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EXPERIMENTAL GAMMA-RAY LOGGING OF DRILL HOLES IN THE CALAMITY AREA, MESA COUNTY, COLORADO

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CONCLUSIONS

1. It was not possible to make a complete check of results obtained by Schlumberger Well Surveying Corporation in the logging of several large diameter holes in the Calamity area. These holes have become plugged through the caving of soft material.

2. It is apparent that the Schlumberger logs were made with a faster cable speed and a longer time constant than is used with "Barnaby". This procedure has the effect of "smearing out" the anomalies so that variations in gamma-ray intensity are not sharply defined on the logs as is the case with the "Barnaby" logs.

3. The scale of the Schlumberger logs is not entirely satisfactory. After the differences in scale, logging speed, and time constant, are reconciled it appears probable that the Schlumberger instrument and "Barnaby" are both capable of measuring substantial variations in gamma-ray intensity. "Barnaby" can measure very small variations in gamma-ray intensity. The fast cable speed and long time constant used by Schlumberger makes it impossible to determine from the logs whether or not their instrument is capable of measuring very small variations in gamma-ray intensity.

4. "Barnaby" uses a much smaller probe than the Schlumberger instrument. This feature permits the logging of smaller diameter holes which can be drilled at less cost.

5. Holes were logged with "Barnaby" at cable speeds of five feet per minute and one foot per minute. The five feet per minute speed is satisfactory for the detection of radioactive ore bodies and for the estimation of equivalent uranium content. The one foot per minute speed brings out considerably more detail and is more satisfactory for stratigraphic work.

6. It is probable that "Barnaby" can be used as a tool for stratigraphic correlation. The present logging procedures permit the separation of sandstone and mudstone strata. Additional experimental work on logging procedure and a more sensitive probe are desirable.

7. "Barnaby" cannot be calibrated by making use of the record of chemical analyses of core samples. The analyses are extremely erratic and do not appear to be accurate indicators of the grade of ore existing in the ground. It is assumed that the chemists furnished accurate analyses of the samples recovered, but, poor core recovery from the ore zones does not furnish representative samples of the ore existing in the ground.

8. Experimental work in the Calamity area indicates that there is a leaching of radioactive material from the ore bodies. This material has not been identified. It appears that ground water dissolves radioactive material from ore bodies, transports it downward through sandstone to the contact of an underlying mudstone stratum, and then moves it laterally along the mudstone-sandstone contact. Several radioactive anomalies were detected on the mudstone-sandstone contact. These anomalies may be helpful in locating ore bodies provided the direction of movement of ground water is known.

EXPERIMENTAL GAMMA-RAY LOGGING OF DRILL HOLES IN THE CALAMITY AREA

INTRODUCTION

Forty-eight drill holes in the Calamity area have been logged on an experimental basis. Thirty-six of these holes were drilled under the supervision of the U. S. Geological Survey in the course of investigations of carnotite deposits. All of these holes were drilled with AX size diamond core bits. The remaining twelve holes were drilled under the supervision of the Grand Junction Extension, New York Raw Materials Office, AEC. Eleven holes of the latter group were drilled with a Porta rig and are approximately six inches in diameter. The last hole was drilled with an NX size diamond core bit.

The initial objective of the experimental logging was to check the results reputed to have been obtained by Schlumberger Well Surveying Corporation while logging the twelve large diameter holes for the AEC group. Since most of these holes were found to be plugged, the experimental logging was extended to the neighboring holes drilled under the supervision of the U. S. Geological Survey. It was not possible to make a complete check of the results indicated to have been obtained by Schlumberger. Some data relative to the merits of two rates of logging speeds was obtained. A comparison of gamma-ray logs and the stratigraphic column penetrated by several of the holes has been made.

SELECTION AND LOCATION OF HOLES LOGGED

The twelve large diameter holes were drilled under the supervision of the Grand Junction Extension, New York Raw Materials Office, AEC. Holes six inches in diameter were drilled to provide an opening large enough to permit the passage of a probe of the size commonly used by oil well surveying companies. Two groups of holes were drilled. Each group consists of six holes arranged along a nearly straight line some three hundred feet in length. Each line of holes was started at the edge of a carnotite ore body previously discovered during the course of exploratory drilling under the supervision of the U. S. Geological Survey, and was extended in a direction presumed to be outward from the ore body. This arrangement was selected for the purpose of testing for the possible existence of low grade concentrations of radioactive materials, or "radioactive haloes", surrounding carnotite ore bodies. One group of holes is located on the Matchless claim in the Maverick portion of Calamity Mesa. The other group of holes is located on Calamity No. 27 claim.

When it was found that most of the large diameter holes were plugged, it was decided to continue the experimental work by logging several nearby small diameter holes. Eleven such holes drilled in the Matchless and Queen of the Hills claims were logged. Also, twenty-five holes drilled in the Calamity No. 23 and No. 25 claims were logged. The relative positions of all holes are shown on the maps attached to this report.

LOGGING INSTRUMENT AND PROCEDURE

A "Barnsby" was used for the experimental logging. This instrument is being developed by the U. S. Geological Survey primarily for the gamma-ray logging of small diameter drill holes. The principal parts of the instrument are a Geiger-Mueller tube contained in a probe, integrating electronic circuits, and a strip chart recorder. The external diameter of the probe is seven-eighths of an inch. The cathode of the Geiger-Mueller tube is seven and one-quarter inches in length and nine-sixteenths inch in diameter. Since the volume in which gamma-rays are detected and counted is that contained by the cathode it is readily seen that this probe is extremely small in comparison to those used by commercial well surveying companies. The integrating circuits are so constructed that by varying range settings a full scale deflection is indicated on an ammeter with a one milliampere movement by a counting rate of 1000, 10,000 or 100,000 counts per minute. High capacity electrolytic condensers are connected in parallel with the milliammeter so that the capacitance can be changed in four steps to give a time constant of 2, 4, 8, and 16 seconds respectively. For this instrument the time constant is defined as the time required for any current surge to decrease to 1/e of its initial value. The milliammeter is a strip chart recorder type of instrument which makes a permanent record of the intensity of gamma-ray intensity along the length of the hole being logged.

A time constant of two seconds was used throughout the course of this experimental work. The short time constant has the effect of causing the instrument to respond to minute variations in gamma-ray intensity. The chart, or log, produced when the short time constant is used, has a ragged appearance. The use of a longer time constant smooths out many of the "sawteeth" but does so at the expense of detecting many of the minor variations in gamma-ray intensity. The short time constant was used throughout the course of this work so that the maximum degree of accuracy in the measurement of gamma-ray intensities could be obtained.

Most of the holes were logged at speeds of five feet per minute and one foot per minute. The object in using two speeds was to obtain some data in regard to the most desirable operating procedure when the instrument is to be used as a tool for stratigraphic correlation.

All of the logging at a speed of one foot per minute was done with the instrument set on a range factor of 10^3, that is, a full scale deflection being given by a counting rate of 1000 counts per minute. The slow logging speed was used to detect differences in the degree of radioactivity present in shale and sandstone strata when no carnotite is present. The counting rate obtained in "barren" strata rarely exceeds 200 counts per minute. A few holes which penetrate ore bodies were repeatedly logged at a speed of five feet per minute with a higher range factor being set into the instrument during each succeeding run until the maximum deflection remained upon the chart.

COMPARISON OF "BARNABY" AND SCHLUMBERGER LOGS

The primary objective of the experimental work, which was to check the results of the logging of the large diameter holes reported by Schlumberger Well Surveying Corporation, was not attained in a completely satisfactory manner. Ten of the twelve large diameter holes were plugged at points considerably above the stratigraphic position of nearby carnotite ore bodies. The two holes which were open all the way to the bottom (S-1, S-4) penetrate "barren" strata and the logs do not show any distinctive features which can be associated with ore bodies.

No copies of logs obtained by Schlumberger are available for inclusion in this report. Logs of only six of the twelve large diameter holes have been given to the personnel of the Grand Junction Extension, New York Raw Materials Office, AEC, by the Schlumberger organization. These logs are of the six holes drilled on the Calamity No. 27 claim. There is no data to indicate what cable speed, sensitivity setting, or time constant was used while logging these holes. A vertical scale of approximately ten feet to the inch was used. The deflection scale has about the same appearance that a "Barnaby" chart through barren strata would have if it were to be blown up to roughly twenty times the normal deflection of the logs accompanying this report. The general appearance of the Schlumberger logs seems to indicate that a relatively fast cable speed and a long time constant were used. Variations in the intensity of gamma radiation resulting from changing stratigraphic features and thin ore zones are not sharply delineated. The same result can be obtained with "Barnaby" by using the longest available time constant and a rapid

cable speed (15 or 20 feet per minute). The effect is to "smear out" the variations in indicated gamma-ray intensity over a considerable vertical range of the chart.

Those portions of the large diameter holes which were found to be open were logged with "Barnaby". Of the six holes drilled on the Calamity No. 27 claim, none were found to be open down to the stratigraphic position of nearby ore bodies. The significant portion of these holes could not be logged. Comparison of the "Barnaby" logs and Schlumberger logs shows a general agreement. The "Barnaby" logs show considerably more detail and a sharp delineation of changes in gamma-ray intensity. Because of these features the "Barnaby" logs are the most useful. The "Barnaby" log has the most favorable vertical scale, one foot per three-eighths inch of chart as against approximately ten feet per inch of chart for Schlumberger. The apparent use of a fast cable speed and a long time constant by Schlumberger makes sharp delineation of variations in gamma-ray intensity impossible.

Several of the small diameter holes drilled under supervision of the U. S. Geological Survey and which are located close to the large diameter "Porta" holes were logged with "Barnaby". The stratigraphy in all of these holes is essentially identical. An indirect comparison of these logs with the Schlumberger logs was made. The results are in agreement with the observations noted in the preceding paragraph.

The "Barnaby" and Schlumberger instruments are devices for measuring the intensity of gamma radiation. The detecting element in "Barnaby" is a Geiger-Mueller tube. The detecting element in the Schlumberger instrument is believed to be an ionization chamber. The "Barnaby" instrument has the advantage of being able to use a probe of much smaller diameter than that which can be used by the Schlumberger instrument. The "Barnaby" instrument can be used to log holes of considerably less diameter than can be logged with the Schlumberger instrument. Since small diameter holes are the cheapest to drill, the use of "Barnaby" in exploratory work is the most economical.

The gamma radiation measured by both "Barnaby" and the Schlumberger instrument originates close to the position of the probe. The absorption of gamma radiation in a solid medium follows an exponentail curve, therefore, detectable amounts of radiation from even an intensely strong source will not penetrate more than a few feet of sedimentary strata. It is probable that more than ninety-eight percent of the radiation detected by both "Barnaby" and the Schlumberger instrument originates within a distance of three feet from the probe.

It is utterly impossible for either instrument to detect radiation originating within an ore body separated from the probe by more than a very few feet of rock. Radioactive anomalies found in the volume of rock surrounding an ore body must represent either a "feathering out" of the ore, or radioactive material which has been transported outward and away from the main body through the medium of ground water or by gaseous defusion. It must be understood that the logs produced by both instruments are measurements of gamma-ray intensity originating very close, less than three feet, from the position of the probe.

EFFECT OF LOGGING SPEED

A cable speed of five feet per minute is entirely satisfactory when the purpose of the logging is to detect the presence of radioactive ore bodies and to make an estimation of the equivalent uranium content. Examination of logs of the same holes run at speeds of five feet per minute and one foot per minute shows that the slower speed brings out considerably more detail. The slower speed is most satisfactory when it is desired to detect small variations in the degree of radioactivity. The positions of mudstone strata are easily distinguishable from those of sandstone strata on the logs run at a speed of one foot per minute. The distinction is not so apparent on the logs run at a speed of five feet per minute.

POSSIBLE USE OF BARNABY AS A TOOL FOR STRATIGRAPHIC CORRELATION

The stratigraphic column penetrated by each of the small diameter drill holes has been plotted on the logs run at a speed of one foot per minute. The thickness and character of individual stratum were obtained from the geologist's record made by visual examination of core at the time the holes were drilled. No record of stratigraphy is available for any of the large diameter holes.

Examination of the logs indicates that the degree of radioactivity in mudstone, clay, or shale is significantly greater than that in sandstone. Generally, sandstone strata are characterized by an extremely low degree of radioactivity, and on the logs, their positions can be easily distinguished from those of mudstone or shale strata. (For examples see logs of Holes CA 238, CA 239, CA 248, CA 322, CA 381 --- Calamity group) The positions of thin mudstone seams in thick sandstone layers are marked by increased indications of radioactivity. (For example see logs of Holes CA 224, CA 230 --- Calamity group. CA 698 -- Maverick group)

The presence of carnotite ore bodies in sandstone upsets the normal relationship. The ore bearing sandstone normally is characterized by an extremely low degree of radioactivity. (For examples see logs of Holes CA 233, CA 238, CA 239, CA 248, CA 322 -- Calamity group) This low degree of radioactivity indicates that there is no carnotite present. That portion of a hole passing through, or in close proximity to, a radioactive ore body is characterized by an extremely high degree of radioactivity. Since the presence of radioactive ore bodies is not a characteristic feature of sandstone formations, the presence of the carnotite deposits constitutes an unusual circumstance. The abnormally high degree of radioactivity existing in the ore bearing portions of the Salt Wash member of the Morrison formation is not characteristic of this sandstone stratum in its entirety. It appears that at a short distance away from the ore bodies the normal low degree of radioactivity characteristic of sandstones in general exists in the Salt Wash member. (See logs of Holes CA 227, CA 381 -- Calamity group CA 587, CA 702 Maverick group)

Drill holes which penetrate carnotite ore bodies quite often are found to have been salted with radioactive sludge during the drilling operation. This contamination increases the gamma radiation throughout the length of the hole and generally completely obscures the small variations originating from different types of sedimentary strata. (For examples see logs of Holes CA 244, CA 312, CA 333 ---- Calamity group. CA 713 -- Maverick group) The log of such a hole is useful only for showing the position, thickness, and grade of an ore body.

"Barnaby" appears to have favorable possibilities as a tool for stratigraphic correlation. A slower logging speed than that which is adequate for the detection of ore bodies is required. It appears advantageous to use the shortest possible time constant. It is probable that a cable speed faster than the one foot per minute rate used during the course of this experimental work will be satisfactory. The most desirable cable speed will have to be determined during the course of additional experimental work. The use of a Geiger-Mueller tube having a higher counting rate for a given source of gamma radiation than those in use at present is desirable since the higher counting rate will accentuate the differences in the degree of radioactivity encountered along the length of a drill hole.

CALIBRATION OF BARNABY THROUGH USE OF ANALYSES OF CORE SAMPLES

During the early states of the development of the "Barnaby" instrument it was thought that there might be a possibility of compiling satisfactory calibration data from the record of chemical

analyses of core samples. The logging of approximately one thousand holes has indicated that this procedure is impractical.

The experimental logging in the Calamity area has verified the above conclusion. The U_3O_8 contents in core samples recovered from ore bodies have been plotted along the left hand side of the logs run at a speed of five feet per minute. There is no consistent systematic relationship between the chemical analyses and the deflections on the "Barnaby" logs. There are two factors which contribute to this discrepancy. The one of least magnitude is that "Barnaby" measures the total intensity of gamma radiation from all sources, that is, from the uranium series of radioactive elements, from the thorium series, from potassium, and from any other source that may be present, while the chemical analysis shows only the uranium content. The factor of greatest magnitude is that rarely, if ever, is the core recovery from the ore zone one hundred percent efficient. As a general rule it may be stated that the efficiency of core recovery decreases with increasing carnotite content.

It is assumed that the chemists furnish accurate analyses of the samples which they received. It is known that the samples frequently are not representative of the ore as it exists in the ground. Examination of the logs attached to this report reveals that for a given deflection there are several widely varying U_3O_8 contents indicated by the chemical analyses. In each case it is probable that the greatest U_3O_8 content is the most representative of the ore existing in the ground. In no case is it certain that a truly representative sample has been obtained.

The circumstances outlined above prevent a satisfactory calibration of "Barnaby" through the use of records of core sample analyses. The calibration will have to be accomplished through the use of simulated drill holes and other experimental methods.

LEACHING OF RADIOACTIVE MATERIAL FROM ORE BODIES

Experimental logging of drill holes in the Calamity area has revealed the presence of radioactive anomalies at the contact of the ore bearing sandstone and the underlying mudstone stratum. These anomalies were not found in all of the holes logged, and, since a substantial degree of radioactivity is indicated, an attempt has been made to explain their significance. The same kind of anomaly has been found in the course of routine logging of drill holes in other areas.

analyses of core samples. The logging of approximately one thousand holes has indicated that this procedure is impractical.

The experimental logging in the Calamity area has verified the above conclusion. The U_3O_8 contents in core samples recovered from the holes have been plotted along the left hand side of the logs for a range of five feet per section. There is no consistent systematic relationship between the chemical analyses and the indications on the "Hurricane" logs. There are two factors which contribute to this discrepancy. The one of least magnitude is that "Hurricane" measures the total intensity of gamma radiation from all sources, that is, from the uranium series of radioactive elements, from the thorium series, from potassium, and from any other source that may be present, while the chemical analysis shows only the uranium content. The factor of greatest magnitude in this study, however, is that core recovery from the ore zone is [illegible] one hundred percent efficient. As a general rule it may be stated that the efficiency of core recovery decreases with increasing carnotite content.

It is assumed that the chemists furnish accurate analyses of the samples which they received. It is known that the samples frequently are not representative of the ore as it exists in the ground. Examination of the logs attached to this report reveals that for a given drill hole there are several widely varying U_3O_8 contents indicated by the chemical analyses. In such case it is doubtful that the greatest U_3O_8 content is the most representative of the ore existing in the ground. In no case is it certain that a truly representative sample has been obtained.

The discrepancies outlined above prevent a satisfactory calibration of "Hurricane" through the use of records of core sample analyses. The calibration will have to be accomplished through the use of simulated drill holes and other experimental methods.

LEACHING OF RADIOACTIVE MATERIAL FROM THE SURFACE

Experimental logging of drill holes in the Calamity area has revealed the presence of radioactive anomalies at the surface of the ore bearing sandstone and the underlying mudstone contacts. These anomalies were not found in all of the holes logged, and, since a substantial degree of randomness is indicated, no attempt has been made to explain their significance. The same kind of anomaly has been found in the course of routine logging of drill holes in other areas.

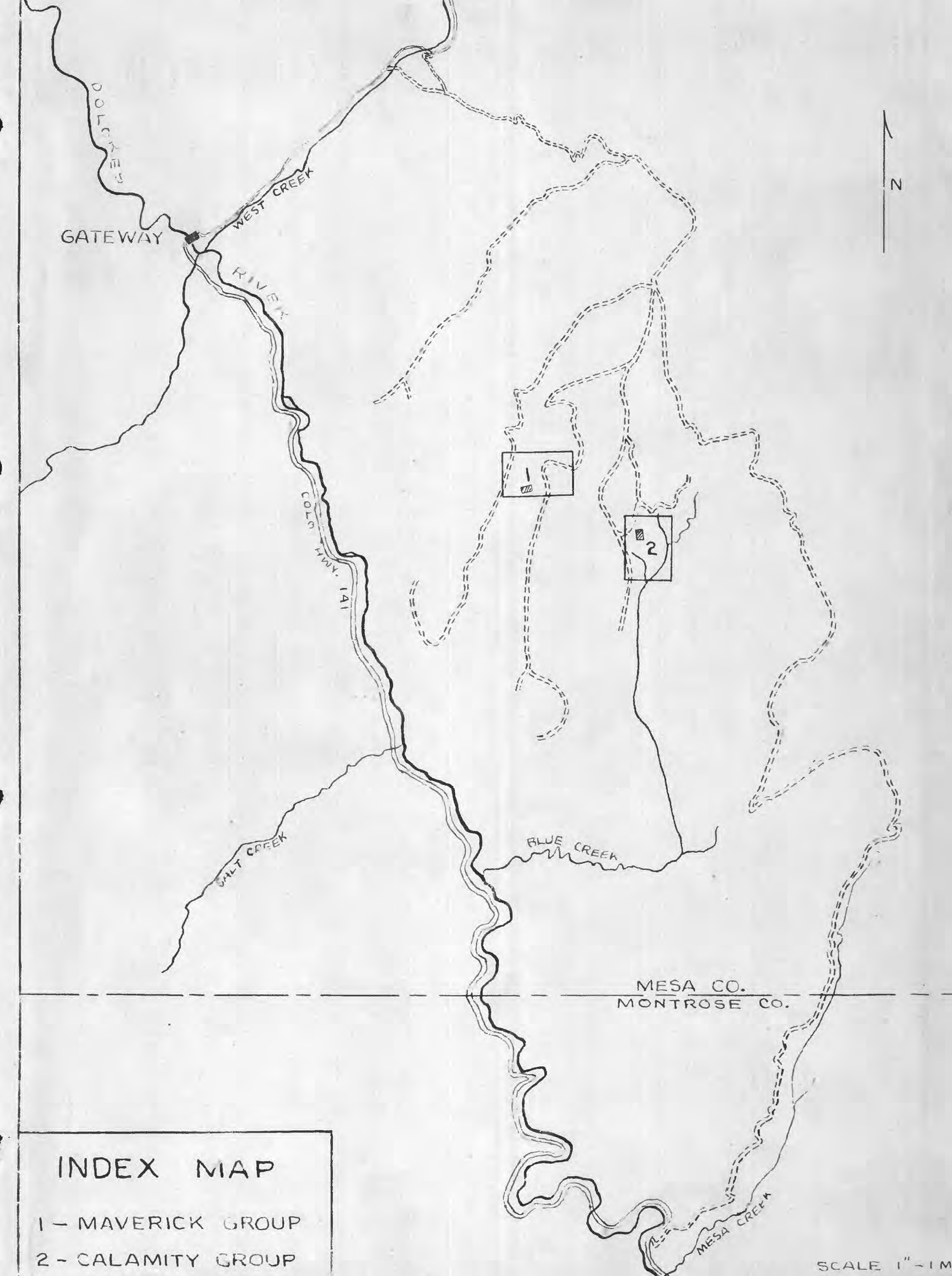
The carnotite ore bodies in the Matchless and Calamity No. 27 claims lie within a thick sandstone stratum. There is a thickness of some three to six feet of sandstone between the base of each ore body and a thick mudstone stratum which underlies the ore bearing sandstone. The mudstone stratum has been dubbed the "altered mudstone" during the course of investigations of the carnotite deposits.

The radioactive anomalies at the sandstone-mudstone contact were found in several holes at distances up to 200 feet from the ore bodies. (See logs of Holes CA 239, CA 246, CA 248, CA 322, CA 345, CA 363, CA 376, CA 379, CA 380 -- Calamity group) The maximum distance from ore bodies at which these anomalies can be found is not known for the reason that this phenomena has not yet been thoroughly investigated.

The most logical explanation for the anomalies appears to exist in the action of ground water. It is probable that ground water leaches radioactive material from the ore bodies, transports it downward to the sandstone-mudstone contact, and then moves laterally along the contact. The surface of a portion of the altered mudstone underlying the Calamity No. 27 claim has been contoured with a two-foot interval. (Map is attached to this report) Most of the anomalies are located down dip from the ore body. A much larger ore body lies in a general easterly direction up dip from the area covered by this map and thus can account for the presence of a few anomalies up dip from the small ore body lying in the area covered by this report.

The identity of the radioactive material causing the anomalies has not been determined. A significant feature is that no sample of core from the immediate vicinity of the sandstone-mudstone contact has been submitted for chemical analysis. It is possible that no such core has been recovered. The radioactive zone is thin, probably not more than two or three inches in thickness, and a slight core loss at the contact would eliminate the material required for analysis. Another possibility is that the radioactive material can be washed out of the core during the drilling operation. The concentration of radioactive material is small, but, core samples representing anomalies of lesser magnitude are frequently selected in the radiometric core scanning laboratory for chemical analysis.

The nature and distribution of these anomalies would appear to make them an useful criterion for the location of ore bodies. More investigation to determine their exact character is needed. Knowledge of the general direction of movement of ground water in any areas under investigation would be required in order to utilize these anomalies to the greatest possible extent.



GATEWAY
DOLORES
WEST CREEK
RIVER
COLO. HWY. 141
SALT CREEK
BLUE CREEK
MESA CO.
MONTROSE CO.
MESA CREEK
N
1
2
INDEX MAP
1 - MAVERICK GROUP
2 - CALAMITY GROUP
SCALE 1" - 1 M