ARKLA Exploration Company
INTERNAL CORRESPONDENCE

TO:	Mr. R. L. Breedlove	Dated: Holbrook, Arizona March 21, 1966
FROM:	W. E. Carr	
SUBJECT:	A review of Potash Exploration, Holbrook Drilling Project	

ABSTRACT

First-phase exploratory drilling by Arkla commenced November 1, 1964 and continued almost without interruption until February 22, 1966, when the one rig in operation was shut down. During this 15 month period 37 cope tests were drilled in the 800 square miles comprising the project area with the purpose of broadly delineating trends of potash deposition in the evaporate sequence of the Permian Supai Formation. Six of these holes were found to contain near commercial potash grade average over minable thickness. Eighteen had significant shows and thirteen were barren or had very low potash grade. Two of the thirteen had all or part of the potash zone faulted out. Additional information is provided b 7 potash core tests drilled by other operators. Four had significant potash shows and three were almost barren.

Inspection of test data suggests that the greatest potential lies near the central and north central parts of the acreage block, where 92.1% of 54,400 acres remains untested. A potential potash reserve is calculated for a part of this area utilizing in isopercent map and considering only that acreage with an indicated ore grade of 15% K2O or more, at least 5 feet thick. <u>19,059 acres may be underlain by deposits in two area totaling 285.4 million tons of 19.76% average grade K2O.</u> Comparing with the rule-of-thumb requirements of 5.5 square miles underlain by a 5 foot thickness of 20% ore (minimum to economically justify mine and process installation), prospective area exceeds requirement by 540% and potential reserve is 596% greater than the specified minimum.

Immediate commencement of second-phase exploratory drilling is recommended to investigate potential inside the widely spaced initial phase activity. For this purpose nine core tests are proposed.

INTRODUCTION

In mid-1964, an area of mutual interest was established by Arkla Exploration Company and New Mexico and Arizona Land Company, to jointly explore for commercial potash deposits. The original area included all of Townships 14 through 16 North, Ranges 22 through 25 East, Township 17 North, Ranges 22 through 24 East and Township 18 North, Ranges 22 and 23 Navajo and Apache Counties, Arizona. The area was later expanded to include Range 21 East adjacent to the west side of the original block, then providing approximately 800 square miles for investigation. Operating centered in Holbrook, near the northwest corner of the area.

Drilling operations were preceded by a gravity-magnetometer survey over a substantial part of the area, tying in with 3 tests previously drilled by Land Company and with other critical well control. Locations of the earliest holes were guided by geophysics, presuming that relatively low indications of density were in part the reflection of cleaner and/or thicker salt deposition. It is believed established that this technique is effective in the delineation of major features in undrilled areas. Drilling commenced on November 1, 1964 of major features in undrilled areas. Drilling commenced on November 1, 1964 with Sojourner Drilling Company of Abilene, Texas furnishing contract drilling equipment. The objective was to explore Permian evaporate beds with known occurrence of potash minerals. The first core test and four of the succeeding 36 potash holes penetrated the entirety of halite occurrence. One hole was drilled to metamorphic rocks to provide reasonable assurance that all prospective zones had been reached by the drill.

As information became available from core tests, increasing reliance in selecting drill sites was placed on zone and unit isopachs, cross-sections, ratio studies, lithology and potash content. Such graphic information was kept current as possible. At times it was desirable to select locations on state land since cost of drilling could be applied to extend prospecting permits, but this practice was never in conflict with geology.

The area is dissected by the Little Colorado and Puerco Rivers, their confluence lying about three miles east of Holbrook. The divide area between the rivers is characterized by generally low grassland ridges, broad drainage areas and ledge form buttes and mesas. South of the Little Colorado similar topography exists but with considerable pinon and cedar cover. Only minor difficulty was experienced in road and location building and most of the area was found to be accessible.

Water for drilling was obtained from range tanks, wells, the Little Colorado and from the Holbrook city water supply. Drilling mud, diesel and butane were locally available but most other services were obtained from Farmington, New Mexico. Contractor furnished trucks for water and equipment drayage, and coring equipment. The diamond core bit is in good condition after coring several thousand feet. A minor amount of coring was done using a Tungsten Carbide core head.

REGIONAL GEOLOGY

Structurally the area of interest lies on the north-dipping “Mogollan Slope”, between the Defiance uplift to the north and the central Arizona uplift to the south, and near the southern extremity of the Colorado Plateau. The majority of folding and faulting to be seen on surface outcrops is the expression of laramide or younger orogeny. Older structure is most often detected by inference from angularity between contacts and easement relationships within the sedimentary sequence. The predominate structural feature in the area is a regional syncline trending northwest, roughly parallel to and north of US Highway 260. There is no apparent relationship between the syncline, or its complementing anticlines, and potash occurrence. Another noteworthy structural features is a lobate area of collapse near the village of Woodruff. Maximum relief on the top of the Coconino sandstone is at least 200 feet. Collapse is believed to be resulted from leaching of the underlying beds but the effect on potash deposits is probably limited to the immediate area of collapse.

Surface exposures of sediments include units in the middle and lower Chinle Formation, the Moenkopi Formation and the Coconino sandstone. Thin remnants of the tertiary (?) Bidahochi Formation is present in the Puerco Ridge and Potter Mesa areas.

Tabulation of major units and approximate thickness follow below:

Tertiary	
Bidahochi Formation	0 – 30'
Triassic	
Chinle Formation	0 – 725'
Moenkopi Formation	0 – 230'
Permian	
Coconino Sandstone	370 – 401'
Supai Formation	
Upper Shale Member	25 – 75'
Evaporate Member	1272 – 1499'
Pennsylvania	
Supai Formation	
Lower Shale Member	±780'
Mississippian	
Redwall Limestone	0 – 60'
Devonian	
Martin Formation	0 – 300'

There may be remnants underlying the Martin Formation representing eroded Cambrian, and in places thin, most likely metamorphosed pre-Cambrian sedimentary rocks may be present.

Following completion of Arkla's second core test a working nomenclature for the evaporate sequence was adopted as a correlation standard. While such description does not meet formal criteria for nomenclature practice, the original definition has served well for reconstruction of events which led to primary potash deposition. Beginning at the top of the Supai and descending the section, organization and significance of various units are discussed below.

Upper Supai. The thin shale unit, intertongued in its upper part with sandstone wedges of the overlying Coconino sandstone, rarely exceeds 50 feet in thickness before encountering anhydrite. Its lower part is also wedged with anhydrite, with only two anhydrite beds apparently continuous across the area. Along the west margin of the block there is only a thin shale section between lowermost Coconino and the "T" anhydrite (description below). Traversing eastward the first encountered anhydrites are progressively younger and the shale becomes somewhat thicker. This condition, coupled with slight eastward thickening of all, evaporate units, suggests that the principal axis of the evaporating basin crossed the southeast part of the interest area.

Supai Evaporates

Cycle 5 Evaporate deposition was almost continuous from the base to very near upper limits of the salt sequence. However, the sea freshened at four distinct periods to allow carbonate deposition, thus providing cyclic markers for subdivision. The final state (5^{th} cycle) contains all concentrations of potash located to date, and beginning at a discernable point in this cycle, marked structural changes are evident. It is believed that this structural movement produced additional restriction against entry of normal sea water, thereby allowing bitterns to concentrate to the point of precipitation. Further, structural pulsation resulted in undulating sea bottom topography to localize potash deposits in the lowest areas. After the bulk of potash salt had been removed from solution, predominantly in one bed, the restriction became less pronounced and once again only less soluble salts were precipitated. After recognition that potash was not likely to occur in commercial concentration below this beginning of structural movement, the majority of core tests were drilled only through the 5^{th} cycle. Further description of this stage follows below.

“V” Anhydrite Occurs only in the eastern portion of the area, wedged out westward.

“U” Anhydrite More extensive than “V” anhydrite but not always present in the northwest.

“T” Anhydrite Present in all core tests drilled to date, the base serving as datum in several stratigraphic cross sections.

“5-A” Salt (Halite) Phase Several tests in the northeast portion of the area encountered halite immediately below the “T” anhydrite, obviously demonstrating a different basinal configuration than for underlying beds. Where this halite is present there is appreciable thickening of interval between correlative overlying and underlying anhydrite beds. Definition of the basin is lacking since there is little available well control except on the south margin. While potash has not yet been identified in these beds, deposits might occur in the deeper parts of pan.

Puerco Anhydrite This bed was found to be diagnostic by its physical characteristics and is consequently relied upon as a correlation standard. It is easily recognized in cores by its mottled, “salamander” appearance and by contemporaneously developed halite crystals in the lower part. The base of the Puerco represents a time line and is therefore utilized as the top in several interval isopachs and stratigraphic cross sections. With the exception of a faulted test hole, the Puerco has been present in tests throughout the area.

“5-B” Salt (Halite) Phase Normally this unit is about 100 feet thick, but one or both of the upper two salt beds have been found missing. In such cases the phase is 65-80 feet thick. The “5-B” is comprised of six halite beds with intervening zones of intermixed clay and halite. Potash minerals have been identified in each of the halite beds, and in some of the clay zones containing halite. The second halite bed from the top thus far exhibits the only persistent potash mineralization and was termed "Zone 4" in the earliest identification. Use of the term has persisted even though it breaches upper limit of the "5-3" phase. Lower restriction of the phase is based on difference between neutron log response to the halite beds noted above and to those underlying. There is a definitive increase in response within the "5-B" phase, easily recognized on mechanical logs.

> "K-5" Marker Point At the base of the second, potash bearing, salt bed there is a characteristic finely granular salt band, usually in contact with an anhydrite parting, which is easily recognized in cores and ordinarily on gamma ray-neutron logs. The granular salt may or may not contain potash and is sometimes in angular contact with beds above and below. Its vertical limits are sufficiently restricted so that it may be used as a marker horizon. This is termed the "K-5" point and it serves as an isopach boundary, a cross section datum and a visual guide for field correlations.
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> "Z" Point Marks the beginning of structural activity which intermittently continued until the close of evaporate deposition. Variations in thickness below this point are apparently due to stratagraphic compensations rather than from structural movement. The underlying "X" and "Y" Points are helpful in determining location of the "Z" horizon.
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> "P-5" Market Point This marker is the base of the "5-B" phase. The distinct reduction of neutron response has always been noticeable in halite beds below this point.

"5-C" Salt (Halite) Phase The interval included here is the balance of 5th cycle with the bottom bed the uppermost of the widespread carbonate marker beds.

Cycle 4 Since no appreciable potash has been found in this or the underlying cycles, the unit is not subdivided other than to designate the basal carbonate as the 2nd dolomite. There is little difference in general appearance when compared to the 5th cycle except the apparent presence of slightly courser clastics. In some tests, thin anhydritic dolomite beds were found but these could not be correlated, as such, between holes.

Cycle 3 Although the salt/clastic ratio was low during this period of deposition, halite is intermixed in high proportion with clay to indicate that salt deposition was continuous with heavy influx of fine clastic material. It is suggested that the amount of clay in a given unit is an indicator of climatic conditions effecting the surrounding land mass; increased clastic deposition represents wet periods and conversely, the reduction of clastics occurred during dry conditions. Basal carbonate in this cycle is the 3rd dolomite.

Cycle 2 The carbonate marking base of this unit appears equivalent to Ft. Apache limestone described on surface outcrops below the Mogollon Rim, south of the drilling area. This is the thickest of the carbonate markers, ranging up to 55 feet in one of the five deeper tests. Because of its thickness, stratigraphic position and correlation with earlier oil and gas test designation; this is termed the Ft. Apache Member of the Supai Formation. Oil and gas possibilities are discussed in the sections to follow.

Cycle 1 Inasmuch as this part of the evaporate section exhibits greatest variation in thickness it may be used to determine relative basinal position, at least for the beginning of evaporate deposition. The largest difference in thickness noted in this section was 260 feet, in a maximum of 505 feet, while the greatest observed difference in the overlying sequence was 123 feet as opposed to a maximum thickness of 1156 feet. From available data it is postulated that the Arkla No. 3 NMA location occupied an axial position in the basin. Base of the unit and base of evaporates is called at the bottom of the lowermost salt; it is not necessarily equivalent stratigraphically from hole to hole.

GEOLOGY OF ZONE 4 POTASH BED

Detailed study of cores reveals five distinct types of halite in the bed showing greatest potash concentration, and each of these types usually occur in correlative layers and in sequence. Type I is described as light - to dark – orange, finely crystalline halite with variable amounts of potash minerals but the usual maximum K2O content is less than 7 percent. The lower part of the bed shows from 0 to 4 feet of the orange halite and minor occurrences are sometimes scattered through all but Type II layers. The latter type is red-pink, medium to coarsely crystalline, translucent-opaque halite often with strong potash mineralization. Sylvite crystals are predominately large (from ¼ inch to rarely 5 inches) and are coated with red residual material, some of which may be carnallite. Considerable copper – or brass colored, iridescent carnallite was observed in two of the core tests located near the edge of apparent potash concentration. Type II is most often the second layer from the bottom of Zone 4 but rarely is it in contact with the “K-5” marker point without intervening Type I. Also it has appeared at two different overlying positions in the section. It is believed that the type owes its identity to thorough conversion from primary products of deposition and therefore may overlap stratigraphic boundaries. Without serious question, rock of this nature will constitute the builk of any minable ore since 1.) It contains relatively higher K2O values than any of the other types and 2.) It would be possible for Type II to have developed over widespread areas, through total thickness of the bed. K2O content has reached 48 percent for 1 foot and 30-35 percent for 1 foot has not been uncommon. Maximum continuous thickness thus far penetrated was 5.4 feet.

Although not extensive in areal occurrence, Type III is so designated because of its placement in the sequence. It appears as a lense, so far present in 3 core tests, of reddish-brown, translucent, finely crystalline halite, almost devoid of potash. Genesis of this material is problematical, but separation of recognizable units suggests a wedge of primary deposition with later alteration. Type IV is gray-smokey finely crystalline halite with numerous anhydrite partings. Although potash reaches rather high levels such minerals are indistinguishable from halite. Anhydrite bands are in some cases flat lying but may be irregular and distorted from post-depositional movement. Occasionally partings are both undisturbed and distorted within a few feet in the same core. Another form of carnallite occurs in some localities, appearing as brittle, purplish-clear, very finely crystalline irregular nodules. When present, cores exhibit the effect of hydraulic erosion, with the cutline of carnallite masses against unleached halite or sylvite. The appearance is much the same as if water was present in drilling fluid to chemically leach the more soluble salts.

Type V material is clear-white-pink, predominately coarsely crystalline halite with variform occurrences of clay. Potash is notably lacking. Halite of this category truncates underlying layers in the bed and does, in fact, comprise the total bed in some areas. It is proposed that following precipitation of potash minerals, brine concentration decreased with the introduction of a relatively small amount of normal sea water. The undulating sea bottom in places protected the more soluble material, but where the freshened brine was most active magnesium and potassium salts were returned to solution and replaced by halite.

Obviously intruded halite has been observed in 2 core tests which is clear-white coarsely crystalline with slickenside on many crystal faces.

Since there is usually stratification of the various halite types in the bed, correlations have been made in order to construct cross-section and isopach maps, showing relationship between types. From these studies Type II is found immediately above Type I, Type III where present is next above and remaining Types IV and V succeed upward. One persistent 6-inch to 1 foot zone containing clay occurs within the bed, usually in the lower one-third, and considered to be a stratigraphic marker. Other clay materials, irregular in form, appear throughout the bed. All of the clays contain soluble fractions, demonstrated by H2O insoluble determinations related to visual estimates of clay content.

When comparisons are made between potash deposits of the world, each is found unique in suites of mineral association, progressive chemical or Metasomatic development and concentration of available potassium. The <u>Holbrook Basin deposits are remarkable in their mineralogical simplicity, apparently having only the halite-carnallite-sylvite series representing the total chemical constituent of Zone 4</u>. Kieserite is conspicuous in its absence, and in this association langbienite, kainite and possibly polyhalite might also be expected. None of these has been thus far identified, and there seems little possibility that any will appear in more than minor occurrences because of chemical content in a broad sampling of the ore zone. Consequently this may be a heretofore unconsidered mode of suite development. Further, it appears that there is primary sylvite in Type IV halite since we have seen K2O equivalent higher than could be expected for minerals other than sylvite in apparently primary rocks. From these observations it would seem meaningless to pursue the almost infinite paths of salt genesis as the principal exploratory tool, since each occurrence is demonstratively unique and can be effectively categorized only after some definition of a given deposit. The resultant technique is the study of tangible criteria which could effect behavior of saturated brines, precipitation of bittern salts and to some degree secondary reaction. Some factors to be considered are 1.) Configuration of the pan or pans containing bittern salts, 2.) Topography of the pan bottom during deposition, 3.) Features surrounding the evaporate basin, 4.) Behavior of solutions effected by concentration, temperature, evaporation and currents, 5.) Nature of the recovered material including preservation or lack of preservation of primary structures, types of stratigraphic contacts, inclusions, degree of altepation and mineralogy and 6.) Events preceding and following deposition of a prospective interval.

SAMPLING AND ANALYSIS TECHNIQUE

During early stages of drilling in areas of potash concentration, chemical analysis was often in conflict with gamma ray-neutron logging. Inasmuch as the acres exhibited highly irregular mineral distribution it became obvious that core sampling as then practiced could result in poor representation of potash content. To remedy the problem, the first step was to increase the size of sampling from the ore zone. This was accomplished by whip stocking above the zone, coring through, and then straightening the original hole from another whip stock or vertical hole to again core the zone. Most often 3 cores were obtained from 3 to 15 feet apart, but 2 cores were cut in 4 of the 25 locations with whip stocking operations.

Wide variances were regularly seen in potash content, between cores that were relatively close. 5-foot averages were found to differ by as much as 45%, though cores were only a few feet apart.

Experience with analysis of one-fourth of 3 ½-inch diameter cores demonstrated that accuracy was affected by size of sample from the potash bed. Further, the manner of crushing and splitting seemed to influence results. Consequently, procedures evolved to the following means of handling:

> The core is split through the section to be analyzed, one half is crushed in 1-foot increments or on lithologic breaks to approximately 20 mesh and then each increment is thoroughly mixed in a small, five-gallon, cement mixer. After mixing, the crushed material is pun through a sand splitter until a 100-gram sample is obtained. This sample is mailed or shipped to a chemist for analysis by the chloroplatinic method. The bulk sample is resplit to obtain two 20-gram samples for K2O content by a temperature-change method, performed locally in the Arkla office. Usually a composite sample is made by combining proportionate amounts of each increment sample over a part of the zone, for determination of chemical content to compare with averaged results of the single samples.

The chloroplatinic method is generally accepted by industry as the standard means of K2O determination. However, a number of samples were run by other means for comparative purposes, including the Sodium Tetraphenolboron Procedure, the Flame Photometer, the Atomic Absorption Spectrophotometer and the Large Volume Counter. Also, fractions of the same sample were sent to different analysts for chloroplatinic assay. The chemist who demonstrated the finer repeatable results was found to be T.J. Futch of 918 N. Alameda, Carlsbad, New Mexico.

The temperature-change procedure was adapted from low, et al for a rapid method of K2O determination, and as a check on chloroplatinic results. Indicated accuracy is within

1% K2O, and results are available in a few hours after the core is delivered. Adaption from the published method, which reports KCL values, was made with the statistical plotting of more than 200 samples run by T. J. Futch, to read as K2O content. A table is Low, Weinig & Schoder, 1939. "Rapid Method for the estimation of KCL in KCL+NAC1 Mixtures" in "Technical Methods of Ore Analysis," eleventh edition, pp 219-221.

Used for values, rather than to obtain results from a graph, as followed in the published procedure.

A reasonable measure of reliance can be placed in relative K2O content as indicated by gamma ray logging. On Mr. Futch's authority (personal communication), a low chlorpolatinic result should be repeated until it is in proportion to a high gamma ray reading over the same investigated area. In view of the irregular mineral distribution, and the numerous instances of both high and low comparative results, it is suggested the primary reason for such differences is that the logging tool investigates a different sample than the core; that is, the gamma ray reports the K2O value of the formation surrounding the well bore, while core analysis is the content of a somewhat different sample. In the No. 1 NMA, and in other core tests, average gamma ray value is lower than the chemical analysis of the core. In such instances it is proposed that results obtained from cores is almost certainly optimistic in appraisal of the ore body, since the gamma ray investigates a larger sample than does core analysis. Conversely, when the gamma ray indicates a higher value in proportion to chemical, some consideration should be given to the possibility that average ore grade is higher than the chemical content of the core.

Limitations of the gamma ray log are in 1.) Lack of perfect shielding to prevent counting of gamma rays above and below the crystal, and 2.) In the manner of handling the tool. Factors which can influence reliability are calibration, power variation, logging speed and interpretation. It is believed that this method can be very effective when efforts are made to duplicate conditions for each log. Imperfect shielding can be compensated for by interpretation of contribution from above and below.

POTASH DEPOSITS

Including apparent drilling concentration by others with results obtained by Arkla, it is possible to restrict potential area to a northeast-southwest trending band, open at both ends. The strip is about 20 miles wide and its center line passes diagonally across the area of mutual interest. Detailed cross-sections and isopach maps depict a number a elongate, en echelon structured ridges (with consequent intervening low areas) showing parallelism to the general trend. On the southeast margin of the trend one of these ridges is strongly developed and this is considered the primary restriction to further influx of less saturated brine into the area where potash was deposited.

The greater concentrations of potash are located in the low areas between ridges, and two of these areas have some measure of definition from Arkla's first phase exploratory drilling. Area I trends southwestward from the south boundary of the Petrified Forest

National Park, in T16N-R23E, to loss of test control in T15N-R23E. Area II is parallel and begins at lack of control near the northeast corner of T17N-R23E and is carried southwest into section 35-T16N-R22E. Within this 500+ square mile area, 38 potash core tests have been drilled, having an average density of one test for each 13 square miles. 27 tests were drilled in 54,400-acre area, density 1 test for each 3 square miles. Closest drilling was near 1 mile separation but spacing was more often 2 miles or more. Assuming that each test evaluates 160 acres, only 7.9 percent of the 54,400 acre area has been tested. In order to calculate potential, an isopepcent map was prepared with values obtained from K2O averages over 5-foot intervals as indicated by the Chloroplatinic Method of chemical analysis. After contouring on 5 percent interval, areas I and II were differentiated by an intervening area indicating less than 15 percent K2O values over 5-foot thickness. With regular contour spacing, the apparent maximum value possible is 26 percent K2O. Since a planimeter was not available, a grid count of acreage was made within the 15 percent contour in both areas, and average content calculated with assignment of 17.5 percent between the 15 and 20 percent contours, 16 percent where the 20 percent contour is not present, and corresponding treatment through the remaining contours.

In area I, 6,348 acres are potentially underlain by a thickness of 5 feet or more of sylvinite ore containing 19.73 percent K2O. Converting to tonnage, 86.4 million tons would be in place over the 5-foot interval, but it seems logical to allow 10 percent increase for possible ore thickness of more than 5 feet, since isopach maps indicate bed thickening and the isopercent map does not provide for any increase over 5 feet. Other factors that would tend to increase tonnage or average value, such as rapid lateral development of ore grade, would be at least partially balanced by anticipation of barren pods within the ore body. The consequent net estimate of potential from area I is 95.0 million tons of 19.73 percent grade potash ore. Area II calculations indicate that 12,711 acres may be underlain by 190.4 million tons of 19.77 percent grade ore, after applying adjustments noted above. Inasmuch as the two areas are in reasonable proximity they are combined to a net potential of 285.4 million tons of 19.76% K2O average grade. Related to the exploration guide, furnished by Arthur G. McKee and Company of San Francisco, of 5.5 square miles underlain by a 5-foot thickness of 20% K2O ore to comprise the minimum specifications necessary to economically justify mine and process installation, this prospective area exceeds requirement by 540% and potential reserve is 596% greater than the specified minimum.

Since a lower ore grade could be considered as economic, and recognizing that each area might expand on trend, the above figures do not reflect maximum potential for this part of the interest area.

RECOMMENDATIONS

Results of this study are believed to provide a credible indication that possibility is excellent for improvement of ore grade in the area of closest test control, in volume exceeding requirements for commercial operation. A second phase of exploratory drilling is recommended, with nine test holes proposed at locations near the better first phase core tests. Approximate locations are listed below, in the order of drilling convenience.

1.) SW SE Section 27-T16N-R23E Location is approximately one-half mile north of the Arkla No. 99 state, which is classified as near commercial (5' average: 14. 69% K2O)

2.) SW SE Section 33-T16N-R23E Approximately ¾ mile southwest of Arkla No. 99 state

3.) SW SW Section 35-T16N-R23E Approximately ½ mile southeast of Arkla No. 99 state. This location would be unnecessary as an exploratory test if favorable results were obtained from 1 and 2.

4.) NW NW Section 24-T16N-R23E Located on a vector of improvement, by cross-section, from Arkla No. 1 NMA and No. 14 state. Anticipate thick type II halite. No. 1 rated as having significant show (5' average: 10.75% K2O); No. 14 near commercial (5' average: 12.66% K2O)

5.) NW NW Section 5-T16N-R23E Approximately ½ mile northeast of Arkla No. 83 state, rated near commercial (5' average: 14.14% K2O).

6.) SW SE Section 13-T16N-R22E 1 ¼ miles southwest of Arkla No. 32 state – near commercial (5' average: 15.59% K2O).

7.) NW NW Section 26-T17N-R23E 1 mile east-southeast of Arkla No. 38 NMA – near commercial (4.8' average: 13.28%)

8.) C Section 21-T17N-R23E Located in indicated thick area (by isopachs), approximately 2 ¼ miles southeast of No. 38 NMA.

9.) SW SW Section 4-T17N-R23E 1 ¼ miles northeast of No. 38 NMA.

Although whip stocked holes through the ore bed would be in some ways desirable, it is suggested that the cost of this technique could be better placed in adding more single holes. However, size of cores should not be reduced from the 3 ½" size recovered in phase 1 coring. Handling of cores and assay techniques should be similar to the earlier practice. Immediate resumption of drilling should follow in order to create a competitive position in the indicated tightening market.

OIL, GAS AND OTHER POSSIBILITIES

Core test drilling has afforded additional indirect control for appraising oil and gas possibilities, and direct indications of uranium, in near-surface deposits, as recorded by gamma ray logging. At some future date, cuttings may prove valuable if aluminum iron, clay or other deposits appear in the area as valuable commodities.

Considering oil and gas potential, five holes penetrated the Ft. Apache limestone member of the Supai Formation, and one reached the apparent base of the sedimentary sequence. Ft. Apache is considered the uppermost unit with more than nominal possibility to develop as a hydrocarbon reservoir. In three of the holes, considerable oil stain was noted, and minor gas kicks were recorded. In all tests the Ft. Apache was impermeable, but selective core analysis indicated low porosity. Conditions surrounding the evaporate basin would provide the classic environment for pen contemporaneous reef growth. At the time that basinal Ft. Apache was deposited, in highly saline water, reefs may have been developing on the margins. Further, any area protruding above supersaturated brines could produce favorable conditions for reef development in the interior area of the basin. Until the Jack Grimm No. 1 Platt was drilled in Section 31-T15N-R26N, offsetting the southeast part of the mutual area of interest, there was no direct evidence that such high features could exist in the interior salt basin. This well, however, encountered predominately anhydrite rather than halite in the Supai, and although unable to log to bottom, the upper part of the evaporate sequence had only nominal thicknesses of any evaporitic material. The well was bottomed in light gray to tan crystalline limestone, assumed to be equivalent to Ft. Apache, but very different from the fetid, earthy, dolomitic type seen in the Arkla core tests. Penetrated thickness of the limestone was 65 feet. A new perspective is therefore provided for assessment of the Ft. Apache as a potential hydrocarbon reservoir.

The gravity-magnetometer survey, added structural control and upper section isopachs will aid in development of deeper prospects. Separate reports will be issued after material is compiled and in form for presentation.

Helium is prospective in interest area since presence of the gas was proven in the completion attempt on the land company's No. 3 core test. The tested interval was in the evaporate sequence, and several blow-outs were experienced in the later program, while drilling through similar BECs. Reservoir capacity is believed limited where gas shows have thus far been encountered, but commercial reserves may be founding course clastics that appear irregularly in the section. The Coconino sandstone, which produces helium in the Pinta Dome Area, has not been thoroughly investigated and there is at least one area with possibility for structural accumulation. One helium test was drilled after recording shows in the No. 27 NMA. There is also helium gas present in T13N-R23E, recovered from wells drilled to the Basal Chinle Formation. Though formation pressure is very weak, a widespread area with gas in the latter reservoir might be commercially developed.

High radioactivity has been recorded by gamma ray-neutron logging in several of the core tests, with probable source from uranium content. Some of the core test occurrences correlate with outcrop sections which have produced minor tonnages of uranium ore.

CONCLUSION

ARKLA Exploration Company
INTERNAL CORRESPONDENCE

Primary accomplishment of first-phase exploration in the Holbrook drilling project was the broad delineation of area with excellent possibilities for commercial potash deposits. This potential can be thoroughly investigated with a minimal number of holes, following which decisions could be made with regard to development drilling.

Additional benefits were derived from expanded knowledge with regard to helium, uranium and oil exploration.

Warren E. Carr