PLAINTIFF'S EXHIBIT

UC-3959

NEW IDRIA CHRYSOTILE

AN UNUSUAL ORE YIELDS NEW PRODUCTS

By

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A07759

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ABSTRACT

The chrysotile asbestos deposit in the New Idria mining district of California differs from the sources of most chrysotile products. These differences are examined with respect to geology, mining, and processing. The significance of a new colloidal grade chrysotile is presented in terms of its physical properties and end=use application. Included are some comparative data between this new form of chrysotile and the more conventional short-fibered products. Also, some of the newer modified asbestos products being produced at Union Carbide's King City Plant are discussed.

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INTRODUCTION

The recent development of the unique deposit of short-fiber chrysotile near Coalinga, California has drastically altered the asbestos production picture of the United States and has resulted in the development of high-purity products which have found application in an entirely new spectrum of industrial uses. There are presently three active asbestos operations in the area, those of Union Carbide Corporation, Atlas Minerals Corporation, and Coalinga Asbestos Company, a joint venture between Kern County Land Company and Johns-Manville Corporation. This paper is concerned with the mining operations and properties of the asbestos material produced by Union Carbide Corporation.

GEOGRAPHY

The ore deposit occurs in the New Idria serpentinite mass, located in the southern portion of the Diablo Range, in Township 18S, Range 12 East and Township 18 South, Range 13 East, southeastern San Benito and western Fresno Counties, California. Union Carbide's mine is in Section 25, T18S, R12E at an elevation of 4200 feet. The area consists of precipitous, northwest trending ridges of steeply dipping sediments which were intruded by the serpentinite host rock. Within the serpentinite itself, the incompetent nature of the material has led to unusual erosion phenomena in the form of rounded, moderately sloping ridges and spurs. Extensive land-slides in recent geologic time have formed typical terraces and

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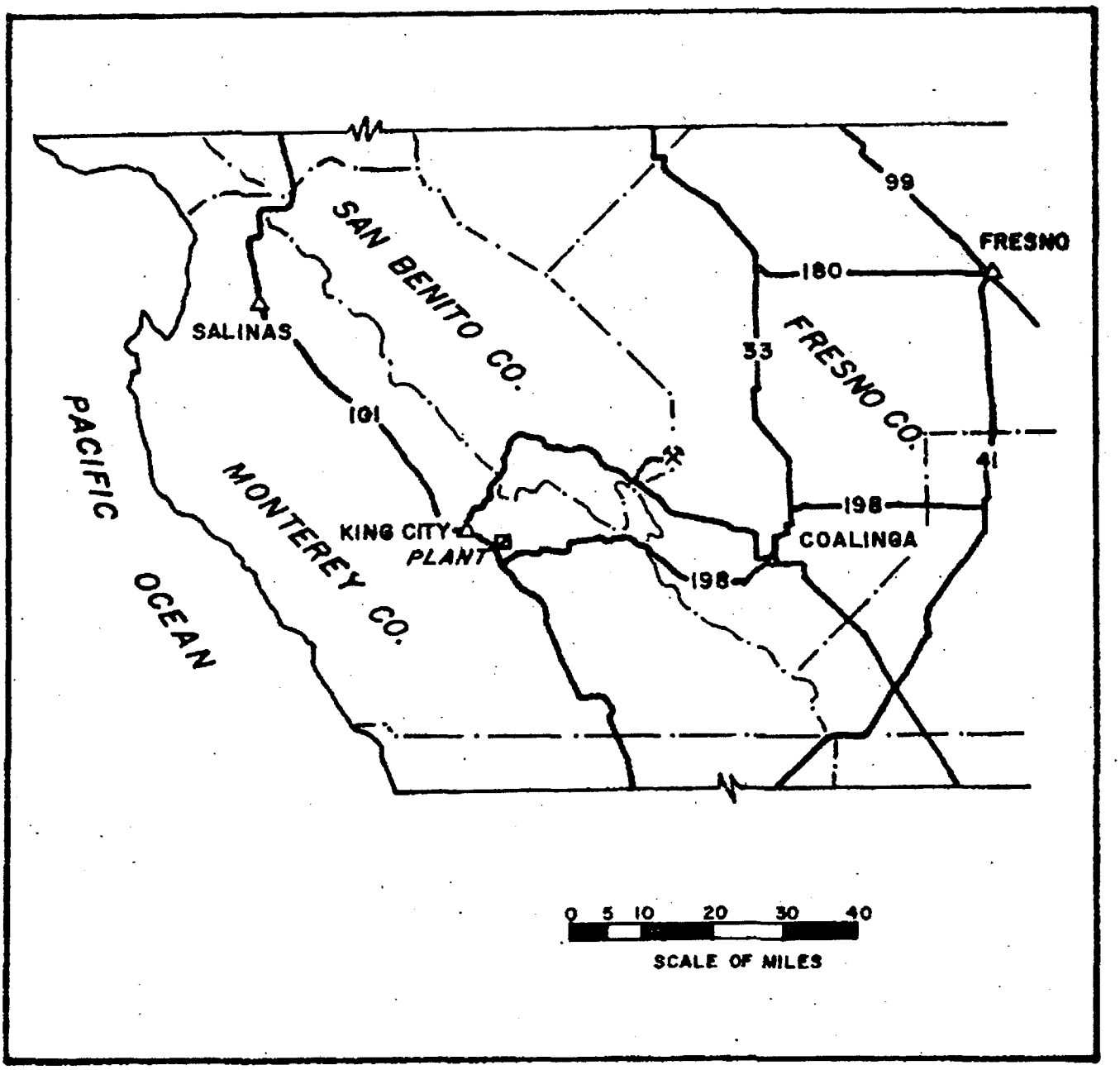


PLATE NO. 1. Index Map

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hummocks along the margins of the serpentinite mass. Elevations within the body range from 2500 feet to a maximum of 5241 feet above sea level.

Access from Coalinga, the nearest population center, to the mine is provided by 28 miles of improved county road and 10 miles of graveled private road. King City, California, the site of Union Carbide's processing plant, is 55 miles away by road, 45 miles of which is over light duty county road, in addition to the same 10 miles of private access road. The airline distance from the mine to the plant is 27 miles.

The climate is arid, with temperatures varying from 100°F in the summer to as low as 10°F in the winter. Although the average annual precipitation is 20-25 inches, most of it occurs from November through April, and the average rainfall from May through October is less than 2 inches. The vegetation is sparse due to the arid climate and consists primarily of manzanita and oak brush, with scattered, thin stands of coulter and digger pine trees. However, in areas more richly endowed with subsurface water, stands of cedar trees supported small logging operations prior to World War I. Similarly, where subsurface water is more prevalent, the brush has grown to almost impenetrable thickness.

HISTORY

The mineral development of the district dates back to the mid-nineteenth century. The New Idria Quicksilver Mine has operated

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almost continuously since its discovery in 1853, and in its history, has produced more than 550,000 flasks of the metal(1). During periods of favorable mercury prices, activity resumes at numerous smaller mines in the district, and at the present time, several are producing small quantities of the metal.

Magnesite was mined at several locations in the district during and after World War I when European supplies were curtailed. The Sampson or Maltby No. 3 mine contains sizable reserves; however, the mining costs are not competitive with the low cost, sea-water extraction methods employed at Kaiser's Moss Landing Plant in California.

From 1951 to 1958 the development of numerous small chromite deposits was undertaken; the stimulus having been provided by the Federal Government's domestic chromite purchasing program. Prices as high as $115 per long ton were paid for premium grade ores and concentrates. At the cessation of the program and the resultant return to a market price of $36 per long ton, all operations soon ended. The total production from the district is estimated to be 24,700 long tons of lump ore and concentrates, most of which came from the Butler Estate Mine located at the southeastern edge of the New Idria body(2).

Evaluation of the chrysotile deposits began in 1958 shortly after one of Union Carbide's exploration geologists took note of the peculiar white, leathery mineral while examining nickel laterite

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occurrences in the area. Detailed mineralogical investigation determined that the mineral was, indeed, chrysotile asbestos, but in a unique physical form. Property acquisition and evaluation began immediately, culminating in access road and plant construction and initial mining operations in the Spring and Summer of 1963.

GEOLOGY

The asbestos ore bodies occur in the southeastern third of the New Idria serpentinite, an elongate and intensely sheared mass, 18 miles long by 3 miles wide. The serpentinite has intruded steeply dipping sandstones, shales, and greywackes of Jurassic and Cretaceous age and is located at the crest of the Coalinga anticline(3) (4). All contacts with the enclosing sediments are faulted. The San Benito fault, on the southwestern margin of the body, is a high angle normal fault dipping to the southwest. The New Idria fault, on the northeastern edge of the serpentinite, is a thrust fault which rapidly changes attitude from steeply dipping to the southwest to almost horizontal.

The intensive brecciation of the serpentinite obscures the original internal structure of the ultramafic. However, numerous conspicuous reef-like structures of silica carbonate rock parallel to the axis of the intrusive are suggestive of earlier faulting. These reefs are the host rock of numerous low-grade quicksilver deposits, especially in the northwest portion of the district. The southeastern half of the intrusive is intruded by numerous syenite

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pipes of Tertiary age. Outcrops of these masses vary in area extent from more than 40 acres to less than several hundred square feet. The larger outcrops consist of massive, relatively unfractured rock. Drilling and surface excavation disclosed a hitherto unknown mass of such material immediately adjacent and southwest of Union Carbide's mine site.

The steeply dipping, faulted contacts and the lack of metamorphism along these exterior contacts, as well as along the contacts with numerous exposed inclusions of Franciscan sediments, indicate that the serpentinite was implaced in a cold, near solid state. The sequency is believed to be as follows: During the latter stages of the unwarping of a thick sequence of marine sediments to form the Coalinga anticline, zones of weakness developed near the anticline's crest. A deep seated ultrabasic magma, believed to be dunitic in composition, was injected upward through the wet sediments. The anhydrous rock, during or after crystallization, reacted with water from the sediments and hydrated to serpentine minerals. The concurrent increase in volume of the ultrabasic mass was opposed by the confining sediments, causing the rock to shear internally.

The presence of barren serpentinite debris at the base of the Cretaceous Panoche formation, of both serpentine and asbestos flakes in the Big Blue member of Miocene Temblor formation, 8 miles northeast of the intrusive, suggests that the serpentinite has been

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uplifted on more than one occasion after its implacement. Similarly, the broad, flat landslide terraces in the southeastern half of the ultrabasic mass are suggestive of an old erosion surface.

The minerals found in varying quantities in the ore bodies include chrysotile, brucite, hydromagnesite, magnetite, chromite, uvarovite, artinite, pyroaurite, aragonite, calcite, olivine, lizardite, and antigorite(3). The latter two minerals are the principal constituents of the residual serpentinite blocks or "boulders." Magnetite occurs in the ore at the 6-8% level. Hydromagnesite has precipitated from magnesium-rich ground waters which permeate the mass and generally occurs as pellets at the base of the surface weathering zone and as such, is an aid in locating this gradational contact.

A new mineral, coalingite, has been identified as reaction products of brucite in partially weathered serpentinite residuals(5). The mineral is believed to be the product of supergene alteration of iron-rich brucite, a major constituent of the serpentinite, by CO_2-charged ground water. It generally occurs as soft, reddish-brown platelets having a resinous luster and has an empirical formula of $Mg_{10}Fe_2(CO_3)(OH)_{24} \cdot 2\ H_2O$.

A unique deposit of the gem mineral benitoite, $BaTiSi_3O_9$, occurs one mile east of the mine. The mineral occurs as light blue transparent crystals in seams of natrolite, which form stock works in a highly altered Franciscan greenstone roof pendant. The cut stones are prized for gems despite the softness of the mineral (6.2-6.5).

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CHARACTER AND GENESIS OF THE ORE BODIES

The principal ore bodies are located in the southeastern third of the serpentinite mass (Plate 1). Several small occurrences have been found in the vicinity of New Idria, but, they appear to be of limited extent. The ore bodies are irregular in shape but tend to be elongated paralleled to the axis of the intrusive. The ore grade is remarkably homogeneous, both laterally and vertically if viewed in a broad sense.

Inclusions of massive, residual blocks of serpentinite can effect variations of ore grade. These residuals vary in diameter from less than a foot to several tens of feet and are subangular in shape. Their distribution appears to be random. The waste residuals weather readily to a soft, brown, powdery mass. The rapid weathering, as short as two years after exposure, is considered to be due to the abundance of brucite within the serpentinite residuals(3). The weathered residuals present contamination problems in the milling process; therefore, overburden consists primarily of weathered residuals enclosed in a matrix of otherwise high-grade ore, plus a capping of soil generally less than one foot in thickness. The overburden will vary in thickness from 15 to over 40 feet, the average thickness being 20-25 feet. Because of the random occurrence of the residuals and the variation of the degree of weathering with depth, the contact between overburden and ore is gradational and is established in mining practice by visual observation.

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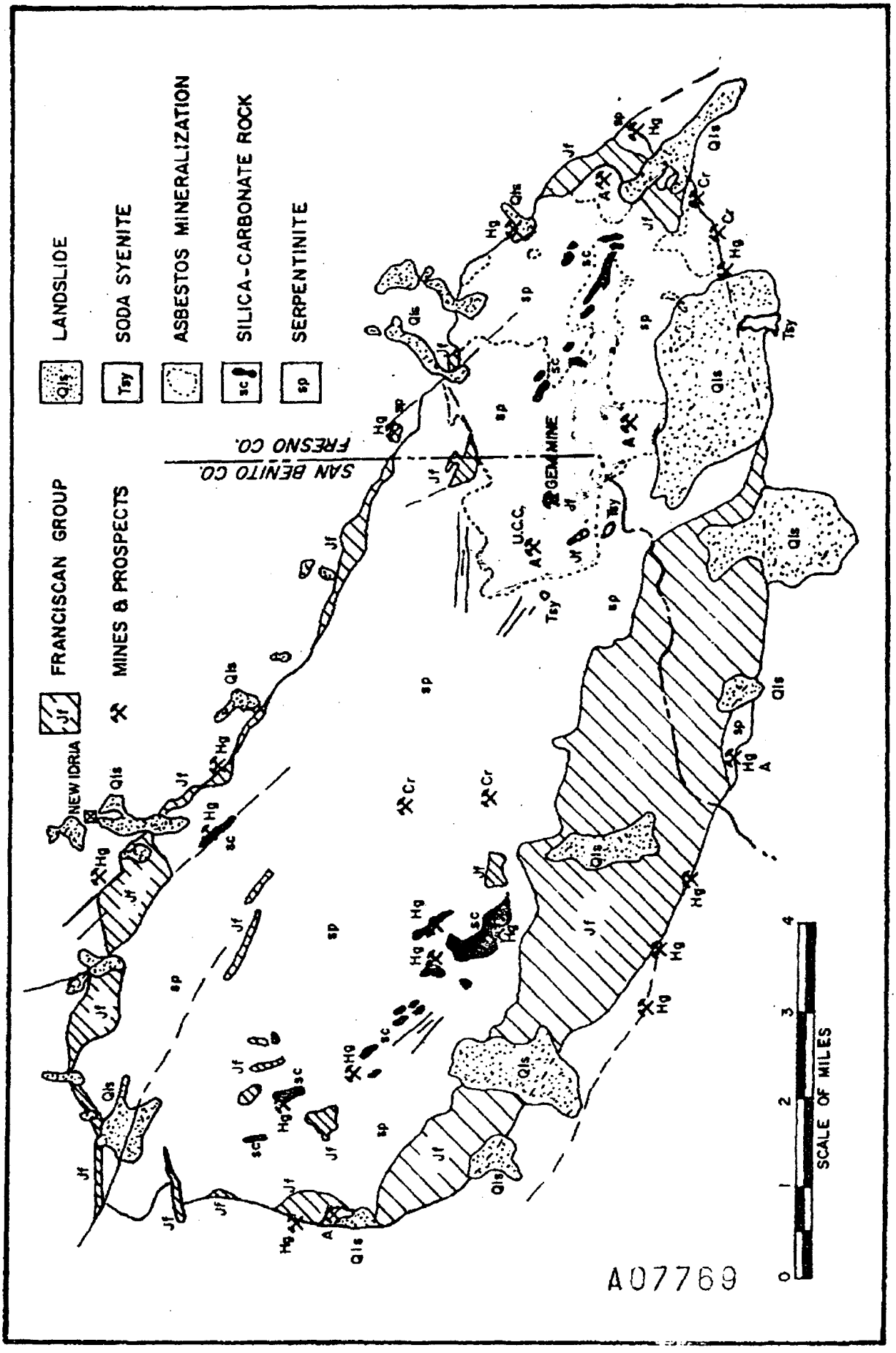


PLATE NO. 2. Geologic Map of the New Idria Mining District, California
(from Eckel & Myers, 1946)

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On close examination, the ore consists of flexible light grey to white flakes resembling leather. The flake diameters vary from less than 0.1 inch to over 1.0 inch. The larger flakes contain kernels of fresh serpentinite.

The flaky character of the ore mineral is considered due to the random orientation of the individual fibrils comprising the flakes. Note the difference between the degrees of orientation of the fibrils of New Idria District flakes and typical Canadian cross fiber, as shown in Figures 1 and 2. It is significant to note that cross-fiber chrysotile, the normal type of material found in most asbestos mines, is virtually absent from the New Idria ore.

The unusual physical appearance of the New Idria asbestos ore is thought to be a direct consequence of the unusual origin of this serpentinite body. As discussed by Mumpton and Thompson[3], intensive shearing and brecciation of the serpentinite parent rock provided vast zones of high permeability. The accompaning grinding and pulverization of the rock produced large quantities of material of extremely fine particle size, which were able to react readily with CO_2-charged water permeating the body. Citing field evidence and the recent hydrological work of Barnes, et al.[13] they suggest that during this process the lizardite and antigorite of the original serpentinite dissolved and reprecipitated as chrysotile, which is found today making up the bulk of the soft, friable ore. Residual fragments and blocks of the original serpentinite still remain, and, of course, their abundance is a direct measure of the grade of the

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ore. The leathery, sheet-like textures of the fresh ore were apparently produced by the dehydration of gelatinous masses of chrysotile, which surrounded particles and blocks of the residual serpentinite rock.

EXPLORATION AND DEVELOPMENT

Initial exploration consisted of constructing roads suitable for pickup trucks, trenching and shallow (45 feet deep) cassion drill holes. Because of the high cost of drilling to significant depths with such equipment, it was decided to sacrifice a degree of sample integrity and employ the more conventional rotary drill rigs originally employed in seismic work such as the familiar Mayhew 1500. The Hawthorne 3-bladed finger bit and competitive variations have been found to be the best general purpose bit from the standpoint of cost, penetration rate, and sample quality, in that this design produces a minimum amount of fines. The tri-cone gear bit is employed when encountering exceptionally hard serpentinite residuals. To date, down-the-hole hammer drills have not been employed.

The usual diameter of holes drilled is 4-3/4 to 5 inches. Larger hole sizes are undesirable from the standpoint of both excess sample volume and the reduction of velocity of the rising air stream. A crew generally consists of a driller, his helper, and three samplers. The three samplers are necessary because of the high drilling rates attained, 200 feet per hour in high-grade ore. A 5" diameter hole will produce 150-200 pounds of sample in the standard 10-foot continuous sample interval. It is, therefore, advantageous to reduce

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the sample size on the location if possible. To this end, a durable field splitter using 2" pipe for riffles is employed. In addition, the discharge pipe of the casing head is fitted with a long-sweep wye, reducing the sample by half as it leaves the hole. The sample is collected in loosely woven cotton sacks as it discharges from one leg of the wye, reduced to approximately 50 pounds in the pipe splitter, and shipped to the laboratory for analysis.

The drill hole samples are analyzed for fiber content and whiteness or reflectance using a Photovolt Model 610 reflectometer in accordance with TAPPI standards. The results are compiled on computer-plotted contour maps showing the aerial variation of the main values of the data obtained for each hole.

MINING METHODS

Mining operations are conducted by open pit methods, working from benches 40 feet wide. The faces are 20 feet high and maintained to a 1:1 slope. The gross slope of the pit wall is therefore 18-1/2°. The ore is mined by self-propelled scrapers having heaped capacities of 28 cubic yards. This capacity extrapolates to 18 dry tons or 15 in-place cubic yards. The swell factor of the ore is 85% or 0.54 load factor. The average moisture content of freshly mined ore is 18.5%.

Hydraulic ripper equipped bulldozers of 230 and 330 flywheel horsepower, are employed to pushload the scrapers, as well as to maintain the slopes of the faces and to perform pit cleanup duties. Tandem pushing with two bulldozers is employed when available loading

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distances are less than 200 feet. The normal scraper loading distance is 200 to 300 feet depending upon the concentration of serpentinite residuals. Loading cycle time averages 0.70 minutes for single pushing.

Ripping is employed to root out the boulders of residual serpentinite. Residuals less than 3 feet in diameter are not sorted from the ore; those larger than 10 feet in diameter generally require blasting prior to removal. Boulder removal at the present stage of pit development is merely a matter of pushing them into a nearby canyon using a bulldozer. Stripping is performed concurrently with mining utilizing the same equipment. The overburden is hauled to nearby dump areas, selected so as not to conflict with future mining operations.

The ore is hauled and spread on the stockpile by the scrapers. The average round trip haul distance is 1300 feet with grades both adverse and favoring the haul. Haul roads must be watered daily for maintenance and dust suppression. Wet unsurfaced haul roads present traction problems since the ore becomes very slippery when saturated, and care must be exercised to prevent the application of excessive quantities of water. The gradability of the scrapers (with standard transmissions) is 20% empty and 18% loaded, when operating on well maintained but unsurfaced roadways. Haul roads are paved with ore to minimize contamination of the stockpile from dirt carried in the tire treads. This also allows the smoothing of the haul roads by dragging the surface with the scraper bowls.

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Water is obtained by impounding nearby drainages. Dust suppression is not necessary in active mining or stripping areas because of the moisture content of the material being excavated. The moisture content remains nearly constant year around.

Because of the homogenity of the ore, exclusive of random distribution of serpentinite residuals ore, control of the ore grade is a matter of minimizing contamination by overburden or organic material such as brush. In this regard, clearing and grubbing are maintained 50 feet beyond the working benches. The overburden-ore contact is gradational and erratic and therefore is determined by visual inspection. As an added precaution, a 3-5 foot thickness of ore immediately below the overburden "contact" is discarded as waste.

The normal equipment configuration consists of 3 scrapers, 2 bulldozers, and a water truck. The average production of the configuration is currently 4680 tons per 8-hour day.

Because of the high production rates obtainable with a minimum amount of equipment, the optimum economics are obtained by operating the mine during the summer season and contracting the operation. Contractor payment is determined by the number of in-place yards of ore and overburden excavated and stockpiled. These quantities are determined photogrammetrically; this engineering work is contracted also.

The mine-run ore is screened by a portable screening plant consisting of a hopper, pan feeder, 38" x 51' conveyor belt and a

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4" x 10' double deck screen. The upper screen cloth contains 4" x 4" openings; the bottom screen cloth contains 1" x 1" openings. The -1" material is stockpiled by a portable stacking conveyor equipped with a 24" x 60' conveyor belt and swivel truck to allow pivoting. The system is fed by a 4-1/2 cubic yard, rubber-tired, front-end loader with the productivity of the system being 100 dry tons of underflow per hour. By utilizing portable equipment, it is readily possible to relocate the system when the face of the stockpile has retreated to an excessive distance from the screening facilities. Since the scrapers tend to compact the moist ore when stockpiling, it has been found advantageous to loosen the stockpile periodically with a bulldozer. This has not only effected a reduction of end-loader maintenance costs but has also increased the production rate and recovery of the screen. This increased recovery is due to the comminution caused by bulldozing the ore in thin lifts from the tip of the stockpile.

The screened ore is shipped to the processing plant at King City, 55 miles from the mine. Six haul units, each consisting of 2 bottom dump trailers pulled by a 330 horsepower tractor, are employed operating 24 hours per day, 5 days per week. Since the majority of the route is over winding mountainous roads of low design standards, the tractors have been equipped with Jacobs' compression braking systems. At present, the average haulage production is 580 dry tons per day. This phase of the operation is also contracted and is shut down during the winter rains.

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FIGURE 1 - Electron Micrograph of Canadian Chrysotile Sample

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FIGURE 2 - Electron Micrograph of Typical New Idria Chrysotile Flake

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MILLING OPERATIONS

As a raw material for the commercial production of chrysotile asbestos products, three aspects of the New Idria ore set it apart from the typical ore found in the Canadian Provinces.

First, its morphology differs radically from Canadian ores. The photomicrograph in Figure 1 shows the structure of a typical close-packed fiber bundle as found in most conventional chrysotile deposits. The individual fibers, or fibrils, are all in line contact and completely straight, with little or no deviation from the parallel configuration. New Idria chrysotile texture is the direct opposite. The photomicrograph in Figure 2 of a New Idria flake shows a random orientation of fibrils, and each fiber in only point contact with its neighbor. Furthermore, none appear to be lying in a straight line since they all exhibit some degree of curvature throughout their lengths.

Secondly, the New Idria ore is virtually devoid of any long fibers. No known method of processing has extracted a grade higher than a 7R as determined by the Quebec Standard test. This is undoubtedly due to the structure which resulted from the peculiar formation process.

Thirdly, the high fiber content of this unusual deposit is uncommon for the conventional chrysotile ore body. As determined by a fiber yield analyses, ores of 50% chrysotile fiber and higher are not uncommon, and in certain sections fiber contents of greater than 60% have been found.

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It is undoubtedly these three unique characteristics that kept the experienced and inexperienced producers away; the experienced because it did not fit into the conventional ore structure and might require a new approach to processing; the inexperienced probably never recognized it as a chrysotile deposit. Union Carbide was interested because the New Idria chrysotile deposit represented a large source of a high-grade industrial mineral.

PROCESSING CONSIDERATIONS

In spite of these unusual characteristics, the ore was found to be amenable to dry beneficiation, as evidenced by the two existing mills currently operating in this manner. Atlas Minerals Corporation and Coalinga Asbestos Company are both producing a short-fibered product, comparable to the Canadian Group 7 grade. The processing techniques are probably similar to those used in the Canadian mills[6]; although the exact process has never been made public by either producer.

Union Carbide's first approach was to make use of the available dry processing technology and a pilot plant was designed and built at its research facilities at Tuxedo, New York. The process consisted of drying the ore, grinding (fiberizing) with impact mills, sizing, and aspiration. Fiber yields varied depending on the quality of product desired. The products obtained in this pilot plant were acceptable for floor tile use (with some modification of the stabilizer system) and even indicated certain advantages over the Canadian

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grades. The California product had the additional benefit of being brighter, which reduced the TiO_2 needed for brightness. The brightness of tile was further enhanced because the reduced asbestos requirement was compensated for by an increase in the addition of 90 brightness limestone.

During this period of dry process testing, the laboratory continued its investigation of the character of this ore. Rather than looking for similarities between the California and Canadian chrysotile products, an alternate program looked at the differences between the fiber products. It was established that the important factor in enhancing these differences was the purity of the beneficiated product. Of all the processing techniques investigated, the wet process was chosen as the most suitable for this purpose.

DEVELOPMENT OF THE WET PROCESS

The literature abounds with references to wet milling techniques which have claims to commercial application, but none appeared to be adaptable to commercial utilization. These techniques, however, offered what was considered the most logical approach to the manufacture of a purified chrysotile product. The New Idria ore was ideally suited for wet processing by virtue of the unique characteristics that made it less suitable for dry processing: the ore was high grade so the requirement was one of removing gangue from the fiber rather than the usual method of removing the fiber from the rock; the absence of a long-fibered fraction eliminated the need for careful reduction in size; and the matted fiber

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structure was well suited for wet dispersion techniques. In addition, other investigators have reported an absence of an amorphous binder commonly associated with the Canadian fibers, which is certainly supported by our own studies.

The final wet process as developed and installed at the King City Mill took cognizance of the foregoing characteristics. Although the details are proprietary, it may be described as a treatment which provides complete liberation of the individual fibrils and removal of the non-fibrous fraction.

One advantage of employing the Carbide process is the ability, for the first time in the Asbestos Industry, of economically producing a pelletized product. Pellet products are available in a variety of grades and degrees of purity. The advantages of this type product are ease of handling, a reduced dust hazard, lower shipping rates, and less troublesome storage. The shipping bulk varies slightly depending on the product, but all are less than 50 cubic feet to the ton. For the first time, an asbestos product that can be handled readily by conventional bulk handling techniques is available and as such represents a major achievement in the asbestos industry.

BASIC PRODUCTS

Union Carbide Corporation manufactures three basic grades and a total of six products at its mill in King City. Each is produced by wet techniques and can be classified as follows:

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Fiber Products

Standard Grade 100 series

Standard Grade 200 series

Colloidal Products

High Purity Asbestos

Resin-Grade 100 series

Modified Products

Resin Grade 244

Asbestos T-135

The standard grade 100 represents a fiber product obtained primarily by straight line beneficiation of the asbestos ore. It corresponds to a Canadian 7R, and is presently used for such applications as vinyl asbestos and asphalt floor tile. The S-G200 products are treated in a further step so that the fibers are more uniform and more open in size. They are more suitable for use in applications where fine grind and high bulk are desired.

The colloidal grades are the most unique products from the King City Mill. They differ from either the Standard Grade series or conventional chrysotile in that they are treated to be more highly purified and refined. They consist almost entirely of liberated chrysotile fibrils. Figure 3 represents the ultimate in fiber reduction that was achieved in our initial dry pilot plant and is probably finer than most commercially available chrysotile asbestos. In the manufacture of our colloidal products, the mill is approaching the ultimate in liberation of colloidal particles

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as shown in Figure 4. The absence of fiber bundles, as well as its purity, make the colloidal grade unique chrysotile products.

Almost all of the present uses for the colloidal products are in areas where asbestos had not previously penetrated. It was possible to obtain these markets only because we were able to provide a uniform, highly purified, non-abrasive fiber product in volume. These products are directed at new markets such as the paper industry(7). The Resin Grade 100 series are specially produced products for the plastics industry.

More recent additions to the product line have been obtained by modifying the asbestos fiber itself. By means of additional treatment, it has been possible to obtain properties which are unique to the industry. For example, Asbestos T-135 is a titanated fiber, manufactured in such a manner that the material is a pigmented fiber that utilizes the scattering power of the titania at its utmost efficiency. Asbestos T-135 is primarily used as an opacifying agent in the manufacture of paper(8).

Resin Grade 244 is a chemically modified product that was developed as a thixotropic agent for polyester resin systems. In aqueous systems it differs only slightly from the High Purity products, but in resin systems, its thickening effects are quite unlike anything available. It is easily distinguished from the unmodified products by its reflectance which is in the low 80's.

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FIGURE 3 - Electron Micrograph of Dry Processed Fiber Agglomerate 407784

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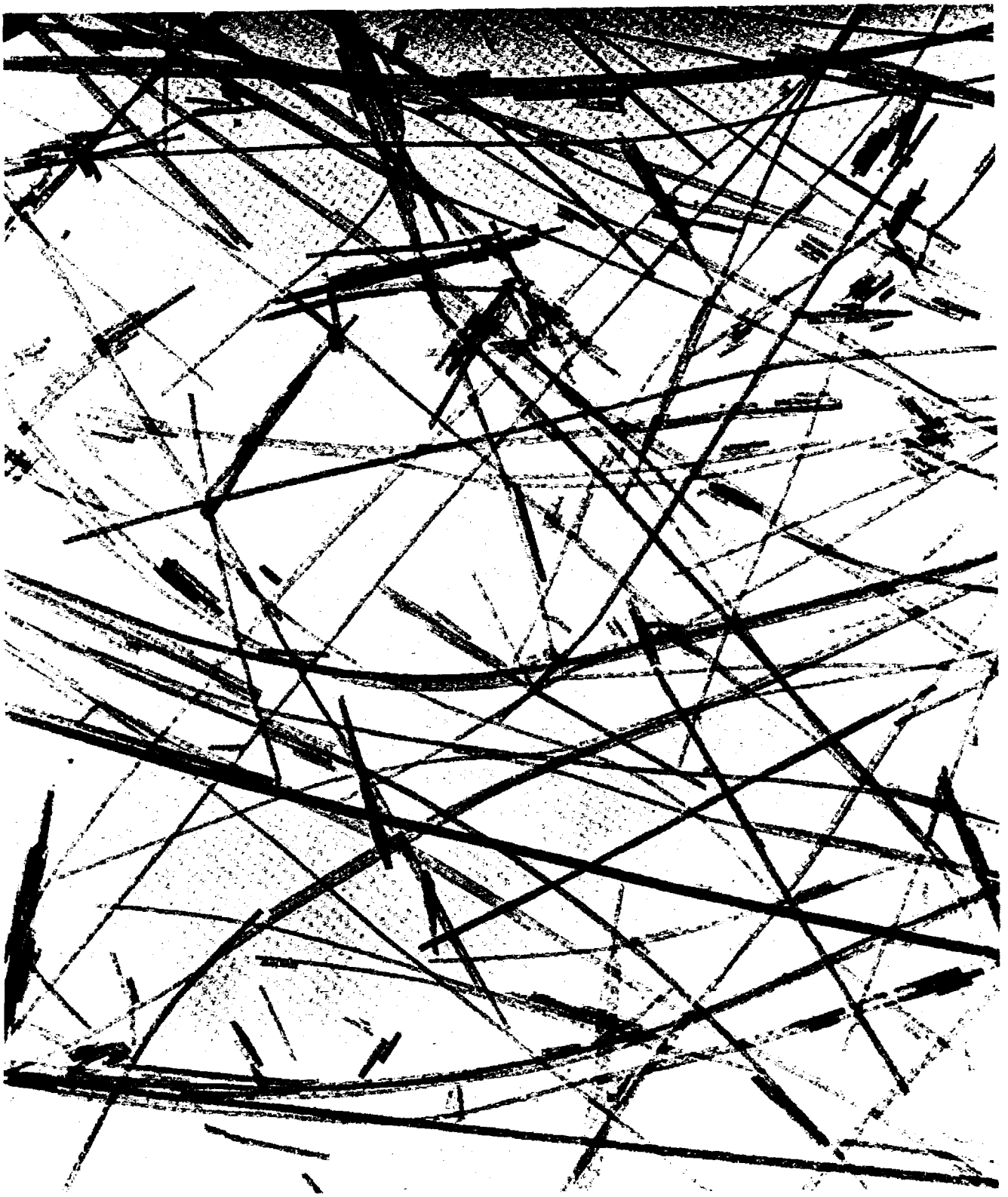


FIGURE 4 - Electron Micrograph of Wet Processed Fibrils A07785

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PHYSICAL PROPERTIES OF UCC ASBESTOS PRODUCTS

The usual tests employed by the asbestos industry actually measure the properties of aggregates of asbestos fibrils. For this reason, the highly purified UCC products cannot be graded by these criteria. However, for comparative purposes, some of these data have been obtained. Inasmuch as the tests were all run in the same manner on all products, the results are considered relative.

Some of the basic properties of UCC asbestos products are shown in Table 1 along with the corresponding values for conventional short-fiber products. These data reflect the degree of refinement exerted on the fiber during processing. This can be seen in the lower magnetite content, higher brightness, increased adsorption capacity and bulk density. Because of the inaccuracy involved in reporting an average value for the Canadian grades, several of the more specific physical property evaluations are also listed.

In one series of tests, the High Purity Asbestos was compared to a variety of chrysotile shorts on the basis of wet bulk. The test consists of agitating 1.0 gram of asbestos in 210 ml. of water for ten seconds in the Waring Blendor. The slurry is then transferred to a 250-ml. graduated cylinder and the volume adjusted to 250 ml. with tap water. To ensure uniform mixing, the slurry is mixed by inverting the cylinder three times and is then allowed to settle for one hour, after which the solids level is read in ml.

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TABLE 1

PHYSICAL PROPERTIES OF CHRYSOTILE ASBESTOS PRODUCT

PROPERTY	AVERAGE CANADIAN	UCC PRODUCTS	
		STD. GRADE	HIGH PURITY
SURFACE AREA $M^2/G.$	10-30	50-60	60-80
OIL (DOP) ADSORPTION ml/100 G.	4-6	8-10	10-14
WATER RETENTION ML. H_2O/10 G. ASB.	12-20	23-33	44-47
BULK DENSITY LB./FT.^{3}	12-20	10-14	3-5
REFLECTANCE %	54-70	62-72	74-77
MAGNETITE %	3-6	<2.0	<0.50

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TABLE 2

LABORATORY WET BULK EVALUATION*

PRODUCT	SOURCE	VALUE (m.l.)
7MO6	JOHNS-MANVILLE	95
7T	JOHNS-MANVILLE	34
7R	VERMONT	72
7T	VERMONT	30
8S	VERMONT	22
7R	PHILIP-CAREY	72
SG	UCC (dry process)	79
HIGH PURITY ASBESTOS	UCC (wet process)	> 240

* TEST CONSISTS OF AGITATING 10 GRAMS OF ASBESTOS IN 210 ML. OF WATER FOR TEN SECONDS IN THE WARING BLENDOR. THE SLURRY IS THEN TRANSFERRED TO A 250-ML. GRADUATED CYLINDER AND THE VOLUME ADJUSTED WITH TAP WATER, INVERTED THREE TIMES, AND ALLOWED TO SETTLE FOR ONE HOUR. THE WET BULK VALUE IS THE LEVEL IN ML. OF THE SETTLED SOLIDS.

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TABLE 3

COMPARATIVE ADSORPTIVE PROPERTIES

PRODUCT	SOURCE	OIL (DOP) ADSORPTION ml. DOP/10 g	WATER RETENTION ml. H_2O/20 gms
7M 06	JOHNS-MANVILLE	4.4	13.2
7TF9	JOHNS-MANVILLE	5.0	14.5
7RF9	JOHNS-MANVILLE	6.3	19
FILLER GRADE*	UCC	7.2	22.0
STD. GRADE 130	UCC	9.2	27.0
STD. GRADE 144	UCC	9.4	28.0
STD. GRADE 210	UCC	10.7	32.3
HIGH PURITY	UCC	15.0	46.0

*Discontinued Production

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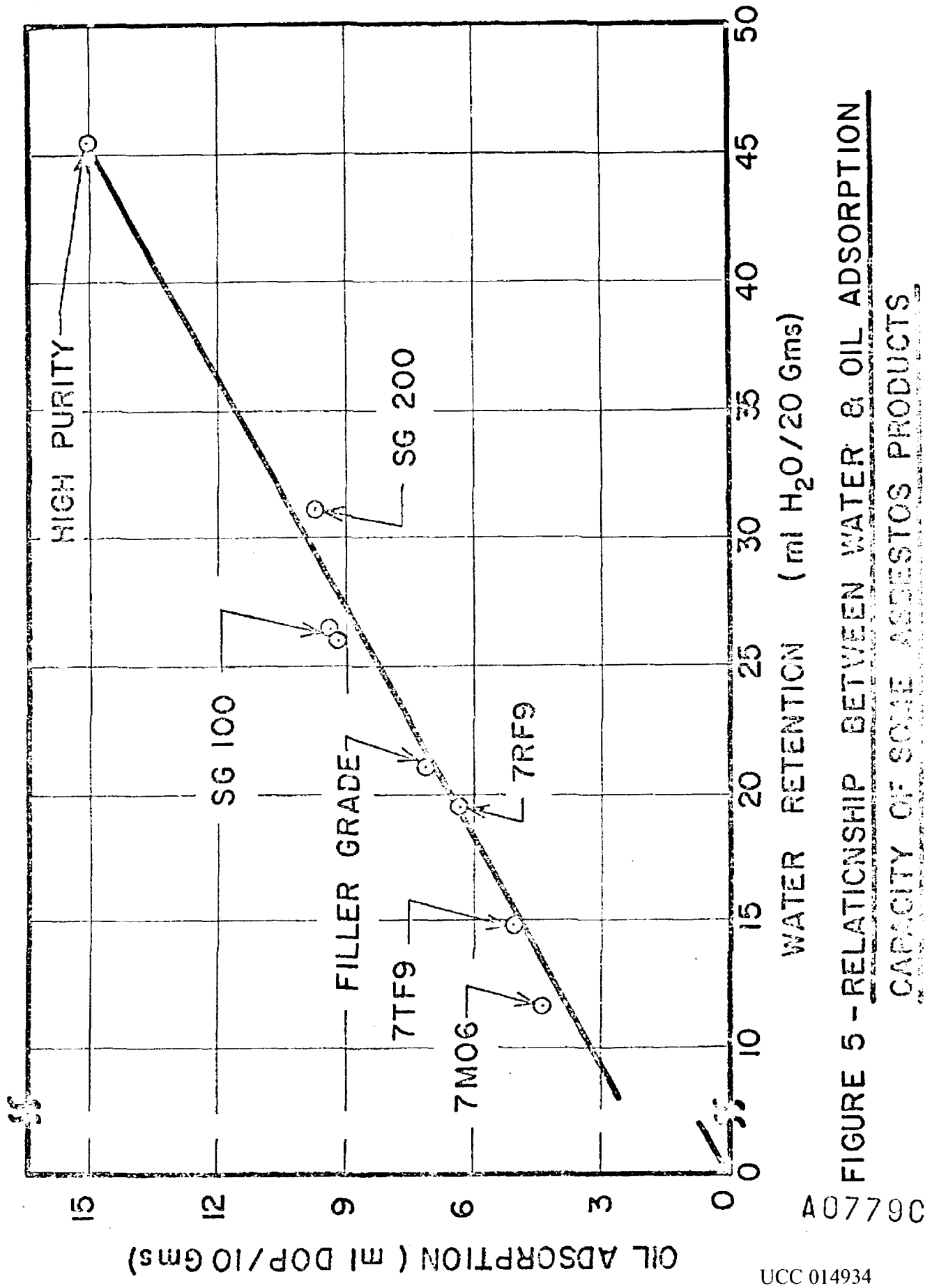


FIGURE 5 - RELATIONSHIP BETWEEN WATER & OIL ADSORPTION CAPACITY OF SOME ASBESTOS PRODUCTS

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In order to handle the UCC pellets directly, it was necessary to employ one step using high shear energy. Inasmuch as this energy was the same for all products, the values are considered relative. The results of this test are shown in Table 2. It is of interest to note the good correlation between the various commercial products as well as the relationship between the grades. The lower quality (and priced) products all show a lower wet bulk value as expected. Little or no settling was observed in the High Purity product, and this is attributed to its colloidal nature.

Another common criterion of asbestos shorts is the water and oil (DOP) adsorption capacity. In Table 3, some data are shown comparing UCC products with a variety of Canadian grades. Oil adsorption was determined by the mortar and pestle technique. The water retention value is the amount of water retained in the vacuumed filter cake obtained from a slurry of the asbestos product. With the UCC grades, both water retention and oil adsorption increase with the degree of refining. This would appear to hold true with the Canadian grades until the long fiber content of the product becomes high enough to affect these properties. It was also observed that a straight line relationship existed between these properties on all products tested. As shown in Figure 5, this relationship can be expressed as $y = 3.1x$ where y = water retention in ml. and x = DOP adsorption in ml./10 g.

These and other physical property tests point out the differences due to mineralogy of asbestos, as well as to the difference

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in processing techniques. It was decided to pursue these differences and our processing plant is designed to further enhance these particular properties. The objective is not to match the properties of commercially available chrysotile grades but rather to offer a line of products that possess their own unique characteristics and advantage for use in both conventional and specialized operations.

DEVELOPMENT OF NEW APPLICATIONS

The development of any new industrial mineral product is only one phase of its development. The next, and equally important phase, is the necessary market development. Because High Purity grades were not suitable, either technically or economically, as replacements for conventional short-fiber products, they required the development of new applications. The initial major efforts were directed at the paper industry and, to a lesser extent, to the plastics industry.

PAPER

Much has already been written and published on the subject of asbestos for uses in paper since 1965[7], [8], [9], [10]. During this period, Union Carbide's High Purity Asbestos was widely accepted as a wet-end additive to the paper furnish. This use employs the product's unique particle shape, surface charge, and surface characteristics for a broad range of applications. Paper mills throughout the United States, Canada, Europe, and Japan are using High Purity Asbestos for pigment retention, softness, pitch control,

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and for many uses specific to particular mills. During the past year, the Asbestos T-135 market has been growing rapidly as a TiO_2 extender and as a pigment in grades requiring additives for opacity. When used as specified in achieving opacity, its cost performance is superior to that of anything else available.

PLASTICS

Considerably less has been written on the application of the new Union Carbide Asbestos Products in Plastics - than in paper, but only because the development was started at a much later date. R-G144 has been commercially available since last year and is now approaching solid acceptance by the industry.

Resin Grade 144 is finding use primarily in two applications: as a thickener and thixotrope for resin viscosity control and as a strengthening additive for thermoplastics. For both uses, the colloidal nature of the product is essential. R-G144 has been particularly compatible with epoxies, plastisols, vinyl mastics, etc. Its thickening and strengthening efficiency has proven superior in these applications to precipitated silicas, both technically and economically.

Our newest product in the Resin Grade line, R-G244, is a specifically modified fiber for use as a thixotrope for low viscosity polyester resins. The resulting products have better thixotropic properties, longer shelf life, and can be clear and transparent. The relative thixotropic properties of R-G244, as compared to a leading silica thickener, are shown in Figure 6.

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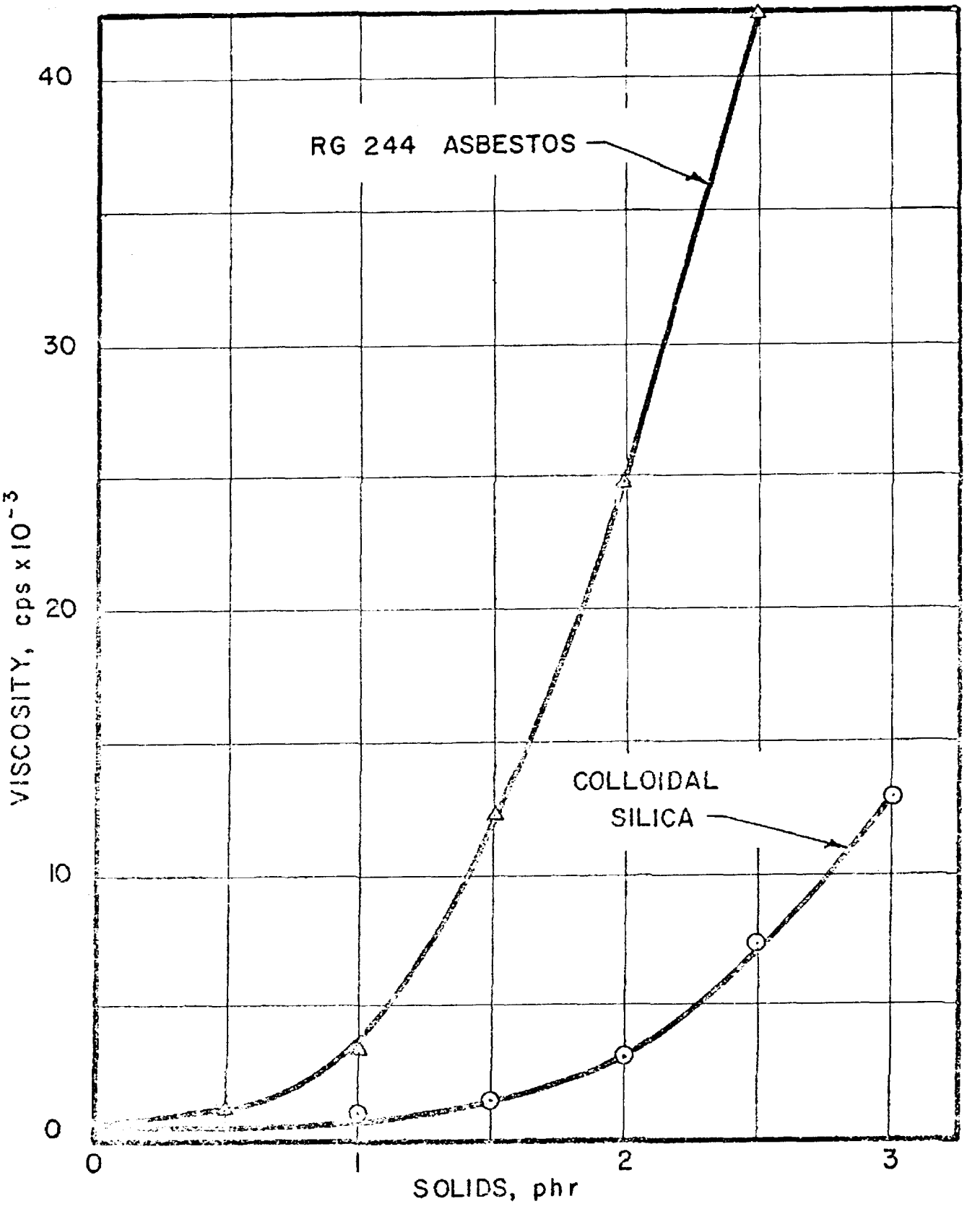


FIGURE 6 COMPARISON OF THICKENING OF POLYESTER RESIN BY RG 244 AND COLLOIDAL SILICA A07794

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As a strengthening additive for thermoplastics, R-G144 is undoubtedly unique. Table 4 lists some typical data obtained on plaques of a copolymer of vinyl chloride and vinyl acetate using various amounts of R-G144. Strength properties improved with R-G144 up to levels of 10 parts per hundred parts resin, as did the heat distortion temperature. At higher levels of asbestos, tensile drops off while modulus continues to increase. In another study on the same copolymer, the effects of Canadian short-fiber grades at the 10 phr loading were compared. These results are shown in Table 5. Except for a small increase in modulus, the Canadian asbestos added little to the strength of the filled plaque. Of even more significance, only the R-G144 product resulted in a clear, transparent plaque in contrast to the discolored, completely opaque plaques obtained from using the Canadian short fiber. This unexpected performance is the subject of a recent patent application.

OTHER APPLICATIONS

A variety of other applications have been developed employing the unique colloidal properties of this chrysotile. For example, the U.S. Patent Office has recently issued a patent(12) covering the use of High Purity Asbestos as a clarification agent in water and waste treatment. Laboratory and field tests show the asbestos to have a capability to attract and co-flocculate with the anionically charged particles. The resulting flocs settle readily and, as in the case of aerobic waste treatment, enhance the subsequent treatment steps.

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TABLE 4

EFFECT OF R-G144 ASBESTOS TO A COPOLYMER OF VINYL CHLORIDE AND VINYL ACETATE

PROPERTY	PARTS BY WEIGHT OF R-G144 PER HUNDRED PARTS BY WEIGHT COPOLYMER			
	0	5	10	20
TENSILE STRENGTH, PSI	7600	8800	9000	6700
TENSILE MODULUS, PSI x 10^{-3}	396	430	531	540
ELONGATION %	2	3	3	2
IZOD IMPACT, FT./LB./IN.	0.6	0.5	0.5	-
HEAT DISTORTION, °C	63.0	-	69.9	

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TABLE 5

EFFECT OF ASBESTOS TYPE ON A COPOLYMER OF VINYL CHLORIDE AND VINYL ACETATE

PROPERTY	TYPE OF ASBESTOS (10 phr)			
	NONE	R-G144	CAREY 7RF-9	JOHNS-MANVILLE 7R-06
TENSILE STRENGTH, PSI	7600	9000	7700	7800
TENSILE MODULUS, PSI x 10^{-3}	396	531	470	490
ELONGATION, %	2	3	16	6
IZOD IMPACT, FT. LB./IN.	0.6	0.5	0.5	0.5
HEAT DISTORTION, °C	63.0	69.9	64.6	63.3

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Another use that is expected to develop into commercial practice is thickening water slurries for fire fighting. Many of its properties make it ideally suited for this use, and the U. S. Department of Forestry has already approved it as a short-term retardant. Manufacturers of fire-fighting chemicals have combined High Purity Asbestos with their fire retardants and are actively developing a long-term retardant. U. S. Department of Forestry approval is expected shortly.

Other uses for colloidal chrysotile are now in the development stage, but their discussion is beyond the scope of this presentation.

FUTURE

Continued prosperity and growth in the asbestos industry depend upon the development of new applications and new products. Certainly, this is a requirement for all Industrial Minerals In a time of great technological advances, most industrial products must go through some transformation. It has become a necessary part of their life cycle. Competition by synthetic materials is a fact that must not be ignored. In-roads made by synthetics in the textile, rubber, and leather industry are poignant examples.

During its 90 years of growth, asbestos has become a $160 million a year industry, and it has been estimated that there are now over 3000 uses for asbestos. Thus, in the past, it can be said that its growth can be attributed in large part to the development of new applications employing conventional asbestos products. When

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Union Carbide elected to enter into the asbestos business, it was because we felt that an alternative route was open. In order to meet the demands of modern technology, our approach is to introduce new or modified products essentially tailored to its end-use application.

Our entry into the asbestos business was with a purified chrysotile product. This material, though chemically unmodified, was unique as a chrysotile fiber product. Because of the encouraging acceptance by industry of this grade, other new products were considered. With the development of a High Purity fiber, further modification has been simplified. This approach was chosen because of our strength in the field of plastics and organic technology. We have already discovered several new or modified products that are showing good market potential. Several more have graduated from the bench to the pilot plant stage and will be ready to add to the product line as soon as production capabilities permit. Examples of some of these modified products which are available in developmental quantities are (1) a hydrophobic fiber, (2) a chrysotile fiber with an electronegative surface charge, (3) an ion-free product, and (4) a chrysotile with modified light scattering properties. The objective is not to compete with commercially available asbestos products but rather to develop the applications that are now beyond normal product limitations. We are confident that the asbestos industry will continue its growth and that the need and demand for specialty chrysotile products will play an important role in this growth.

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FIGURE 8 - Ground View of UCC Mine Site

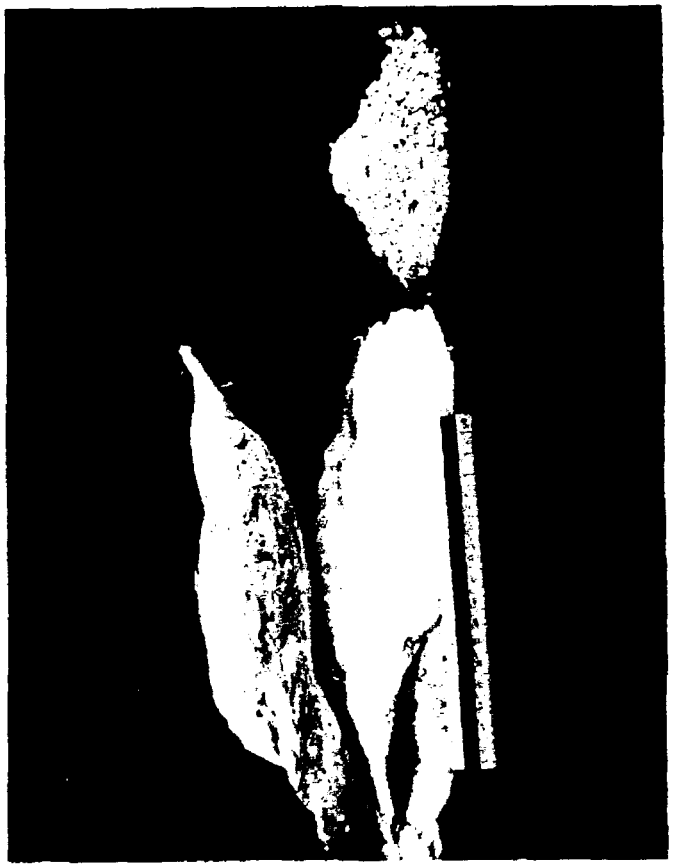


FIGURE 9 - Appearance of Ore Flakes



FIGURE 7 - Aerial View of UCC Mine Site

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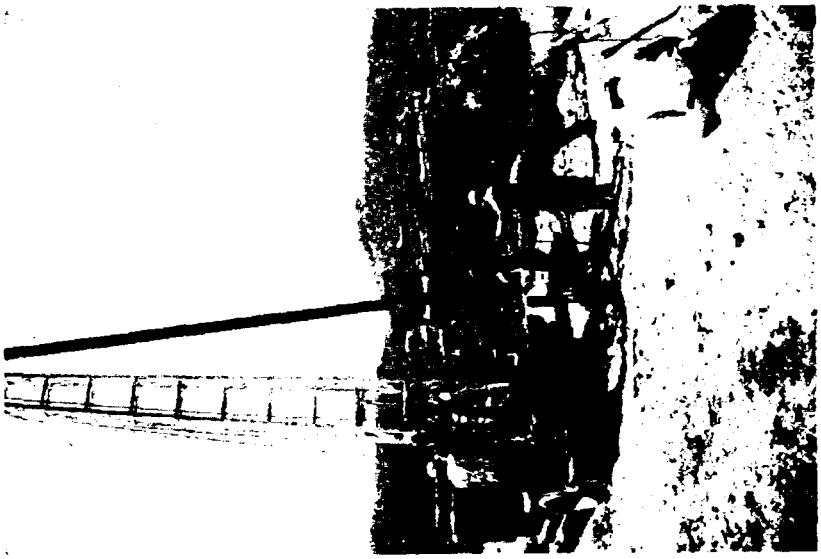


FIGURE 10 - Exploration Drilling



FIGURE 11 - Portable Screening Operation

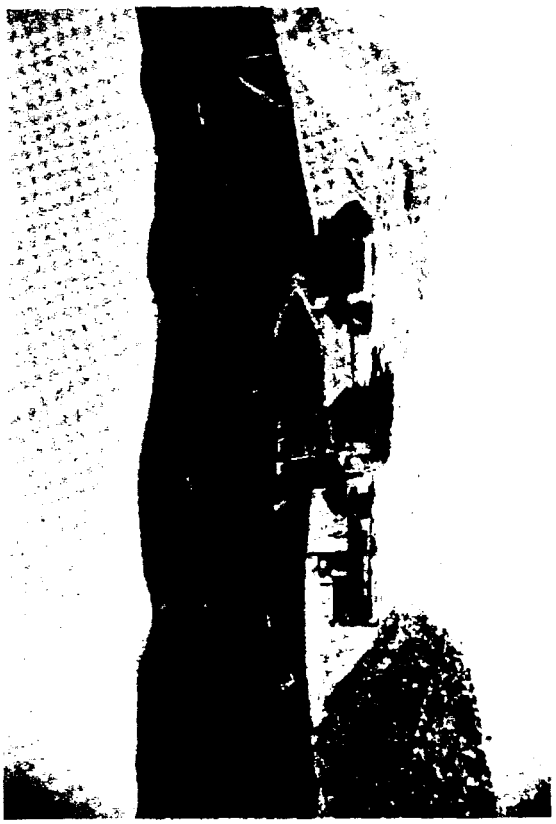


FIGURE 12 - Loading of Screened Ore

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