R. I. 4414

March 1949

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

REPORT OF INVESTIGATIONS

INVESTIGATIONS OF THE KOBUK RIVER ASBESTOS DEPOSITS KOBUK DISTRICT, NORTHWESTERN ALASKA

BY

H. E. HEIDE, W. S. WRIGHT, AND F. A. RUTLEDGE

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INVESTIGATION OF THE KOBUK RIVER ASBESTOS DEPOSITS, KOBUK DISTRICT, NORTHWESTERN ALASKA[1]

By H. E. Heide[2], W. S. Wright[3], and F. A. Rutledge[3]

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ILLUSTRATIONS

INTRODUCTION AND SUMMARY

The serious shortage of domestically produced asbestos during the war prompted the Bureau of Mines to investigate reported asbestos deposits in Alaska. The most promising appeared to be these in the Cosmos Hills and Jade Hills areas along the Kobuk River in northwestern Alaska.

The deposits along the west side of Shungnak River, a tributary of the Kobuk River, were the first to be investigated by the Bureau, in the summer of 1944. Four bulldozer trenches were excavated, from which a 2-ton sample was taken. This sample was shipped to Rolla, Mo., for testing in the Bureau of Mines laboratory.

In the summer of 1945 an investigation of asbestos deposits on Cosmos Creek, also a tributary of the Kobuk River, was begun; the work was completed during the field season of 1946.

In this area serpentine is sheared and cut by a stockwork of cross-fiber and slip-fiber asbestos, for a strike length of over a mile. Six bulldozer trenches were excavated on this formation, from which two large samples of asbestos material were taken. These samples were shipped to the Canadian Johns-Mansville Co. for testing.

The Dahl Creek deposits, situated east of Cosmos Creek, were partly developed by Arctic Circle Exploration Co. That company had excavated four trenches and driven an adit 228 feet in length. The Bureau cleaned out, deepened, and sampled the trenches and obtained samples from the adit. In all, 1,090 pounds of sample from the Dahl Creek area was sent to the Bureau's Rolla laboratory for testing.

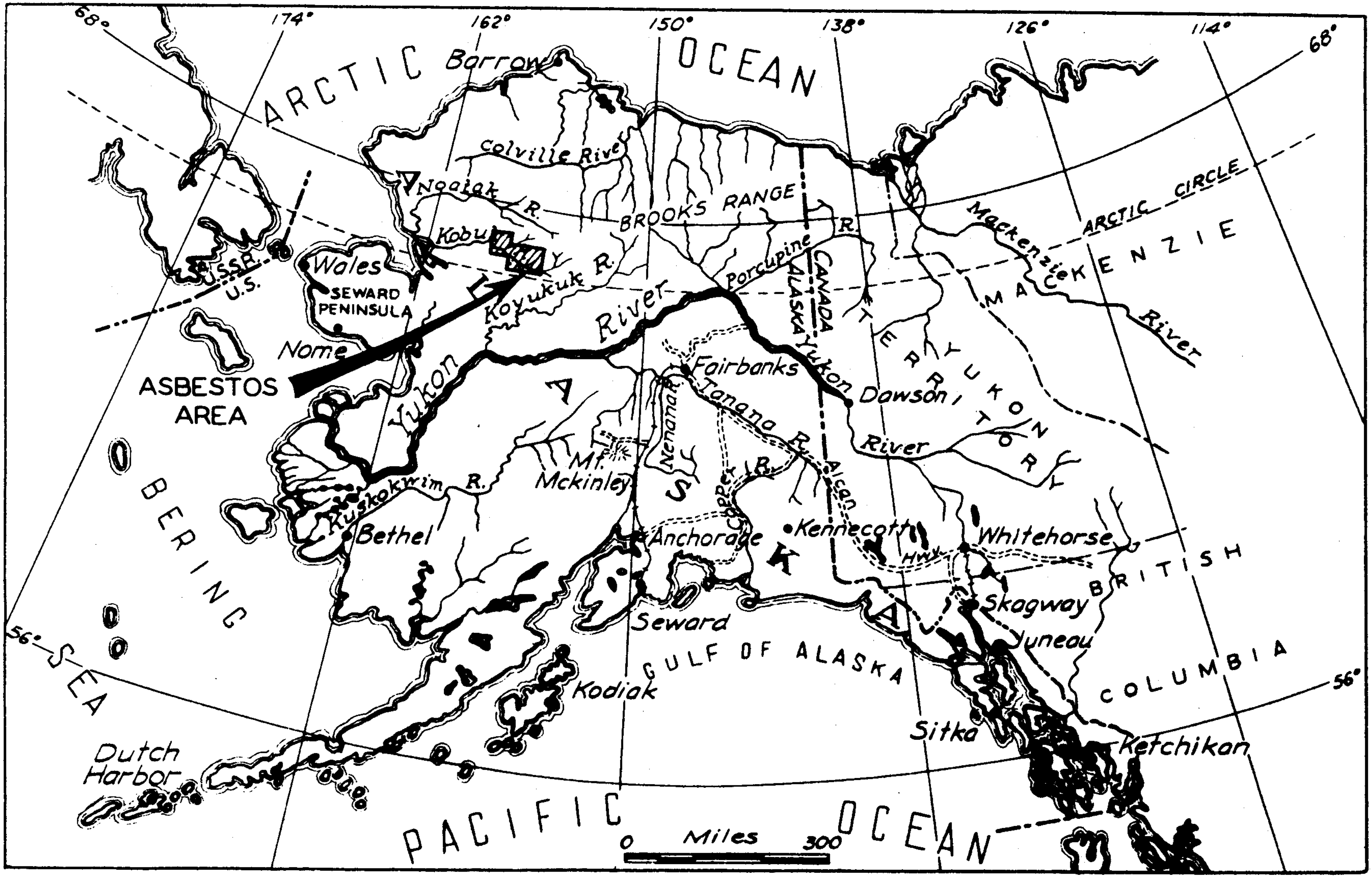


Figure I. - Index map, Kobuk River, Asbestos, Alaska.

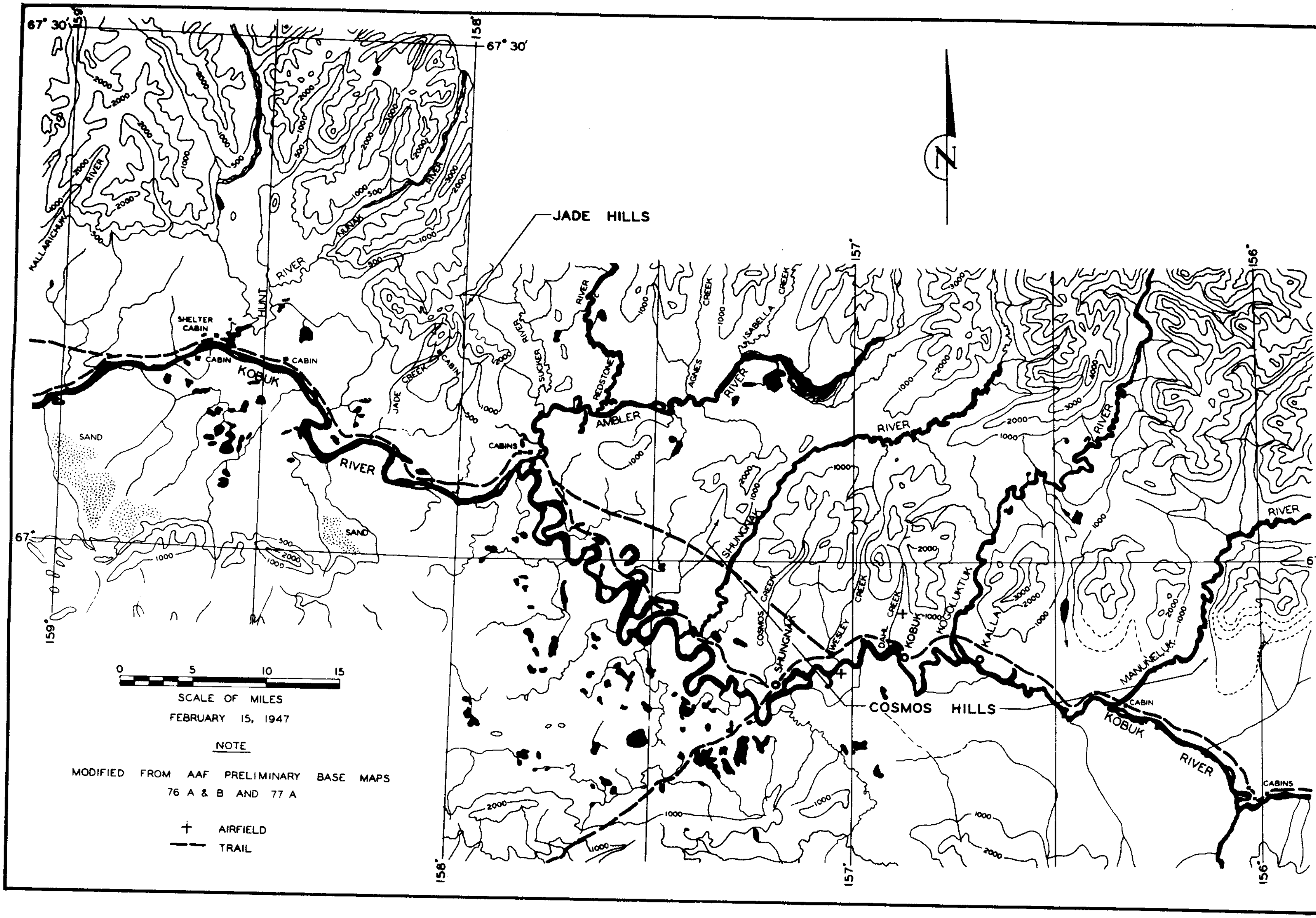


Figure 2. - Kobuk River asbestos areas.

This report discusses the procedures of sampling the deposits and presents the result of beneficiation tests.

ACKNOWLEDGMENT

Special mention is made of the information and assistance given by the Canadian Johns-Manville Co., Ltd., Asbestos, Quebec, Canada; and more especially of A. R. Fisher, vice president; George K. Foster, vice president; Charles A. Borror, chief mining engineer; H. S. Deeley, assistant to manager; H. C. Marek, mine superintendent; C. D. Chandler, assistant mine superintendent; H. F. Janson, mill superintendent; and G. L. Gartshore, assistant mill superintendent of the Canadian Johns-Manville Co. The diamond-drill procedures and specifications of the special equipment designed at their Jeffrey mine for use in the asbestos-bearing rock along with their methods of core sampling and estimation of grade were appreciated. The Bureau of Mines also is indebted to the Johns-Manville Co. for beneficiation tests of large samples from the Kobuk River deposits with determination of fiber content, grades of fiber products, and possible uses.

Acknowledgment is also made of the information procured from B. D. Stewart, commissioner of mines, Territorial Department of Mines, and the cooperation in the field by Eskil Anderson, mining engineer, Territorial Department of Mines and Robert R. Coats of the Federal Geological Survey.

Heine Kenworthy, metallurgist, of the Rolla Branch, Metallurgical Division, of the Bureau of Mines conducted the beneficiation tests for the recovery of asbestos fibers from the samples submitted from the Shungnak River area in 1944.

The cooperation and assistance given by James S. Robbins, president, Arctic Circle Exploration, Inc., and his employees, by Harry Brown, Kobuk, Alaska, and by Mr. and Mrs. Collins, of the CAA weather station at Shungnak, are gratefully acknowledged.

LOCATION AND ACCESSIBILITY

The location of the asbestos areas in the Cosmos Hills and the Jade Hills paralleling the Kobuk River in Northwestern Alaska is shown in figures 1 and 2. The deposits are 30 to 45 miles north of the Arctic Circle and lie within a zone approximately 45 miles long, extending from 156° 35' to 158° 15' west longitude. This zone of mineralization reaches from Jade Mountain in the Jade Hills on the west to the first mountain east of the Kogoluktuk River on the east.

The Kobuk River asbestos district is in the Kobuk-Noatak mining precinct in the Second Judicial District, and the mining records are kept at Kotzebue.

The Kobuk River is navigable for river boats and barges during the summer months to a point a short distance above Kobuk. Freight rates in 1946 were $20 a ton from Kotzebue to Shungnak or Kobuk; but for larger down-river tonnages, rates as low as $4 a ton may be assumed. Kobuk is approximately 270 miles by water from Kotzebue but only 150 miles by air.

Kotzebue, on Kotzebue Sound, serves as the port of call for the Kobuk, Noatak, and Salawik districts and is open to navigation between June and October of each year. The Alaska Steamship Co. freight rate on general cargo from Seattle, Wash., to Kotzebue shipside during 1946 was 47-1/2 cents a cubic foot. Additional charges - 16 percent surcharge, 2-1/2 cents a cubic foot wharfage at Seattle, and a 21-1/2 cents a cubic foot lighterage at Kotzebue - made a total charge of 80.1 cents a cubic foot or $32.04 a ton.

A small motorship, M. S. Meteor, makes biweekly trips between St. Michael, Alaska, and Kotzebue, stopping at Nome and other coastal towns enroute. Freight rates from Nome to Kotzebue are $37.50 a ton shore to shore. In 1946 the Kotzebue Sound Lighterage Co. started a like service at the same rates with the M. S. Kotzebue.

The district is accessible by plane from Nome, Fairbanks, or Kotzebue. Existing landing fields are suitable for the light planes used for "bush" flying. In 1946 air express rates were $0.35 a pound from Nome or Fairbanks and $0.25 a pound from Kotzebue. Passenger fares were $75 from Fairbanks, Nome, or Kotzebue.

There are no roads in the district, but several "cat" trails have been brushed-out and can be used for hauling heavy freight from the river to the deposits. However, since the frost is out of the tundra during the summer months, most of the freighting is done over the snow with tractors and sleds.

Kotzebue, with 362 inhabitants, is the closest town of any importance and source of supplies with four general stores. The Alaska Native Service (U. S. Department of the Interior, Indian Office) operates a school and hospital in Kotzebue and a school in Shungnak. Shungnak, with a population of 193, and Kobuk, with 31 inhabitants, are on the Kobuk River south of the Cosmos Creek and Dahl Creek asbestos deposits, respectively. Staple groceries can be obtained from a store in Kobuk.

PHYSICAL FEATURES AND CLIMATE

The Kobuk River, north of which the asbestos areas lie, rises in the Schwatka Mountains of northwestern Alaska and flows westerly into Kotzebue Sound and the Arctic Ocean. Throughout most of its course, the Kobuk River forms the line of separation between the rolling, hilly country of the Koyukuk Plateaus to the south and the rugged Brooks Range to the north; however, most of the drainage area is in the Brooks Range.

The Brooks Range is composed of several mountain groups. One of these, the Baird Mountains, lies north of the Kobuk River along its lower part between the Kobuk and Noatak Rivers. Another, the Schwatka Mountains, lies between the head of the Kobuk River and the Alatna and upper Noatak Rivers. The Jade Hills and Cosmos Hills, in which the asbestos-bearing serpentine is found, are part of the Baird and Schwatka mountain groups, respectively.

The Cosmos Hills, though part of the Schwatka Mountains, are separated from the rest of the group by a lowland drained by the Ambler, Shungnak, and Kogoluktuk Rivers. These rivers head in the Schwatak Mountains, flow southward into this lowland, and then cut through the Cosmos Hills to the Kobuk River. The major axis of the Cosmos Hills is east-west. Beside these main streams traversing the Cosmos Hills, several smaller streams originate within the area. Although some flow north and others south, all eventually join the Kobuk River. Those flowing north enter the lowland or a transverse stream and unite with one of the main streams flowing south to the Kobuk River, while the southward-flowing streams are direct confluents of the Kobuk.

The Kobuk River lowlands lie south of the Cosmos and Jade Hills (fig. 2). The lowlands at Shungnak range from 12 to 14 miles in width and from 200 to 400 feet in altitude. Crests of the Cosmos Hills are 2,000 to 3,000 feet in altitude and the southward facing slopes are steep and well-alined.

The Jade Hills lie north of the Kobuk River lowlands between the Hunt and Redstone Rivers. Topographic relief in the Jade Hills is more pronounced than in the Cosmos Hills, and the crests of the mountains are 2,000 to 3,550 feet in altitude. Jade Mountain is the highest.

The Kobuk River lowlands are predominantly muskeg, and permanently frozen ground is found throughout the lowlands and along the slopes of the mountains. Fair stands of spruce grow along the banks of the river and its tributaries, and a sufficient number are large enough to furnish logs and lumber for a small mining operation. Birches grow on the low hillsides near the edge of the lowlands, and the steep mountain slopes are frequently covered with small spruce, willows, and alders to an elevation of about 1,500 feet.

The climate is typical of subarctic northern Alaska. Ice and frost conditions prevail from the middle of September to late June. July and August are normally the months of heaviest rainfall. The average precipitation for a 5-year period at Shungnak was 21.06 inches. During 1944, 65.4 inches of snow were recorded. More snow can be expected at the asbestos deposits which are at higher elevations. The average mean temperature during the above 5-year period was 21.7° F. The highest and lowest temperatures recorded were 90° F. and -61° F., respectively.

HISTORY AND PRODUCTION

The earliest recorded exploration of the Kobuk River Valley by white men was in the early "eighties". Placer gold was discovered in the Shungnak and Squirrel River areas, and in 1898 there was a stampede of gold seekers to the Kobuk. Although deposits of both placer and lode gold, copper, and lead were found in the region, only a small amount of placer gold was produced, and most of the prospectors soon left for the new strikes at Nome and the Koyukuk.

The asbestos deposits were first noted during the gold rush, and although a small quantity of placer gold has been produced annually since the original discovery, there has been very little prospecting and general development of the area. The first officially recorded reference to asbestos deposits in the region along Dahl Creek, a tributary to the Kobuk River (fig. 3), is found in Federal Geological Survey bulletin 480.4/ The reports on the early samples of asbestos taken by the Geological Survey were discouraging as the asbestos, though of good color, had low tensile strength. In 1925 and 1926 one of the traders at Kotzebue financed prospecting of the asbestos deposits in the Jade Hills west of the lower Ambler River but no noteworthy discoveries were made.

Additional prospecting in the Cosmos Hills was undertaken in 1931 and 1932 by Michael Garland under the Territorial Department of Mines prospecting program. The asbestos deposits in the serpentine at the head of Dahl Creek were discovered, and samples containing slip fiber 1 foot in length were submitted to the Bureau of Mines for analysis. Several claims were staked by Garland. Although the sample of slip fiber was identified as chrysotile asbestos of fine grade, no development was attempted, and the claims were allowed to lapse.

Until recently it has been the common assumption that all the asbestos in the region was of the chrysotile variety. However, in 1943 James S. Robbins, president, Arctic Circle Exploration, Inc., of Candle, Alaska, submitted to the Territorial Department of Mines at Fairbanks, Alaska, a sample that was identified as tremolite asbestos. Arctic Circle Exploration located several lode claims covering some of the old Garland group and started mining tremolite asbestos from a deposit near the summit of Asbestos Mountain. Up to November 1945, when operations were recessed for the winter, Arctic Circle Exploration had produced the following: 36.5 tons of tremolite asbestos, 1 ton of chrysotile slip fiber, and approximately 5 tons of jade boulders from the streams draining the area.

With the aroused interest in the jade and asbestos occurring in the serpentine in the Jade and Cosmos Hills, a large number of additional claims were staked covering the serpentine outcrops, and placer claims for jade were located along the streams transecting the areas.

GENERAL GEOLOGY

The asbestos deposits of the Cosmos Hills and Jade Hills occur within serpentines altered from ultrabasic rocks. The ultrabasic rocks were intruded in a series of black slates, schists, limestones, and conglomerates of Paleozoic and possibly pre-Paleozoic age that form both the Jade Hills and the Cosmos Hills.5/ This series has never been studied in detail. The large exposed thickness, since it outcrops on both the Noatak and Kobuk River, may be due to folding or faulting. This is apparently true since the schistose conglomerate, though dipping to the south where it forms the front of the Cosmos Hills and the capping over the rest of the series, was also found on the Noatak River by the Geological Survey.6/ Many folds in the series were observed in the Schwatka Mountains along the transversing valleys of the Shungnak and Ambler Rivers.

4/ Smith, P. S., and Eakin, H. M., The Shungnak Region Kobuk Valley; Mineral Resources of Alaska: Geol. Survey Bull. 480, 1911, pp. 306-319.

5/ Smith, Philip S., The Noatak-Kobuk Region, Alaska: Geol. Survey Bull. 536, 1913, plate II (160 pp.).

6/ Work cited in footnote 5, p. 58.

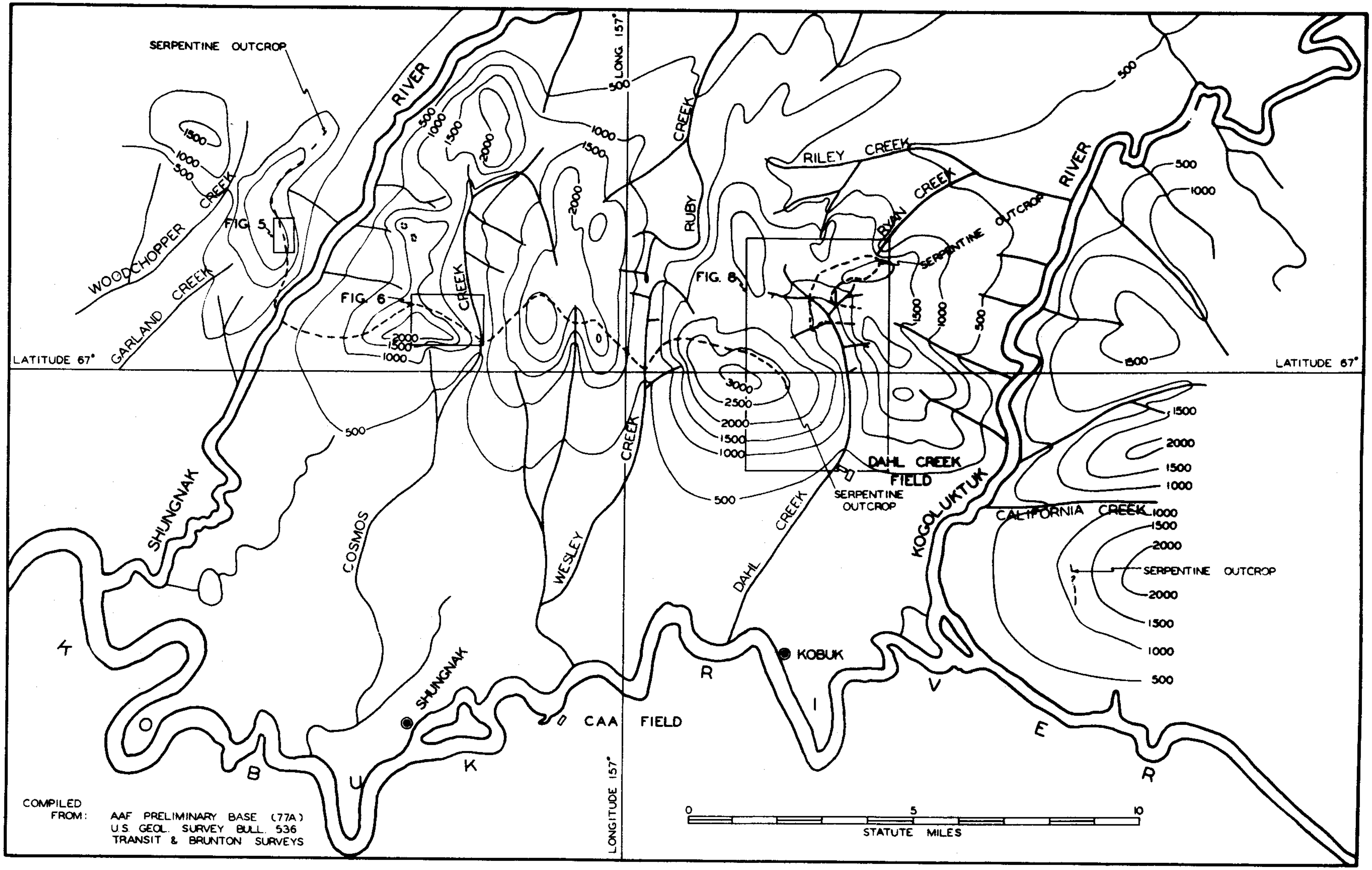


Figure 3. - Asbestos-bearing serpentine, Shungnak-Kogoluktuk area.

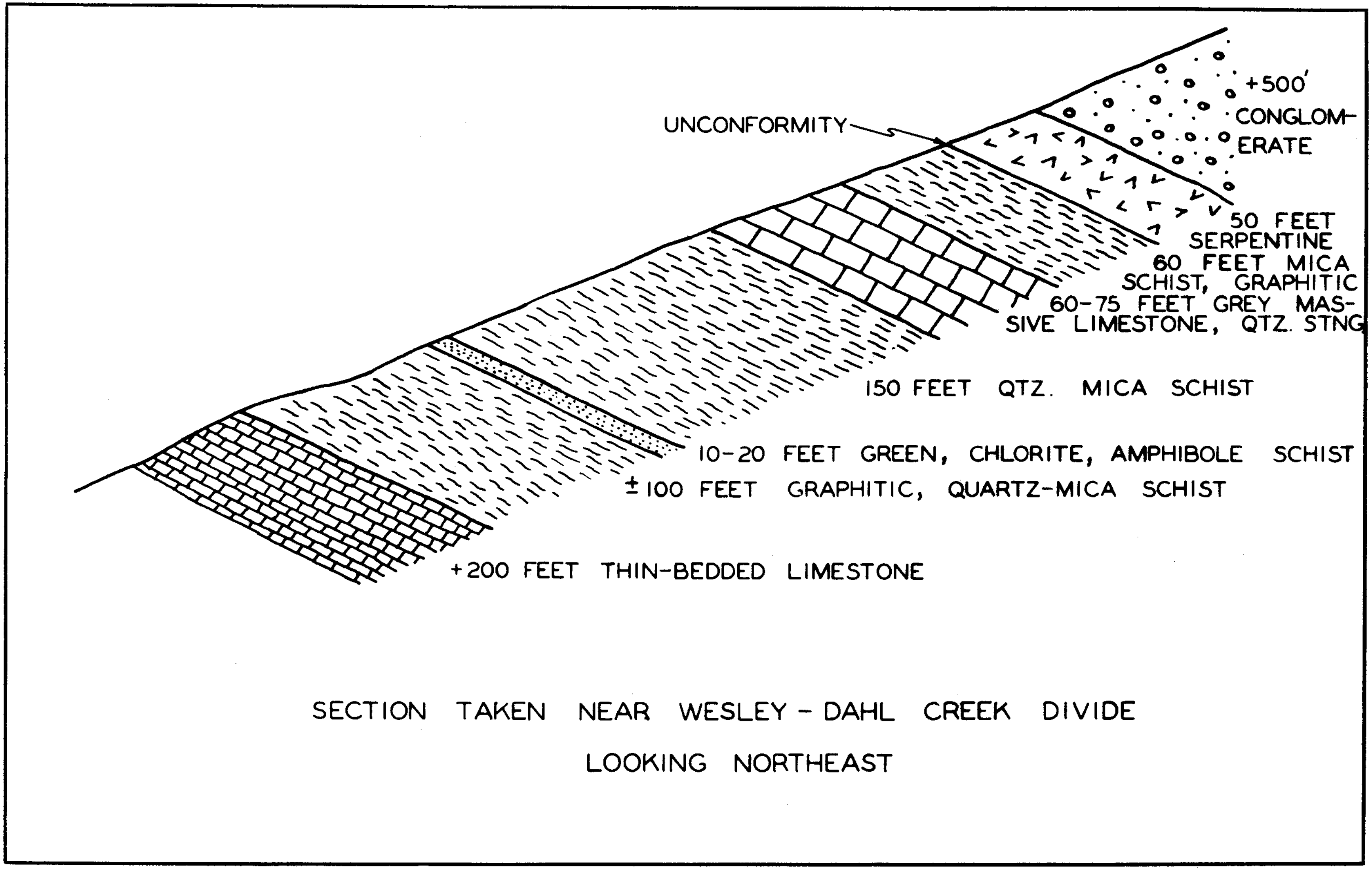


Figure 4. - Geologic section.

The schists in the area have not been differentiated but dissimilarities in their composition have been observed. Mica schist predominates but carbonaceous and chloritic schists are also plentiful. Most of the schist contains abundant quartz.

Two limestones were noted in the series of metamorphosed rocks within the area. One was a gray thin-bedded limestone and the other a gray massive limestone containing numerous quartz stringers (see fig. 4).

The deposits of asbestos along the Shungnak River, Cosmos Creek, Wesley Creek, and extending to the right limit of Dahl Creek are all within the same interformational sheet of altered basic rock (fig. 3). This serpentine has been formed from a basic intrusive, probably originally consisting mainly of olivine, lying unconformably on the slates, schists, and limestones. Figure 4 is a sketch made west of the Cosmos Creek-Wesley Creek divide. Here the serpentine is lying on a massive gray limestone and is at least 300 feet higher in the series than its position on the Shungnak River-Cosmos Creek divide where it is lying on a thin-bedded limestone (fig. 6). Along Cosmos Creek the serpentine is separated from the thin-bedded limestone by schist. Throughout the entire strike length of this outcrop, the serpentine is overlain by the conglomerate.

The conglomerate is composed of pebbles of chloritic schist, quartz, black slate, mica schist, and limestone which clearly confirms the unconformity. The conglomerate is sheared and schistose throughout much of its length, and the grain size ranges down to an extremely coarse sandstone.

The dip of the formation along the front of the Cosmos Hills is 15° to 45° south, and the average strike of the serpentine is east-west. An anticlinal fold is readily seen in the thin-bedded limestone under the serpentine along the Shungnak River-Cosmos Creek divide and in the divide that it forms to the north. This fold explains the flattening of the serpentine and its long horizontal outcrop west of the Shungnak River and the two small outcrops of serpentine found on the divide east of the Shungnak River and north of the main outcrop.

The deposits near the head of Dahl Creek, while of similar occurrence, are in an ultrabasic stock within an area of mica schists (fig. 8). Most outcrops of asbestos are near the summit of Asbestos Mountain. The intrusive is generally massive and, where unaltered, weathers to the brown color typical of peridotite. The asbestos occurs where the intrusive has been altered to serpentine. Small grains of magnetite are disseminated throughout the intrusive, and locally small concentrations of magnetite may be found.

The asbestos occurrences in the Jade Hills are very similar to those at Asbestos Mountain, and the light-green serpentine forming Jade Mountain and the surrounding area has been formed from the same type of an ultrabasic stock in schist. A petrographic examination of the partly altered intrusive shows serpentine replacing olivine and pyroxene.

The term "asbestos" is applied to numerous minerals having fibrous structure, which, because of resistance to heat, tensile strength, and flexibility of the fibers, may be used for certain industrial purposes. The minerals are also more or less acid-resistant. In commercial use the asbestos minerals are roughly divided into two classes - the spinning variety, which must have fibers of sufficient length, strength, and flexibility to permit spinning into yarn for the manufacture of asbestos fabrics; and the nonspinning variety, which is suitable for manufacturing such articles as molded brake blocks, asbestos board, paper, shingles, and many other products. A test for differentiating between spinning and nonspinning fibers is rubbing the fibers between the fingers. Poor fibers will split into harsh, brittle pieces, sometimes even breaking up into fine powder. The good fiber will stand considerable tension, bending, and twisting and will come apart in silky threads.

Three mineral groups have the fibrous structure and properties relevant to asbestos. These are the anthophyllite group - magnesium-iron silicates; the amphibole or hornblende group - hydrated silicates of calcium, magnesium, and ferrous iron with manganese, potassium, sodium, or aluminum; and the serpentine group - hydrated magnesium silicate.

The chrysotile variety of asbestos is the principal source of spinning fiber. Two forms occur - cross fiber and slip fiber - but the cross fiber is preferred. Chrysotile is an alteration production of serpentine and virtually identical in chemical composition.

The tremolite variety is usually short-fibered, brittle, and unsuitable for spinning purposes, and a very minor amount of spinning-grade tremolite is found. However, tremolite, a calcium-magnesium silicate, is highly acid-resistant. It is, therefore, especially suited to the manufacture of filter pads for filtering acids and fruit juices and for other chemical uses involving filtering and heating.

Both kinds of asbestos - chrysotile and tremolite - are erratically distributed along the length of the serpentine outcrops as float and in the rock exposures. Distribution of the asbestos is not uniform, and some outcrops are barren or almost barren. A large part of the surface is covered with talus material, and the quantity of asbestos float is as variable in these places as the quantity of asbestos in the outcrops. Both cross- and slip-fiber asbestos are present.

In nearly all observed cases, the cross-fibered variety produces fibers less than 3/4 inch long. Cross-fibered chrysotile with fibers up to 3 inches in length was found only in float about 2 miles northwest of the Shungnak River.

The cross-fibered variety of chrysotile is generally of good quality. It is easily separable into fine, silky fibers of good tenacity and flexibility. However, nearly all fibers that were found by the Bureau of Mines were less than 1/2 inch.

Over large areas, the serpentine is highly altered and schistose and contains short slip fibers of chrysotile along the foliations. Numerous veins up to 6 inches in width contain slip fibers of chrysotile 3 inches and more long, and 20-inch fibers of good grade have been produced. Locally the fibers are harsh; but in places they are soft, flexible, and tenacious. The color of the chrysotile ranges from pale yellow to brown.

The tremolite is pale green to white and occurs mainly as slip fiber in seams and small veins. Fibers 20 inches long have been separated from a vein on the property of the Arctic Circle Exploration, Inc., on Asbestos Mountain.

STAIN TEST FOR CHRYSOTILE ASBESTOS

Since both chrysotile and tremolite fibers are found in the area, a prerequisite for identification and separation was a method of distinguishing between the fibers of different composition. At the Johns-Manville laboratories, Asbestos, Quebec, a staining method using a 1-percent solution of iodine in C. P. gylcerin was developed for the identification of chrysotile7/ and is summarized as follows:

> This iodine solution was found to have distinct staining properties when used on the local chrysotile fibres, and to improve greatly their visibility under the microscope. It was soon revealed, however, that this staining is apparently limited to the chrysotile variety of asbestos, as against other varieties. It can be readily seen that, if such were the case, the staining test would become a very useful tool in differentiating between chrysotile fibre and the other mineral fibres, without recourse to a lengthy chemical analysis.***
>
> In all, thirty-seven different fibres from various parts of the globe were examined. The technique is very simple, a pinch of the fibre being mixed thoroughly with a few drops of the stain and then transferred to a microscope slide for observation. In the case of chrysotile, the staining is instantaneous although varying in intensity for fibre from different mines or localities. For maximum staining effect, the asbestos must be in a loosely fiberized state, which is easily accomplished by 'fluffing' between the fingers or by light grinding in a motar where necessary.*** The property of iodine staining thus seems to be an exclusive characteristic of the chrysotile fibres, regardless of source or mode of origin.***
>
> Since the apparently selective action of the iodine stain on chrysotile fibres suggests that the staining is a consequence of some definite property of the latter, the first question that occurs is: Does iodine also react with the nonfibrous form of the same material, i.e., massive serpentine?***
>
> It can be seen that, of the minerals examined, only brucite and serpentine, and to a lesser degree hydromagnesite, are stained by the iodine solution. The negative reaction by the two first-named minerals after ignition apparently points to magnesium hydrate as the active agent in this stain phenomenon. Of the magnesium silicates tested, apparently serpentine alone contains this hydrated magnesia in a form such that it can acquire the stain.

7/ Morton, Maurice, and Baker, W. G., Stain Test for Chrysotile: Trans. Canadian Inst. Min. and Met., vol. 44, 1941, pp. 515-523.

The similarity of behaviour of serpentine and brucite is not surprising, as X-ray studies show the spatial arrangement of the magnesium and hydroxyl groups in these minerals to be identical. Hydromagnesite can also be expected to exhibit this activity, due to the presence of the hydrated magnesia.

During investigation of the asbestos deposits on Bismark Mountain by the Bureau of Mines, an unusual variety of brucite was discovered. This was identified by Jewell J. Glass of the Geological Survey as nemalite, an iron-bearing fibrous brucite (fig. 5). Tests by the Bureau of Mines using the iodine solution resulted in a positive stain as expected from its composition.

DESCRIPTION OF THE DEPOSITS

Shungnak River

The asbestos deposits along the west side of Shungnak River were the first explored by the Bureau of Mines in 1944 (figs. 3 and 6). The outcrops are several hundred feet below the crest of Bismark Mountain on the east slope. Not enough previous information was at hand to permit selection of the best locations for preliminary work, and dozer trenching was begun on a convenient outcrop. The serpentine at this point contained a light-colored, glassy, somewhat brittle mineral in addition to the chrysotile. Four trenches were excavated. Nearly 2 tons of samples were taken from the trenches and shipped to the Rolla Branch, Metallurgical Division, Bureau of Mines, for testing. Results are given under Beneficiation by Bureau of Mines.

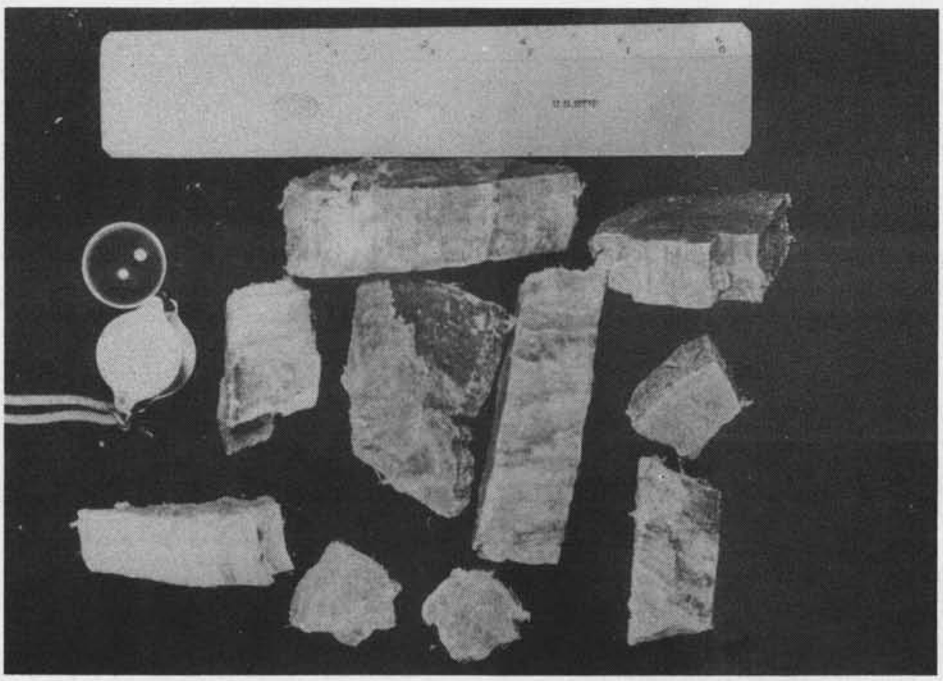
Of the four trenches completed on Bismark Mountain, only trench 4 exposed chrysotile of fair quality. Trenches 1, 2, and 3 revealed a small quantity of very short fibered chrysotile and a much larger proportion of asbestiform mineral nemalite. A network of slip-fiber veinlets 1/2 to 2 inches wide was disclosed in the sides and bottom of trench 4, and a sparse distribution of cross-fiber veinlets was also found in the less-sheared serpentine formation 100 yards north.

A reconnaissance survey was completed along the rest of the outcrop to the north. The serpentine along the right limit of Shungnak River, instead of continuing in the same interformational sheet exposed in the rest of the area, is discontinuous and forms two approximately parallel sills. The serpentine at the location of the trenches is in one of these sills lying on the conglomerate. To the north, for 1-3/4 miles, it is an interformational sheet capped by the conglomerate. At this point the exposure of serpentine is discontinued, and in its stead another serpentine outcrop is found 600 feet down the slope. The lower outcrop is at least 900 feet wide and extends northward 3/4 mile. The material is decomposed and talcy, showing a marked resemblance to the sheared area at Cosmos Creek, except that it contains less asbestos.

Farther to the north is an interval of about 1/2 mile in which no serpentine outcrops; where next observed, the serpentine stands out boldly in an almost vertical bluff reaching a height of about 500 feet. No asbestos was found in this outcrop.

No serpentine was found in the area northwest of Bismark Mountain and west of Woodchopper Creek.

A



B

Figure 5. - A, Nemalite from Bismark Mountain on right limit of Shungnak River;
B, cross-fibered chrysotile from Cosmos Creek-Shungnak River divide.

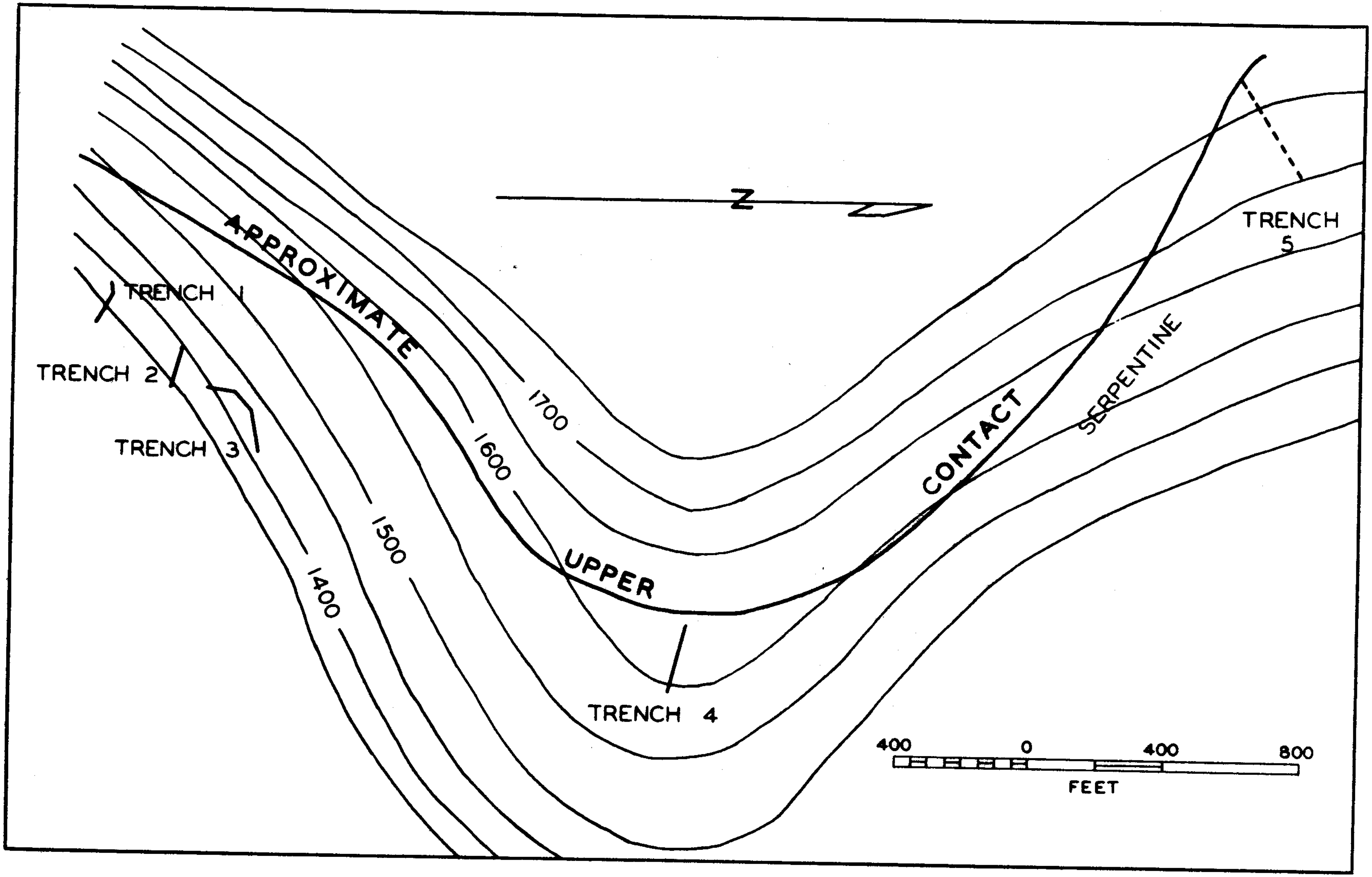


Figure 6. - Trenches near Shungnak River.

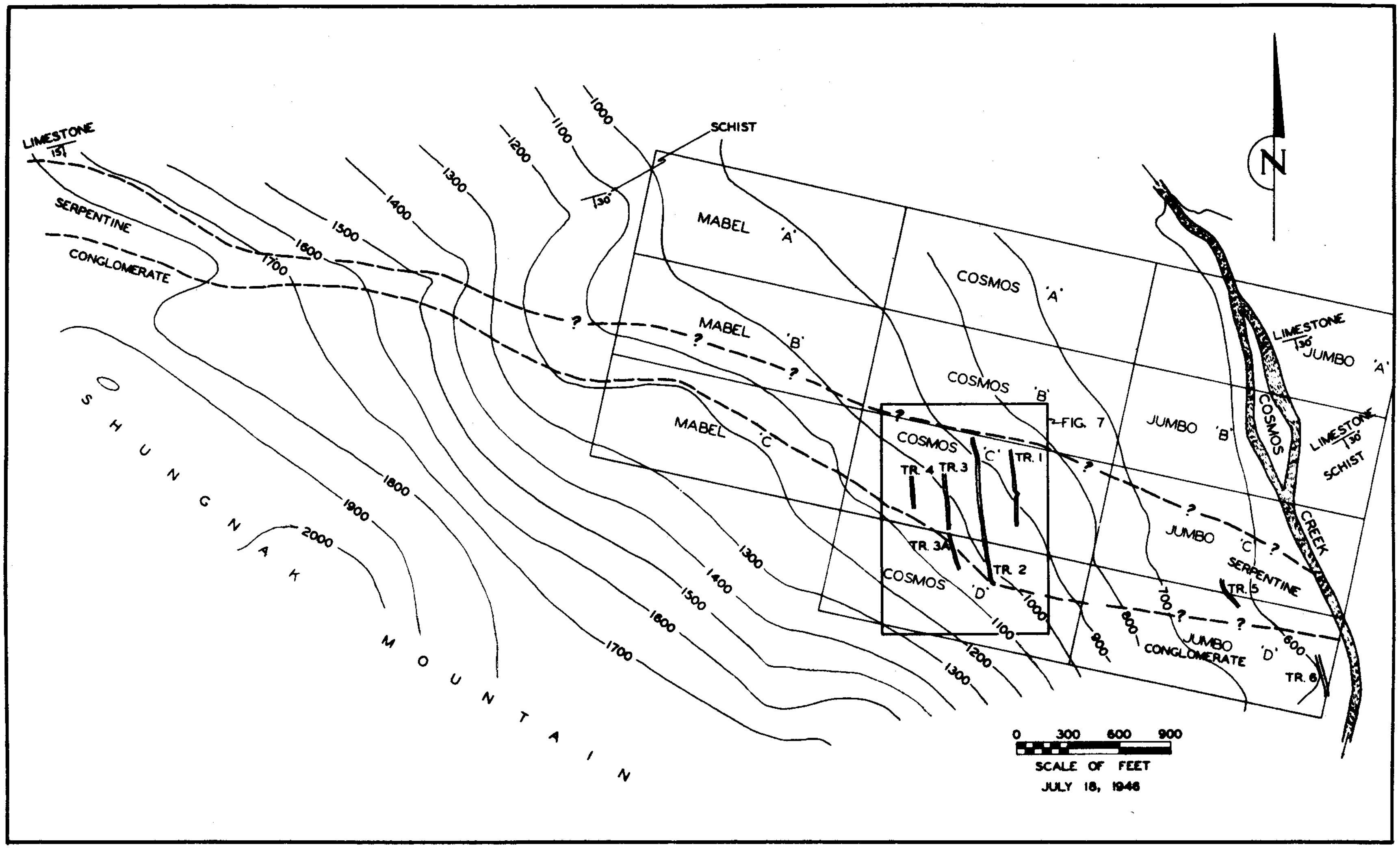


Figure 7. - Cosmos Creek asbestos deposit.

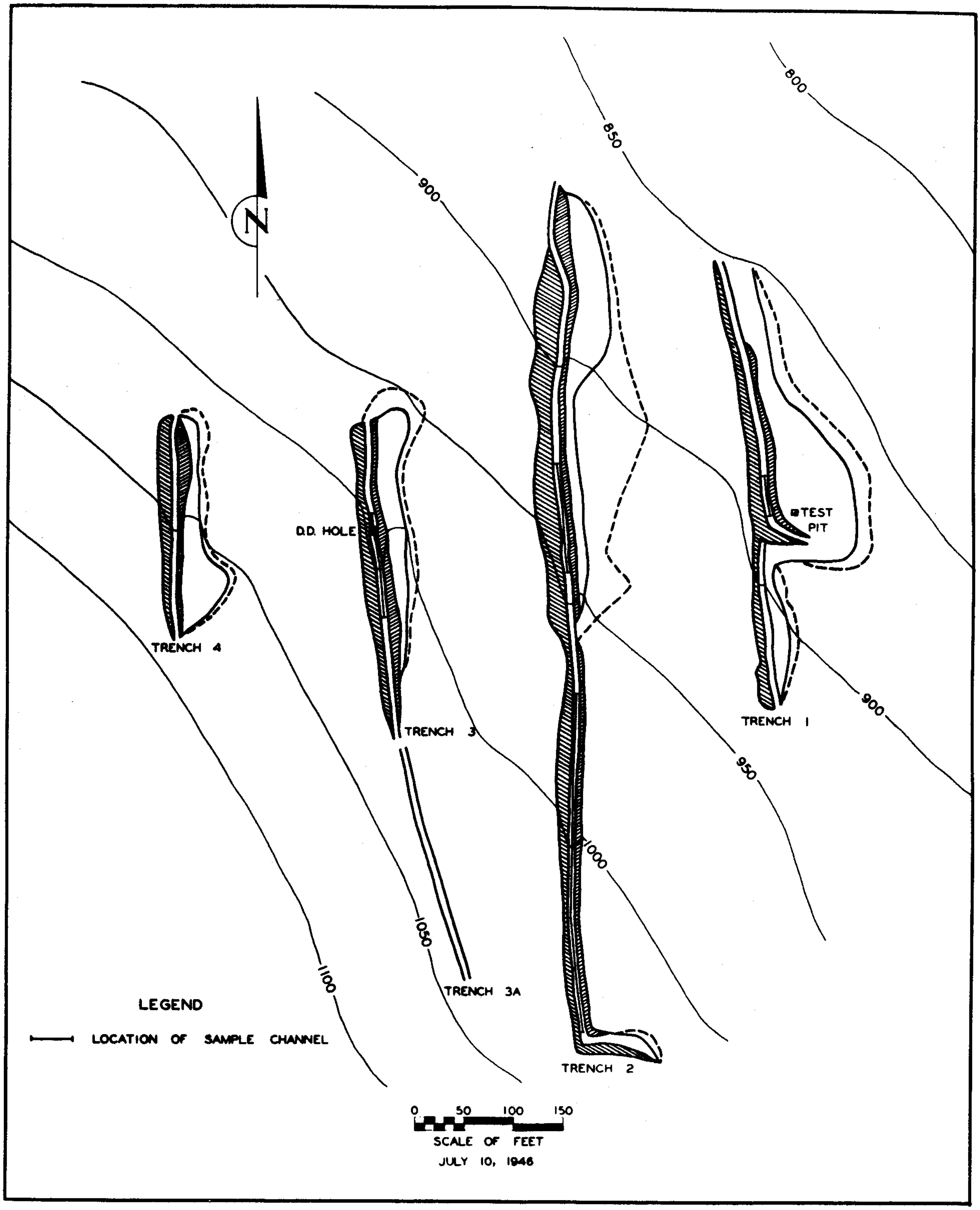


Figure 8. - Details of dozer trenches, Cosmos Creek.

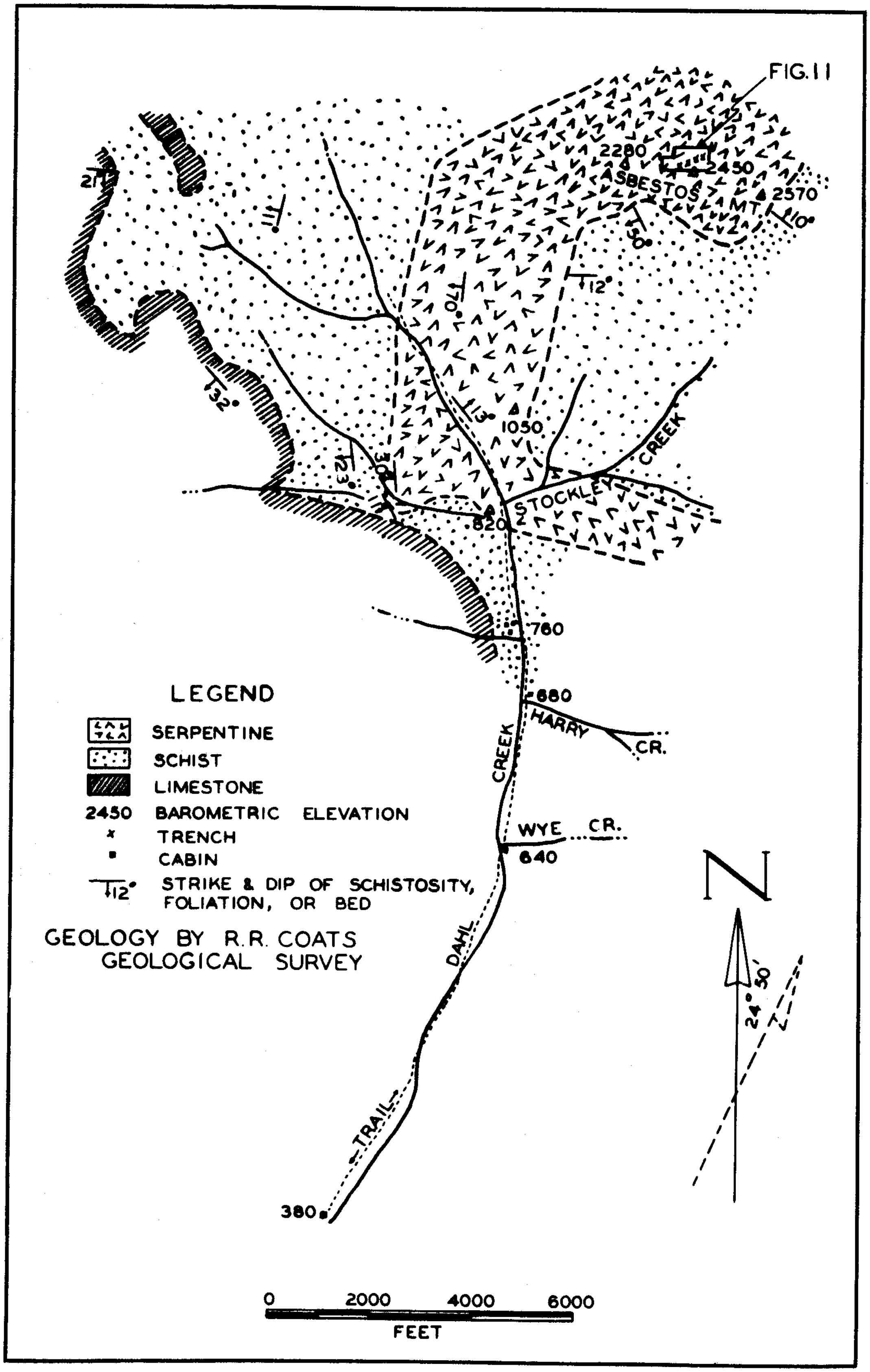


Figure 9. - Dahl Creek asbestos.

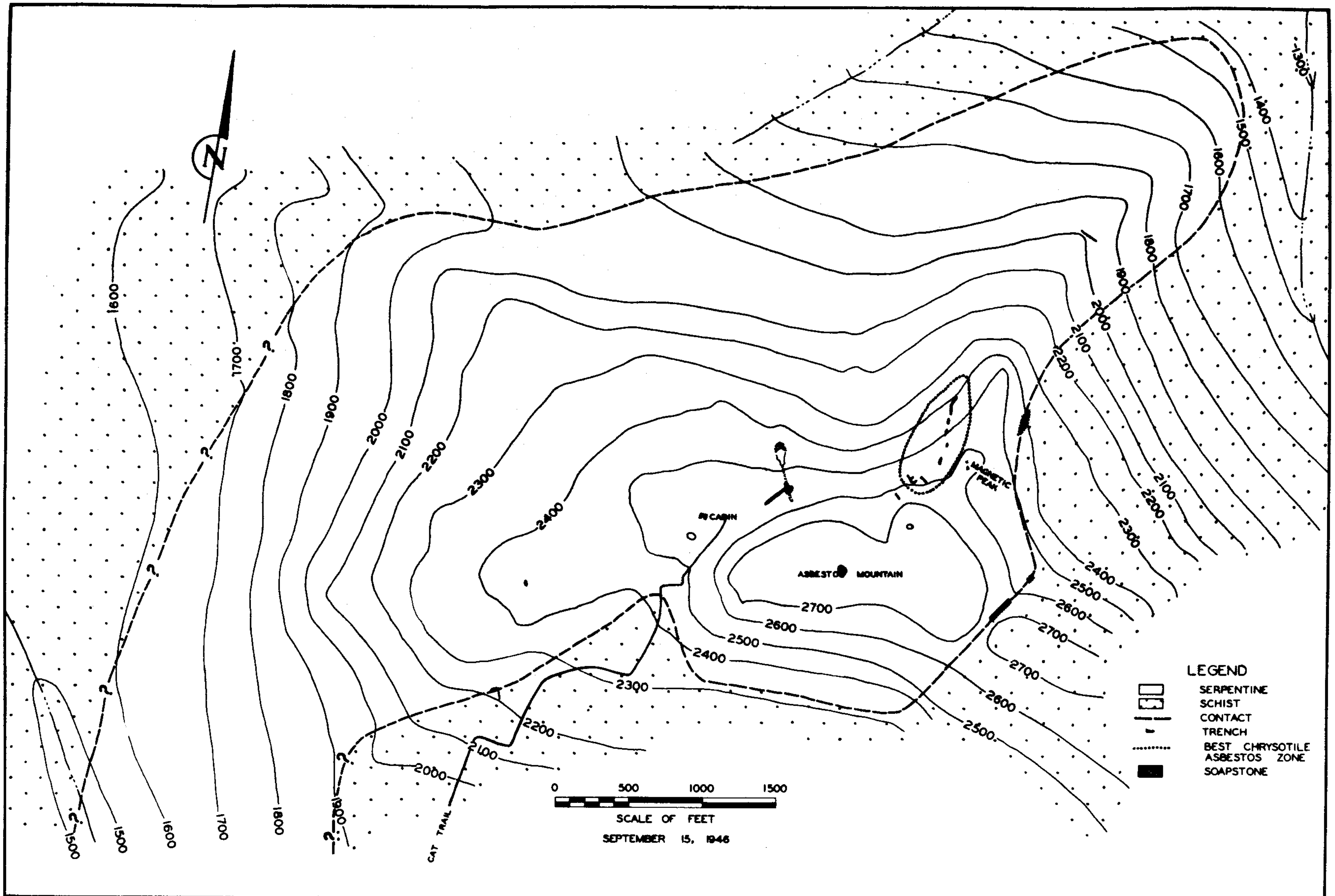


Figure 10. - Ing-Ihk mine, Asbestos Mountain, Alaska.

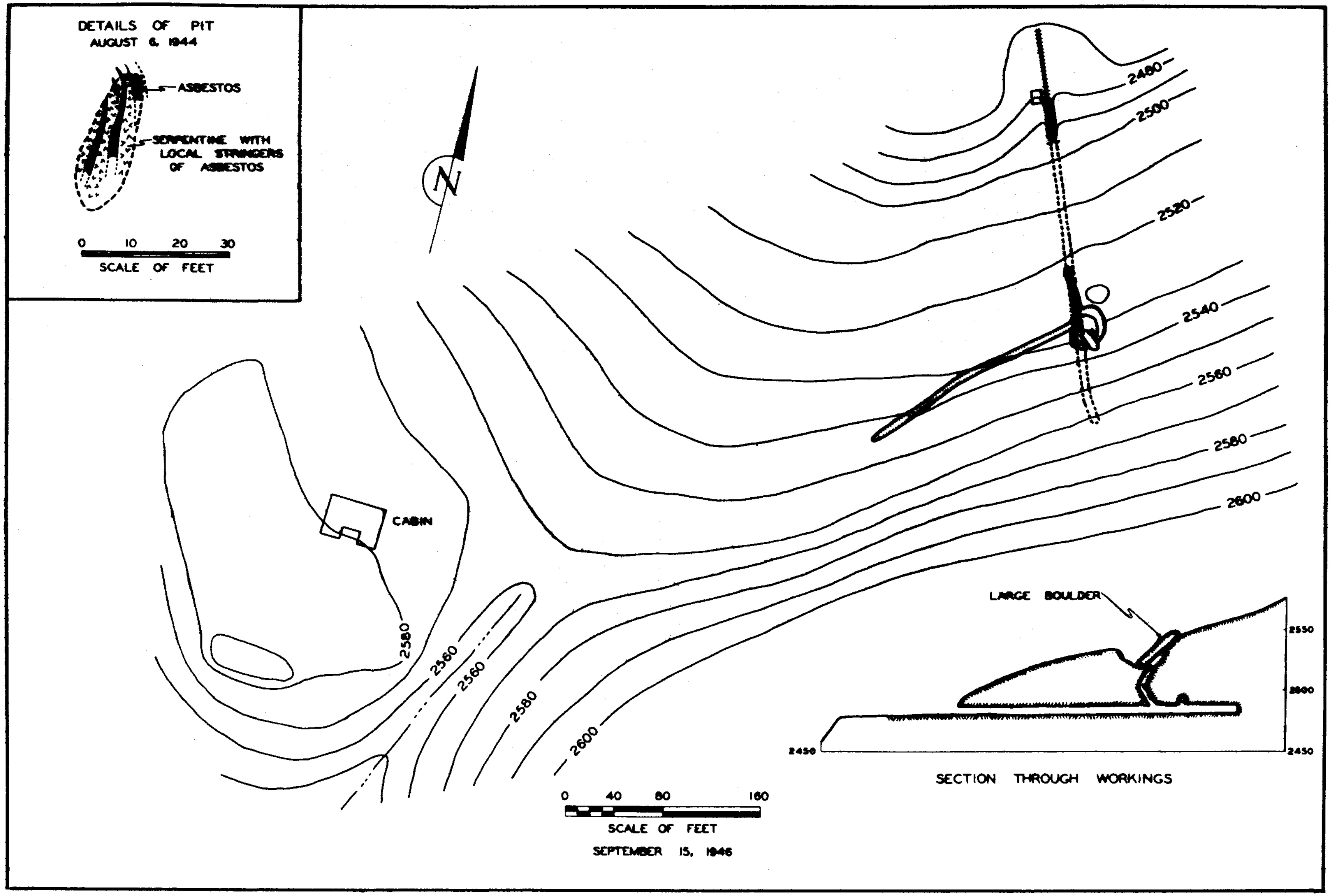
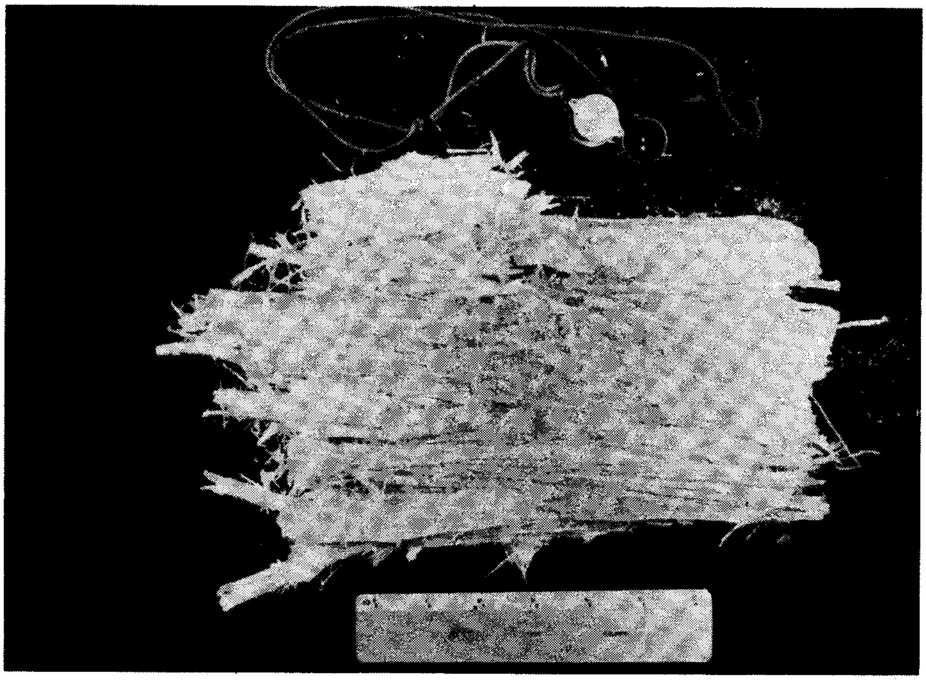


Figure 11. - Plan and section, Ing-Ihk mine.



A

B

Figure 12. - A, Tremolite from Ing-Ihk mine;
B, long-fiber chrysotile from Asbestos Mountain.

Cosmos Creek

Extensive exploration by the Bureau of Mines of the asbestos deposits in the Cosmos Hills was scheduled for 1945. Only that section of the serpentine outcrop west of Cosmos Creek and east of the Shungnak River divide was selected for exploration (fig. 7). Here the serpentine is extensively sheared, and cut by a stockwork of both cross- and slip-fiber asbestos for a strike length of over a mile.

During the spring and summer of 1946 the trenches were continued and extended. Two large samples were taken and shipped to the Canadian Johns-Manville Co., Ltd., for testing. Sample C, consisting of 56 sacks, was taken in trenches 1 and 3 and the northern portion of trench 2 (fig. 8) across the lower portion of the asbestos-bearing formation. Sample D (59 sacks) was taken in the southern part of trench 2 from the upper part of the same formation. The area sampled consists entirely of highly sheared serpentine and a large proportion of the fiber occurs as slip fiber on the foliations of the serpentine.

The westerly continuation of the interformational sheet of altered basic intrusive can easily be followed to the Shungnak River. At one place about 200 yards east of the crest of the ridge the sheet appears to have a thickness of about 125 feet and to contain chrysotile fiber in nearly the same abundance as in the trenched area. Nearer the crest, or about 200 feet east of the saddle, the serpentine is harder, less sheared, and contains tough slip fiber 2 to 4 inches long as well as veinlets of cross fiber. Veins of cross fiber are 1/4 to 1-1/2 inch wide (fig. 5, B). Very little asbestos was found on the Shungnak side of the ridge.

A reconnaissance of the continuation of the serpentine easterly from Cosmos Creek to Dahl Creek (fig. 3) revealed no asbestos deposits of commercial value. Several small outcrops of chrysotile were found on the east and north slopes of Mount Ineveruk between Dahl and Wesley Creek, and a few additional outcrops of chrysotile, both cross fiber and slip fiber, were found on the east and north slopes of Cosmos Mountain between Wesley and Cosmos Creeks.

Dahl Creek

The asbestos deposits on Dahl Creek were first examined by H. E. Heide during August 1943, in company of Robert E. Coats of the Federal Geological Survey and Eskil Anderson of the Territorial Department of Mines. Figure 9 is a sketch map prepared by Coats at that time. The best outcrops of asbestos lie near the top of Asbestos Mountain (fig. 10) at an altitude of approximately 2,500 feet. At the time of the first examination, four shallow trenches had been dug by Arctic Circle Exploration, Inc., across part of a 50-foot shear zone trending N. 50° E. Tremolite asbestos of the slip-fiber variety, forming a 6-inch vein, was present in all four trenches, and the vein dipped steeply southeast. In the last trench to the east a 2.5-foot vein of slip-fiber tremolite was exposed later. Details of the exposures in this trench in September 1944 are shown in the insert on figure 11. These veins dip approximately 65 degrees to the southeast and strike N. 10-15° E. The fibers from this outcrop were as much as 18 inches long and were light gray to white in color. (See fig. 12, A.) Although the fibers were of weak tenacity, impurities were virtually absent, and there appears to be constant demand for this type of asbestos. From this lens of slip-fiber tremolite, 36.5 tons was produced and shipped for use in filters.

Development by Arctic Circle Exploration, Inc., up to September 1945 is shown on figure 11. The name given by the mine by the operators is Ingik mine or, more properly, Ing-Ihk mine. The long trench shown on figure 11 follows the 6-inch vein of slip-fiber tremolite exposed in the original four trenches. All of the trenches contained up to a foot of mat composed of residual fibers of tremolite asbestos. Fibers up to 20 inches are not unusual. Within the 250-foot strike interval covered by the trenches, there is considerable surface float of long-fibered tremolite.

A 228-foot adit was driven to tap the tremolite lens at a depth of 60 feet. Although small veins of asbestos were encountered throughout the length of the adit, the lens being mined pinched out before the level of the tunnel was reached. Only narrow veins of brittle asbestiform fiber were found in the first 155 feet. From there to the face at 228 feet, five veins of asbestos 6 inches to 2 feet wide were encountered. The strike of these veins were N. 30° E. to S. 70° E. All veins were dipping steeply.

About 300 yards east of the trenches, indications of another sheared zone of the same type were observed. Much of the ground is covered by overburden, and very little float or other indications of asbestos bodies of any size were observed. Hand trenching at this location did not expose rock in place. However, only a small amount of short tremolite fibers of an inferior grade was found as float in this trench.

Float at two other localities 2,000 and 2,600 feet, respectively, northeast of the mine indicated other possible deposits. Trenching at the second of these, on the saddle of the long point running northeast, failed to show any fiber in place. The other location was near the contact with the schist. Here a mat of white tremolite fibers 8 to 10 inches thick covered the ground over a width of 10 feet. Trenching here exposed a 6-inch vein of good tremolite

In addition to the tremolite asbestos deposits, the top of Asbestos Mountain contains slip-fiber chrysotile. Varying amounts of fiber can be found throughout the area east of the cabin comprising the main peak and the point to the north. The zone having the best chrysotile mineralization is shown on figure 9 approximately 1,000 feet east of the adit. Arctic Circle Exploration produced over one ton of chrysotile fibers from three trenches at the south end of this area in 1945. The chrysotile fibers are brown and extremely long and tough (fig. 12, B).

In the trenches excavated by Arctic Circle Exploration, the long-fibered asbestos was found lying along shears in the walls and bottoms of the trenches. The attitude of many of the seams was nearly horizontal, although others were close to vertical. Two sets of vertical fractures at approximately right angles were noticed in the trenches, one striking S. 45° E. and the other S. 45° W. The seams of asbestos ranged from 1/4 inch to 4 inches in width.

The Bureau of Mines extended and deepened the above trenches and dug the remaining trenches shown within the mineralized area on figure 10. No attempt was made to follow individual seams of fiber, since they were too narrow to be mined separately. Instead, the long fiber in the overburden and loose rock excavated was hand-sorted to afford an estimate of the quantity of this material present as well as a sample for spinning tests. In all, 1,090 pounds of long fiber chrysotile was obtained from 719 cubic yards of trenching.

The quantity of chrysotile float in this area is remarkable. In places, a mat of fibers several inches thick has been formed, even though the slope of the hill is exceedingly steep. In places the fiber is found clinging to the sides of large boulders, and in others it is half-buried in the soil in front of the boulders. The face of one boulder was covered with a 4-inch vein of long-slip fiber from which hanks of asbestos as much as 2-1/2 feet long could be torn. Although slip-fiber chrysotile in veins 1/2 to 4 inches wide comprises the bulk of the fiber, small veins of cross fiber and slip fibers along the foliations of the serpentine are also present.

Two samples were taken for testing. The first, sample F, was a composite channel sample along the bottom of all the trenches. This sample is representative of the asbestos-bearing serpentine in the area of best chrysotile mineralization. The second, sample G, was composed of the chrysotile fibers hand-sorted during trenching.

In addition to the alteration deposits of asbestos and serpentine in the areas of ultrabasic intrusives, small deposits of talc and soapstone are present. In fact, all of the tremolite deposits apparently are associated with talc and it may be possible were formed at or near the contact of the intrusive with the schist. Several deposits of soapstone are shown on figure 10.

Although magnetite was disseminated in much of the intrusive, no large concentrations were noticed. A short adit was driven into the point marked "magnetic peak" (fig. 10) because of the high local magnetic anomaly, but only very small lenses of magnetite were found.

Other Deposits

The asbestos-bearing serpentine has been traced as far east as the outcrop mapped east of the Kogoluktuk River south of California Creek (fig. 3). A reconnaissance of this area did not reveal any noteworthy exposures of asbestos, although a very small amount of float and several thin veins of asbestos were found.

Jade Mountain

The asbestos deposits of Jape Mountain in the Jade Hills are approximately 25 miles northwest of the confluence of the Shungnak and Kobuk Rivers (fig. 2). Here the asbestos-bearing ultrabasic rocks of Jade Mountain appear to have formed a stock in schist similar to the occurrence at Asbestos Mountain. The rocks in the lower foothills along Jade Creek are made up largely of olivine and pyroxene. Farther up the slope and along the ridge between Jade Creek and West Fork, serpentine predominates. Large boulders and ledges of nephrite are found at the heads of Cabin Creek and a small gulch on the right limit of Tunnel Creek.

A small quantity of float slip-fiber chrysotile with fibers up to 5 inches in length was found on a high knoll near the north contact, but the asbestos here was sparsely distributed. Cross fiber in veinlets 1/4 to 1/2 inch wide was found at the portal of a small tunnel on Tunnel Creek. Slide rock covered the entire surface in this area, so that little of the significance of this showing could be determined. Cross-fiber chrysotile was also found in some of the more prominent serpentine outcrops on the left limit of West Fork. Cross- and slip-fiber amphibole asbestos was found in a prominent outcrop of serpentine on the same side of West Fork about 300 yards downstream from the chrysotile showing. White talcy material associated with tremolite outcrops as veinlets 2 to 6 inches wide at four different places along a slope distance of 125 feet.

Serpentine outcrops on the first ridge east of Jade Creek but no asbestos was found.

On the northeast side of the Jade Hills, the intrusive appeared larger, had a more massive texture, and showed less alteration.

VALUE OF PRODUCT

The main production of asbestos in the North American continent is in Canada and the Canadian classification of May 1, 1940, of crude and mill fiber asbestos is standard in the United States. Asbestos mine products are divided into two classes: (1) Crude asbestos, consisting of the hand-selected cross-vein material, and slip-fiber material, essentially in its native or unfiberized form; and (2) milled asbestos, consisting of all grades produced by the mechanical treatment of asbestos-bearing material. Both crude and milled asbestos is further divided into groups based on the Quebec standard testing machine.[8/] Table 1 shows the various grades of crude and milled asbestos.

TABLE 1. - Subdivisions of asbestos

Class	Standard designation of crude	Definition
Group 1	Crude No. 1	Consists basically of crude asbestos three-quarters of an inch staple and longer.
Group 2	Crude No. 2	Consists basically of crude asbestos three-eighths of an inch staple up to three quarters of an inch.
	Crude run-of-mine............	Consists of unsorted crudes.
	Crudes, sundry...............	Consists of crudes not otherwise specified.

8/ Mining Operations in the Province of Quebec for 1937, pp. 36-37.

Subdivisions of groups of milled asbestos

Class	Standard designation of crude	Definition
Group 3	Spinning or textile fiber....	Consists of fiber testing 1/ 0-8-6-2 and over.
Group 4	Shingle fiber...............	Consists of fiber testing below 0-8-6-2 to and including 0-1-1/2-9-1/2-5.
Group 5	Paper fiber.................	Consists of fiber testing below 0-1-1/2-9-1/2-5 to and including 0-0-8-8.
Group 6	Waste stucco or plaster......	Consists of fiber testing below 0-0-8-8 and above 0-0-5-11.
Group 7	Refuse and shorts............	Consists of fiber testing 0.0-0.0-5.0-11.0 and below.
Group 8	Sand.........................	Consists of such asbestos mill products as sand weighing over 35 lb. and under 75 lb. per cu. ft., loose measure, and containing a preponderance of rock.
Group 9	Gravel and sand..............	Consists of such asbestos mill products weighing 75 lb. and over per cu. ft. loose measure.

1/ There are more than 100 standard designations of grade in the various fiber groups, and each designation must meet its respective minimum requirement for shipping.

Taking as an example the fiber designated as 3D of the spinning or textile-fiber group, the 8-6-1-1 means that, of a 1 pound sample of fiber, the following ounces are required to remain on the respective meshes to meet the guaranteed minimum shipping test:

Fiber	1/2-mesh	1/4-mesh	10-mesh	Undersize
3-D	8-oz.	6-oz.	1-oz.	1-oz.
3-Z	0-oz.	8-oz.	6-oz.	2-oz.

The prices quoted in the Engineering and Mining Journal for November 1947 for asbestos are as follows2/:

Asbestos, f.o.b. Canadian (Quebec) mines (U. S. funds), ton:

Crude No. 1......................	$800
Crude No. 2..............	$302 @ $410
Spinning fibers...........	$170 @ $230
Paper stock..............	$ 43 @ $ 65
Shorts....................	$ 20 @ $ 38

The main production from the Dahl Creek deposit was tremolite asbestos. The most important use of this kind of asbestos is not in the usual asbestos products but as filters in industrial plants. It was reported that a premium price of $1,000 a ton was paid for the exceptionally long fiber tremolite mined.

9/ Engineering and Mining Journal, vol. 148, No. 11, November 1947, p. 166.

BENEFICIATION BY BUREAU OF MINES

The samples taken from the trenches on Bismark Mountain along Shungnak River were submitted for beneficiation tests by the Metallurgical Division of the Bureau of Mines. The results of the experimental work by Heine Kenworthy, metallurgist, Rolla Branch, follow:

Two composite samples, A and B, were prepared for test work. Composite sample A, consisting of samples 1 to 19, inclusive, and sample 26, contained considerable slip fiber and was inferior in grade to composite sample B, which consisted of samples 20 through 25. The composite samples were representative of material from areas approximately 1,500 feet apart. The samples consisted of serpentine, nemalite, magnetite, and magnesite. The serpentine was composed of chrysotile and antigorite.

The treatment for processing the samples was similar to the method used in the Canadian asbestos mills. This practice consists of hand-sorting the coarse material, followed by hammer-milling to fiberize the chrysotile, screening, and air separation of the fiberized serpentine from the antigorite serpentine. Milling tests on each composite sample are discussed in the following paragraphs.

Composite Sample A

The ore was screened on 1/2-inch, and the oversize material was examined for long-fibered asbestos that might be recovered by hand sorting, but no long-fibered material was present. The entire sample was then crushed in a hammer mill, with the screen bars set 1/2 inch apart and operated at a speed of 3,000 r.p.m. The crushed ore was passed over a 32- by 16-inch shaking screen, with 35-mesh square openings, which had a suction head over the discharge end at a height of 5/8 inch above the screen. The suction discharged into a cyclone separator. The speed of the shaking screen was 350 to 400 strokes a minute and the feed rate 1 to 2 pounds a minute. Asbestos that was sufficiently fiberized was removed from the screen by the suction, while the plus 35-mesh rock and unfiberized asbestos were discharged as oversize and returned to the hammer mill before it was again treated on the screen. This cycle was repeated until all the material was reduced to minus 35-mesh.

The cyclone asbestos product contained chrysotile fibers of various lengths, some adhering dust, coarse flat particles of rock, and magnetite. The screening and suction treatment used in collecting this material was therefore repeated on a 20-mesh screen with the suction head set 1 inch above the screen discharge. This treatment removed the better-quality material. The plus 20-mesh screen discharge was crushed in a smaller hammer mill, again passed over the 20-mesh shaking screen, and the process repeated until no plus 20-mesh material remained.

The minus 35-mesh material was then screened on a 32- by 16-inch shaking screen, with 65-mesh openings, operated at the same speed with a stroke of 1 inch. The feed rate was about 3/4 pound a minute, and the suction head was adjusted to 3/4 inch above the screen discharge. The screening was not efficient, and some minus 65-mesh material was collected in the cyclone and in the screen oversize.

The plus 65-mesh material was hammer-milled and again passed over the 65-mesh shaking screen, but the cyclone product obtained after two passes through the hammer mill and over the screen weighed over 35 pounds a cubic foot so the treatment was carried no further. The final products from the various treatments are shown in the following table:

Summary of combined treatment

Product	Weight		Classification or pulp weight, pounds a cubic foot
	Pounds	Percent	
Plus 20-mesh asbestos	8	1.6	1/ 0-1-7-8
Minus 20-mesh asbestos	87	17.4	33.5
Plus 35-mesh asbestos (first pass)	148.5	29.7	34.5
Plus 35-mesh asbestos (second and third passes)	42	8.4	39.5
Plus 65-mesh sand	47	9.4	45
Minus 65-mesh sand	129	25.8	43.5
Mechanical and dust loss	38.5	7.7	
Total	500	100.0	

1/ This material was classified by the standard method of screening 16 ounces of asbestos in a nest of 1/2-inch, 4-mesh, and 10-mesh screens for 2 minutes with 300 strokes a minute and a travel of 1-9/16 inches. The screen was not level, and the above figures are subject to revision when this deficiency is corrected.

This sample contained very little asbestos of appreciable fiber length, and hence the quality of the asbestos recovered was poor.

Composite Sample B

The ore, which as received was about minus 2-inch in size, was screened, and the 3/8-inch oversize material was hand-sorted to remove the No. 1 and No. 2 grades of crude asbestos, then crushed to minus 3/8-inch in a jaw crusher and added to the primary minus 3/8-inch ore. This material was passed through a hammer mill and screened on a 10-mesh shaking screen, which had a suction head attached to the discharge end to remove the fiberized asbestos. The oversize ore was again crushed in the hammer mill and rescreened; this operation was repeated until there was no more oversize. The minus 10-mesh ore was treated in a similar manner on a 20-mesh screen, and the minus 20-mesh ore was treated on a 35-mesh screen. Only a portion of the plus 35-mesh material was crushed through 35-mesh, as very little asbestos was obtained after the third pass through the hammer mill. The minus 35-mesh ore was tested on a 65-mesh screen, but the air-separated material weighed 37.5 pounds a cubic foot, so the material was not treated further, although it still contained some asbestos which was unfiberized by the treatment.

The final products from the various treatments are shown in the following table:

Final products

Product	Weight		Classification
	Pounds	Percent	
Plus 3/4-inch asbestos........	0.25	0.05	No. 1 crude.
Plus 3/8-inch asbestos........	.5	.10	No. 2 crude.
Plus 10-mesh asbestos.........	2.25	.45	0 - 2 - 12 - 2
Plus 20-mesh asbestos.........	5.25	1.06	0 - 0 - 7 - 9
Plus 35-mesh asbestos.........	20.25	4.09	20.75 lb. a cu. ft.
Minus 35-mesh asbestos........	22	4.44	29 lb. a cu. ft.
Plus 35-mesh sand.............	48.5	9.80	64.5 lb. a cu. ft.
Minus 35-mesh material........	386.5	78.09	52.5 lb. a cu. ft.
Mechanical and dust loss......	9.5	1.92	
Total....................	495.00	100.00	

Remarks

The final products of the Rolla laboratory test runs on the samples from Bismark Mountain were submitted to commercial producers and fabricators of asbestos products for identification and evaluation of their possible economic uses. Samples were sent to Keasbey & Mattison Co., Ambler, Pa., and the United States Asbestos Division of Raybestos-Manhattan, Inc., Manheim, Pa. All of the products were rejected as unsatisfactory by Keasbey & Mattison on the grounds that the fibers were too brittle for their commercial uses.[10] Their observations, based on the requirements for the production of their textile products, follow:

> Sample B was of good length but was a slip fibre having less value than slip fibre from Vermont. We have previously worked with Vermont slip fibre and, while it was a better quality than sample B, we could find no use for it in our present manufacturing operations. The quality of fibre in sample B was brittle and of low strength.
>
> The "on 35-mesh" portion of sample A would be useful as a shingle fibre if the fibres were not so brittle. Asbestos-cement products require fibres having a considerable tensile strength.

Of the duplicate samples submitted to the United States Asbestos Division of Raybestos-Manhattan only one of the milled products seemingly could be utilized in the products this firm manufactures.[11] Its conclusions follow:

> The sample marked "B" 3/4" No. 1 Crude Asbestos has good fibre length and the fibre has reasonably satisfactory tensile strength. The fibre as you have reported, has considerable iron oxide staining. This stained condition might be objectionable in some finished products, but it would be suitable for other products, which we make. Possibly this fibre was taken from a point near the ground level, and it might be free from the iron oxide staining at lower levels.

10/ Written communication.
11/ Written communication.

The fibre represented by Sample B 3/8" No. 2 Crude Asbestos is mostly slip fibre and very brittle. This material is not suitable for any textile process.

The material represented by the remaining samples is of no value in the textile field, and as a matter of fact, I do not know of any process of product such as asbestos paper, building materials, and molded materials, in which this material could be used.

JOHNS-MANVILLE TESTS

The samples taken during the summer of 1946 were submitted to the Fibre Development Department, Canadian Johns-Manville Co. Ltd., Asbestos, Quebec, for testing. Samples C and D were representative of the material sampled on the right limit of Cosmos Creek. Sample F was taken from the slip-fiber zone on Asbestos Mountain and sample G was long-fiber chrysotile asbestos hand-sorted from the same deposit.

The following is taken from the Johns-Manville report on the pilot-mill tests.12/

Summary

Approximately 10 tons of ore and fibre, reported as being from the Dahl Creek Asbestos Project 2308, were received from the U. S. Bureau of Mines, Alaska.

As had been previously arranged, the various lots were processed in the Pilot Plant at Asbestos, Quebec, for the recovery and grading of the different groups of inherent and free fibres.

Briefly the treatment of the ore consisted of crushing through a cone crusher to approximately 2" size, followed by further crushing in impact mills for the purpose of releasing the fibre from the rock.

The above treatment was then followed by several successive screenings to remove the granular fines or undersizes and to permit the free fibres to be floated and picked up or separated on the gangue rock by aspirating hoods over the ends of the screens.

The aspirated fibres were recovered in conical collectors and subjected to further screenings and grader treatment and classified according to the Quebec Standard Fibre Groups.

Pertinent results of these tests are as follows:

The recoveries of fibre (as percent of the ore sample) for lots C, D and F ranged from 5.38 - 11.33% for fibre groups 3 - 7 and from 13.56 - 16.55% when including the 8S or fibrous sand group.

12/ Canadian Johns-Manville Co. Ltd., Pilot Mill Tests on Alaskan Asbestos Ore: Rept. 0-P-26-28-482, May 5, 1947.

By fibre groups, the recoveries ranged from 0.11 - 0.50% for group 3, 0.6 - 1.37% for group 4, 1.74 - 4.28% for group 6, 3.28 - 6.89% for group 7 and 5.06 - 8.18% for group 8.

Of the three lots of ore, Lot F had the highest recovery of the long and medium length fibres, i.e., groups 3 and 4.

The recovered fibres are of the chrysotile variety and are considerably darker in colour than the Canadian asbestos which could be due to mining at or near the surface of the deposit.

In comparison with Canadian fibres, the Alaskan fibres have an unusually high dust or fines content, a higher loose density and a somewhat shorter staple length, the latter determined by wet screening method.

The long fibre is quite strong, is closely matted, difficult to separate and unsuitable to normal opening processes. It lacks the silkiness of Canadian fibre.

Much of the fibre is in the form of long ropes which are not easily separated, consequently portions of same are found after processing, in the group 3 fibre.

Despite the high dust content, the groups 4 - 6 fibres show an unusual fast rate of filterability.

Treatment

The various lots were pan dried over a coal fired furnace and bagged and tagged for processing separately. The total dried weight was 10.09 tons.

The ore as received varied in size up to 13 inches. It was reduced to approximately 2 inches and smaller by crushing through a cone crusher.

Further treatment consisted in crushing in impact mills for further reduction in ore size and for the purpose of releasing the fibre from the rock (the rock breaks along the line of weakness, which is for the most part the fibre vein).

The above treatment was followed by screening, the purpose of same, in addition to removing the valueless undersizes or fines, being to float the free fibres liberated in previous treatment, to the top of the screen load so that they could be readily picked up or separated from the gangue rock by aspirating hoods located over the ends of the screens. The aspirated fibres having been recovered in conical collectors were subjected to further screening and grader treatment and classified according to lengths, all in accordance with the Quebec Standard classification for groups 3, 4, 5, 6, 7, and 8.

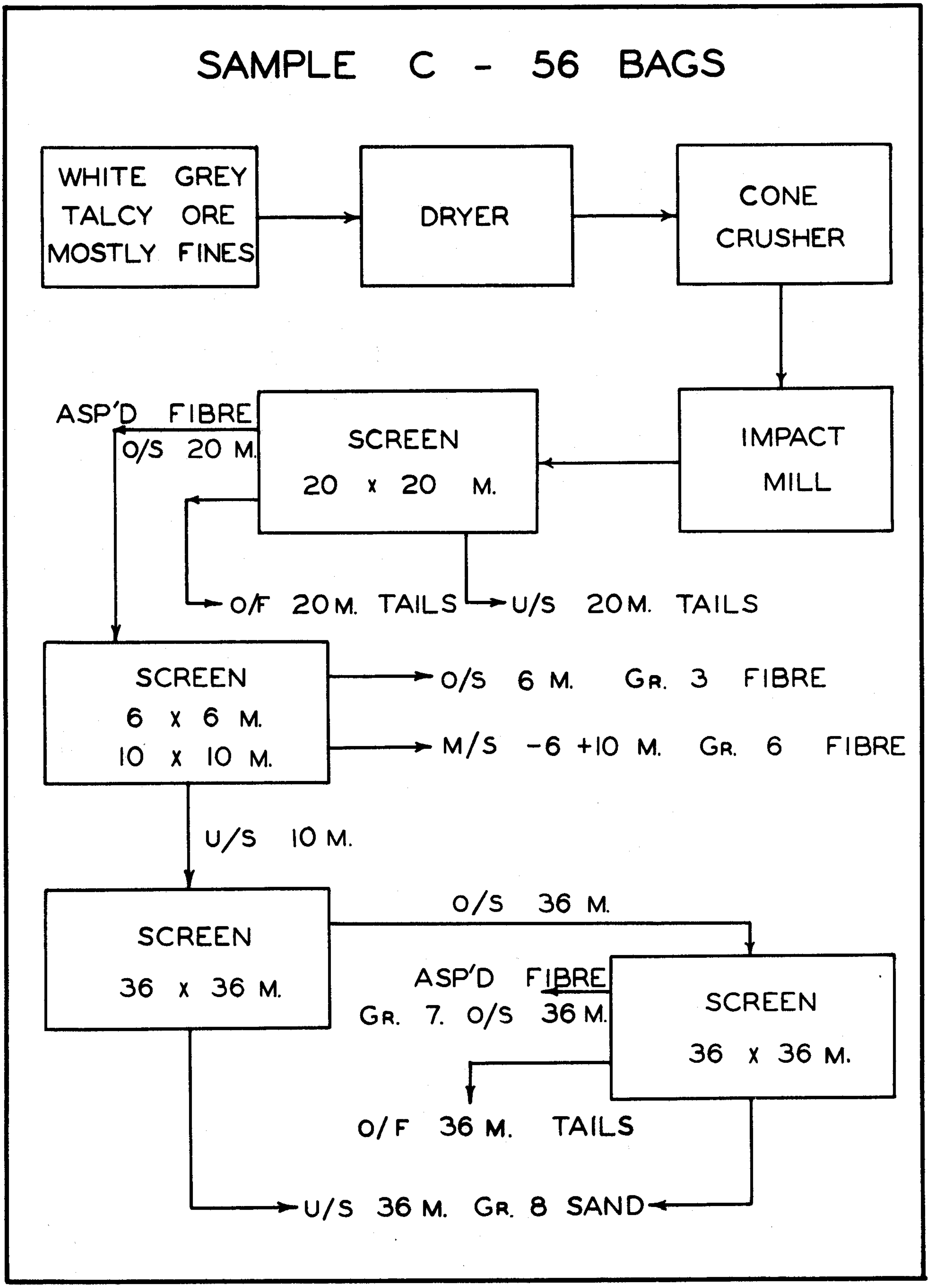

SAMPLE C - 56 BAGS
WHITE GREY TALCY ORE MOSTLY FINES
DRYER
CONE CRUSHER
IMPACT MILL
ASP'D FIBRE
O/S 20 M.
SCREEN 20 x 20 M.
O/F 20 M. TAILS
U/S 20 M. TAILS
SCREEN 6 x 6 M. 10 x 10 M.
O/S 6 M. GR. 3 FIBRE
M/S -6 +10 M. GR. 6 FIBRE
U/S 10 M.
SCREEN 36 x 36 M.
O/S 36 M.
ASP'D FIBRE
GR. 7. O/S 36 M.
SCREEN 36 x 36 M.
O/F 36 M. TAILS
U/S 36 M. GR. 8 SAND

Figure 13.

Summary of Recoveries from Ore Samples

Recovered fibre as percent of the ore sample

Fibre Group	Lot C	Lot D	Lot F
3	0.11	0.11	0.50
4	-	.06	1.37
6	1.74	4.27	4.28
7	3.53	6.89	3.28
(Groups 3 - 7)	5.38	11.33	9.43
8	8.18	5.22	5.06
Total Fibre Rec'y (Groups 3 - 8)	13.56	16.55	14.49

Details of Fibre Recoveries and Grading

Designation - Sample C - 56 bags (see fig. 13)

Location - Taken on Cosmos Creek from the lower portion of the asbestos formation. Weight of dried material, 6552 lb.

Description - This lot consisted of mostly light-coloured talcy, finely broken ore.

Processing - The ore was dried, crushed, and further treated in impact mills for the reduction of ore size and release of fibre, followed by screening and aspiration to collect and grade the various fibres.

Recoveries

Fibre classification	Weight (lb.)	% of ore	% of fibre recovered	
Group 3	8	0.11	2.05	.81
Group 6	114	1.74	32.34	12.83
Group 7	231	3.53	65.61	26.03
Total, groups 3 - 7	353	5.38	100.00	
Group 8	536	8.18		60.33
Total, groups 3 - 8	889	13.56		100.00

Grading

Group	Que. Std. Tests Mesh 1/2	4	10	Pan	Classification	Remarks
3	1.8	7.0	5.7	1.5	3T	(Low box 2 (High box 3
6	.0	Tr.	7.5	8.5	6D	
7	.0	.0	1.0	15.0	7R	

All fibres are grey-white in colour and have a high percentage of dusty fines, resulting in their loose density or weight per cu. ft. being much higher than usual.

Designation - Sample D - 59 bags (fig. 14).

Location - Taken from the upper portion of the same formation on Cosmos Creek. Weight of dried material, 6,203 lb.

Description - This lot consisted of mostly coarse, dark-brown ore, containing a few fibre veins.

Processing - Similar to that in lot C.

Recoveries

Fibre classification	Weight (lb.)	% of ore	% of fibre recovered	
Group 3	7	0.11	0.97	0.67
Group 4	4	.06	.53	.36
Group 6	264	4.27	37.69	25.80
Group 7	428	6.89	60.81	41.63
Total groups 3 - 7	703	11.33	100.00	
Group 8	324	5.22		31.54
Total groups 3 - 8	1027	16.55		100.00

Grading

Group	Mesh	Que. Std. Tests 1/2	4	10	Pan	Classification	Remarks
3		1.2	7.8	5.3	1.7	3T	(Low box 2 (High box 3
4		.0	2.6	9.8	3.6	4T	-
6		.0	Tr.	7.6	8.4	6D	-
7		.0	.0	.9	15.1	7R	-

All fibres are light-brown in colour and have a high percentage of dusty fines, resulting in their loose density or weight per cu. ft. being much higher than usual.

Designation - Sample F - 93 bags (fig. 15).

Location - Taken from the slip fibre zone on Asbestos Mountain at the head of Dahl Creek, about 9 miles (air line) east of Cosmos Creek. Weight of material 6,819 lb.

Description - This lot consisted of mostly coarse, brown ore, and containing some veins and loose slip fibre.

Processing - Similar to that of lot C.

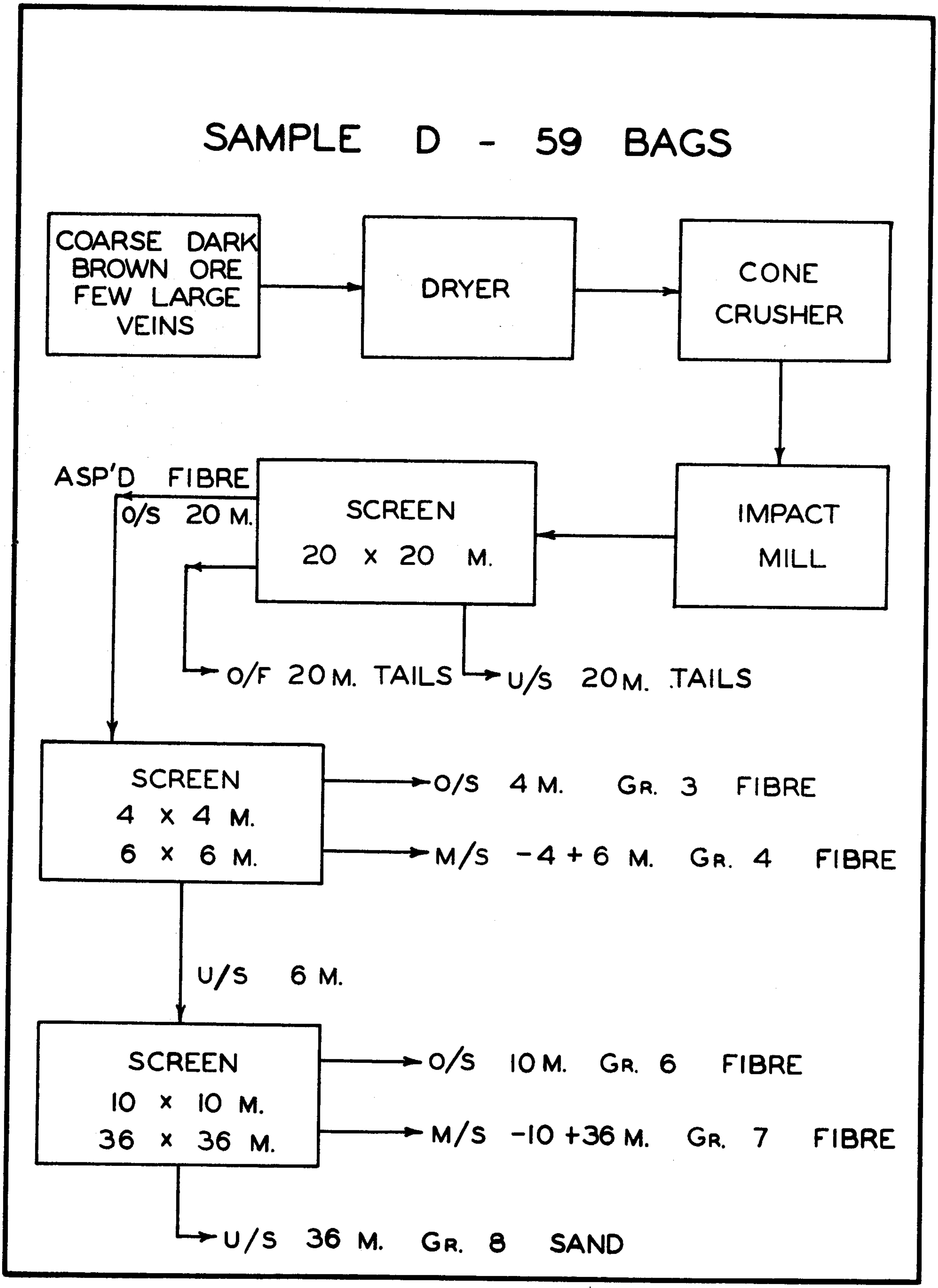

SAMPLE D - 59 BAGS
COARSE DARK BROWN ORE FEW LARGE VEINS
DRYER
CONE CRUSHER
IMPACT MILL
SCREEN 20 x 20 M.
ASP'D FIBRE O/S 20 M.
O/F 20 M. TAILS
U/S 20 M. TAILS
SCREEN 4 x 4 M. 6 x 6 M.
O/S 4 M. GR. 3 FIBRE
M/S -4 + 6 M. GR. 4 FIBRE
U/S 6 M.
SCREEN 10 x 10 M. 36 x 36 M.
O/S 10 M. GR. 6 FIBRE
M/S -10 +36 M. GR. 7 FIBRE
U/S 36 M. GR. 8 SAND

Figure 14.

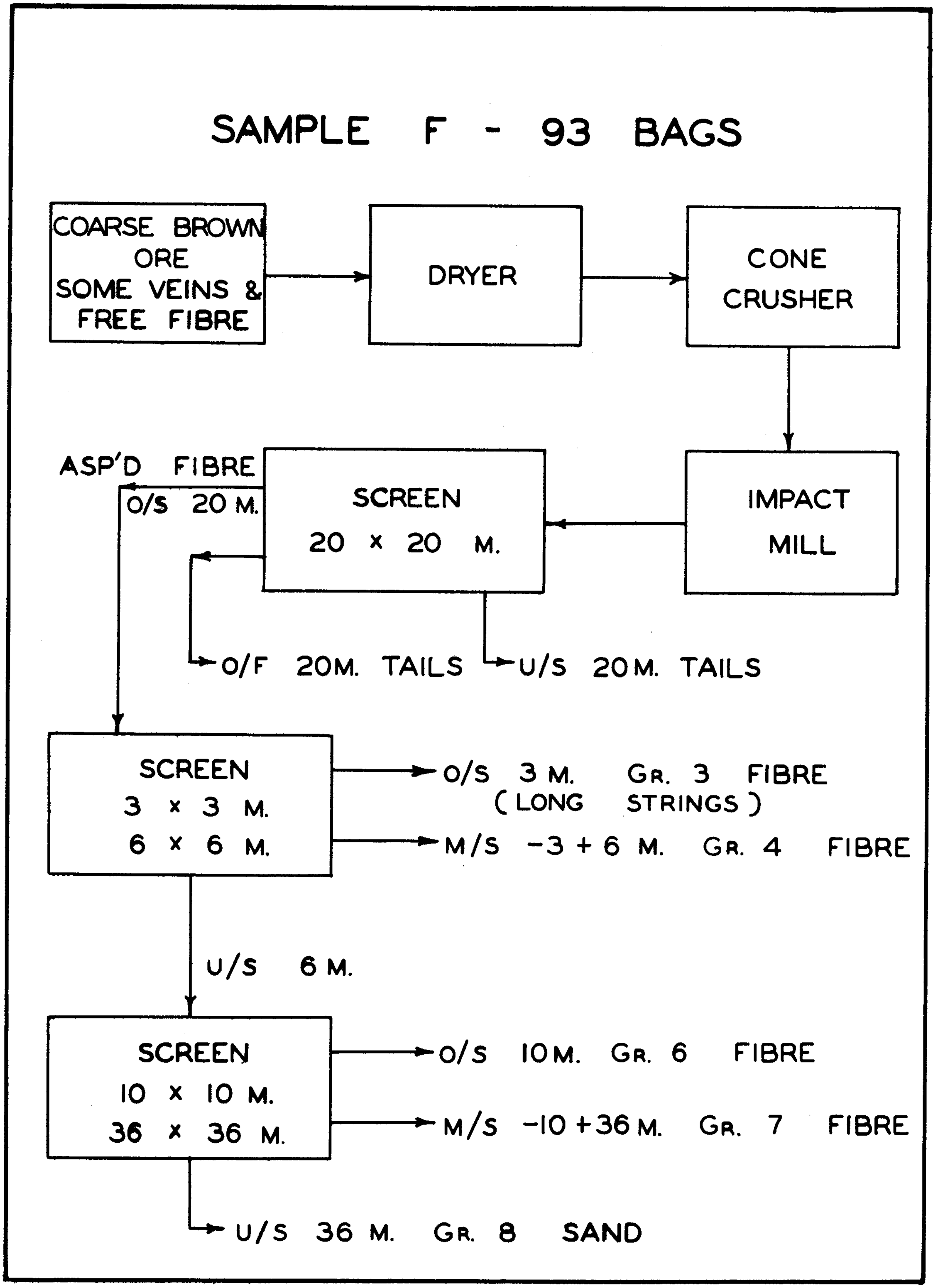

SAMPLE F - 93 BAGS
COARSE BROWN ORE SOME VEINS & FREE FIBRE
DRYER
CONE CRUSHER
IMPACT MILL
SCREEN 20 x 20 M.
ASP'D FIBRE O/S 20 M.
O/F 20M. TAILS
U/S 20M. TAILS
SCREEN 3 x 3 M. 6 x 6 M.
O/S 3 M. GR. 3 FIBRE (LONG STRINGS)
M/S -3 + 6 M. GR. 4 FIBRE
U/S 6 M.
SCREEN 10 x 10 M. 36 x 36 M.
O/S 10 M. GR. 6 FIBRE
M/S -10 + 36 M. GR. 7 FIBRE
U/S 36 M. GR. 8 SAND

Figure 15.

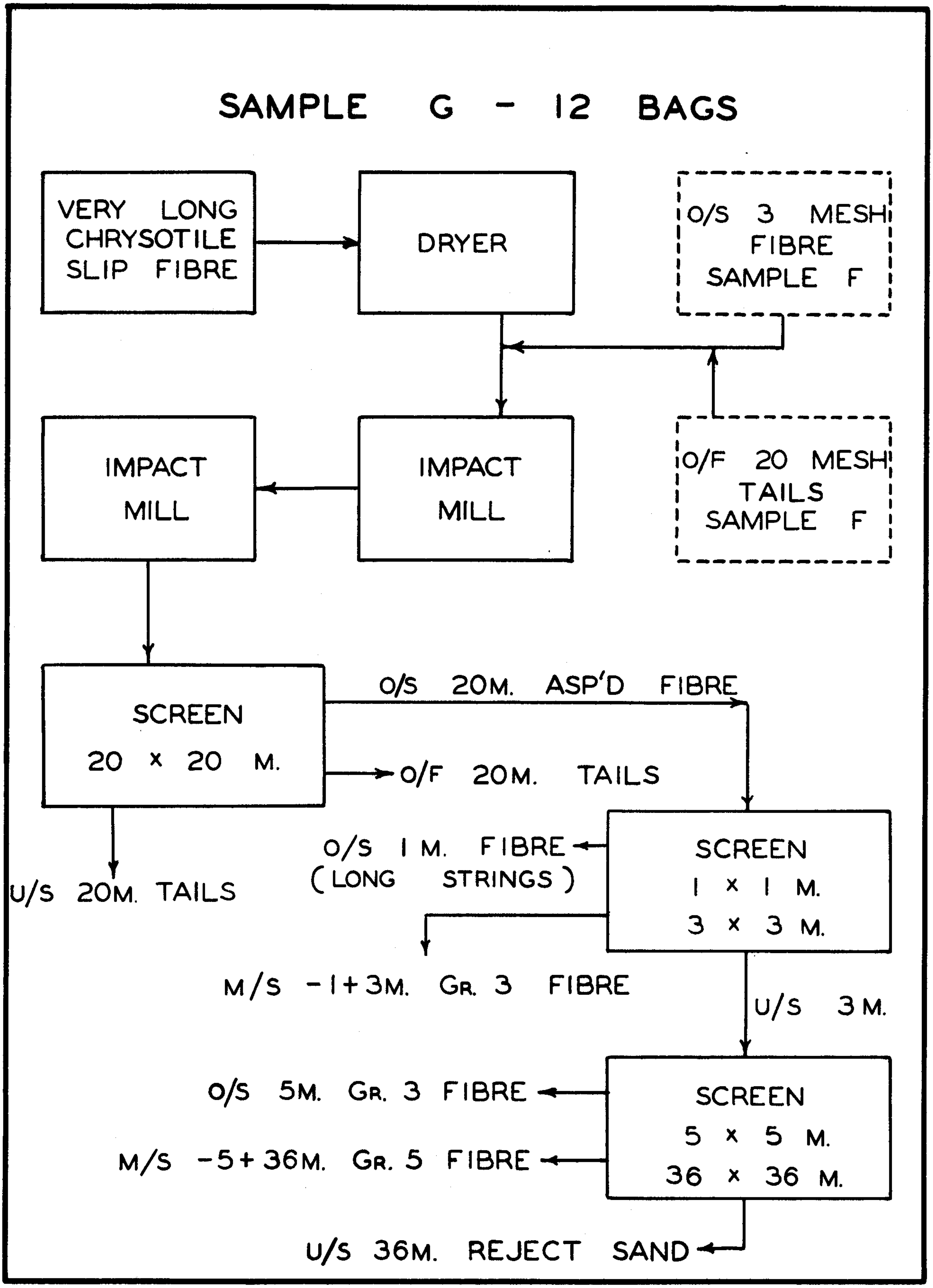

SAMPLE G - 12 BAGS
VERY LONG CHRYSOTILE SLIP FIBRE
DRYER
O/S 3 MESH FIBRE SAMPLE F
IMPACT MILL
IMPACT MILL
O/F 20 MESH TAILS SAMPLE F
SCREEN 20 x 20 M.
O/S 20M. ASP'D FIBRE
O/F 20M. TAILS
U/S 20M. TAILS
SCREEN 1 x 1 M. 3 x 3 M.
O/S 1 M. FIBRE (LONG STRINGS)
M/S -1+3M. GR. 3 FIBRE
U/S 3 M.
SCREEN 5 x 5 M. 36 x 36 M.
O/S 5M. GR. 3 FIBRE
M/S -5+36M. GR. 5 FIBRE
U/S 36M. REJECT SAND

Figure 16.

Recoveries

Fibre classification	Weight (lb.)	% of ore	% of fibre recovered	
Ropy fibre	35	0.50	5.30	3.45
Group 4	94	1.37	14.53	9.45
Group 6	292	4.28	45.39	29.54
Group 7	223	3.28	34.78	22.64
Total groups 3 - 7	644	9.43	100.00	
Group 8	344	5.06		34.92
Total groups 3 - 8	988	14.49		100.00

Grading

Group	Que. Std. Tests Mesh 1/2	4	10	Pan	Classification	Remarks
3	No test				-	Long strings
4	0.0	3.9	8.5	3.6	4M	Low box 2
6	.0	.0	8.6	7.4	6D	High box 3
7	.0	.0	0.5	15.5	7R	-

All fibres are dark grey in colour and have a high percentage of dusty fines, resulting in their loose density or weight per cu. ft. being much higher than usual.

Designation - Sample G - 12 bags (fig. 16).

Location - Taken from the surface of Asbestos Mountain. Weight of material, 606 lb.

Description - This lot consisted of hand-sorted, long chrysotile slip fibre.

Processing - Due to the dried fibre being very long, tough and stringy, normal mill processing could not be used. In an effort to treat the fibre to open same and reduce its length, a laboratory high-speed opener was used, but the material jammed in the unit.

A quantity of reject rock (minus 20-mesh) from run F was therefore mixed with the fibre and treated in an impact mill. By making 2 passes in this unit, the fibre was opened up somewhat, but some still remained in the form of long ropes.

The opened and shorter fibre was then aspirated from a screen and graded by subsequent screening.

Due to the difficulties encountered in the fibre sticking in the machines, as well as the necessity of introducing the granular material as an abrasion agent, the recoveries from this lot should only be considered as approximate.

25 lb. of long group 3 fibre from lot F was mixed with this for processing, as it was approximately the same type of material.

The fibre losses were added to the actual recoveries, being weighted accordingly.

Recoveries

Fibre classification	Weight (lb.)	% of original material
Long ropy fibre	146	24.09
Group 3	94	15.51
Group 3	142	23.43
Group 5	178	29.38
Reject sand	46	7.59
Total fibre & sand	606	100.00

Group	Que. Std. Tests Mesh 1/2	4	10	Pan	Classification	Remarks
?	-	-	-	-	-	Long ropy fibre
3	4.8	8.9	1.5	0.8	3K	(High box 2 (Low box 3
3	.5	8.6	5.0	1.9	3Z	Low box 3
5	.0	.4	10.6	5.0	5R	-

All fibres are dark brown and have a somewhat high percentage of dusty fines, resulting in their loose density or weight per cu. ft. being higher than usual.

General Remarks

The recovered fibres were of the chrysotile variety and were considerably darker in colour than the Canadian asbestos which partly, could be due to mining of the ore at or near the surface.

All fibres show an unusually high dust or fines content and a loose density, or weight per cu. ft., considerably greater than Canadian fibre. This high fines content is reflected in the somewhat shorter staple length of the various fibres determined by wet screening method.

The long fibre is quite strong, but is closely matted, difficult to separate and unsuitable to normal opening processes, lacking the usual silkiness of Canadian fibres.

Local Textile personnel feel that the long, ropy fibres would be unsuitable for textile use, whereas, the group 3 fibres could be processed in the carding machines, although a high loss in drops etc. is anticipated.

The filterability of the medium or group 4 fibres shows an unusual fast rate, considering the high dust content, and from this standpoint, they would be of interest where good filtering characteristics are required, such as in the manufacture of shingles and other asbestos-cement products.

The use of the group 6, 5 and 4 fibres in paper products would undoubtedly show a high loss, due to the washing out of the dusty fines.

The dust content of the group 7 fibres is somewhat lower in proportion to the other grades and for this reason, they would be suitable for most of the products where asbestos shorts are used.

CONCLUSIONS

Tests on the asbestos materials from these deposits, performed at the Bureau of Mines laboratory, Rolla, Mo., and by industrial concerns, lead to the following conclusions:

(1) Recovery of the higher grades of asbestos is so low that these deposits cannot be considered as a source of spinnable asbestos.

(2) There is a possibility that the material could be utilized in the manufacture of asbestos shingles and asbestos board, although the asbestos is more brittle than the Canadian product.

(3) There is also a possibility that this asbestos could be used as a filter medium because of the rapidity with which water passes through the finer sizes.

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