DMA Form 1

DEFENSE MINERALS ADMINISTRATION
Control Slip

CONTROLLED DOCUMENT

DMEA ~~DMA~~ Docket No. 2558

DO NOT DETACH THIS SLIP

Action on this document is recorded and controlled in Reports and Records Branch. Any movement of this document between divisions or offices of DMA or movement outside DMA must be reported to the Reports and Records Branch. Actions taken that affect status of the case must also be reported.

This document has been recorded as

EXPLORATION PROJECT

Any action taken to change the type of request for assistance must be promptly reported to the Reports and Records Branch. Use DMA Form 2 for submitting these reports.

Routing Slip Copiesto USBM and USGS. One copy was retained by Region IV.

To:	Code 600, Rm. 4637	Date	6-2-52
To:	Robertson	Date	6/3/52
To:	Op Com	Date	6-13-52
To:		Date	
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DO NOT DETACH

CONTROLLED DOCUMENT

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C. 600

August 26, 1952

Memorandum

To: Chief, Operations, Control and Statistical Division

From: Nonmetallic Minerals Division

Subject: DMEA-2558 (Asbestos)
Western Chemical Company's property
Gila County, Arizona

Re: A voluntary withdrawal of application.

The subject application is voluntarily withdrawn per letter dated August 14, 1952, from W. D. Cluff, President of the Company to Walter R. Storms, Chief, Arizona-New Mexico Branch, Mining Division, Region IV. A copy of this letter is attached as are the memoranda on the subject, one from W. R. Storm to W. H. King and the other from W. H. King to the Operating Committee; the memoranda are dated August 15 and August 19, 1952, respectively.

The application should, therefore, be withdrawn and any future action for this mine should require a new application.

The Docket DMEA-2558 is returned herewith.

Jasper T. Robertson
Jasper T. Robertson
Nonmetallic Minerals Division

Attachments 4

FILE COPY
SURNAME:

Robertson
Houk

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C. 600

August 26, 1952

Memorandum

To: Chief, Operations, Control and Statistical Division

From: Nonmetallic Minerals Division

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Western Chemical Company's property
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The application should, therefore, be withdrawn and any future action for this mine should require a new application.

The Docket DMEA-2558 is returned herewith.

Jasper T. Robertson
Nonmetallic Minerals Division

Attachments 4

JTRobertson:gad

Copy to: Admin. Reading File
Docket File
Mr. Norton, G-232 GSA Bldg.
Dr. Bowles, 3510
Mr. Houk

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

224 New Customhouse
Denver 2, Colorado

August 19, 1952

Memorandum:

To: Secretary to the Operating Committee

From: Executive Officer, Field Team, Region IV

Subject: DMEA Docket 2598, Western Chemical Co's.Asbestos Property, Gila County, Arizona

Enclosed are three copies of a letter from W. D. Cluff, President, Western Chemical Company, in which he states that he is no longer interested in Exploration Assistance.

The application has been placed in our inactive file.

W. H. King

Enclosures

Denver Division
Date Rec'd.
AUG 13 1952
BUREAU OF MINES
Denver, Colorado

MINING DIVISION
REGION IV

August 15, 1952

Memorandum

To : W. H. King, Denver, Colorado

From : Chief, Arizona-New Mexico Branch, Mining Div., Region IV

Subject : DMEA Docket 2558, Western Chemical Co's. Asbestos Property, Gila County, Ariz.

Several days ago we wrote to Mr. W. D . Cluff, President of the Western Chemical Co., and asked him if he wished to withdraw his application for an exploration loan on the above property as Stewart and Shride understood that the company planned no further work on the claims.

Attached is a letter from Mr. Cluff, and although it is not signed, I assume that no further action is necessary in regard to Docket DMEA-2558. Therefore we are returning the brochure in order that it may be placed in the inactive files.

Walter R. Storms

CC: W. H. King (5)
A. F. Shride
DMEA-2558
DF

WRStorms:als

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
AUG 25 1952

Mining Division
Loans Rec'd.
AUG 1 1952
BUREAU OF MINES
Denver, Colorado

MINING DIVISION
REGION IV

August 15, 1952

Memorandum

To : W. M. King, Denver, Colorado

From : Chief, Arizona-New Mexico Branch, Mining Div., Region IV

Subject : DMMA Docket 2593, Western Chemical Co's. Asbestos Property, Gila County, Ariz.

Several days ago we wrote to Mr. W. D. Cluff, President of the Western Chemical Co., and asked him if he wished to withdraw his application for an exploration loan on the above property as Stewart and Shride understood that the company planned no further work on the claims.

Attached is a letter from Mr. Cluff, and although it is not signed, I assume that no further action is necessary in regard to Docket DMMA-2593. Therefore we are returning the brochure in order that it may be placed in the inactive files.

Walter R. Storms

Cc: W. M. King (5)
G. F. Shride
DMMA-2593
RF

WRStorms:als

C O P Y

C O P Y

WESTERN CHEMICAL CO.
625 South 5th Street
P.O. Box 3726
Phoenix, Arizona

August 14, 1952

U. S. DEPT. OF THE INTERIOR
BUREAU OF MINES
Tucson, Arizona

Attention: W. R. Storms

Dear Mr. Storms:

I have your letter of August 13, 1952. Referring to its contents, you are right in assuming that we do not wish your department to go ahead with any field action on John-Manville properties, DMEA Docket 2558, and as requested, there is to be no further action taken on Western Fiber Ores application. I am sorry my previous letter was not entirely understandable. I am

Very truly yours,

WESTERN CHEMICAL COMPANY

W. D. Cluff
President

WDC:mdp

C O P Y

FILE COPY
SURNAME:

Robertson
Houk

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C. 600

July 8, 1952

Memorandum

To: Oliver Bowles, U. S. Bureau of Mines

From: J. T. Robertson, Non-Metallic Minerals Division, DMEA

Subject: Docket No. DMEA-2558 - Asbestos
Gila County, Arizona
Western Chemical Company

Attached is a copy of a letter from F. G. Herlihy requesting that this application be held in abeyance.

Signed
J. T. Robertson, Non-Metallic
Minerals Division, Defense
Minerals Exploration Administration

J.H. 7-8-52

Attachment

JTRobertson:gad

Copy to: Docket File
Admin. Reading File
Mr. Houk

FILE COPY
SURNAME:

Robertson
Houk

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C. 600

July 8, 1952

Memorandum

To: J. J. Norton, U. S. Geological Survey

From: J. T. Robertson, Non-Metallic Minerals Division, DMEA

Subject: Docket No. DMEA-2558 - Asbestos
Gila County, Arizona
Western Chemical Company

Attached is a copy of a letter from F. G. Herlihy requesting that this application be held in abeyance.

Signed
J. T. Robertson
Non-Metallic Minerals Division
Defense Minerals Exploration
Administration

J.N.
7-8-52

Attachment

JTRobertson:gad

Copy to: Docket File
Admin. Reading File
Mr. Houk

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

224 New Customhouse
Denver 2, Colorado

June 24, 1952

Memorandum

To: C. O. Mittendorf, Acting Administrator
Defense Minerals Exploration Administration

From: Executive Officer, Field Team, Region IV

Subject: Docket DMEA 2558, Western Chemical Company (Asbestos)

Enclosed is a copy of a letter from F. G. Herlihy requesting that this application be held in abeyance.

W. H. King

W. H. King

Enclosure

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
JUN 27 1951

C
O
P
Y

HERLIHY & HERLIHY
Attorneys at Law
Suite 516 Park Central Building
412 West sixth Street
Los Angeles 14, California
Telephone Trinity 4911

June 20, 1952

Mr. W. H. King, Executive Officer
Region 4
Bureau of Mines
224 New Customhouse Building
Denver 2, Colorado

RE: DOCKET NO. DMEA-2558
Asbestos
Gila County, Arizona
Western Chemical Company

Dear Mr. King:

Under date of March 24, 1952 the Western Chemical Company filed its application for exploration aid with the Defense Minerals Exploration Administration.

It is our understanding that this application is now in your hands for processing.

The applicant now believes that further engineering and geological work should be done by it upon the property involved before an inspection is made by your Bureau, and before the application is in any way acted upon by the Administration.

The applicant therefore requests that the application be held in abeyance by you, without further action being taken thereon, until such time as the applicant is in possession of additional engineering and geological information. Thereafter the applicant will either withdraw the application or request further proceedings herein.

Thanking you for your attention given this matter, we are,

Yours very truly,

WESTERN CHEMICAL COMPANY

By /s/ F. G. Herlihy
Its Attorney

FGH:mc

E. HERBERT HERLIHY
F. GEORGE HERLIHY
K. A. STOLL
THOMAS E. RYAN
JOHN F. McLAUGHLIN
E. H. KENDIG, JR.
RAY B. CUMMING

HERLIHY & HERLIHY
ATTORNEYS AT LAW
SUITE 516 PARK CENTRAL BUILDING
412 WEST SIXTH STREET
LOS ANGELES 14, CALIFORNIA
TELEPHONE TRINITY 4911

CABLE ADDRESS
HERANDHER

~~M. A. CORNELL~~
~~ASSOCIATE COUNSEL~~

June 20, 1952

Mr. W. H. King, Executive Officer
Region 4
Bureau of Mines
224 New Customhouse Building
Denver 2, Colorado

RE: DOCKET NO. DMEA-2558
Asbestos
Gila County, Arizona
Western Chemical Company

COPY

Dear Mr. King:

Under date of March 24, 1952 the Western Chemical Company filed its application for exploration aid with the Defense Minerals Exploration Administration.

It is our understanding that this application is now in your hands for processing.

The applicant now believes that further engineering and geological work should be done by it upon the property involved before an inspection is made by your Bureau, and before the application is in any way acted upon by the Administration.

The applicant therefore requests that the application be held in abeyance by you, without further action being taken thereon, until such time as the applicant is in possession of additional engineering and geological information. Thereafter the applicant will either withdraw the application or request further proceedings herein.

Thanking you for your attention given this matter, we are,

Yours very truly,

WESTERN CHEMICAL COMPANY

By F. G. Herlihy
Its Attorney

FGH:mc

FILE COPY
SURNAME:

Robertson
Houk

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

600

JUN 16 1952

Mr. W. H. King
Executive Officer, Region IV
Bureau of Mines
224 New Customhouse Building
Denver 2, Colorado

Subject: Docket No. DMA-2558
Asbestos
Western Chemical Company
Gila County, Arizona

Dear Mr. King:

The supporting information submitted with the subject application is very inadequate and it will be necessary for the Field Team to review the case and send to this office their report and recommendations.

No specific program of work is submitted by the applicant, no geological information to justify the work is presented, and the equipment requirements listed in the application seem excessive. A review with the applicant and a field inspection of the mine appears to be desirable.

Enclosed please find for your information memoranda comments of the Commodity Specialist of the Geological Survey and the Bureau of Mines.

Sincerely yours,

(signed) FRANK E. JOHNSON
(JTR)

Chairman, Operating Committee
Defense Minerals Exploration
Administration

P.N.
6-16-52

Enclosures - 2

JTRobertson:mp 6/11/52
cc: Docket File
Operating Committee (2)
Adm. Reading File
Dr. Oliver Bowles, 3522
Mr. Norton, G-232, GSA Bldg.
Mr. Houk

Approved:

Charles N. Merrill
Member, Bureau of Mines

D. M. Lemmon
Member, Geological Survey

FILE COPY
SURNAME:

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

600

JUN 16 1952

Robertson
Houk
Wyrick
Johnson

Mr. William . Cluff, President
Western Chemical Company
c/o Herlihy & Herlihy
412 West Sixth Street
Los Angeles 14, California

Subject: Docket o. A-2558
Asbestos
Gila County, Arizona

Dear Mr. Cluff:

Your application is being referred to r. . H. King, Executive Officer, Region IV, Bureau of Mines, 224 ew Custom-House Building, Denver 2, Colorado, for further information.

Sincerely yours,

C. O. Mittendorf

J.N. 6-16-52

Acting Administrator
Defense Minerals Exploration
Administration

JTRobertson:mp 6/11/52
cc: Docket File
Field Team, Region IV (2)
Operating Committee (2)
Mr. Norton, G-232, GSA Bldg.
Dr. Oliver Bowles, 3522
Mr. Houk

FILE COPY
SURNAME:

Robertson

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C. 600

June 10, 1952

Memorandum

To: Chairman, Operating Committee, DMA

From: Non-Metallic Minerals Division, DMA

Subject: Docket No. DMA-2558 - Asbestos
Western Chemical Company
Gila County, Arizona
Recommendation to refer to Field Team

The applicant proposes to explore for asbestos in four unpatented lode claims, part of a larger group of 78 claims now owned by the applicant. The four claims, lying close to the Southeast Corner of the property have not been worked, but the mine as a whole has many workings, having employed up to 170 men in former operations by Johns-Manville Company.

The estimated cost of the present project is $63,369. However, the estimates are not detailed as to specific work or a definite planned program but in a very general way. The applicant, in explaining the program, simply states "exploratory drifts and tunnels will be made upon the four claims at points indicated by the geological formation and showings now upon the claims." The items of cost for equipment are extravagant and excessive and the necessity for much of it is not proven.

The application is entirely inadequate in the presentation of a specific program of work and no geology is shown to point up the best places to explore.

A Field Team report is requested. The attached memoranda from Geological Survey and Bureau of Mines, also suggest that the application be referred to the Field Team.

A copy of proposed letter to the Regional Office Field Team is attached.

Jasper T. Robertson
Non-Metallic Minerals Division

Attachments
JTRobertson:mp
cc: Dr. Oliver Bowles, 3522
Mr. Norton, G-232, GSA Bldg.
Mr. Houk

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D. C. 600

June 10, 1952

noted 6-13-52

Memorandum

To: Chairman, Operating Committee, DMEA

From: Non-Metallic Minerals Division, DMEA

Subject: Docket No. DMEA-2558 - Asbestos
Western Chemical Company
Gila County, Arizona
Recommendation to refer to Field Team

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A copy of proposed letter to the Regional Office Field Team is attached.

Jasper T. Robertson
Jasper T. Robertson
Non-Metallic Minerals Division

Attachments

IN REPLY REFER TO:

G-MD-PLW

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

June 9, 1952

Memorandum

REVIEW OF APPLICATION DMEA-2558 (Chrysotile).

To: L. G. Houk, Non-Metallic Minerals Division, DMEA.
From: P. L. Weis, U. S. Geological Survey.
Applicant: Western Chemical Company.
Name of property: 4 Mining Claims: Asbestin No. 43, 44, 51, 52.
Location of property: McMillan Mining District, Gila County, Arizona.
Estimated cost of project: $63,369.32.
Summary of applicants' proposal:

(1) Build 1¼ miles of access road.
(2) Exploratory trenching and drifting on all four of the mining claims.

Sources of information on applicants' property:

(1) Arizona Bureau of Mines Bulletin 126, 1928.

Comments: None.

RECOMMENDATION:

Refer to field team.

Paul L. Weis

Paul L. Weis

Department of the Interior
Defense Minerals Administration
RECEIVED
JUN 10 1952

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON 25, D. C.

June 3, 1952

Memorandum

To: Lawrence G. Houk, Chief, Nonmetallic Minerals Division
Defense Minerals Exploration Administration

From: Oliver Bowles, Commodity Specialist
Construction and Chemical Materials Branch

Subject: DMEA-2558, Western Chemical Company

The areas where the proposed work is to be done are not fully described. Are the areas A-43, A-44, A-51 and A-52 undeveloped at this time or do they include some of the Johns-Manville underground workings?

The nature of the proposed work is not fully defined. Do the plans include drilling, drifting or both? Number and arrangement of holes, their depth and total footage should be defined. Also the length of proposed drifts, and their location and direction require definition.

I would recommend that the application be sent to the field team for report on the geology of the area, and the prospects for discovery.

Oliver Bowles

Oliver Bowles, Commodity Specialist
Construction and Chemical Materials Branch

Form MF-103
(Revised June 1951)

UNITED STATES DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

Budget Bureau No. 42-R1035.1.

MF-103 Should Be Filed With General Technical Data Form MF-100

APPLICATION FOR AID FOR AN EXPLORATION PROJECT PURSUANT TO MINERAL ORDER 5, UNDER DEFENSE PRODUCTION ACT OF 1950

Not To Be Filled in by Applicant

Docket No. DMEA-2558
Metal or Mineral
Date Received 6-2-52
Amount $
Participation (Government %)

JUN 2 1952

Western Chemical Co., (a corp.)
c/o Herlihy & Herlihy
412 West Sixth Street
Los Angeles 14, California

Name and address of applicant

Date March 24, 1952

If you have already filed MF-100, give date filed Concurrently, type of assistance requested Aid under MO-5,

DMA Docket Number (if available) None available.

INSTRUCTIONS

Read Mineral Order 5, Regulations Governing Government Aid in Defense Projects, before completing this application. Submit four copies each, of the signed application form, General Technical Data Form MF-100, and answers to questions as specified, to Defense Minerals Administration, Department of the Interior, Washington 25, D. C., or to the nearest field executive office thereof, with your name and address on each sheet of the application and all accompanying papers. If you have previously filed MF-100, it is not necessary to file it again. However, you should indicate in space provided above the type of assistance previously applied for (loans, procurement contracts, etc.) and DMA Docket Number, if available. *When a question is inapplicable it should be so stated in the form.* Additional sheets should be attached in answering any questions or in supplying additional information. IF YOU CANNOT ANSWER A QUESTION, SO STATE.

1. (*a*) Give a description of the real property that will be in any way involved in the exploration project, including any existing mine or operating property.

   (*b*) If you are not the owner of the property, submit a copy of the lease, purchase option, or other agreements under which you are authorized to operate the property with each copy of your application.

   (*c*) Give the legal description of the exact parcel, plot, or area upon which the exploration is to be conducted.

   NOTE: (1) If both areas are the same, so state. The only obligation to repay the Government is from the net earnings from any commercial discovery made in the area specified in (*c*) above in which the exploration is to be conducted, and the expenditure of funds which may be charged as costs of the project must be limited to that area or to work necessary to perform the exploration in that area.

   (2) If applicant is not the owner of the property or if there are any liens or encumbrances against the property, copy of agreements of claimants, lienors, encumbrances, and lessors subordinating their interests in the property to the interest of the Government under the Exploration Project Contract will be required for attachment to the Contract.

2. (*a*) What metals or minerals do you expect to find?

   (*b*) Furnish statement of the geologic features of your property, giving type of ore deposit and reasons for expecting to find commercial ore bodies. Illustrate with maps or sketches. If you have a geologic or engineering report, or assay maps showing width and grade, please send them with application, stating whether or not you wish to have them returned.

The information requested in questions 3, 4, 5, 6, 7, 8, and 9 below should be answered specifically and in detail, as this information will be attached to and incorporated as part of the Exploration Project Contract, if such contract is entered into with you by the Government.

ANSWER EACH QUESTION ON SEPARATE SHEETS OF PAPER AND SUBMIT A COPY OF EACH ANSWER FOR EACH COPY OF YOUR APPLICATION.

3. (*a*) Describe fully the proposed work and give the total cost of the project.

   (*b*) State the time required to start the project and to complete it.

4. Submit a map or sketch of the property involved showing a plan (and cross section, if needed) of the present mine workings and the *location of the proposed exploration work* as related to geologic features, such as contacts, veins, ore-bearing beds, etc.

5. Furnish an itemized list of existing facilities, buildings, installations, and fixtures with a statement of the cost of any necessary rehabilitation or repairs to put into useful and operable condition.

6. Furnish a detailed list of additional facilities, buildings, and fixtures to be purchased, installed, or erected by you, with the estimated cost of each item.

7. Furnish a detailed list of operating equipment, separated into items to be—

   (*a*) Rented

   (*b*) Purchased

   (*c*) Furnished by you

   with the rental, purchase price, or depreciation of each item, as the case may be, to be charged as a cost of the project.

8. Furnish an itemized schedule of labor, by numbers and classes (miners, muckers, etc.) and of supervisors by numbers and positions, with the maximum wages or salaries to be paid to each.

9. Furnish a detailed list with estimated cost of each item for materials, supplies, engineering, assaying, accounting, power, water, utilities, and any other items not provided for above.

10. (*a*) How much are you prepared to invest in the proposed project?

    (*b*) Is this amount sufficient to pay your part of the cost of the project, in accordance with the regulations on Government participation (Sec. 9 of MO–5)?

11. State any conditions or circumstances regarding the property not sufficiently brought out by the foregoing questions.

CERTIFICATION

The undersigned company, and the official executing this certification on its behalf, hereby certify that the information contained in this form and accompanying papers is correct and complete to the best of their knowledge and belief.

WESTERN CHEMICAL COMPANY (a corp.)
(Name of company)

By William D. Bluff
(Signature of authorized official)

March 24, 1952
(Date)

President
(Title)

Title 18, U. S. Code (Crimes), Section 1001, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U. S. GOVERNMENT PRINTING OFFICE 16—64067-2

I.

(a) The property owned and held by the applicant consists of the following mining claims located in the McMillan Mining District in the County of Gila, State of Arizona, and consists of 22 patented mining claims known as Asbestin Numbers 1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 16, 17, 18, 19, 20, 25, 26, and 30; and Rim Rock Numbers 3, 4, and 5; and Rocky Point Number 1; together with 42 unpatented mining claims described as Asbestin Numbers 4, 8, 13, 15, 23, 24, 27, 28, 29, 31, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 51, 52, 53 and 54; Rim Rock Number 8; Rocky Point Numbers 2, 3, 4 and 5; Victory Numbers 1, 3, and 4; Depression Numbers 1, 2, 3, 4, 5 and 6.

(c) The area upon which the exploration is to be conducted is contained in those 4 certain unpatented lode mining claims situated in the McMillan Mining District, Gila County, State of Arizona, the names of which, the dates of recordation, and the book and page of records of mines in the office of the County Recorder of said Gila County, Arizona, are as follows:

LODE NAME	DATE RECORDED	MINING LOC. #	BOOK NO.	PAGE NO.
Asbestin #43	July 5, 1921	57781	35	480
Asbestin #44	July 5, 1921	57782	35	481
Asbestin #51	May 8, 1929	96821	43	384
Asbestin #52	Sept. 26, 1929	99829	43	566

II.

(a) Chrysotile Asbestos Ore, unmilled.

(b) In response to this question, reference is made to the Arizona Bureau of Mines Bulletin Number 126, entitled "Asbestos Deposits of Arizona", copies of which are attached to Form MF-100, and said bulletin is made a part hereof as though fully set out herein. Attention is particularly directed to Pages 37 to 48 inclusive, of said bulletin. The applicant proposes to make a road into the various claims from the existing graded road, and to improve the present grading road to the point where it joins with paved Highway Number 60. With laterals, approximately one to one and one-quarter miles of road will be made, and the graded road will be relocated and regraded at two points. Since very little rainfall is anticipated, road servicing on the new road will not be required or necessary during the exploration phase of the work. Thereafter, applicant proposes to use three one hundred sixty foot compressors and one two hundred ten cubic foot compressors, eight air drilling machines and other necessary equipment, and to employ eight miners. Exploratory tunnels and drifts will be made upon the four claims at points indicated by the geological formation and showings now upon the claims. It is not anticipated that core drilling will be undertaken, unless later developments indicate the advisability thereof. The exploratory work will be spread over the four claims herein insofar as it is possible and advisable to do so.

The total cost of the project, based upon present known costs of equipment and labor is the sum of Sixty-three thousand three hundred sixty-nine and 32/100 dollars ($63,369.32).

(b) Upon the application being approved and funds being made available, work can be commenced forthwith. The project will require six months to complete.

IV.

A photostatic copy of a map showing the relation of the property herein involved to known production is herewith attached, and by reference made a part hereof.

V.

There are no existing facilities, buildings, installations nor fixtures upon the four claims mentioned herein. However, located upon the patented properties owned by the applicant, there is a residence, a warehouse, and a machine shop, all of which will be available for use in the exploration work.

VI.

(a)	The applicant proposes to purchase three trailer houses for living quarters for the crew. The cost of these trailer houses will be $600.00 each, for the total sum of	$ 1,800.00
(b)	Three ore bins will be constructed at a cost of $400.00 each for a total sum of	1,200.00
	Total Cost of Item VI:	$ 3,000.00

VII.

(a)	Rented.	
	1. Road building equipment, fully maintained and driven, 30 days at $80.00 per day	$ 2,400.00
	2. One dump truck, fully maintained and driven, 150 days at $24.00 per day	3,600.00
	3. Three 160 cubic foot compressor units, at $15.00 a day each for 150 days	6,750.00
	4. One 210 cubic foot compressor at $17.00 a day for 150 days	2,550.00
(b)	Purchased.	
	1. Eight air drilling machines at $400.00 each	3,200.00
	2. Drill Steel for 150 days	800.00
	3. Air hose and pipe for drills	500.00
	4. Miscellaneous small tools and items	500.00
	5. Powder, caps and fuse for 150 days	3,000.00
	6. Gas, diesel and oil for 150 days	3,740.00

	7. Mine timber	$ 1,000.00
	8. Four hand-operated mine cars and 1,000 foot of track	1,400.00
(c)	None.	
	Total operating equipment, Item VII	$29,440.00

VIII.

(a)	Eight laborers at $50.00 per week, for eight weeks	3,200.00
(b)	Eight miners at $1.75 per hour each, 8 hours per day for 150 days	16,800.00
(c)	Superintendent, $500.00 per month for six months	3,000.00
(d)	Foreman, $400.00 per month for six months	2,400.00
	Total labor and supervision, Item VIII	$25,400.00

IX.

(a)	Accounting, timekeeping and bookkeeping, $400.00 per month for six months	$ 2,400.00
(b)	Workman's Compensation, Underground Mines and supervision at $10.25 per $100.00 of payroll	2,430.90
	Laborers at $6.61 per $100.00 of payroll	211.52
(c)	Public Liability and property damage insurance	105.90
(d)	Social Security at .015	381.00
(e)	Water is available in sufficient quantities at no cost.	
	Total miscellaneous Item IX	$5,529.32
	TOTAL COST OF PROJECT ----------	$ 63,369.32

X.

(a) Applicant is prepared to invest in the project the sum of Six Thousand Three Hundred Thirty-Six Dollars Ninty-Five Cents ($6,336.95).

(b) Said amount is sufficient to pay applicant's portion of the cost of said project.

XI.

An associated company owned by the stockholders of this applicant is now successfully engaged in the City of Los Angeles, California, in the commercial processing and fiberizing of asbestos crudes. The said associated company now plans to construct an asbestos cruding mill at Chrysotile, Arizona, for the purpose of cruding asbestos ores, if any

are produced as a result of the exploration project herein planned. Therefore, should asbestos ores in commercial quantities be found as a result of this exploration project, it will then be possible to produce, crude, process and fiberize the asbestos under a unified plan of operation, and within a limited geographical area, thus eliminating excessive freight hauls.

Form MF-100
(May 1951)

U. S. DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

Form approved.
Budget Bureau No. 42-R1026.

GENERAL TECHNICAL DATA FOR USE UNDER THE DEFENSE PRODUCTION ACT OF 1950

NOT TO BE FILLED IN BY APPLICANT

Docket No. DMEA-2558

Date received 6-2-52

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
JUN 2 1952

Western Chemical Company
c/o Herlihy & Herlihy
412 West Sixth Street
Los Angeles 14, California

Name and address of applicant

Date March 24, 1952

INSTRUCTIONS

This form is to be filed with Defense Minerals Administration, Department of the Interior, Washington 25, D. C. It should be accompanied by appropriate application form when a specific type of Government assistance is requested, in the form of (1) loan, (2) purchase contract, (3) Government guarantee of a private loan, (4) priorities or allocation of mining equipment, and maintenance, repair and operating supplies, and (5) other forms of Government assistance that might arise under the Act. Submit four (4) signed copies of the form and accompanying papers. Name and address should be stamped or typed on each sheet of this form and all accompanying papers. *When a question is inapplicable it should be so stated on the form.* Additional sheets may be attached in answering any questions or in supplying additional information. (IF YOU CANNOT ANSWER A QUESTION, SO STATE.) If a question is answered elsewhere indicate where answered. It is not necessary to answer it again.

GENERAL TECHNICAL DATA

Supply the following information on separate sheets, arranged, numbered, and lettered as indicated:

1. Materials produced:
   (*a*) What are the chief mine, mill, or smelter products?
   (*b*) What are the byproducts, if any?
2. Name(s) and type(s) of mine(s), mill(s), smelter(s), refinery(ies), pit(s), quarry (ies), drilling operation(s). Include old names of property, if any. Show extent of workings, including the following:
   (*a*) Linear feet of shafts.
   (*b*) Linear feet of drifts and crosscuts.
   (*c*) Linear feet of tunnels or adits.
   (*d*) Linear feet of other mine openings (explain briefly).

   Indicate whether mine is flooded or not. Describe any pumping problems. Give size or productive capacity.
3. For each operation listed above supply the following:
   (*a*) Distance and direction from nearest town and shipping point.
   (*b*) Mining district.
   (*c*) Township, Section, Range.
   (*d*) County, State.
4. (*a*) State whether or not property is now in operation, and if in operation, by whom operated.
   (*b*) Are you operating this property as:
   - ☐ Owner.
   - ☐ Lessee.
   - ☐ Contractor.
5. Number of years in production _____

   If not in production or operation, estimated date when production will begin _____
6. Experience of operators:
   Describe the mining and general business experience of (*a*) the applicant, and (*b*) the person or persons who manage the project.
7. History:
   (*a*) Give a statement, as complete as possible, of previous exploration, development, operation, and production of property, with reasons for suspension of operation.
   (*b*) State briefly the known history and production of adjoining and neighboring properties.
   (*c*) Furnish any available (private) reports that may apply to this application, including results of mine examinations, recommended exploration and development, and metallurgical investigations.

8. Names and addresses of Officers, Directors, or Partners, and in addition thereto, the five largest stockholders if applicant is a corporation.

Name and Address (a)	Official Title (If officer is also director indicate by "D") (b)	Total of Annual Salary, Commissions, Bonuses, Etc., Received From Applicant and Affiliates During Last Fiscal Year (c)	Estimated Net Worth Outside of Interest in Applicant (d)	Number of Shares Held in Applicant Corporation: Common (e)	Number of Shares Held in Applicant Corporation: Preferred (f)	Life Insurance Carried for Benefit of Applicant: Amount (g)	Life Insurance Carried for Benefit of Applicant: Net Cash Surrender Value After Loans (h)
William D. Cluff	President D	$ 13,050.	$ 50,000	3044	None	None	
W. Eldon Mitchell	Vice-Pres D	4,096.	3,500	1	None	None	
Gareld W. Johns	Secy-Treas D	10,850.	30,000	1522	None	None	
(The address of the above persons is: 625 South 5th Street, Phoenix, Arizona.)							
	Total		x x x x x			x x x x x	x x x x x

If more lines are needed continue on separate sheet.

9. Capital Stock Issues:

For Corporate Applicants

Item	Authorized (a)	Outstanding (b)	Par Value (c)	Number of Shares Outstanding (d)	Dividend Rate Last Paid* (e)
Common stock	50,000.00	45,670.00	$10.00	4567	None
Preferred stock	$ None	$	$		

*Indicate period covered.

10. Production:

Item	Kind of Product (a)	1948 Total (b)	1949 Total (c)	1950 Total (d)	Present Average Monthly (e)
1. Quantity of product mined or quarried (Short, long, metric tons; barrels; pounds; etc.)	None				
2. Quantity of product processed (specify unit of measure and type of process)	None				
3. Quantity and grade of product sold or shipped (specify units of measure)	None				

11. Do you contemplate a change in the present average monthly rate of production? If so, state estimated maximum monthly production and basis of change.

12. Ore or Mineral Reserves:

(a) Describe the ore or mineral deposit briefly. Accompany the application by any available report on the geology and ore reserves.

1. (a) Chrysotile Asbestos Ore, unmilled

   (b) None to date.

2. Unpatented Asbestos mining claims located in the McMillan Mining District, Gila County, Arizona, being 4 in number and more particularly described as follows:

LODE NAME	DATE RECORDED	MINING LOC. NO.	BOOK NO.	PAGE NO.
Asbestin No. 43	July 5, 1921	57781	35	480
Asbestin No. 44	July 5, 1921	57782	35	481
Asbestin No. 51	May 8, 1929	96821	43	384
Asbestin No. 52	Sept. 26, 1929	99829	43	566

The foregoing claims are part of the property formerly owned by the Johns-Manville Products Corporation at Chrysotile, Arizona, now owned by the applicant.

(a) (b) (c) (d) Only assessment and development work has been done upon the property to date.

No flooding problem exists, nor is likely to arise upon the property.

3. (a) Thirty-five miles northerly from Globe, Arizona. Shipping point Globe, Arizona.

   (b) McMillan Mining Districts.

   (c) Information not available.

   (d) Gila County, Arizona.

4. (a) Above described property is not now in operation, other than for assessment work.

   (b) As owner of said mining claims.

5. Number of years in production, none. It is estimated that production will start within seven months from and after contract is made under this application.

6. Mr. W. D. Cluff, President, has been engaged in the business of buying, selling and grading non-metallics for a period of fifteen years. For the last two years of this period he has also engaged in processing and fiberizing asbestos. The applicant intends to employ as mining foreman a man of ten years experience in mining asbestos and other non-metallic ores.

7. (a) (b) (c) Attached hereto and by reference made a part hereof is a copy of Arizona Bureau of Mines Bulletin No. 126, entitled "Asbestos Deposits of Arizona". Attention is directed to Pages 37 to 48, inclusive. Road conditions have materially improved and road distances have been shortened since this bulletin was written.

13. Approximately 3 miles of graded road which then connects with Highway 60, a paved highway into Globe, Arizona. Roads are excellent except the three miles mentioned, which will require reworking.

14. Ash Creek runs through the property and furnishes all the water required throughout the year.

15. Internal combustion engines will be used.

16. Eight miners and eight laborers will be employed.

17. A residence, a warehouse, a machine shop and a mill building is upon the patented portion of the property owned by the applicant. An electric light and power plant is available for lights and machine shop power.

18. In the event that the exploration project planned herein is successful, a unified plan will be undertaken for prompt and economical mining, cruding, accurate grading, processing and fiberizing the asbestos ores.

(*b*) If deposit is other than placer:

(1) Submit assay plans and/or sections showing location and size of proved (measured) and probable (indicated) ore or mineral reserve.

(2) State the tonnage (indicate type of ton) and grade of each class of ore reserve, as above, and show how computed. Tabulated total ore reserve as follows:

TOTAL ORE OR MINERAL RESERVES

Ore or Mineral Reserve	Estimated Tons (a)	Metal or Mineral Content Per Ton (Grade) (b)	Gross Value Per Ton (c)	Recoverable Unit Value Per Ton (d)	Estimated Cost of Production Per Ton (e)
Measured (proved)	None				
Indicated (probable)	None				

(*c*) If placer: Inapplicable.

(1) Give estimated total yardage and average marketable mineral content of each deposit.

(2) Submit map showing location of placer deposit and surrounding area, with all test holes or pits. Submit logs of each hole and test pit with depth and average value of each.

(3) Describe gravel, stating whether fine, medium or coarse; loose, tight, cemented, or frozen, and whether it contains stumps or boulders more than 1 foot in diameter; if so, how large, and in what proportion.

(4) Describe bedrock, giving type (granite, sandstone, shale, etc.) and state whether it is hard or soft, smooth, uneven or rough.

(5) Describe overburden, stating whether loose, tight, or cemented; fine or coarse textured; furnish estimate of average thickness and total amount.

(6) Tabulate the reserves using the form outlined above for ore or mineral reserves.

13. Access Roads:

Give road distances to shipping, supply and residence points, stating kind and condition of roads.

14. Water Supply:

State source and quantity of water available for operations and whether sufficient for all seasons of year.

15. Power:

State amount of power used, rate per hour, and source thereof.

16. Labor:

State number and classes (miners, muckers, millmen, etc.) of men employed during a recent representative payroll period.

17. Equipment and Facilities:

Describe present equipment on the property, including buildings. (State condition.) List major pieces of equipment now owned or controlled and in serviceable condition available for this operation.

18. Are there any particular conditions or circumstances affecting your operations that are not described above? If so, explain.

CERTIFICATION

The undersigned company, and the official executing this certification on its behalf, hereby certify that the information contained in this form and accompanying papers is correct and complete to the best of their knowledge and belief.

Western Chemical Company
(Name of company)

By William D. Cluff
(Signature of authorized official)

March 24, 1952
(Date)

President
(Title)

Title 18, U. S. Code (Crimes), Section 1001, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U. S. GOVERNMENT PRINTING OFFICE 16—63792-1

EXPLORATION

Subject: DMEA-2558
Re: Exploration Loan
Asbestin Nos. 43, 44, 51, and 52
June 2, 1952

Mr. William D. Cluff, President
Western Chemical Co.
c/o Herlihy & Herlihy
412 West Sixth Street
Los Angeles 14, California

My dear Mr. Cluff:

This will acknowledge receipt of your application dated March 24, 1952 for a loan under the Defense Production Act of 1950.

Your application was assigned Docket Number DMEA-2558 and referred to the Non-Metallics Division.

Kindly refer to DMEA-2558 in any future correspondence relating to your application.

Sincerely yours,

ROBERT E. ADAMS

Robert E. Adams
Administrative Officer

7862

DMEA-0558

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

DEPARTMENT OF THE INTERIOR
Bureau of Mines
JUN 2 1952

224 New Customhouse
Denver 2, Colorado

May 27, 1952

Memorandum

To: Secretary to the Operating Committee, Defense Minerals Exploration Administration

From: Field Team, Region IV

Subject: (Asbestos) Application of Western Chemical Company, Chrysotile, Arizona

Enclosed herewith is the subject application for Government assistance in exploration work estimated to cost $63,369.32.

W. H. King
W. H. King

A. H. Koschmann
A. H. Koschmann

DMEA 2558

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

224 New Customhouse
Denver 2, Colorado

May 27, 1952

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To: Secretary to the Operating Committee, Defense Minerals Exploration Administration

From: Field Team, Region IV

Subject: (Asbestos) Application of Western Chemical Company, Chrysotile, Arizona

Enclosed herewith is the subject application for Government assistance in exploration work estimated to cost $63,369.32.

W. H. King
W. H. King

A. H. Koschmann
A. H. Koschmann

Form MF-103
(Revised June 1951)

UNITED STATES DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

Budget Bureau No. 42-R1035.1.

MF-103 Should Be Filed With General Technical Data Form MF-100

APPLICATION FOR AID FOR AN EXPLORATION PROJECT PURSUANT TO MINERAL ORDER 5, UNDER DEFENSE PRODUCTION ACT OF 1950

Not To Be Filled in by Applicant

Docket No. DMEA-2558
Metal or Mineral
Date Received 6-2-52
Amount $
Participation (Government %)

JUN 2 1952

Western Chemical Co., (a corp.)
c/o Herlihy & Herlihy
412 West Sixth Street
Los Angeles 14, California

Name and address of applicant

Date March 24, 1952

If you have already filed MF-100, give date filed Concurrently, type of assistance requested Aid under MO-5

DMA Docket Number (if available) None available.

INSTRUCTIONS

Read Mineral Order 5, Regulations Governing Government Aid in Defense Projects, before completing this application. Submit four copies each, of the signed application form, General Technical Data Form MF-100, and answers to questions as specified, to Defense Minerals Administration, Department of the Interior, Washington 25, D. C., or to the nearest field executive office thereof, with your name and address on each sheet of the application and all accompanying papers. If you have previously filed MF-100, it is not necessary to file it again. However, you should indicate in space provided above the type of assistance previously applied for (loans, procurement contracts, etc.) and DMA Docket Number, if available. *When a question is inapplicable it should be so stated in the form.* Additional sheets should be attached in answering any questions or in supplying additional information. IF YOU CANNOT ANSWER A QUESTION, SO STATE.

1. (*a*) Give a description of the real property that will be in any way involved in the exploration project, including any existing mine or operating property.

   (*b*) If you are not the owner of the property, submit a copy of the lease, purchase option, or other agreements under which you are authorized to operate the property with each copy of your application.

   (*c*) Give the legal description of the exact parcel, plot, or area upon which the exploration is to be conducted.

   NOTE: (1) If both areas are the same, so state. The only obligation to repay the Government is from the net earnings from any commercial discovery made in the area specified in (*c*) above in which the exploration is to be conducted, and the expenditure of funds which may be charged as costs of the project must be limited to that area or to work necessary to perform the exploration in that area.

   (2) If applicant is not the owner of the property or if there are any liens or encumbrances against the property, copy of agreements of claimants, lienors, encumbrances, and lessors subordinating their interests in the property to the interest of the Government under the Exploration Project Contract will be required for attachment to the Contract.

2. (*a*) What metals or minerals do you expect to find?

   (*b*) Furnish statement of the geologic features of your property, giving type of ore deposit and reasons for expecting to find commercial ore bodies. Illustrate with maps or sketches. If you have a geologic or engineering report, or assay maps showing width and grade, please send them with application, stating whether or not you wish to have them returned.

The information requested in questions 3, 4, 5, 6, 7, 8, and 9 below should be answered specifically and in detail, as this information will be attached to and incorporated as part of the Exploration Project Contract, if such contract is entered into with you by the Government.

ANSWER EACH QUESTION ON SEPARATE SHEETS OF PAPER AND SUBMIT A COPY OF EACH ANSWER FOR EACH COPY OF YOUR APPLICATION.

3. (*a*) Describe fully the proposed work and give the total cost of the project.

   (*b*) State the time required to start the project and to complete it.

4. Submit a map or sketch of the property involved showing a plan (and cross section, if needed) of the present mine workings and the *location of the proposed exploration work* as related to geologic features, such as contacts, veins, ore-bearing beds, etc.

5. Furnish an itemized list of existing facilities, buildings, installations, and fixtures with a statement of the cost of any necessary rehabilitation or repairs to put into useful and operable condition.

6. Furnish a detailed list of additional facilities, buildings, and fixtures to be purchased, installed, or erected by you, with the estimated cost of each item.

7. Furnish a detailed list of operating equipment, separated into items to be—

   (*a*) Rented

   (*b*) Purchased

   (*c*) Furnished by you

   with the rental, purchase price, or depreciation of each item, as the case may be, to be charged as a cost of the project.

8. Furnish an itemized schedule of labor, by numbers and classes (miners, muckers, etc.) and of supervisors by numbers and positions, with the maximum wages or salaries to be paid to each.

9. Furnish a detailed list with estimated cost of each item for materials, supplies, engineering, assaying, accounting, power, water, utilities, and any other items not provided for above.

10. (*a*) How much are you prepared to invest in the proposed project?

    (*b*) Is this amount sufficient to pay your part of the cost of the project, in accordance with the regulations on Government participation (Sec. 9 of MO–5)?

11. State any conditions or circumstances regarding the property not sufficiently brought out by the foregoing questions.

CERTIFICATION

The undersigned company, and the official executing this certification on its behalf, hereby certify that the information contained in this form and accompanying papers is correct and complete to the best of their knowledge and belief.

WESTERN CHEMICAL COMPANY (a corp.) By William D. Ehrlich
(Name of company) (Signature of authorized official)

March 24, 1952 President
(Date) (Title)

Title 18, U. S. Code (Crimes), Section 1001, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U. S. GOVERNMENT PRINTING OFFICE 16—64067-2

I.

(a) The property owned and held by the applicant consists of the following mining claims located in the McMillan Mining District in the County of Gila, State of Arizona, and consists of 22 patented mining claims known as Asbestin Numbers 1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 16, 17, 18, 19, 20, 25, 26, and 30; and Rim Rock Numbers 3, 4, and 5; and Rocky Point Number 1; together with 42 unpatented mining claims described as Asbestin Numbers 4, 8, 13, 15, 23, 24, 27, 28, 29, 31, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 51, 52, 53 and 54; Rim Rock Number 8; Rocky Point Numbers 2, 3, 4 and 5; Victory Numbers 1, 3, and 4; Depression Numbers 1, 2, 3, 4, 5 and 6.

(c) The area upon which the exploration is to be conducted is contained in those 4 certain unpatented lode mining claims situated in the McMillan Mining District, Gila County, State of Arizona, the names of which, the dates of recordation, and the book and page of records of mines in the office of the County Recorder of said Gila County, Arizona, are as follows:

LODE NAME	DATE RECORDED	MINING LOC. #	BOOK NO.	PAGE NO.
Asbestin #43	July 5, 1921	57781	35	480
Asbestin #44	July 5, 1921	57782	35	481
Asbestin #51	May 8, 1929	96821	43	384
Asbestin #52	Sept. 26, 1929	99829	43	566

II.

(a) Chrysotile Asbestos Ore, unmilled.

(b) In response to this question, reference is made to the Arizona Bureau of Mines Bulletin Number 126, entitled "Asbestos Deposits of Arizona", copies of which are attached to Form MF-100, and said bulletin is made a part hereof as though fully set out herein. Attention is particularly directed to Pages 37 to 48 inclusive, of said bulletin. The applicant proposes to make a road into the various claims from the existing graded road, and to improve the present grading road to the point where it joins with paved Highway Number 60. With laterals, approximately one to one and one-quarter miles of road will be made, and the graded road will be relocated and regraded at two points. Since very little rainfall is anticipated, road servicing on the new road will not be required or necessary during the exploration phase of the work. Thereafter, applicant proposes to use three one hundred sixty foot compressors and one two hundred ten cubic foot compressors, eight air drilling machines and other necessary equipment, and to employ eight miners. Exploratory tunnels and drifts will be made upon the four claims at points indicated by the geological formation and showings now upon the claims. It is not anticipated that core drilling will be undertaken, unless later developments indicate the advisability thereof. The exploratory work will be spread over the four claims herein insofar as it is possible and advisable to do so.

The total cost of the project, based upon present known costs of equipment and labor is the sum of Sixty-three thousand three hundred sixty-nine and 32/100 dollars ($63,369.32).

(b) Upon the application being approved and funds being made available, work can be commenced forthwith. The project will require six months to complete.

IV.

A photostatic copy of a map showing the relation of the property herein involved to known production is herewith attached, and by reference made a part hereof.

V.

There are no existing facilities, buildings, installations nor fixtures upon the four claims mentioned herein. However, located upon the patented properties owned by the applicant, there is a residence, a warehouse, and a machine shop, all of which will be available for use in the exploration work.

VI.

(a)	The applicant proposes to purchase three trailer houses for living quarters for the crew. The cost of these trailer houses will be $600.00 each, for the total sum of	$ 1,800.00
(b)	Three ore bins will be constructed at a cost of $400.00 each for a total sum of	1,200.00
	Total Cost of Item VI:	$ 3,000.00

VII.

(a)	Rented.	
	1. Road building equipment, fully maintained and driven, 30 days at $80.00 per day	$ 2,400.00
	2. One dump truck, fully maintained and driven, 150 days at $24.00 per day	3,600.00
	3. Three 160 cubic foot compressor units, at $15.00 a day each for 150 days	6,750.00
	4. One 210 cubic foot compressor at $17.00 a day for 150 days	2,550.00
(b)	Purchased.	
	1. Eight air drilling machines at $400.00 each	3,200.00
	2. Drill Steel for 150 days	800.00
	3. Air hose and pipe for drills	500.00
	4. Miscellaneous small tools and items	500.00
	5. Powder, caps and fuse for 150 days	3,000.00
	6. Gas, diesel and oil for 150 days	3,740.00

	7. Mine timber	$ 1,000.00
	8. Four hand-operated mine cars and 1,000 foot of track	1,400.00
(c)	None.	
	Total operating equipment, Item VII	$29,440.00

VIII.

(a)	Eight laborers at $50.00 per week, for eight weeks	3,200.00
(b)	Eight miners at $1.75 per hour each, 8 hours per day for 150 days	16,800.00
(c)	Superintendent, $500.00 per month for six months	3,000.00
(d)	Foreman, $400.00 per month for six months	2,400.00
	Total labor and supervision, Item VIII	$25,400.00

IX.

(a)	Accounting, timekeeping and bookkeeping, $400.00 per month for six months	$ 2,400.00
(b)	Workman's Compensation, Underground Mines and supervision at $10.25 per $100.00 of payroll	2,430.90
	Laborers at $6.61 per $100.00 of payroll	211.52
(c)	Public Liability and property damage insurance	105.90
(d)	Social Security at .015	381.00
(e)	Water is available in sufficient quantities at no cost.	
	Total miscellaneous Item IX	$5,529.32
	TOTAL COST OF PROJECT ----------	$ 63,369.32

X.

(a) Applicant is prepared to invest in the project the sum of Six Thousand Three Hundred Thirty-Six Dollars Ninty-Five Cents ($6,336.95).

(b) Said amount is sufficient to pay applicant's portion of the cost of said project.

XI.

An associated company owned by the stockholders of this applicant is now successfully engaged in the City of Los Angeles, California, in the commercial processing and fiberizing of asbestos crudes. The said associated company now plans to construct an asbestos cruding mill at Chrysotile, Arizona, for the purpose of cruding asbestos ores, if any

are produced as a result of the exploration project herein planned. Therefore, should asbestos ores in commercial quantities be found as a result of this exploration project, it will then be possible to produce, crude, process and fiberize the asbestos under a unified plan of operation, and within a limited geographical area, thus eliminating excessive freight hauls.

Form MF-100
(May 1951)

U. S. DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

Form approved.
Budget Bureau No. 42-R1026.

GENERAL TECHNICAL DATA
FOR USE UNDER THE
DEFENSE PRODUCTION ACT OF 1950

NOT TO BE FILLED IN BY APPLICANT

Docket No. DMEA-2558

Date received 6-2-52

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
JUN 2 1952

Western Chemical Company
c/o Herlihy & Herlihy
412 West Sixth Street
Los Angeles 14, California

Name and address of applicant

Date March 24, 1952

INSTRUCTIONS

This form is to be filed with Defense Minerals Administration, Department of the Interior, Washington 25, D. C. It should be accompanied by appropriate application form when a specific type of Government assistance is requested, in the form of (1) loan, (2) purchase contract, (3) Government guarantee of a private loan, (4) priorities or allocation of mining equipment, and maintenance, repair and operating supplies, and (5) other forms of Government assistance that might arise under the Act. Submit four (4) signed copies of the form and accompanying papers. Name and address should be stamped or typed on each sheet of this form and all accompanying papers. *When a question is inapplicable it should be so stated on the form.* Additional sheets may be attached in answering any questions or in supplying additional information. (IF YOU CANNOT ANSWER A QUESTION, SO STATE.) If a question is answered elsewhere indicate where answered. It is not necessary to answer it again.

GENERAL TECHNICAL DATA

Supply the following information on separate sheets, arranged, numbered, and lettered as indicated:

1. Materials produced:
   (*a*) What are the chief mine, mill, or smelter products?
   (*b*) What are the byproducts, if any?
2. Name(s) and type(s) of mine(s), mill(s), smelter(s), refinery(ies), pit(s), quarry (ies), drilling operation(s). Include old names of property, if any. Show extent of workings, including the following:
   (*a*) Linear feet of shafts.
   (*b*) Linear feet of drifts and crosscuts.
   (*c*) Linear feet of tunnels or adits.
   (*d*) Linear feet of other mine openings (explain briefly).

   Indicate whether mine is flooded or not. Describe any pumping problems. Give size or productive capacity.
3. For each operation listed above supply the following:
   (*a*) Distance and direction from nearest town and shipping point.
   (*b*) Mining district.
   (*c*) Township, Section, Range.
   (*d*) County, State.
4. (*a*) State whether or not property is now in operation, and if in operation, by whom operated.
   (*b*) Are you operating this property as:
   - ☐ Owner.
   - ☐ Lessee.
   - ☐ Contractor.
5. Number of years in production _____

   If not in production or operation, estimated date when production will begin _____
6. Experience of operators:
   Describe the mining and general business experience of (*a*) the applicant, and (*b*) the person or persons who manage the project.
7. History:
   (*a*) Give a statement, as complete as possible, of previous exploration, development, operation, and production of property, with reasons for suspension of operation.
   (*b*) State briefly the known history and production of adjoining and neighboring properties.
   (*c*) Furnish any available (private) reports that may apply to this application, including results of mine examinations, recommended exploration and development, and metallurgical investigations.

8. Names and addresses of Officers, Directors, or Partners, and in addition thereto, the five largest stockholders if applicant is a corporation.

Name and Address (a)	Official Title (If officer is also director indicate by "D") (b)	Total of Annual Salary, Commissions, Bonuses, Etc., Received From Applicant and Affiliates During Last Fiscal Year (c)	Estimated Net Worth Outside of Interest in Applicant (d)	Number of Shares Held in Applicant Corporation: Common (e)	Number of Shares Held in Applicant Corporation: Preferred (f)	Life Insurance Carried for Benefit of Applicant: Amount (g)	Life Insurance Carried for Benefit of Applicant: Net Cash Surrender Value After Loans (h)
		$	$				
William D. Cluff	President D	13,050.	50,000	3044	None	None	
W. Eldon Mitchell	Vice-Pres D	4,096.	3,500	1	None	None	
Gareld W. Johns	Secy-Treas D	10,850.	30,000	1522	None	None	
(The address of the above persons is: 625 South 5th Street, Phoenix, Arizona.)							
	Total		x x x x x			x x x x x	x x x x x

If more lines are needed continue on separate sheet.

9. Capital Stock Issues:

For Corporate Applicants

Item	Authorized (a)	Outstanding (b)	Par Value (c)	Number of Shares Outstanding (d)	Dividend Rate Last Paid* (e)
Common stock	$50,000.00	$45,670.00	$ 10.00	4567	None
Preferred stock	$ None	$	$		

*Indicate period covered.

10. Production:

Item	Kind of Product (a)	1948 Total (b)	1949 Total (c)	1950 Total (d)	Present Average Monthly (e)
1. Quantity of product mined or quarried (Short, long, metric tons; barrels; pounds; etc.)	None				
2. Quantity of product processed (specify unit of measure and type of process)	None				
3. Quantity and grade of product sold or shipped (specify units of measure)	None				

11. Do you contemplate a change in the present average monthly rate of production? If so, state estimated maximum monthly production and basis of change.

12. Ore or Mineral Reserves:

(a) Describe the ore or mineral deposit briefly. Accompany the application by any available report on the geology and ore reserves.

1. (a) Chrysotile Asbestos Ore, unmilled

   (b) None to date.

2. Unpatented Asbestos mining claims located in the McMillan Mining District, Gila County, Arizona, being 4 in number and more particularly described as follows:

LODE NAME	DATE RECORDED	MINING LOC. NO.	BOOK NO.	PAGE NO.
Asbestin No. 43	July 5, 1921	57781	35	480
Asbestin No. 44	July 5, 1921	57782	35	481
Asbestin No. 51	May 8, 1929	96821	43	384
Asbestin No. 52	Sept. 26, 1929	99829	43	566

The foregoing claims are part of the property formerly owned by the Johns-Manville Products Corporation at Chrysotile, Arizona, now owned by the applicant.

(a) (b) (c) (d) Only assessment and development work has been done upon the property to date.

No flooding problem exists, nor is likely to arise upon the property.

3. (a) Thirty-five miles northerly from Globe, Arizona. Shipping point Globe, Arizona.

   (b) McMillan Mining Districts.

   (c) Information not available.

   (d) Gila County, Arizona.

4. (a) Above described property is not now in operation, other than for assessment work.

   (b) As owner of said mining claims.

5. Number of years in production, none. It is estimated that production will start within seven months from and after contract is made under this application.

6. Mr. W. D. Cluff, President, has been engaged in the business of buying, selling and grading non-metallics for a period of fifteen years. For the last two years of this period he has also engaged in processing and fiberizing asbestos. The applicant intends to employ as mining foreman a man of ten years experience in mining asbestos and other non-metallic ores.

7. (a) (b) (c) Attached hereto and by reference made a part hereof is a copy of Arizona Bureau of Mines Bulletin No. 126, entitled "Asbestos Deposits of Arizona". Attention is directed to Pages 37 to 48, inclusive. Road conditions have materially improved and road distances have been shortened since this bulletin was written.

13. Approximately 3 miles of graded road which then connects with Highway 60, a paved highway into Globe, Arizona. Roads are excellent except the three miles mentioned, which will require reworking.

14. Ash Creek runs through the property and furnishes all the water required throughout the year.

15. Internal combustion engines will be used.

16. Eight miners and eight laborers will be employed.

17. A residence, a warehouse, a machine shop and a mill building is upon the patented portion of the property owned by the applicant. An electric light and power plant is available for lights and machine shop power.

18. In the event that the exploration project planned herein is successful, a unified plan will be undertaken for prompt and economical mining, cruding, accurate grading, processing and fiberizing the asbestos ores.

(*b*) If deposit is other than placer:

(1) Submit assay plans and/or sections showing location and size of proved (measured) and probable (indicated) ore or mineral reserve.

(2) State the tonnage (indicate type of ton) and grade of each class of ore reserve, as above, and show how computed. Tabulated total ore reserve as follows:

TOTAL ORE OR MINERAL RESERVES

Ore or Mineral Reserve	Estimated Tons (a)	Metal or Mineral Content Per Ton (Grade) (b)	Gross Value Per Ton (c)	Recoverable Unit Value Per Ton (d)	Estimated Cost of Production Per Ton (e)
Measured (proved)	None				
Indicated (probable)	None				

(*c*) If placer: Inapplicable.

(1) Give estimated total yardage and average marketable mineral content of each deposit.

(2) Submit map showing location of placer deposit and surrounding area, with all test holes or pits. Submit logs of each hole and test pit with depth and average value of each.

(3) Describe gravel, stating whether fine, medium or coarse; loose, tight, cemented, or frozen, and whether it contains stumps or boulders more than 1 foot in diameter; if so, how large, and in what proportion.

(4) Describe bedrock, giving type (granite, sandstone, shale, etc.) and state whether it is hard or soft, smooth, uneven or rough.

(5) Describe overburden, stating whether loose, tight, or cemented; fine or coarse textured; furnish estimate of average thickness and total amount.

(6) Tabulate the reserves using the form outlined above for ore or mineral reserves.

13. Access Roads:

Give road distances to shipping, supply and residence points, stating kind and condition of roads.

14. Water Supply:

State source and quantity of water available for operations and whether sufficient for all seasons of year.

15. Power:

State amount of power used, rate per hour, and source thereof.

16. Labor:

State number and classes (miners, muckers, millmen, etc.) of men employed during a recent representative payroll period.

17. Equipment and Facilities:

Describe present equipment on the property, including buildings. (State condition.) List major pieces of equipment now owned or controlled and in serviceable condition available for this operation.

18. Are there any particular conditions or circumstances affecting your operations that are not described above? If so, explain.

CERTIFICATION

The undersigned company, and the official executing this certification on its behalf, hereby certify that the information contained in this form and accompanying papers is correct and complete to the best of their knowledge and belief.

Western Chemical Company
(Name of company)

By William D. Ehrlich
(Signature of authorized official)

March 24, 1952
(Date)

President
(Title)

Title 18, U. S. Code (Crimes), Section 1001, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U. S. GOVERNMENT PRINTING OFFICE 16—63792-1

posits are given in the detailed descriptions of the Arizona deposits on pages 28 to 93.

AMPHIBOLE ASBESTOS

Actinolite and tremolite asbestos usually occur as slip-fiber veins in crystalline schists of high magnesia content, and are products of metamorphism. Small amounts of these minerals are of widespread occurrence in the metamorphic regions of Arizona and elsewhere. Notable deposits occur in Italy, Ontario, Quebec, Transvaal, Switzerland, France, and in the eastern United States.

ANTHOPHYLLITE ASBESTOS

Anthophyllite asbestos occurs as mass-fiber in Georgia, North Carolina, and Idaho. In the long-productive deposits of Georgia, it occurs as an alteration product of peridotite, and constitutes as much as 95 percent of the rock mined. According to Hopkins,[14] its fibrous texture there is due to weathering. It is also found in Cyprus, and as slip-fiber veins in California and Maryland.

CROCIDOLITE

Crocidolite occurs as thin, cross-fiber veins in the jasper shales of the Asbestos Mountains in Griqualand West, South Africa. It has been reported from France, Rhode Island, and Ontario.

AMOSITE

Amosite is found only in a belt in northeastern Transvaal. This belt is about sixty miles long by six miles wide, and contains three groups of cross-fiber veins that vary in width up to twelve inches.[15]

GRADES AND SPECIFICATIONS

As Ladoo[16] states, "The quality of asbestos and its suitability for most uses may be determined by a few simple tests. Length, color, silkiness, flexibility and, to some extent, fineness of fiber and tensile strength may be determined by inspection. A sample of asbestos should be fiberized by rubbing or crushing between the fingers. Single fibers may then be tested for flexibility and tensile strength by bending and breaking. Several fibers may be twisted into a strand or yarn and again tested for flexibility and strength. Asbestos of good quality

[14]Hopkins, O. B., Ga. Geol. Survey Bull. 29. 1914.
[15]See Hall, A. L., Asbestos in the Union of South Africa: Geol. Survey S. A., Memoir 12. 1918.
[16]Ladoo, R. B., work cited, pp. 62-63.

should be easily fiberized, soft, silky, strong, flexible, and easily twisted into a strong yarn. Fibers one-fourth inch or more in length and otherwise of good grade are of commercial interest."

No standard classification of asbestos is in general use, but the Department of Mines of the Province of Quebec, Canada, recognizes the following five grades: Crude No. I, Crude No. II, Mill Stock No. I, Mill Stock No. II, and Mill Stock No. III. Some mines ship only No. I Crude, others both Nos. I and II Crude, while still others send the whole product mined to mills which may produce from two to five different qualities of mill fiber.

In order that Arizona prospectors may have some conception of the probable classification of any good asbestos that they may find, the following table has been prepared:

Department of Mines of the Province of Quebec classification	*Approximate length of fiber*	*Commercial name*
Crude No. I	More than ¾ of an inch	Crude No. I
Crude No. II	5/16 to ¾ of an inch	Crude No. II
Mill Stock No. I	5/16 of an inch and over	Spinning fiber
Mill Stock No. II	1/32 to 5/16 of an inch	Shingle fiber
Mill Stock No. III	Up to 1/32 of an inch	Paper stock and others
Asbestic	Very short fibers mixed with powdered serpentine	Asbestos for wall plaster

The commercial names in the third column are the terms used in the asbestos quotations given in the Engineering and Mining Journal. Different producers follow different practices, and separate their products into grades of different fiber lengths, so that the above table is not absolute, but should serve as a guide.

While the length of the fibers is a very important factor in determining the grade and market price of asbestos, the value is also dependent upon the fineness of the fibers, the temperature at which they fuse, their flexibility, and their tensile strength. From the tables on page 19, it may be seen that the value of chrysotile does not decrease in direct proportion as the length of fiber decreases. For instance, if fiber one-half inch in length, which might be worth $375 to $450 per ton, were broken into half, the resulting material might be worth only $55 to $115 per ton.

USES

The fibrous structure, toughness, incombustibility, and low heat conductivity are the main properties that make asbestos valuable. Silkiness, high tensile strength, resistance to moisture, sea water, acids, and alkalies, and high resistance to electricity are desirable and often essential. The uses for asbestos are so numerous, however, that not all of these properties are of prime importance in every instance.

The most important way in which asbestos is utilized is as yarn or thread in the manufacture of brake linings, clutch facings, steam packings, fireproof cloth, theater curtains, electrical insulators, tape, etc. No known substance can be satisfactorily substituted for asbestos in the manufacture of the better qualities of these articles, and only the highest grades of Nos. I and II Crude can be used for such purposes.

Material consisting of shorter or less flexible fibers is used very extensively in the manufacture of insulating material to cover steam pipes, boilers, etc.; asbestos paper and millboard for high-pressure gaskets and packings; stove linings; air-cell pipe coverings; shingles and other roofing material; wall plaster; "Bitulithic" paving; "85 percent magnesia;" acid- and corrosive-proof pipe, wall tile, and deck coverings; filters; paint; etc. Large quantities of such asbestos is also used in refrigeration and cold storage plants. It could also be used to great advantage as an insulator beneath the roofs of residences and other buildings in hot climates.

For a list of the principal uses of asbestos, the reader is referred to the "Asbestos" journal, vol. 7, pp. 28-35, July, 1925.

DEMAND AND MARKET VALUE

CHRYSOTILE

For spinning purposes, Canadian chrysotile has the best reputation and demand. Arizona chrysotile, as already stated, is of superior quality. Many of the early Arizona producers, however, by shipping poorly-sorted, harsh, or even worthless material, injured the demand for the Arizona fiber, and only by rigid adherence to careful sorting has this unjust reputation been partially overcome.

Unfortunately, only a small proportion of the asbestos mined in most places is of high grade—the material chiefly sought and most widely used. In attempting to meet the demand for the higher grades of the mineral, an over-supply of low grade asbestos is produced. This fact explains why such striking differences exist in the value of the better and the poorer grades.

In Basic Igneous Rocks:—Chrysotile in the serpentine within peridotites occurs both as cross-fiber veins and as disseminated fiber in the rock. These veins sometimes are parallel but usually are in the form of a network. This type of deposit is found in Quebec, Canada[9], in the Ural Mountains of Russia [10], in Finland, in South Africa, and in Vermont,[11] California, and Wyoming.

In Quebec, where the major portion of the world's chrysotile is produced, the cross-fiber asbestos veins vary in thickness from that of mere threads up to two or three inches, and most of the material recovered is only from one-fourth to one-half inch in length. The rock mined, however, contains from four to twelve percent of asbestos.

The Russian deposits are extensive, but their fiber is said to be much harsher than the Canadian.

In eastern Finland, the deposits are said to occur in serpertine rock that carries about 25 percent of fiber.

In the Transvaal, about 28 miles northwest of Barberton, high-grade, pure-white chrysotile, of which over 25 percent is more than one inch long, constitutes about forty percent of the rock.[12]

The Vermont[13] deposits, which are a continuation of the Quebec belt, contain rather short fiber.

The California[13] deposits appear to be small or of low grade.

In the Wyoming[13] deposits, only a small proportion of the fiber is an inch long and of spinning grade.

In Limestone:—Chrysotile in the serpentine within limestones occurs for the most part as cross-fiber veins that are roughly parallel to the stratification. These veins vary in thickness from that of mere threads up to several inches, and excellent, unbroken fiber fourteen inches long has been found in Arizona. The bulk of the material mined, however, is less than two inches long. Deposits of this type occur in the Carolina district of the Transvaal, in Arizona, and to a small extent in southwestern Montana, and have been reported in Mexico.

Further data concerning the geologic occurrence of chrysotile de-

[9]See Cirkel, Fritz, Chrysotile-asbestos, its occurence, exploitation, milling, and uses: Can. Dept. of Mines, Mines Branch, Bull. 69, 1910; also, Quebec Bureau of Mines, Report on mining operations in the Province of Quebec, 1923, pp. 24-28.

[10]See Cirkel, F., work cited, pp. 222-229; also Diller, J. S., Mineral Resources of the United States for 1908, pt. II, pp. 702-703.

[11]See Richardson, C. H., Seventh Ann. Rept., Vermont Geol. Survey, pp. 315-330. 1909-1910.

[12]Hall, A. L., On the asbestos occurrence near Kaapsche Hoop in the Barberton district; Geol. Soc. S. Africa, Trans., vol. 24, pp. 168-181. 1921.

[13]See Ladoo, R. B., "Non-metallic minerals," pp. 50-51. McGraw-Hill Book Company. 1925.

CROCIDOLITE

Crocidolite is known to the trade as "Cape blue" asbestos, and is a silicate of iron and sodium with the approximate formula $NaFeSi_2O_6.FeSiO_3$. A substance with this formula should contain 22 percent of ferric oxide, 18.9 percent of ferrous oxide, and 8.6 percent soda. Crocidolite always contains several percent of water, and other common impurities are magnesia, lime, potash, and manganese monoxide. The high proportion of iron makes the mineral less resistant to heat and electricity than are most other types of asbestos.

The most distinctive feature of crocidolite is its color. It is nearly black when massive, but the fine fibers have a dull bluish-drab tint, very different from those of any other type of asbestos. Crocidolite always occurs in deposits of the cross-fiber type. The fibers commonly range in length up to 1½ inches, but rarely exceed three inches, are very tough, and can be used in the manufacture of textiles.

AMOSITE

Amosite is essentially a ferrous silicate containing small amounts of magnesia, alumina, and lime, with or without soda. Its ferrous oxide content averages nearly 40 percent. It occurs in much the same way, and can be used for the same purposes, as crocidolite, but differs therefrom in that the fibers average longer (four to seven inches), the color is grayish or greenish when fresh (brown when weathered), and the heat resistance is greater. It is harder and harsher than chrysotile. The name is derived from the initials of the firm "Asbestos Mines of South Africa," which developed the deposits. Wherry[8] has shown that amosite is not a new mineral, but is the iron-rich anthophyllite already described as ferro-anthophyllite.

THE GEOLOGIC OCCURRENCE OF ASBESTOS

CHRYSOTILE

Chrysotile asbestos is known to occur only in association with serpentine. Chrysotile-bearing serpentine has been found, first, within olivine-rich igneous rocks, such as peridotites and dunites, where it is a product of alteration, and, second, within limestones that have been intruded by diabase, where it is a product of replacement and alteration.

[8]Wherry, E. T., Am. Mineralogist, vol. 6, p. 174. 1922.

Since the largest use for spun asbestos is in brake linings and clutch facings for motor cars, the prosperity of the automobile and asbestos industries are roughly parallel.

The market value of asbestos increased rapidly during and after the World War, until, at the peak in early 1921, Crude No. I sold for over $3,000 per ton. A rapid decline ran through 1921 and 1922, and a gradual decline followed until the end of 1924, when Crude No. I reached the low price of $325 to $400 per ton, or almost the pre-war level. The following table shows the prices per ton of the various grades of asbestos prevailing F.O.B. Canadian mines at certain dates, according to the Engineering and Mining Journal:

	February 26, 1921	January 3, 1925	June 9, 1928
Crude No. I	$2,000-3,000	$325-400	$600-650
Crude No. II	1,400-2,000	175-215	375-400
Spinning fiber	400-1,000	90-125	190-225
Magnesia and comp. sheet fiber	325- 500	65- 90	160-175
Shingle stock	110- 150	45- 55	55-115
Paper stock	60- 75	35- 40	45- 50
Cement stock	17.50- 30	15- 25	25
Floats	8.50- 15	9- 12	15

The demand for asbestos appears to be steadily increasing. Since the public is just beginning to realize the usefulness of this mineral, the future possibilities of the industry seem very promising. The market value of asbestos, however, appears to be controlled by the intensity of competition between the Canadian and the South African fields.

TREMOLITE AND ACTINOLITE

Tremolite, when pure, is chiefly in demand by the chemical industries for use as filters.

Actinolite is mined and used in Canada as an ingredient for a roofing compound.

ANTHOPHYLLITE

Anthophyllite, because of being brittle, is in demand only for purposes that do not require flexibility or tensile strength. When pure, it is serviceable to the chemical industries for filters.

CROCIDOLITE AND AMOSITE

Crocidolite, because of having a relatively low fusion point and being dirty, dusty, and somewhat difficult to fiberize, is not in great demand in the United States. Amosite, although having a higher fusion point than crocidolite, is somewhat harsh and dirty. These two varieties are in more demand in Europe, especially for mixing with chrysotile.

WORLD'S PRODUCTION

The world's production of asbestos of all varieties and grades in 1926 was approximately 196,000 tons. The principal producing countries and the tonnage produced by each during 1926, exclusive of by-products, are as follows:[17]

Canada	143,172 short tons
Rhodesia, Southern	33,274 short tons
Union of South Africa	14,068 short tons
Cyprus	7,289 short tons
Finland	1,841 short tons
United States	1,358 short tons

The Russian deposits, before the World War, were the second largest producers, although their fiber is harsher than the Canadian. The Russian production for 1925 was approximately 15,000 short tons, and, from September 30, 1926, to September 30, 1927, 23,700 short tons.

During 1927, the total quantity of asbestos sold or used by producers in the United States was 2,986 short tons, valued at $338,066, according to figures compiled by the United States Bureau of Mines. The chief producing states are Arizona, Georgia, and Maryland. The sales of chrysotile were much larger, both in quantity and value, than those of 1926, while the sales of amphibole asbestos showed an increase in quantity but a decrease in value.

Practically the entire spinning fiber production of the United States comes from Arizona. Such figures of the State's asbestos production as are available for publication are given on page 26.

MINING AND TREATMENT

The mode of occurrence of any given deposit of asbestos determines the method of mining. In the Canadian asbestos districts the serpentine bodies that contain the veins and veinlets of asbestos outcrop at the surface as irregular masses. The veins of asbestos occur irregularly distributed in these serpentine masses, and are themselves

[17]Mineral Resources of the United States for 1926, pt. II, p. 200.

what waxy to dull or earthy. It is usually white or grayish, but is sometimes yellow, brown, or green. The color of the powder is white. It may be easily scratched with a knife, but not with the finger nails. It has no cleavage (does not break more or less evenly in any definite direction), and the fracture is usually smoothly rounded, but it may be uneven. It is excessively fine-grained (if at all granular), very dense, and pieces of any considerable thickness are opaque. Like the fibrous variety, it often feels smooth or soapy.

AMPHIBOLE ASBESTOS

Amphibole is a silicate mineral of which there are many varieties that differ from each other in composition and physical characteristics. Among the varieties which are fibrous and which are called "amphibole" asbestos, "hornblende" asbestos, and "Italian" asbestos are *tremolite* ($CaMg_3Si_4O_{12}$) and *actinolite* ($Ca(Mg,Fe)_3Si_4O_{12}$). The mineralogical name "asbestos" was first given to these amphiboles. Most of the various kinds of amphibole asbestos cannot be distinguished from each other except by chemical analysis; and it is sometimes difficult or impossible to distinguish between amphibole asbestos and chrysotile except by optical or chemical analysis. In general, however, it may be said that the fibers of amphibole asbestos average longer, but are more loosely aggregated, than those of chrysotile, and that they are not as strong, are less suitable for spinning, are somewhat harsher to the feel, and are not as good non-conductors of heat as are chrysotile fibers. The fusion temperature is about the same as that of the poorer grades of chrysotile. Amphibole asbestos is usually of the slip-fiber type, is white or ash-gray in color, and is never associated with serpentine.

ANTHOPHYLLITE

Anthophyllite, which is an orthorhomic amphibole, is a silicate of magnesium and iron with the formula $(Mg,Fe)SiO_3$. Alumina often replaces a considerable proportion of the magnesia, and lesser amounts of lime and other impurities may be present. The mineral contains from two or three to twenty or more percent of ferrous oxide. With its grayish or brownish color, it resembles amphibole asbestos more closely than it does chrysotile.

Anthophyllite is considerably harsher and more brittle than good chrysotile, and is unsuitable for textile purposes, but more resistant to heat and to acids than is chrysotile. It usually occurs as mass-fiber, but sometimes as slip-fiber, and it may be associated with amphibole asbestos, but never with serpentine.

bestos is due to an extreme elongation of the crystals, it seems that the original orientation of the crystals ought to play an important role in determining the characteristics of the asbestos in its final form. In view of the properties of the unaltered serpentine rock, it is not difficult to believe that the quality of softness might vary with the degree of transformation."

In discussing further the cause of the harshness of some Arizona fiber, Diller states:

"Most of the asbestos in the Grand Canyon has harsh fiber, and its chemical composition, as shown in the table, accords closely with that of the harsh fiber of Ash Creek and Sierra Ancha."

Professor J. T. Donald claims[5] that chrysotile that contains a high proportion of water is more flexible than specimens with less water. While his conclusions are probably applicable to material found in some localities, there are evidently other factors besides the percentage of contained water that affect the flexibility of the fibers.

Bateman[6] says: "Much of the purest of the harsh fiber gives no effervescence with acid, and under the microscope is seen to consist wholly of chrysotile with no visible calcite. Therefore, all the harsh fiber cannot be attributed to replacement by calcite. Examination so far has not shown conclusively the cause of this unusual variety of chrysotile. Chemically and optically it cannot be distinguished from the silky variety. I am inclined to believe that it represents either another variety of chrysotile or an incompleted stage of transformation of massive serpentine to chrysotile, or that the harshness may be due to a later infiltration of serpentine (retinalite) around the chrysotile fibers."

Sampson[7] states: "It seems to me that the effect of cleavage has not been sufficiently considered. If a broken end of soft fiber be viewed under the microscope there appears to be no limit to the degree of subdivision that may be obtained. . . . All gradations may be observed between indistinctly crystalline serpentine and soft fiber chrysotile. . . The fact that it can be reduced to extremely fine, loose fibers is probably due to cleavage rather than to the splitting apart of original faces in individual crystals."

Characteristics of the Massive Serpentine Associated with Chrysotile:—Chrysotile asbestos always occurs in massive serpentine which has essentially the same composition as the fibrous mineral, but differs therefrom in physical properties.

The serpentine associated with chrysotile varies in luster from some-

[5]Transactions General Mining Association of Quebec, 1891, p. 27.
[6]Bateman, Alan M., An Arizona asbestos deposit: Econ. Geol., vol. 18, pp. 670-671. 1923.
[7]Sampson, Edward, Econ. Geol., vol. 19, p. 387. 1924.

irregular in length and width. They are rarely more than 200 feet long, and are from a fraction of an inch up to several inches wide. Veins of three to four inches in width are rare, although six-inch veins have been reported. Considerable asbestos also occurs in irregular, disseminated bodies in the serpentine.

The mining method practiced in Canada has conformed to the mode of occurrence. The quarry or open cut, the "Glory Hole," and underground systems are used. Some of the quarries have attained a depth of 350 feet and are 600 to 1,200 feet in length.[18] The rock is removed from the quarry by means of cable derricks, inclined trams, or vertical hoists. The average recovery of fiber varies at the different properties, but is from three to eight percent of the rock treated. During 1925, asbestos fiber recovered in the mills amounted to nearly eight percent of the rock milled. Those mines in which a considerable amount of long-fiber occurs practice hand-cobbing as well as milling. At some of the mines only milling is practiced, but no two mills have exactly the same flow-sheet. The mills consist in the main of electrically-driven crushers, driers, rolls, fiberizers, beaters, cyclones, shaking screens, fans, collectors, and pulverizers. A complete description of the mining and milling practices is given by Ru Keyser.[19] Tests made on certain wet methods of milling have given encouraging results.[19-a]

The occurrence of asbestos in Arizona, in zones lying flat or dipping at a low angle, and having a heavy overburden of limestone, is such that its economic mining usually necessitates the use of underground methods. Most of the mines practice hand-cobbing, and only one small cobbing mill was in use during 1927.

LOCATION OF AND ACQUISITION OF TITLE TO ASBESTOS CLAIMS

When asbestos occurs in veins in rock in place on the public domain, it may be located and patented as a lode claim although it is a non-metallic mineral.

On Indian Reservations:—Until a few years ago, asbestos deposits could not be located or mined on unallotted lands on Indian reservations in Arizona, but by Act of Congress of June 30, 1919, certain unallotted lands on Indian reservations in Arizona were thrown open to

[18]Quebec Bureau of Mines, Report on the mining operations in the Province of Quebec during 1925.
[19]Ru Keyser, W. A., Asbestos mining and milling in Quebec: Eng. & Mining Journal-Press, vol. 113, pp. 617-625, 670-677. 1922.
[19-a]See Freeman, C. H., Canada Dept. of Mines, Mines Branch Pub. No. 687, pp. 69-79. 1928.

prospecting for metalliferous minerals, and deposits found became subject to location and lease.

By Act of Congress of March 3, 1921, on and after twelve o'clock noon, on April 15, 1921, all lands heretofore opened under Sec. 26 of the Act of June 30, 1919, also became subject to exploration for deposits of magnesite, gypsum, limestone, and asbestos, which could be located and leased under the same terms as metallic minerals.

Under these acts the prospector after discovery locates a claim and, within sixty days, files duplicate copies of the location notice with the superintendent in charge of the reservation. Within one year after the location of a claim the locator must apply, through the superintendent of the reservation, to the Secretary of the Interior for a lease which runs for twenty years. If an application for a lease is not made within a year, the locator forfeits all rights to the claim. The lessee may, in the discretion of the Secretary of the Interior, make written relinquishment of all rights in the lease at any time. A royalty of not less than five percent of the net value of the output of the minerals at the mine must be paid to the Government, and, in addition, a rental of 25 cents per acre for the first year, fifty cents per acre for the second to fifth years, and not less than one dollar per acre for each year thereafter must also be paid.

The following scale of royalties was incorporated in leases in May, 1922:

No. I crude, ten percent.

All other grades crude and mill fiber, five percent.

The net value to be determined by deducting from settlement the following items:

1. All railroad freight charges to selling point.

2. All local packing and hauling expenses to be allowed at the following flat rates: $1.50 per ton-mile for packing on burros or mules; $0.50 per ton-mile for team or motor haulage.

3. Hand-cobbing expenses at the flat rate of $150 per ton of No. I crude, $250 per ton of No. II crude, and $250 per ton of mill fiber, regardless of grade.

4. Mechanical cobbing or milling allowance to be determined in each case based on operating cost of milling plant, to which shall be added fifteen percent per annum of mill investment to cover interest, insurance, repairs, depreciation, and amortization.

Besides the payment of royalties and rental, a locator or lessee must expend not less than $100 per year in development work on each claim located or leased. Claims on Indian reservations are limited to paral-

chrysotile. The most distinctive features of the Arizona variety are the unusually low percentage of ferrous oxide present in it, and the fact that a considerable portion of the fiber is somewhat harsh and splintery as compared with the best grade, which is soft and silky."

Harshness of Fiber:—In degree, harshness may vary from slight to extreme.

Diller also says: "In the Globe field both grades (silky and harsh) occur in the same vein near together without a definitely visible boundary. A comparison of the two grades discloses the fact that the harsh fiber generally, and perhaps always, has a deposit, in places only a thin film, of calcite between the fibers of the asbestos. Searching for a chemical cause adequate to explain the differences of harsh and soft fiber, Dr. R. E. Zimmerman, assistant director of the research laboratory of the American Sheet & Tin Plate Company, of Pittsburgh, made analyses of four samples selected by the writer at the mines on Ash Creek and the Sierra Ancha." The results are given on page 6 under *"Composition."* With reference to these analyses, Dr. Zimmerman remarks:

"A study of the results in the table will show that the magnesia and silica contents are practically normal in every case, and this is also true, within reasonable limits, of the water of crystallization. We are especially glad to note that the ferrous oxide is below one percent in every case.

"One feature of the information contained in the results is the occurrence of lime in Samples Nos. 2 and 4 and its absence in samples Nos. 1 and 3. While the amount of calcium oxide in the fiber is small, it may be a matter of significance that it was detected only in the samples of harsh fiber. Whether or not the infiltration of such small amounts of lime could impart the quality of brittleness, its presence seems to go hand in hand with the tendency of the serpentine to produce harsh fiber.

"Another item of interest, although it may not have any great significance, is the fact that the samples of soft fiber, Nos. 1 and 3, contained higher percentages of alumina than samples Nos. 2 and 4.

"Although it is thus possible to point out small differences in the chemical constitution of harsh and soft material, it does not seem to us that the variations are of such magnitude that they can account for the difference in physical properties. The presence of calcite would no doubt make for brittleness of fiber, but it would appear that this quality is dependent more particularly upon the physical structure of the material. If we assume that the peculiar fibrous structure of as-

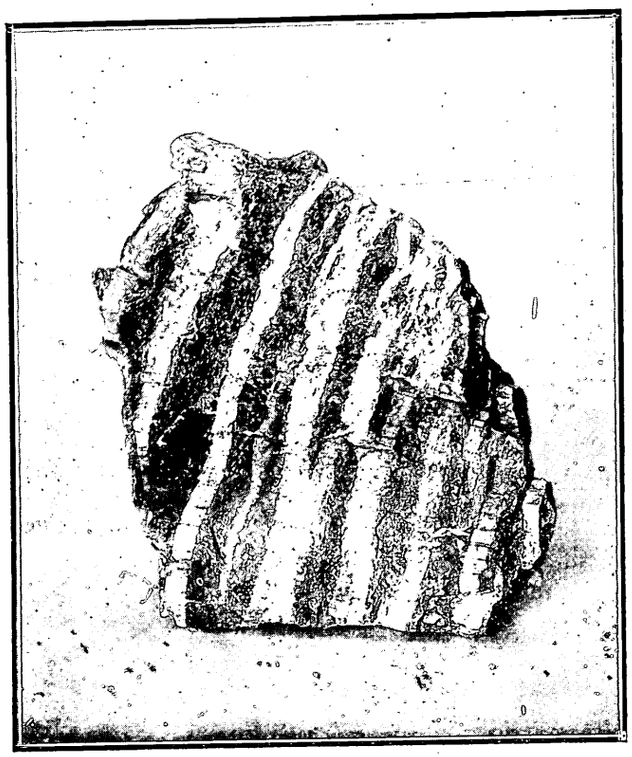

Plate I-B.—Asbestos veinlets in serpentine (natural size), San Carlos Indian Reservation, Arizona. Photograph by G. M. Butler.

lelograms not over 1,500 feet long by 600 feet wide, and lessees "have the right to mine only within the exterior boundaries of the leased lands and to lines drawn vertically downward therefrom." There is no such thing as "extra-lateral rights" on a claim on an Indian reservation.

Full information on the provisions of the laws relating to this matter and the areas that have been thrown open to exploration may be obtained upon application to the Arizona Bureau of Mines.

PART II—ARIZONA OCCURRENCES OF ASBESTOS

The principal asbestos deposits of Arizona, as indicated by figure 1, are in Gila and Coconino counties, and one deposit is in Pinal county.

HISTORY

Chrysotile asbestos is reported to have been seen in the Grand Canyon, west of the Powell Plateau, by members of the Powell expedition during their boat trip down the Colorado River in 1869.

Burchard,[19-b] in 1883, stated that asbestos with long white fibers and a delicate texture was found in Yavapai County, which in 1883 included the Grand Canyon area. He also mentioned the occurrence of asbestos in Gila County.

Arizona fiber was brought to public attention by the Hance Asbestos Company, shortly after the location of the deposits in the Grand Canyon, opposite Grand View, in 1900.[20] A small amount of fiber was mined by this company in 1903, and, a few years later, similar deposits were reported in the Grand Canyon below Bass Camp.

In 1903, asbestos was found in southern Arizona, near the head of Pinto Creek, Gila County, but it never was mined.

In 1913, the Ash Creek deposit, at the site of Chrysotile village, was located. The successful development of this deposit led to intensive prospecting and numerous locations in that vicinity and in the Sierra Ancha region. By the end of 1915, approximately 500 claims had been located between Young and Globe. Between 1916 and 1921, the Sierra Ancha (American Ores), Penn, Colorado-Arizona (now the Regal), Aileen, Reynolds Creek, and Globe Co. asbestos mines came into prominence. Activity was greatly stimulated by the rapid increase in asbestos fiber prices, for, by January, 1921, Crude No. I was selling at over $3,000 per ton.

Early in 1921, the Fort Apache and San Carlos Indian reservations were opened for asbestos prospecting, locations, and leases. Numerous locations followed this action, but a breaking of the fiber market in 1921 curtailed operations.

During 1922 and 1923, asbestos mining in the State was practically suspended, but prospecting, assessment work, and some development

[19-b]Burchard, Horatio C., Production of gold and silver in the United States, 1883: Report of Director of the Mint.

[20]Diller, J. S., U. S. Geol. Survey Mineral Resources of the United States for 1918, pt. II, p. 546.

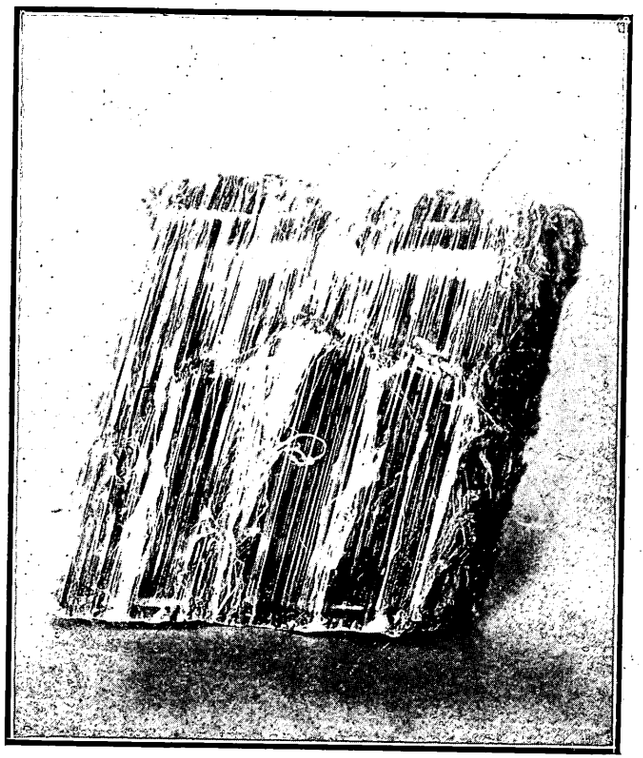

Plate I-A.—Crude No. I asbestos (natural size) from the property of the Arizona Asbestos Association. Photograph by G. M. Butler.

replacement or displacement, or both, and to have met and coalesced along a more or less irregular plane which may or may not be equidistant from both walls. This plane is shown in sections of veins as a line which is sometimes decidedly serrated, and the fibers tend to break along this plane. In Plate I-A, this plane is notably irregular, but, in Plate I-B, such planes are much more regular and occupy approximately the middle of each vein. Often many small, nearly parallel veins are separated by layers of serpentine with about the same width as the veins, as shown in Plate I-B. It is believed that this banded appearance suggested to some one the skin of a serpent, and that for this reason the massive mineral, of which chrysotile asbestos is a variety, and with which it is always associated, is called serpentine.

Slip-fiber occurs in fault planes (slips), and the fibers run approximately parallel to the direction of the movement. This variety is not usually of as high quality as the cross-fiber, is not ordinarily found in as solid masses, and is commonly white or light gray in color.

Mass-fiber asbestos is composed of a confused aggregate of fibers running in all directions or radiating from many centers. Mass-fiber chrysotile is comparatively rare, but yields a larger amount of available fiber in proportion to the quantity of rock mined that does any other variety.

Blowpipe and Chemical Tests:—In a closed glass tube chrysotile yields water. The finest fibers are fused with great difficulty before the blowpipe, and are decomposed by boiling hydrochloric and sulphuric acids, leaving the silica in the form of very fine fibers.

Although some specimens of chrysotile are not fused when heated to a temperature of 5,000°F., the fibers usually become brittle when exposed for protracted periods to a temperature of 1,000°F. or more.

Miscellaneous:—The smooth feel, the extreme toughness, the light color of the fibers, and the geological relationships described later will usually suffice to distinguish chrysotile from other forms of asbestos. It should not be forgotten, however, that weathered outcrops may be rather harsh and brittle. In general, it is safe to assume that the flexibility of fibers will improve below a weathered outcrop, but this is not always the case, since heat from an igneous intrusion in close proximity to the asbestos may make the fibers brittle, as may other causes mentioned later.

Peculiar Characteristics of Arizona Chrysotile:—Diller suggests[4] that "Arizona chrysotile differs so much from the material found in most other localities that it should be designated 'the Arizona variety' of

[4]Work cited, p. 302.

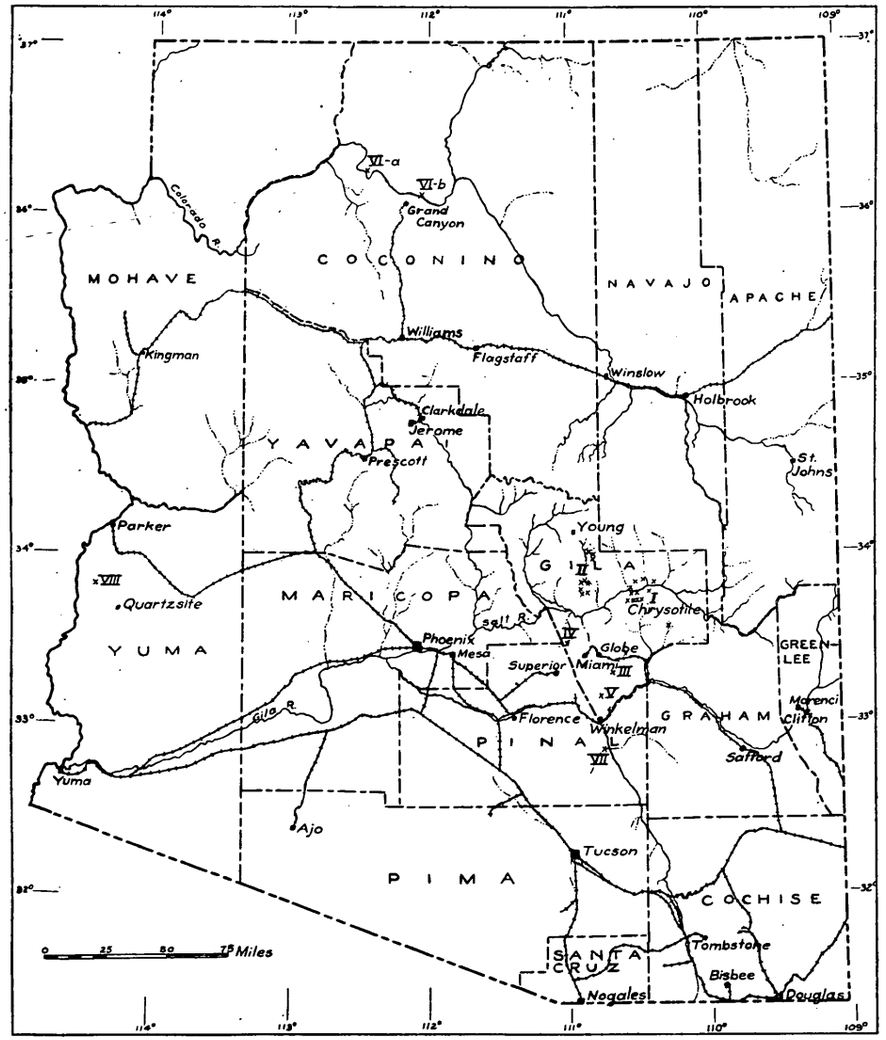

Fig. 1.—Index map showing general distribution of asbestos deposits in Arizona.

Area I, Chrysotile-Salt River region.
II, Sierra Ancha.
III, Southeastern Pinal Mts.
IV, Pinto Creek.
V, Mescal Mts.
VI-a, Grand Canyon Shinumo.
VI-b, Grand Canyon Hance.
VII, Putnam Wash.
VIII, Quartzsite (amphibole).

continued. Activity in the Fort Apache and San Carlos Indian reservations resulted in the granting of leases on ten groups of claims, and the approval of application on nine other groups, by the end of 1922.

Accompanying the slow rise in prices of asbestos since 1924, its mining in the State has gradually revived, and in 1928 is in a better condition than it has been since the slump of 1921.

PRODUCTION

Asbestos production in Arizona began in 1914, but amounted to probably less than fifty tons for that year. It increased ten-fold in 1915, and from 1915 to 1918, inclusive, amounted to about 1,900 tons.[21] According to the United States Geological Survey Mineral Resources, the State's asbestos production for 1919 was 423 tons, worth $219,950; for 1920, 1,200 tons, worth $625,822; for 1921, 413 tons, worth $311,-768; and for 1922, 92.5 tons mined, but only partially shipped.

No definite figures of the production since 1922 are available for publication. In 1923, the established asbestos mines were not operating, and only a small output came from the other properties. In 1924, five operators shipped something over 100 tons. Only two operators shipped during 1925. Three properties, the Arizona Asbestos Association, the Regal, and the San Carlos, produced in 1926. Besides these three, the Accident, Andrews, and Aileen properties produced in 1927.

ACKNOWLEDGMENTS

Courtesy and hospitality were extended to the writer by all the mine operators and prospectors of the regions visited. The rare privilege of studying the Arizona Asbestos Association property, at Chrysotile, was afforded by the Johns-Manville Company. Mr. Frank Knuckey, Assistant Superintendent of this property, furnished maps, assistance, and much useful information. Likewise, the Regal Asbestos Mines, Inc., permitted a study of the Regal Mine. Mr. John L. Alexander, Manager of this property, furnished maps and much useful information, and provided animal transportation to neighboring deposits.

Mr. Carl Lausen, formerly of the Arizona Bureau of Mines, Mr. J. B. Tenney, of the Arizona Bureau of Mines, and the members of the Department of Geology of the University of Arizona, gave helpful suggestions and information. Dr. A. A. Stoyanow, Professor of Paleontology, identified the algae.

[21]Diller, U. S. Geol. Survey Mineral Resources of the United States for 1918, pt. II, p. 551.

of chrysotile which deserves the attention of engineers who are searching for asbestos low in iron."

Luster:—Resinous or greasy to *silky*.

Color:—Usually light green, light yellow, ash gray, or white; sometimes dark green to blackish green or brownish red; occasionally weathered outcrops are brown. Fine fibers are usually white no matter what the color of the massive mineral may be.

Streak (color of powder):—Only material of very poor quality, such as is sometimes found in outcrops, can be pulverized. It always yields a white powder.

Hardness:—Easily scratched with a knife, but the more or less greasy-lustered, fresh material is usually too hard to be scratched with the finger nail.

Fracture:—Cross-fiber asbestos breaks into irregular prismatic fragments with fibrous surfaces, whereas slip-fiber breaks into fibrous sheets, and mass-fiber has a very irregular, jagged fracture.

Specific Gravity:—About 2.3, being considerably lighter than quartz.

Toughness:—Cross- and slip-fiber asbestos can be easily broken parallel to the fibers, and weathered specimens of all varieties may yield quite brittle fibers. Fresh, high-grade fibers are extremely tough. It is very difficult to break a piece of mass-fiber asbestos in any direction, or cross- or slip-fiber asbestos perpendicular to the direction of the fibers. Harsh fiber is splintery, prickly, and somewhat brittle, so that a small bundle of it breaks if twisted a number of times.

Feel:—Good grades of chrysotile feel very smooth or "soapy."

Occurrence:—Chrysotile occurs in three habits designated cross-fiber, slip-fiber, and mass-fiber.

The cross-fiber occurs in veinlets from a small fraction of an inch to several inches wide, and, as the name suggests, the fibers of which the material is composed and into which it may readily be separated lie approximately perpendicular to the walls of the vein. Frequently, however, the fibers cross the vein diagonally (See Plate I-A) and often they are bent. The excessively fibrous texture of the material is its most characteristic feature, and a solid fragment of good asbestos can be beaten up or picked apart so as to form a mass of very fine, light fibers. It is not usually true that a single vein of cross-fiber can be mined profitably. Fortunately, however, in most localities a considerable number of more or less parallel or interlacing veinlets of various thicknesses occur in close proximity to each other, and they, together with the intervening barren rock, are all mined together. Cross-fiber asbestos usually *appears* to have grown out from both walls, either by

	1	2	3	4	5		6
MgO	42.05	41.85	40.69	41.41	40.64		41.41
SiO_2	41.56	41.35	40.75	42.28	43.68		40.49
Al_2O_3	1.27	0.91	1.82	1.07	0.34		1.27
FeO	0.64	0.69	0.74	0.88	0.51	(Fe_2O_3)	2.53
MnO	.....	.....	.....	.....	0.17		.....
CaO	0.00	0.07	0.00	0.10	0.09		.....
K_2O	.....	.....	.....	.....	0.11		.....
Na_2O	.....	.....	.....	.....	0.14		.....
H_2O (−)	1.39	1.38	1.86	1.33	1.18		.....
H_2O (+)	12.92	11.96	12.65	12.23	13.12		14.06
	99.83	98.21	98.51	99.30	99.98		99.76

No. 1, Ash Creek mine; soft fiber,
No. 2, Ash Creek mine; harsh fiber,
No. 3, Coon Creek Butte; soft fiber,
No. 4, Coon Creek Butte; harsh fiber,
} Analyst, R. E. Zimmerman, January 24, 1918.

No. 5, Grand Canyon, under Grand View; harsh fiber. Analyst, R. C. Wells, U. S. Geol. Survey, April 22, 1915.

No. 6, Average of eleven analyses of Canadian chrysolite.

Diller [3] further states that "An important difference between the chemical composition of the Arizona variety of chrysotile asbestos and that of the Canadian chrysotile is the small quantity of iron oxide the former contains. This feature was pointed out in the report on asbestos in Mineral Resources of the United States for 1912, where it was suggested that on account of the small quaitity of iron oxide present the Arizona variety of asbestos might be better than the Canadian variety for electric insulation. In order to ascertain the quantity of iron present in the best Canadian fiber, the writer sent to Dr. Zimmerman a sample of soft silky Canadian chrysotile which had been furnished by Dr. Huber, president of the Asbestos Fiber Spinning Company, of North Wales, Pa., as the best asbestos he had ever seen from Canada. Dr. Zimmerman reported January 24, 1918:

" 'We have determined the iron content of the Canadian asbestos you sent, and it contains at least 2.5 percent of FeO. We believe this is an important result and proves to our satisfaction that the Canadian material carries more than twice as much iron as the Arizona asbestos.'

"This low content of iron is characteristic of the Arizona variety

[3]Work cited, p. 303.

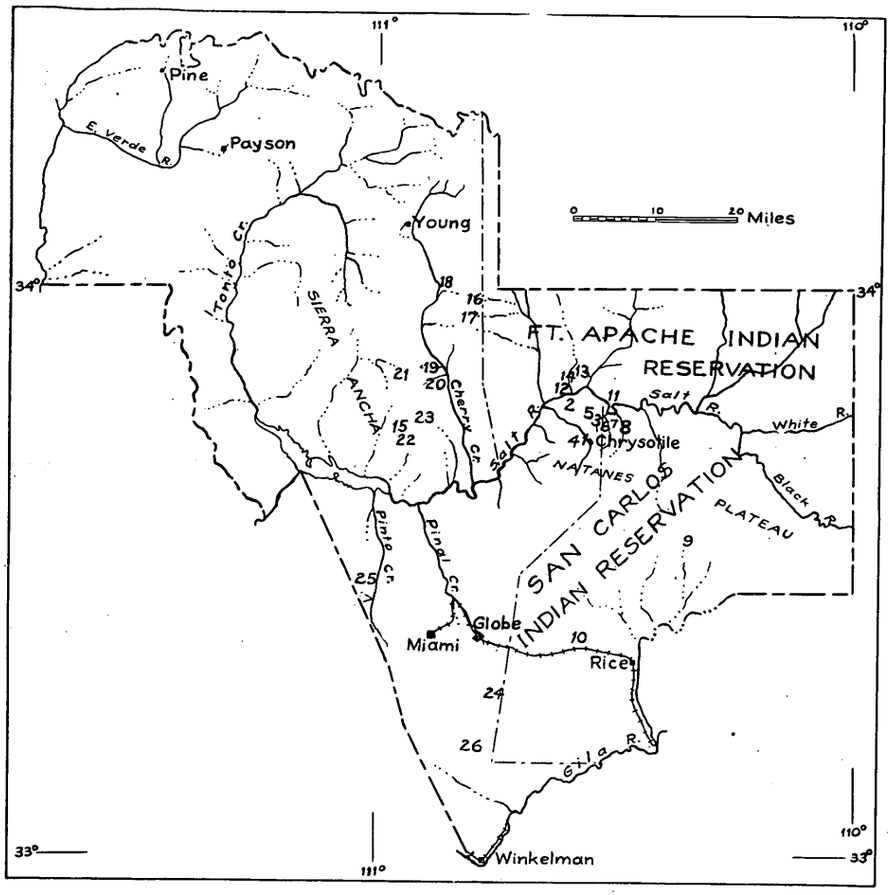

Fig. 2.—Index map showing distribution of Gila County asbestos properties considered in this report.

1, Ariz. Asbestos Association.
2, Regal.
3, Seventy-two and Monte Christo.
4, Globe Asbestos Co.
5, Crosthwaite-Steward.
6, Accident (Seneca).
7, Falls.
8, Cobb & Dunaway.
9, Lunn & Mathews.
10, Apache.
11, Horse Shoe.
12, Riverside.
13, Lorie & Lena.
14, Seven Star.
15, American Ores, or International.
16, Aileen.
17, Rock House.
18, Triangle.
19, Sloane.
20, Pueblo.
21, Reynolds Falls.
22, Friday.
23, Knighton.
24, Southeastern Pinal Mts.
25, Pinto Creek.
26, Mescal Mts.

GILA COUNTY DEPOSITS

Gila County contains the largest known, the most numerous, and at present, the only productive asbestos deposits of Arizona. The most important of these deposits lie within a triangular area between Roosevelt Reservoir, the Natanes Plateau, and Pleasant Valley, and their distribution is indicated by figure 2.

GEOLOGY

The asbestos invariably occurs with serpentine in limestone, not far from an intrusive contact of diabase. This limestone, which is termed the Mescal, is a member of a succession of strata known as the Apache group.[22] A typical, complete, vertical section of the Apache group has the following formations from top to bottom:

Formation	*Character*	*Thickness in feet*
Troy quartzite or sandstone	Light colored, often cross-bedded and pebbly, varies in hardness from sandstone to quartzite; thickest in the Sierra Ancha region. Weathers brown	160-1,100
Basalt flow	Vesicular, epidotized lava, often present	0- 100
Mescal limestone		225- 300+
Dripping Spring quartzite	Fine-grained, massive to thin-bedded, often similar to Troy	450- 700
Barnes conglomerate	Smooth pebbles in hard, arkosic matrix	5- 35
Pioneer shale	Hard shale, weathers red-brown	150- 250
Scanlan conglomerate	Smooth pebbles in hard, arkosic matrix. Often grades upward into coarse, arkosic sandstone	0- 30

Figure 3 shows the distribution of these formations in northeastern Gila county.

Normally, the Scanlan conglomerate rests upon pre-Cambrian granite or schist, and the Troy underlies Devonian limestone.

In the asbestos districts, diabase sills and dikes have invaded the Apache group to the base of the Troy. These sills and dikes vary in

[22]See Ransome, F. L., Some Paleozoic sections in Arizona and their correlation: U. S. Geol. Survey Prof. Paper 98-k, 1916; also Darton, N. H., A resumé of Arizona geology: Ariz. Bureau of Mines. Bull. 119. 1925.

ASBESTOS DEPOSITS OF ARIZONA

By Eldred D. Wilson

With an Introduction on

ASBESTOS MINERALS

By G .M. Butler

PART I—INTRODUCTION

ASBESTOS MINERALS

The name *asbestos* is derived from the Greek word for inextinguishable or indestructible, and the adjective *asbestiform* is applied to any mineral that is readily separable into more or less flexible fibers. Among the more important asbestiform minerals, from the standpoint of toughness, incombustibility, and low heat conductivity, the following are included under the general trade name of asbestos: Chrysotile (serpentine asbestos), amphibole asbestos (including fibrous varieties of tremolite, actinolite, etc.), anthophyllite asbestos, crocidolite (Cape blue asbestos), and amosite. Unless stated otherwise, however, the term "asbestos" usually means chrysotile. It is the only variety of asbestos known to occur in commercial quantities in Arizona.

CHRYSOTILE

Composition:—Chrysotile is a variety of the mineral serpentine which has the formula $3MgO.2SiO_2.2H_2O$ (hydrous magnesium silicate). Iron monoxide usually replaces a little of the magnesia, and alumina, lime, and other elements may be present in minute quantities. Pure magnesia chrysotile should contain 43.0 percent magnesia, 44.1 percent silica, and 12.9 percent water, but a percent or two more of water is usually present, and the percentages of silica and magnesia are often slightly reduced through the invariable presence of some iron oxides, and, less frequently, alumina.

The first five [1] of the following analyses are of Arizona chrysotile, and the sixth [2] is of Canadian chrysotile:

[1]Diller, J. S. U. S. Geol. Survey, Mineral Resources for 1919, pt. II, p. 302.
[2]Cirkel, Fritz, Canadian Dept. Mines, Mines Branch, Bull. 69, p. 21. 1910.

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thickness from a few inches to several hundred feet, and, although they frequently cut across the bedding, their upper surfaces more often are parallel to the stratification.

The geologic age of the Apache group is still in question. Ransome[23] regarded it as probable Cambrian, but Darton[24] believed that the strata below the Troy are Algonkian.

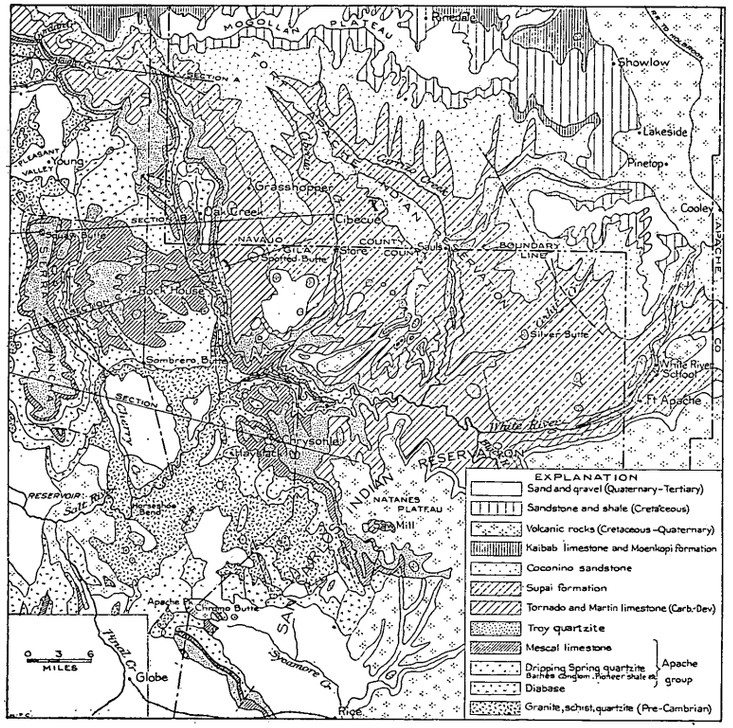

Fig. 3.—Geologic map of the upper part of the Salt River region. (By N. H. Darton, Univ. of Ariz., Arizona Bureau of Mines Bull. 119, p. 199.)

Character of the Mescal Limestone:—The Mescal normally consists of about 300 feet or less of medium to thin-bedded, hard, cherty, dolomitic limestone. Where weathered, it is gray to buff or darker in color, and the edges of its thin chert bands or nodules stand out in prominent relief.

In the Sierra Ancha-Chrysotile region, the middle portion of the Mescal is often a pure, crystalline, magnesian limestone and does not contain the usual amount of chert.

[23]Ransome, F. L., work cited, p. 164 .
[24]Darton, N. H., work cited, p. 35.

The upper portion of most sections of the Mescal contains a massive, algal member, of about fifty feet maximum thickness, that is an important horizon-marker. This algal member is made up almost entirely of spheroidal masses that have a concentric, shell-like structure and a maximum diameter of several inches (see Plate II). These spheroidal masses probably were formed by magnesian limestone being deposited around certain plants that are known as algae.

Diabase sills have split the Mescal formation, usually along its bedding, but often in an irregular fashion, into a varying number of segments. The metamorphism accompanying this intrusion is most marked in the middle, purer portion, and has resulted predominately in the development of serpentine and chrysotile. Calcite (fibrous) and wollastonite in places have been developed with the serpentine, and magnetite in many places is present in the limestone at a distance of several feet away from the main serpentinization. Additional metamorphic effects will be considered in the detailed descriptions of the deposits.

Character of the Diabase:—The normal, unaltered diabase is a tough, dark-colored, medium-grained rock that consists of crystallized aggregates of basic feldspar, augite, olivine, and a little magnetite, brown mica, titanite, and apatite. Near contacts, it is fine or dense in grain. A thin slice of the rock viewed under the microscope shows its feldspars to be in the form of irregularly-interlacing laths, while its other minerals are crowded within the available spaces between these laths. Much of the augite has a speckled texture due to inclusions of the other minerals of the rock.

Magmatic differentiation in places has resulted in gradations to pink, syenitic masses that attain large size in the Sierra Ancha region.

Microscopic study of diabase from the immediate vicinity of an asbestos deposit almost invariably shows it to have been affected by hydrothermal alteration. The feldspars are somewhat sericitized, more or less of the olivine has changed to serpentine and hematite or limonite, and much of the augite has become hornblende and chlorite. This alteration of the diabase is a significant fact in connection with the origin of the asbestos.

Upon weathering, the diabase acquires a dull, slightly-green color, and finally decomposes into a brownish-green soil that usually contains resistant nodules of the original rock.

Structure:—In general, the strata in the asbestos fields are nearly horizontal, but often this conditon has been slightly modified by local tilting and small-scale folding that apparently accompanied the diabase intrusion. Locally, also, a minor amount of normal faulting has caused displacements of a few feet to a few hundred feet magnitude. Faults

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canyon of Ash Creek. An ample water supply is derived from tunnels, and a part of the flow of Ash Creek is diverted to irrigate several terraced gardens.

REGAL GROUP

Situation and Accessibility:—The Regal group, which includes 25 unpatented claims, as shown in figure 6, is situated on the south side of the canyon of Salt River, south of the Salt Banks, and mainly on the east side of Corral Creek, about six miles in air-line north-northwest of Chrysotile. From the railway at Rice, the group is accessible over some 51 miles of road. A trail approximately 1¼ miles long, joining this road to the Regal camp, was being made into a road in the summer of 1928.

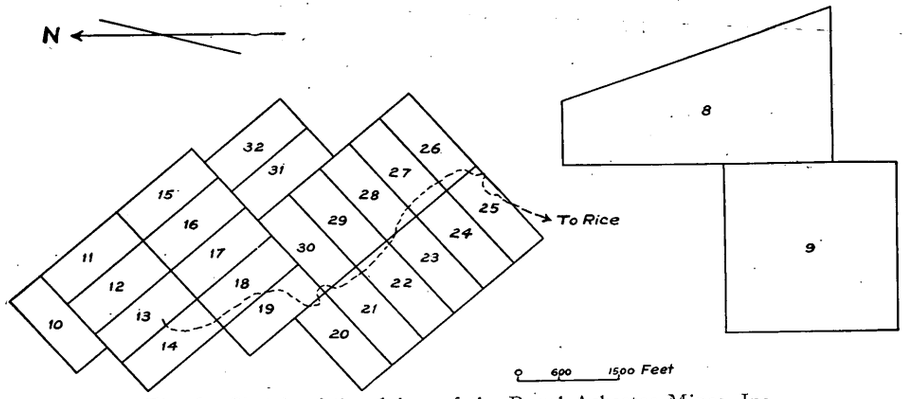

Fig. 6.—Sketch of the claims of the Regal Asbestos Mines, Inc.

History:—The nucleus of this group consisted of about ten claims that were located a few years prior to 1917, and held by a Mr. Larsen. During 1918, the property was being developed by the Colorado-Arizona Asbestos Mining Co., and a small production was reported. The Denver Arizona Asbestos Co. produced some fiber from the property in 1919. The claims were purchased in 1919 by Mr. E. Schaaf-Regelman, and relocated shortly thereafter. By the end of 1921, the Regal Asbestos Mines, Inc., of which Mr. E. Schaaf-Regelman is president, had taken over the property. It was left idle, except for assessment work, from April, 1921, until 1925. During 1925 and 1926, lessees were its principal, but intermittent, operators. These lessees are said to have shipped several carloads of excellent fiber that for the most part was three inches in length. In June, 1927, the company resumed regular development and production.

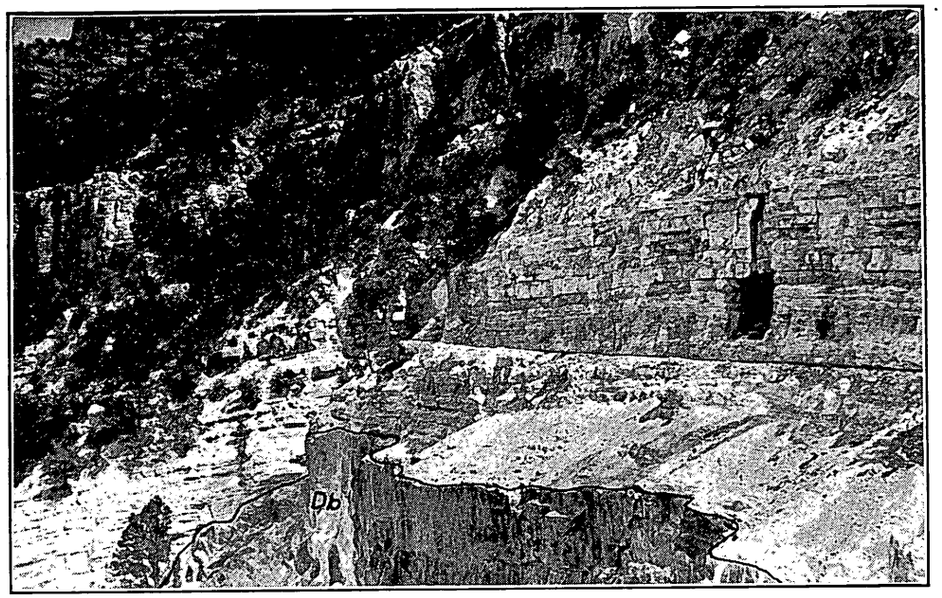

Plate VII.—Mescal limestone intruded by diabase (Db) at Regal Mine. Photograph by R. E. S. Heineman.

Plate VIII-A.—Asbestos vein (a) on Cowboy claim, Aileen group.

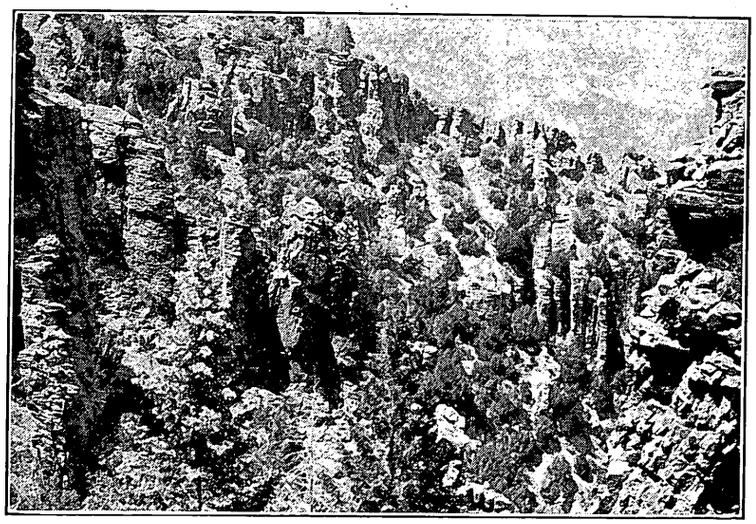

Plate VIII-B.—Troy sandstone on west side of Cherry Creek, above Sloane claims.

dry-wall back fills usually are sufficient to support the strong, limestone back. See Plate VI.

After shooting every round in an asbestos stope, the miner carefully sorts the rock, and hammer-cobbs the Crude No. I and No. II fiber. A large part of the waste is used for back filling, but the remainder is put into a chuté, which usually is within convenient distance. Rock containing possible mill stock or fiber only slightly unworthy of his cobbing goes into a different chute. The Crude No. I and No. II grades of fiber are weighed into separate sacks and trundled in wheelbarrows to the surface warehouse, where they are inspected and resacked into 105-pound units for shipment. The contents of the raises are emptied into cars on the adit level, hand-trammed to the surface, and selectively dumped. All possible mill rock is kept separate from waste, to await the probable construction of a mill.

In general, the drifting and raising are done on contract, but the fiber is mined under the company's direction, by lessees paid on a per-pound basis.

Labor:—In March, 1928, the mine was working 159 men underground and twelve on the surface. All the underground common labor is Mexican, because it is the most patient and careful class available for this tedious type of mining.

Surface Equipment:—Surface equipment consists of a power plant and a blacksmith shop. In the power plant are two Ingersoll-Rand Diesel compressors of 350 cubic feet per minute capacity each, one semi-Diesel of 309 cubic feet capacity, and a small, 110-volt, 60-cycle generator. A zeolote water softener serves the Diesels. The blacksmith shop has an electric-blown oil forge and a Waugh drill sharpener.

A mill, consisting of crusher, cyclone, shaking screens, trommel, and grading screens, was tried out from 1916 to 1921. Its product was three or four grades of fiber, but its capacity was only about five tons of rock per day, and its efficiency was unsatisfactory.

Transportation:—The nearest railroad points, Rice and Globe, are respectively 42 and 64 miles distant by road. Nearly thirty miles of this road is in mountainous country and has many long, steep grades. The roughest fifteen miles, connecting Chrysotile with Sawmill settlement, was built and is maintained by the company, but often becomes impassable in winter. Trucking the asbestos to Rice now costs from $15 to $18 per ton, while a first-class road would cut this cost nearly in half.

Camp:—The camp of Chrysotile, which consists of stone and tent houses, a store, and a postoffice, is pleasingly situated in the shady

east side of Ash Creek, contains several lenticular asbestos zones that outcrop from ten to fifty feet above the irregular upper surface of the diabase. These outcrops, as a rule, are traceable along lengths of from fifteen to ninety feet. Except for southeast dips of 5° or less, near the surface, the strata here are practically horizontal.

The highest observed zone occurs ten to twenty feet above the main diabase and two to three feet below a semi-horizontal diabase sill of three to six feet thickness. Where prospected, this zone consists of from eight to fourteen inches of alternating asbestos veins and green serpentine. Its fiber, which is of excellent quality and partly of No. I length, appears to be best developed in the vicinity of an area of vertical fractures. Workings upon this zone in March, 1928, were limited to the few feet of tunnels 67, 11, and 7, whose portals are at about 5,220 feet elevation.

Another zone occurs from forty to fifty feet above the main diabase at an elevation of about 5,210 feet. Near its northern extremity, where prospected in tunnel 25, it lies six feet below a two-foot diabase sill and eight feet above a twelve-foot sill, and contains about nine inches' thickness of short, good fiber. A short distance farther south, at tunnel 61, this zone outcrops seven feet below a two-inch sill of diabase and nine feet below a one-foot sill. In this tunnel, adjacent to a fault that strikes N.65°W., dips 61° southwestward, has about six feet of vertical displacement, and follows a 2½-foot dike of diabase, the asbestos zone is about three feet thick, is associated with abundant serpentine, and has a large proportion of fine, Crude No. I fiber.

Several other short tunnels have been driven on the asbestos outcrops on the west side of the canyon, but their showings are less noteworthy than the ones just described.

Mining Methods:—As elsewhere in Arizona, the asbestos zones are mined by room and pillar methods, and the fiber is cobbed and graded by hand.

Mining, and usually development, proceed laterally from the surface into the hillside. In the principal productive area, a branching adit is driven in the diabase, beneath the lowest fiber zone, at a rate sufficient to keep pace with development of the upper levels. Finger-raises are run, not steeper than 60°, to intercept the stope floors of the different levels in such a fashion that a chute should always be within 25 to 65 feet of a miner in a stope. Sometimes, for the sake of prospecting, these finger-raises are run in advance of the development of the higher levels. No timber is required in this adit or in the raises. Very little timber is needed in the upper levels, bcause solid pillars and

Geology:—The south side of the canyon of the Salt River here exposes nearly 2,000 feet of Troy sandstone, diabase, Mescal limestone, and Dripping Spring quartzite. The following section, from the top of the mesa south-southeast of the Regal Mine down to the Salt River, was measured by aneroid:

Top of mesa; aneroid reading, 5,050.

(a)	Troy sandstone	425
(b)	Diabase	140
(c)	Mescal limestone; upper 15 feet brown, slabby, siliceous; next 110 feet thin-bedded, somewhat impure and cherty; then about 50 feet of cliff-forming, algal limestone in beds 2 to 10 feet thick; bottom 50 feet medium-bedded, weathers chalky	225
(d)	Diabase	345
(e)	Mescal limestone; in places along base has a 10 to 50 foot member of brown, slabby sandstone that grades into limestone along its strike	115
(f)	Diabase	115
(g)	Mescal limestone; lowest 10 to 15 feet locally a lensing, impure sandy shale, overlain by some 7 feet of thin-bedded, nodular limestone	50
(h)	Dripping Spring quartzite	175
(i)	Diabase	215
(j)	Dripping Spring quartzite to bed of Salt River, opposite the Salt Banks, where aneroid reading is 3,185	60

This section shows four sills of diabase and three divisions of Mescal limestone. Although the top or bottom surfaces of the diabase sills usually tend to follow planes of stratification in the sedimentary rocks, the sills often are of irregular thickness and sometimes cut diagonally across the bedding. Thus, in the side draw occupied by the Regal's principal waste-dump, sill (f) cuts sharply across the strata of (e) and connects with sill (d), which itself is roughly arch-shaped on top. (Plate VII.)

The most pronounced effect of metamorphism of the limestone visible in the vicinity of diabase contacts is the development of serpentine and chrysotile in certain beds. Also, a slight recrystallization of the limestone, or a sufficient breaking down of its original structure to permit chalky weathering, is generally evident.

As shown by Plate II-B, the Mescal strata in the vicinity of the asbestos outcrops are slightly crenulated. Broadly considered, they lie

flat, but in detail they commonly show dips that range widely in direction and from 3° to 15° in magnitude. The north-side outcrops dip northeast from 3° to 7°, but their attitude is due to surface creep. Persistent fracturing and minor faulting, predominately in southwest and southeast directions, have affected the limestone that contains the asbestos. As elsewhere in the Arizona asbestos fields, part of this fracturing and faulting is earlier than the ore, and part is later.

Asbestos and Workings:—Three principal fiber-bearing zones are known in this section. Two occur in the lower portion, below the algae cliff, of the upper limestone, and the third lies near the top of the lowest limestone.

Uppermost Zone:—The uppermost zone, which is some forty feet above the diabase, has been prospected by only a few short tunnels. It shows several veins of semi-harsh fiber, up to more than an inch thick, in four impure, serpentinized zones that are from six to fourteen inches across.

Middle Zone:—The middle zone, which has yielded most of the asbestos mined from the property, is about eighteen feet below the upper zone, or fourteen feet above the diabase. It contains two asbestos-bearing serpentine bands that vary in thickness from narrow stringers up to eighteen inches and are well exposed on the surface along a length of some 400 feet. These bands consist of alternating, lenticular veins of serpentine and asbestos, and are separated by four to six feet of limestone. Within this limestone, a persistent, one- to three-inch band of impure, dark bluish-green serpentine, locally termed the "green ribbon" or "blue streak," occurs three to four feet below the upper band and fifteen feet above the diabase.

The principal mining in this zone has been on claims Nos. 13, 14, and 18, and the productive ground, so far, has been an area of about 400 by 500 feet that lies southeast of the intersection of Corral Creek with Salt River Canyon. As shown by figure 7, the principal stoping has extended southeast, along the trend of the principal faulting, intermittently for a distance of 350 feet.[29] Cross-faulting and fracturing also are well represented. The most striking feature of this ore body is the low, crenulated, structural dome that it occupies (see dips plotted in figure 7).

Most of the fiber from this zone is of the finest quality, much of it is over two inches long, and more than half of the material shipped is of Crude No. I length. Some rather harsh fiber occurs near the larger faults, and a relatively small amount of semi-harsh is in the upper band.

[29]The eastermost tunnel is said to have been extended more than 400 feet by July, 1928, and to have encountered much fiber of two to three inches' length.

On the T62 side, stoping has extended intermittently in a N.55°E. direction for a horizontal distance of approximately 500 feet from the surface, and with a maximum width of eighty feet. A diabase contact follows closely the southeastern border of the commercial asbestos. The dips of the strata are irregular in direction and amount. Near the outcrop, they are 7°N.15°E.; near the center, 5°E.-SE.; midway between the center and the end of stoping, 15°N.20°W.; and at the northeastern end, 15°S.10°E. The best ore has been found in the vicinity of certain fractures.

Alaska Zone:—Asbestos occurring in the uppermost limestone has been prospected to a small extent by the Alaska workings, which are situated 4,000 feet north of the mine office, at an elevation of about 5,150 feet, and are accessible by trail. This limestone varies in thickness from twenty to 75 feet, is limited below by the diabase, and underlies the Troy sandstone. Two or more thin, irregular dikes of diabase cut it. The principal fiber zone is eight feet above the diabase, from eight inches to two feet thick, and dips a few degrees east. Part of the fiber is short or semi-harsh, but some is excellent Crude No. I. It is best near the western contact of a nearly-vertical, two-foot dike of diabase that was cut by two tunnels at a distance of twenty to 25 feet in from the surface. However, a north-south, vertical fault, with downthrow on the east, cuts off the zone at the dike in one tunnel and ten feet beyond the dike in another tunnel. Workings on this zone consist of three short adit tunnels.

A thin zone, showing short fiber, outcrops fifteen feet above the diabase and sixty feet below the Troy sandstone, but it has not been prospected.

Asbestos and Workings (West side):—On the west side of Ash Creek, asbestos occurs in the lowest and in the next lowest limestone members.

In the lowest limestone, the fiber-bearing zone is about one foot thick and outcrops for a length of about 600 feet, within two feet of the base of the overlying diabase sill. The fiber of this zone is of both silky and harsh quality, and ranges in length from a fraction of an inch up to 1½ inches. Some nineteen old tunnels extend south-southwestward into the diabase at the top of the limestone. This diabase, however, is sufficiently decomposed to cave badly and to require timbering. A few of the tunnels, which were being reopened and extended in early 1928, are from 140 to 400 feet long.

The next lowest limestone, which appears to be the approximate stratigraphic equivalent of the middle and productive limestone of the

At the surface, however, it showed several veins of good fiber, an inch and less in length, over a face eighteen inches wide.

Fourth Zone:—The fourth, or "T17-T62," zone is only a few feet above the diabase outcrop. Its principal commercial fiber-bearing bodies, so far, have been found above the northern branches of the main extraction tunnel, as in the T3 zone, and also above the southern branches. A width of some 425 feet of apparently barren limestone separates these two major areas of ore.

Mining on this zone has been in three main stoping areas on the north, or T17, side, and in two main stoping areas on the south, or T62, side. See figure 5.

On the T17 side, stoping has extended intermittently in a N.55°E. direction for a horizontal distance of 1,050 feet from the surface. A diabase dike, from five to seventy feet thick and accompanied by a minor fault, dips 50°SE. and trends along the southeastern margin of the stoping areas for a distance of about 650 feet. It then apparently pinches out, but the fault continues on through.

The first area of T17 stoping extends N.50°E. from the surface outcrop, and is about 275 feet long by 225 feet wide. Its northern and southern margins are near diabase contacts.

The second area of T17 stoping, which starts about 250 feet northeast of the limits of the first area, extends N.15°E. for about 350 feet and is from 20 to 150 feet wide. The diabase dike and the fault already mentioned cut part way along its northwestern margin, until the dike apparently pinches out. The fault continues through the remainder of the area, which widens out across it.

The third area of T17 stoping, which starts about 35 feet north of the northern limit of the second area, is roughly horseshoe-shaped in plan. It extends eastward for about 210 feet, and the distance across its limbs is 200 feet. The fault already mentioned continues through this area, with a southeastward dip of 70°, and is intersected by an E.-W. fault of 70°N. dip on the northern limb of the horseshoe.

The prevailing dips of the strata in the second area vary from east to northeast in direction and from 7° to 20° in amount. In the third area, the dip at the southern limb is 7°N. 30°E., at the apex is 9°-20°N., and at the northern limb is 7°NW.

A low anticline separates the northern, or T17, from the southern, or T62, fiber-bearing bodies. Its crest is approximately midway between the stoping areas. The dips of its flanks increase from 3° near the crest to 7° to 20° at the margins of the fiber bodies.

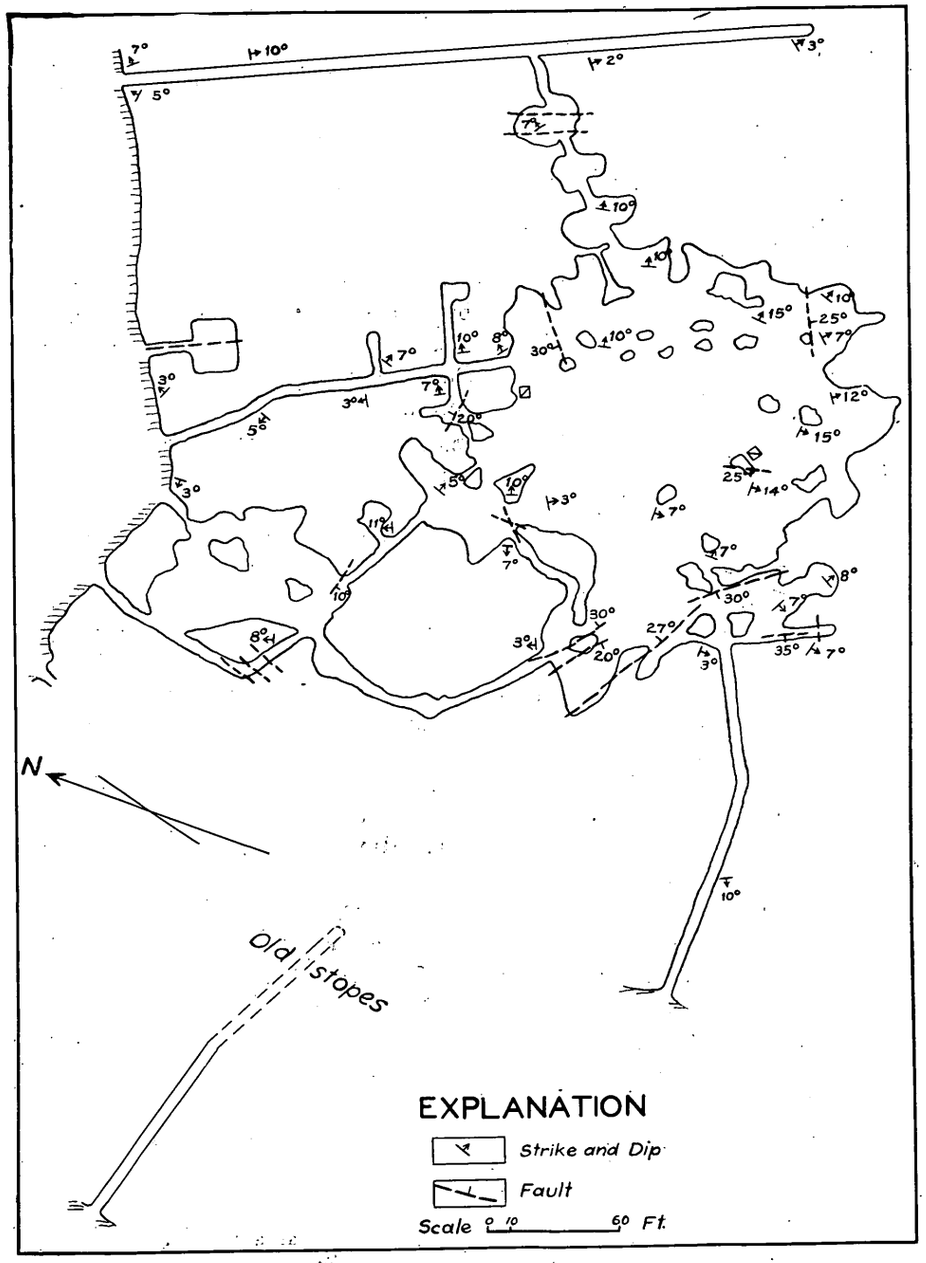

Fig. 7.—Map showing relation of structural features to principal areas of stoping in the Regal Mine.

Lowest Zone:—The lowest zone consists of a six- to twelve-inch band of lenticular serpentine and asbestos veins within a strongly-serpentinized portion of the lowest limestone, and is about two feet below diabase (f) or 45 feet above the Dripping Spring quartzite. The fiber of this zone generally is of good quality, but much of it is less than two inches long. It has been prospected by a few short tunnels and several open cuts, and a few shipments of asbestos are said to have been made from claims 10 and 12.

Since this zone is of some 575 feet lower elevation than the middle zone, its mining is handicapped by greater transportation difficulties.

Other Zones:—According to E. Schaaf-Regelman,[30] five other zones occur beneath the middle zone. Due to their minor importance and lack of development, however, they were not visited by the writer.

Mining Methods:—The asbestos is mined by a modified room and pillar method. Adit tunnels are run in on the promising outcrops, and the economic ore found is removed by lateral stoping. Since dry-wall back fills, built from waste rock, and occasional pillars usually suffice to hold up the stope backs, only a small amount of timber is required. See Plate VI.

After shooting a round, the miner carefully sorts out the economic asbestos-bearing rock, and hammer-cobbs the Crude No. I and No. II fiber. The waste rock goes either into back filling or over the dump. Possible mill rock is stored in a separate dump, to await the construction of a mill.

Mining and cobbing of the fiber is paid for upon a per-pound basis, but the company pays for removing the rock.

Labor:—In March, 1928, the Regal Mine was employing 55 men, but increased the number to 150 by July. As elsewhere in the Arizona asbestos fields, the underground labor is Mexican.

Surface Equipment and Camp:—Surface equipment in March, 1928, consisted of an air compressor of 310 cubic feet per minute capacity, and a blacksmith shop. In July, 1928, according to Mr. John L. Alexander,[31] Manager of the property, a mill was being installed. This mill is to have a capacity of approximately five tons of crude and spinning fiber, besides shorter grades, per eight hours. The camp, likewise, was greatly improved, and consists of framed tent-houses. An ample water supply is pumped from springs, situated in the canyon of Corral Creek, about one mile south of the camp.

[30]Schaaf-Regelman, E., Asbestos and its importance as a national asset: Mining Congress Jour., vol. 13, p. 179. March, 1927.

[31]Oral communication.

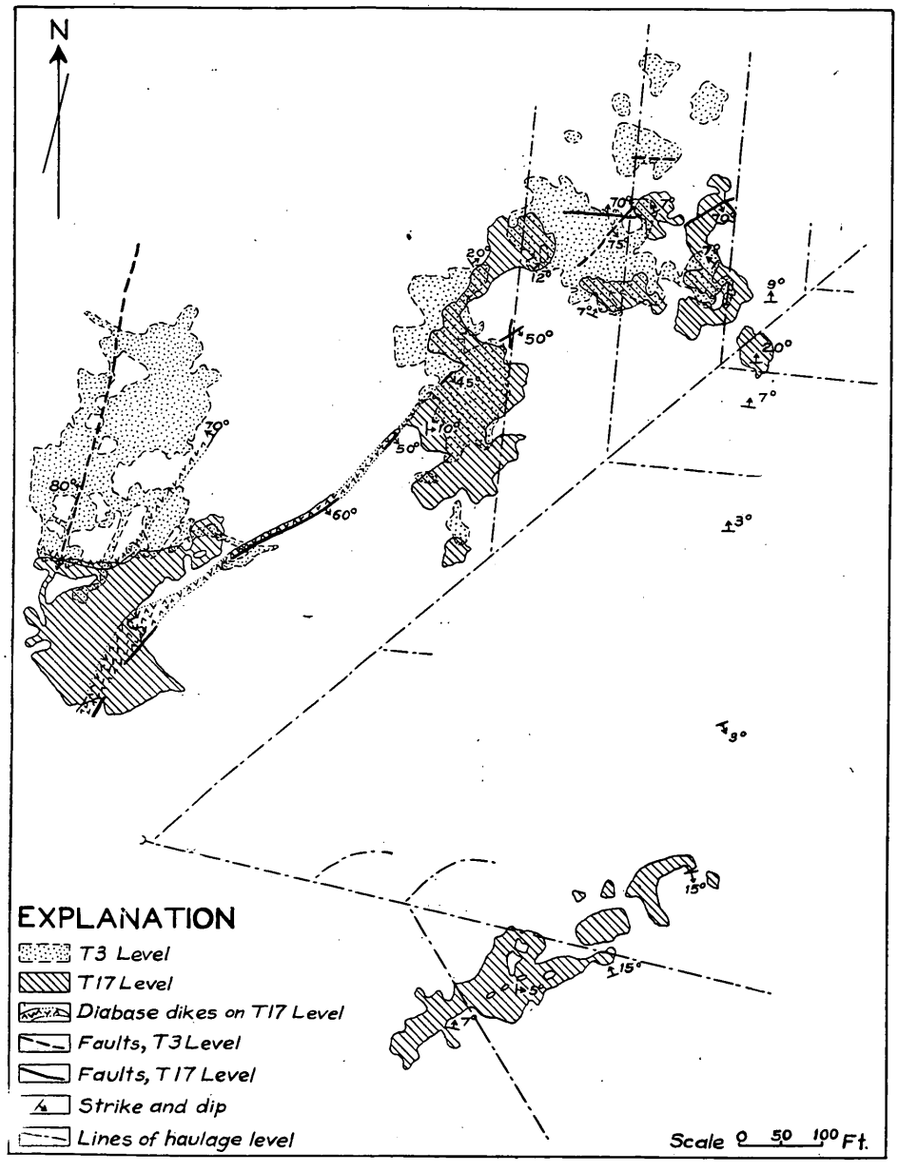

Fig. 5.—Map showing relation of certain geologic features to principal areas of stoping on the T3 and T17 levels of the Arizona Asbestos Association mine at Chrysotile.

Asbestos and Workings (East side):—On the east side of Ash Creek, four prominent asbestos zones outcrop in the middle limestone at distances of 90, 75, 65, and 5 feet above the diabase. Most of the productive workings are within the Asbestin No. 2 and Asbestin No. 17 claims.

Upper Zone:—The upper, or "Candy," streak, which outcrops about ninety feet above the diabase, was worked out several years ago, but is said by Mr. Frank Knuckey,[28] Mine Superintendent, to have been a relatively small body of about three feet thickness. A large proportion of its fiber was four or more inches long and of the finest quality.

Second Zone:—The second, or "T3" zone is 75 feet above the diabase outcrop. The asbestos ore bodies exposed on this level in early 1928 usually contained two main serpentine streaks, each up to 1½ feet thick, separated by three or five feet of limestone. Each streak contained a varying number of asbestos veins that generally were less than two inches thick.

Mining on this level has been in two main areas above the northern branches of the main extraction tunnel, and has extended intermittently in a N.55°E. direction for a horizonal distance of 1,000 feet from the surface. See figure 5.

The first area of stoping extends in a N.30°E. direction from the surface outcrop, and is about 350 feet long by 75 to 200 feet wide. A diabase dike ten feet thick which strikes northeast and dips 47°SE., outcrops opposite the southeastern extremity of this area and extends nearly to the elevation of T3 level. A prominent fissure trends N.14°-20°E. through the area of stoping and is joined by many fissures of N.-S. and N.65°W. trend. As this stoping is several years old, no fiber was being mined from the area in early 1928.

The second area, which begins about 250 feet east of the limits of the first, contains two large and several small stopes. One of the larger stopes is about 250 feet long by 75 to 135 feet wide and trends northward, while the other is about 225 by 100 feet and trends southeastward. In this area, fracturing is prominent, and notable minor faults of 50°-80° southeastward dip trend N.35°-50°E. The prevailing dips of the strata are 10°-20°E.-NE., but, near the northeastern limits of the area change to approximately 7°NW.

Third Zone:—The third zone, or T1½" zone, is about ten feet below T3 level, or 65 feet above the diabase outcrop. As the workings on this zone are old and not extensive, they were not visited by the writer.

[28]Oral communication.

Transportation:—In March, 1928, about 1¼ miles of trail connected Regal camp with the end of the road that leads to Rice and Globe. The cost of packing over this trail was $4.50 per ton, but the trail has since been widened into a road.

From the property to Rice, the nearest railway point, is fifty miles by road. More than thirty miles of this road is in mountainous country, with many long, steep grades, and parts of it often are impassable in winter. The roughest 24 miles, from the property to Sawmill settlement, consists of nine miles built and maintained by the company, and fifteen miles built and maintained by the Arizona Asbestos Association. Trucking costs from the property to Rice amount to about $22.00 per ton, but a first-class road would reduce this figure nearly one-half.

SEVENTY-TWO AND MONTE CHRISTO GROUPS

The Seventy-Two and Monte Christo groups, which consist respectively of seventeen and five unpatented claims, are situated in the vicinity of Seventy-Two Springs, about one mile southwest of the Mule Shoe meander of the Salt River, and immediately west of the San Carlos Indian Reservation line. They are accessible over about 1½ miles of unimproved road that branches east from the Regal road at a point 5½ miles from the Chrysotile fork. Therefore, the claims are some 49 miles from the railway at Rice.

Original locations of these claims are said to have been made in 1916, and mining upon them was begun by the Penn Asbestos Mining & Refining Company in 1917. According to Mr. Montez,[32] this company employed a maximum of forty men and ran more than 1,600 feet of workings on the Shoemaker and Eagle claims. A number of tons of predominately Crude No. II fiber, mainly from the Shoemaker claim, were shipped during 1917, and a few tons were mined during 1918. The property was not worked by the Penn Company after 1918, but was acquired by Messrs. Montez, Vernett, and Barrios in 1922. These men have done assessment work and, by January, 1928, had shipped about nine tons of crude fiber.

The northeastward-flowing tributaries of the Salt River have rendered the immediate region moderately rugged, and, downstream, have cut deep, steep-sided canyons.

A thick sill of diabase underlies, with an intrusive contact that occasionally is sharply irregular, some fifty feet of Mescal limestone. Several asbestos veins, ranging up to four inches in thickness, occur

[32]Oral communication.

within a few feet above the contact, and usually are best developed where the surface of contact is irregular. Most of the long fiber seen, which was mainly on the Monte Christo and Eagle claims, was harsh. However, much of the fiber from the veins of 1½ inches or less thickness, as at the Shoemaker workings, was of good quality.

GLOBE ASBESTOS GROUP

The Globe Asbestos group, which contains 57 unpatented claims, is situated some 2½ miles west of Chrysotile, and is accessible from there by trail.

Some of these claims were located in early 1919, and the rest were added later. Production of Crude No. I and No. II fiber, which began in 1920 and continued until 1922, is said to have amounted to about fifty tons.

This area includes the upper reaches of two northward-trending, wet-season creeks, of which one is tributary to Ash Creek and the other to Salt River. Its topography from south to north changes from slight relief to deep dissection.

The exposed rock formations are Mescal limestone, diabase, Troy sandstone, and Tertiary gravels. The diabase occurs as several sills of variable thickness that split, and occasionally include large masses of the limestone.

Asbestos occurs on several of the claims, but the principal showings are at the Locke workings, which are in the southwestern portion of the group, or about a mile upstream from the camp. There, in an irregular, southward-trending block of limestone of some 250 yards length and low northwest dip, two asbestos zones occurring five feet apart have been explored by several hundred feet of workings. The principal workings start on the southwest margin of the limestone, beside the diabase contact that dips about 80° west, and extend northeast and east. The fiber zone near the floor is a few inches thick and inclosed in a thickness of about one foot of light-colored, impure serpentine. Part of its fiber is more than 1½ inches long, but, due to serpentine inclusions, is mostly shorter than Crude No. I length. A large proportion of it is semi-harsh. The upper zone is somewhat like the lower in length and quality of fiber. At a distance of about 150 feet within the N. 35° E. tunnel, it has a maximum thickness of eight inches and contains three or more asbestos veinlets that are one inch or less thick. The fiber of the upper portion of this zone often is rather harsh, but the lowest veinlet is very fine in quality, although only one-eighth to one-fourth inch in length.

perennial affluent of the Salt River, into V-shaped canyons and intervening flat-topped mesas. At Chrysotile, the main canyon is some 1,100 feet deep and 4,000 feet wide.

The rock formations exposed include gravels of late Tertiary or Quaternary age, Troy sandstone, diabase, Mescal limestone, and Dripping Spring quartzite. Often, a variable thickness, up to 75 or more feet, of vesicular basalt lies between the Troy and the Mescal. The following section down the east side of Ash Creek Canyon was measured by aneroid (see also Plate V.):

Top of knoll northeast of "secret stairway"; aneroid reading, 5,775 feet.

		Thickness in feet
(a)	Troy sandstone; lower 425 feet forms cliff	600
(b)	Mescal limestone, silicified and chert-banded; weathers brown	20
(c)	Diabase	355
(d)	Mescal limestone; contains principal mine workings	150
(e)	Diabase, to bed of Ash Creek, west of mine office; aneroid reading, 4,500	150

Some 300 feet farther downstream, but 75 feet higher, an outcrop of Mescal limestone, with a maximum exposed thickness of approximately 175 feet, is beneath diabase (e). Its lower twenty feet are quartzitic but probably do not represent the Dripping Spring quartzite, which is exposed about 3,000 feet downstream from the mine office.

This total section shows two major sills of diabase and three divisions of Mescal limestone. Although the top or bottom surfaces of the sills tend to follow planes of stratification in the limestone, the sills often are of irregular or lenticular cross-section and sometimes cut diagonally across the stratification.

In the vicinity of the diabase contacts, the limestone generally shows a slight recrystallization, or a sufficient breaking down of its original structure to permit chalky weathering. Serpentine and chrysotile, together with occasional fibrous calcite veins have been developed in certain beds.

Broadly considered, the strata are flat-lying. In detail, however, many minor folds, whose limbs dip from five to fifteen degrees, are apparent. Fracturing is rather prevalent, and faults of minor throw are numerous. The principal systems of fissuring are in S.65°W., N.25°W., N.65°E., N.20°E., E.-W., and N.-S. directions.

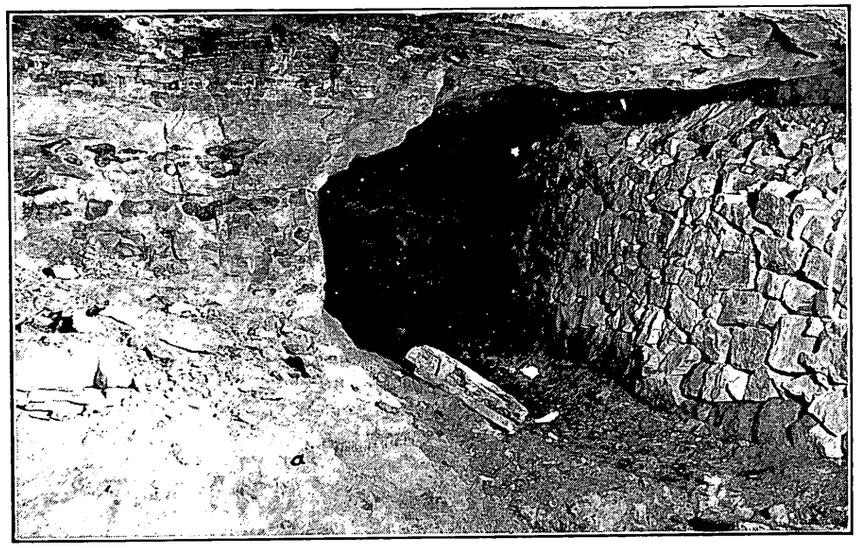

Plate VI.—Dry-wall back fill in a stope of a Gila county mine. a, a, veins of asbestos. Dark nodules are serpentine. Photograph by Carl Trischka.

On the Nail claim, east of the camp, a thin zone of rather harsh fiber occurs above the diabase and about 75 feet below the Troy sandstone, in limestone that dips some 10° north. Two tunnels, totalling approximately 200 feet in length, have been run on this zone.

Only assessment work has been done on the property since 1922. A small camp is maintained, at a spring in the northern portion of the group, for the few Mexicans who keep up the necessary assessments.

CROSTHWAITE-STEWARD GROUP

The Crosthwaite-Steward group, which includes 26 unpatented claims, is situated approximately one mile south of the Salt River and 2½ miles east of the Regal group. It is accessible by two miles of road that branches north from the Regal road at a point seven miles from the Chrysotile fork. Thus, the group is 51 miles from the railway at Rice.

The Crosthwaite-Steward Corporation acquired control of these claims in April, 1928, built about three miles of road, and started intensive exploration work.

North and northeast, the Salt River and its tributaries have cut deep, steep-sided canyons, but, for a few miles south and southwest, only broad, shallow valleys have been eroded.

The principal operations of the present company have been limited to the Lone Tree claim, where a small hill of Mescal limestone rests upon the intrusive diabase that floors much of the adjacent region. The lower thirty feet of this limestone is medium to thin-bedded, but the upper portion consists of massive, algal beds. Particularly near the surface, rather intensive fracturing in general east-west and north-south directions is evident. A low anticline, whose limbs dip a maximum of about 20°, plunges 16° N. 80° E. through the hill.

Three separate asbestos-bearing serpentine bands occur within a vertical range of six feet. Where seen, the lowest band, which lies two feet or less above the diabase contact, was about one foot thick, and the middle and upper bands were from ten to fourteen inches thick. A visible amount of sericite frequently occurs in the serpentine. The asbestos veins of these bands range up to 1½ or two inches in thickness. Their fiber is rather harsh at the surface, but becomes appreciably better further underground.

The principal workings in July, 1928, consisted of thirteen adit tunnels that varied from 25 to ninety feet in length and extended eastward from a face of about 400 feet length at 4,700 feet elevation above sea level.

Surface equipment consisted of a blacksmith shop and a portable air compressor.

SAN CARLOS INDIAN RESERVATION

Accident Group:—The Accident group, which contains nine claims, is situated on the west side of Cienega Creek, northwest of Cienega Falls. All but two of these claims are within the San Carlos Indian Reservation. The group is accessible, via Cienega Ranch, by about 9¼ miles of unimproved road that branches north from the Rice-Chrysotile road at a point twelve miles northwest of Sawmill settlement, or by about three miles of trail that extends east from the Chrysotile-Regal road.

These claims were located in May, 1921, by Mr. Robert M. Anderson. Small-scale, intermittent operations, which were limited to the Accident claim, yielded some thirty tons of crude fiber up to the end of 1927, and a little over one ton in the first quarter of 1928. About half of the production was Crude No. I and the remainder Crude No. II. During the spring of 1928, pending a reorganization of personnel, only two men were working the property.

The steep-sided canyon of perennial Cienega Creek, which here is 1,000 feet deep and three-fourths mile wide, exposes Troy sandstone, diabase, Mescal limestone, and Dripping Spring quartzite. The following section down the west side of the canyon was measured by aneroid:

Edge of mesa at a point some 700 feet south of milepost twenty on Reservation line; aneroid reading 4,600; base of Troy sandstone is some 75 feet higher.

	Thickness in feet
(a) Diabase	85
(b) Mescal algal limestone, with some magnetite developed at top. Minor asbestos, in two streaks seven feet apart, near base	40
(c) Diabase	160
(d) Mescal limestone, with occasional small fiber showings	15
(e) Diabase	50
(f) Mescal limestone, containing principal fiber zones near its base	75
(g) Diabase	280
(h) Mescal limestone	20
(i) Dripping Spring quartzite, to bottom of canyon where aneroid reading is 3,600	275

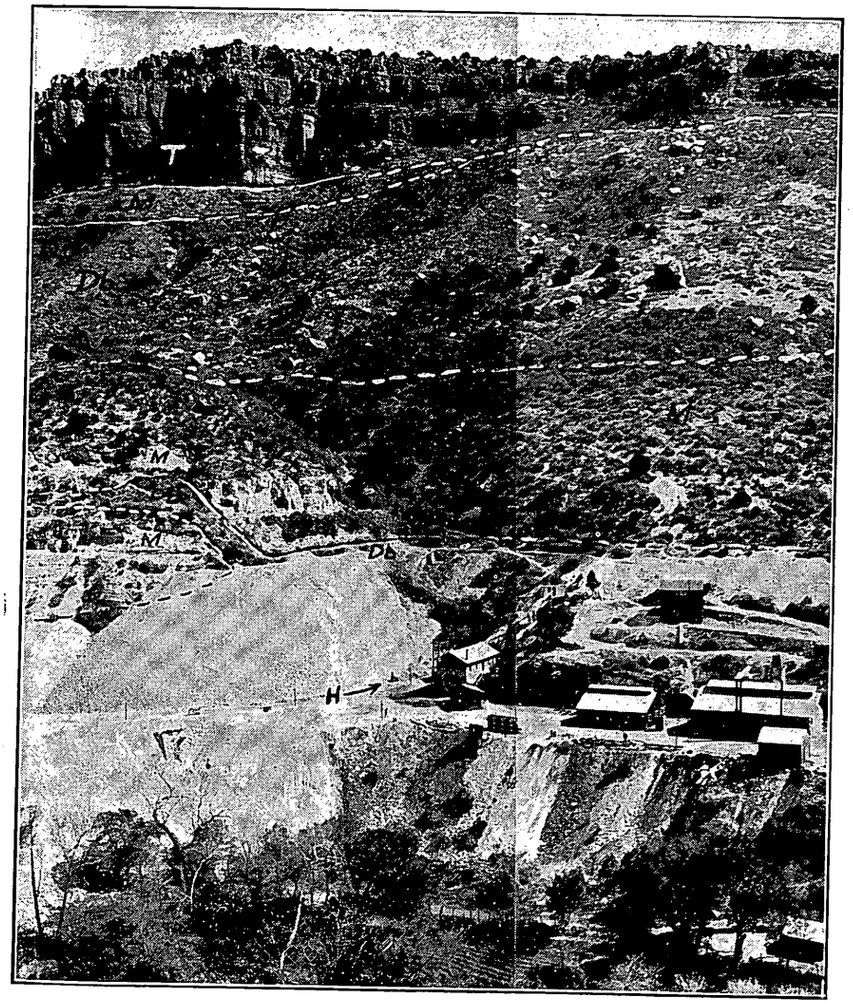

Plate V.—View of east slope of Ash Creek Canyon, at Arizona Asbestos Association property. T, Troy sandstone; M, Mescal limestone; Db, diabase. Arrow (H) points to portal of main haulage level.

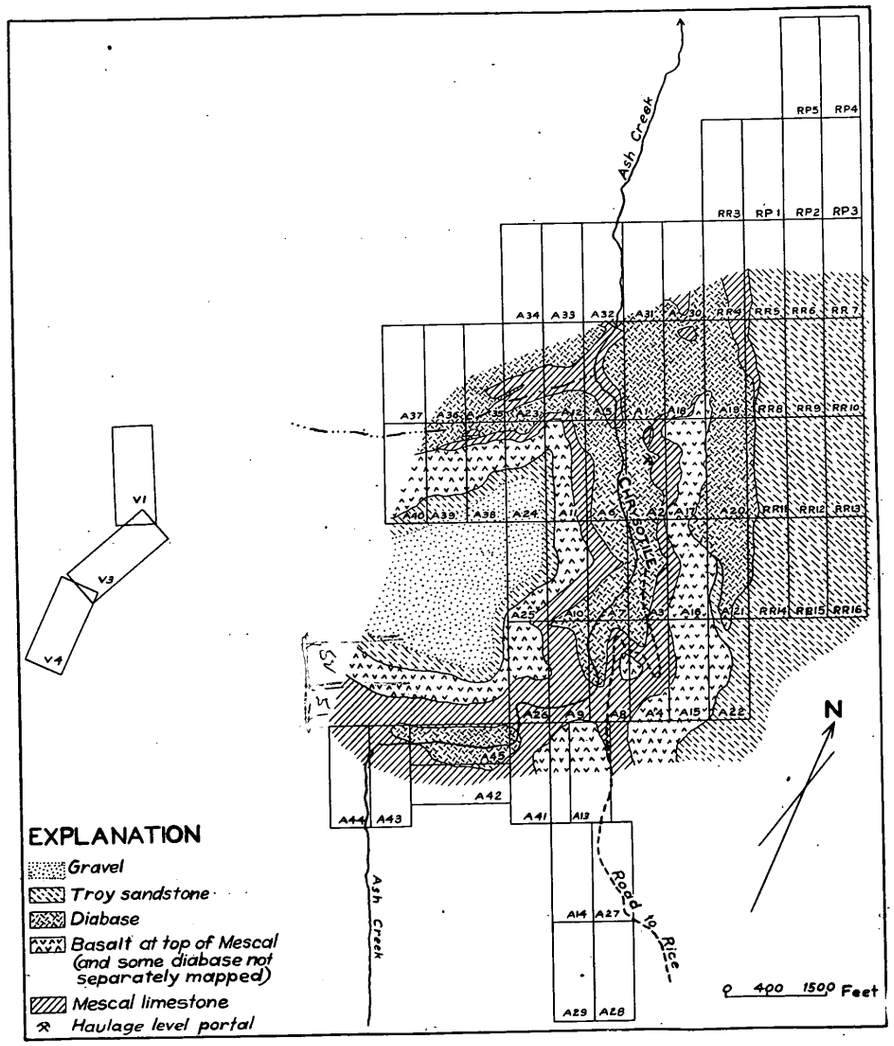

Fig. 4.—Claim map of Arizona Asbestos Association property at Chrysotile. Claim symbols: A, Asbestin; RP, Rocky Point; RR, Rim Rock; V, Victory. Geologic sketch by Carl Trischka, with slight modifications.

The diabase sills are of variable thickness along their strike, and may either follow or cut across the planes of stratification of the sedimentary rocks. Besides a slight recrystallization, metamorphism near the diabase-limestone contacts frequently is expressed in the development of serpentine, chrysotile, and magnetite. Wollastonite also was observed.

The principal fiber-bearing horizon, which is about twenty feet thick and exposed laterally for some 300 feet, occurs in the lower portion of the second (designated as "f" in the above section) Mescal limestone outcrop from the bottom. The lower diabase, by cutting across from below with a north-northwest dip of 15° to 20°, terminates the fiber zone at the southeast end of this face. Near the bottom of the fiber-bearing horizon, a minor sill of diabase from a few inches to one foot thick follows, with occasional splitting, the general stratification. A few inches of wollastonite extends along both contacts of this sill. Aside from small, minor flexures, the limestone strata prevailingly strike N. 55° E. and dip N. 35° W. from 8° to 10°. Minor fracturing, in S. 35° E., S. 60° W., and S. 70° E. directions, is apparent.

Three zones contain the principal asbestos of the fiber-bearing horizon. The lowest is within a foot above the thin diabase sill, the middle is five feet higher, and the upper is some fifteen feet above the middle zone.

The lowest zone consists of about one foot of alternating bands of serpentine and asbestos, within strongly-serpentinized limestone and immediately above a two- to four-inch streak of black serpentine. Its fiber varies in length from four inches to less than three-fourths inch, and, as a rule, is of very excellent quality.

The middle zone is usually less than six inches thick, but a large proportion of its fiber is of Crude No. I and No. II length and quality. Where exposed, the limestone for about three feet above it is heavily serpentinized.

The upper zone, which also is within strongly serpentinized limestone, is some fifteen inches thick. Part of its fiber is slightly harsh at the surface, and, due to the presence of numerous, minute serpentine lenses throughout its veins, only a minor percentage of the material exposed is of Crude No. I or No. II length. This zone should, however, be satisfactory for milling.

Workings on the Accident group, which are all on the Accident claim, include two tunnels on the lowest fiber zone and five tunnels on the upper. One of the lower tunnels is at the base of the lowest zone, while the other intercepts the lowest and the middle zones, and both

extend S. 55° W., with some lateral stoping, for about 85 feet. The five upper tunnels extend southwest for only a few feet each.

Surface equipment consists of a blacksmith shop and a camp. The latter is situated immediately above Cienega Falls, or 1½ miles by trail from the workings. All transportation to the railway is over some three miles of pack trail and 43 miles of road to Rice.

Falls Group:—The Falls group contains six claims on the east side of Cienega Creek Canyon, across from the Accident group.

These claims, which are within the San Carlos Indian Reservation, were located in March, 1921, by Mr. Robert M. Anderson. No production from them has been made.

The geologic relationships on this side of Cienega Creek Canyon are in general similar to those on the west side, but different in the details of thickness, number, and sequence of the diabase sills. Two major sills of diabase separate the Mescal limestone into three parts. A nearly vertical fault, with a downthrow on the north of some 100 feet, trends a little north of east.

Asbestos has been found in each of these three divisions of the Mescal limestone. In the upper division, some long, but usually harsh, fiber is exposed. In the middle, fiber of good quality appears a few feet above the lower diabase. In the lower, good fiber appears near the top and bottom.

Only a few small openings for assessment work have been made on the Falls group.

Cobb & Dunaway Group:—The Cobb & Dunaway group, which includes four claims, is situated in the northwestern portion of the San Carlos Indian Reservation, about 1½ miles east of the Accident workings and S. 56° E. of the southernmost extremity of the Mule Shoe. These claims are accessible from Anderson's camp by about two miles of the trail that leads to Mule Shoe crossing.

This ground was located in 1921, and a few small shipments of fiber have been made from it. In March, 1928, it was under option to Mr. W. H. Webster, but was not being worked.

Here, a north-northwest-flowing tributary of Salt River has cut a steep-sided canyon that exposes Troy sandstone, Mescal limestone, and diabase. Some fifty feet of Mescal limestone lies between the Troy sandstone and the principal diabase. At the main workings, it strikes N.60°W. and dips 15°N.30°E., but in the vicinity of a small fault that appears about 150 feet east of the portal, it dips steeply east. Notable fracturing occurs in N.30°E. and N.60°W. directions. A one-foot sill of diabase outcrops some 25 feet above the main diabase sill, and, a few feet above it, considerable magnetite occurs.

The following analysis of a sample of the water from these saline springs was made by Mr. W. A. Sloan, of the United States Bureau of Mines:

	Parts per million
Suspended matter	16.4
Iron sesquioxide	13.6
Silica	2.8
Total dissolved solids	24,134.0
Calculated composition:	
Sodium chloride	22,141.9
Calcium chloride	394.9
Calcium sulphate	771.5
Magnesium sulphate	287.9
Magnesium carbonate	393.5
Ferrous carbonate	10.3
Silica	81.0
Volatile and organic matter	55.2

ARIZONA ASBESTOS ASSOCIATION GROUP

Situation and Accessibility:—The Arizona Asbestos Association group, shown in figure 4, includes 67 claims, of which 22 are patented and 45 unpatented. These claims are situated about seven miles south of the Salt River, on both sides of Ash Creek, in the vicinity of Chrysotile village. This village, which is built on the bottom of Ash Creek Canyon at an elevation of about 4,600 feet above sea level, is accessible from Rice and Globe by 42 and 64 miles of road, respectively.

History:—The first locations upon this ground were made in 1913 by West Brothers and Mr. Fred Patee, who took up fourteen claims. In 1914 and 1915, Messrs. Snell and Fiske operated the property for the Arizona Asbestos Association of Globe, Arizona. Their first year's mining resulted in about 1,000 feet of workings that yielded an average of ninety pounds of Crude No. I fiber per foot,[26] and their 1915 production is said to have amounted to about one ton of Crude No. I per day.[27] All these shipments were packed to the railway at Globe or Rice by burro train. In 1916, the Arizona Asbestos Association became a subsidiary of the H. W. Johns-Mansville Co., which developed it into the largest asbestos mine in the United States.

Geology:—The prevailingly-horizontal strata of this vicinity have been eroded by the drainage system of Ash Creek, a northward-flowing,

[26]Diller, J. S., U .S. Geol. Survey Mineral Resources for 1914, pt. II, p. 97.
[27]Diller, J. S., U. S. Geol. Survey Mineral Resources for 1915, pt. II, p. 15.

Plate IV.—Mule Shoe meander on Salt River. q, Dripping Spring quartzite, intruded by diabase; M, Mescal limestone; Db, diabase. Arrow points downstream.

Four asbestos-bearing serpentine bands occur within a five-foot zone and within ten feet of the diabase contact. The upper band, which is less than one foot thick, contains fiber that is partly of one inch length but mostly of less than one-half inch length. Some of this fiber is of good quality, although a considerable portion of it is semi-harsh. The other three bands occur about one foot apart, but their fibers are rather short.

Workings consist of an adit tunnel, at approximately 4,700 feet above sea level, that runs S. 56° E. for about sixty feet and has two short, left-hand branches.

Bear Canyon Asbestos Co.—Lunn & Mathews Group:—The Lunn & Mathews group, which includes twenty claims, is situated along Bear Creek, in the San Carlos Indian Reservation and in the northwestern portion of the Natanes Plateau. It is accessible by some 3½ miles of unimproved road that branches east from the Rice-Sawmill road at a point sixteen miles from Rice.

This ground was located in 1921 by the Apache Asbestos Co., and relocated in 1927 by Mr. F. J. Lunn. Only a few tons of fiber have been shipped. In July, 1928, six men were working on the property.

In October, 1928, it was announced that the group had been absorbed by the Bear Canyon Asbestos Co., of Ambler, Pa. Dr. Richard V. Mattison, of Keasbey & Mattison Co. and a leading figure in the North American asbestos industries, is president of this company, and Mr. F. J. Lunn, of Globe, Arizona, is vice president.

Here, the canyon of Bear Creek, which is a southward-flowing tributary of the San Carlos River, has cut through the thin Tertiary basalt and gravel cappings of the Natanes Plateau to expose some ninety feet of Mescal limestone and 35 to 45 feet of diabase. The upper 35 feet of this limestone is made up of massive, algal beds, the middle thirty feet is thinner-bedded and weathers into a slope, and the lowest 25 feet is thin- to medium-bedded, with occasional cherty members.

Along its length of principal exposure of approximately 1,000 feet, the limestone constitutes a low arch whose crest plunges 5° N. 20° E. Fracturing in southeast, southwest, and south directions is visible but not everywhere prominent.

A number of sinuous diabase dikes, of irregular thickness up to six inches, cut at random across the limestone beds. Occasionally, the asbestos veins cut across these dikes, but usually show a small decrease in thickness at the intersections.

Two principal asbestos-bearing serpentine bands occur, and, at the outcrop, are within sixteen feet of the diabase contact. The upper band is about 1½ feet thick and contains several asbestos veins that

range up to 1½ inches in thickness. The other band, which is five to six feet lower and about one foot thick, contains two minor asbestos veins and one vein of a maximum thickness of two inches. This band seems to be absent at the southern end of the limestone exposure.

At the surface, the fiber mostly is harsh, but, underground and away from the influence of pronounced surface weathering, much of it is of good quality and part of it is semi-harsh. The best length and quality of fiber seen on the property was in a stope some 100 feet in from the portal of the northernmost tunnel. There, the dip changes to 18° N. 70° E., and good, two-inch fiber occurs in the lower band.

Workings, which extend in a northeast direction from the outcrop, consist of approximately 245 feet of tunnels from four openings, and a small amount of stoping. These openings are at an approximate elevation of 4,425 feet above sea level.

Apache Claims:—The Apache claims are situated in the San Carlos Indian Reservation, four miles northwest of Gilson, a station on the Bowie-Miami branch of the Southern Pacific Railway, and about thirteen miles east of Globe. They are accessible by unimproved road from the Rice-Globe highway.

These claims were first located in 1922 by Messrs. Frank Proctor and Frank Haynes, and were obtained by Mr. W. G. Shanley in 1923. The property was operated but a short time, and only a small amount of fiber was shipped.

Here a low, narrow, northwest-southeast ridge of the Apache Mountains has been eroded into rounded hills, separated by shallow canyons that are 3,700 to 4,000 feet above sea level. This ridge is made up of fault blocks of the Apache group of sediments, flanked on the northeast and southwest by Gila conglomerate and later gravels. In the vicinity of the asbestos workings, the rock outcrops form a patch-like pattern of Mescal limestone and irregular diabase sills. The limestone strikesN.70°W., dips 30° southwestward, has a few short, very minor folds, and has been affected considerably by faulting.

Two asbestos-bearing zones, both of which strike nearly north-south and dip a few degrees westward, are present. One of these zones lies from three to four feet above the diabase, and the other four or five feet higher. Their fiber is rather harsh, but becomes appreciably better farther underground from the outcrop. The lower zone is from one inch up to eight inches thick, but contains many lenses of dark to light-colored, impure serpentine and silica, so that most of its fiber is less than two inches long. This zone pinches out about forty feet west of its outcrop. The upper zone, which in general is similar to

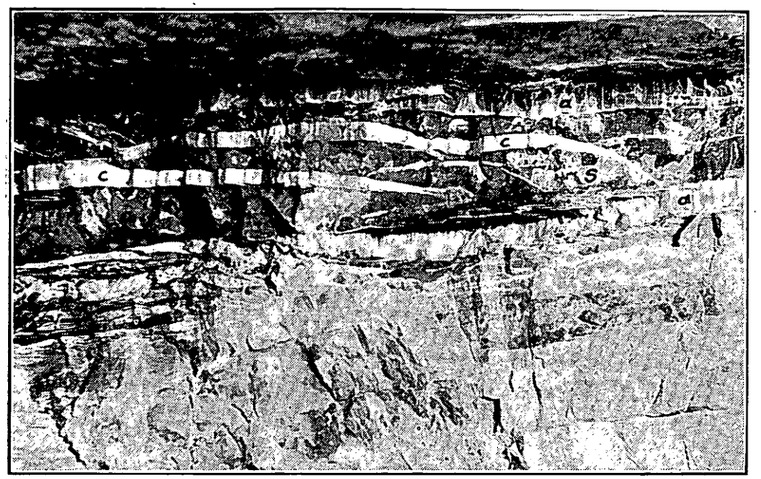

Plate III-A.—Cross-fiber veins (a) of commercial asbestos in a Gila County mine. c, fibrous calcite veins; s, serpentine. Photograph by Carl Trischka.

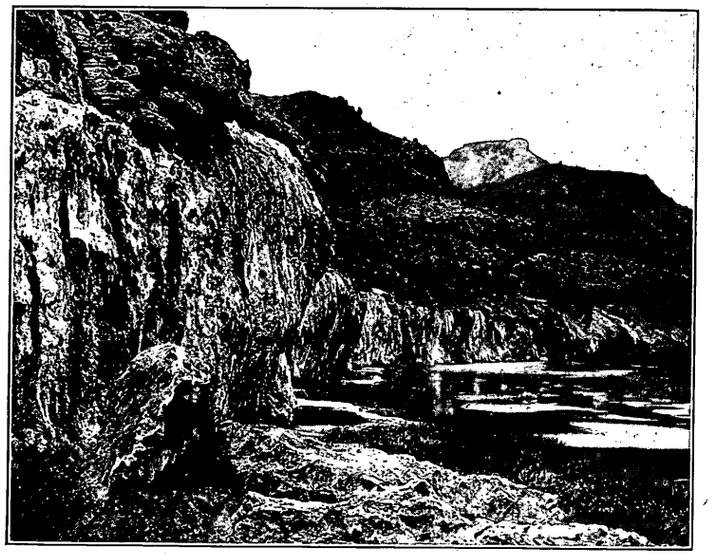

Plate III-B.—Salt Banks on Salt River. Photograph by U. S. Reclamation Service.

Climate and Vegetation:—No exact climatological data are available for the region. However, each year has its wet summer and winter seasons, with dry months between. In July and August, torrential rains, accompanied by considerable lightning, fall nearly every afternoon. These rains sometimes result in violent, but short-lived, floods in even the normally dry creeks. From December to March, inclusive, the storms are less violent, but the snow that falls in the higher elevations may block the roads there for a month or more. At elevations of a mile above sea level, the total yearly precipitation probably is about twenty inches, and the total yearly snowfall is about 28 inches.

The summer temperatures usually are not great enough to lower human efficiency, except in the sunny portions of the narrow canyons. The winter temperatures are sufficiently low to freeze surface waterlines and to render light camp outfits inadequate.

Between approximately 4,600 and 5,600 feet above sea level, the principal trees are oak and juniper, but above elevations of 5,600 feet, yellow pine predominates. A Government sawmill, situated fifteen miles southeast of Chrysotile, formerly supplied timber for the Indian Reservation, but has been idle for several years.

Water Supply:—The Salt River and Cibecue, Canyon, Cienega, Ash, and Salt River Draw creeks are perennial except in very dry years. Small springs, whose flow usually can be augmented by proper tunneling, occur every few miles. Shallow wells in the diabase, if properly situated, generally yield good water in quantities ample for domestic purposes.

Salt Springs:—Several small, saline springs are situated a short distance above the mouth of a southward-trending gulch on the north side of the Salt River, N. 10° W. from the Regal Mine.

Although the rock exposures at the springs are obscured by talus and precipitated material, their water appears to issue from along a contact of the Dripping Spring quartzite with diabase. The course of the small stream fed by their water is marked by much effloresence and iron stain. Where the saline water cascades into the gorge of the Salt River, it has deposited a mantle, locally known as the Salt Banks, that is about one-fourth mile long and in places more than fifty feet high, and consists mainly of travertine and sodium chloride. See Plate III-B.

Animals are fond of this water, and it is reported to have been used, in the seventies of the past century, as a source of salt for the silver mines of McMillenville. It contributes materially to the salinity of the Salt River.

the lower, forks into several parts about forty feet west of its outcrop, but its main vein maintains a thickness of two or more inches for an additional forty feet, until it meets an upward extension of the diabase.

Workings of the property, which are mainly on the Apache No. 4 claim, consist of a few adit tunnels, shallow shafts, and open cuts. One tunnel extends S.80°W. for about forty feet along both zones. Some fifty feet southeast of its portal, a branch runs irregularly northwest to cut the upper zone at a distance of about fifty feet in, and then follows it westward for about forty feet.

Surface equipment includes a mill that was built in the summer of 1924, but has since been abandoned. As the long fiber from this property is too harsh for spinning, the mill was equipped with crusher rolls and shaker screens to prepare asbestos short fiber and sand for stucco, etc.

FORT APACHE INDIAN RESERVATION

Horse Shoe Group:—The Horse Shoe group of claims is situated in the southwestern portion of the Fort Apache Indian Reservation, immediately north of the Peninsula, or Mule Shoe meander of the Salt River. These claims are accessible from the railway at Rice, via Cienega Ranch, by 47 miles of road and about 6 miles of trail. As the river is not fordable during high water, a suspension bridge formerly served this trail, but, in the winter of 1923, a packer overtightened the suspension wires, and the bridge collapsed. The claims are also accessible by road via Fort Apache, but the 23 miles from Carrizo Creek to the property was, due to lack of maintenance, rather rough in early 1928.

The application for lease, made by the San Carlos Asbestos Mining Co., to work this ground was approved in 1921. During 1922 and 1923, considerable asbestos was mined from the property, but, during 1924 and 1925, no production was reported. A small amount of fiber was shipped in 1926 and 1927, but very little work has been done on the property since October, 1926.

Here, the canyon of Salt River has a miximum depth of more than 2,000 feet. A steeply eastward-dipping flexure of the strata, transverse to the course of the river, has induced the Mule Shoe meander. (Plate IV.)

The principal formations exposed in the vicinity of the property are Troy sandstone, diabase, Mescal limestone, and Dripping Spring quartzite. The sequence of these formations is shown by the following section, which was measured by approximate aneroid readings:

		Thickness in feet
(a)	Troy sandstone at edge of mesa above the principal workings	150-300
(b)	Diabase	300
(c)	Mescal limestone; forms bench and contains principal workings in middle at 4,200 feet elevation	100-175
(d)	Diabase	565
(e)	Mescal limestone	85
(f)	Dripping Spring quartzite, intruded by diabase	250

Mescal limestone (*c*) apparently is in the form of a long sliver engulfed by diabase. Aside from occasional local flexures, the strata are essentially horizontal.

The principal asbestos zone occurs in the upper limestone, about fifty feet above the diabase. Near the outcrop, several asbestos veins, four inches in maximum thickness, occur alternating with limestone and impure serpentine and are irregularly distributed over a face of a maximum of five feet in height. Part of this fiber is of good quality, but some of it is harsh. It appears to be best developed in the vicinity of minor irregularities within 7° to 15° north and northeast dips of the strata. At the time of visit, most of the good fiber in sight had been mined out.

Workings consist of several systematic tunnels and irregular, lateral stopes that extend from a large cut on the south side of the precipitous bluff in which the deposit occurs.

Surface equipment includes a hothead engine, an air compressor, and a blacksmith shop.

Riverside Group:—The Riverside group includes nine claims in the southwestern portion of the Fort Apache Indian Reservation, along the north side of Salt River, northeast of the Salt Banks and opposite the Regal Mine. It is accessible by about three miles of steep trail from the Regal Mine. These claims are said to have been located in 1921 by Mr. W. G. Shanley, and worked to some extent in 1923, when a small amount of fiber was produced. In late 1927, they were relocated by Mr. Roy Riedhead.

Here, the high, steep, north side of Salt River Canyon is modified by several benches and is escalloped by tributary canyons. Dripping Spring quartzite, Mescal limestone, diabase, and Troy sandstone are exposed. The thick diabase sills contain numerous small included blocks of limestone, and split the strata into a succession that is different from that which obtains on the south side of Salt River.

bodies with transverse fissures indicates that the asbestos was deposited from mobile solutions which used those fissures as pathways of entry to such strata as were amenable to development of serpentine and asbestos.

Likewise, the association of many fiber-bearing bodies with minor folding indicates that structural irregularities served to localize the mineralizing solutions. This localization appears to have been aided by the relatively impervious capping provided by the algae beds, for only a minor amount of serpentine, and no asbestos have been found in or above them. Microscopic examination of the diabase indicates that it has undergone hydrothermal alteration. Probably a final emanation from the diabase magma brought about this alteration and also the development of the serpentine and asbestos. Sufficient magnesium and silicon for these minerals may have been derived wholly from the olivine of the diabase, or part of the magnesium may have been supplied by the Mescal dolomitic limestone.

CHRYSOTILE-SALT RIVER REGION

Limits and Topography:—The Chrysotile-Salt River region, as here considered, includes the northwestern portion of the Natanes Plateau and extends from a few miles north of the Salt River, between Canyon Creek and the Peninsula, or Mule Shoe, south to the latitude of Globe. North of the river, it includes a portion of the Fort Apache Indian Reservation, and south of the river, a portion of the San Carlos Indian Reservation. Its area south of the river sometimes is called the McMillen mining district.

Broadly considered, this region is a plateau of nearly-horizontal, hard strata, capped in places by remnants of lava, and intruded by sills of diabase. The surface of this plateau varies in elevation from 4,500 to 6,800 feet above sea level, but the Salt River and its tributaries have deeply dissected it, down to as low as 3,000 feet above sea level, with steep-sided canyons.

The main channel of the Salt River here follows a sharply-winding course, in strong contrast to its rather straight tributaries. Its most notable meander, known as the Peninsula, or Mule Shoe, is situated about 1¼ miles upstream from the San Carlos Indian Reservation boundary. A steeply eastward-dipping flexure of the strata, transverse to the river course, has produced this meander, which is more than a mile in longest dimension by 200 feet across its neck. A 200-foot tunnel through this neck would provide a 78-foot head of water for power purposes. See Plate IV.

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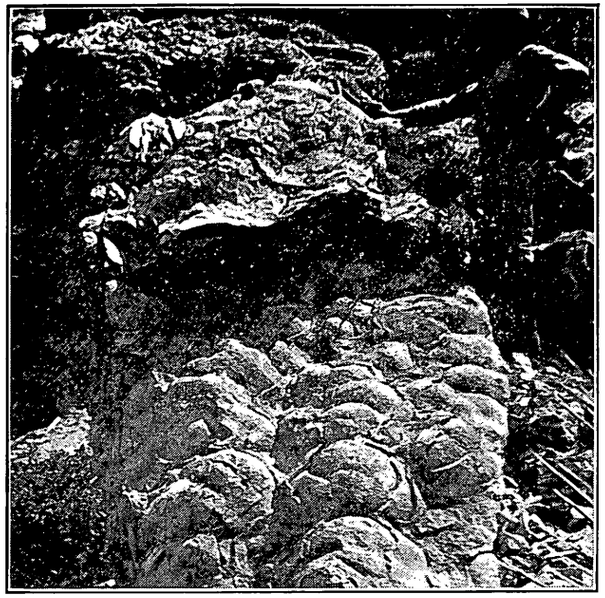

Plate II-A.—Near view of algal limestone, at Regal Mine. Photograph by R. E. S. Heineman.

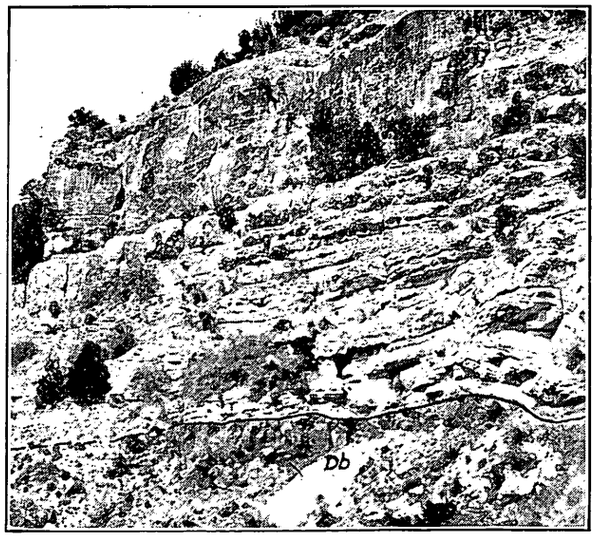

Plate II-B.—Mescal limestone intruded by diabase (Db). Upper, massive member is algae reef.

of very small throw, and several systems of visible fractures, are rather numerous. Part of the fracturing and faulting is earlier than the asbestos, and part is later.

General Features of the Asbestos Deposits:—The asbestos occurs almost entirely as cross-fiber veins, and rarely as slip-fiber. These veins vary in thickness from a microscopic amount up to a known maximum of fourteen inches, but the majority of them are less than two inches thick. The serpentine bands or lenses range up to about two feet in thickness, and may contain from one to twenty or so veins of asbestos. Often, two or more zones, each consisting of one or more asbestos-bearing serpentine bands, occur separated by only a few feet of limestone, and can be worked from the same tunnel. Several zones may occur within a distance of as much as ninety feet from the diabase contact.

The shape of an asbestos-bearing body seems to be governed largely by structural factors, so that a roughly-lenticular form is the most common. In horizontal dimensions, these bodies vary from a few feet to as much as 100 by 200 feet, but the large sizes are exceptional. Due to the tendency of cross-fiber asbestos veins to pinch or swell suddenly, their continuity and probable volume are difficult to foretell.

The asbestos is more commonly developed above the upper contacts of the diabase, but it sometimes occurs below the lower contacts. When above, it seldom is nearer than one or two feet to a contact, but, when below, it may be within a few inches. No commercial fiber is known to occur above the base of the algae beds.

Although serpentine often is barren of asbestos, the most desirable fiber is found in strongly-developed serpentine. See Plate III-A.

The best fiber-bearing bodies are apt to occur where a zone, or two interlacing zones, of fractures cut across a Mescal limestone stratum that is favorable in composition and favorably situated in reference to the diabase. This fact has been used for some years by the larger mines in prospecting, and has been recorded by Trischka.[25] Where a minor fold happens to be in the plane of such an intersection of fractures, the conditions for asbestos are even more favorable. Good fiber often occurs along the crests, troughs, or flanks of minor folds that have not been appreciably fractured, particularly when they are to one side of a transverse diabase contact.

Origin of the Asbestos:—The proximity of diabase to the asbestos deposits of the Gila County field suggests that the asbestos owes its origin to the diabase. The association of most of the best fiber-bearing

[25]Trischka, Carl, Asbestos and the Arizona Industry: Eng. & Min. Jour., vol. 124, pp. 337-340. 1927.

PREFACE

Seven years ago the Arizona Bureau of Mines published its Bulletin No. 113 entitled "Asbestos," by M. A. Allen and G. M. Butler. This pamphlet has now been out of print for some time, yet inquiries concerning Arizona's asbestos deposits continue to reach the Bureau with considerable frequency, and it seems desirable to republish the bulletin. This publication is not, however, merely a reprint of the first bulletin. Many more Arizona deposits are described herein than in the earlier booklet, and Mr. Wilson visited and studied most of them before preparing the descriptions. Furthermore, the subject matter has been brought up to date, and the result is really, in large part, a new bulletin. It is offered in the hope that it will increase interest in the asbestos deposits of Arizona, and that their development may be thereby stimulated.

G. M. Butler,
Director, Arizona Bureau of Mines.

September 28, 1928.

1918. In early 1925, the group was leased to the Riga Asbestos Mining Co., which made small shipments during 1925 but forfeited their lease in 1927. It was next leased to Mr. T. V. Davenport, and, in early 1928, sublet to Mr. C. Lopez.

Topography and Geology:—The high, western side of Cherry Creek Canyon here exposes about 1,000 feet of Troy sandstone (Plate VIII-B), underlain by Mescal limestone, diabase, and Dripping Spring quartzite. The Mescal limestone, which is eighty to ninety feet thick, contains several massive, algal beds at its top, and has diabase in some places above it, thick diabase below it, and lesser diabase dikes cutting it. Serpentine, chrysotile, silica, calcite, magnetite, hematite, and sericite have been developed at certain places in the limestone near the diabase contacts. In general, the limestone strata lie nearly horizontal, but minor, sharp flexures occasionally occur. Moderate fracturing, in N.75°W., N.20°E., and north-south directions, is present.

Ore and Workings:—Prospecting for asbestos along the limestone outcrop has extended mainly for a length of approximately 1,500 feet, at 5,950 feet above sea level.

North portion:—The northernmost portion of this work was along a bench that has been cut in a southeast direction for a length of 150 feet and a width of five to eight feet. The Mescal limestone beds are from a few inches to sixteen inches thick, horizontal, and rather pure. A minor diabase sill, from two inches to one foot thick, outcrops from 25 to thirty feet above the main diabase along the northern half of the cut, but forks along the southern half.

At the north end of the cut, a tunnel extending S. 30° W. for fifty feet shows two fiber-bearing, serpentinized zones. One zone, which is immediately above the minor diabase dike, is ten inches thick and carries three principal asbestos veins whose fiber is less than three-fourths inch long. The other zone, which is three feet higher, is eighteen inches thick and carries several asbestos veins whose fiber is of fine quality and sometimes one inch, but usually less than three-fourths inch, long. This zone contains beautiful, but very lenticular, serpentine, and a few post-ore veinlets of fibrous calcite. Post-ore, north-south fracturing is moderately expressed.

Near the south end of the cut, the workings show, in well-serpentinized limestone, an asbestos-bearing zone that has a maximum thickness of twelve inches and consists of from 25 to fifty percent fiber in lensing veins. The fiber is of fine quality and sometimes one inch, but usually less than three-fourths inch, long. This zone appears in a stope of approximately ten by twenty feet size near the surface, but, at a distance of fifty feet within a westward, eighty-foot drift, it narrows down and gives way to a vein of calcite. Another drift, extending from the stope for thirty feet in a S. 70° W. direction, also shows the zone pinching down. Particularly above the southern half of the stope, some 1½ feet of limestone immediately overlying the fiber zone is heavily impregnated with magnetite. Apparently, the best fiber occurs beneath the strongest development of magnetite.

South Portion:—Approximately 450 feet farther southeast, at a dripping spring beside the main trail, an east-west cut of 35 feet long and a S. 10° W. tunnel more than 100 feet long, have been driven. Some fifty feet of medium- to thin-bedded Mescal limestone lies above the main diabase sill, dips 7° southward, and underlies 35 feet of cliff-forming, algal limestone. A minor sill of diabase, one foot in maximum thickness, outcrops five feet beneath the algal beds. About three feet above this minor sill, a fifteen-inch zone of green serpentine carries a few veins of fine-quality fiber that occasionally is one inch, but usually less than one-half inch long. Some of these fiber veins are of a rich, green color. The limestone immediately above the serpentine zone, and also for a few feet below the diabase sill, is heavily impregnated with magnetite.

Some 600 feet farther east, beside the main trail and below the camp, a synclinal trough in the limestone plunges about 7° southward, and its limbs dip a maximum of twenty degrees, with some ninety feet of amplitude. The thin sill of diabase, already mentioned, splits and has beneath it a one- to two-foot bed of hematite and magnetite. Serpentine, harsh asbestos, and fibrous calcite occur in a one-foot zone above, and occasionally as included spheroidal masses within, the minor sill. Below the magnetite and specularite, an eight- to ten-inch zone carries fiber that is of good quality, but due to serpentine inclusions, rather short. Occasional, irregular veins of fibrous calcite cut the asbestos veins. On the east limb of the syncline, a tunnel extending S. 70° E. for fifty feet, with some stoping, shows a six- to twelve-inch zone that carries fiber of good quality and occasional 1½-inch length.

PUEBLO GROUP

The Pueblo group includes fourteen unpatented claims situated in the southeastern portion of the Sierra Ancha, near the head of Pueblo Canyon, which is a western tributary of Cherry Creek. These claims are accessible from Reynolds Creek Ranger Station, which is 56 miles from Globe via the Globe-Pleasant Valley highway, by about one mile of road and seven miles of trail. The last two miles of this trail descend for 1,000 feet over steep, rough country.

This ground was held for several years by Mr. Wm. Andrews, but in early 1928 appeared to be controlled by the Regal Asbestos Mines, Inc.

Production from the Pueblo group is said to have amounted to about 3½ tons of Crude Nos. I and II fiber for the first half of 1928. No details were learned of the small production that was made prior to 1928.

Due to the high, western side of Cherry Creek Canyon, Pueblo Canyon has a steep gradient that enables it to expose Troy sandstone, Mescal limestone, diabase, and Dripping Spring quartzite.

The principal asbestos exposure is about one-fourth mile south of the camp, or 200 yards northeast of a dripping spring, at an elevation of approximately 6,300 feet above sea level. There, some 110 feet of gray, medium-bedded Mescal limestone, between the Troy and the diabase, strikes northeast, dips 5° northwestward, and shows northwest fracturing.

A tunnel running west-southwest for 75 feet shows three principal serpentinized zones that carry asbestos of good quality. Each of the two lower zones, which lie about ten feet above the diabase and are separated by ten inches of limestone, has a maximum thickness of six inches and carry several asbestos veins. Occasionally, these veins attain a thickness of one inch, but usually they branch and angle through the serpentine. Five feet higher is another zone, of a maximum thickness of one foot, that carries several branching veins, occasionally one inch thick, of excellent asbestos. The limestone is well-serpentinized for three feet above this zone.

REYNOLDS FALLS GROUP

The Reynolds Falls group consists of several unpatented claims along the upper reaches of Reynolds Creek, in the southeastern portion of the Sierra Ancha. These claims are accessible from Reynolds Creek Ranger Station, which is 56 miles from Globe, via the Globe-Pleasant Valley highway, by about one mile of road and four miles of trail.

This ground was worked to a small extent in 1917 by Mr. B. L. Rogers who sold about half a ton of fiber.[40] It has been held for a number of years by Mr. Wm. Andrews, who made a few shipments in 1924 and 1928. Its production during the first quarter of 1928 amounted to about two tons of Crude Nos. I and II fiber.

Here, a northward-trending, perennial fork of Reynolds Creek has eroded a deep gulch through Troy sandstone, Mescal limestone, and

[40]Diller, J. S., Asbestos in 1918: U. S. Geol. Survey, Mineral Resources of the United States for 1918, pt. II, p. 549.

about one-quarter mile west of Wilson Creek. Approximately 500 feet north of the workings, Dripping Spring quartzite outcrops in a prominent ridge that trends east-southeast and in places is underlain by diabase. The Mescal limestone at the workings strikes southwest and dips southeast a maximum of 7°.

Asbestos is exposed along a north-south face of the limestone for approximately 300 feet. In the northern fourth of this face, a diabase dike, which strikes S. 60° E., dips 65° northwestward, and is some fourteen inches thick, cuts with clean contacts across the limestone beds and the fiber zones.

Five tunnels, extending eastward for 65, 138, 120, 118, and 127 feet, have been run to prospect the asbestos. In the northernmost tunnel, short fiber was found near the roof, and in the southernmost tunnel, the fiber is mainly of poor quality because of a high lime content. In the other three tunnels, a four-foot, serpentinized zone contains several thin veins, and four prominent veins whose fiber is of good quality and of one-half to one inch maximum length.

Equipment here consists of a camp and a portable air compressor.

Some additional, but relatively small, workings have been run on Brewery and Buckhorn mesas and along Cherry Creek. On the Redwing claim, which is situated on Cherry Creek, about fifteen miles by road southeast from Young, a little asbestos outcrops 150 feet above the canyon bottom and two feet above the diabase. Here, the Mescal limestone lies nearly flat, shows fracturing in northeast and northwest directions, and weathers chalky near its contact with the diabase. A lower zone, of a maximum thickness of two inches, contains dark, harsh fiber. An upper zone, four feet higher and of a maximum thickness of six inches, contains several veins whose harsh fiber, due to serpentine inclusions and calcite veinlets, usually is less than three-fourths inch long.

SLOANE GROUP

Situation and Accessibility:—The Sloane group contains five unpatented claims situated in the Flourine district, on the steep west side of Cherry Creek Canyon. It is accessible from Reynolds Creek Ranger Station, which is 56 miles from Globe via the Globe-Pleasant Valley highway, by about one mile of road and seven miles of trail. The last two miles of this trail descend for 1,000 feet over steep, rough country.

Histroy and Production:—These claims were located in 1917 by Messrs. J. C. and M. B. Kennedy. A few months later, they were acquired by the late Charles F. Sloane, and some fiber was shipped in

12 feet above the diabase. Its fiber is up to one-half inch in length and of fair quality.

Workings:—Workings upon the Rock House group include a sixty-foot tunnel and a twenty-foot tunnel on the Arizona claim, six tunnels from forty to fifty feet long within one-half mile south of the camp, a few short tunnels farther south, a 25-foot tunnel on the Montezuma claim, and numerous shallow cuts.

Equipment:—Equipment includes a portable Denver Rock Drill compressor of 118 cubic feet per minute capacity, and a fiber-cleaning mill that was under construction in May, 1928. This mill is to consist of a forty-horsepower gasoline engine, a Blake crusher, two sets of rolls in series, and a special six-mesh, rotating, suction screen. According to Mr. E. V. Draper,[39] mine superintendent of the property, it is planned to feed the mill ore that contains fifty per cent fiber, and to obtain 2,800 pounds of product each eight-hour run. This product is to be shipped to the Emsco manufacturing plant at Downey, California.

TRIANGLE ASBESTOS CO. GROUPS

The Triangle Asbestos Company has 72 claims, all of which except fourteen are in one group. These groups are situated in northern Gila County, east of Cherry Creek, in the vicinity of Walnut Creek, Brewery Mesa, and Buckhorn Mesa. They are accessible by thirteen miles of unimproved road that leads south from the Young-Holbrook road at Bottle Springs, and are 26 miles from Young, 108 miles from Globe, or 82 miles from Holbrook. They are also accessible from Young by fifteen miles of unimproved road that follows Cherry Creek.

Original locations upon the portion of the property nearest to Cherry Creek were made in 1916 by Mr. Clyde Kennedy. Most of the remaining claims were located in 1918 by Messrs. Reed, Wilson, and Gregg, and the first fiber was shipped in 1921. During 1922, 1923, and 1924, the property was held by the Riga Asbestos Company and small shipments of asbestos were made. In August, 1927, it came under the control of Messrs. W. M. Tenney, Jr., R. G. Mistron, and J. W. Fulton, who shipped a small quantity of fiber. In May, 1928, about twelve men were working on the claims.

Cherry Creek and its tributaries have carved the region with many steep-sided canyons, but have left intervening mesas that stand from 5,000 to 5,600 feet above sea level.

The principal workings are on the Walnut No. 5 claim, which is near the northeastern end of the property, along Walnut Creek and

[39]Oral communication.

diabase. As the slopes of this gulch in many places are mantled by soil and dense woods, the rock exposures often are not clear.

The principal workings visited were those of Tunnel 1-A, which is situated on the west side of the creek, at an elevation of approximately 6,200 feet above sea level, and about one-half mile south of the camp. This tunnel runs N. 80° W. for approximately 150 feet, and its portal is about 75 feet above the diabase that outcrops a few hundred feet downstream.

At its outcrop, the Mescal limestone is dark gray, medium- to thin-bedded, nearly flat, and well-fractured in northwest and southwest directions. Five asbestos-bearing, serpentinized zones are visible. The two upper zones are about one foot apart, rather thin, and contain fiber that in general is less than one inch long . The milddle zone, which is one foot lower, has a maximum thickness of one foot and carries several asbestos veins that range in thickness from a film to one-half inch. Three feet lower, a zone three inches thick carries some fiber one inch in length. Ten inches beneath it is a two-inch zone that shows half-inch fiber. Material on the dump indicates that some of the veins are two inches thick, but, due to included blebs of serpentine, their fiber generally is less than one inch long. Much of the fiber is slightly harsh, but it seems to be best and longest near fractures in the limestone.

On the opposite side of the creek, a cut shows several thin, semi-harsh asbestos veinlets in a face seven feet high within thin- to medium-bedded, crenulated, weakly-serpentinized limestone.

Equipment here includes a cobbing-shed and a blacksmith shop.

FRIDAY CLAIM

The Friday claim is situated about 1½ miles south of the American Ores Mine, or 26 miles in air line north-northwest of Globe, at an elevation of approximately 4,300 feet above sea level in the steep foothills of the southern Sierra Ancha. It is accessible by about two miles of trail that leaves the Globe-Pleasant Valley highway at a point 46 miles from Globe.

This ground is part of the former Clarke property, which is said to have contained 27 claims. It was worked during late 1920 and part of 1921, when held by Mr. J. K. Bury, by the Globe Asbestos Co., and, in late 1921, it was worked to some extent by Mr. C. A. Watkins. This claim has not been worked actively for several years, but was relocated in February, 1927, by Messrs. T. Gordon and T. L. Carter.

Here, a block of Mescal limestone, which is overlain by Troy quartzite and intruded by a thick diabase sill, extends southeastward for about two miles, dips approximately 5° southwestward, and is about one-half mile in maximum width. A few minor folds and dips are present in the Mescal, and its contact with the diabase on the northeast appears to be a fault.

Two asbestos-bearing zones are exposed near the northwestern extremity of this Mescal limestone outcrop. The lower zone, which has not been opened up to any extent, shows only a small amount of rather short fiber. The upper zone, which is sixty feet higher, extends along the south and west sides of the hill for a total length of approximately 1,500 feet. Its fiber, although of good quality, is generally less than one-fourth inch long, except near its northern limit, near the diabase contact, where it is from one-fourth to one-half inch long. Rather impure serpentine is associated with the asbestos, and considerable magnetite has been developed in the limestone a few feet above the lower horizon.

Workings on the property include one short tunnel on the lower horizon, and twelve or more tunnels, with considerable lateral stoping, on the upper horizon.

KNIGHTON PROPERTY

The Knighton property is situated on the southeastern slope of the Sierra Ancha, approximately two miles east-northeast of the American Ores Mine, from which it is accessible by about 2½ miles of steep trail.

Here, the Mescal limestone, below the Troy sandstone and above the diabase, is about ninety feet thick, medium- to thin-bedded, nearly horizontal, and somewhat cherty.

The principal workings seen were sixty feet above the diabase and consist of a tunnel that extends northward for approximately 125 feet and has, twelve feet in from its portal, a westward branch 25 feet long.

Two fiber-bearing zones, six to eight inches in maximum thickness and three feet apart, continue intermittently for the first twelve feet of the tunnel. One zone continues, with a maximum thickness of ten inches, for an additional fifty feet before pinching out, and carries several veinlets of very short fiber in abundant serpentine. In the branch tunnel, some fiber from one-fourth to 1½ inches long occurs along a strong, westward fracture. Most of the fiber seen in these workings was semi-harsh.

No. II and three tons of Crude No. I were shipped prior to 1921[38]. This fiber was packed, via Cherry Creek and across the Salt River at Horseshoe Bend, to Globe.

Early in 1928, the Emsco (E. M. Smith) Asbestos Company, of Los Angeles, purchased the property. This company improved the road from Bottle Springs, established a permanent camp, and in May, 1928, was installing a fiber-cleaning mill. On July 1, seventeen men were working on the property.

This ground lies near the divide between Cherry and Canyon creeks, above 5,000 feet elevation, but its drainage area, which is tributary to Canyon Creek, is not great enough to have caused the cutting of very deep canyons. The principal formations exposed are Troy sandstone, Mescal limestone, and diabase. Usually, the diabase floors small basins and narrow, flat-bottomed valleys, where its surface is decomposed by weathering.

The stratified rocks are practically flat-lying, and the upper surfaces of the diabase sills, except for local irregularities, are parallel to the limestone bedding. About one-half mile south of the camp, a northwest-southeast fault, whose downthrow is on the northeast and probably less than 100 feet, cuts across the property.

Ore:—On the Arizona claim, which is in the northwestern portion of the group, two zones of asbestos are apparent. Here, the limestone dips about 3°SW., and has been affected by a minor amount of north-south and east-west fracturing. The upper zone has a maximum thickness of about fourteen inches, but pinches down at a point some thirty feet within the tunnel. Five feet lower, or about six feet above the diabase, is a zone some ten inches thick. In both these zones, the fiber for the most part is of good quality, but, due to contained lenses of serpentine and limestone, is mostly less than three-fourths inch long.

For a distance of about one-half mile south of the camp, asbestos was observed at several points. Often it is in two zones from five to eight feet apart, with the lower zone from three to five feet above the diabase. These zones usually are less than one foot thick, and are composed of lenticular serpentine bands alternating with asbestos whose fiber is mostly of less than No. I length.

On the Montezuma claim, some 200 yards northwest of the Rock House, an eight-inch fiber zone outcrops 12 feet above the diabase and a few feet below the present erosion surface of the limestone. This fiber has a maximum length of one-half inch, but is harsh.

Across the wash, on the May claim, a six-inch fiber zone outcrops

[38]Personal communication from Mr. H. P. Wightman.

fracturing in various directions. The action of surface waters has widened these fractures, sometimes as much as four inches, so that the ground is rather blocky.

The main tunnel on this claim extends easterly for approximately 130 feet. At its portal, it shows several thin asbestos veins which, farther in, gradually thicken at the top and bottom of the tunnel. The upper zone contains excellent fiber of amber color and of a maximum length of 1½ inches, but the lower zone, seven feet beneath the upper, has fiber generally less than one inch long. Occasionally, thin veins of fibrous calcite alternate with the asbestos veins.

Some 200 feet northeast, a tunnel extends east-southeastward for approximately ninety feet, and has a short, right-hand branch and a stoped, left-hand branch that connects with the surface. Thirty feet southwest of this portal, a diabase dike, one to 1½ inches thick, strikes S. 60° E. and dips 80° northwestward. The tunnel shows occasional good, one-inch fiber in an eighth-inch, serpentinized zone, and some fiber of less than three-fourths inch length in a zone a few feet lower.

Asbestos Springs Claim:—The Asbestos Springs claim is situated in a canyon approximately 3,000 feet south of the Blue Jay workings and 150 yards downstream from a dripping spring that issues from a diabase-Mescal limestone contact. The limestone is medim to thin-bedded, lies nearly flat, and shows weak serpentinization. An open cut, 150 by thirty feet in size, shows, ten feet above the diabase, a six-inch zone of serpentine that carries occasional half-inch fiber.

Equipment:—Equipment of the Aileen group includes a blacksmith shop and a camp. All the drilling is by hand, and the tramming, except from the Blue Jay tunnel, is by wheelbarrow.

Mr. Kyle maintains in Globe a cobbing mill for the Aileen group and for custom service. This mill, which is driven by a gas engine, consists of rolls and a set of agitating screens of four different sizes of mesh, and has a maximum capacity of 1,000 pounds of feed per hour.

ROCK HOUSE GROUP

The Rock House group consists of sixteen unpatented claims situated in northern Gila County, immediately north of the Rock House, seven miles east of Cherry Creek, and about one-half mile west of the Fort Apache Indian Reservation. These claims are accessible by eighteen miles of unimproved road that leads south from the Young-Holbrook road at Bottle Springs, and are 31 miles from Young, 113 miles from Globe, or 87 miles from Holbrook.

This ground was first located for asbestos by Messrs. E. V. Pierce and H. P. Wightman in 1915. Approximately seven tons of Crude

OTHER GILA COUNTY ASBESTOS DEPOSITS

SOUTHEASTERN PINAL MOUNTAINS

Carl Lausen has given the following description of an asbestos occurence situated about fourteen miles from Globe and one-fourth mile east of the Globe-Winkelman highway:

"About six miles south of Cutter, a station on the Arizona Eastern Railway, and in the foothills southeast of the Pinal Mountains, is an area of Cambrian sediments intruded by diabase. These sediments have been dislocated and tilted by numerous normal faults, and the dips are usually greater than thirty degrees.

"Asbestos occurs in Mescal limestone intruded by diabase. The fiber is generally less than one-half inch in length and not of the best quality. The owners were offered $500 per ton in 1918 for material hand-sorted and free from serpentine. Although the fiber has some strength, it is usually somewhat brittle. Numerous bands of serpentine occur on each side of the asbestos seen.

"Claims have been located in this area, which is just off the reservation boundary, and some development work has been done. A tunnel driven into the hillside for eighty feet cut the asbestos seam, but it had pinched down to less than a quarter of an inch."

PINTO CREEK REGION

Asbestos outcrops over a small area along a western tributary of Pinto Creek in southwestern Gila county, four miles northwest of Horrell's ranch, or 23 miles west of Globe, at an elevation of about 3,500 feet above sea level. This area lies in a rather rugged region that is accessible by mountain trail from the end of the road at Horrell's ranch.

This asbestos deposit is said to have been discovered in 1903, and located by Mr. M. L. Shackelford. When visited in January, 1928, it was under location as the Lopez No. 3 claim by Messrs. Loftus, Clifford, Brockett, and Lopez. No production is known to have been made.

The rocks exposed in the general region are pre-Cambrian granite, Apache sediments, diabase, Devonian and Carboniferous limestone, Tertiary dacite flows, and Gila conglomerate. Complex block-faulting and erosion have arranged the outcrops of these formations into a rather intricate pattern. In the immediate vicinity of the asbestos deposits, the prevailing rocks are complexly-faulted Apache sediments which are bounded, about 1½ miles farther east and with steep

contact, by Gila conglomerate. The Mescal limestone there strikes N. 80° W., dips 20° southwestward, and has been intruded irregularly by a thick sill of coarse-textured diabase.

All the exposures of asbestos noted were on the south side, and near the bottom, of a deep, eastward-trending canyon. The fiber-bearing zone, which is about one foot wide and fifty feet long, lies immediately above the diabase. Its narrow, branching, asbestos veinlets generally are under one-half inch thick, although some are over one inch. The fiber, which is somewhat harsh where exposed, is associated with much pale-colored serpentine. Only a small amount of assessment work has been done on the claim.

MESCAL MOUNTAINS

Asbestos claims have been held for several years in a small area in the Mescal Mountains of southern Gila County, on the west side of El Capitan Canyon, one-half mile south of El Capitan Mine. The Globe-Winkelman highway crosses this area at a point 21 miles from Globe and fifteen miles from Winkelman.

Here, a northwest-trending block of Mescal limestone, about one-eighth mile long and 100 yards wide, is capped by a few feet of Troy quartzite and surrounded by diabase. This limestone exposes some ninety feet of strata that dip southwest and south from 5° to 45° and are split and cut by dikes of diabase. There is a weak development of serpentine in the limestone, which has a chalky appearance, due to the diabase intrusion.

The asbestos occurs about seventy feet below the top of the limestone, or five feet below a diabase sill of ten feet thickness and five feet above a sill of a few inches thickness. Three asbestos zones are visible on a four-foot face. The uppermost zone is a stringer about one-eighth inch thick; the lowest is one-fourth inch thick; and the middle is from two to eight inches thick, with some fiber up to one-half inch long. Most of the fiber visible is rather harsh.

Workings upon this exposure consist of two tunnels of about twenty and 35 feet length.

COCONINO COUNTY DEPOSITS

The known chrysotile asbestos deposits of Coconino County occur within the limits of the Grand Canyon National Park, in the depths of the Grand Canyon, opposite Bass Camp and Grand View.

Asbestos-bearing serpentine is exposed intermittently for a length of some 750 feet along the southwestern side of this ridge.

Near the southwestern limit of this exposure, a 25-foot tunnel shows three fiber zones. The upper zone shows two asbestos veins, two inches apart, of a maximum thickness of one-half inch. The middle zone, which is two feet lower, consists of 2½ feet of limestone and serpentine that contains several asbestos veins of a maximum thickness of one-half inch. The lowest zone, which is seven feet below the topmost zone, is eight inches thick, contains two main asbestos veins that carry some one-inch fiber, and is exposed over a length of about 100 feet.

Some 250 feet northwest, where the beds dip north-northwest 15°, considerable 1½-inch fiber of good quality was obtained from below a three-inch dike of dense, serpentinized, diabase that occurs in strongly-serpentinized limestone.

Approximately 250 feet farther upstream, a tunnel extends eastward, with some stoping, for forty feet. It cuts strata that dip 18°NW. and are well fractured in the directions of dip and strike. Two asbestos zones, seven feet apart and carrying some 1½-inch fiber of good quality, are present. Eighteen inches below the upper zone, two wollastonite veins, three inches in maximum thickness, occur separated by limestone and serpentine.

Big Stope Workings:—The Big Stope workings are situated about 300 feet S. 40° W. of the portal of the workings just mentioned, and consist mainly of a tunnel that extends 150 feet in a N. 70° W. direction. The Mescal limestone is gray, pure, thin-bedded, flat-lying, and well-fractured in north, northwest, and east directions. Some 200 feet above the workings, it is in contact with diabase. Approximately seven feet of the limestone carries abundant, green serpentine, in which two asbestos zones, five feet apart, occur. The upper zone is three inches thick, the lower is one to two inches, and both contain good quality of fiber of a length of one-eighth to 1¼ inches.

Mitt Claim:—The Mitt claim lies on the opposite side of the creek south of the Big Stope workings. Its Mescal limestone is medium-bedded and crenulated. A thirty-foot tunnel shows a ten-inch serpentinized zone that carries choppy asbestos veins of less than three-fourths inch thickness. The portal of this tunnel is approximately 200 feet north of a diabase outcrop.

Blue Jay Claim:—The Blue Jay claim is situated east of the Mitt claim, and also on the south side of the creek. Its Mescal limestone carries abundant, green serpentine, lies nearly flat, and shows extensive

Reservation line, however, a small open cut exposed excellent-quality fiber that had a maximum length of five inches and was often three or four inches long. See Plate VIII-A.

Workings upon the Cowboy claim in May, 1928, consisted of a narrow cut along the exposure of the asbestos zone, and an open cut of six by eighteen feet size. The latter had yielded 5,200 pounds of Crude No. I fiber.

Aileen Claim:—The Aileen claim lies immediately west of the Cowboy. There, the Mescal limestone is thin-bedded, dips slightly northward, and shows prominent northwest fracturing. An asbestos-bearing zone, six inches thick and about ten feet above the diabase outcrop, contains fiber that occasionally is one inch, but usually is less than one-half inch, long. Workings consist of two tunnels, situated in the eastern portion of the claim, that extend north-northwestward for some thirty feet each.

Last Chance Claim:—The Last Chance claim lies on the north side of the canyon and west of the Aileen claim. Its Mescal limestone is medium-pure, thin-bedded, nearly flat, and contains many fractures that trend northwest and otherwise. A serpentinized zone two feet thick contains many thin veinlets of asbestos that mainly are from one-fourth to one-half inch, and occasionally one inch, thick. An additional two feet below this zone consists of alternating serpentine and limestone. No diabase is visible for at least 100 feet lower. Workings consist of a tunnel that extends northward for approximately 140 feet.

Bluff Claim:—The Bluff claim is immediately west of the Last Chance, and similar to it in the character and structure of its limestone. Considerable serpentine occurs in one- to five-inch bands alternating with limestone. A six-inch zone contains good, amber-colored fiber of Crude No. I and No. II length. Diabase outcrops 200 to 250 feet north of this asbestos exposure. Workings consist of a 35-foot tunnel, situated some 250 feet northwest of the Last Chance workings.

Turkey Track Claim:—The Turkey Track claim is situated upstream from the Bluff claim, and occupies mainly a ridge of about 200 feet height that separates the north and the southwest forks of Sloane Creek. The southwestern half of this ridge is made up of gray, pure, thin-bedded limestone, and the northern half is diabase. In general, the strata lie nearly flat, but rather sudden northwesterly dips, varying in magnitude from a few degrees up to 18°, are common. Fractures, definitely of both pre- and post-ore ages, are prevalent in the directions of strike and dip.

GEOLOGY

In the Grand Canyon, between Tapeats Creek and Nunkoweap Valley, nearly 12,000 feet of tilted, beveled, Algonkian strata are exposed above the Archean complex and beneath 3,500 feet of gently-dipping, Paleozoic strata. The lower portion of these Algonkian beds contain certain limestone beds that are intruded by diabase, and, opposite Grand View, contain asbestos.

Eighteen miles farther northwest, in the vicinity of Shinumo Creek, opposite Bass Camp, about 4,800 feet of the lower portion of the Algonkian strata are exposed. These beds were measured and named by Noble[41] as follows:

	Thickness in feet
Dox sandstone	2297+
Shinumo quartzite	1564
Hakatai shale	580
Bass limestone	335
Hotauta conglomerate	0-6

These beds are cut by sills of diabase, and the Bass limestone contains the asbestos.

Character of the Bass limestone:—In general, the Bass limestone resembles the Mescal limestone of southern Arizona. According to Noble,[42] its upper two-thirds consist of blue slate and white limestone, and its lower third consists of argillaceous and calcareous red shale and limestone, with basal white limestone.

Character of the Diabase:—Noble has described the diabase of the Shinumo region as follows:

"Fresh specimens typical of the greater part of the mass show that the diabase is a tough, heavy holocrystalline rock of medium to coarse grain and of gray color. . . . The slides examined show that the typical rock consists primarily of plagioclase feldspar (near labradorite) and olivine in about equal amounts, a subordinate quantity of augite and brown biotite, and very little magnetite. The feldspar is somewhat altered, but all the other minerals are fresh . . ."

This diabase closely resembles that of Gila County.

DEPOSITS OF THE SHINUMO, OR BASS CAMP, REGION

Diller[43] says: "Within the last few years (prior to 1907) . . .

[41] Noble, L. F., The Shinumo quadrangle, Grand Canyon District, Arizona: U. S. Geol. Survey, Bull. 549. 1914.
[42] Work cited, p. 44.
[43] Diller, J. S., U. S. Geol. Survey, Mineral resources of the United States for 1907, pt. II, pp. 720-721.

deposits have been found on the north side of the canyon, 25 miles northwest of Grand Canyon station, in the vicinity of Bass Ferry. The Grand Canyon at this point is 4,500 feet deep, and the asbestos occurs about 450 feet above the bottom. When the river is low, it is crossed in a rowboat, but when it is high, by means of a suspended car. The most direct line of trail, when completed, will be about eight miles long, and transportation up to the rim is effected by means of burros, each animal carrying about ninety pounds.

" . . . The Algonkian is markedly unconformable with the overlying Cambrian as well as the underlying Archean, and forms a wedge-shaped mass with its edge along the canyon near its botton and thickening rapidly to the north."

Noble[44] gives the following section and description of part of the Bass limestone beneath the lower contact of the diabase near the tunnel of the asbestos mine in Hakatai Canyon:

	Thickness in feet
Diabase sill	1000+
Layer of green serpentine	2
Pure white crystalline limestone	1½
White crystalline limestone, with bands and nodules of serpentine	2
Serpentinous nodular and banded layer carrying veins of asbestos	1
Banded crystalline limestone, with bands of nodules of serpentine	10
Nodular cherty limestone	4
Soft blue slate	3
Dense purple calcareous slate	9

"The limestones above the upper contact of the diabase contain several alternating layers of green serpentine and narrow veins of asbestos, which occur at several horizons near the contact.

" . . A microscopic study was made of 25 thin sections cut from the limestones, the bands and nodules of serpentine, and the veins of asbestos. Aside from the serpentine and asbestos no other minerals were revealed in the limestones than the dolomitic calcite and interlocking grains of quartz in the slides cut from the limestones of the same horizon . . . where the strata lie in undisturbed sedimentary contact. The limestones have the texture of marble. The serpentine of the bands and nodules show no trace of alteration in structure due to derivation from pyroxene, hornblende, or olivine. The slides cut across

[44]Noble, L. F., work cited, pp. 58-59.

AILEEN GROUP

The Aileen group, which contains eleven unpatented claims, is situated in northern Gila County, along Sloane Creek about six miles west of Canyon Creek and immediately west of the Fort Apache Indian Reservation. These claims are accessible by fifteen miles of unimproved road that leads south from the Young-Holbrook road at Bottle Springs, and thus are 28 miles from Young, 110 miles from Globe, or 84 miles from Holbrook.

This ground was located for asbestos by Messrs. Roger Kyle and E. V. Pierce in 1916. Fifteen tons of fiber were shipped in 1917, three tons in 1918, and a small amount during 1919 and 1920. In 1921, Messrs. Sanchez and Fonderhide operated the property and are said to have worked sixty men, but mined only about forty tons of fiber. Since 1921, Mr. Kyle has operated the property with only four to eight men, and has made only occasional shipments.

The trunk and branches of Sloane Creek, which is an east-southeastward-flowing, perennial tributary of Canyon Creek, have eroded the region into V-shaped canyons of a few hundred feet depth, but have left narrow, intervening mesas that are from 5,200 to 5,500 feet above sea level. Ash, sycamore, oak, walnut, and alder flourish along the water courses.

Mescal limestone, diabase, and Dripping Spring quartzite are the principal rock formations exposed. The quartzite, which forms a bold, east-southeastward-trending ridge along the north side of Sloane Canyon, probably owes its exposure to a fault.

Cowboy Claim:—The Cowboy claim is in the eastern portion of the Aileen group. There, an oval-shaped mesa, 1,500 feet long, stands 200 feet above the drainage of Sloane Creek that bounds it on the west, south, and east. This mesa is capped by Mescal limestone and underlain by diabase that comes to the surface along its northern margin and appears as a narrow band between the limestone and the Dripping Spring quartzite.

About 100 feet below the eastern and southeastern rim of the mesa, an asbestos zone outcrops for a length of some 600 feet and at an average distance of seven feet above the diabase. The limestone is gray, pure, crystalline, and medium- to thin-bedded, and is somewhat serpentinized for five feet above the asbestos zone. It dips 10° northwestward, and is considerably fractured in the directions of its dip and strike.

Along much of its exposure, the asbestos zone shows only a few thin veins. Near its northern end, or some 240 feet west of the Indian

used and costs obtained at the mine when it was actively operating are abstracted from Melhase:[37]

Roughly-parallel adits were driven in the middle limestone, and an attempt was made to block out the ore by cross-cutting. However, the ore seams were found to be irregular and pockety, sometimes pinching out entirely or else alternating from roof to floor of the limestone, so that it was necessary to drive the drifts excessively high in order to find the ore. Therefore, this plan of development was abandoned, and mining was confined to the irregular areas in which commercial asbestos occurred. Often, the entire thickness of the limestone was stoped out, but the solid diabase roof required no timber. The waste rock, which included large quantities of short fiber, was used to fill the stopes, and the better grade of ore was hauled to the surface for hand-cobbing. All of the cobbed material of a grade less than Crude No. II was thrown on the waste dump.

During the period of greatest activity at the mine, about 275 men were employed. The main tunnels and haulageways were driven on contract at $4 per foot, but the contractor furnished all the necessary labor, equipment, and supplies. In this work, machine drills were used for the most part. Next, the richer areas were marked off into blocks about fifty feet square and leased to miners, usually two men to the block, who mined, cobbed, and graded the fiber for shipment. This work, which was all done by hand, was paid for according to the amount and grade of fiber produced; for Crude No. I, the rate was from eight to fourteen cents per pound, and for Crude No. II, 7½ to 12½ cents per pound. The average production by the skilled Mexican miners amounted to 75 pounds daily per man.

It is said that the mine had approximately 10,000 feet of workings in 1921.

Equipment:—Immediately below the principal workings is a mill which, by use of a jaw crusher, rolls, cyclones, and suction screens, is said to be capable of yielding approximately two tons of Crude Nos. I, II, and III fiber per shift.

A power plant, situated at an ample supply of wood and water on the north side of the mountain, about two miles by road from the mine, is equipped with a seventy-horsepower steam engine and a 150-horsepower generator. A three-hammer compressor, driven by a 35-horsepower gas engine, is situated at the mine.

[37]Melhase, John, work cited, p. 809 .

the veins of asbestos showed that they are later than the serpentine in which they are generally inclosed . . .

"The asbestos in the larger veins is of high grade . . .Locally its cross fiber is four inches in length and is of great tensile strength. The larger veins, so far as known, are confined to the limestones that lie beneath the diabase sill, the veins above the sill, though more widely distributed through the limestones, being generally smaller. The veins below the sill are not absolutely constant in stratigraphic positions; they may lie anywhere from three to fifteen feet below the contact. The width of these veins varies greatly from place to place, so that a vein that is three inches wide in one locality may be represented by a zone of innumerable small veins in another, but the actual continuity of the zone that carries the asbestos is rarely broken."

Diller continues: "Four asbestos claims have been taken up, one on the upper and three on the lower limestone, along with the thin belt of included asbestos-bearing serpentine has been prospected in a number of shallow open cuts for over half a mile. The continuity of the narrow asbestos belt is very irregular, and it disappears locally; but it is abundant enough in places to suggest the probability that Nos. I and II crude fiber carefully selected from the veins may be mined to a small extent at a profit. It does not seem at all probable, however, considering the limited quantity, location, and distribution of the deposit, that it would pay to mill."

Only a small quantity of asbestos has been mined from this locality, and apparently the high mining and transportation costs have discouraged development. In the Mineral Resources for 1920, Sampson states: "Mr. Bass mined a small quantity of fiber and later leased the mine to E. L. Quist who operated during the winter of 1920. A cable crossing has been installed near the mine, which permits the transfer of asbestos, men, and light supplies. The fiber is rather harsh, but the length is good."

DEPOSITS OF THE GRAND VIEW-HANCE REGION

Pratt[45] has described these deposits as follows: "The asbestos deposits in the Grand Canyon of the Colorado River, Arizona, belonging to the Hance Asbestos Mining Company, of New York City, are located in the Grand Canyon Mining district, Coconino County, Arizona, on the north side of the Colorado River, about seventy miles a little west of north of Flagstaff, the county seat. The deposits are near the

[45]Pratt, J. H., U. S. Geol. Survey, Mineral Resources of the United States, 1904, pp. 1137-1140.

bottom of the Grand Canyon about 4,900 feet below the rim, with a portion of the property rising to about 1,500 feet above the river. The nearest point on the railroad is Grand Canyon at the terminus of the Grand Canyon railroad, which connects at Williams, a distance of 65 miles, with the main line of the Santa Fe railroad. There is a good wagon road from Grand Canyon station to the head of Grand View and Red Canyon trails, which lead from the rim to the bottom of the canyon and are fourteen and nineteen miles, respectively, from Grand Canyon station. Both these trails are in good condition, and pack trains could carry from eighty to 100 pounds per burro, or from 175 to 210 pounds per mule.

"The only present means of crossing the river to the asbestos deposits, which are on the north side, is by rowboat. With the installation, however, of a cable and an aerial tramway from the south to the north bank at an elevation of approximately 1,200 feet above the river, the distance from the rim to the crossing point of the river would be reduced from three to five miles, and there would also be 1,200 feet less of climbing. The property extends for a distance of about 9,000 feet down the river from the crossing point.

"The rocks of the district in which the asbestos occurs consist of the Algonkian series of sedimentary rocks, lying unconformably beneath the Cambrian and the Carboniferous sedimentary rocks, which extend above them from 3,200 to 4,000 feet. Beneath the Algonkian sedimentary rocks are the Archean series, consisting of granites and gneisses, cutting which are numerous pegmatitic dikes. Between these two latter series of rocks there is a dike of basaltic rock which penetrates in some cases the strata of the Algonkian sediments, and is separated from the igneous rocks below by a stratum of conglomerate which is very constant. Occasionally, however, this basaltic rock is in direct contact with the igneous rock below. These rocks dip at an angle of about 12° to 15° toward the east, and have a general strike of about N. 20° W. They also pitch about 10° toward the north. They are cut out by the Tonto sandstone of the Cambrian series at an elevation of about 1,400 feet just west of Claim 15. From this point they dip uniformly toward the east and disappear under the river at a distance of from 10,000 to 10,100 feet. Within this distance these rocks are faulted four times, the displacement being from ten to fifty feet; the faults are normal.

"This basaltic dike has broken through the strata of the sediments (in some cases breaking off and inclosing within itself masses of some of these sedimentary rocks), and small dikes of similar rock were observed cutting across the strata at two other points, one a third of a mile farther up the canyon and directly across the river from the mouth

five-foot horizontal intervals throughout all of the workings, that the average thickness of all the asbestos veins in the main zone is 0.654 feet, and this contains an average recoverable content of spinning fiber of 14 percent. It was further calculated that each 1,000 square feet of mineralized area in the main ore zone would yield: 0.1 tons No. I crude; 0.29 tons long harsh; 0.34 tons mill fiber; and 17.5 tons mill rock.

"The upper diabase has been the important factor in localizing the asbestos-bearing serpentine, for all of it lies within eight feet of the overlying diabase contact. The diabase dikes which cut the middle limestone are also important localizers of asbestos; the best fiber mined lay close to the diabase dike in No. 5 Tunnel. Also the thin edges of the middle limestone lens, where diabase is close both above and below, is particularly favorable for the development of pure serpentine and chrysotile.

"The composition of the limestone was also important in localizing the chrysotile; the best fiber occurs in the magnesian limestone, where it is free from impurities, whereas the impure beds of the limestone are barren.

"The promiscuous intermingling of harsh and soft, and short and long, fiber apparently follows no rule of localization.

"Distribution:—The asbestos is known over a length of 1,650 feet and it has been followed into the hill for a distance of 325 feet from the south side of the mountain. On the north side, the host limestones extend for a total distance of about 1,900 feet, but are for the most part unexposed. The superior quality of the asbestos on the south side, as contrasted with the north side, indicates that a given amount of exploratory work would meet with more promising results in the south. The north and south workings are 3,000 feet apart and it is conjectural if asbestos is distributed between them; the lens-like character of the containing limestone suggests that the deposit will not continue uninterruptedly between them. Over the greater part of the mountain, the middle limestone is absent, and only that area underlain by the middle limestone will afford any likelihood of yielding asbestos upon exploration."

This asbestos deposit is unique in having yielded fiber that occasionally was of exceptional length. Some of its specimens, which were as much as fourteen inches long, are believed to represent the longest cross-fiber chrysotile yet found in the world.

Mining Methods and Costs:—The following data on mining methods

Bateman continues: "The diabase intrusion is in the form of a huge sill which follows closely the bedding planes of the sedimentary rocks. Here and there it cuts across the beds at a gentle angle, but its upper contact was not found to cross more than two twenty-foot contours. An apparent transgression of the diabase sill across the sedimentary formations on the southwestern side of the mountain, amounting to 140 feet, proved to be due to a reverse fault that elevated the southwestern corner of the mountain by that amount. The highest knob on top of the mountain marks the site of this upthrown block."

The Mineral Deposit:—

Occurrence:—Bateman says: "The asbestos occurs as horizontal seams of cross fiber chrysotile in bands of serpentine in the middle limestone, and parallel to its bedding. Only the upper part of the middle limestone, near the upper diabase, has proved productive; the lower two thirds of it has been tested in a few places with disappointing results. One to three bands of serpentine may occur in the upper part of the limestone, one or more of which may contain asbestos. In some areas the serpentine may be present without asbstos. One band of serpentine, notably persistent throughout all of the workings, lies within about two feet of the upper diabase, and in most places contains some asbestos. Practically all the serpentine lies within a six-foot zone of limestone. The individual serpentine bands vary from a few inches to 24 inches in width, and from one to fifteen individual seams of asbestos of varying sizes may occur within a serpentine band; usually there are three to five.

"The serpentine is mostly a brownish-green variety with waxy luster and conchoidal fracture, but some is deep green, black, brown, or yellowish. The individual bands may themselves be distinctly banded due to color differences of the different varieties. In several places the central part of the serpentine bands consists of an unusual whitish, waxy-looking substance which resembles opal. . . Its physical properties . . . agree with the variety of serpentine called retinalite . . .It is most abundant immediately adjacent to the chrysotile, and accompanies the harsh more often than the silky fiber.

"The asbestos. . . is localized in shoots that are separated by blank or poorly mineralized areas. Within the shoots, the fiber is spotty; rich areas pass abruptly to lean areas, long fiber to short fiber, harsh to soft, and vice versa. Mill rock, mill fiber, and long harsh are rather intimately intermingled, but the soft crude occurs only in scattered pockets.

"It was determined by means of careful measurements, made at

of Red Canyon Creek, and the other one mile up Red Canyon and on its western wall. This basaltic dike is from thirty to seventy feet in thickness and along its contact with the sedimentary rocks, whether they are above or below or included within this rock, it is more or less altered to serpentine. In some instances where the seams of the basaltic dike have penetrated into the strata of the sedimentary rocks they are completely altered to serpentine, and it is in association with these serpentinized areas of the basaltic rock that the asbestos is found. In some instances the basaltic rock is in contact with shales, and when this is the case there has been little or no serpentine formed. In most cases, however, the basalt is in contact with limestone, and then the serpentine areas are very constant, although they are only from a few inches to eighteen inches, and, in very rare cases, to 24 inches in thickness. The chrysotile asbestos is found only in those areas of the basaltic rock that have been serpentinized. As has been stated, these areas are almost constant for the whole 9,000 feet of the claims, although the asbestos varies very widely in length of fiber and in quality.

"One noticeable exception to the usual occurrence of asbestos is the regularity of the seams. In some instances they are constant for a distance of 150 feet or more. Another difference is that instead of a thick mass of serpentine containing numerous seams of asbestos, the Grand Canyon deposit is a thin body of serpentine with but two or three prominent seams, which are, however, regular and nearly constant.

"Most of the development work has been done near the western end of the property on what is known as Claim 14, or Wool Claim. The asbestos deposits have been developed at different points on this claim, following three different seams or zones of serpentine, which are in contact with three distinct layers of limestone. Openings were made on the upper and lower contacts of a middle seam of basaltic rock and on the extreme upper contact. At the middle opening a tunnel has been run for a distance of about 75 feet in a direction N. 10° E. following the pitch of the rock, which is about 10° N. From this tunnel cross-cuts have been driven and there has been considerable stoping. Just to the north of the mouth of the tunnel a quarry face has been opened for a distance of 126 feet in length and twenty feet in height, which exposed asbestos for a small area near the bottom of the face of the quarry. The asbestos seams, as exposed in the quarry and in the underground workings, vary considerably in width, widening and pinching, and sometimes splitting up into a number of seams in like manner, as has been observed in all deposits of chrysotile asbestos. The

quality of asbestos is exceptionally good and equal to the Canadian. This claim lies about 1,300 feet above the level of the river.

"The next point at which there has been considerable development work is near the center of the property on Claim 8. The deposit on this claim has been developed extensively by means of quarrying and the asbestos is exposed for a distance of about 160 feet. Asbestos of splendid quality, ranging from three-quarters to 1½ inches in length, has been obtained from this claim. One peculiar quality of this asbestos is the beautiful golden color which it assumes in the massive specimens, although the individual fibers are pure white and very silky. In the mass it is almost transparent.

"The third point at which there has been considerable development work is near the eastern end of the property, where a quarry face about 25 feet in length has been opened from which two tunnels, one about ten and the other about twenty feet long, have been drifted on the asbestos seam. Some of the asbestos fiber from this claim was three inches in length, but it is not of as good quality as that obtained from Claim 14 and Claim 8.

"Altho this property is located at the bottom of the Grand Canyon, thus making the cost of transportation of the asbestos to the railroad very high, still there are no mechanical problems in connection with the mining and the transportation of this asbestos that cannot be readily overcome when it has been definitely and positively determined that there is a sufficient quantity of the asbestos to warrant the outlay necessary. The quality of the asbestos, which is of the best, is a practical guarantee of a constant demand for any of the material that may be mined."

A small amount of asbestos has been mined from the property, but apparently high mining and transportation costs have discouraged operations.

PINAL COUNTY DEPOSITS

A deposit of asbestos occurs in northeastern Pinal County, on Putnam Wash, three-fourths mile west of the San Pedro River, or twelve miles south of Winkelman, at an elevation of 2,200 feet above sea level. The locality is only one mile west of the Mammoth-Winkelman highway, and easily accessible except when the San Pedro is in flood.

This northeastern margin of the Black Hills, which has been eroded into an intricate pattern of mediumly-deep, steep-sided canyons, is made up of complexly-faulted blocks of Apache sediments, and flanking, detrital gravels.

most asbestos occurs. The alteration consists in the formation of varicolored narrow bands, parallel to the bedding and therefore nearly horizontal. Layers of light gray, finely banded, crystalline dolomitic lime alternate with light and dark green bands of a dense smooth substance which resembles serpentine, and with bands of dense, waxy-looking, light colored material which in appearance and fracture somewhat resembles opal. . ."

Considerable sericite has been developed in the middle limestone along the contact with the upper diabase.

" . . . In the vicinity of the asbestos occurrence, a . . .lens of limestone, twenty to 35 feet thick and 1,650 feet in length was broken off from the main body and is completely surrounded by diabase. A smaller lens of limestone occupies the same position on the west side of the hill and another large one, 1,900 feet long and seventeen feet thick, is on the north side. It is in the upper parts of these included lenses that the productive asbestos occurs and the one on the south side of the hill contains much more fiber than the one on the north."

Character of the Diabase:—Bateman continues: "The normal diabase is greenish black, medium grained, and even textured, but near its contacts the grain becomes notably dense within a space of six to eight inches. Under the microscope the diabase is seen to be made up of basic feldspar and augite, with lesser amounts of olivine and brown mica, and a little magnetite. The pronounced decomposition of the augite, olivine, and feldspar shows that heated solutions permeated the diabase after it had crystallized."

It is interesting to note that the upper diabase, when examined in thin section under the microscope, shows alteration of a much greater intensity than does the lower diabase. In the upper diabase, the feldspars have been extensively sericitized, and very little, if any, of the augite or olivine is discernible. Abundant chlorite, formed mainly at the expense of the augite and of the mica, and also replacing the feldspar, is present. Considerable limonite has developed, probably at the expense of the olivine. In the lower diabase, however, this alteration has not been sufficiently intense to obliterate the original minerals, and often the feldspars are rather fresh.

Structure:—In general, the strata are nearly horiontal. A low, gentle, northward-trending anticline, whose height is about forty feet, arches over the area in which most of the asbestos occurred.

As Bateman noted, the exposures on the south side of the mountain show a gentle, slightly undulating, northward dip, and on the north side of the mountain, a gentle southward dip.

(d)	Like (b), but salmon-colored, when fresh. Weathers red, brown, and black	18
(e)	Diabase; when weathered, resembles basalt	10-12
(f)	Gray, rather pure, serpentinized magnesian limestone containing the principal asbestos	20–35
(g)	Diabase	500
(h)	Gray, cherty limestone; contains minor serpentine and asbestos near top	150
(i)	Reddish quartzite	200
(j)	Diabase, base not exposed.	

Members (a) and (b) represent the Troy sandstone, (c), (d), (f), and (h) belong to the Mescal limestone, and (i) represents the Dripping Spring quartzite. The thicknesses of (g), (h), and (i) are taken from Diller.[35]

Character of the Limestone:—Bateman[36] has described the limestone as follows: "The upper, middle and lower limestones are each of somewhat different composition and in consequence have been differently affected by the diabase intrusion. The upper and lower limestones contain considerable impurities in the form of clayey-matter and chert, and on weathering present a gnarled appearance. The top of the lower limestone, in contact with the diabase sill, has been baked for a depth of three feet to a dense hard reddish rock. Below this, for another few feet, it has been altered to a dirty gray-colored crystalline limestone, which gradually passes into the dark gray normal impure limetsone. The upper limestone has been crystallized to dolomite marble, and in immediate contact with the upper diabase it has been silicified.

"The middle limestone is a magnesian limestone of gray color and is relatively free from impurities. This difference in purity apparently has been an important factor in the localization of the asbestos in the middle limestone to the exclusion of the others. Upon alteration it has yielded serpentine, whereas the upper and lower limestones were of such composition that minerals other than asbestos or serpentine tended to form under the conditions of alteration that gave rise to the asbestos deposit. Hence, in this locality, the upper and lower limestone can be excluded as containers of commercial quantities of asbestos.

"The middle limestone is most altered in its upper part, just beneath the upper diabase, and where the alteration is most intense the

[35]Diller, J. S., Asbestos in 1917: U. S. Geol. Survey, Mineral Resources of the United States for 1917, pt. II, p. 199.

[36]Bateman, Alan M., An Arizona asbestos deposit: Economic Geology, vol. 18, pp. 663-683. 1923.

Asbestos outcrops on both the north and south sides of the wash. On the north, in a fault block about 1,000 feet long and 500 feet wide, the following section is exposed above the wash bed: A few feet of diabase (at the bottom); seven feet of Mescal limestone, in which are two zones of asbestos; eight feet of diabase; fifty feet of Mescal limestone; and about thirty feet of Troy quartzite, which there contains a two-foot conglomerate member four feet above its base. These strata strike N. 75° W., and dip 35° northeastward.

The upper asbestos zone of this block is about eight inches across and is made up of branching veinlets from a fraction of an inch to one inch thick. The lower zone consists of a very thin veinlet. A little serpentine is associated with the asbestos.

On the south side of the wash, or southeast from the exposure just described, where a small fault block of Mescal limestone and diabase protrudes from the detrital gravels, the strata strike N. 60° W. and dip 30° northeastward. There the asbestos zone, which lies about seven feet above the diabase, is ten inches across, and carries fiber of a maximum length of one inch, associated with considerable light-colored serpentine.

The fiber from both sides of the wash is amber-yellow to gray in color, and rather brittle. Part, at least, of this brittleness may be due to surface weathering.

Only a small amount of assessment work has been done on these asbestos exposures.

YUMA COUNTY DEPOSITS

The occurrence of asbestos in northwestern Yuma County, thirteen miles northwest of Quartzsite and nine miles east of the Colorado River was reported to the Arizona Bureau of Mines prior to 1921 by Mr. Jos. Bowyer, upon whose property it lies.[46] This locality was visited in 1927, but the asbestos was found to be of the amphibole variety.

It occurs, alternating with lenses of marble, as a four-foot zone in a bed of marmorized limestone within the schistose quartzites, limestones, and gneissess of the northern Dome Rock Mountains. The fiber is white, flaky, and often of good length, but is weak and brittle.

Examined under the microscope, the material was found to have a maximum extinction angle of 16° in the vertical zone, and positive

[46]Allen, M. A., and Butler, G. M., Asbestos: Univ. of Ariz., Arizona Bureau of Mines Bull. 113, p. 28. 1921.

elongation. Dr. R. J. Leonard, of the Geology Department of the University of Arizona, determined that it contained slight impurities of alumina and lime, but that its three indices of refraction are 1.610, 1.625, and 1.630. It is, therefore, tremolite.

Amphibole asbestos occurs in the metamorphic rocks of numerous other localities in Arizona, but it is of little or no immediate commercial value.

PRACTICAL DEDUCTIONS

A study of Arizona's asbestos resources leads to certain obvious conclusions regarding their future economic possibilities.

A number of asbestos deposits are known in Arizona, but only a small proportion of them have been thoroughly explored. If conservatively developed and efficiently managed, as, for example, has been done on the Johns-Manville property, many of these less-explored deposits may attain considerable economic importance. Any marked increase in the demand for, and the market value of, the Arizona fiber, or any marked decrease in costs of production and transportation will, of course, enable certain properties, at present idle, to operate at a profit.

Proper, conservative development and prospecting necessitate an understanding of the importance of certain features, such as character of the limestone, intensity of alteration and serpentinization, character of the diabase and of its contact, and the presence of pre-ore structural flexures and fractures. These features are discussed on pages 29 to 33.

Harshness of fiber in a given asbestos deposit does not always decrease away from the erosion surface, and length of fiber is not a factor of depth. Because of abrupt, natural variations in the thickness and continuity of cross-fiber asbestos veins, estimates of ore tonnages in ground that has not been thoroughly blocked out are apt to be far from accurate.

The best quality of Arizona chrysotile is equal to any in the world, and is superior to that of practically all known localities in its low content of chemically-free iron. However, in the early days of asbestos mining in Arizona, many of the small operators shipped everything that resembled asbestos, and thus the Arizona fiber acquired, with many purchasers, a bad reputation that is difficult to overcome. The need of careful grading, therefore, cannot be overestimated, if Arizona asbestos is to be in rapidly-growing demand and is to command its worth on the market. Further education of the public in regard to the many uses of asbestos, particularly of the cheaper or shorter grades for

History:—Original locations upon the nucleus of these claims are said to have been made by Mr. Charles Watkins in 1914, and mining was started in 1916. The property was bonded in 1917 to the late Charles F. Sloane, who organized the American Ores & Asbestos Company. This company actively operated the mine and shipped Crude No. I fiber until the Raybestos and the United States Asbestos companies obtained control of the property in 1919. Active mining continued until the end of 1920, when the limit of most of the known ore was reached. Surface equipment was dismantled in 1922, and assessment work on the claims was allowed to lapse. In 1923, Mr. W. G. Shanley acquired control of the property and organized the International Asbestos Co., whose principal operations have been confined to experimenting with milling methods.

Total production from the property, according to Melhase,[33] amounted to 1,300 tons of Crude No. I and 300 tons of Crude No. II fiber. In addition, thousands of tons of mill rock were discarded on the dump or used to fill stopes. Mr. Shanley[34] recovered some 65 tons of Crude Nos. I, II, and III during a 23-day experimental mill run in 1927.

Topography:—This asbestos deposit is near the top of a rectangular mesa that is 1¼ miles in east-west length by one-half mile in breadth, and is from 6,200 to 6,300 feet above sea level, or 4,100 feet higher than Roosevelt Reservoir. This mesa has been nearly separated from the main mass of the Sierra Ancha on the north by the headward erosion of Pocket Creek. The east, south, and west sides slope steeply down for some 1,500 feet to the surface of a deeply-dissected platform whose steep, escalloped, southwestern front breaks onto the dissected, detrital plain that slopes down to Roosevelt Reservoir.

Geology:—Troy sandstone, Mescal limestone, diabase, and Dripping Spring Quartzite are exposed in the immediate region. The following section of the rocks was measured down the south slope from the top of the mesa:

		Thickness in feet
(a)	Red-brown, cross-bedded, somewhat pebbly sandstone. Contains pebbles of (b) near base	15
(b)	Black, thin-bedded, and flinty beds; upper two feet red-brown and hematitic; occasionally red-banded; very dense	35
(c)	Thin-bedded, gnarled, cherty limestone; somewhat changed to marble and serpentine	9

[33]Melhase, John, Asbestos deposits of Arizona: Eng. & Min. Jour.-Press, vol. 120, p. 808. Nov. 21, 1925.
[34]Oral communication.

claim, where a thirty-foot tunnel has been driven S.50°W. from a point 300 feet above the bed of the canyon or approximately 4,500 feet above sea level. At this outcrop, a thin zone of asbestos and serpentine is eight feet above a five-to-ten-foot sill of diabase. Eighteen inches higher is a similar zone, and it joins the lower zone near the end of the tunnel. The fiber exposed is pure white and of excellent quality, but generally less than three-fourths inch long.

SIERRA ANCHA REGION

Limits and Topography:—The Sierra Ancha region, as here considered, includes the area that extends north of the Salt River to the latitude of Young, or Pleasant Valley, and west of Canyon Creek to longitude 111°. This region, as its Spanish name for "Wide Mountain" implies, is a plateau. It is made up of resistant strata that dip in general slightly eastward, are intruded by huge and small sills of diabase, and have been considerably affected by minor faulting. Its surface varies in elevation from 5,000 to 7,400 feet above sea level, but the Salt River drainage system has deeply dissected it, down to as low as 3,000 feet above sea level, with steep-sided canyons. The most notable of these canyons is that of Cherry Creek, which begins northeast of Pleasant Valley, extends south-southeastward, and has a maximum depth of 4,000 feet opposite the summit of Aztec Peak. Tributaries to Cherry, Coon, Oak, Medler, Pocket, and Sallymay creeks have carved groove-like canyons, many of which have greater depth than breadth.

Climate and Vegetation:—The general description of the climate and vegetation of the Chrysotile-Salt River region, given on pages 33 and 34, is applicable to the Sierra Ancha region. Timber flourishes in the higher elevations.

Water Supply:—Cherry, Reynolds, and Workman creeks are perennial except in very dry years. Small springs, whose flows usually can be augmented by proper tunneling, occur every few miles. Shallow wells in the diabase, if properly situated, generally yield good water in quantities ample for domestic purposes.

AMERICAN ORES, OR INTERNATIONAL ASBESTOS, GROUP

Situation and Accessibility:—The International Asbestos group, which contains 29 unpatented claims, is situated along the southern crest of the Sierra Ancha, about eight miles north-northeast of the eastern end of Roosevelt Reservoir. It is accessible from the Globe-Pleasant Valley highway by some three miles of steep road that branches off at Pocket Creek, 47 miles from Globe.

roofing and general rough insulation, will greatly stimulate the prosperity of the industry.

Improvements in present-day asbestos milling methods may do away with most of the hand work of mining and cobbing, and so effect great reductions in costs. Cheap electric power doubtless would hasten such improvements. The asbestos districts of Arizona, particularly those of Gila County, are in great need of better roads for transporting supplies and ore. In the case of those mines that are situated forty or more miles from the railway, first-class highways would reduce transportation costs at least $8.00 per ton below present levels.

APPENDIX

PRINCIPAL PRODUCERS AND POTENTIAL PRODUCERS OF ASBESTOS IN ARIZONA

Property	*Owner or agent*	*Post office address*
Accident and Falls	Robert M. Anderson	Globe, Arizona
Aileen	Roger Kyle	Globe, Arizona
American Ores (International)	W. G. Shanley	Globe, Arizona
Apache	W. G. Shanley	Globe, Arizona
Arizona Asbestos Assoc.	Ariz. Asbestos Assoc.	Chrysotile, Arizona
Bear Can. Asb. Co.	Bear Canyon Asb. Co.	Ambler, Pa.
Bass	W. W. Bass	Grand Canyon, Arizona
Canadian	W. G. Shanley	Globe, Arizona
Cobb & Dunaway	W. H. Webster	Globe, Arizona
Crosthwaite-Steward	R. L. Crosthwaite	140 S. Dearborn St., Chicago, Ill.
Friday	T. Gordon & T. L. Carter	Globe, Arizona
Globe Asbestos	Globe Asbestos Co.	Globe, Arizona
Hance	Hance Asbestos Co.	Grand Canyon, Arizona
Horse Shoe	San Carlos Asbestos Co.	Lakeside, Arizona
Lorie & Lena	Roy Riedhead	Showlow, Arizona
Pueblo	Wm. Andrews	Globe, Arizona
Regal Asbestos	Regal Asbestos Mines, Inc.	Rice, Arizona
Reynolds Falls	Wm. Andrews	Globe, Arizona
Riverside	Roy Reidhead	Showlow, Arizona
Rock House	Emsco Asbestos Co.	Downey, Calif.
Seven Star	Roy Reidhead	Showlow, Arizona
Seventy-Two and Monte Christo	P. Montez and A. Barrios	Chrysotile, Arizona
Sloane	Mrs. Alice Sloane	Los Angeles, Calif.
Triangle	W. M. Tenney, Jr.	Young, Arizona

Asbestos outcrops on many of the claims, but the principal prospecting was done in the vicinity of a point N.10°E. from the Regal Mine, three-fourths mile north of the river, and at an approximate elevation of 3,400 feet above sea level. There, a northward tunnel, some 175 feet long, exposes an eighteen-inch zone of serpentine, five feet above the diabase, that contains several asbestos veins. Most of this fiber is less than three-fourths inch long, and much of it is of fair quality, but it appears to become harsher farther underground. Approximately 650 feet north-northeast, where the beds strike S.35°W. and dip 7°NW., a fifty-foot tunnel along the strike shows some fair quality of fiber, up to one inch long, occurring with serpentine, twelve feet above the diabase. Approximately 300 feet farther N.38°E., some two-inch, harsh fiber occurs six feet above the diabase, but it pinches out ten feet in from the surface.

Lorie & Lena Claim:—The Lorie & Lena claim is situated in the southwestern portion of the Fort Apache Indian Reservation, on the north side of, and about three-fourths mile above the mouth of, a southeastward-flowing tributary of Cibecue Creek, or two miles north of Salt River. It is accessible by some eight miles of rough trail from the Regal Mine. This claim was located in 1923 by Mr. Roy Riedhead, but only a small production from it has been attempted.

Here, the deep, steep-sided canyon of Cibecue Creek exposes diabase, Mescal limestone, and Troy sandstone that form a high cliff.

The principal exposure of asbestos-bearing serpentine occurs some twenty feet above the diabase, or 35 feet below the sandstone, and continues intermittently for a length of more than one-fourth mile. In its maximum thickness of fourteen inches, it contains several pinching veins of asbestos whose fiber is of fine quality and occasionally is one inch long.

Workings on the claim in March, 1928, were limited to one 25-foot tunnel, near a small spring, at an elevation of approximately 4,000 feet above sea level.

Seven Star Group:—The Seven Star group contains seven claims in the southwestern portion of the Fort Apache Indian Reservation, along Salt River Draw, about 3½ miles north of its junction with Salt River. This ground is accessible by some six miles of rough trail from the Regal Mine. The claims were located in 1923 by Mr. Roy Riedhead, but only a small production from them has been attempted.

Here, the deep, steep-sided canyon of Salt River Draw exposes thin-bedded, occasionally-cherty Mescal limestone, split by several sills of diabase and overlain by Troy sandstone.

The most prominent asbestos outcrop is on the Seven Star No. 3

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PRINCIPAL PURCHASERS OF ASBESTOS WITHIN THE UNITED STATES

Following is a list of the principal purchasers of asbestos within the United States. Several of these firms at present, however, either are only small users of Arizona fiber or buy all of their raw material elsewhere.

Allbestos Corporation, 21st & Godfrey Ave., Gtn., Phila, Pa.
American Asbestos Co., Norristown, Pa.
American Solvents & Chemical Corporation, Agnew, Calif.
Armstrong Cork & Insulation Co., Pittsburgh, Pa.
Asbestos Fibre Spinning Co., North Wales, Pa.
Asbestolith Mfg. Co., 1 Madison Ave., New York City, N. Y.
Asbestos Shingle, Slate & Sheathing Co., Ambler, Pa.
Asbestos Spinning & Weaving Corp., 16 Beaver St., New York City.
Asbestos Textile Co., 475 5th Ave., New York City, N. Y.
Belmont Packing & Rubber Co., 12th & Arch Sts., Phila., Pa.
Philip Carey Company, Lockland, Cincinnati, Ohio.
A. Daigger & Co., 54 Kinzie St., Chicago, Ill.
R. J. Dorn & Co., 400 Valmont St., New Orleans, La.
Duraflex Company, Inc., Continental Bldg., Baltimore, Md.
Emsco Asbestos Co., Dolland & Iowa Sts., Downey, California.
Eternit, Inc., 15th & Locust Sts., Lewis Bldg., Phila., Pa.
Ferodo & Asbestos, Inc., New Brunswick, N. J.
Garfield Mfg. Co., Garfield, N. J.
Garlock Packing Co., Palmyra, N. Y.
Thomas L. Gatke, Railway Exchange Bldg., Chicago, Ill.
General Asbestos & Rubber Co., Charleston, S. C.
B. F. Goodrich Co., Akron, Ohio.
Goodyear Tire & Rubber Co., Akron, Ohio.
Johns-Manville, Corporation, 292 Madison Ave., New York City.
Keasby & Mattison Co., Ambler, Pa.
Mohawk Asbestos Slate Co., 1147 Mohawk St., Utica, N. Y.
Multibestos Co., Walpole, Mass.
Norristown Magnesia & Asbestos Co., Norristown, Pa.
Plant Rubber & Asbestos Works, 537 Brannen St., San Francisco, Calif.
Raybestos Co., Bridgeport, Conn.
Rockbestos Products Corp., P. O. Drawer 1102, New Haven, Conn.
Ruberoid Company, Bound Brook, N. J.
Russell Mfg. Co., Middletown, Conn.
Sall Mountain Co., 140 S. Dearnborn St., Chicago, Ill.
Southern Asbestos Co., Charlotte, N. C.
Standard Asbestos Mfg. Co., 816-22 W. Lake St., Chicago, Ill.
Stokes Asbestos Co., Trenton, N. J.
Union Asbestos & Rubber Co., Cicero, Ill.
United States Rubber Co., 1790 Broadway, New York City.
United States Asbestos Co., Manheim, Pa.
H. F. Watson Co., Erie, Pa.

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The Arizona Bureau of Mines still has the following bulletins available for free distribution to residents of Arizona. Bulletins not listed herein are out of stock and cannot be procured from the Bureau. Any five bulletins will be sent free of charge to non-residents of the State, and additional numbers may be purchased at the uniform rate of ten cents each.

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16. Mica, by Frank L. Culin, Jr.
25. Cement, by Frank L. Culin, Jr.
40. Building Stones, by Frank L. Culin, Jr.
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45. Lead, by P. E. Joseph.
46. Lime Rocks, by Frank L. Culin, Jr.
62. Selling Prospects, by Chas. F. Willis.
68. What To Do With the Other Eight Hours, by S. C. Dickinson.
72. Roads for Mines, by G. R. Fansett.
78. Valuation of Prospects, by G. R. Fansett.
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124. Arizona Gold Placers, by Eldred D. Wilson.
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3. A geologic map of Arizona on the same scale as the base map, printed in many colors. It was issued in 1925, and is sold both mounted and unmounted for the same prices as the topographic map.

4. A relief map of Arizona on the same scale as the base map, printed in various shades of brown, black, and blue. It was issued in 1925, and looks exactly like a photograph of a relief model of the State. This map was prepared by the U. S. Geological Survey, and is sold by the Survey for $1.00. Unmounted copies may be obtained from the Arizona Bureau of Mines at the same price. The same map mounted on cloth with rollers at the top and bottom is sold by the Bureau for $3.00.

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The Arizona Bureau of Mines will classify free of charge all rocks and minerals submitted to it, provided it can do so without making elaborate chemical tests. Assaying and analytical work is done at rates fixed by law, which may be secured on application.

The Bureau is always glad to answer to the best of its ability inquiries on mining metallurgical, and geological subjects; and takes pride in the fact that its replies are always as complete and authoritative as it is possible to make them.

All communications should be addressed and remittances made payable to "The Arizona Bureau of Mines, University Station, Tucson, Arizona."

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University of Arizona

Bulletin

Arizona Bureau of Mines

G. M. BUTLER, *Director*

ASBESTOS DEPOSITS OF ARIZONA

BY ELDRED D. WILSON

WITH AN INTRODUCTION ON

ASBESTOS MINERALS

BY G. M. BUTLER

APPLICATION OF WESTERN
CHEMICAL COMPANY UNDER
M. O. 5

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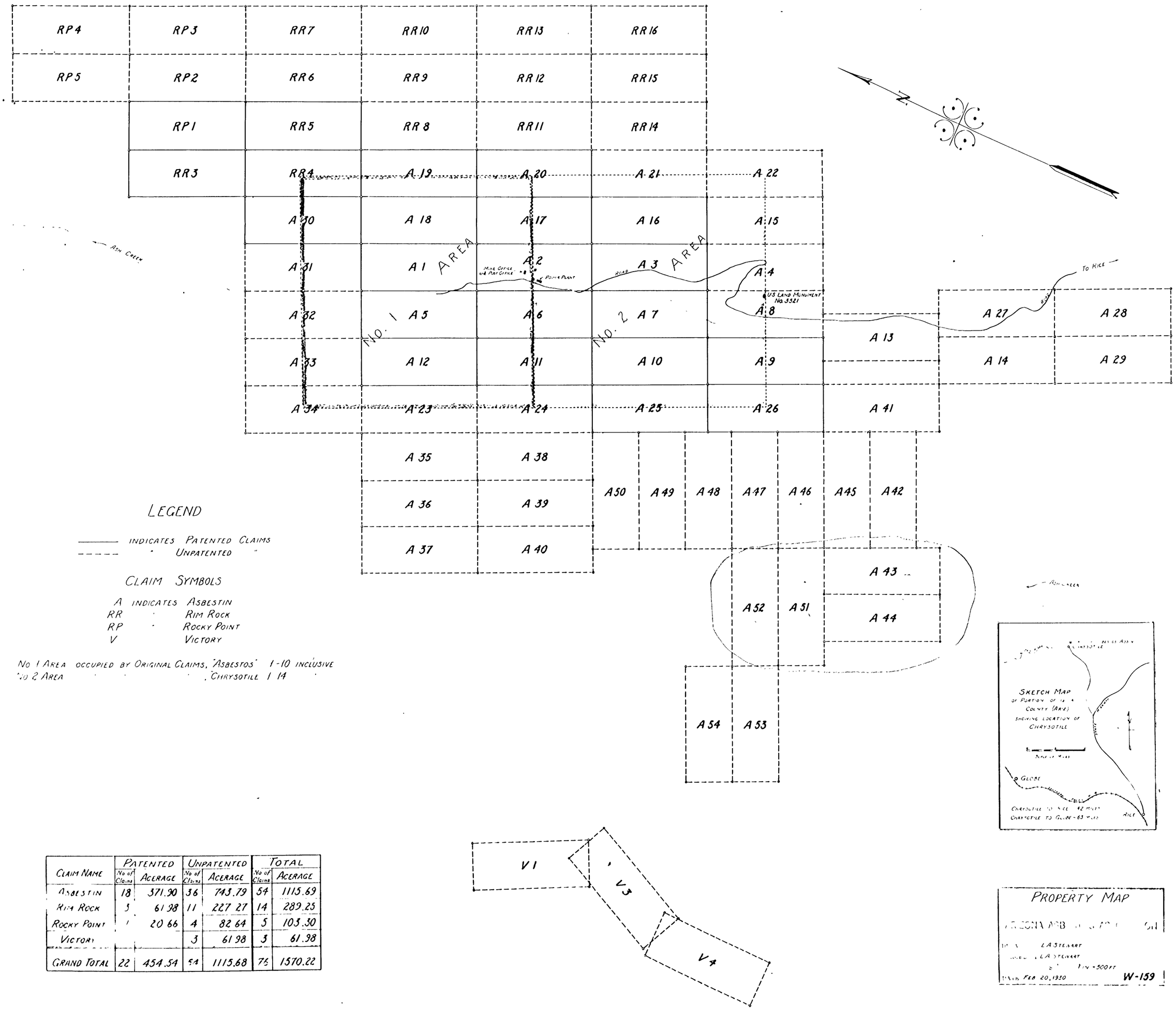

Claim Name	Patented		Unpatented		Total	
	No of Claims	Acerage	No of Claims	Acerage	No of Claims	Acerage
Asbestin	18	371.90	36	743.79	54	1115.69
Rim Rock	3	61.98	11	227.27	14	289.25
Rocky Point	1	20.66	4	82.64	5	103.30
Victory			3	61.98	3	61.98
Grand Total	22	454.54	54	1115.68	76	1570.22