often tend to confuse rather than to simplify the nomenclature system. The grades differ primarily in particle size and size distribution, although many other properties are important for special uses. The industry is almost unbelievably diversified as to end use -- over 300 different uses are recognized.

Three broad classes of products are produced. The so-called "natural" grades are crushed, dried, freed of oversize impurities, such as sand, by air separation, air classified, and bagged. This type of product is used primarily as a filler in the paper industry and as an anti-caking agent for ammonium nitrate fertilizers.

Calcined grades are produced by a similar process with an added calcination step in a rotary kiln at temperatures of 1200° to 2000° F. By this technique the water of hydration is eliminated, and the iron oxidized so that the product has a typical pink color. Calcined grades are used in high temperature insulation, as filteraids, and as mild cleaning agents in automobile polishes.

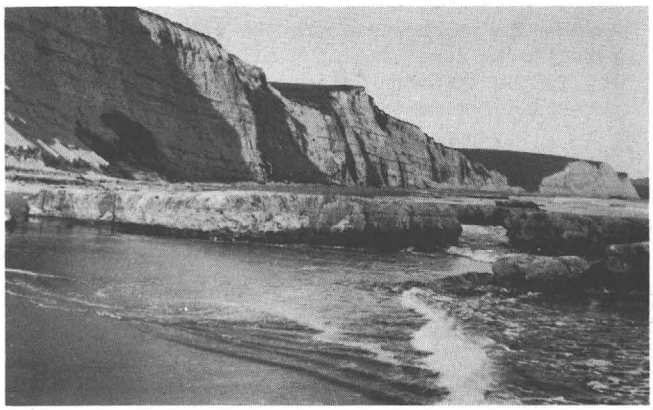
By far the largest and most important use of diatomaceous earth is as a filteraid after calcination in the presence of soda ash. This operation whitens the product and reduces the surface area with a corresponding increase in filtration flow rate.

The complexity of the filteraid manufacturing process can be best illustrated by citing the fact that the product passes through as many as twelve cyclone separators and collectors in its route through the plant.

In the field of filteraids, the industry has achieved its highest level of technology. Basically nine grades of filteraids are produced with 20 to 1 range of flow rate from the fastest to the slowest. The faster grades have a somewhat lower clarification efficiency, and the selection of the optimum grade for an industrial filtration operation involves actual laboratory-scale filtration tests. The industry has achieved a high level of product quality control, approached by only a few other non-metallic mineral processing industries.

Most of the United States productive capacity is divided between the Johns-Manville Corporation, which operates a multi-unit plant at Lompoc, California, and the Dicalite Division of Great Lakes Carbon Corporation, which operates plants at Lompoc and Walteria, California, Terrebonne, Oregon, and Basalt, Nevada. Several smaller producers account for less than 30% of the industry with operations in Nevada and Washington.

Filteraid technology is extremely interesting to the physical chemist. Basically, filteraids are employed to increase the specific permeability of slimy, difficultly filtered colloidal materials. This action is closely connected with the high void volume of the filteraid which "opens-up" the filter cake. Through the use of the proper grade of a high quality filteraid, the specific resistance of the cake can be reduced to 1/10,000 of its original value, with correspondingly higher filter throughputs. In many cases, filteraids permit clarification by filtration that could not be accomplished without their use. This performance and others related to its light weight and chemical inertness, together with the aforementioned diversification of its end use through literally dozens of industries, assures the diatomite industry of a continued demand for its products.



Diatomaceous shale and siltstone of the Miocene Monterey formation on the beach and sea cliffs at Sir Francis Drake State Park near Point Reyes. The lofty light-colored banks are believed to have reminded Drake of white cliffs of his native Albion, hence his name for California, "Nova Albion." These were the first rocks seen by white man in California.

DIATOMITE DEPOSITS IN CALIFORNIA

Upper Miocene Deposits

The foothills of the Santa Ynez Mountains south of Lompoc Valley and the Santa Rita Hills comprise an area in Santa Barbara County including the greatest deposits of commercial diatomite in the world. This diatomite reaches a maximum thickness of over 1000 feet and covers an area of about 17 square miles. Johns-Manville Products Corporation, which recently celebrated the 60th anniversary of the first shipment of commercial diatomite in California, operates a huge quarry 3 miles south of Lompoc. The other major diatomite operator in California, Dicalite Division of Great Lakes Carbon Corporation, works a similar deposit 7 miles southeast of Lompoc. Both these great deposits are of marine origin and belong to the Sisquoc formation of upper Miocene to lower Pliocene age (10 to 15 million years old). Their geologic occurrence has been described by Dibblee (50). Best grade of commercial diatomite is in the lower part ("Monterey formation") of the Sisquoc formation. A report of the U.S. Geological Survey by Woodring and Bramlette (50) describes and shows the location of diatomite beds in the Sisquoc formation in the Santa Maria district north of the area mapped by Dibblee. These two papers constitute the best guide to the location of the diatomite deposits of commercial grade in that part of California.

Dicalite operates the second largest commercial deposit of diatomite in California occurring in marine beds of the upper Miocene Valmonte formation on the north side of the Palos Verdes Hills in Los Angeles County. A paper by Woodring, Bramlette, and Kew (1946) includes a description and map of the Valmonte diatomite. Rapid home-building in this area makes it unlikely that it will be developed any further for diatomite production.

Elsewhere in the Transverse Ranges and southern and central Coast Ranges, diatomite occurs in the upper Miocene formations known by various names but essentially equivalent to the Monterey formation. Among such occurrences are the extensive diatomite deposits in Hames Valley 5 miles northwest of Bradley in the southern Salinas Valley and continuing northward for several miles from that locality.

Upper Eocene Deposits

The marine sedimentary Kreyenhagen formation of upper Eocene age (50,000,000 years old) extends as a narrow belt in the foothills along the west side of the San Joaquin Valley, northwest from the Coalinga district. This formation contains a great deal of diatomite of possible commercial importance. It has been worked, for example, at the mouth of Panoche Creek, and west of Crows Landing.

Cretaceous Deposits

In the Panoche Hills on the west side of the San Joaquin Valley the oldest known diatomite in California is found in the upper part of the marine Upper Cretaceous (roughly 75,000,000 years old) Moreno formation. About 200 feet of buff diatomaceous shale were sampled and the diatoms described by Hanna (27). The beds are non-commercial but demonstrate the existence of marine diatoms of far greater age than is ordinarily recognized.

Tertiary and Quaternary Lake Deposits

Freshwater diatomite, formed in late Tertiary and Quaternary lake beds and interbedded with lava flows and volcanic ash, is extensively distributed through parts of Inyo, Shasta, Siskiyou, and Modoc counties. Such deposits have been worked on a small scale at Zurich in Inyo County, Tionesta in Modoc County, and along the Pit River in Shasta County. Those near the junction of the Pit River and Hat Creek are several hundred feet thick and appear to deserve consideration for commercial use.

SELECTED REFERENCES

Dibblee, T.W., Jr., 1950, Geology of southwestern Santa Barbara County, California: California Div. Mines Bull. 150. (Includes geologic maps and maps showing all large diatomite deposits of the Lompoc district).

Franke, H.A., 1935, Mines and mineral resources of San Luis Obispo County: California Div. Mines Rept. 31, pp. 419-20.

Hanna, G.D., 1927, Cretaceous diatoms from California: California Academy of Sciences, Occasional Paper XIII, p. 5-48.

Jenkins, O.P., 1931, Stratigraphic significance of the Kreyenhagen shale of California: California Div. Mines Rept. 27, pp. 141-186. (Includes index map on p. 186 showing areas of Kreyenhagen shale in San Joaquin Valley.)

Laizure, C. McK, 1925, Monterey County: California Div. Mines Rept. 21, pp. 32-36. (Various diatomaceous earth deposits, especially those west of Bradley.)

Logan, C.A., 1926, Shasta County: California Div. Mines Rept. 22, pp. 163-166. (Diatomaceous earth of Hat Creek-Pit River area, including analyses.)

Oakeshott, G.B., 1950, Diatomite in Mineral commodities of California: California Div. Mines Bull. 156, pp. 150-155. (Short general summary of diatomite in California; statistics through 1946.)

Payne, M.B., 1951, Type Moreno formation and overlying Eocene strata on the west side of the San Joaquin Valley, Fresno and Merced Counties, California: California Div. Mines Special Rept. 9. (Includes maps, figs. 6,4,2, Kreyenhagen shale formation -- which contains diatomite -- northward from Panoche Creek in Fresno County to Ortigalita Creek in Merced County.)

Schoellhamer, J.E., and Kinney, D.M., 1953, Geology of a part of Tumey and Panoche Hills, Fresno County, California: U.S. Geol. Survey Oil and Gas investigations map OM 128. (Map shows Kreyenhagen shale including area of diatomite deposits recently worked near mouth of Panoche Creek.)

Stewart, Ralph, Popenoe, W.P., and Snavely, P.D., Jr., 1944, Tertiary and late Upper Cretaceous stratigraphy of west border of San Joaquin Valley, north of Panoche Creek, Fresno, Merced, and Stanislaus counties, California: U.S. Geol. Survey Prelim. Chart 6, Oil and Gas investigations Ser. (No

map, but shows Kreyenhagen formation in a series of cross-sections from Panoche Creek in Fresno County across Merced County to Puerto Creek in Stanislaus County).

Woodring, W.P., and Bramlette, M.N., 1950, Geology and paleontology of the Santa Maria district, California: U.S. Geol. Survey Prof. Paper 222. (Includes geologic maps showing deposits of diatomite in the Sisquoc formation in the area.)

Woodring, W.P., Bramlette, M.N., and Kew, W.S. W., 1946, Geology and paleontology of Palos Verdes Hills, California: U.S. Geol. Survey Prof. Paper 207. (Includes geologic map showing distribution of Valmonte diatomite).

CALIFORNIA DIATOMITE OPERATIONS IN 1952

Operator and address		
Inyo County		
Hazen Mining Co. Norval F. Hazen Independence, Calif.	Produced in 1952	"Grinding done by Blue Star Mines, Ltd." Home address: 508 Fonda St., La Habra, Calif.
Los Angeles County		
Great Lakes Carbon Corp. Dicalite Division 612 So. Flower St. Los Angeles 17, Calif. N.Y.C. address, 18 E. 48th St.	Large production in 1952	Walteria in Palos Verdes Hills, L.A. Co.; also in Monterey, San Luis Obispo (?) and Santa Barbara Co's.
Orange County		
Harlow M. Simpson 212 W. 5th St. Santa Ana, Calif.	No known production in 1952	
Monterey-San Luis Obispo (?) County		
Great Lakes Carbon Corp. Dicalite Division 612 So. Flower St. Los Angeles 17, Calif.	No production in 1952 at this deposit.	Los Angeles and Santa Barbara Counties also.
Santa Barbara County		
California Diatomite & Asphalt Corp. c/o F.M. O'Brien 351 California St. San Francisco 4, Calif.		
Great Lakes Carbon Corp. Dicalite Division 612 So. Flower St. Los Angeles 17, Calif.	Large production in 1952	7 miles SE of Lompoc. Lompoc Branch, Walter Gramm Senior Vice-Pres.
Johns-Manville Products Corp. 22 E. 40th St. New York 16, N.Y.	Large production in 1952	3 miles S. of Lompoc.
Grant & Grant Eng. Co. P.O. Box 1206 Lompoc, Calif. (Natl. Silica Products Co. owner; A. Terkel, Sec., Lompoc)	Produced 1946-50, 1951 reported experimental basis; produced in 1952	"La Salle Canyon mine," W. of Lompoc, S. of highway 150.
Siskiyou County		
Glass Mt. Volcalite Co., H.W. Free Tionesta, Calif.	1949: Samples only, 1950-52: Idle	
Stanislaus County		
Simon Newman Co., Newman, Calif. (Operator Base Materials, Newman)	Produced in 1952. Idle June 1953	"Crow Mine" 6 miles S.W. of Crows Landing

MINERAL MARKETING INFORMATION

Nationwide Market Quotations

The following quotations are taken from E&MJ Metal and Mineral Markets, published weekly by McGraw-Hill Publishing Company.

Metals (Oct. 8, 1953)

COPPER, electrolytic, 29.650¢ per pound, domestic refinery.

LEAD, refined 13.300¢ per pound, St. Louis; 13.500¢ per pound, (New York)

ZINC, prime western, 10.000¢ per pound, East St. Louis.

Metallic ores (Oct. 8, 1953)

CHROME ore, per long ton, dry basis, subject to penalties if guarantees are not met, f.o.b. cars New York: Indian ore, 48% Cr_2O_3, 3 to 1 chromium to iron ratio, lump $52 to $53.

MANGANESE ore, on current business, nearby arrivals, quotations on Indian ore, basis 46% to 48% Mn, nominal at $1.14 to $1.16 per long ton unit, c.i.f.

California Market Quotations

The following quotations are from San Francisco area processors and dealers, and were those in effect on Oct. 14, 1953.

Metals

QUICKSILVER, per flask of 76 pounds prime virgin, price paid to miner about $175 to $179, San Francisco; limited market.

CHROME ore, G.S.A. stockpile, Grants Pass, Oregon, 48% Cr_2O_3, 3 to 1 chromium to iron ratio, basis lump ore $115 per long ton; concentrates $110; premiums for better grade; penalties for less grades.

MANGANIFEROUS ore for delivery to Geneva, Utah, in car lots 20% Mn or better per long ton unit, 80¢ f.o.b. railroad car. Premium for iron in excess of 10% Fe of 3¢ a unit. Penalties for zinc, sulphur, and other impurities.

TUNGSTEN concentrates and ore, per short ton unit. Concentrates 60% WO_3 $63 in ton lots f.o.b. rail shipping point; penalties for molybdenum, copper, and other objectional impurities. Low grade tungsten ore delivered Pine Creek mill in 100-ton lots, per short ton unit WO_3 contained 0.300% to 0.349%, $20; 0.350% to 0.399%, $28; 0.4000% to 0.599%, $36; 0.6000% and higher, $37.

Nonmetallic Minerals (Crude unless otherwise stated) (Prices depend upon chemical analysis, color, impurities, and physical properties. Market generally limited).

BARITE, per short ton, San Francisco and Los Angeles areas, 90% to 98% $BaSO_4$, $14 to $16.

BENTONITE (Wyoming type), per ton, carload lots, pulberized 200 mesh, $32.50 San Francisco and Los Angeles area.

FLUORSPAR, per short ton, San Francisco area, metallurgical grade (85% CaF_2, maximum of 5% SiO_2, 0.3% S), $35 to $50; ceramic grade (98% CaF_2, maximum of 1% SiO_2, 1% $CaCO_3$ ground, bagged, $68 to $80.

PERLITE crude per ton, delivered at plant in Los Angeles area, concrete crude, $12.80 to $14.75; plaster crude, $11.80 to $13.75. Napa crude delivered in San Francisco-Oakland area, 10 to 14 mesh, $11.00; 14 to 40 mesh, $14.00; 14 to 60 mesh, $10.50.

NEW LIBRARY GIFT

The Division of Mines has received an important gift of books from the mining library of George J. Young of Oakland, mining engineer, consulting editor of Engineering and Mining Journal, and author of the widely used text Elements of Mining.

Mr. Young, a native San Franciscan and a graduate of the University of California, has been accumulating his valuable library since the turn of the century. In addition to publications of the American Institute of Mining Engineers, the U.S. Geological Survey, the U.S. Bureau of Mines, and many volumes of mining subjects, Mr. Young's gift includes a useful file of mining equipment catalogs. The entire collection is being catalogued by the Division of Mines Library staff, and will be placed on the library shelves where it will be available to the public for study.

A photographer and etcher by avocation, Mr. Young has previously presented the Division with some of his photographs taken in the high Sierras, several of which were published in the Division's recently issued Bulletin 158, EVOLUTION OF THE CALIFORNIA LANDSCAPE.

SYNTHETIC MICA

The Electrotechnical Laboratory of the Bureau of Mines at Norris, Tennessee in cooperation with the Army Signal Corps has made definite progress in the development and evaluation of synthetic mica. Pilot plant operations have been arranged by means of an agreement between the Bureau of Mines and the Micalex Corporation of America.

Industrial interest has been shown in the use of hot-pressed synthetic mica as a matrix material for silicon carbide and in the application of mica ceramics for jet engines.

BORAX

Borax is an essential ingredient in the manufacture of such special glasses as laboratory glass, thermometer glass, Pyrex, and optical glass. The amount of contained boric oxide in these glasses ranges from 2 to 20 percent.

Large quantities of borax are also used in glazes because of its strong solvent action on color oxides and to form easily fusible compounds, increase the gloss and to lower the coefficient of expansion of the finished product.

MOTHER LODE GUIDEBOOK REPRINTED

The third edition of the Division of Mines' best known book, GEOLOGIC GUIDEBOOK ALONG HIGHWAY 49, is now ready for distribution.

First published in 1948 as the Division's contribution to California's centennial celebration, the initial issue of 7500 copies was exhausted in less than three months. The second edition, which has now been out-of-print for some time, consisted of some 10,000 copies. Although the book is designed primarily for California readers, the list of purchasers awaiting the new printing includes many whose addresses are in other states and countries.

This book, issued as Bulletin 141, is a semi-technical treatise prepared to serve as a guide to the traveler who is desirous of information concerning the mines, minerals, and rocks of the region, as well as the old structures erected during the gold rush days.

Ten different authors contributed to the text and valuable information was obtained from a score of mining men and geologists. The volume includes "Sierran Roads of Today and Yesterday," by Dorothy G. Jenkins, an article well worth reading as it gives the traveler a survey of the roads traversing the area and illustrates their history. "The Discovery of Gold in California," by Donald C. Cutter, has to do with the history, life and romance of the Gold Rush period. The place of gold placer mining is well presented in Charles V. Averill's paper on the "History of Placer Mining for Gold in California". The reader is oriented as to the nature of the Sierra Nevada and the place it occupies in relation to history, geology, civilization and economics by Olaf P. Jenkins' paper on the "Sierra Nevada Province" and the "Geologic History of the Sierran Gold Belt". C.A. Logan presents an educational as well as entertaining treatise on the "History of Mining and Milling Methods in California", and "Geologic Maps and Notes Along Highway 49", by Oliver E. Bowen, Jr., and Richard A. Crippen, Jr., containing 12 strip maps on route geology, is a well illustrated work on the position of the mines and quarries, the importance of their mineral deposits, and the geologic reasons for their being. "The Formation of Quartz Veins", by John A. Burgess will be of interest to all amateur mineralogists as well as those more technically trained, and his "Mining on Carson Hill", tells of Jim Carson's activities in that region and gives the history of the Carson Hill Gold Mining Company. The charm of the old mining towns that harmonize so perfectly with the natural loveliness of the Sierran foothills and stand as mute evidence of the early development of what is now called industrial minerals, is well shown by picture and s story in Robert F. Heizer's and Franklin Fenenga's "Survey of Building Structures of the Sierran Gold Belt, 1848-70". This article contains 168 illustrations taken at various localities in the Gold Belt.

The volume contains a series of geologic maps covering the entire highway, a strip 277 miles in length, from Mariposa in the south to Sattley in the north, and features 8 colored and 231 black and white photographs. As an effort was made to include the names and locations of the older abandoned settlements as well as existing towns, the principal mines and mineral deposits, the locations of the historic monuments, and mileage for use in location while traveling, this volume is one of the most educational and interesting books published on the Mother Lode Country.

BULLETIN 141 is priced at $1.00 plus 3% tax for California residents. Copies may be ordered from the Division of Mines, Ferry Building, San Francisco 11, California.

URANIUM PROSPECT DESCRIBED

A new report on a uranium prospect in the Mojave Desert has just been released by the Division of Mines.

The report, prepared by George W. Walker of the staff of the U.S. Geological Survey, incorporates the results of work done in 1952 for the U.S. Atomic Energy Commission. Entitled, ROSAMOND URANIUM PROSPECT, KERN COUNTY, CALIFORNIA, the report is issued as SPECIAL REPORT 37 by the Division of Mines.

The author found small quantities of autunite, hydrous uranium and calcium phosphate, and another unidentified radioactive mineral which occur in tuffaceous sedimentary rocks of the Rosamond formation of Miocene age at the Rosamond prospect, which is about 10 miles south of Mojave, Kern County, California, in the western Mojave Desert.

The autunite occurs principally as coatings on fracture and joint surfaces and, to a lesser extent, as disseminations in the tuffaceous rocks adjacent to faults. A waxy, reddish-brown to black radioactive mineral is found in small quantities on slickensided fault surfaces associated with iron oxides and chlorite (?). The uranium minerals are erratically distributed over an area of about 15 acres. Assays of 12 samples indicate a uranium content ranging from 0.002 to 0.59 percent and an average content of slightly less than 0.08 percent uranium.

SPECIAL REPORT 37, which consists of 8 pages including photographs, maps, and sections, is priced at 25¢. Copies may be purchased from the Division of Mines, Ferry Building, San Francisco 11.

SELENIUM AND TELLURIUM

Selenium and tellurium are relatively uncommon nonferrous metals with similar properties and uses. Tellurium is known in the native form, as oxide, and combined with selenium in volcanic sulfur. Selenium occurs in small amounts in volcanic sulfur, iron pyrites, in sulfide ores of large copper and copper-nickel deposits, and in some lead sulfide deposits. Both metals also occur in relatively rare minerals with gold and silver. All selenium and tellurium of commerce is produced as a by-product from the treatment of ores mined primarily for other metals. The major sources of the two elements are the copper, nickel-copper, and lead industries, in which slimes from the electrolytic refining process carry appreciable amounts of both metals. Selenium is also recovered as a by-product in the manufacture of sulfuric acid from pyrite or sulfur.

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NEW PUBLICATIONS

_____ copies, BULLETIN 141 (Mother Lode guidebook reprint) @ $1.00 each.

_____ copies, SPECIAL REPORT 37 (Rosamond uranium prospect) @ 25¢ each.

DIATOMITE

_____ copies, BULLETIN 154 (San Francisco guidebook, contains "Diatom deposits") @ $2.50 each.

_____ copies, REPORT 32b (contains paper on diatomite at Lompoc) @ 60¢ each.

_____ copies, BULLETIN 150 (Southwestern Santa Barbara County, contains description of diatomite deposits) @ $5.00 each.

_____ copies, REPORT 31d (San Luis Obispo County) @ 60¢ each.

_____ copies, SPECIAL REPORT 9 (Type Moreno formation) @ 60¢ each.

QUARTERLY JOURNAL

_____ subscription to the California Journal of Mines and Geology @ $3.00 per year (4 issues) beginning with current issue.

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KNOW YOUR MINERALS ... By John Morrow

Arizona Diatomes Inc. of Phoenix in recent years.

Diatomaceous Earth

STATE OF ARIZONA
DEPARTMENT OF MINERAL RESOURCES
MINERAL BUILDING, FAIRGROUNDS
PHOENIX 7, ARIZONA

August 23, 1961

Mr. Kenneth Porter
Farm Builders, Inc.
2505 Thomas Road, Suite 21
Phoenix 16, Arizona

COPY

Dear Mr. Porter:

In answer to your inquiry about sources of diatomite in Arizona, the following list may be useful:

- Aguila Deposit, Harquahala District, Yuma Co. (Location not closely known.)
- Camp Verde Deposit, Camp Verde, Arizona - E.L. Sturges, Box 188 Camp Verde, or George Wingfield, Camp Verde.
- Cleator Deposit, S. 1-4, T. 10 N., R. 1 E., Big Bug District. (Location approximate.)
- Curtis Deposit, near Curtis, Benson District, Arizona. (Robert Gray visit the 1965?) San Pedro Valley SW of St David - new Hwy to Ft Huachuca - down the Grade
- Duncan area deposits - 3-3½ miles north of Duncan, approximately Secs. 2, 11, T. 8 S., R. 31 E. Elmer Stephens and Ben S. Billingsley, Duncan. X
- Whitlock - Flat Tire Mine, about Secs. 22 & 27, T. 8 S., R. 28 E., A. H. Haralson & Sons, 702 Main Street, Safford, Arizona. 111 Ranch beds - dig pit 1½ Quad X
- San Carlos Indian Reservation, Sec. 28, T. 1 N., R. 18 E. - San Carlos Indian Reservation Headquarters, San Carlos, Arizona. X - N
- Stephens Diatomite, 3 miles north of Duncan, Arizona, Secs. 2 - 11, T. 8 S., R. 22 E., Elmer Stephens, Duncan, or American Diatom, Inc., 2345½ W. McDowell Rd., Phoenix. 3½-4 miles No of Duncan E Side of Hwy 75 (Duncan Clifton Hwy) 1/4 to 1/2 mile E of Hwy X
- Triplets Peaks area, San Carlos Indian Reservation, 8 miles east of San Carlos, San Carlos Indian Reservation Headquarters, San Carlos, Arizona. N
- White Cliffs Deposit, south of Mammoth, Arizona - American Diatom, Inc. 2345½ West McDowell, Phoenix. SEC 17 thru 20, 29 & 30 T9S, R18E (BLR 2nd PAGE) 13 - 24 T 9S, R 17E N
- Whitlock Deposits, Twin Peaks District, near Duncan, Arizona. X
  ~~111 Ranch Beds~~
  SULPHUR SPRINGS MINE E½ 33 T16S, R25E - 7 miles N of Pearce N
  300 Ac Homestead PATENT

Mr. Kenneth Porter 8-23-61

These deposits in some cases are only approximately located. The deposits near San Carlos have not, to my knowledge, been tested, but are fairly extensive. The deposits in most cases would doubtless need some beneficiation for all purposes except for soil conditioning. The Verde deposit is scattered through several mesa promentories and would in some places have some clay stripping to contend with.

Hoping that this list, while imperfect, will help, I remain

Sincerely,

LEWIS A. SMITH
Field Engineer

LAS/H

WHITECHIEFS - 11 miles SE of MAMMOTH. 2 miles N from MAMMOTH on Mammoth - Winkelman Hwy, TURN RIGHT (SE) about 1/2 mile after Xing San Pedro River Bridge & then drive 9 miles SE on gravel ROAD To The PROPERTY

4-21-82
SCM

Diatomite – Diatoms are plants – water plants ±15,000 varieties

50 million individual skeletons per cu. inch

Need light to live

Make skeletons of Silica out of mineral matter

Multiply rapidly & short life span – after they die, the organic matter decomposes & the skeletons sink to the bottom

Coscinodiscus (Golf Ball) diatom most common
Synedra – long & needle shaped (Fresh water at Mammoth)

Found in all kinds of water – quiet or running, hot or cold, saline or fresh.

Calcined – To expose to heat – roast, etc to remove water, sulphur, etc

References: Diatomaceous Earth

1. Wm. P. Blake, Diatom earth in Ariz AIME Trans Vol 33 pp 38-45 (1903)

2. Carl Thrishka, Diatomite in Arizona, Eng. Min Journal Vol 127 pp 13-14, 1929

3. Eldred D. Wilson, Diatomaceous earth, Univ. of Ariz, Ariz Bur of Mines Circular No 1., 1940 mimeograph

X 4. Long, John T. Jr & George G. Olson - Diatomaceous Earth in Arizona Field & Laboratory Report prepared for the Arizona Development Board 1960 22pp.

X 5. Mineral Facts & problems, U.S. Bureau of Mines Bull. 630, 1965 w/Chapter on Diatomite, perlite & Pumice

Clifford Hicks Pz
Wes Pearce } - Address Bur of Mine
Dick Moore

54586 W.W. 1/92

County Maps phx Map 1320 no 1st St
Graham Ariz 2626 w Indsch
Greenlee
Pinal

Diatomaceous Earth Prospects

Best up to 100' thick in pleistocene of Pliocene

1. White Cliffs deposit 8 miles S. of Mammoth on East side of the San Pedro River, PINAL Co. Clark Ranch or Peppersauce Wash Quads

2. San Carlos deposit E. of Peridot on the N. bank of the Gila River, Graham Co. San Carlos 2½ m & Mt. Triplet Quads Bylas

3. Solomon deposit. 10 mi N. of Solomon, Graham Co. Safford Quad

4. Whitlock deposit, along the E. side of San Simon Creek, 5 mi South of U.S. Highway 70, Graham Co. Artesia NE Quad

5. Duncan Deposit Just N. of Duncan in Greenlee Co. Duncan & York Valley Quads

6. Verde Valley deposit S. of Camp Verde in Yavapai Co.

7. Concho deposit S. of Concho in Apache Co.

Get County Road map
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RAPID METHOD OF SAMPLING DIATOMACEOUS EARTH *

By GEORGE B. CLEVELAND
Geologist, California Division of Mines and Geology, Los Angeles, Calif.

ABSTRACT

A relatively rapid and simple method of sampling diatomaceous earth consists of impressing a strip of common plastic gummed tape against the surface of the diatomite and removing a thin layer of particles for microscopic examination.

INTRODUCTION

The examination of diatomaceous earth under the microscope yields certain data that cannot be gained by other means. Knowing the shapes and sizes of diatoms, the relative abundance of each type and the identities of admixed rock and mineral fragments helps in appraising the economic value of diatomaceous earth. The recognition of diatom species and diatom assemblages also may supply data on paleoecology and geologic age. However, the properties of diatomaceous earth can be strikingly different from place to place within the same bed and from one bed to another. Consequently, the comparison between the relatively small amount of diatomaceous earth that can be observed through the microscope and the much greater volume of material actually being studied is commonly so disproportionate that it is difficult and time consuming to collect and examine representative material. Moreover, the standard collecting and preparation techniques disturb the spatial and abundance relationships between diatoms of different species and diatoms and any other materials in the sample.

MATERIALS NEEDED

Field

1. Roll of single gummed, translucent plastic tape, one-half inch wide (for sampling).
2. Strips of relatively stiff, clear cellulose acetate, three-quarter inch by 12 inches (for mounting the sample tape).
3. Masons hammer (chisel head).
4. Stiff brush.
5. Tape measure.
6. Small nails.
7. Labels.

Laboratory

8. Glass atomizer.
9. Hyrax (commercial high index (RI 1.65) mounting compound).
10. Xylene.

FIELD PROCEDURE

A relatively flat, shallow channel is cut in the outcrop with a masons hammer. The channel is cut normal to, or parallel with, the bedding, depending upon the desired objective of the sample. One-foot increments are laid off along the side of the channel and marked by nails (fig. 1). With a stiff brush the channel is swept clean of loose material. The sweeping should begin at the upper part of the channel and proceed downward using only down strokes. About one foot of gummed tape is pressed evenly against the outcrop at the top of the channel. The top end of the tape is held by one hand while the thumb of the other hand gently smooths it down along the channel. The tape is lifted off the outcrop and pressed onto a stiff clear plastic strip. The plastic strip is labeled in proper stratigraphic order or other sequence and protected for transportation to the laboratory.

LABORATORY PROCEDURE

The gummed tape is stripped off the stiff plastic strip leaving a thin layer of diatomaceous earth adhering to the strip. The thin layer of particles is apparently held electrostatically to the plastic strip. Using a solution of Hyrax diluted with xylene in a glass atomizer, a thin coating is sprayed onto the plastic strip, anchoring the particles. After allowing the coating to dry for an hour or more, depending upon atmospheric conditions, the strip then constitutes a slide that may be examined directly under the microscope. The coating is resistant to corrosion from the common immersion liquids used with high power objectives (castor oil, glycerine, etc.). The slides appear to be relatively permanent, but after continual flexing the coating may become checked.

* Manuscript submitted for publication January 1969.

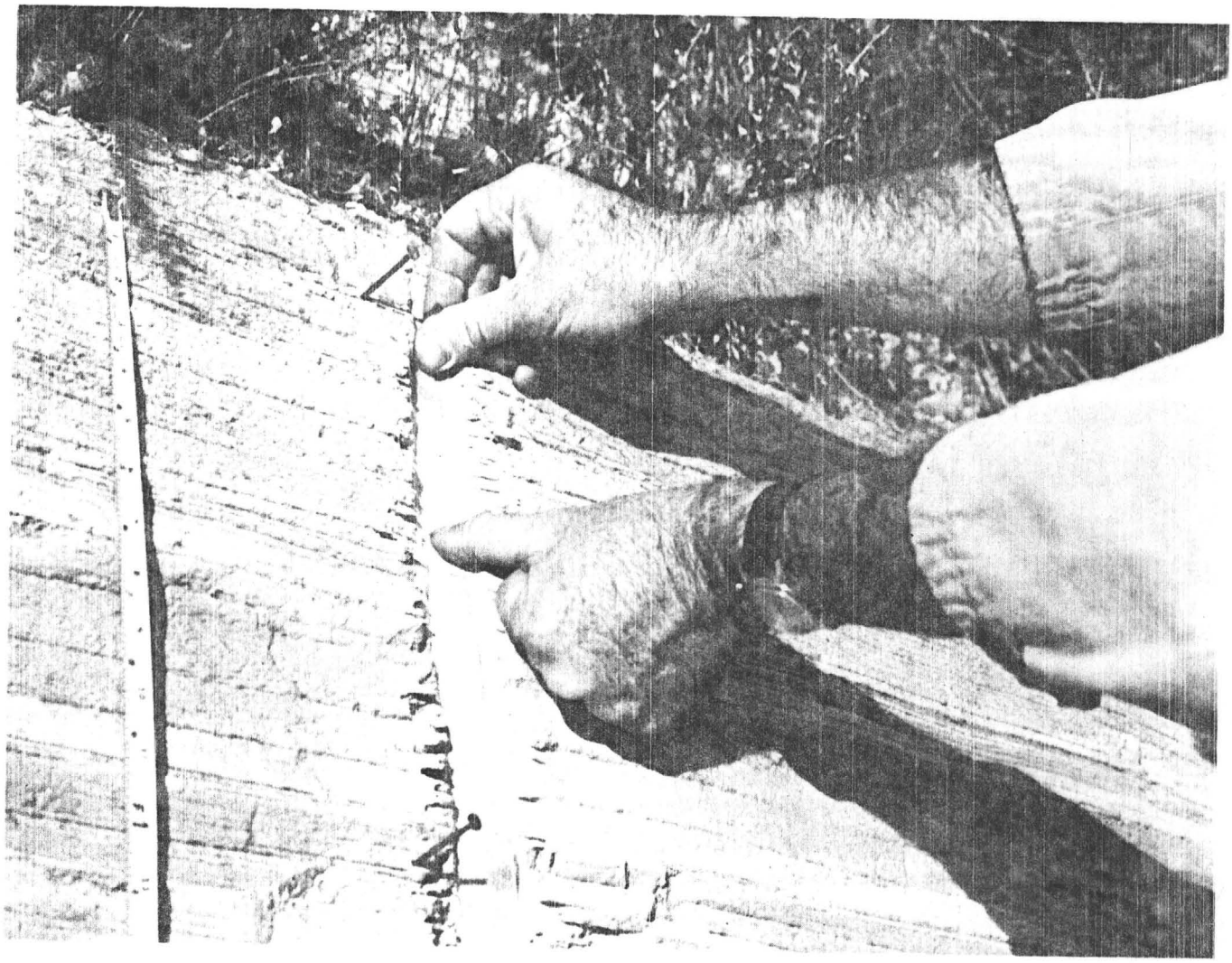

Figure 1. Field Procedure.

DISCUSSION

The physical properties of diatomaceous rocks range so widely that it is seldom possible to take a continuous sample using this method. The tape may pluck relatively large fragments from the outcrop that will not adhere to the clear plastic strip, and that section of the record will be incomplete. Also, the fragments that do adhere will represent a wide size distribution, ranging from individual diatoms, or broken segments, to opaque aggregates of diatoms and other impurities, leading to further imperfection in the record. However, any of the sampled fragments that do not adhere to the clear plastic strip will still be preserved in proper relative position on the gummed tape. Thus, the missing parts of the record can be restored, if necessary, by making separate slides of these fragments.

Normally, taxonomic determinations can be made from the slides produced by this method. However, where only a few individuals of the same species are represented, their orientation may not reveal a sufficient number of diagnostic features to allow identification.

This technique is most useful for the sampling of diatomaceous earth where the general nature or possible economic value is to be determined. The rapidity with which a representative sample can be obtained and the preservation of both the spatial relationships and compositional ratios are the most valuable features of the method. Moreover, a nearly complete sample of an outcrop can be transported to the laboratory and stored in only a fraction of the space that is normally required for hand specimen or channel samples.

The method could be used solely in the laboratory to make any desired length of microscopic slide from a bulk sample of diatomaceous earth. It also might be used to sample fine grained rocks other than diatomaceous earth, such as claystones.

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				1	2
		Expenses			
		Lodging			
2-25 to 2-27		Safford - Sudie Motel - Best Western	(3)	107 12	107 12
3/5-6		Tucson - Executive Inn - "	(2)	55 97	163 09
3/9-10		Kearney - Kearney Inn	(2)	46 96	210 05
		Meals			
2/25-27				98 17	98 17
3/5-6		"	210.05	55 97	154 14
3/9-10		"	3-13 224 / 434	70 48	224 62
		Mileage			
2/25-27		651 x 40 = 260 40	549.05 3-12-82	260 40	260 40
3/5-6		341 x 40 = 136 40	1370 x .40 =	136 40	396 80
3/9-10		378 x 40 = 151 20		151 20	548 00
		Misc			
2-22		Topo Sheets, Xerox 9	3-12-82 70.00	25 00	25 -
3/5-6		Topo Sheets (93)		25 20	50 20
3/9-10		Film		12 67	62 87
3-11		Phone calls - U.A.A. & San Carlos Tribe & BIA	(3)	7 13	3-12-82 70 00
3-12		Topo Sheets (6)		12 60	82 60
3-9		Phone calls from Kearney & white cliffs field	(2)	5 62	88 22
3-14		Photo Reprints - White Cliffs area		6 07	94 29
3-15		3 Topo Sheets		6 30	100 59

(over)

Diamond Shamrock Corp
Diatomaceous Earth Project

			1	2
	Professional Services			
2/23	Research & check records	(2)	500 -	
2/25	Field - Tucson, Benson, Duncan, Safford, San Carlos	(2)	500 -	
26	" "	(2)	500 -	
27	" "	(2)	500 -	2000 -
3-1	Office - assemble data	(1)	350 -	2350 -
3-2	" " " Weekly Report 1/2 day @ 350/day	(1)	175 -	2525 -
3-3	" " " " " "	(1)	175 -	2700 -
3-5	Field - Mammoth Area (W. Tortolita Mine & Sd. Area	(2)	500 -	3200 -
3-6	"	(2)	500 -	3700 -
3-9	" " " " "	(2)	500 -	4200 -
3-10	" " " " "	(2)	500 -	4700 -
3-11	Office: Contact K.A.A., San Carlos Tribe re: status & assemble data 1/2 day	(1)	175 -	4875 -
3-12	" : Assemble data, research & Weekly Report 1/2 day	(1)	175 -	5050 -
3-15	" " " " Check ownership in BLM Rec. 1 day	(1)	350 -	
				Total Fees Paid 4463.83
				3-10-82 5745.14

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Safford
2-25-82

1. Conf w/ Bob & Larry Fellows - State Geol. Tucson

2. all Deposits are small, on the east side of the River, small in areal extent. Thin beds with marl & other interbedded contaminants.
Believes deposits have been eroded away & only remnants left. Limited extent

3.

Was Pecos - not SCR

Another word

DIATOMITE
AND ITS ASSOCIATION WITH ASBESTOS

By W. E. Sinclair, M.I.M.M.

The frequent reference to the mineral diatomite, in the asbestos industry, suggests some close relationship between the two minerals. Actually there is no relationship. Although the minerals associated with asbestos, in its native form, are legion, diatomite is not one of them. This fact will have been gathered from the recent article, "Asbestos and its Associated Minerals".*

The only association diatomite has with asbestos is in the manufacturing sphere because of certain inherent properties and characteristics which are common to both. This fact gives rise to some quite interesting points; the main one of which is that there is no semblance of similarity in their physical state, diatomite being an earthy and powdery substance while, of course, asbestos is a fibrous mineral. Indeed it is because of this material difference in the two and their chemical dissimilarity that, in the manufacture of certain products, they are complementary to one another.

It appears quite clearly that the dissimilitude in the physical state of the two minerals is definitely responsible for some of their different properties, but not sufficient in opposition to nullify the even value of many of their commercial qualities.

First, to consider some of these differences, the origin and composition of diatomite must be briefly noticed, especially in contrast to asbestos. The mineral was once better known by the names kieselguhr or tripolite. Diatomite, a common name today, however, is the more descriptive, since the origin of this earthy substance consists essentially of siliceous accumulations consisting of diatoms. These are minute organisms whose skeletal remains (of countless varieties) constitute the important property of the mineral and together have formed deposits in marine beds or lakes. These deposits occur as a chalk-like rock or as a friable earthy mass and sometimes as a mud-like occurrence in bogs or marshes. Never are they, geologically or lithologically, like asbestos deposits.

The distribution of diatomite deposits is widespread, various forms being found in most countries of the world, and, since it is one of the most widely used of the secondary industrial minerals, it is produced, to satisfy the demand wherever it is wanted and available.

As one of the major manufacturing countries the United States, is the largest producer, averaging well over 350,000 tons annually. Most of this output is recovered from extensive deposits in several Pacific Coast States.

An indication of the association of diatomite with asbestos might also be gathered from the fact that one of the largest producers of the mineral in the world is also one of the largest asbestos producers, namely, Johns-Manville Ltd. This company utilizes an average of over 150,000 tons of the processed ore annually. The source of this tonnage is located at Lompoc, California, where modern crushers and special processing equipment are installed for the production of improved filtration and filler products, many of which are used in the manufacture of diatomite-asbestos products. Some of the diatomite produced is sold under the trade name of Celite which is one of several trade names by which diatomite is known by, such as, Dicalite, Fosalsil, Celatom and others, all of which possess similar properties and all are used in extensive industrial applications as an absorbent, a mild abrasive and polishing powder, a light-weight filler and as an insulating and filtering medium.

The many and varied properties of diatomite are such that its application in industry as a general utility product is widespread, but it is only in the last three spheres of usefulness mentioned above, that the mineral is mostly associated with asbestos. As already suggested, it is only where the similarity of certain of the qualities of the two minerals is such, that their union is complementary, that the importance and the interest is manifest.

Since diatomite is fireproof and able to withstand high temperatures, it naturally coincides with one of the invaluable properties possessed by asbestos, and when used in conjunction with one another, in certain insulating products, the combination is perfect. Indeed, it is in this

sphere that diatomite is most often associated with asbestos, as for example, when used as a filler with asbestos fibres, to provide insulating mixtures for covering boilers and for insulating steam pipes and in other similar conditions.

Used in this manner, the earthy mineral resembles the functions of 85% magnesia, or calcium silicate as a filler in asbestos insulations, but the typical physical and thermal properties of diatomaceous silicas have been proved superior to both magnesia and calcium silicate. Similarly, its density range is higher and it possesses a greater compressive strength. An interesting point in the matter of the insulating qualities of diatomite is that an unseen air space is provided in the material by the innumerable minute diatoms extant. This is similar to the effect of bulk density and the tubular form of the fibres in asbestos insulating products.

For this same reason, the earthy mineral plays an important part in the filtration of such liquids as wine, vinegar, varnish, etc. It is the irregular but rigid shape of the diatoms that accounts for its valuable filtration properties, which again are also enjoyed by asbestos fibres.

The wide surface offered by the mineral and its extreme lightness and its absorbent and adsorbent qualities are factors of such importance that it finds many uses as a filler in numerous applications. Another common use is, when mixed as a plastic with asbestos products, they are manufactured and used as absorbents in liquified gas cylinders, and recently they have been used in radioactive emanations. In this connection it is interesting to recall that when nitro-glycerine was difficult and dangerous to handle, Nobel found that by mixing the diatomite with the dangerous "soup", it was possible to knead the mixture into the form of cartridges which were easier and safer to handle, as we know today.

This was, of course, before the days that diatomite was associated with asbestos, and it is only one of the examples of the unaided role played by this mineral in industry.

* "Asbestos and its Associated Minerals", by the author, "ASBESTOS", July 1958.

X

I. C. 6391 FEBRUARY, 1931

DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR

INFORMATION CIRCULAR

DIATOMITE

DEPARTMENT OF MINERAL RESOURCES
MINERAL BUILDING
FAIR GROUNDS
PHOENIX, ARIZONA

N. Mex
Espanola & Socorro
(Rio Grande ?)

BY

PAUL HATMAKER

I. C. 6391
February, 1931.

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

DIATOMITE[1]

By Paul Hatmaker[2]

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2 Building materials section, U. S. Bureau of Mines.

DEFINITION OF DIATOMITE

Diatomite is the name now generally given to a mineral substance composed of the tiny, skeletal remains of diatoms, which are microscopic, flowerless, water plants related to the algae. This residuum is essentially hydrous amorphous silica.

Common names for diatomite are: Diatomaceous earth, tripolite, kieselguhr, and infusorial earth. Strictly speaking, however, the latter material is not diatomite, as it is composed of the fossil remains of infusoria, which usually do not occur with the diatomaceae. Other synonyms for diatomite are: Diatomaceous silica, kieselmehl, bergmehl, diatomeenpeelite, polirschiefer, moler, molera, molererde, desmid earth, fossil flour, mountain flour, farine fossil, white peat, radiolarian earth, chalk rock, ceyssatite, randanite, and tellurine; also various diatomite products of individual companies are known by their own trade names.

Diatomite should not be confused with fuller's earth, for the two are separate and distinct substances. Bentonite, pumice, and tripoli, have also been used erroneously to designate diatomite. Tripolite, however, is a true diatomite formerly mined near Tripoli.

VARIETIES

More than ten thousand varieties of diatoms have been studied and classified. Among the more important are the Coscinodiscus which resembles a golf ball in appearance and the Synedra which is long and needle-shaped. Circular disk-like forms are common. Others are of every conceivable shape and size, but all are relatively tiny. Their geometrical designs are fanciful and intricate. They may be short or long, triangular, in the form of a half-moon, needle-like, disk-shaped, spherical or ladder-shaped; in fact the variations are almost infinite. Diatoms are unicellular, and are described as being like pill boxes, with two halves that fit upon each other snugly. They range in size from that of a pin's head to minute particles visible only with a microscope of high magnification.

MODE OF LIFE

These microscopic water plants, which have such interesting posthumous value, are found in all kinds of water, quiet or moving, hot or cold, and saline or fresh. Certain conditions, however, seem to be more favorable than others for their growth and development. Light is an important factor for their propagation, while too great a salinity of water is detrimental to their well-being. For millions of years succeeding generations of diatoms have left their fossil remains in many of the rocks throughout the earth's crust.

These small organisms, some of which move freely while others attach themselves to various objects, absorb mineral salts from the water in which they live. They make skeletons of silica out of this mineral matter in much the same fashion that oysters make shells out of lime taken from sea water. Diatoms multiply rapidly, but their life span is short. After they die the organic matter decomposes, and the skeletons sink to the bottom where they gradually build up deposits of diatomite. It is estimated that there may be as many as 50,000,000 individual skeletons in a cubic inch of diatomite.

At present diatoms are found in oceans, in swamps and lakes, and also in various hot springs. Diatoms thrive practically in every place where there is water and sufficient light.

OCCURRENCE OF DEPOSITS

In general the deposits of diatomite may be divided into three types: First, those occurring as ancient marine beds, compact and more or less massive, but sometimes with seams and partings of clay; second, deposits adjacent to rivers and lakes, probably for the most part made from fresh-water diatoms of more recent age than those in the marine beds; and third, deposits in lakes and swamps where the process of accumulation is even now going on. Deposits of the third type usually contain more or less organic matter which has not completely decomposed and which in some places is in the form of a mantle of peat-like material. Deposits as a whole vary in texture from soft mud-like or clayey masses to hard compact massive beds in the older and more consolidated formations.

The marine beds occur as sedimentary deposits, in many places conformable with the underlying strata. In some localities they are found at considerable depths, but most of the commercial deposits occur at or near the surface. Many of the deposits have a pronounced dip, which may be as much as 30° where there has been considerable subsequent tilting of the strata.

Calvert[3] states that, according to Dr. Mann, the diatoms composing the Lompoc deposits of California were of the plankton, or free moving, type, and that at some remote time the ocean was teeming with these small aquatic plants. In Miocene times they floated southward from the cold seas of the Arctic to what is now the Lompoc region. This area, according to Dr. Mann, was at that time a bottle-neck bay of the ocean. Here the minute plants died, their skeletons sank, and in the course of time built up the great beds of diatomite which are now being exploited.

These beds naturally were accumulated over long periods during which the diatoms like other transported materials were deposited according to their size and weight. In the course of their southward migration the heavy diatoms sank to the bottom while the lighter ones, which presented a maximum of surface contact and consequently a minimum tendency to settle, were carried along and finally reached a quiet, sheltered arm of the ocean. Here conditions favored mainly the deposition of fine-grained diatomite and, except for occasional streaks of clay, these beds are little contaminated by other material.

Some of the deposits in Washington and Oregon are a result of ancient volcanic dams which made lakes along the rivers. Here the accumulation of diatoms went on for a long time, occasionally interrupted by thin layers of volcanic ash from nearby active craters. Some of the deposits were covered by subsequent lava flows. Other lake beds were finally filled up either by glacial drift or water-borne material. Later when the rivers assumed their original channels, they cut down through the overlying beds and exposed the deposits of diatomite.

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3 Calvert, Robert, Diatomaceous Earth: New York, 1930, pp. 100-101.

Many deposits in the Eastern States also are of commercial importance. In Florida, diatomite occurs in the form of a light, muddy substance, either in the bottom of lakes or hidden under the accumulated vegetable matter of swamp bottoms. Deposition in the Northeastern States probably took place in lakes and swamps. Some of the deposits are quite pure in silica content but others are contaminated with mud, clay, and glacial debris.

Many Canadian deposits occur adjacent to rivers and lakes, some as ancient marine beds, and some in swamps where the material is soft and unconsolidated.

DISTRIBUTION

Diatomite is widely distributed over the world. At present the United States has the largest commercial beds and leads in world production, with Algeria second. In the United States the most important commercial deposits are in California, although diatomite is produced in Washington, Oregon, Nevada, and some of the Eastern States. The more important occurrences of diatomite in the United States are shown in Figure 1 and are as follows:

Western States

California. - Immense deposits of marine diatomite are found along the coast of California from the southern part to a point north of San Francisco. The most important commercial deposits are in this belt, and those in Santa Barbara County, which occur in the Monterey (middle Miocene) formation, are especially important. The character of these deposits varies extremely. Some beds are soft, unconsolidated material; others are more compact and may even be flint-like. In places the diatomite grades into a shale. The color may be white, gray, yellow or black. The thickness varies from a few inches to nearly a thousand feet.

Los Angeles County.- Deposits of diatomite occur north of the San Jose Hills near Cobina, 30 miles east of Los Angeles.

San Luis Obispo County.- Deposits have been found on the south side of Los Asos, two miles south of Moro Bay and 10 miles west of San Luis Obispo.

Monterey County.- Diatomite is found near the junction of the San Antonio and Solinas Rivers, and also in the vicinity of Monterey.

Shasta County.- Deposits of diatomite occur on the Pitt River north of Burney, 50 miles east of the junction with the Sacramento River. These deposits are said to be of fresh water origin, differing in that respect from the marine deposits of the coastal region.

Oregon. - Deposits of diatomite occur in Deschutes, Baker, Grant, Klamath, Wasco, Union, Malheur and Crook Counties.

Washington. - Diatomite occurs along the Columbia River in the central portion of the State. One deposit now being worked lies about 20 miles southeast of Ellensburg.

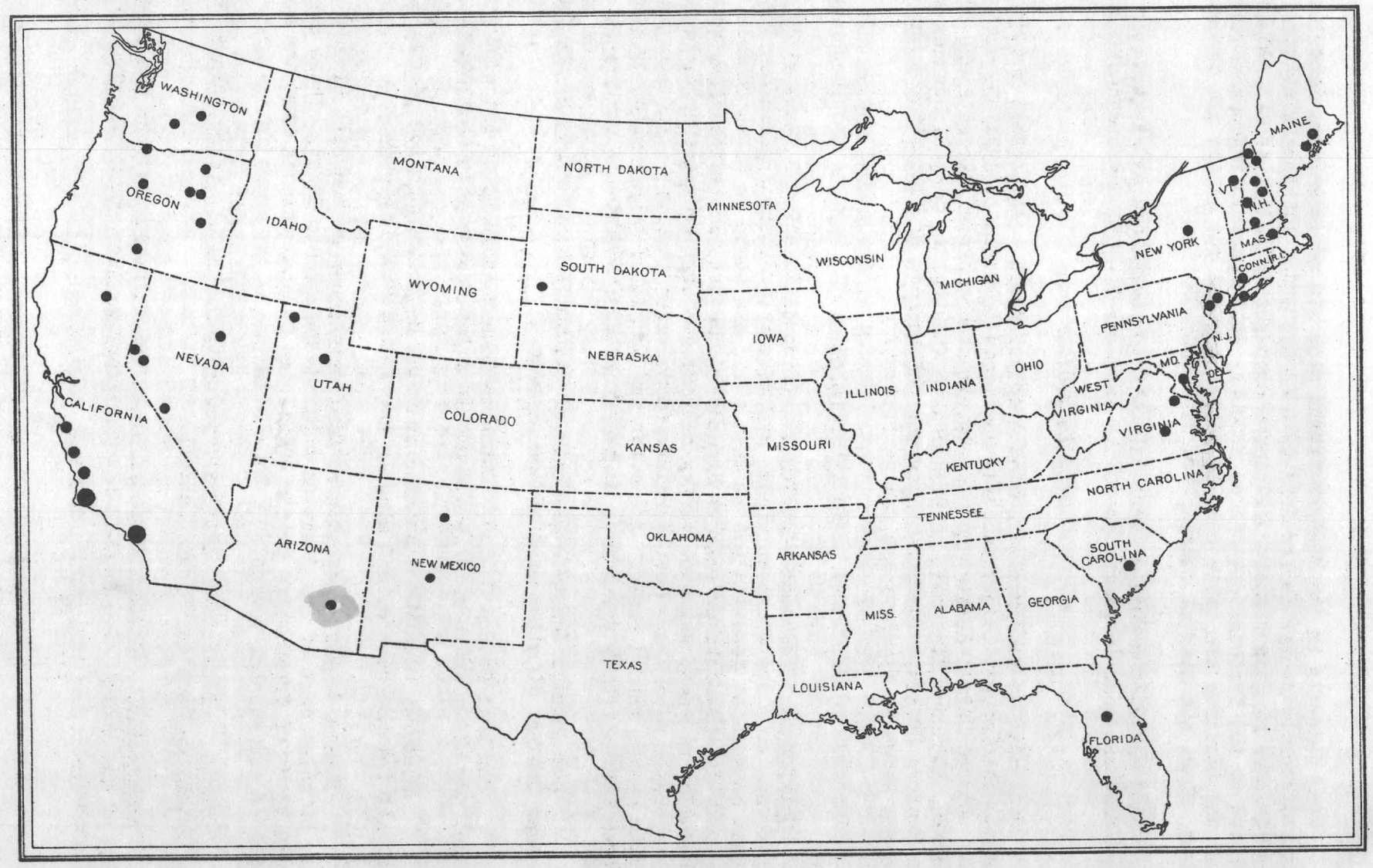

Figure 1.- Principal deposits of diatomite in the United States

Nevada. - Diatomite has been reported from every county of the State. Those counties which have received most attention are Churchill, Elko, Esmeralda, Mineral, Nye, Pershing, Storey, and Washoe.

South Dakota. - Diatomite has been found near Hermosa in Custer County.

Arizona. - Some diatomite has been reported from the San Pedro Valley in Graham County. Mammoth Whitlock, Graham Co., etc

PINAL

New Mexico. - Deposits are reported near Espanola and Soccoro.

Utah. - Diatomite occurs in Utah County and Box Elder County.

Montana. - Diatomite has also been reported from this State.

Central States

In the Middle West diatomite deposits have been found in Missouri, Illinois, Mississippi, and other States, but their commercial importance is negligible at present.

Eastern States

Maryland. - Beds of diatomite occur in several counties from Herring Bay on the west side of Chesapeake Bay to Popes Creek on the Potomac River. There are also deposits on the Patuxent River near Dunkirk.

Florida. - Diatomite is found as fresh water deposits near Eustis and Clermont in Lake County. It occurs in the bottom of shallow lakes and in swamps.

Other States where diatomite has been found are as follows:

In Connecticut, near Stepney; in Massachusetts, near South Framingham in Middlesex County; in New Hampshire, as lake beds in the northern part of the State, at Laconia in Belknap County, in Carroll County, Cheshire County, Grafton County, and at Lake Umbagog in Coos County; in Maine, at Blue Hill and Surry in Hancock County, and South Beddington in Washington County; in Vermont, in Caledonia County; in New York, at White Lake in Herkimer County and at Cold Spring Harbor on Long Island; in New Jersey, in Morris and Sussex Counties.

In Virginia occurrences have been noted in King George County, and near Richmond in Henrico County, and northwest of Petersburg in Dinwiddie County; in South Carolina, in Williamsburg County.

Canada

The most important deposits of diatomite in Canada are found in British Columbia along the Fraser and Quesnel Rivers. It is also found at Prospect Lake near Victoria. It occurs in Tolchester, Cumberland, and Pictou Counties, Nova Scotia. Some also has been reported from the southern part of New Brunswick. In Ontario diatomite occurs in the Muskoka region, and in Montcalm and Port Leuf Counties, Quebec.

Other Countries

In Africa diatomite deposits occur in Tripoli and in Algeria, which latter country is second to the United States in world production. Diatomite is found also in the Transvaal and the District of Masai.

In Asia the centers of production are in the Dutch East Indies along the West Coast of Sumatra, and near Cheribou in Java. Some diatomite also is found in the southern part of Japan.

In Australia, New South Wales produces an appreciable tonnage.

In Europe diatomite is found in Ireland and Scotland, in lower Austria, in the north-central part of Denmark, in Germany, Italy, Norway, Sweden, France, Portugal, Spain, Hungary, Belgium, and Russia.

Other countries of minor importance include Chile, where it is found near Arica; also Mexico, Peru, China, and Manchuria.

PROPERTIES

Physical

Color.- Diatomite is white when no impurities are present. The deposits, however, vary greatly in color, depending upon the presence of organic matter and other impurities such as clay and iron. These may change the color to gray, brown, pink or green.

Luster.- The luster of diatomite is dull and earthy. A sample of crude diatomite closely resembles chalk, but diatomite is more harsh to the touch.

True specific gravity or density.- The true specific gravity of diatomite is 2.1 to 2.2 (water is 1.0), or the same as hydrous silica such as opal.

Apparent density.- The apparent density is low because of the high porosity. Lump diatomite as it occurs in nature averages about 0.45, or weighs 28 pounds a cubic foot. However, this varies greatly, depending upon the nature of the deposit, and may be as high as 60 pounds a cubic foot. The dry, loose powder ranges from 7 to 16 pounds a cubic foot. Because of its extreme lightness and bulkiness it commands high freight rates.

Porosity.- Diatomite is a highly porous substance. A cubic foot of solid silica weighs 131.2 pounds. The difference between 131.2 and 28, the weight for a cubic foot, indicates the excessive volume of pore space in the material.

Thermoconductivity.- Because of the minute size of its air cells and its high porosity, diatomite is a very poor conductor of heat.

Angular nature of particles.- When diatomite is finely pulverized, the minute cell walls, even though they may be broken, present sharp edges and corners of silica. On this account diatomite makes an excellent polishing medium.

Coefficient of expansion.- Unless diatomite has been subjected to very high temperatures, in which case its amorphous nature changes, it expands or contracts very little with changes of temperature. This adds to its usefulness in making insulating bricks for furnaces.

Melting point.- The melting point of silica is 1,600° C. The range for diatomite is from 1,400° C. to 1,750° C., or from 2,552° F. to 3,182° F. These variations depend upon the purity of the material and also upon its density. If it is very impure or contaminated with clay, the melting point may be as low as 1,000° C.

The index of refraction is 1.45.

Chemical

Diatomites from various parts of the United States show the following range in composition:

	Per cent
Silica (SiO_2)	65 to 97
Alumina (Al_2O_3)	0.45 to 11.71
Iron oxide (Fe_2O_3)	Trace to 3.34
Lime (CaO)	0.11 to 22.61
Magnesia (MgO)	Trace to 1.06
Potash (K_2O)	0.0 to 3.58
Soda (Na_2O)	0.0 to 1.43
Water (H_2O) and organic matter	3.40 to 14.01

Upon ignition diatomite reacts in the same manner as ordinary opal. It gives up its combined water between 500 and 800° C. It is insoluble in neutral solutions and also in acids other than hydrofluoric. It is soluble in hydrofluoric acid and in caustic alkalies such as sodium carbonate.

It may be observed from the above that diatomite is chemically inert in the presence of ordinary reagents, but its properties are affected considerably by impurities.

Diatomite does not effervesce when acids are applied to it. This quality sometimes is helpful in its recognition.

USES

Diatomite has many important uses because of the wide adaptability of its extraordinary physical properties. It has rapidly assumed greater and greater importance in modern industry as markets are developed and industry becomes familiar with the various benefits to be derived from its use. One of the interesting features in respect to its marketing is that new uses continually are being found for diatomite which more than make up for the decrease in some of the older ones. An example of this is the employment of diatomite as an absorbent in dynamite. It is no longer used in this way, and what was once a major use now is of negligible importance. On the other hand it is comparatively recently that diatomite has been employed as a concrete admixture. Its use as a filler for battery boxes also has grown rapidly in recent years.

The more important uses are: First, as a filtration medium, second, as a heat insulation material; and third, as an admixture in concrete.

Filtration

The cane sugar industry at present is the largest consumer of diatomite. It is used mainly in filtering sugar solutions, being far superior to other media. Powdered material is added to the sugar solutions, which are then filtered through cloth. The cloth is previously prepared by coating it with a thin layer of pulverized diatomite. This is done by filtering through the cloth a small quantity of a solution carrying pulverized diatomite in suspension. This preparatory coating prevents the first filtrate from being cloudy before the added diatomite collects on the filter cloth and begins the filtering process. A high degree of efficiency is obtained by this method. For this work different varieties of diatoms are said to give different rates of filtering.

Diatomite is used to a certain extent in the beet sugar industry, but the total tonnage consumed is small in comparison with that used in the cane sugar industry.

Diatomite also may be used[4] for filtering orange juice, lemon juice, and grape juice, vinegar, pectin, citric acid, glucose, lactose, maltose, molasses, syrups, cottonseed oil, corn oil, fish oil, caster oil, lard, used crank case oil, used transformer oil, petroleum, petroleum-water emulsions, beverages, antitoxins and serums, nitro-cellulose, dyestuffs, glycerine, alcoholic extracts, adhesives, various emulsions, sewage, liquid soaps, and chemicals.

Deposits containing salt or much clay or other impurities are usually objectionable unless these impurities can be eliminated before use. Salt dissolves and contaminates the filtrate, and clay has a tendency to clog the filter cake, retarding the speed of filtration.

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4 Calvert, Robert, Page 26 of work cited.

Heat Insulation

Owing to its extreme porosity and fineness of individual air chambers, diatomite in various forms is extensively used as insulating material. Air is a very poor conductor of heat. However, if the air chambers are large, heat is transferred by convection. If the air chambers are very small, as in diatomite, transference of heat by convection is reduced to a minimum, hence diatomite has excellent heat insulating qualities. For insulating, diatomite may be used as sawed bricks which are cut from the rock in place at the quarry, as a granular powder, as bricks which are prepared with some bonding material and then calcined, or as mortars and cements. The bricks are used extensively for lining furnaces, in which they are usually placed behind a firebrick facing and are backed up by ordinary brick. Thus sandwiched in, they are very efficient in preventing heat losses.

Eardley-Wilmot has summarized the insulating uses of diatomite, employed as powder, bricks, slabs, pipe coverings, or cements, as follows:[5]

Steam-power plant equipment:
Boilers, steam pipes, breechings and flues, superheaters, and economizers.

Petroleum refinery equipment:
Stills, still furnaces, rotary kilns, boilers, pipes, oil lines and flues, storage tanks and reservoirs, forewarmers dephlegmating towers, etc.

Iron and steel melting fabricating:
Hot-blast stoves, mains and bustle pipes, regenerators and flues, by-product coke ovens, core baking ovens, producer gas mains, billet heating furnaces, annealing furnaces, heat-treating furnaces, malleable annealing ovens, foundry ladles, furnace doors, crucible furnaces, gun furnaces.

Nonferrous smelting, refining, and fabricating:
Reverberatory furnaces, rolling-mill melting furnaces, sintering furnaces, roasters (single and multiple hearth), melting furnaces, annealing furnaces, heat-treating furnaces, calcine hoppers, zinc retorting furnaces, sulphur burners, lead pots, metal mixers.

Lime and cement plant equipment:
Rotary kilns, vertical-shaft limekilns, boilers, flues, and settling-chambers.

Glass manufacturing equipment:
Day tanks, pot arches, boilers, producer gas mains and flues, refining end of melting tanks, regenerators and recuperators, tunnel kilns for preheating pots, flattening ovens.

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5 Eardley-Wilmot, V. L., Diatomite, Its Occurrence, Preparation and Uses: Canada Department of Mines, Ottawa, No. 691, 1928, p. 14.

Ceramic plant equipment:
Periodic kilns, tunnel kilns, fritting-furnaces, enamel drying ovens, waste heat or direct heat boilers, waste heat flues, enamelling furnaces.

Gas-generating equipment:
Water and oil gas sets, coke ovens, gas producers, mains and flues, coal gas retorts, waste heat flues, boilers (waste heat and direct fired).

General:
Bakers' ovens, crematories, driers, dust catchers, electric furnaces, evaporators, fireless cookers, forewarmers, incinerators, pipe-covering (all kinds), preheaters, safes, filing cabinets, soap-kettles, etc.

Refrigeration and construction:
Chill rooms, ice cellars, cold storages, refrigerators, in walls of buildings, roofing tiles, fireproof and other paints, and for sound deadening.

Diatomite makes good insulating material for dwellings. The usual practice is to spread 2 inches of powdered diatomite between the ceiling joists. If desired, the space between the wall studs may be filled also. This gives an insulating equivalent of 30 to 40 inches of ordinary brick and keeps the building warm in winter and cool in summer. Vermin are kept out and an added quality of fireproofing is given to the structure. Since diatomite readily absorbs moisture it should not be used near the ground level or in excessively damp places.

Pulverized diatomite bonded with about 10 per cent asbestos is made into a pipe-covering compound. The mixture is moistened with water and pressed into suitable shapes. These are usually made in longitudinal halves and wrapped with canvas upon installation.

Concrete Admixture

As a concrete admixture, from 2 to 5 pounds of pulverized diatomite may be mixed intimately with one bag of cement. The other aggregates and water are then mixed with the cement in the usual manner. It is thought that the diatomite, because of its high absorbent quality, takes up the excess water, although it probably yields some of it later during the hardening stages. Used in this way it adds greatly to the workability of the mix and retards segregation of the sand and gravel. This is a particular advantage when concrete is mixed at a central plant and where some time may elapse before it is poured into the forms. Subsequent stripping also is rendered easier. In the curing of concrete, laitance or the surface scum which usually forms is diminished by its use. Whether or not diatomite adds to the eventual strength of the concrete is a question much discussed. In many cases it probably does, not because of any inherent cementing qualities in the diatomite but because less water may be used for a given degree of workability. It is a well-known fact that too much water detracts materially from the ultimate strength of

concrete. By using diatomite the desired workability is obtained without an excess of water and a corresponding increase in strength results. Concrete which will come in contact with the ocean is rendered more immune to the disintegrating influence of the salt water by the addition of diatomite. In this respect it has been used in the building of concrete ships. Its use also is growing for aqueducts and siphons, as concrete containing diatomite is said to be more waterproof than ordinary kinds.

It seems that the use of diatomite in concrete should eventually become of even greater importance to the diatomite industry than it is now. Further research along this line is being done.

Minor Uses

The use of diatomite as a filler for battery boxes has increased rapidly in the last few years. The annual tonnage now so employed is considerable, and this market is one of the most important of the newer outlets which are being developed. Finely ground diatomite is also used as a filler in hard-rubber products, phonograph records, papier mache, paints and varnishes, oil cloth, linoleum, insecticides, and for other purposes where a light, porous material is required.

Diatomite is used as an absorbent in the manufacture of acetylene gas. It is used also for absorbing chemicals such as bromine, alcohol, and acids, for liquid fuels, liquid manures, and disinfectants. It makes a good packing material for strong acids such as nitric and sulphuric acids because in case of breakage it tends to absorb the spilled acid.

Diatomite is used as a source of silica for ultramarine blue, and in the wet process of manufacturing water glass. Diatomite is used often as a carrier for catalysts in the hydrogenation of oils for the manufacture of soaps. Diatomite also is said to possess certain bleaching qualities.

In structural work, besides its use in concrete, diatomite is used in the manufacture of roofing tiles and for certain building blocks and bricks where light weight is desired. It may be used for soundproofing rooms and telephone booths, and fireproofing safes and storage vaults.

Because diatomite when finely pulverized yields minute particles which still retain angular characteristics, even though the individual diatoms may become broken, it is widely used as an abrasive for polishing. Where metal surfaces are required to take a high luster, the desired effect or polish is had by making minute microscopic scratches on the metal which in turn reflect light. Pulverized diatomite sometimes mixed with other ingredients makes an ideal material for this purpose.

Many metal polishes now on the market use diatomite as a base. The small, tough, freshwater varieties are said to be the best for this purpose. Polishes of this kind may be used for silverware and for scientific and surgical instruments. Such polishes usually are marketed in the form of pastes or powders. Diatomite also may be used in automobile polishes, and the purest and finest material is used to some extent in dental powders and pastes and in finger-nail polishes.

Diatomite has been used as a parting medium in steel foundry practice, as a substitute for chalk in crayons, and as dusting powders for automobile tubes and tracing cloth. Diatomite is used to some extent in the ceramic industry in the manufacture of porcelains and tiles, as an adulterant in cheap foodstuffs, as a constituent of modelling putty and shoe polishes, and as a medium through which to blow air for aerating liquids.

MINING

Commercial deposits of diatomite may be divided into three general types: First, those close to the surface, which may be mined by quarry methods; second, those which extend deeper and are exploited by shaft and stoping; and third, those which occur in shallow lakes or swamps.

The California deposits are of the first two types. For quarrying operations the overburden is removed either by machinery or by scrapers and hand tools. Blasting usually can not be resorted to in this operation as it might shatter the underlying beds. After the strata of diatomite are cleaned off, the actual quarrying is begun and benches are developed as fast as possible in order to give a sufficient number of working places. Any clay partings in the beds aid in the splitting off of slab material, although sometimes light charges of powder are employed. For certain types of products the material is sawn nearly to the desired shape by means of specially constructed machinery in the quarry. Otherwise the slabs are pried out by hand or loosened by small charges of powder and then shoveled into wagons for transference to drying sites. Power shovels are not used to any appreciable extent, although in Washington there is a deposit near Ellensburg where a gasoline shovel is used to strip off the overburden and also to load trucks with diatomite.

Recent practice at the larger operations is to mine the great beds of diatomite by underground methods. From a main haulage tunnel raises are put up at suitable intervals to the strata desired, and stoping is done by room-and-pillar methods. The loosened and broken diatomite is handled by scrapers to the raises from which it is passed down to cars in the haulage tunnel. Such mining methods may be supplemented by quarry operations in the general mining scheme.

In Nevada a deposit of diatomite is mined from a shaft which is sunk parallel to the dip of the strata. From the shaft drifts are run at suitable intervals along the strike, after which stoping proceeds. Pillars left for support are to be removed later.

In Lake County, Fla., the diatomite is found in shallow water deposits. A floating dredge is used with a suction hung from a boom. It is equipped with specially constructed revolving blades which collect the loose material, after which it is conveyed to the top.

In some cases it is feasible to drain a shallow lake before attempting to recover the beds of diatomite. Usually, however, this practice is much too expensive, and some form of dredging must be resorted to.

PREPARATION FOR MARKETING

Crude diatomite because of its sponge-like qualities naturally tends to soak up ground water or rain. Therefore, after being mined, the first step in the preparation of the material is to eliminate this uncombined water - uncombined because it is in addition to the 4 or 5 per cent of water which is locked up chemically with the silica and can be driven off only by calcination. Removal of this excess sponge-water may be done in several ways. At some plants the material, in the form of slabs, is carted to suitable drying sites. There it is stacked in long windrows where the hot, dry desert winds remove most of the uncombined water. After being allowed to dry in this manner for several weeks the moisture content is reduced to 10 per cent or less and the material may be carted to the grinding plant.

In regions which do not have these natural drying conditions the material must be dried by artificial means. Also, recent practice at the larger plants is to do most of the drying in ovens or kilns even though natural drying conditions are available.

Where a pulverized product is desired, common practice is as follows:

After the preliminary drying, done either by natural or artificial means, the material is passed through crushers or toothed rolls. A trommel returns the oversize and passes the undersize to some form of pulverizer, such as the swinging-arm type. Pulverizing must be done carefully. The object is to free the individual diatoms but not to crush them unnecessarily. The material from the pulverizer is screened and the coarser sizes are ready for packing. The finer material is passed through a series of cyclone air separators which classify it to the various fine sizes desired. Prior to air classifying, sand traps remove as many of the objectionable impurities as possible. The material from the cyclones is sacked and is then ready for shipment. Sometimes these sacks are passed between light rolls to compress them so that more may be loaded into the freight car.

Two classes of diatomite brick are made, sawed brick and pressed brick. The sawed brick may be of two kinds, natural or calcined. In preparing natural brick, diatomite is cut in the quarry nearly to size by specially constructed saws. The brick are then dried and are trimmed by grinders, after which they are packed in cartons. The calcined brick are fired to the desired temperature, after which they are packed for shipment.

There are three general varieties of pressed brick. First, the ordinary brick which is made from a high-quality diatomite. The powdered or granulated diatomite is moistened with water to a paste, pressed to shape, dried and fired to the desired temperature. Sometimes bonding materials are used, such as lime or clay.

The second class of pressed brick is made from a heavier form of diatomite. This is lightened by the inclusion of organic matter, such as cork, which burns away during the firing process. This leaves many small cavities throughout the brick, which add to the lightness and porosity.

The third type of pressed brick is largely in the form of tridymite. Where a brick is desired to withstand high temperatures this type is recommended by the manufacturers. At certain high temperatures the crystalline form of silica changes to either cristobalite or tridymite. Cristobalite is very objectionable because it contracts or expands appreciably with only slight changes in temperature. This, of course, would result in spalling or cracking. Tridymite, however, maintains a nearly even size.

Coss, U. S. Patent 1,544,433, has patented a process for making tridymite brick for high temperature insulation, such as for marine boilers. A binder of a refractory clay is used with 1 to 3 per cent of lime which, it is claimed, favors the transformation of amorphous silica to tridymite when fired at a temperature of 2,500° F.

In Florida the material after being dredged is allowed to settle in long boxes or vats. The water is drained off and the material, which is by now more or less consolidated, is air-dried, passed to vacuum chambers for further drying, and then to furnaces which burn out all organic matter. It is next crushed or pulverized, sized, and packed for shipment.

In a Nevada mill the very wet material is given a preliminary crushing and is then dried on conveyors by steam in a closed room. It is next pulverized, screened, and passed to the cyclone system for final classification.

MARKETING, PRICES, AND BUYERS

Any one contemplating the marketing of diatomite should bear in mind that its uses are somewhat dependent upon the kinds of diatoms and their individual characteristics. For instance, qualities of heat insulation may vary between wide limits, depending upon the physical properties of the different varieties of diatoms and impurities present. As most United States diatomite is mined by one producer and marketed under trade names, no general specifications can be laid down concerning the various products.

Before any attempt is made to place new material upon the market a very thorough investigation should be conducted. This should include complete chemical and physical analyses of samples taken from the separate horizons of the deposit.

Check runs should also be made from different places in the same horizon. Chemical analyses will give data on the various impurities such as organic matter, salt, clay, etc. Physical tests should include a microscopic examination to learn something of the kinds of diatoms present. The moisture content, porosity, and specific gravity also should be determined.

It would be advisable to make actual tests of the material in the uses contemplated. For example, if it were thought that a particular deposit was suitable for use in filtering, experiments should be made with the solutions it was intended to filter. This applies equally with proposed uses as insulating material because of the wide variation in the heat insulating qualities of the various types of diatoms. In fact, all considered uses should always have exhaustive preliminary tests.

Owing to their fragile nature, for shipment bricks or blocks are placed in crates or cartons. Crude, air-dried material is customarily packed in burlap sacks of 90 to 100 pounds each. Pulverized diatomite may be packed in paper bags. Bulk shipments also are made.

Transportation is an important marketing problem. Owing to its relatively light weight and corresponding bulk, diatomite commands high freight rates, and a minimum carload of 20 tons is seldom attained. For this same reason the cost of containers per ton is relatively high. The fact, too, that most of the larger deposits occur in the West tends to make the material rather costly for eastern consumers.

The latest available prices as quoted in "Metal and Mineral Markets," Engineering and Mining Journal, June 5, 1930, are as follows:

> Diatomite per short ton, f.o.b. producing plant:
> Kiln-fired brick, $65; kiln-fired aggregate, ¼", $45; insulating powder $25; natural aggregate ¼" $18 @ $20; air floated powder, $45; 80 to 85% silica, 98 per cent through 200 mesh, $20 in carload lots.

1931 Prices

These quotations are more or less nominal and should be taken only as a rough guide because diatomite at present is sold largely under contract between the individual producers and the consumers. Prices of these contracts may vary greatly from the above figures because of the various factors involved such as tonnage, individual specifications, and characteristics of the material. They are usually the result of direct negotiation between the producer and the buyer.

Buyers.- The following companies are some of the more important buyers of diatomite.

Jerome Alexander, 50 east 41st Street, New York, N. Y.
F. Behrend (Inc.), 170 Front Street, New York, N. Y.
Bon Ami Co., 17 Battery Place, New York, N. Y.
H. C. Bugbird Co., 59 Pearl Street, New York, N. Y.
Charles B. Chrystal Co. (Inc.), 99 John Street, New York, N. Y.
Cooper & Cooper (Inc.), 23 Cliff Street, New York, N. Y.
Eimer & Amend, 201-209 east 13th Street, New York, N. Y.
The Exolon Co., Commercial Avenue & Erie R. R., Blasdell, N. Y.
Hammil & Gillespie (Inc.), 240 Front Street, New York, N. Y.
The Harshaw Chemical Co. of New York, (Successors to The Superfos Co. (Inc.)), 150 Nassau Street, New York, N. Y.
Leon Hirsh & Son, 368 Greenwich Street, New York, N. Y.
J. L. Hopkins & Co., 135 William Street, New York, N. Y.
Industrial Chemical Sales Co., 230 Park Avenue, New York, N. Y.
Innis, Speiden & Co. (Inc.), 50 Cliff Street, New York, N. Y.
A. Klipstein & Co., New York, N. Y.
Larkin Co. (Inc), 680 Seneca Street, Buffalo, N. Y.
New England Quartz Co. of New York, 152 Nassau Street, New York, N. Y.
Orelite Co. (Inc.), 109 Broad Street, New York, N. Y.
Pomeroy & Fischer (Inc.), 95 Madison Avenue, New York, N. Y.
L. A. Salomon & Bro., 216 Pearl Street, New York, N. Y.
Wm. H. Scheel (Department A), 179 Water Street, corner Burling Slip, New York, N. Y.
Smith Chemical & Color Co. (Inc.), Moore & South Streets, New York, N. Y.
Samuel H. French & Co., 400-412 Callowhill Street, Philadelphia, Pa.
General Refractories Co., 106 south 16th Street, Philadelphia, Pa.
Shimer & Co. (Inc.), 133 south Fourth Street, Philadelphia, Pa.
Charles W. Young & Co., 1247 north 26th Street, Philadelphia, Pa.
R. F. McGrory Co., Calhoun Street & Pashley Avenue, Trenton, N. J.
Thomas Manufacturing Co., 117 west Camden Street, Baltimore, Md.
Mineral Soap Manufacturing Co., Lowell, Mass.
Abbott Laboratories, 14th Street & Sheridan Road, North Chicago, Ill.
Holman Soap Co., 3104 Fox Street, Chicago, Ill.
Hylonite Products Co., 1107 Addison Street, Chicago, Ill.
Tamms Silica Co., 30 north La Salle Street, Chicago, Ill.
Wishnick-Tumpeer (Inc.), 363 east Illinois Street, Chicago, Ill., 251 Front Street, New York, N. Y., Davenport & east 14th Streets, Cleveland, Ohio.
Coleman & Bell Co. (Inc.), Norwood, Ohio.
The DuBois Soap Co., 1120 west Front Street, Cincinnati, Ohio.
Excelsior Ball Clay Co., 31 East 13th Street, Cincinnati, Ohio.
The Globe Chemical Co., Murray Road & Big Four R. R., St. Bernard, Cincinnati, Ohio.
National Sales (Corp.), 31-35 east 13th Street, Cincinnati, Ohio.
Rub-Tex Products (Inc.), Indianapolis, Ind.
Braun (Corp.), 363 New High Street, Los Angeles, Calif.
Los Angeles Soap Co., 617 east First Street, Los Angeles, Calif.
Algernon Lewin Curtis, P.O. Box 61, Westmoore Laboratory, Chatteris, England.

PRODUCERS

Companies in the United States reporting to the Bureau of Mines as producers of diatomite in 1929 are as follows:

California

Fresno County: Mendota - Mineral Products Manufacturing Co. (1735 Ventura Avenue, Fresno).

Los Angeles County: Torrance - Floatstone Products Co. (423 Wall Street, Los Angeles).

Monterey County: Monterey (near) - The Calatom Co. (Inc.), (Monterey); Pacatome Co. (814 Kohl Building, San Francisco).

Santa Barbara County: Lompoc - (Celite Corporation) Johns-Manville Corp. (292 Madison Avenue, New York, N. Y.).

Oregon

Deschutes County: Terrebonne - Atomite Corporation (1021 Pacific Building, Portland).

Malheur County: Harper - Whiteurth Products Corporation. (Harper, Oregon).

Washington

Kittitas County: Kittitas - Kittitas Diatomite Co. (Ellensburg). Roza - Washington Silica & Fire Clay Co. (3205 Hewitt Avenue, Everett).

Nevada

Elco County: Carlin - Carlin Products Co. (Inc.), (676 Subway Terminal Building, Los Angeles, Calif.); Tri-o-lite Products Co. (Carlin, Nevada).

Esmeralda County: Basalt (near) - U. S. Diatom Co. (800 Santa Fe Avenue, Los Angeles, Calif.).

Storey County: Virginia City - The Electro-Silicon Co. (22 Cliff Street, New York, N. Y.).

Florida

Lake County: Clermont - Florida Diatomite Co.

Virginia

Westmoreland County: Oak Grove - American Diatom Co. of Virginia (618 Witherspoon Building, Philadelphia, Pa.).

Maryland

Calvert County: Dunkirk (near) - Diatomaceous Products Co. (Inc.), (907 Fifteenth Street, N. W., Washington, D. C.

New York

Herkimer County: Poland - Adirondack Diatomaceous Earth Co. (Herkimer).

New Hampshire

Grafton County: Canaan - New England Minerals (Inc.), (85 Devonshire Street, Boston, Mass.).

PRODUCTION STATISTICS

World production of diatomite by countries, 1920-1928, in metric tons

Country	1920	1921	1922	1923	1924	1925	1926	1927	1928
Algeria	1,500	800	2,480	10,000	[a]9,092	[a]8,343	[a]7,931	[a]9,542	[a]10,144
Australia:									
New South Wales.	390	209	489	523	573	712	926	1,229	1,381
Canada	(b)	(b)	199	118	30	(c)	(c)	241	334
France	3,800	4,580	4,620	4,550	2,300	1,500	7,130	(d)	(d)
Germany (exports).	4,943	[e]3,415	5,207	4,096	4,326	4,555	5,919	6,023	6,703
Ireland (northern)	6,203	4,228	1,909	1,680	2,480	3,397	3,023	3,427	4,312
Italy	25	875	175	420	420	420	1,200	700	1,180
Japan.....	(b)	(b)	4,690	5,319	5,040	4,727	(d)	(d)	(d)
Norway (exports)..	75	113	82	110	67	48	58	80	84
Russia	(b)	(b)	(b)	(d)	(d)	2,344	8,055	5,187	(d)
Sweden	(d)	600	322	696	608	819	475	622	(b)
Union of South Africa	(b)	(b)	(b)	217	236	(c)	(d)	(c)	(c)
United States	56,174	50,016	40,606	59,722	57,300	66,251	79,039	(f)	(f)

a Exports.
b No record.
c No production.
d Data not available.
e Figures from May to December, 1921.
f Bureau of Mines not at liberty to publish figures.

ECONOMIC CONDITION OF THE INDUSTRY

The size of the industry at present is due quite largely to the educational advertising and pioneer work of one company which is now the largest single producer. Because of this dominant position of an individual concern the recent production figures may not be published. However, the volume produced has enjoyed a vigorous increase for some time.

Further development and enlargement of markets is still possible. Owing to its peculiar characteristics diatomite has a very wide range of uses. As an admixture to concrete there would seem to be a tremendous potential field of consumption which should open up as further research work is done and more complete specifications for its use laid down. Much wider use is possible for insulation in steam plants and in buildings, in the separation of water-oil emulsions, and for reclaiming lubricating oil.

With the growth of consumption new deposits will naturally be looked to with interest. Some of these, no doubt, may be opened and operated profitable. Taken as a whole, the diatomite industry is a specialized ore, requiring continuous comprehensive research work on the crude material, and its preparation and sale. Scientific and engineering skill is demanded throughout if the requirements of the consumer are to be met satisfactorily and profitably. Failures have resulted in the past from a lack of these essentials.

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ARIZONA INDUSTRIAL MINERALS

COMMODITY	COUNTIES													
	Apache	Cochise	Coconino	Gila	Graham	Greenlee	Maricopa	Mohave	Navajo	Pima	Pinal	Santa Cruz	Yavapai	Yuma
Alunite				X								X		X
Asbestos		X		X						X	X			X
Barite		X		X	X		X	X		X	X	X	X	X
Clays	X	X	X	X		X	X	X	X	X			X	X
Corundum								X			X			
Diatomite	X	X		X	X	X	X				X	X	X	
Feldspar				X			X	X		X	X		X	
Fluorspar		X		X	X	X	X	X		X	X	X	X	X
Garnet	X			X	X	X				X				
Graphite		X						X						
Gypsum		X	X	X			X	X	X	X	X		X	X
Limestone-Dolomite	X	X	X	X		X	X	X	X	X	X	X	X	X
Lithium Minerals							X			X			X	
Magnesite-Brucite								X					X	
Mica		X					X	X		X	X		X	X
Perlite				X	X	X	X	X		X	X			X
Pumice Group	X	X	X	X	X	X	X	X	X			X	X	X
Salt (Rock)													X	
Sand (Specialty)	X		X					X	X					
Shale (Expansible)			X								X			X
Silica - Quartz		X		X	X	X	X	X	X	X	X		X	
Sillimanite Group		X		X			X	X					X	X
Sodium Sulfate													X	
Strontium							X							
Vermiculite							X	X			X			
Wollastonite		X		X						X				X
Zeolite	X	X			X	X	X	X			X			X

APACHE COUNTY (Continued)

Location	Quadrangle Map	Known Names	Description-Comments
CLAYS (Cont'd)			
approx. sec. 9, 21N-29E			Bleaching clay.
sec. 21,22 21N-29E		Graywater Wash	Bleaching clay/lenses in altered vitric tuff.
2N-11W Nav. B.L.	Ganado 1 NE 7½'	Beautiful Valley	Bentonitic clay in Chinle Form; capped by shale.
		Balakai Mesa	White kaolinized sandstone overlying Dakota sandstone.
sec. 26 proj. 21N-29E		Allentown Mine	Bleaching clay, past production.
sec. 18 proj. 21N-29E		Cheto No. 2	Active bleaching clay mine, used for filtering, vitric tuff lenses in Bidahochi Form.
sec. 7 proj. 21N-29E		Cheto No. 1	Active bleaching clay mine, used for filtering, vitric tuff lenses in Bidahochi Form.
DIATOMITE			
E½ 12N-26E	Hunt 15'	Concho Creek	Diatomite bed capped by basalt.
GARNET			
9 mi. SW of Mexican Water	Dinnehotso 15'	Garnet Ridge	Pyrope garnets in volcanic breccia pipe.
3 mi. W of Mexican Water	Mexican Water 7½'	Mexican Water	Garnet-bearing material in alluvium.
approx. sec. 30, 3N-5W, sec. 13,26 3N-6W Nav. B.L.	Buell Park 15'	Buell Flat	Pyrope garnets in kimberlite tuff, some olivine.
LIMESTONE			
2 mi. SW of Dinnehotso	Dinnehotso 15'	Dinnehotso	Limestone lenses within Navajo sandstone.

COCHISE COUNTY (Continued)

Location	Quadrangle Map	Known Names	Description-Comments
BARITE (Cont'd)			
sec. 30 23S-25E	Bisbee 15'	Gold Hill	Barite gangue with manganese oxides in Naco limestone (Penn.-Permian).
CLAYS			
sec. 35 (?) 17S-19E	Benson 15'	Whetstone Mtns.	Black graphitic clay, used for brick lining of smelter converters.
sec. 20,21 17S-20E	Benson 15'	Benson	Bentonitic clay, gypsum lenses.
DIATOMITE			
sec. 27 17S-20E	Benson 15'	Post Ranch	Diatomite, past production for lt.-wt. aggregate and scouring powder.
sec. 17 18S-21E	St. David 15'	Curtiss	Horizontal diatomite bed interbedded with volcanic ash.
FLUORSPAR			
sec. 34 13S-27E	Luzena 15'	Buckeye Canyon Prospect	Fluorspar veinlets in granite (Pre-Camb.) cut by rhyolite dikes.
sec. 13 14S-20E	Dragoon 15'	American Mine, War Eagle, LA Ventia	Fluorite-barite gangue, metallic sulphides in granodiorite (Pre-Camb.).
sec. 23 15S-22E	Dragoon 15'	Peabody Mine	Fluorite-quartz gangue, copper-zinc ores in limestone (Penn.).
sec. 17 16S-30E	Cochise Head 15'	Indian Creek, Pague Prospect	Fluorspar vein in faulted limestone (Penn.).
sec. 1 16S-22E	Dragoon 15'	Banks Mine	Fluorite gangue, scheelite, huebnerite in quartz monzonite.
sec. 5 16S-22E	Dragoon 15'	Homestake Prospect	Fluorite-quartz associated with scheelite, gold-copper ores in Pinal schis (Pre-Camb.)

GILA COUNTY (Continued)

Location	Quadrangle Map	Known Names	Description-Comments
BARITE (Cont'd)			
sec. 5 9N-10E	Payson 15'		Barite veinlets.
sec. 6 9N-10E	Payson 15'	Grey Fox Group	Barite stringers in diorite (Pre-Cambrian).
sec. 7 9N-11E	Payson 15'	Gisela (Spook) Deposit	Barite vein in fractured granite.
sec. 31 proj. 8N-12E	Picture Mtn. 7½'	Top Hat Group	Barite vein in faulted quartzitic schist (Pre-Cambrian).
sec. 35 7N-9E	Reno Pass 7½'	Lone Pine Claim	Barite vein in pyroxenite(?
sec. 7,8 proj. 2N-16E	Rockinstraw Mtn. 15'	Richmond Basin	Barite veins.
sec. 29 proj. 1N-14E	Inspiration 7½'	Castle Dome Mine	Barite-fluorite mineralization, copper ores within quartz monzonite.
CLAYS			
sec. 20,29 8N-10E	Payson 15'	Quintonite	Active clay mine.
approx. sec. 28 7½N-9E	Pine 15'	Pine Area	Kaolinitic clay, calcite.
sec. 27 7N-23E	Rount Top Mtn. 7½'	North Fork, White River	Kaolinite in sandstone.
sec. 24 (?) 1N-15E	Globe 15'	Weary Lode	Past production, kaolinitic clay in altered granitic rocks, used for tiles, pond linings, ceramicware.
sec. 11 3S-13E	Sonora 7½'	No. 1 Mine	Kaolinite in altered granitic porphyry.
DIATOMITE			
sec. 26 proj. 1N-18E	Natural Corral 7½'	Skeleton Wash	Diatomite interbedded with limestone within lake sediments.

GILA COUNTY (Continued)

Location	Quadrangle Map	Known Names	Description-Comments
SILLIMANITE GROUP (See FELDSPAR)			
WOLLASTONITE (see GARNET)			

GRAHAM COUNTY

BARITE (Also see FLUORSPAR)			
sec. 19 4S-20E	San Carlos Reservoir 15'	Barium King Group, Mitchell Barite	Barite vein with fluorite in trachyte.
sec. 28,29 4S-19E	San Carlos Reservoir 15'	Copper Reef Mine, North Star, Coronado Group	Barite vein, fluorite in limestone (Carboniferous), lead-copper ores.
sec. 12 proj. 5S-19E	San Carlos Reservoir 15'	Silver Star Prospect, Little Mule Group	Barite veins in fractured diorite.
sec. 20 8S-22E	Sierra Bonita Ranch 15'	Graham Prospect	Barite vein with fluorite in granite.
sec. 13 8S-21E	Sierra Bonita Ranch 15'	Kinney Kye Mine, Marcotte Group	Barite veins with fluorite, copper oxides in volcanic agglomerate.
DIATOMITE			
sec. 33 proj. 1S-19E	San Carlos 7½'		
sec. 1,11 proj. 2S-19E	Mt. Triplet 7½'	Triplets Wash	Diatomite overlain by alluvium.
sec. 24 4S-23E	Ft. Thomas 15'		Impure diatomite.
sec. 21,22,23,26, 27,28, 8S-28E	Dry Mtn. 7½'	Whitlock Deposit	Impure diatomite beds and volcanic ash.

Location	Quadrangle Map	Known Names	Description-Comments
DIATOMITE (Cont'd)			
approx. sec. 19 6S-27E	Safford 15'	Solomon Deposit	Diatomaceous beds interbedded with clay and alluvium.
FLUORSPAR (Also see BARITE)			
sec. 19 4S-20E	San Carlos Reservoir 15'	Barium King Mine	Fluorite, barite, calcite vein in brecciated trachyte.
sec. 28,29 4S-19E	San Carlos Reservoir 15'	Coronado Group	Fluorite, barite, quartz vein in limestone.
sec. 12 proj. 5S-19E	San Carlos Reservoir 15'	Little Mule Group, Silver Spar Prospect	Vein of fluorite, barite, quartz, lead-silver values in latite or andesite breccia.
sec. 29 5S-20E	Klondyke 15'	Landsman Group	Purple fluorite stringers, lead-silver values in faulted limestone.
sec. 6 6S-22E	Jackson Mtn. 15'	Mt. Jackson, Rhodes Spar	Past production, purple-green fluorspar veins in granite (Pre-Camb.).
sec. 29 6S-20E	Klondyke 15'	Grand Reef Mine	Fine-grained brecciated fluorite, quartz, lead-silver values in schist intruded by rhyolite dikes.
sec. 22 7S-21E	Jackson Mtn. 15'	Edith 1 & 2	Fluorspar veinlets in granite (Pre-Camb.).
sec. 13 8S-21E	Sierra Bonita Ranch 15'	Marcotte Claims	Veins of barite, fluorite, calcite, silver-gold values in volcanic agglomerate.
sec. 20 8S-22E	Sierra Bonita Ranch 15'	Graham Prospect	Barite, fluorite, copper oxides in granite (Pre-Camb.).
GARNET			
sec. 36 4S-19E	San Carlos Reservoir 15'	Quartzite Mtn.	Andradite garnet in metamorphosed limestone (Paleozoic).

GREENLEE COUNTY (Continued)

Location	Quadrangle Map	Known Names	Description-Comments
ZEOLITE			
sec. 16 3S-29E	Clifton 15'		Clinoptilolite and mordenite in lapilli and tuff (Tert.).

MARICOPA COUNTY

BARITE (see FLUORSPAR)			
sec. 34 5N-10W	Lone Mtn. 15'	Princess Ann, Fay L	Past production, barite veins, fluorspar in volcanic conglomerate.
sec. 35 5N-10W	Lone Mtn. 15'	White Rock Claims, Blue Bird	Barite-fluorspar veins in basalt.
sec. 4 2N-7E	Granite Reef Dam 7½'	Granite Reef Mine, Macco, Arizona Barite, Christman	Past production for drilling mud, barium chemicals, barite veins in faulted conglomerate.
sec. 19 proj. 2S-6W	Woolsey Peak 15'	B&H Claim #6	Barite vein in biotite schist (Pre-Cambrian).
sec. 25 4S-8W	Dendora Valley 15'	Rawley Mine	Barite gangue, copper-gold ores within andesite.
DIATOMITE			
sec. 15 6N-1E	Biscuit Falt 7½'	Lake Pleasant Mine	Past production, diatomite beds in Cenozoic lake sediments interbedded bentonite.
FELDSPAR (see MICA)			
sec. 16 7N-3W	Red Picacho 7½'	Morning Star	Past production, potash feldspar pods, green muscovite, quartz, lithium minerals in pegmatite.
sec. 16 7N-3W	Red Picacho 7½'	Sunset	Potash feldspar, quartz, muscovite, in pegmatite within amphibole schist.
sec. 23 7N-3W	Red Picacho 7½'	Hertz, Weatherman	Pegmatite with feldspar, quartz.
sec. 4 or 5 2S-3W	Buckeye 7½'	Varnum Feldspar	

PINAL COUNTY (Continued)

Location	Quadrangle Map	Known Names	Description-Comments
CORUNDUM			
sec. 12 5S-5E	Gila Butte SE 7½'	Sacaton Mtns.	Irregular corundum masses with rutile and quartz in felsite dikes.
DIATOMITE			
sec. 19,9S-18E sec. 24,9S-17E	Clark Ranch 7½'	White Cliffs Mine	Past production for fillers and filter aids, horizontal diatomite beds beneath clay.
sec. 26 6S-16E	Saddle Mtn. 7½'	Feldman	Active gypsum mine, some diatomite interbedded with gypsum beds.
FELDSPAR			
sec. 7,8 4S-2E	Enid 7½'	Sierra Estrella	Microcline, muscovite, quartz in pegmatite.
FLUORSPAR			
sec. 26 8S-16E	Mammoth 7½'	Mammoth Mine, St. Anthony	Fluorspar-barite gangue, lead-zinc-copper sulfides, quartz monzonite host rock.
GYPSUM			
sec. 25 5S-15E	Winkelman 7½'	Winkelman	
sec. 2,11 5S-16E	Christmas 7½'	Ash Creek	Gypsum in andesite flows.
sec. 23 6S-16E	Saddle Mtn. 7½'	Crystal Cove	White massive gypsum beds.
sec. 26,27 6S-16E	Saddle Mtn. 7½'	Feldman, Winkelman Gypsum Pit	Active quarry, massive gypsum beds in lake sediments (Cenozoic), processed into plaster board, agric. applications.
sec. 26,35,36 6S-16E	Lookout Mtn. 7½'	Arizona Gypsum	Active mine, gypsum beds in lake sediments (Cenozoic), for agricultural use and cement retarder.
sec. 13,14 7S-16E	Lookout Mtn. 7½'	Pinal Mammoth Gypsum	Active mine, gypsum interbedded with silt.

PINAL COUNTY (Continued)

Location	Quadrangle Map	Known Names	Description-Comments
SILICA-QUARTZ (Cont'd)			
sec. 2,11 8S-18E	Klondyke 15'	Copper Creek District	Quartz crystals.
sec. 26 8S-16E	Mammoth 7½'	Tiger Mine Tailings	Active mine, silica-copper flux.
sec. 33 9S-15E	Oracle 15'	Gold Hill Mine	Active mine, silica-copper flux.
sec. 25,26 proj. 9S-4E	Silver Reef Mtns. 15'	Orizaba Silica Mine	Active silica mine.
sec. 30 5S-15E	Winkelman 7½'	Babbitt Claims, Winkelman Silica Mine	Active quarry, silica flux.
VERMICULITE			
sec. 10 (?) 10S-15E	Oracle 15'	Irene Wash	Vermiculite occurrence
ZEOLITE			
sec. 25 7S-8E	Picacho Reservoir 7½'		Analcime in silty claystone (Tert.).

SANTA CRUZ COUNTY

ALUNITE			
sec. 36 22S-15E	Nogales 15'	Three R, Evening Star Prospect	Pinkish alunite, quart pyrite,chalcopyrite in pegmatitic granite.
BARITE			
approx. sec. 33 22S-16E	Lochiel 15'		Barite veinlets.
DIATOMITE			
approx. sec. 35 21S-18E	Pyeatt Ranch 7½'	Lyle Creek	Impure diatomite outcr
FLUORSPAR			
approx. sec. 8 23S-11E	Ruby 15'	Annie Laurie Claims	Purple fluorspar string quartz, calcite, galena and sphalerite in grani
sec. 3 proj. 23S-16E	Harshaw 7½'	Alta Mine	Reddish fluorite gangue quartz, silver-lead val in quartz diorite cut b rhyolite dike.

YAVAPAI COUNTY (Continued)

Location	Quadrangle Map	Known Names	Description-Comments
CLAYS (Cont'd)			
sec. 12 13N-6W	Bismarck Mesa 7½'	Lyles Deposit	Past production, lit magnesium bentonitic clay used for reserv sealer, lake beds (C zoic) under basalt.
sec. 11 13N-5E	Camp Verde 7½'	Larson Quarry	Past production bent clay associated with gypsum, used for iro pelletizing and cana reservoir sealer.
sec. 21 proj. 8N-6E	Chalk Mtn. 7½'	Chalk Mtn.	Kaolin (?) reported.
SE¼ 9N-2E	Squaw Creek Mesa 7½'		Sepiolite reported, magnesite.
DIATOMITE			
sec. 16 13N-5E	Camp Verde 7½'	Verde River	Diatomite beds interbedded with gypsum, clay and calcium carbonate.
FELDSPAR (see MICA)			
sec. 16 proj. 10N-1E	Crown King 7½'	Silver Christmas Mine	Orthoclase feldspar.
sec. 34 8N-3W	Red Picacho 7½'	Friction Mine	Perthite feldspar, quartz in pegmatite.
sec. 34 8N-3W	Red Picacho 7½'	Outpost Extension	Pegmatite bodies containing perthite, alt massive quartz.
sec. 3 7N-3W	Red Picacho 7½'	Outpost Mine	Potash feldspar pods, muscovite, bismutite, quartz masses in pegmatite.
sec. 10 7N-3W	Red Picacho 7½'	Picacho Vien Mine	Potash feldspar pods, mica, quartz in pegmatite.

Janu , 1929

DIATOMITE IN ARIZONA

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Miscroscopically there is no difference between the diatomite of Arizona and that of any other place, as it consists of siliceous tests of diatoms, radiolaria, and other aquatic organisms, beautiful in shape and great in variety. Those specimens examined are mostly of the fresh-water type, but some, because of their location between sandstones and limestones, may be of marine origin. More work, however, will have to be done on this phase of the subject before conclusions can be reached. Chemically also, the Arizona diatomite is similar to that of the best found elsewhere. It contains, SiO_2, 85.75 per cent; Al_2O_3, 3.50; Fe_2O_3, 1.50; CaO, 2.0 and H_2O, 5.0. Physicall it is a white to cream-colored, dull in luster, light in weight, and finely granular porous aggregate. It will absorb 1.5 to s times its weight in water and weighs when dry 18 to 20 lbs per cublic foot.

Leddo, in "Non-Metallic Minerals," gives an excellent description of diatomite. In Arizona it is found inbedded deposits in the Pleistocene or Piliocene (late Tertiary) along the banks of the San Pedro and Gila River system. The accompanying map gives the four localities, which will be described. Other deposits probably exist, but no information regarding them has been obtainable. The conditions set fort in the foregoing description, and the fact that fossils of mammoth and other prehistoric animals have been found along the banks of these rivers, warrant the conclusion that marshes, lakes and possibly inland seas once existed in this now almost arid part of Arizona. Curtis Flat is a notable locality for fossils of the Pleistocene.

The following description suggest that Arizona has valuable deposits of diatomite although probably only one is economically accessible at present, and that all of them are in a common river system.

1. Mammoth, Pinal County--This deposit is 8 miles southeast of Mammoth and 20 miles from the nearest railroad at Winkelman, Gila County. The thickness of the depos ranges from 40 to 70 ft. and it has alternate 20 to 40 ft. layers of good grade diatomite and worthless sandy material. Thin, green, cherty bands are often found. It covers 10 to 20 squares miles and is undoubtedly a good deposit. Unfortunately it is too far from the railroad. Thin chert-like layers are intercalated. The capping an intermediate layer are composed of sandstones.

At Clark School, on the edge of the property, an artesian well was drilled to depth of 700 to 800 ft. In it diatomite was encountered off and on, but no log available. In this deposit, of which a section is shown there are also found two layers of volcanic ash 8 and 14 in. thick, respectively, indicating that volcanic activity occurred during deposition. The ash probably furnished some of the silica for the organisms. It is an excellent polishing material as it is composed of small broken bubbles of volcanic glass. Three large washes cut this deposit and have in a manner prepared it for mining. The faces that resulted from erosion are steep and extend in most places to the bottom of the deposit.