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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Region IV

FINAL REPORT OF MAJOR EXPLOSION DISASTER
NO. 1 INCLINE MINE
AMERICAN GILSONITE COMPANY
BONANZA, UINTAH COUNTY, UTAH

November 5, 1953

By

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Mining Health and Safety Engineer

A. C. Husted
Federal Coal-Mine Inspector

R. D. Reeder
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INTRODUCTION

A widespread gilsonite-dust explosion, that occurred in the No. 1 Incline mine (opencut) at Bonanza, Uintah County, Utah about 8:10 a.m. Thursday, November 5, 1953, killed eight mine employees, the only men in the mine at the time, and slightly injured three men working on the surface. Five of the eight bodies were recovered on November 19-20, 1953, 15 days after the explosion, two of the other three bodies were recovered early Friday morning, March 12, 1954, and the third body was recovered Sunday afternoon, March 14. Owing to the large open, unsupported wall area and the amount of debris that fell into the inclined shaft area, recovery of the last three bodies was delayed because a shaft had to be sunk 131 feet into solid ore and then a drift had to be extended 126 feet east along the strike of the vein to reach the inclined shaft where the three men were working at the time of the explosion and where the bodies were found. The explosion probably originated on the surface near the bucket elevator when a cloud of gilsonite dust, caused by a car of ore that had just been dumped, was ignited probably by electric arcing at the bucket-elevator enclosure, or from static discharge. The explosion was propagated throughout the entire length and depth of the mine.

GENERAL INFORMATION

The American Gilsonite Company owns and operates three gilsonite mines at and near Bonanza, Uintah County, Utah. One mine, the Eureka, is an underground mine in the Cowboy vein and the ore is mined by hand picking. The No. 1 Incline mine, in which the disaster occurred, is in the Little Bonanza vein and is about half a mile east of Bonanza. This No. 1 Incline

mine was originally part of an opencut mine and included what is called the Mc shaft mine (see appendix C, sketch of mine). The No. 2 Incline mine, another opencut, is immediately west of the No. 1 Incline mine, in the same vein. The No. 1 and No. 2 Incline mines were separated by a substantial pillar.

Prior to 1949 the ore from the Little Bonanza vein was mined underground from the Bonanza Nos. 1 and 2 mines, which were situated about half a mile west of the aforementioned opencut mines but they are not shown on the mine sketch (appendix C). These mines were abandoned following several bad explosions and fires, caused by blasting with permissible explosives and Cardox. The worst explosion and fire was in the Bonanza No. 2 mine on October 9, 1945. No one was killed or injured in the previous explosions because they happened when all men were out of the mine.

Blasting with permissible explosives was continued for some time after the opencut mines were started but was discontinued after several explosions and fires had occurred. Cardox was tried but it was abandoned also after an explosion occurred.

In 1951 both opencuts had become too deep for using slushers from the bottom to the surface and the method of mining was changed. A vertical shaft was sunk near the east end of the easterly opencut, now known as the Mc shaft, but it was not in operation at the time of the present disaster. An inclined shaft, 60 degrees from horizontal, was sunk from the floor of the easterly opencut and is now known as the No. 1 Incline mine. An inclined shaft was sunk also near the west end of the westerly opencut mine and is now known as the No. 2 Incline mine.

Bonanza, Uintah County, Utah is about 50 miles by road southeast of Vernal, Utah. Crude ore and ore from the preparation plant at Bonanza are trucked in bulk to Craig, Colorado, a distance of about 120 miles, where the company operates a bagging plant. Bagged ore and carload shipments of crude ore are shipped by rail from Craig over the Denver & Rio Grande Western Railroad.

The main office of the company is at 134 West Broadway, Salt Lake City, Utah, and officials of the company in Salt Lake City are: E. F. Goodner, President; R. E. Nelson, Production Manager; E. H. Owen, Secretary-Treasurer. Officials residing at Bonanza, Utah are: J. H. Baker, Superintendent; L. F. Williams, Mine Foreman; and G. A. Collins, Shift Boss.

The average daily production of ore from the three operating mines was 200 tons. Twenty-four men were employed at the No. 1 Incline mine, of whom 16 were employed underground. The mine was operated two shifts a day, 5 days a week, and normally 8 men worked underground on each shift.

The No. 1 Incline mine was opened by an inclined shaft, which was extended about 660 feet in a westerly direction on a dip of 60 degrees in the top part of the shaft and 57 degrees in the bottom part. The mine was equipped with a steel headframe, a single-drum hoist geared to an electric motor, and a 2-ton capacity, four-wheeled steel car having a track gauge of 66 inches. This inclined shaft was used for transporting ore to the surface, handling supplies including timbers, and for handling employees.

The strike of the Little Bonanza vein is about N. 60 degrees W., the dip is nearly vertical, and the thickness ranges from 9 to 11 feet. Both walls are of sandstone and stand well, except for a small area about 150 feet from the surface, midway along the opencut. This area had loosened somewhat and was supported by several bolts, which were holding the walls effectively. The systematic method of timbering consisted of setting stulls (props) on 5-foot centers, which were hitched about 4 inches into both rock walls. According to hitches observed along the walls where timbers had been dislodged, this plan was being followed.

Records show that no previous explosion had occurred in the No. 1 Incline mine but eight previous explosions had occurred in the company's other mines, including the opencut, caused by blasting, but no one was killed because blasting was done from the surface when all men were out of the mine.

MINING METHODS, CONDITIONS, AND EQUIPMENT

Mining Methods

The ore was mined by the open-stope underhand method, using stulls set on 5-foot centers vertically and horizontally for supporting the walls. Prior to stoping, the inclined shaft was extended below the floor of the old opencut stope for about 120 feet. Then the floor was benched by underhand drilling starting at the inclined shaft and eventually forming a gravity stope floor to the loading chute at the inclined shaft. After the 40-degree slope was obtained, successive cuts were made, starting at the shaft and progressing upwards on a 40-degree angle, thus lowering the stope floor from 6 to 8 feet for each cut.

Explosives

An Armstrong Airbreaker, manufactured by Armstrong Coalbreak Company, was used to blast the ore. The compressor unit was installed on the surface about 85 feet south of the Mc shaft (east of No. 1 Incline mine). It was grounded to earth in a salt solution. The surface air line was extended about 1,700 feet to No. 1 Incline mine and it was grounded to a water line at two separate places. It was extended into the mine about 400 feet vertically, along the north wall to the bottom of the opencut. A

300-foot air line had been extended up the west-side slope to a drill rig, consisting of a covered steel car propelled by a compressed-air tugger hoist and used by the drillers for protection from flying shells and for the transportation of drilling equipment.

A 50-foot length of copper tubing and a 25-foot length of rubber-jacketed tubing had been extended from the drill rig for connection to the shells. Seven shutoff valves had been installed in the air line between the compressor and the rig. Five insulated "safety" blocks had been installed in the air line: one at the compressor, one at the top of the opencut, one at the bottom of the west-side slope, one near the drill rig, and one near the end of the main air line. A release valve was installed at the end of the main air line for firing.

Two steel shells were available and when both shells were used, one shell was placed in a hole about a foot from one wall and the other shell was placed in the corresponding hole along the opposite wall. The tubes from the shells were extended to the main air line at the firing station. One tube was connected to the main line and the shell was filled with compressed air by opening the line valve until the air pressure ruptured the disc quickly and broke the ore. The tube was disconnected from the main air line and the other tube was connected and fired. Then the shells were carried to the next two holes where the blasting and breaking procedure was repeated. The use of two shells required about half the travel time between the firing station and the face as when only one shell was used.

It was the general practice to drill two rows of six holes from 6 to 8 feet in depth on 4-foot centers and not closer than 1 foot from each side wall. The holes were drilled with pneumatic-type drills equipped with rotary augers, and the holes were charged and fired separately. An air pressure of 6,000 to 8,000 pounds per square inch was necessary to rupture the disc and break the ore. This method of breaking the ore had been used only since May 1953. Blasting was done any time during the shift. Explosives were not used in this mine immediately before the explosion.

Ventilation and Gases

At the time of the explosion the mine was ventilated by natural means, approved by the State; however, a 3-foot centrifugal fan, operated exhausting, had been installed on the surface and 12-inch metal tubing had been extended into the mine for use when deemed necessary. Ventilating fans were not used underground.

Methane was released in very small amounts in this mine and, according to the management, methane in explosive amounts was never detected. An E-2 methane detector was provided at the mine but it had not been used for several years. Air samples had not been collected previous to the

explosion; however, air samples collected on July 25, 1945 in the nearby Eureka No. 1 mine and the Bonanza No. 2 mine showed 0.05 and 0.04 percent methane.

Oil or gas wells have not been drilled in the immediate vicinity of this mine.

Dust

The mine was very dry and, according to reports, dangerous quantities of gilsonite dust were present immediately before the explosion on the ledges, stulls, and walkways throughout the mine, with extra heavy accumulations of dust under the surface dumping station. The dust is dispersed easily in the form of a cloud in the air, which assists in its distribution.

Means were not used for allaying the dust. Rock-dusting was not practiced and mine dust samples were not collected.

Tests made by the Bureau of Mines indicate that more than 90 percent of added inert dust would be required to render the pure gilsonite dust nonflammable. The report giving the results of tests made of gilsonite dust is shown on appendix F.

Transportation

The gilsonite ore was loaded by gravity chutes into a four-wheeled car of 2-ton capacity and a 66-inch track gauge, and then transported to the surface through the inclined shaft by means of a hoist and rope. The ore passed by gravity from the slope faces to the loading chute in the inclined shaft and thence by gravity into the car. Men were transported into and out of the mine in this car.

Electricity

Electricity was not used in the mine, but it was used on the surface for operating the hoist, the belt conveyor, the ventilating fan (when operated), the equipment in the preparation plant, and for illumination. Electric power, received as 4,160 volts alternating current at the transformers (installed on a platform 12 feet above the ground) was transformed to 440 volts alternating current for power and 110 volts for illumination. All electric-light and power wires were in conduit.

Illumination and Smoking

The workmen used permissible electric cap lamps underground for portable illumination. Smoking was strictly prohibited in the mine. The underground workmen were hoisted to the surface for their noon lunch and

while on the surface they were permitted to smoke, as smoking was permitted on the surface but not in the preparation plant. Tobacco, cigarette paper, and matches were found in lunch boxes on the surface during the investigation.

Mine Rescue

Underground workers had not been trained in mine rescue as oxygen breathing apparatus was not provided. Four supervisors were trained in mine rescue about 4 years ago. The company has one all-service gas mask and 12 self-rescuers.

Excellent fire-fighting facilities and equipment were provided on the surface for the protection of surface buildings, and an ample supply of water was maintained for such purposes.

The source of water was a well at White River, 7 miles from the mine, from which the water was pumped to a 228,000-gallon reservoir about a mile from the mine. The water flows by gravity from the reservoir to the pump station, about 300 yards south of the mine. From the station the water is pumped through a 6-inch pipe line to the mine where the line is reduced to 4 inches. Taps, taken off the 4-inch line paralleling the mine at 100-foot intervals, were available for attaching the 150-foot lengths of 1-inch rubber hose, equipped with nozzles and mounted on reels. A fire hydrant for $2\frac{1}{2}$-inch hose is at the Mc shaft. Fire extinguishers (Carbon Dioxide type) were placed at each surface hoist.

STORY OF EXPLOSION AND RECOVIRY OPERATIONS

Activities of Bureau of Mines Personnel

Federal Coal-Mine Inspector T. H. O'Neal heard about the disaster during the 12:15 p.m., November 5, radio news broadcast and telephoned the news to the Salt Lake City office at 12:30 p.m. Mr. James Westfield, chief of the Health and Safety Division of the Bureau of Mines, Washington, D. C. telephoned to the Salt Lake office about 1 p.m. inquiring about the disaster and requested that at least two men be sent at once to the mine. R. D. Reeder, chief, Salt Lake City Office, Accident Prevention and Health Division, telephoned at 3:15 p.m. to E. B. Confer and T. T. Reay, Jr. at Kenilworth, Utah and instructed them to proceed to the mine. They left Helper, Utah at 6 p.m. via automobile and arrived at Bonanza, Utah about midnight. Federal Coal-Mine Inspector R. E. Evans left Grand Junction, Colorado at 6 p.m., after being notified by Mr. E. H. Denny, chief, Accident Prevention and Health Division, Region IV, of the disaster, and arrived at Bonanza, Utah at 10:30 p.m. He was at the mine when the first exploratory trip was made into the opencut at 11 p.m. by two men - the shift boss and a miner.

A conference of company officials, the chairman of the Industrial Commission of Utah, State inspectors, and R. E. Evans was being held in the company office at Bonanza when Messers Confer and Reay arrived. They joined the conference and offered their services.

It was evident, from surface observations of the violence of the explosion and from the report of the two men who made the exploratory trip into the opencut, that all eight men employed in the mine had been killed. No further recovery work was attempted Thursday night. On Friday, November 6, an investigation was made of the surface conditions, and again a conference of company officials and representatives of the Industrial Commission of Utah and Bureau of Mines was held. Witnesses (see appendix B for statements) were called for statements and interrogation regarding surface conditions immediately prior to the explosion. R. D. Reeder arrived at 11:40 a.m. and participated in the conference. A plan to retimber a part of the opencut and to enter the mine for recovery work was agreed upon by all present.

A. C. Husted of the Salt Lake City office arrived at the mine at noon, November 12, to relieve T. T. Reay, Jr., who left for his headquarters at Price, Utah. D. R. Ratkovich and R. D. Faddis of the Denver office and J. A. Zubal of the Salt Lake office arrived at the mine Monday evening, November 16; Mr. Ratkovich relieved Mr. Evans, who left for his headquarters at Grand Junction, Colorado. The aforementioned Bureau men, together with Messers Confer and Reeder, inspected the work of forming a shaft and ladderway from the surface, past a pillar, to the west slope of the mine, which progressed three shifts daily. They participated also in the recovery of the five bodies. They continued their search for evidence regarding the source and point of origin of the explosion. Bureau and State men were at the mine continuously from their first arrival until the five bodies were recovered on November 19 and 20. R. D. Reeder and E. B. Confer accompanied State and company officials on Tuesday, November 24, on an investigation of the west slope area where the five bodies were found. The delay in making this investigation was due to the building of a travelway of stulls, plank, and wire netting from the shaft to the face of the west slope, a distance of 126 feet.

The sinking of the shaft into solid ore, off the floor of the west-side slope, in search for the other three bodies was started on January 6, 1954, after the required equipment such as hoist, headframe, ore bin, and shaft guides were installed. The shaft reached a depth of 131 feet by February 3, 1954 and during that time periodic inspections were made by Bureau personnel. A **drift** was driven off the east side of the shaft (9 feet wide and 7 feet high) along the **strike** of the vein toward the inclined shaft. The **drift** reached the inclined shaft on February 27, 1954 and the bodies of the three men, working in that area prior to the explosion, were recovered - two on March 12 and one on March 14, 1954.

During the period from February 12 to March 14 one or more Bureau men, including Confer, Reay, Evans, Husted and Reeder, and State Inspectors Arnett and Phillips were at the mine to supervise recovery operations.

Mine Conditions Immediately Prior to Explosion

The weather on November 5, 1953 at Bonanza, Utah was partly cloudy, but no precipitation was recorded. Barometer readings were not taken. The high temperature for the day was 56 degrees, the low was 35 degrees, and the normal for the month was 35.2 degrees.

The mine normally operated two 8-hour shifts a day, 5 days a week and it was operating on the day of the explosion, including the preparation plant situated about half a mile from the mine. Ore, loaded on the second shift, was stored in the surface bin.

The opencut was ventilated by natural means, and preshift examinations of the mine were not made.

Story of Explosion

Four operations were in progress immediately before the explosion. They were as follows:

First operation: Five men were breaking gilsonite (ore) with compressed air at the face of the west slope of the opencut, under a pillar about 14 feet in vertical thickness and 126 feet long. Four shots were heard by Shift Boss George Collins, who was in the mine at the beginning of the day shift, but he did not visit the face of the west slope because of the blasting. It appeared, however, during the investigation of the west-slope face, after the five bodies had been recovered, that a fifth hole had been fired. The last shot that the shift boss heard was just a few minutes prior to the explosion. During the recovery work on the west slope one steel shell with the disc missing was found in the debris, indicating that it had been fired. The other steel shell was found, badly bent, in the next hole to be fired at the face, but the disc of this shell was in place, indicating that it had not been fired. A change of tubing to the air line from one shell to the other or a change of the air line may have been in progress when the explosion occurred.

Second operation: This involved three men in the mine who were rebuilding a loading chute in the No. 1 Incline at a place shown on map (appendix C). This operation had been visited by the shift boss only a few minutes before the explosion. He instructed the men to stay there until he returned. Generally only one man loaded the skip.

Third operation: A car of ore, the second hoisted that morning, was being dumped on the surface. The amount of fine ore and dust in this car was about normal. The ore passed through a grizzly onto a feeder to the bucket elevator (steel buckets attached to a belt), which hoisted the ore and dumped it into the bin from where it was transported by autotrucks to the preparation plant. The feeder to the bucket elevator was driven by compressed air, but according to reports the feeder and the elevator were not operating at the time of the explosion. A workman at the side of the grizzly in line with the south wall of the opencut was about to break large lumps of ore that did not pass through the grizzly when the flame appeared immediately in front of him. He turned and ran away. The hoistman stated that he was dumping the second car of ore when he saw flame between the hoist house and the elevator. He set the brake on the hoist and ran from the hoist room.

Fourth operation: A miner was working on the surface uncovering the air line about 25 feet from the elevator, with his back toward it, when he heard the noise of the dust ignition, turned his head, saw the flame at the elevator, and ran away.

A miner's helper stated that he was on the surface at the south side of the hoist house when he saw the flame about 3 feet from him. He thought the fire started at the elevator and then extended along the cut.

The shift boss stated that he was hoisted to the surface on the first car of ore hoisted and had walked about 1,350 feet along the opencut toward the No. 2 Incline mine when the explosion occurred. The flame, heat, smoke, roar, and flying debris on the surface were evidences of the explosion. These were witnessed by the shift boss and others, and the rumble of the explosion was heard at Rangely, Colorado, 32 miles away. No communications were made with the eight persons in the mine at the time of the explosion, and they were believed to have been killed instantly.

All timbers, walkways, track, and air lines in the mine, except possibly a half dozen stulls, were dislodged. An estimated million linear feet of timbers (stulls and lagging) were dislodged. Most of the timbers were ejected from the mine and scattered over a 2,000-foot area, mostly on the north side of the opencut. Some material was carried as far as three-fourths of a mile away. The pickup autotruck, which was parked on the surface alongside the hoist, was burned and destroyed. The ore bin, grizzly, and feeder under the dump were badly damaged.

The elevator and storage bin, which were badly distorted, fell to the ground and the hoist house collapsed. The enclosed electric switches in the hoist house were destroyed by the intense heat.

Recovery Operations

The explosion was followed by a fire in the mine, which was brought under control with water, piped to the mine and poured into the mine during the day. After the smoke in the opencut had cleared, two men - the day shift boss and an employee - were lowered about 250 feet into the opencut about 11:00 p.m. Thursday, November 5, for a period of about 20 minutes, to observe whether the five men, who were believed to be at or near the face of the west slope when the explosion occurred, were still alive. They did not see anyone but did notice that all timbers, except two, were missing from the area.

The area, in which the wall supports were removed, was V-shaped, 1,100 feet in length on the surface, 500 feet in depth at the vertex, and ranging from 9 to 11 feet in width.

With all the side-wall supports removed from the mine and with the hoisting facilities destroyed by the force of the explosion, it was considered too hazardous to enter the opencut until the vertical walls were supported in the area of travel and a travelway was installed. Falls of wall material were heard frequently and some loose walls were observed from the surface.

The shortest and quickest approach to the two groups of men in the mine was into the west slope where five men had been working. It was decided to form a shaft from the surface to the west slope, which would just pass the pillar, by hitching stulls, on 5-foot centers, into the side walls with four stulls to a set after the surface wash material was supported by timbered and planked retaining walls. The four stull sets were used to the pillar, and below the pillar they were reduced to three stull sets, which again were reduced to two stull sets near the bottom. At the bottom of the shaft the floor of the west slope was nearly clear of debris but about 50 feet up the slope a (jumbo) car had been caught, and loose ore, broken timbers, other debris and the five bodies had been lodged back of it.

The shaft bottom was reached Wednesday morning, November 18, and at 1:00 p.m. J. H. Baker, mine superintendent, L. L. Arnett, State mine inspector, John Clark, mine safety committeeman, and E. B. Confer, Bureau of Mines, inspected the area for the purpose of deciding on a plan to search for the bodies.

Since the slope at the shaft was clear of debris and no evidence of the bodies was observed, it was decided to search the area above the small steel (jumbo) car, which was used to transport drilling and blasting equipment to the working face. Stulls were set and a walkway was made from the shaft up the 40-degree slope. The car was secured to a stull and the debris was secured by other stulls and plank.

Three bodies were found in the debris immediately above the car at 2:45 p.m. Thursday, November 19, by R. D. Faddis, Bureau of Mines, J. H. Baker, mine superintendent, and two workmen. One body was recovered and loaded into a Navy-type stretcher by Baker and Faddis while they were wearing Chemox oxygen breathing apparatus; however, apparatus was not used after recovering the first body. The body was lowered to the platform at the bottom of the shaft and secured to the stretcher and hoisted to the surface at 6:25 p.m. In the meantime stulls were set to keep the debris from slipping, and walkways were extended to the other two bodies, which were lying nearby.

The fourth body was found in the debris at 7:00 p.m. and the fifth body at 3:50 a.m. Friday, November 20. The second body was hoisted to the surface at 8:25 p.m.; the third body at 12:45 a.m. November 20; the fourth body at 1:45 a.m.; and the fifth body at 4:30 a.m.

The morticians from Vernal, Utah arrived at 5:30 p.m. November 19 and removed one body from the mine immediately after it was hoisted to the surface. The second and third bodies were taken away immediately after the third body was hoisted to the surface. The fourth and fifth bodies were removed from the mine after the fifth body was hoisted to the surface. These bodies were transported to the mine office by company truck and transferred at 7:00 a.m. to the mortician's car.

The electric cap lamp batteries were numbered and these numbers were used in lieu of life check numbers. One cap lamp battery was found under a body but not attached thereto. The clothing and belts, with some exceptions, were missing from the bodies. The bodies were decomposed, and parts of the bodies were missing. A shoe and part of a sweater assisted in identifying two bodies. The body features helped to identify them by workmen who were acquainted with the men. Final identification of each body was made in the morgue at Vernal, Utah. Mr. O. A. Wiesley, chairman, the Industrial Commission of Utah, was present when the bodies were identified. He reported that the victims had only first-degree burns.

Prior to recovering the five bodies in the west slope area, plans were prepared by the company for extending the shaft into solid ore to a maximum depth of about 190 feet and for driving one or two drifts eastward along the strike of the vein to the inclined shaft where the other three men were working at the time of the explosion. The plan was approved by the Industrial Commission of Utah and by the Bureau of Mines

Following the recovery of the five bodies on November 19 and 20, 1953, work was started (three shifts daily on a 7-day week basis) toward recovering the other three bodies. All debris was removed from the floor of the west slope; the east side and the greater part of the west side of the shaft were enclosed with planks to prevent rock from the side walls

falling into the shaft; wooden guides were placed on the east and west sides of the shaft; a hoist, enclosed in a corrugated metal-covered building, was installed about 80 feet south of the shaft; a steel headframe, equipped with a sheave, was installed over the shaft; and a steel bin was erected on the north side of the headframe into which the ore, hoisted in a steel bucket (about 1,000-pound capacity) was dumped and from where it was loaded into trucks for transportation to the preparation plant, situated about half a mile away. Waste was hauled to a refuse dump near the mine.

A 3-foot centrifugal fan, connected by V-belts to a 440-volt alternating current motor, was installed about 85 feet east of the hoist house. Twelve-inch galvanized corrugated tubing was extended from the fan to the shaft and 10-inch corrugated tubing was extended down the shaft and into the drift. The fan was operated exhausting and the end of the tubing was kept within 10 feet of the working face. Much of the dust created during mining and loading operations was withdrawn through the tubing.

The sinking of the shaft in ore, off the floor of the west slope, was started on January 6, 1954. The shaft was 9 feet wide (full width of the vein) and 7 feet long. The ore was mined with compressed-air chipping hammers, fitted with pick-pointed bits, and loaded by hand into a steel bucket attached to the hoisting rope. Stulls, hitched into the sandstone side walls, were set 5 feet apart on the east and west sides of the shaft to support the side walls and the shaft guides.

When the shaft reached a depth of 131 feet in ore, February 3, (474 feet from the surface) a drift was started east off the shaft along the strike of the vein, toward the inclined shaft. The drift was 9 feet wide (full width of vein) and 7 feet high. Stulls were set every 5 feet near the roof of the drift and lagged the full width with planks to protect the workmen from roof falls. Track laid with 12-pound rails to an 18-inch gage was used for hand-tramming the bucket, set on a small four-wheeled truck, from the shaft to the face of the drift.

When the drift had been extended about 50 feet from the inclined shaft, three horizontal boreholes were drilled from the face of the drift to the inclined shaft to draw off the water poured into the opencut to extinguish the fire after the explosion. Three angled holes were drilled also in the roof of the drift into the west-side slope area. Water flowed through only one horizontal hole and one angled hole into the drift to the shaft bottom from where it was pumped to the surface. Advancement of the drift was delayed several days while the opencut was being unwatered. Over two hundred thousand gallons of water was pumped from the mine.

When the inclined shaft was reached, on February 27, 1954, an entanglement of woven-wire fencing, timbers, mud, loose ore, and planks

was found lying mostly above the roof level of the drift; however, there was an open space part way across the inclined shaft, on level with the drift. But the inclined shaft below the drift level was filled with another entanglement of planks, timbers, woven-wire fencing mixed with muck (loose ore, water, and mud). Stulls, spilling, and lagging (planks) had to be set to hold the material in place above the drift level.

The material was loaded by hand shoveling into the steel bucket. As progress was made downward along the inclined shaft, a compressed-air operated tugger hoist was installed to hoist the loaded bucket to the drift level. A double-steel block was fastened by chains to a stull set about 3 feet above the drift roof level, and a double-steel block had to be used at the bucket because otherwise the hoist could not raise the loaded bucket. From 20 to 30 buckets of ore, etc. were hoisted each shift. Usually three men worked underground on each shift (three shifts daily) and a hoistman on each shift on the surface. Workmen and supervisors rode down and up the shaft, standing on the steel frame above the shaft bucket.

Two of the three bodies were found about 12:50 a.m. Friday, March 12, lying close together on the floor of the inclined shaft. Most of their clothing, including shoes, were intact and their cap lamp batteries were attached by belts to their bodies; however, one man held in his hand the headpiece and lamp cord belonging to the third victim. The bodies were removed from the mine about 3:40 a.m. The body of the third victim was found Sunday morning, March 14, lying on the inclined slope, about 35 feet below the other two bodies. His clothing was intact and his cap lamp battery was attached by belt to his body; however, the lamp cord and headpiece was missing, indicating that it had been pulled off by the aforementioned victim. Evidently the men were killed by shock or by falling material as the bodies were not burned.

Evans was onshift when the two bodies were recovered early Friday morning, March 12, and State Inspector Phillips and Reay were onshift when the third body was recovered Sunday afternoon, March 14, 1954.

INVESTIGATION OF CAUSE OF EXPLOSION

Investigating Committee

The surface investigation of the disaster was started about 8:45 a.m. November 6 and completed the same day, and the underground investigation in the west-slope area was started at 1:20 p.m. November 24 and completed that same afternoon. No evidence of burning was observed in the inclined shaft area where the three bodies were found; however, the force of the explosion dislodged the timbers and ore chutes.

The names of the persons who made the surface investigation on November 6 are as follows:

The Industrial Commission of Utah	
Otto A. Wiesley	Chairman
James H. Phillips	District Coal-Mine Inspector
L. L. Arnett	" " " "

American Gilsonite Company	
E. F. Goodner	President
R. E. Nelson	Production Manager
J. H. Baker	Superintendent
L. F. Williams	Mine Foreman
G. A. Collins	Shift Boss

U. S. Bureau of Mines	
E. B. Confer	Mining Health and Safety Engineer
T. T. Reay, Jr.	Federal Coal-Mine Inspector
A. C. Husted	" " " "

The names of the persons who made the underground investigation on November 24 are as follows:

The Industrial Commission of Utah	
James H. Phillips	District Coal-Mine Inspector
L. L. Arnett	" " " "

American Gilsonite Company	
L. F. Williams	Mine Foreman
G. A. Collins	Shift Boss
Ivan Karren	Lead Miner

U. S. Bureau of Mines	
R. D. Reeder	Chief, Salt Lake City Office
E. B. Confer	Mining Health and Safety Engineer

Messers Reay, Evans, Ratkovich, Faddis, and Zubal of the Bureau assisted materially in the gathering of the data on which this report is based.

Immediately following the surface investigation on November 6 Mr. Wiesley called a meeting of representatives of the Industrial Commission of Utah, the American Gilsonite Company, and the Bureau of Mines. After a brief discussion of the disaster, witnesses were interviewed regarding the explosion (see appendix B). Mr. Wiesley then prepared a statement regarding the disaster (see appendix G).

Underground Investigation

During the underground investigation on November 24, the west-slope face area was observed closely, particularly the remaining evidence as to drilling and blasting procedures, for information regarding the work in progress immediately before the explosion.

The melted gilsonite coating on the walls had diminished toward the face of the west slope and it was almost nonexistent at the face, except that coked gilsonite was observed in four of the blasting holes at the face. According to reports the holes along the slope for breaking the ore were drilled 6 to 8 feet deep, but the holes at the face, at the time of the investigation, were from 3 feet 10 inches to 4 feet 9 inches deep. There were 11 holes at the face which were not blasted, but a borehole along the right wall had been blasted. This was the opening hole of the cut and it broke the ore very well. The holes of the previous cuts also broke the ore very well. A compressed-air shell (8 feet long and badly bent) was in the adjoining hole but only 2 feet of the shell was in the hole. The shell contained a disc, which indicated that it had not been discharged, but the tubing to the shell was missing. The other shell, the car (jumbo), tools and compressed-air lines had been moved by the force of the explosion and were broken badly.

Some of this material was found on the floor of the west slope, and it was hoisted to the surface for inspection. This material, which was examined on November 24, consisted of an electric cap lamp with cable to headpiece disconnected, a bent 10-inch crescent wrench, a broken compressed-air drill, two air-line valves used in connection with breaking ore, and a steel shell without a disc.

Explosive Gas

Methane had not been detected in this opencut mine. Permissible flame safety lamps were not taken into the mine, by order of the Industrial Commission of Utah, because the gauzes clogged quickly when the lamps were in dusty atmospheres and the gilsonite dust, which contacted the heated gauzes, melted to the extent that it spread over the gauze openings and closed them, thus impairing the use of the lamp. State mine inspectors made bimonthly inspections of the mine in 1952 and in 1953, before the mine was idled because of labor difficulties. Analytical results of the three air samples collected during the underground investigation are shown on appendix E. One sample showed no methane and each of the other two samples showed only 0.01 percent methane.

Dust as a Factor in the Explosion

Witnesses of the disaster on the surface stated that flame of the burning dust was observed at the dumping station and elevator, then along the entire length of the opencut and for a considerable distance on both sides of same. The evidence observed during the investigation indicated that this was purely a dust explosion. Reportedly large accumulations of gilsonite dust were present on the timbers and walkways, with the heaviest accumulations under the surface dump, which was directly over a part of the opencut, permitting dust from the dumping operation to enter the mine. Water was not used to allay the dust. The mine was not rock-dusted and mine dust samples were not collected.

The relative flammability of mine-size gilsonite dust is 90 percent. The minimum explosive concentration for minus 200-mesh gilsonite dust is 0.020 ounces per cubic foot. (See appendix F)

Flame

A small frame building on the surface, 145 feet from the cut, with corrugated sheet-metal sides and an asphalt roof was badly scorched. The heat caused the asphalt (tar) to melt and run.

The fire in the mine, which followed the explosion, was along the east slope, and it was brought under control with water. Other evidences of flame in the mine were charred timbers and burnt clothing of men working in the west-side slope. Melted gilsonite was deposited as a heavy black coat on all the timbers, plant, metal materials, and all walls of the opencut that could be inspected. The flame appeared to have diminished considerably at the face of the west slope, where a hemp rope tied to a compressed-air shell in a shot hole was only slightly scorched. The hitches in the walls to support the stulls (timbers) near the west slope face showed considerable deposits of melted gilsonite on the side of the hitch toward the face, with little or no deposit on the side away from the face.

Forces

A large amount of the mine timbers, walkways, and some track material, including a 15-foot length of 40-pound rail, were blown from the opencut. The material ejected from the mine consisted of broken and full length stulls, fragments of timbers, and it covered an area for 2,000 feet on each side of the opencut, with some material being carried as much as three-fourths of a mile away, indicating that a tremendous force was exerted toward the surface.

Melted gilsonite was deposited in the side of the hitches nearest the face of the west slope, while the opposite side of the hitches showed

little or no deposit of gilsonite, which indicated that the force of the explosion was toward the face. The hitches, about 4 inches deep, were cut in the walls to support the stulls. Burning was not detected in inclined shaft area. Timbers in the east side of the opencut near the Mc shaft were intact.

The car (jumbo) had slid down the opencut about 50 feet where it was caught in a mass of bent air pipe. This blocked the five bodies, ore, and debris from sliding farther down the 40-degree slope.

Evidence of Activities

The shift boss stated that he had entered the mine with the eight men at 7:30 a.m. November 5, and had stopped where three workmen were preparing to rebuild a loading chute. He had planned to visit the other five employees, who were working in the west slope, but he heard shots and decided not to travel there while blasting was in progress. He returned to the surface on a loaded car, the first car hoisted during this shift, and walked along the opencut toward the adjoining mine, a distance of about 1,350 feet, and stopped to talk with a workman, when the explosion occurred, during the unloading of the second car of ore. The workman at the grizzly stated that the elevator had been started that morning, but that it had been stopped before the explosion occurred. A workman was uncovering an air-line valve, about 25 feet from the elevator, and the hoistman was at the hoist controls in the hoist house, when the explosion occurred.

Origin and Cause of Explosion

The destruction wrought on the surface and underground by the explosion, the intense heat generated by the burning gilsonite dust, and the deposits of melted gilsonite over wrecked equipment, buildings, and all surfaces generally made it impossible to determine the point of initial dust ignition or the exact source of the dust ignition.

The writers consider that the flame observed by the several employees before the explosion definitely fixes the origin of the explosion to be on the surface. They believe that the ignition source was an electric arc, either from a short in the electric equipment or from static discharge. Although no evidence was introduced as to smoking at the opencut at the time of ignition, apparently no rules had been adopted pertaining to smoking on the surface, except in the preparation plant, and therefore the possibility of ignition by a match or a lighting device cannot be entirely ruled out.

The ignition of the dust cloud present on the surface and in proximity to the top of a portion of the opencut developed sufficient heat, flame, and pressure to raise into suspension the dust on timbers and surfaces in the opencut with the resulting extension of the explosion throughout the mine and back to the surface.

The evidence observed during this investigation indicated that this was purely a dust explosion. A blast, which resembled a heavy shot of explosives, was heard and this was followed almost instantly by a roaring sound of the terrific explosion.

Possible sources of ignition considered during the investigation are as follows:

1. Breaking ore with compressed air was in progress immediately before the explosion, and the possibility of a flying shell from a blast striking another metal object or the sandstone wall, thus causing a spark, was considered; or, a change in the compressed-air line may have been in progress. Reportedly electric arcs have been seen in the mine when metal pipe lines were brought together or were separated. If the ignition had been underground, the persons on the surface at the opencut, especially the hoistman and the grizzly attendant, who were directly over the opencut when they saw the flame, could not have escaped the explosion.

2. Smoking tobacco, cigarette papers, and matches were found in the lunch boxes at the hoist. Reportedly smoking was practiced during the lunch period in or at the hoist house. The shift boss stated that he believed smoking was not practiced underground. No direct evidence of smoking was observed.

3. A pickup truck was parked about 25 feet from the elevator when the explosion occurred. When examined the truck was in gear and since no person was in the truck it is evident that the engine had been stopped.

4. Two open-type electric heaters were installed and were in operating condition in the hoist house near the hoistman when the explosion occurred. An open-type motor was used to operate the hoist, and the switches in the hoist house for the hoist, elevator, and lights were of the enclosed type. Undoubtedly the dust cloud in the hoist house was of insufficient density to be ignited by the heaters, hoist motor, or power switch. The hoistman stated that the flame was observed first between the hoist house and the elevator, which would indicate that the ignition did not start in the hoist house.

5. An electric light of dusttight construction was installed in the headframe over the car dump in a dusty place. This electric light was broken when observed during the investigation and its condition prior to the explosion could not be determined.

6. A remote-control switch was attached to the bucket-elevator enclosure about 4 feet above the walkway, and it was used to start and stop the elevator. The magnetic starter switch for the elevator motor was in the hoist house and the motor was at the top of the elevator, about 40 feet

above the surface. The contacts of the remote-control switch, when examined, were "frozen" in the off position and the wiring was in conduit. The sleeve in the conduit, an inch from the switch, was half-broken, crosswise, and completely separated. The dense dust cloud, produced while the car of ore was unloaded, spread around the elevator where probably it was ignited by an electric arc at the broken conduit. This break in the conduit had not been observed before the explosion; but, if the break had occurred during the explosion, the switch probably would have been broken off. The intense heat burned the switch contacts and the wires in the conduit near the switch. The switch lever was stuck in the housing and it could not be moved. The elevator motor casing when examined was found in good condition, except that it was blistered badly from external heating. This type motor was inspected for hazardous locations by Underwriters' Laboratories, Inc.

Spread of Explosion

The flame and the forces of the explosion extended through the entire mine and to the surface.

Summary of Evidence

Conditions observed on the surface and underground during the recovery operations and the investigation following the disaster, together with statements of witnesses provide evidence as to the cause and probable origin of the explosion. The evidence, from which the conclusions of the Federal investigators were reached, is summarized as follows:

1. The flame was observed first between the hoist house and the elevator.

2. The first direction of travel of the flame was from the surface into the mine.

3. Flame and forces of the explosion extended throughout the mine and then to the surface.

4. The force of the explosion was at the maximum in the mine directly underneath the dumping station, which indicates that large accumulations of fine dust had been deposited in the area.

5. The open-type electric equipment in the hoist house, the electric light in the headframe, the electric motor at the top of the elevator, the remote-control switch on the elevator enclosure, and the electric-light and power wires were recognized as possible sources of ignition on the surface.

6. The ore was broken off the solid with compressed air released from a shell by a ruptured disc. The shot firer closed the line valve to

shut off the air after the shell was discharged. Electricity was not required to perform the blasting. The compressor and the air line were grounded on the surface, and insulator blocks were used in the line underground. The length of the line underground was about 700 feet. A reinforced rubber hose was used next to the shell in the air line between the operating valve and the shell.

7. The five bodies, when found, were grouped in a 25-foot space on the 40-degree slope directly underneath the firing station, which indicated that they were close together when the explosion occurred. The other three bodies were also close together when found in the inclined shaft area.

8. All materials in the mine were coated with melted gilsonite; the coating diminished toward the face of the west slope and it was nearly negligible at the face. Evidence of burning in the inclined slope area, where the three bodies were found, was not observed.

9. Since the equipment in the mine was wrecked so badly, its condition before the explosion could not be determined.

RECOMMENDATIONS

The prevention of dust explosions in this mine involves measures to eliminate the possibility of dust, capable of igniting by arc, flames or sparks and measures to minimize the possible sources of flame or arc.

It would be possible to minimize hazards by mining only by hand methods and sacking the ore near faces, with small production from a number of small operations, and hauling and hoisting methods geared to such small production. Surface operations could be so situated and conducted as to make impossible the extension into the mines of any surface-dust ignitions.

It is assumed, however, that the continuation of mining operations on a large scale by opencut is desired. To continue such operations without continued hazard of large-scale explosions, measures are needed to prevent the formation of dust clouds both on the surface near the opencut and underground and to minimize danger of arcing, flame, or sparks in places where dust clouds might conceivably occur on the surface near the mine or in the mine. Such measures to reduce ignition hazards would include frequent testing as to adequacy of grounds used on surface and as to possible stray current and static accumulations underground. The following recommendations are made accordingly:

Dust

1. Gilsonite dust should not be permitted to accumulate on the ledges, timbers, and walkways in the mine. The ledges, timbers, and walkways, where dust concentrations are present, should be washed down daily.

2. The dust from the dumping operation on the surface, which was directly over the mine opening, should not be permitted to re-enter the mine; the opening near the dumping operation should be covered or other effective means employed.

3. A positive ventilating system should be devised for the underground workings, which will remove dust, as produced in face workings and at loading stations, directly to the surface.

Electricity

1. Electrical equipment should not be used near any mine opening where it might cause an ignition of airborne dust that could be propagated into the mine.

2. Metal pipe lines in the mine should be grounded effectively to guard against arcing from stray currents and static electricity. These grounds should be tested frequently by a competent person to determine their effectiveness.

Autotrucks

1. Autotrucks should not be operated near any mine opening where the exhaust could ignite airborne dust and propagation extend into the mine.

Smoking

Smoker's articles should not be taken to the mine and smoking should not be permitted on the surface near the mine and particularly not near places on the surface where clouds of dust may occur, such as at or near dumping operations.

Mine Examinations

The mine should be examined for methane and other hazards within 4 hours immediately before the first ore-producing shift each day.

Static Electricity and Blasting

1. Tests should be made to determine whether static electricity can ignite gilsonite dust.

2. Tests should be made to determine whether breaking the gilsonite ore with compressed air can ignite the dust.

ACKNOWLEDGMENT

The writers acknowledge the courtesies extended and the help given by the officials of the American Gilsonite Company representatives of the Industrial Commission of Utah, and the mine employees who gave, without reservation, all information requested in connection with this investigation.

Respectfully submitted,

/s/ E. B. Confer

E. B. Confer
Mining Health and Safety Engineer

/s/ A. C. Husted

A. C. Husted
Federal Coal-Mine Inspector

/s/ R. D. Reeder

R. D. Reeder
Chief, Salt Lake City Office

Approved by

/s/ James Westfield
Chief, Health and Safety Division

APPENDIX A

VICTIMS OF EXPLOSION, NO. 1 INCLINE MINE
AMERICAN GILSONITE COMPANY
BONANZA, UINTAH COUNTY, UTAH

November 5, 1953

KILLED

Name	Age	Occupation	Years experience	Dependents
Ulis Elven Harper	42	Mine helper	6 mos.	3
John Orval Smuin	30	Mine helper	5 yrs.	-
Glenn W. Jackson	37	Miner	3 "	9
Jay Var Timothy	20	Mine helper	1-3/4 yrs.	-
Hal Leonard Cook	26	Certified miner	3½ yrs.	4
Kenneth Ray Richins	25	Miner	3 "	1
Joe K. Baker	24	Mine helper	5 mos.	2
Everett Goodrich	31	Laborer	2½ yrs.	-

Names listed in the order of recovery. Bodies of first five men were recovered November 19-20, 1953. Bodies of the sixth and seventh men were recovered on March 12, 1954. Body of the eighth man was recovered on March 14, 1954.

INJURED

Name	Age	Occupation	Years experience	Nature of injuries
Lloyd Smuin	28	Miner (on surface at time of explosion)	10 yrs.	Serious back burns
Charles Bowden	49	Elevator operator	10 yrs.	Face burns
Orman Stevens	33	Hoistman	6 yrs.	Cracked ribs

APPENDIX B

STATEMENTS OF WITNESSES

Marlo Bowthorpe, Miner:

"I met George Collins, the shift boss, who was talking about shooting so early on the shift. He was putting an auger on drill No. 2 mine, preparing to go into the mine.

"We were 1,350 feet from the head house at No. 1 Incline cut when the explosion occurred. I saw flame in the material of the cut, and the flame was 20 feet in the air, when smoke came out of the drift. I do not know whether flame was in the hoist station.

"I heard two shots and 4 minutes later saw the flame."

When questioned, Mr. Bowthorpe stated that he had seen static arc when touching two pieces of metal together. He had never seen an arc while breaking gilsonite with compressed air. He stated also that a compressed-air shell, when flying and striking a wall or metal, would throw sparks.

George A. Collins, Shift Boss:

"After hearing two air shells explode, I left the lower crew of three men pulling a newly constructed chute, approximately 70 feet above bottom of No. 1 Incline.

"On reaching the surface on the skip I heard two more shells explode. After talking a few words with two men who were preparing to install another high-pressure line, I started to walk along the opencut with another miner, Marlo Bowthorpe.

"At almost reaching No. 2 Incline hoist house, I heard a sharp report, and looking back saw flames near No. 1 hoist house. At this instant there was a tremendous shaking and noise. The air was all timber and smoke.

"I told Bowthorpe to get the crew at No. 2 workings. I back-tracked toward No. 1 Incline to check on the men close to the No. 1 hoist house and to man the water hose."

Norman Fletcher, Mine Helper:

"I was at the side of the hoist house when the explosion occurred and was 3 feet from the flame. I do not remember hearing any shots that morning."

Mr. Fletcher stated that he saw the flame beside him; thought flame started at the elevator; later thought flame was all around the cut. Never saw any arcing in the mine.

Charles Bowden, Elevator Operator:

"I was standing at the hopper at the No. 1 opencut slope; the skip of ore had just been dumped. Excessive amounts of fine gilsonite dust were suspended into the air. I heard a puff and observed smoke and fire. I immediately started to run toward the large stock pile of ore when I was hit on the right shoulder by a piece of timber, which I believe came from the second blast. I also received severe burns to my face. I do not believe the flames came from the bottom of the mine.

"I was employed on the day of the explosion to break large pieces of ore and to run the elevator at the top of No. 1 Incline shaft."

Lloyd Smuin, Miner:

"I was uncovering valve in air line, near the No. 1 Incline hoist, with my back to the wall. I heard a noise, looked around and saw the flame of the burning dust. I then ran over the bank of the refuse. I saw the flame at the elevator but not in the material of the cut."

When questioned, he reported that he had seen compressed-air shells blow out of the blasting holes and that he had seen sparks off a rock wall when hit with a pick. He further expressed opinion that the explosion possibly was started by a flying shell hitting a metal car or wire cable.

Orman Stephens, Hoistman:

"I hoisted and was dumping the second load of ore that morning when I saw a flame between the hoist house and the elevator. I set the brake of the hoist and ran from the hoist house. I first took shelter under the transformer station. When timbers began to fall around me, I ran a short distance farther and went into a small building to protect myself from falling material. The heat drove me out of the building and I went behind the building."

When questioned, he stated that black clouds of dust were raised into the air along the dump station while dumping ore. He stated that he heard a shot in the mine while unloading this car of ore, but that he did not hear the shots while the hoist was running. He stated further that he was bothered with static on the telephone.

APPENDIX D

PROPERTIES, OCCURRENCE, AND MINING OF GILSONITE 1/

Gilsonite, named after Samuel H. Gilson (who became interested in asphaltic deposits), occurs in the veins in a solid homogeneous mass and breaks with a conchoidal fracture. Even in the minutest pieces the brilliant fracture is preserved. Long exposure to the weather causes it to lose this brilliant black luster and it becomes dull and black. Occasionally it has a fine columnar structure at right angles to the walls. This is called "pencillated" ore and is frequently found on both sides of the vein. The veins crop out on hilltops but elsewhere the ore is covered with 15 feet or more of soil.

"The surface ore melts at about 400° and is used principally as a saturant of felt in the manufacture of roof and floor covering. Select ore will melt at 275° F. and is used in the manufacture of high-grade paints, varnishes, inks, and electric insulation. Although gilsonite lacks any elastic properties, it makes a varnish whose elasticity is remarkable. A thin piece of tin coated with good gilsonite varnish may be bent repeatedly without the coating being cracked.

"Gilsonite is closely related to wurtzilite or elaterite and to ozocerite, which are also found in the Uintah Basin. A kindred hydrocarbon, grahamite, is found in Oklahoma. Gilsonite is a black tarrylike substance with a brilliant luster. Its specific gravity is 1.035, its hardness is 2, and the streak on a porcelain plate is brown. It is exceedingly brittle and during mining gives off clouds of chocolate brown dust which softens under the heat of the body and is very penetrating to the skin. It is insoluble in water and removed from the body with difficulty. It is not affected by acids but is soluble in carbon disulfide, turpentine, carbon bisulfite, heavy oils, and fats."

Its average composition, according to the American Gilsonite Company, are:

Composition of Gilsonite

	Percent	
	Bonanza mine	Eureka mine
Carbon	84.28	85.20
Hydrogen	10.45	9.75
Sulphur	0.30	0.48
Nitrogen	0.85	2.19
Oxygen	3.44	1.76

1/ Quotes from Bureau of Mines Information Circular 6069 by Fene, W. J. entitled "The Mining of Gilsonite in Utah."

APPENDIX D (Contd.)

EXTENT OF DEPOSIT

"The Uintah Basin is approximately 170 miles from east to west and 100 miles from north to south. It is bounded on the west by the Wasatch Mountains and extends into Colorado about 50 miles in the direction of Meeker. On the north it is bounded by the Uinta Mountain and on the south by the Book Cliffs. This area of some 15,000 square miles contains a storehouse of asphaltum, asphaltic sandstone, and oil shale so large that expressed in figures it is staggering. The basin is a syncline formed by the upbending of the strata against the Uinta Mountains and is cut through the center by the deep gorge of the Green River which flows towards the south."

THEORY OF ORIGIN

"...The most plausible theory appears to be that the formation of this great synclinal basin resulted in gigantic cracks in the brittle and nonelastic sandstone measures of the Uinta formation with enough heat to distill the oily matter in these carbonaceous measures from the underlying Green River shales."

USES OF GILSONITE

"The higher grades of gilsonite are made into varnish, paint, electrical insulation, and inks for rotogravure sections of newspapers. The intermediate grade is used for such articles as telephone mouthpieces, switch handles, and knobs and buttons of various kinds. The poorer grade is used in the saturation of felt.

. . . . . .

"A very small amount of foreign matter in a shipment of select ore will render it unsuitable for varnish so that the utmost care must be taken to prevent chips or rock or grains of sand from getting into the high-grade ore."

MINING METHODS

"The ore crops out in the surface where mining is started and progresses inward and downward, all of the ore of the vein being removed. In working, a system of slopes and benches is used.

"...The ore is very brittle and a sharp pick can be driven into it easily. Trenches about 18 inches wide are dug along each side wall, thus releasing the pressure on the center of the mass so that the ore expands and breaks out of itself or can easily be picked out...."

The mining of gilsonite now requires an elaborate surface plant for preparation. The gilsonite ore is screened and washed with water to remove foreign material. It is hauled in bulk to Craig, Colorado, where it is sacked and shipped by rail to market.

Mining in the No. 1 Incline mine was changed from hand picking to drilling holes in the vein with compressed-air drills and augers, using permissible explosives for blasting. The permissible explosives were replaced later with Cardox. Blasting with explosives and Cardox had the disadvantage of delays because of travel time before and after blasting. As many as 50 holes were blasted at a time with permissible explosives, causing dust ignitions quite frequently. Breaking the ore with compressed air, while men were in the mine, was started in May 1953, and it was used until the explosion on November 5, 1953. The company is considering a hydraulic method of mining whereby the ore will be loosened by a stream of water under pressure, and it will be raised to the surface by a flow of water in a pipe line.

APPENDIX E

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
MINE ATMOSPHERE ANALYSIS REPORT

Mine American Gilsonite Operator American Gilsonite Company Bed Gilsonite
State Utah County Uintah Town Bonanza Collector E. B. Confer

Bottle No.	C-8599	C-8088	C-8896	
Laboratory No.	1929	1930	1931	
Kind of sample	Sample collected in Gilsonite mine during investigation following explosion.	Sample collected in Gilsonite mine during investigation following explosion.	Sample collected in Gilsonite mine during investigation following explosion	
Location in mine	No. 1 Incline, face of West slope	No. 1 Incline, face of West slope	No. 1 Incline, face 20 feet above bottom new shaft.	
Date and hour sampled	11/24/53 1:45 p.m.	11/24/53 1:55 p.m.	11/24/53 2:20 p.m.	
Air quantity				
Pressure on seal				
Barometer (inside)				
Carbon dioxide (CO_2)	0.03	0.10	0.03	
Oxygen (O_2)	20.93	20.85	20.93	
Hydrogen (H_2)				
Carbon monoxide (CO)	0.000	0.000	0.000	
Methane (CH_4)	0.00	0.01	0.01	
Nitrogen (N_2)	79.04	79.04	79.03	

Date December 1, 1953 (Signed) Albert Maxian, Chemist

APPENDIX F

REPORT ON LABORATORY INFLAMMABILITY TESTS OF GILSONITE DUSTS FROM BONANZA NO. 2 MINE, BARBER ASPHALT CORPORATION BONANZA, UTAH[b/]

August 27, 1945

At the request of Mr. E. H. Denny, supervising engineer, District H, Bureau of Mines, Salt Lake City, Utah, chemical analyses and inflammability tests were made on four samples of gilsonite collected by Mr. A. W. Worcester, mining engineer, Bureau of Mines, in the Bonanza No. 2 mine of the Barber Asphalt Corporation, Bonanza, Utah. The results of the tests are summarized in this report.

Description of Samples

The samples will be referred to by laboratory numbers assigned by the Experimental Coal Mine Section. From a letter by Mr. Worcester to Mr. Denny, dated July 28, (copy received in Pittsburgh on August 2) the following information was obtained concerning the sampling method and location:

Sample No. 1199: A sample of solid gilsonite taken from the back of No. 1 slope, block No. 3, in the Bonanza No. 2 mine. Sample shipped in can No. 250.

Sample No. 1200: A sample of gilsonite dust taken from the walls of the above stope. The walls of the stope had not been rock-dusted, and the sample should contain very little if any foreign matter. It is possible that a small amount of sandstone from the walls is present in the sample. Sample shipped in can No. A-032.

Sample No. 1201: A sample of gilsonite dust taken from the walls and timbers of the 400 east drift of the Bonanza No. 2 mine. This is the haulage level immediately under the above stope and the walls and timbers have been rock-dusted, but not in sufficient amount. The rock dust, consisting of dolomite, has been applied manually. There has been considerable spillage on the floor of the drift and gilsonite, granular to dust in size, averages six inches in depth on the floor. Sample was shipped in can No. 248.

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b/ Hartmann, Irving. Incorporated in report by Worcester, A. W., Mine Safety Inspection Report Gilsonite Mines, Barber Asphalt Corporation, Bonanza, Uintah County, Utah, July 24-26, 1945.

Sample No. 1202: A sample of gilsonite dust taken from the floor, stairlandings, and various members in the screening, cleaning, and washing plant of the Bonanza No. 2 mine. A dust collecting system is provided in this plant, but is not 100 percent efficient. Housekeeping is good, and dust is removed frequently, at least once a shift from all exposed places. Sample shipped in can No. P-649; it should contain very little if any foreign matter.

The above dust samples (as well as three air samples) were taken on July 25; they were received in Pittsburgh on July 30.

Chemical Analyses

A portion of each of the four gilsonite samples was given to Mr. Cooper of the Coal Analysis Section of the Pittsburgh station for analysis. Following are the results of proximate analyses on an "as received" basis:

Experimental Mine Samples Nos.	1199	1200	1201	1202
Cooper lab. Nos.	C-46024	C-46025	C-46026	C-46027
	Proximate analysis, percent			
Moisture	1.1	0.9	1.3	1.3
Volatile matter	86.5	96.5*	76.7*	98.3*
Fixed carbon	12.1			
Ash	0.3	2.6	22.0	0.4
	100.0	100.0	100.0	100.0

*Combined percentage of volatile matter and fixed carbon.

For Sample No. 1199 the ultimate analysis was also determined, with the following results on an "as received" basis:

Hydrogen	10.4 percent
Carbon	84.9 "
Nitrogen	2.6 "
Oxygen	1.5 "
Sulphur	0.3 "
Ash	0.3 "
	100.0

Preparation and Screen Analyses of Samples

As received and tested all of sample 1202 passed through a 20-mesh Tyler sieve. Sample 1200 contained 29.7 percent (by weight) particles

coarser than 20 mesh, and sample 1201 contained 13.6 percent on 20 mesh. Prior to testing, these coarse fractions were removed from the samples. Sample 1199 was received in the form of small lumps. For the inflammability tests a portion of the sample was ground to prepare a dust of so-called "mine-size", which is 100 percent minus 20 mesh and approximately 20 percent minus 200 mesh; a second portion of this sample was tested in 100 percent minus 200-mesh fineness.

Following are the screen analyses (cumulative of the mine-size sample No. 1199 and of the other three samples as tested:

Sample Nos.	Cumulative percentage passing through Tyler sieve Nos.		
	20	100	200
1199 (mine-size sample)	100.0	38.5	23.1
1200	100.0	42.6	27.9
1201	100.0	66.7	52.0
1202	100.0	73.2	44.0

Results of Inflammability Tests

On the mine-size sample 1199 and on the three other samples, tests were made to determine the ignition temperature of the dust clouds, and the relative inflammabilities (percentage of added inert dust required to prevent ignition and flame propagation) in the laboratory furnace test and in a spark-ignition apparatus. The laboratory furnace has been standardized so that for coal dust samples the relative inflammability values determined in it indicate closely the proportion of rock dust needed with the coal dust to prevent ignition and flame propagation in large-scale tests in the Experimental Coal Mine.

For the minus 200-mesh dust on sample 1199, in addition to the above tests determinations were made of the lower explosive limit of dust clouds, pressures and rates of pressure rise developed following ignition of clouds in a closed vessel, and the minimum energy required to ignite dust clouds and undispersed dust layers by sparks from condenser discharge. The procedure followed and the apparatus used in making the tests are described in Bureau of Mines Report on Investigations No. 3751.

Following are the test results for the mine-size sample No. 1199 and the other three samples:

APPENDIX F (Contd.)

	Sample Numbers			
	1199 (Mine-size)	1200	1201	1202
Ignition temperature of dust clouds, °C.	580	600	570	650
Ignition temperature of dust clouds, °F.	1075	1110	1060	1200
Relative inflammability, percent:				
In furnace, at 700° C.	90+	90	85	90+
In spark apparatus	40	50	60	70

. . . . . .

Conclusions

The results of the foregoing tests indicate that dust clouds of all four samples of gilsonite can be ignited readily by hot surfaces and by electric sparks of very low energy and no doubt by other ignition sources; under right conditions these dusts might produce violent dust explosions. This is true even of sample 1201, which was collected from a section of the mine where the walls and timbers had been rock-dusted, as noted by Mr. Worcester and as shown by the tests the proportion of rock dust used was entirely inadequate. The ignition and explosion hazard of the gilsonite dust is greater than for bituminous coal dust from the Pittsburgh seam; undoubtedly, one reason for this is the high proportion of combustible volatile matter in the gilsonite. The relative inflammability of mine-size Pittsburgh dust as determined in the furnace test is 65 percent, whereas for the gilsonite sample (1199) of similar fineness it is over 90 percent. The minimum explosive concentration for minus 200-mesh Pittsburgh coal dust is 0.050 to 0.055 oz./cu. ft., whereas for the gilsonite dust it is 0.020 oz./cu.ft.

To reduce the hazards of dust explosions in the gilsonite mine and in the preparation and other surface installations it is important that strict precautions be taken to reduce insofar as possible the formation, dissemination and accumulation of fine dust and to eliminate all sources of ignition.

APPENDIX G

November 6, 1953 - 6:00 p.m.

STATEMENT OF THE UTAH STATE INDUSTRIAL COMMISSION

At about 8:10 a.m., November 5, 1953 an explosion occurred in a portion of the opencut (trench) mine operation of the American Gilsonite Company, Bonanza, Utah.

Eight men were fatally injured and three men were slightly injured, two by burns and one by flying debris.

The operation under consideration was a so-called opencut (trench) in the Little Bonanza vein. This vein varies from 14 feet in width at one end to 11 feet in width at the other. As ore was removed stulls were installed on at least 25 feet spacing with intermediate stulls as needed. In some areas roof bolts were used. Three pillars of ore were left to provide protection from questionable wall structure above. Steel chain-link fencing was installed to provide floors on 25 feet vertical spacing. This avoided excessive accumulation of dust which constitutes a problem with solid floors.

The mining method employed here was to break the ore on slopes inclined about 40° from the horizontal. The method of breaking was to drill holes on 3-foot centers 8 feet deep vertically. An Armstrong Airbreaker shell was placed in the hole and fired with approximately 8,000 pounds air pressure. The shell was then removed and placed in an adjoining hole and the operation repeated. The ore broken by this method slid down the slope where it was subsequently loaded into the skip through gravity chutes.

The skip traveled on rails (installed as a 60° angle from the horizontal) to the ore bin at the head house on the surface.

At the time of the explosion a crew of 5 men was drilling and shooting the ore immediately under the most westerly pillar. One man was at the foot of the slope operating the ore chute and two men were preparing to install another ore chute in the same locality.

At the surface the skip discharged through a grizzly into a bin which was built between the side walls where the ore had previously been removed. The ore was removed from this bin by means of a reciprocating feeder driven by an air motor. This was not running at the time of the explosion. This discharged into the goot of a belt-bucket elevator. The elevator was incased with steel plate from the surface up to the head pulley located at approximately 45 feet above the surface. The drive was by means of totally enclosed 440-volt 60-cycle 3-phase motor, mounted on a steel platform at the top of the elevator. This elevator discharged into a 20-ton steel bin located north of the vein.

Hoisting was by means of a Vulcan single-drum hoist, located east of the elevator and powered by a 75-horsepower electric motor installed in a steel and concrete building, which was supported over the opencut by means of heavy steel beams.

George Collins, shift boss, was returning to the surface on the loaded skip when he heard two perfectly normal compressed-air shots. Upon reaching the surface he walked approximately 100 yards when he heard a report, which he describes as having sounded like a high-powered rifle. At this point he remarked to Marlo Bowthorpe that it did not sound like an air shot; the explosion followed immediately.

Orman Stephens, the hoistman, reports that he dumped the skip as soon as George Collins had left it, returned the skip to the bottom of the mine, hoisted the skip and dumped it. Immediately thereafter he saw a flame between the hoist house and the elevator. He reports that no noise accompanied the flame. He immediately set the hoist brake and ran from the hoist house. Before he had travelled 100 feet mine debris was falling around him. He stated that he heard a normal air shot just before dumping the skip. The round trip time of the skip from the surface to the bottom including loading, and dumping at the surface was about 5 minutes.

All timber, including stulls and support timber, was blown from the mine throughout its 1,100-foot surface length to its maximum depth of 500 feet which occurs at the apex of the "V" shaped cut.

These timbers were blown over the surrounding area for a distance of about 2,000 feet. The large areas of unsupported walls and pillars, the volume of fallen debris and caving walls, and the small fire, which is still burning combined to make the mine inaccessible.

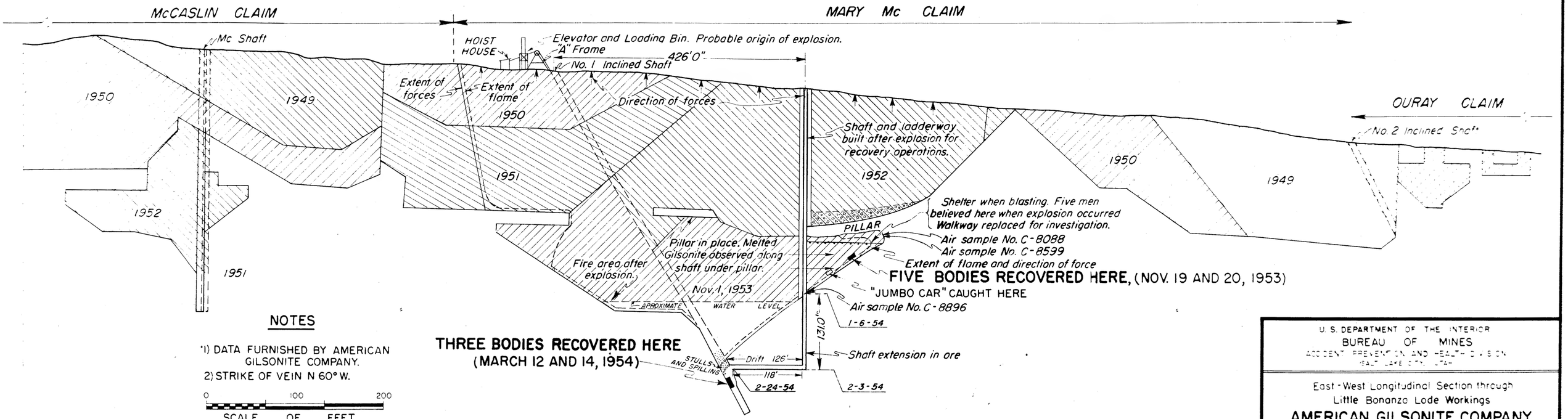
The rescue men from the coal mines of Carbon County were considered, but were not called, owing to the aforementioned hazardous conditions.

Efforts were made to reach the area under the pillar where the five men were working. Four men descended the slope by the use of ropes and safety belts onto the top of the pillar but were unable to proceed farther. Two men equipped with oxygen breathing apparatus were then lowered by bucket from the surface to a point where they could observe the entire area under the pillar. They reported the area completely empty.

One or more of the three operations in progress may have been the source of the explosion. However, the evidence as stated by two witnesses indicates that the flame originated on the surface at or near the head house, possibly at the elevator. This is supported by the fact that men,

who were about 3 feet from this flame ran and escaped from the force of the explosion. It is believed that the flame then entered the mine with sufficient intensity to propagate an explosion throughout the entire mine.

/s/ O. A. Wiesley
Chairman



NOTES

1) DATA FURNISHED BY AMERICAN GILSONITE COMPANY.
2) STRIKE OF VEIN N 60° W.

0 100 200
SCALE OF FEET

U. S. DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
ACCIDENT PREVENTION AND HEALTH DIVISION
SALT LAKE CITY, UTAH

East - West Longitudinal Section through
Little Bonanza Lode Workings

AMERICAN GILSONITE COMPANY

BONANZA, UINTAH COUNTY, UTAH

ENGINEER:	DATE MAR 19, 954
DRAWN: MAR., 1954, BY A.P.T.S.	800 - 33 - C
CHECKED:	