UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

AFFILIATED WITH

THE COLLEGE OF MINES AND MINERAL INDUSTRIES

UNIVERSITY OF UTAH

SALT LAKE CITY, UTAH

CLAYS
OF UTAH COUNTY, UTAH

By EDMOND P. HYATT

Bulletin 55

May, 1956

Price $2.00

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

The Utah Geological and Mineralogical Survey was authorized by act of the Utah State Legislature in 1931; however, no funds were made available for its establishment until 1941 when the State Government was reorganized and the Utah Geological and Mineralogical Survey was placed within the new State Department of Publicity and Industrial Development where the Survey functioned until July 1, 1949. Effective as of that date, the Survey was transferred by law to the College of Mines and Mineral Industries, University of Utah.

The *Utah Code Annotated 1943, Vol. 2, Title 34,* as amended by *chapter 46 Laws of Utah 1949,* provides that the Utah Geological and Mineralogical Survey "shall have for its objects":

1. "The collection and distribution of reliable information regarding the mineral resources of the State.

2. "The survey of the geological formations of the State with special reference to their economic contents, values and uses, such as: the ores of the various metals, coal, oil-shale, hydro-carbons, oil, gas, industrial clays, cement materials, mineral waters and other surface and underground water supplies, mineral fertilizers, asphalt, bitumen, structural materials, road-making materials, their kind and availability; and the promotion of the marketing of the mineral products of the State.

3. "The investigation of the kind, amount, and availability of the various mineral substances contained in State lands, with a view of the most effective and profitable administration of such lands for the State.

4. "The consideration of such other scientific and economic problems as in the judgment of the Board of Regents, should come within the field of the Survey.

5. "Cooperation with Utah state bureaus dealing with related subjects, with the United States Geological Survey and with the United States Bureau of Mines, in their respective functions including field investigations, and the preparation, publication, and distribution of reports and bulletins embodying the results of the work of the Survey.

6. "The preparation, publication, distribution and sale of maps, reports and bulletins, embodying the results of the work of the Survey. The collection and establishment of exhibits of the mineral resources of Utah.

7. "Any income from the sale of maps and reports or from gifts or from other sources for the Survey shall be turned over to the State Treasurer and credited by him to a fund to be known as the Survey Fund to be used under the direction of the Director of the Survey for publication of maps, bulletins or other reports of investigation of the Geological and Mineralogical Survey."

The Utah Geological and Mineralogical Survey has published maps, circulars, and bulletins as well as articles in popular and scientific magazines. For a partial list of these, see the closing pages of this publication. For other information concerning the geological and mineralogical resources of Utah address:

ARTHUR L. CRAWFORD, *Director*

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

College of Mines and Mineral Industries

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Salt Lake City 12, Utah

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FOREWORD

In the foreword to Bulletin 35 of this series, the writer made the following observations which seem here pertinent:

> "Of the neutral refractories, those high in alumina are the most common. Of these, the kaolin type clays are the oldest and best known. High-grade clays of Utah are very limited. Large deposits of clay are usually formed by long-continued weathering in a warm moist climate, where the organic acids from the dense vegetative covering leach the clay of all its impurities. For best development, this leaching process requires long periods of time under conditions of great geological stability. In an arid mountainous region such as Utah that has been subjected to frequent uplifts and extensive erosion, a geologist would not expect to find high-grade clays in great abundance. The clays he could expect would be either (1) those preserved in the strata from former geological periods when conditions were more favorable or (2) those in mineralized districts where hydrothermal solutions or cold acidulated waters have produced local deposits of high-grade material."

As pointed out by Professor Hyatt, the author of the present bulletin, the now famous Dragon clay of Juab County and several of the minor deposits discussed by him owe their origin to hydrothermal alteration. However, most of the clays of Utah County have been "preserved in strata (of the Manning Canyon formation or of the Long Trail shale) from former geologic periods when conditions were more favorable."

The Manning Canyon shale is a bed of comparatively pure end products of weathering which slowly accumulated during the closing epoch of Mississippian time and during the initial stages of the Pennsylvanian period. This was a time of relative crustal stability in that part of the earth now known as Utah County, Utah. Immediately thereafter, this part of the earth began to sink; as it sank, the downwarp was filled with enormous thicknesses of sands and calcareous sediments, so that the thickest sequence of Pennsylvanian strata yet known anywhere on earth is now preserved in the Oquirrh Mountains. Such rapid deposition of sediments furnished little opportunity for the slow processes of weathering and end-product segregation necessary for the accumulation of clays or of high-grade shales from which valuable clays might be derived. Thus, of the strata now exposed in Utah County, the Manning Canyon shale and the pre-existing Long Trail shale (from which much of the Manning Canyon shale may have been a reworked and transported derivative) are the most favorable geologic formations in which to prospect for clays.

However, the prospector should bear in mind that these unaltered shales have little value in brickmaking, but do have a potential value in certain other uses. When they were laid down, they almost invariably contained small amounts of carbonaceous matter which acted as a precipitant of sufficient iron sulfide to make the shales of little value to us now as a refractory. Furthermore, small amounts of lime carbonate, a deleterious impurity which lowers the fusion point of clays, if not already present as an original constituent of deposition, became later precipitated as veinlets and impregnations brought in by ground water from the great thicknesses of limestones both above and below these shales. Hence, most present-day clay beds derived from these shales, to have appreciable commercial value, must have received "secondary enrichment" through oxidation and leaching. By oxidation iron pyrite is converted into soluble ferrous sulfate and sulfuric acid which in turn reacts with the lime carbonate impurities to form soluble products which are removed by leaching. As a result, the original impure dark-colored shale may under favorable local circumstances be converted into a light-colored high-grade clay of commercial value.

As pointed out by Professor Hyatt, the Manning Canyon shale typically forms a pronounced strike valley where it is present in a folded sequence beveled by erosion. Its softer constituents are more easily eroded than are the adjacent limestones and siliceous sediments. However, it is not in these strike valleys that the best clays are always found. In such valleys: (1) the dip is often too steep to allow exposures wide enough for quantity production without expensive underground development; (2) the water table is often too consistently high to permit deep oxidation and leaching of significant tonnage; (3) concentration of runoff along the "protore" bed is such as to accelerate removal of the valuable leached clay almost as soon as it is formed.

In view of these circumstances, the prospector looking for clays derived from the Manning Canyon shale should seek an area having as many of the following characteristics as possible: (1) a great relative thickness and consistency of the "protore" bed with a minimum of interstratified limestone or sandstone impurities; (2) low angle of dip (and thus wide exposure) of the "protore" bed; (3) deep ground-water table (as on divides or benches) where oxidation and leaching will have penetrated a maximum depth; (4) stabilized erosion such as may be found on low divides or in broad flats where the clay outcrops will be neither stripped by premature sapping nor buried by subsequent fill.

Even with all these aids to prospecting, the outlook is not bright for the discovery of large deposits of truly high-grade clays in Utah. It is becoming increasingly evident to those who have studied the problem most that the ceramic industry in Utah must choose one of two unfavorable dilemmas: In the main, either relatively low-grade raw materials which are suitable only for the less exacting requirements must be used; or high-grade kaolins, bauxites, etc. must be imported from other areas for local manufacture or for upgrading the inferior raw materials here available.

Utah is fortunate in having with us a man of Professor Hyatt's background. He was reared and educated in Missouri in the heart of one of the high-grade clay-producing areas of the United States. He combines the fields of ceramics and geology. His experience and training give him particular fitness for the survey he has here made, the results of which are recorded in this bulletin.

Arthur L. Crawford, Director
UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

CLAYS OF UTAH COUNTY, UTAH

by

Edmond P. Hyatt[1]

A B S T R A C T

The first comprehensive report on the clay deposits of this county is subdivided into the major types of clay found: Manning Canyon shale, probably accounting for at least 75% of the total clay production of the county; Long Trail shale; primary clays; and lacustrine and alluvial clays.

Each of the types of clays is discussed by geographical areas with the shales appearing in seven distinct areas; primary clays in ten; other clays are found in nine locations.

Clay materials from each deposit visited were tested in the field and in ceramic laboratories to determine mineralogical nature and economic significance. Results of the tests are given in four tables.

Special attention is given to weathering of the Manning Canyon shale which in some places is found to be a good brick clay and in others to be worthless. Origin of the Fox Hills halloysite is also discussed in its place.

Clay production figures for Utah County are tabulated for the past few years.

Twenty-two location maps and other figures graphically supplement the fifty-two pages of text. Appendices include information concerning clay minerals, prospecting, testing facilities, fluorine and selenium contents, and pyrometric cones.

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1 Instructor in Geology, Brigham Young University, Provo, Utah.


Index Map of
UTAH
Showing Location
of Utah County
SCALE~MILES
BOX ELDER
GREAT SALT LAKE
CACHE
Logan
Randolph
RICH
Brigham
WEBER
Ogden
MORGAN
Morgan
DAVIS
Farmington
Coalville
SUMMIT
DAGGETT
Manila
Salt Lake City
SALT LAKE
Tooele
TOOELE
Heber
WASATCH
UTAH
COUNTY
DUCHESNE
Duchesne
UINTA
Vernal
JUAB
Nephi
CARBON
Price
SANPETE
Manti
MILLARD
Fillmore
Castle Dale
EMERY
GRAND
Moab
Richfield
SEVIER
BEAVER
Beaver
PIUTE
Junction
Loa
WAYNE
IRON
Parowan
GARFIELD
Panguitch
Monticello
SAN JUAN
WASHINGTON
St. George
KANE
Kanab
VIRGIN R.
COLORADO R.
SAN JUAN R.
GREEN RIVER
GRAND RIVER
SEVIER RIVER

I N T R O D U C T I O N

PURPOSE AND SCOPE OF INVESTIGATION

Utah's recent growth in population, partly the reflection of the establishment of large industrial and government installations, has made new demands upon her raw materials, not the least of which is clay.

Prospectors have turned to Utah County, long the chief supplier of Utah clay, for new and better locations from which to extract this valuable raw material. The chief drawback the many searchers have met is the almost total lack of information regarding favorable locations for clays.

This investigation was undertaken for the purpose of inspecting, mapping, classifying, cataloging, and evaluating the clay deposits of Utah County so that complete and accurate information would be available. It represents almost the first efforts of its type either in the state or in any local area within Utah.

All clay occurrences in Utah County that have come to the attention of the writer to date have been investigated and reported herein. Much of the county has not been critically examined for clay and it is very likely that other occurrences, probably of minor significance, will be located in the future. The reasons for this suggestion are developed in a later chapter.

The possible clay locations, whether spoken of by novice prospectors or by important producers or mentioned in the geologic literature, were visited and examined. Quality rather than quantity of the clay was the principal object and no estimation of reserves was attempted.

Portions of the samples collected at each of the deposits were retained and form the nucleus of the clay collection of the Utah Clay Library and Testing Laboratory, the repository of which is the Department of Geology, Brigham Young University, Provo, Utah.

ACKNOWLEDGMENTS

The nucleus of this report was a study made under the direction of the writer and filed as a master's thesis by Richard H. Ornelas, Brigham Young University, January 1953. The Utah County Planning Commission, I. Dale Despain, Director, sponsored compilation of the 1953 report, and the Brigham Young University Research Committee, Dr. Harvey Fletcher, Director of Research, sponsored further work during 1953 to bring the project to its present status. Others who have materially assisted either in the earlier work or in the present writing include: Dr. Carl J. Christensen, former Dean,* College of Mines and Mineral Industries, University of Utah (use of laboratory facilities of the Department of Ceramic Engineering); and Robert L. Root, geologist (location of deposits and collecting of samples).

*Now Coordinator of Research, University of Utah.

CLAY AND ITS USES

Clay is the name applied to those naturally occurring, earthy materials which are plastic when wet and which become hard and rock-like when heated to a temperature above redness (Ries, 1927). Sedimentologists define a clay as a sediment composed of very small particles of which the upper dimension is 1/256 millimeters (Pettijohn, 1949, p. 13). Mineralogists differentiate a number of clay minerals, the chief of which are kaolinite, halloysite, montmorillonite and illite. See Appendix A for tabulation of these minerals.

Clay may be classified as residual or transported. The residual clays result from decomposition of older rocks and are found upon the parent rock from which they are derived. Transported or sedimentary clays are formed mainly from residual material which is washed by rains into streams and transported varying distances. In the process of transportation the particles are sorted, abraded, broken, and finally deposited along stream banks, in swamps, lakes, estuaries, or in the sea (Greaves-Walker, 1939, p. 8).

Depending upon its color, texture, bonding strength, adsorption, firing, and other physical characteristics, clay is used as a filler in the manufacture of paper, rubber, and fabrics; as a bonding agent in synthetic foundry sands; as a catalyst; and in the manufacture of refractories, abrasives, whitewares, and building materials. The clay which is found in Utah County is of such grade that it nas been successfully used only in the manufacture of low-grade refractories, as runner clay, and for the manufacture of building materials such as sewer pipe, tile, and brick. Halloysite from the Dragon mine near Eureka, Juab County, is used in the manufacture of catalysts.

REVIEW OF LITERATURE

Very little has been published regarding the producing possibilities of Utah County clays. Many of the clay deposits of the county have been investigated and a few reports written, but most of the reports are not available to the public. Production figures from the pits currently in operation and from those which have been operated in the past are, for the most part, not obtainable.

Ries (1927), a national authority on the subject, stated that he had seen "no published information regarding the clay resources of the state" (Utah).

Greaves-Walker (1939, pp. 80-81) wrote several paragraphs concerning the clays of Utah. He describes Permian and Pennsylvanian refractory clays occurring near Lehi, Cedar Fort, and Fairfield, all in Utah County. However, he does not refer to the deposits by name nor by exact location. An earlier publication on Utah clays by Greaves-Walker (1911) fails to mention Utah County clays.

Crawford and Buranek (1948) in a geologic and mineralogic reconnaissance of Lake Mountain, Utah County, describe the Fox and several of the Western Fire Clay Company deposits on the east side of the mountain. Sharp and Stringham (1950) made a detailed study of the Fox clay deposit. Bullock (1951) briefly mentions the Fox clay occurrence and proposes a theory regarding the origin of this body. He also studied the Manning Canyon shale in the Lake Mountain area. Chelikowsky (1935) states that there are no fire clay deposits of significance in Utah.

Ornelas' 1953 thesis, though unpublished, represents the first attempt to make a complete survey of Utah County clay.

PROCEDURE

Field Investigations: Field work was carried on principally during the summers of 1952, 1953, and 1954. Each deposit listed in this report was investigated and the following data recorded in the field: location, unfired color of clay, thickness of deposit, extent of outcrop, the presence of calcium carbonate (by acid test), attitude of beds, lithology of adjacent units, and fossil evidence. In addition, a ten- to fifty-pound representative sample was collected from the exposed face of the outcrop.

Laboratory Investigations: Facilities of the Ceramic Engineering Laboratory of the University of Utah and of the Geology Clay Laboratory of Brigham Young University were utilized in making the tests on samples of the clays collected. In general the tests were made on composite samples from each location in an attempt to determine average properties which would be encountered in commercial operations.

A simple firing behavior test was conducted on ground portions of the clays. Samples were drawn at cone 04 (36° rise per hour to 1920°F.), cone 2 (2080°F.) and, in a few cases, at cone 4 (2130°F.), cone 6 (2170°F.), or cone 8 (2240°F.).

Fired color, shrinkage (or bloating) and porosity were determined for each specimen according to the specifications of the American Society for Testing Materials (1948). Both raw and fired colors were noted according to best match on the National Research Council's "Rock-Color Chart" (1948). Hue, value, and chroma are noted in the color symbol, e. g., 5 YR 9/1.

Fusion or pyrometric cone equivalent (PCE) tests were made on those clays exhibiting highest refractoriness in the preliminary tests.

Mineralogical nature was determined by visual examination and by the differential thermal analysis method.

UTAH COUNTY

Utah County's location makes it unique for several reasons. Three major physiographic provinces share parts of the county's 2,140 square miles; the westernmost half, chiefly broad semi-arid valleys and fault-block mountains, lies within the Basin and Range Province; the southeastern corner has uniformly dipping beds belonging to the Colorado Plateau; and the remainder (east-central portion) includes part of the rugged Wasatch Mountains of the Middle Rocky Mountain Province.

The county is served by four major highways and one railroad. Provo, the county seat, is 45 miles south of the business and population center and capital of the state, Salt Lake City.

The economy of Utah County is dependent largely upon its steel-producing and fabricating plants and upon its agriculture. Of considerable importance also is Brigham Young University, one of the leading institutions of higher education in the state.

See figure 1, location map of Utah County, Utah.

M A N N I N G C A N Y O N S H A L E

F O R M A T I O N

GENERAL GEOLOGY

The most important clay-producing horizon in Utah County is the Manning Canyon shale formation. As seen in figures 1 and 3-15, it forms outcrops in several widely scattered areas. In a few of these locations mining has proceeded for several years and all indications are for continued and expanded production.

Gilluly (1932) named this formation after its type location in Manning Canyon in the Oquirrh Mountains (fig. 9). It was described as dominantly shale with some thin, interbedded limestones and at least two quartzite beds. G. H. Girty, after fossil studies, indicated that the Mississippian-Pennsylvanian contact was near the middle of the formation.

As pointed out by Gilluly (1932, p. 32) and confirmed by the present writer, the squeezed, deformed, and contorted nature of the Manning Canyon shale and its differential thinning greatly complicate the measuring of any sections.

The measured sections shown on pages 11-13 illustrate the lithology. Figure 2, page 14, gives diagrammatic representation for these sections and shows the difficulty of correlation.

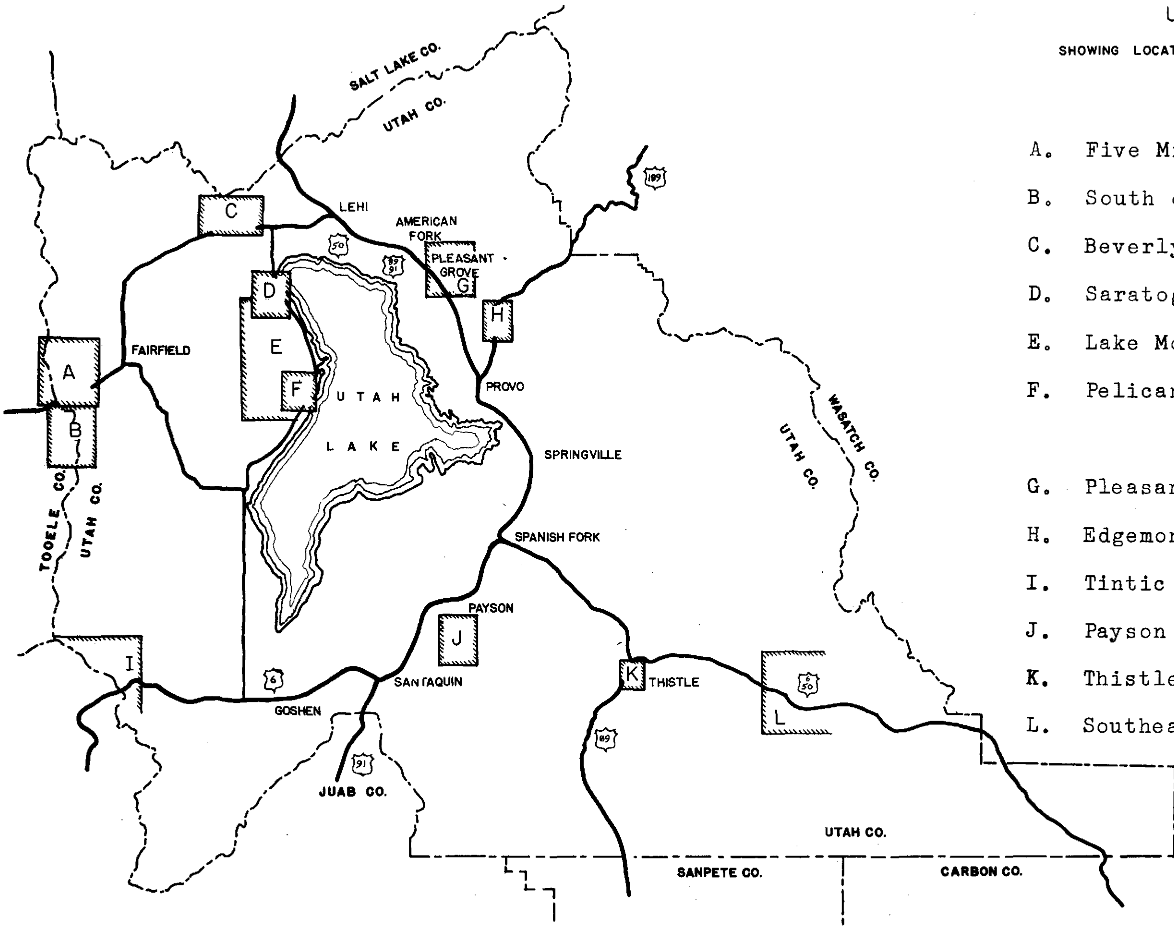


FIG. 1

UTAH COUNTY, UTAH

SHOWING LOCATION OF PRINCIPAL AREAS OF CLAY DEPOSITS

KEY

A.	Five Mile Pass	Fig. 9
B.	South of Five Mile Pass	Fig. 11
C.	Beverly Hills area	Fig. 12
D.	Saratoga Springs area	Fig. 4
E.	Lake Mountains	Fig. 3
F.	Pelican Hills area	Fig. 6 Fig. 7 Fig. 8
G.	Pleasant Grove area	Fig. 18
H.	Edgemont-Pole Canyon area	Fig. 15
I.	Tintic district	Fig. 21
J.	Payson	Fig. 14
K.	Thistle	Fig. 22
L.	Southeastern Utah County	Page 66

Section of Manning Canyon shale measured on north side of Soldier Canyon about half a mile above its mouth, section 33, T. 5 S., R. 4 W. (Section measured by James Gilluly, 1932.)

Oquirrh formation:

Limestone, in beds as much as one foot thick, carrying plentiful fossils.

Conformable contact.

Manning Canyon shale:

Bed No.	Description	Feet
1.	Limy shale and shaly limestone, interbedded..................................	185
2.	Dark shale, with a few thin limestones interbedded..............................	235
3.	Thick-bedded gray limestones, forming a ledge..................................	32
4.	Black shale, without fossils..........	78
5.	Thin-bedded limestone.................	1
6.	Dark-gray carbonaceous shale, unfossiliferous..................................	150
7.	Brown-weathering quartzite, forming a ledge...................................	4
8.	Dark-gray shale........................	147
9.	Gray limestone, in beds about 2 feet thick...................................	12
10.	Chiefly shale, with some interbedded limestone...............................	35
11.	Limestone, in beds about 2 inches thick.	17
12.	Carbonaceous shale.....................	43
13.	Limestone, like bed 11, carrying fossils.	40
14.	Carbonaceous shale.....................	78
15.	Limestone, like bed 11.................	8
16.	Concealed, probably chiefly shale, but with some limestone................	75
	Total	1,140

Conformable contact.

Great Blue limestone:

Shaly limestone interbedded with less shaly material, the shale decreasing in abundance downward.

Stratigraphic section of Manning Canyon shale measured on west side of Cedar Valley Hills, west side of Lake Mountain, Utah, October 19, 1950, by Keith W. Calderwood, H. J. Bissell, and Grant Smith. (Calderwood, 1951.)

Oquirrh formation:

Orthoquartzite, very fine-grained, dense, buff to medium light brown and reddish brown, slightly to moderately calcareous; well bedded in 1/2-inch to 18-inch beds, streaked with black argillaceous and possibly manganiferous layers.

Conformable contact.

Manning Canyon shale:

Bed No.	Description	Feet
9.	Limestone, shaly, sandy to silty, also calcareous sandstones. Limestones dark blue gray on fresh surface, weather gray brown. Sandstones shaly and weather reddish brown to flesh colored..........................	95
8.	Base of a ledge of mudstones, argillaceous calcareous shales, sandy and silty limestones, siltstones, and interbedded orthoquartzites. Numerous reed (?) impressions, mud cracks, and other indications of shallow water environment. Upwards limestones, dark blue gray, brown sandy rough-weathering, shaly fragments and sub-graywacke-like limestones, dense black, weather pink and lavendar..................	173
7.	Shale, at base, to shaly limestone. Shales tan, yellow brown, buff and tan, some dark gray. Limestones, dark gray, weather pale blue gray to gray blue. Banded orthoquartzites, flesh colored to reddish brown (on weathered surface)...............	139

6.	Medial limestone of the Manning Canyon: limestone, dark gray to medium dark gray, dense, hard, weathers pale somber gray to gray blue and light to light medium gray; nonfossiliferous lower part, few brachiopods upper part, well bedded in beds, average 18"-24".	93
5.	Series of arkosic orthoquartzites, subgraywackes, orthoquartzites and chloritic to micaceous shales, grit, and arkose. (May represent the Mississippian-Pennsylvanian contact).	128
4.	Shale, brown, red brown, purplish brown, containing lingulid brachiopods; soft, argillaceous clay shales. Beds contain seams of calcite and gypsum. Some yellow, ochre, and limonite-stained shales present; most beds in this unit are clay shales....................	92
3.	Base of ledge of scintillating brown-weathering, gray, pink and flesh-colored orthoquartzites; seamed with white quartz. Well bedded in 6-inch to 2-foot layers. Arkosic in part, locally cross-bedded...............	94
2.	Top of black shales, base of a semi-slope of scintillating, very dense, hard, very fine-grained orthoquartzite, flesh colored to tannish gray, with many white quartz seams and small veinlets, with interbedded black shale similar to underlying shales.......	140
1.	Base: shale, brown and black, fissile, and interbedded 1- to 3-foot beds of dense black siliceous limestone; shale weathers black and very dark brown. Some siliceous ironstone concretions present..............................	176
	Total	1,130

Conformable contact.

Great Blue limestone:

Upper part consists of massive limestones containing abundant chert nodules.

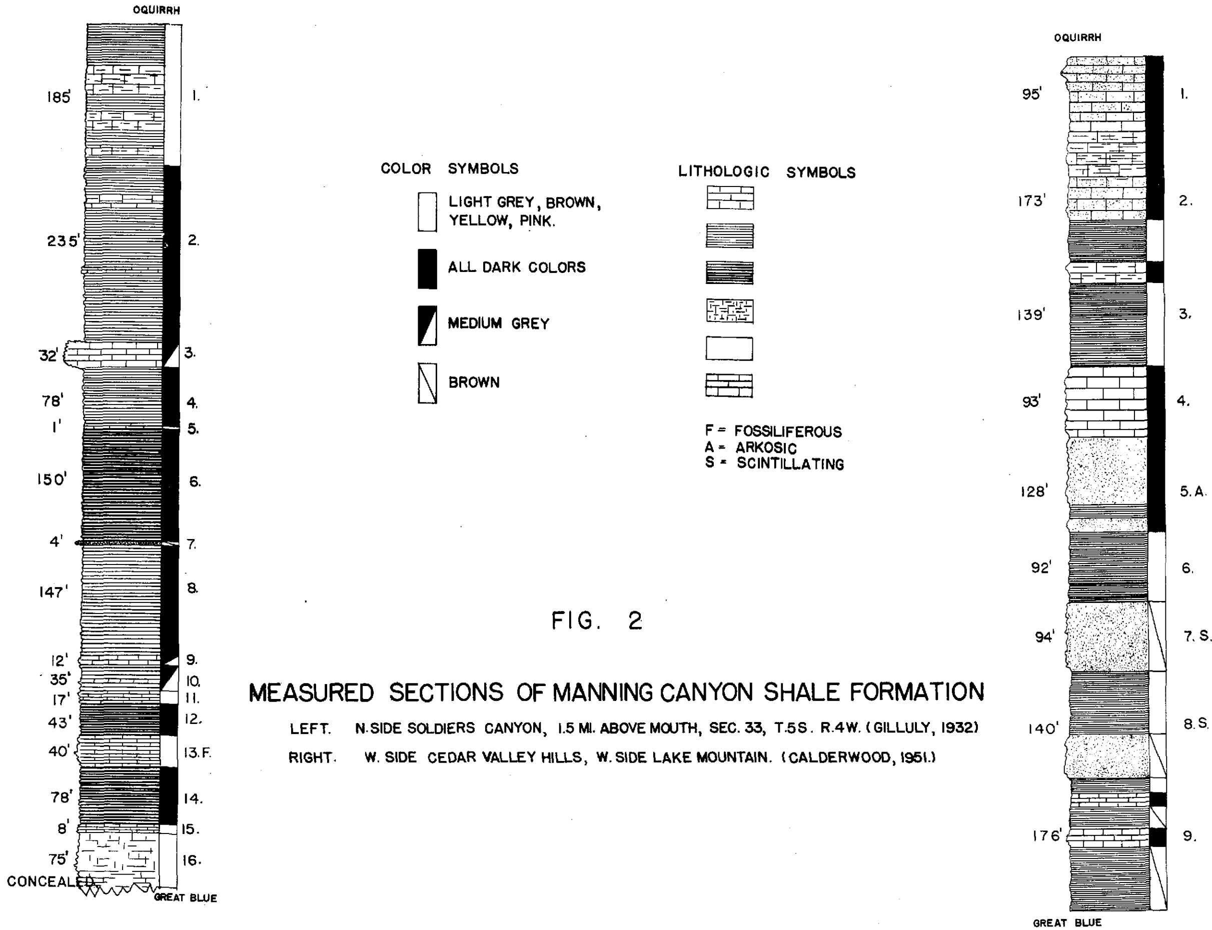


FIG. 2

MEASURED SECTIONS OF MANNING CANYON SHALE FORMATION

LEFT. N.SIDE SOLDIERS CANYON, 1.5 MI. ABOVE MOUTH, SEC. 33, T.5S. R.4W. (GILLULY, 1932)

RIGHT. W. SIDE CEDAR VALLEY HILLS, W. SIDE LAKE MOUNTAIN. (CALDERWOOD, 1951.)

DEPOSITS OF LAKE MOUNTAINS

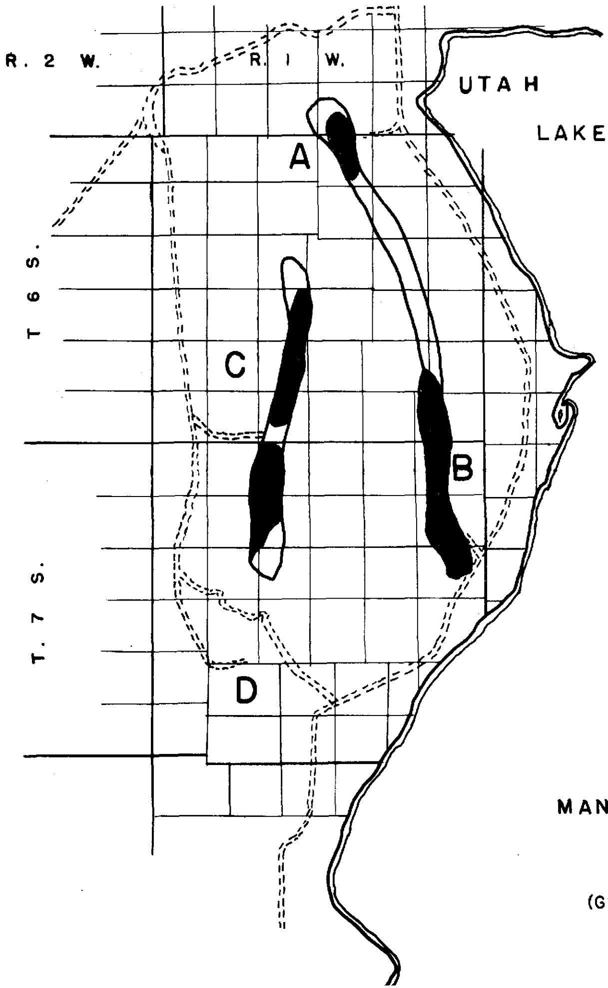
Bullock (1951) detailed the geology of the Lake Mountains and indicated the major locations of Manning Canyon shale outcrops. Figure 3 shows the outcrop pattern of this synclinally folded formation.

The eastern outcrops have been extensively prospected and a number of mines have been opened and some of these are in current production. The western outcrops are less favorable for open pit mining and are not currently being exploited.

Northeast Lake Mountains: The Powell deposit and the Interstate Brick Company deposits No. 1 and No. 2 are located in a small valley approximately seven miles west and south of Lehi in section 3, T. 6 S., R. 1 W., S. L. B. & M.

The Powell pit is in the SE 1/4 of section 3. (See fig. 4 for location and fig. 5 for cross-section.) Beds of the thirty-foot exposure strike N. 50° W. and dip 25° SW.; they are immediately overlain by black limestone. The clay is light gray with much rust-brown, purple, and yellow material interbedded in the upper part. In the lower part of the exposure the clay is mostly pinkish gray and also thinly banded and bedded. Although the noncalcareous clay is silty, it is also fairly plastic. A pit twenty feet deep and two hundred feet long has been opened and has been worked intermittently for several years. Table I contains data of tests made on a composite sample taken from the west side of the pit.

The Interstate Lake Mountain No. 1 deposit is located half a mile north of the Powell deposit and is situated in the NE 1/4 of section 3. In this particular area the Manning Canyon shale forms a portion of the east limb of the Lake Mountain syncline, and topographically is a pediment slope



KEY

A.	Interstate and Powell pits	Fig. 4 Fig. 5
B.	Pelican Hills	Fig. 6 Fig. 7 Fig. 8
C.	Wiley Canyon area	Page 23
D.	Fox Hills	Page 60

FIG. 3.

MANNING CANYON SHALE OUTCROPS

ON LAKE MOUNTAINS

(GEOLOGY AFTER BULLOCK, 1951)

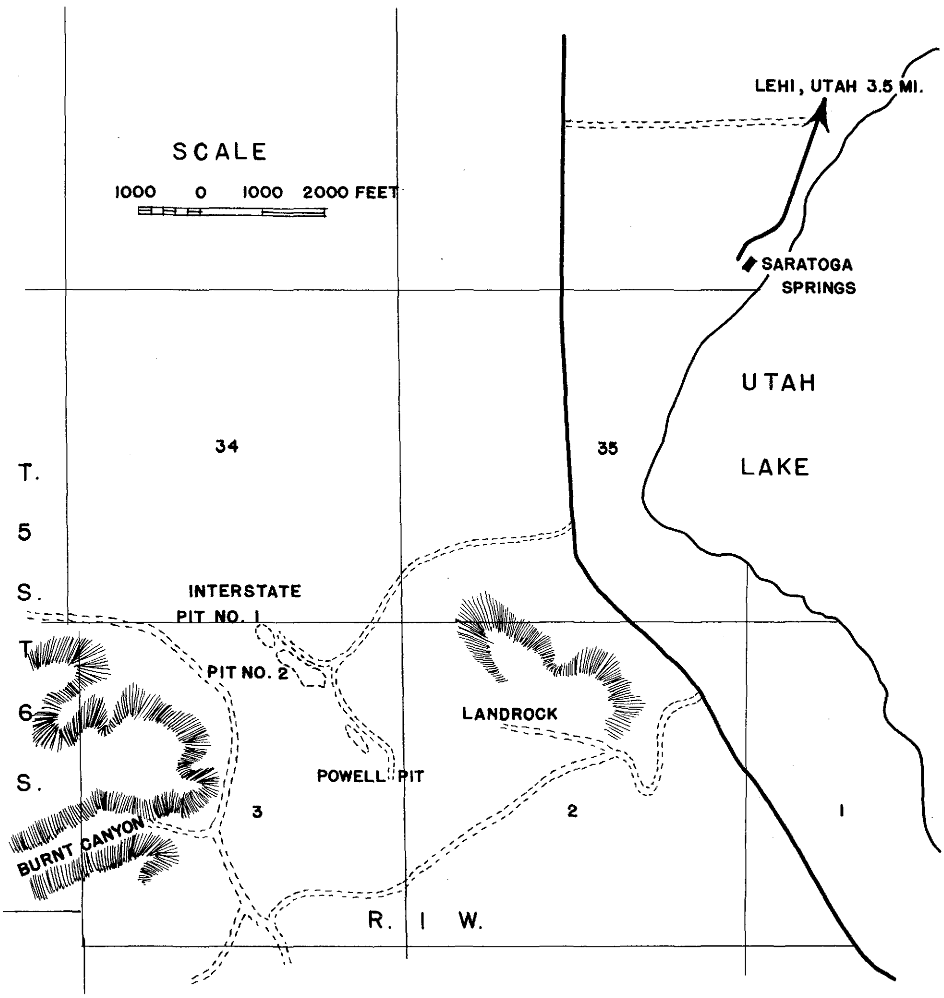


FIG. 4 LOCATION MAP
INTERSTATE AND POWELL CLAY PITS
NEAR SARATOGA SPRINGS, UTAH.

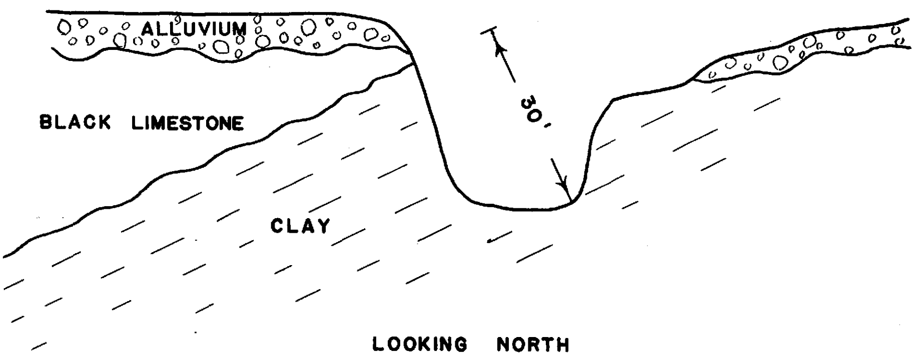


FIG. 5 IDEALIZED CROSS SECTION
POWELL PIT AND INTERSTATE PITS
SARATOGA SPRINGS, UTAH.

(Bullock, 1951, p. 38). The beds strike N. 65° W. and dip 25° SW. Greatest exposed thickness of the clay shale is thirty feet and it is described lithologically as being identical to the Powell deposit. Disc-like clay concretions with pyrite-limonite cores occur in some layers of the clay shale zone. (See fig. 16, p. 44.) Figure 5 indicates that good exposures of the black limestone immediately above the clay shale zone are also present in this area. The clay bed has been worked for a distance of 500 feet along strike and to a depth of twenty feet. Data of the tests made on several samples taken at regular intervals from both sides of the pit can be found in table I.

The Interstate Lake Mountain No. 2 deposit is located about a quarter of a mile south, along strike, from the deposit previously described. The strike of the beds is N. 50° W. with a dip of 25° SW. The clay is greenish gray with much interspersed and interbedded rust-brown and black carbonaceous clay also noticeable. It is plastic, shale-like, and breaks in splintery, flat pieces. Except for a thin bed of gray limy clay exposed at the bottom of the pit, the zone is noncalcareous. Black limestone is present here and occurs as ledges twenty to forty feet high. There is a sharp but evidently conformable contact between the clay and limestone units on the west wall where the clay is best exposed. The open pit is about 500 feet long and 150 feet wide and follows the strike of the clay zone. The pit has not been worked for several years. Data from tests made on composite samples taken across the west face of the pit can be found in table I.

Central Lake Mountains, Pelican Hills area: The Overcross claim, the Jack Rabbit claim, and the Cedarstrom pit--all owned by Roger Cedarstrom--are located in the same general area near Pelican Point approximately thirteen miles southwest of Lehi, Utah, in sections 1 and 12, T. 7 S., R. 1 W., S.L.B. & M. (See figs. 6, 7, and 8.)

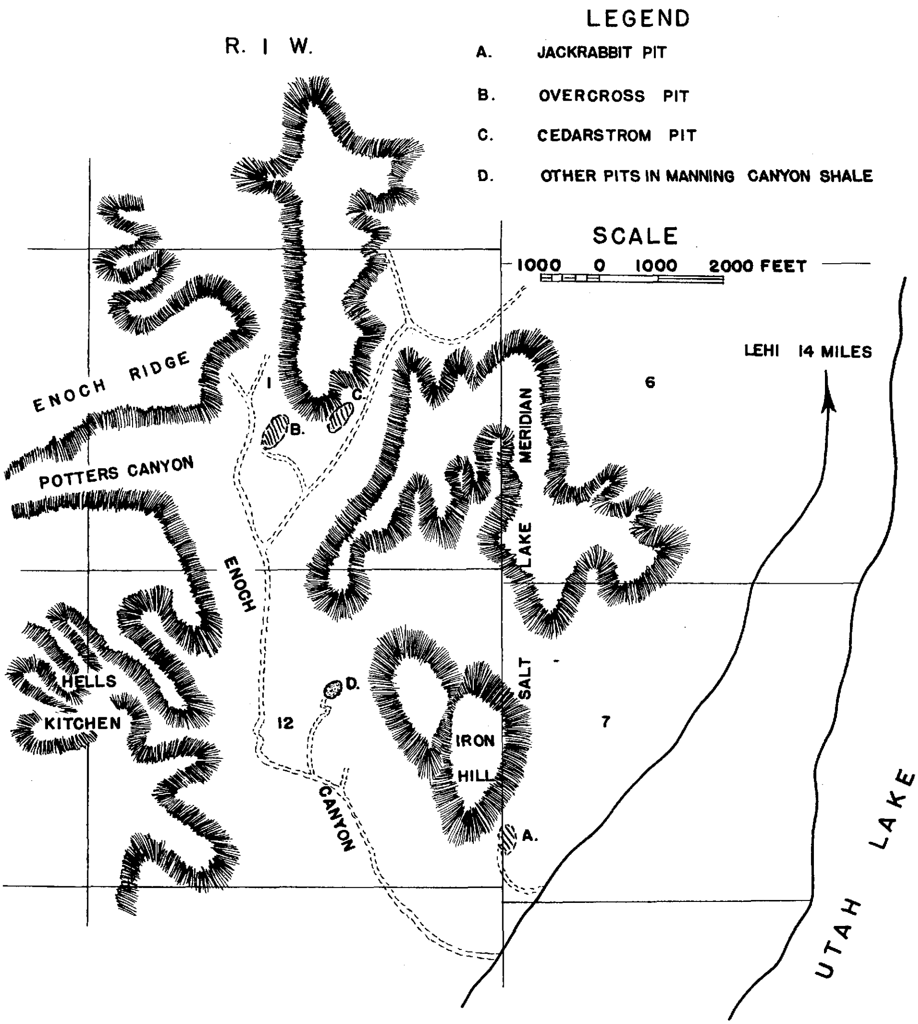


FIG. 6 LOCATION OF CLAY DEPOSITS
PELICAN HILLS AREA,
LAKE MOUNTAINS, UTAH.
(EXTENSIVE AREA OF MANNING CANYON SHALE OUTCROPS)

The beds in the Overcross deposit (in NE 1/4, SW 1/4 of section 1) have a general strike of N. 5° W. and dip 28° SW. The clay is noncalcareous and has an outcrop thickness of about twenty-five feet. Lithologically the clay can be described as follows: greenish gray, soft and plastic, with some interbedded yellow, brown and rust-brown silty shales. Stratigraphically below the clay beds is a thick, massive, black, sub-lithographic limestone which is dense, somewhat scintillating on fresh fracture and which weathers light bluish gray becoming argillaceous near the clay contact. The clay is overlain by beds of brown and pink limonitic siltstones and gray orthoquartzites. At the present time, clay is being mined by open-cut methods from a pit which is approximately thirty feet wide and 200 feet long. Clay is also exposed along the strike to the north where the overburden has been removed and where future operations will be carried on. It is used for refractory purposes in blast furnace plugs, runners, roof props and foundry sand binder. Data of tests on samples taken at random from the face of the exposure is contained in table I.

The Jack Rabbit claim is located about 1-1/2 miles south of the Overcross claim in the SE 1/4, SE 1/4 of section 12 (see fig. 6). The forty-foot clay bed has a strike of N. 5° W., with a dip of 75° NE. The material in this deposit is considered to be a facies in the Manning Canyon shale and is lithologically similar to the Overcross deposit. The facies unit to the west of the clay beds is a thick, black, fine-grained limestone with obscure bedding and many crisscrossing calcite stringers. It weathers light bluish gray and has an attitude similar to that of the clay bed. Overlying the clay on the east is a series of red, silty shales, which are in turn overlain by black limestones. This claim was originally mined by underground methods (Crawford and Buranek, 1948, p. 17), but was later worked as an open cut pit. The pit is no longer in operation, and the clay is now exposed only at the north end, where it was last worked. Though the

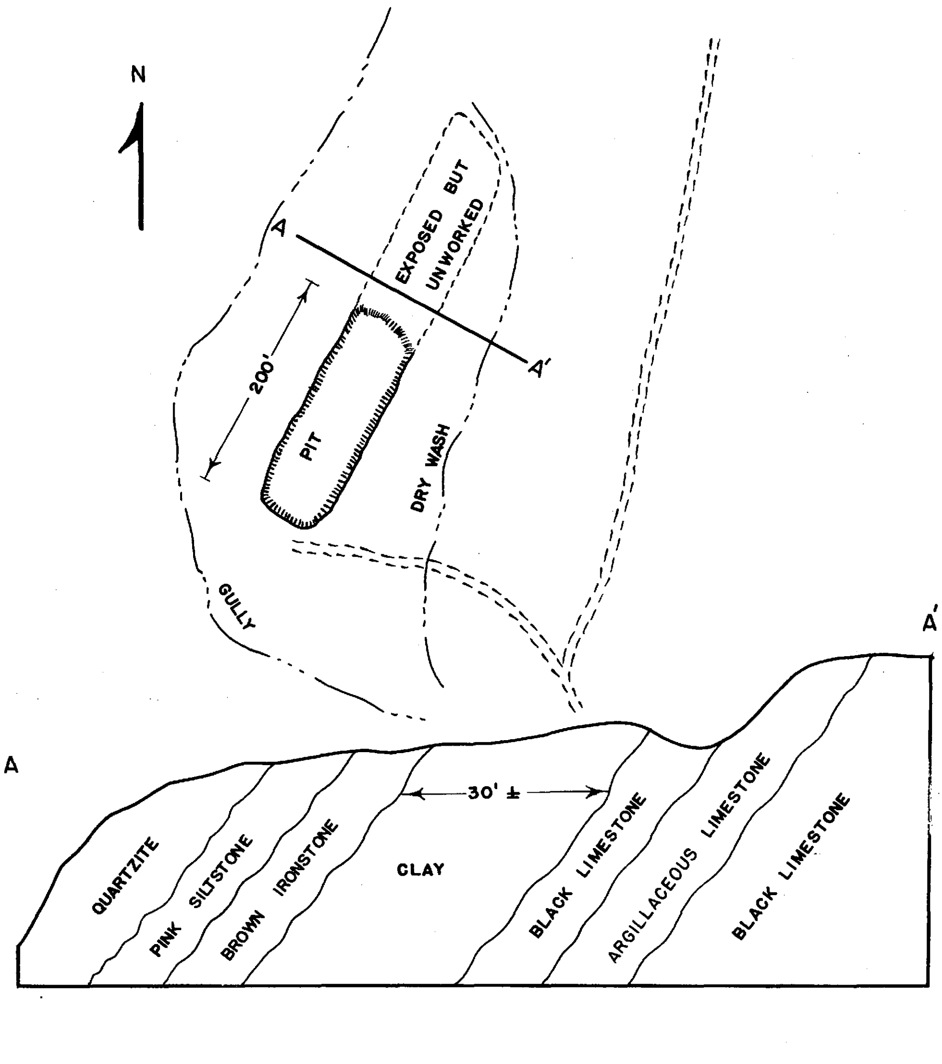


FIG. 7 DETAIL MAP AND CROSS SECTION
OVERCROSS DEPOSIT
LAKE MOUNTAINS, UTAH.
(SEE PIT B, FIG. 6)

clay zone extends downward, the cost of excavation at depth is presently uneconomical. The total production from this deposit is not known. Table I contains data of tests made on composite samples taken from the north end of the pit where the clay is exposed in a fan about twenty feet wide and twenty feet high.

The Cedarstrom pit is located in the NW 1/4, SE 1/4 of section 1 just northeast of the Overcross claim. On the basis of lithology and geography, the clay shale in the deposit is thought to be Manning Canyon. This tan-weathering shale is hard, black and gray on fresh fracture. It is calcareous and locally contains reddish-brown beds. The upper twenty feet of the exposed clay shale is reddish brown with iron oxide and contains many ellipsoidal concretions ranging in diameter from one to eight inches. Because none of the adjoining lithologic units are exposed, determination of the exact stratigraphic position is not possible. The unit is between 150 and 200 feet thick, has a general north-south strike, and dips about 25 degrees to the west. A large open cut on the side of a hill has exposed the clay shale. Since the hill trends in the same direction as the strike of the beds and since no large faults are apparent, the entire hill is probably composed of the same material. The deposit has recently been worked, but production figures are not available. The clay has refractory uses similar to those described in the Overcross claim on page 21. Data from tests on the samples taken at random from the face of the pit are found in table I, pp. 26-27.

<u>Wiley Canyon area</u>: The Wiley Canyon area is some distance to the west of the aforementioned areas. (See fig. 3.)

Wiley Canyon trends approximately northwest-southeast, separating the Cedar Hills from Lake Mountain. The canyon is a strike valley following the Manning Canyon shale outcrop southward to

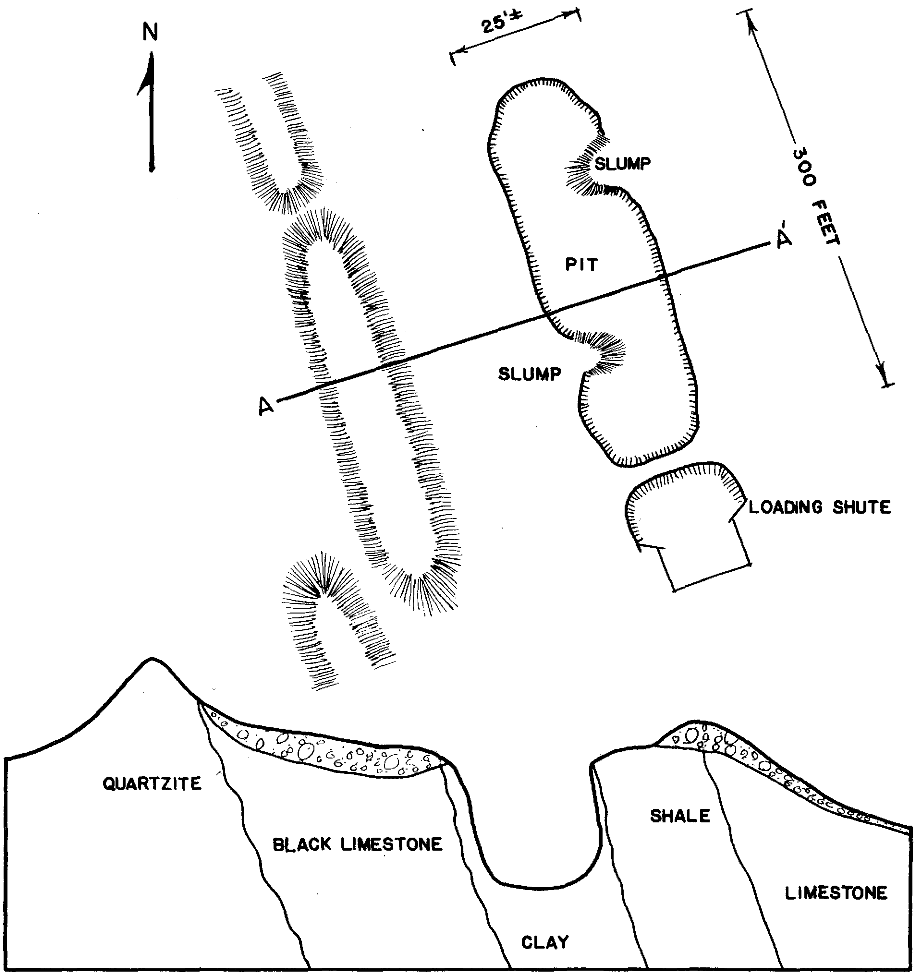


FIG. 8 DETAIL MAP AND CROSS SECTION
JACK RABBIT DEPOSIT
LAKE MOUNTAINS, UTAH

Mercer Canyon (Bullock, 1951). Several samples of dark shale were collected from the Wiley Canyon area. Thickness of the shale was not determinable because of extensive cover. It seems logical to assume that a clay shale zone similar to that seen on the eastern side of Lake Mountain exists here also. Table I contains data of tests made on a composite sample of the shale.

Deposit	Unfired Color	Fired Color Cone 2	Fired Color Cone 8	Linear Shrinkage Cone 2	Linear Shrinkage Cone 8
Powell Deposit	greenish gray	gr. lt brn. 5YR6/2	slt. mot. pl. org. 10R7/2	1.5	2.5
Inter-state Brick Co. #1	lt. gray	gr. lt. brn. 5YR6/2		2.5	
Inter-state Brick Co. #2	greenish gray	pale org. 10YR7/2		3.4	
Roger Cedar-strom Over-cross Claim	greenish gray	mod. gr. red 10R5/2		2.5	
Roger Cedar-strom Jack Rabbit Claim	greenish gray	gr. yel. brn. 10YR7/2	gr. org. pnk. 5YR7/2	0.0	1.5
Roger Cedar-strom Cedar-strom Pit	rd. brn. to blk.	br. gr. 5YR4/1		2.5	
Appar-ently No Claim Wiley Canyon	dk. gray	pl. gr. red 10R5/2	red brn. 10R4/2	1.5	2.5

TABLE I

Porosity		Bloating		P.C.E.	Evaluation
Cone 2	Cone 8	Cone 2	Cone 8		
18.2	16.3	none	none	27	Common brick clay
15.7		none		-23	do.
19.1		none		+26	do.
19.8		none		-20	Good low heat refractory and foundry
22.2	18.3	none		27	Exhausted
10.2		much		-20	Good low heat refractory and foundry
20.4	18.2	very slight	slight	-20	Unknown

MANNING CANYON SHALE OF LAKE MOUNTAINS

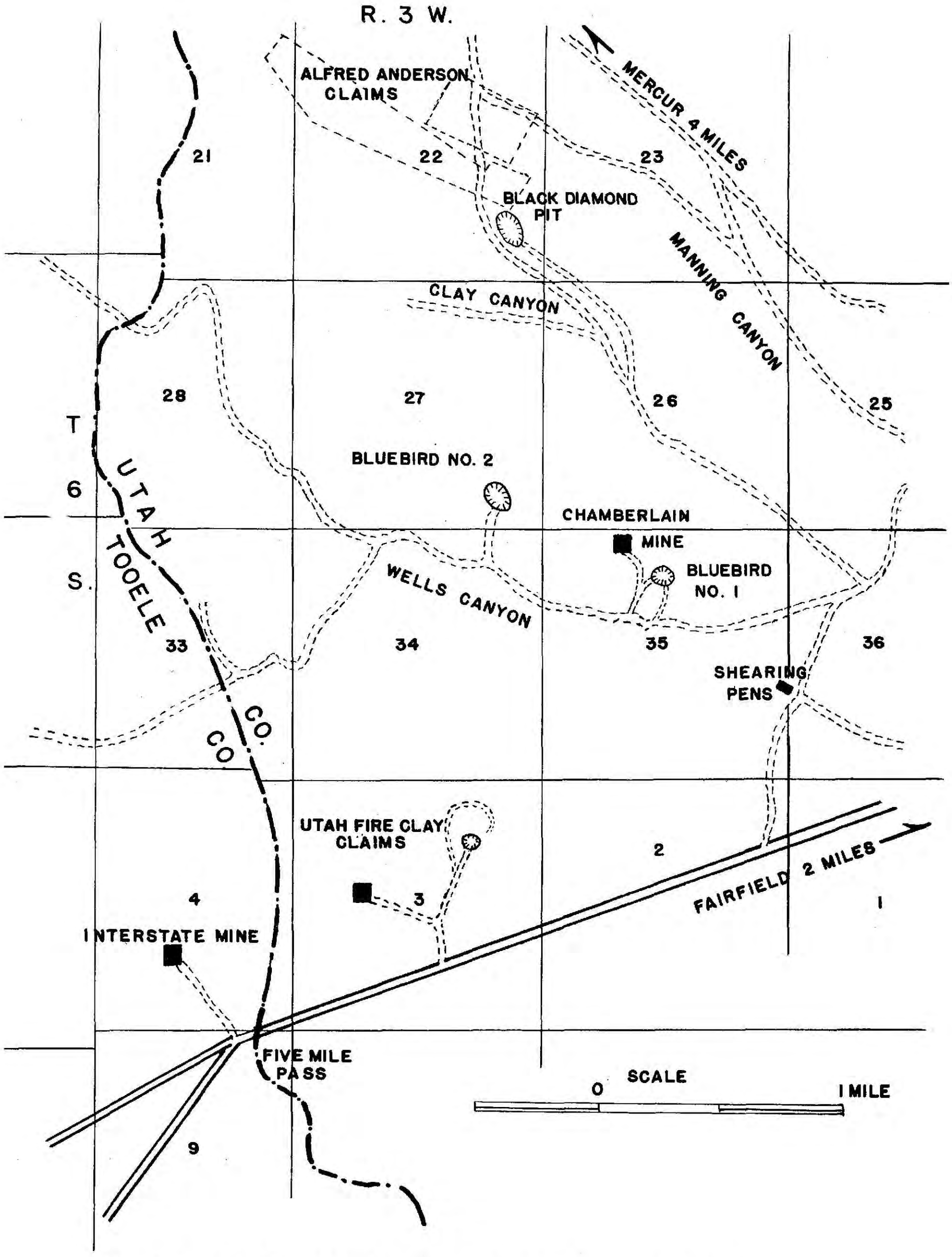


FIG. 9 CLAY DEPOSITS OF THE FIVE MILE PASS AREA

Five Mile Pass: The Chamberlain clay mine and the Chamberlain Bluebird No. 1 and No. 2 claims are located approximately three miles west of Fairfield, Utah, in adjoining sections 27 and 35 of T. 6 S., R. 3 W. The Black Diamond claim is in the E 1/2, SE 1/4, section 22, T. 6 S., R. 3 W. The Interstate Five Mile Pass clay mine and the Utah Fire Clay Company mine are located in section 4, T. 7 S., R. 3 W. (See figure 9.)

The Chamberlain clay mine is specifically located in the NW 1/4 of section 35. The clay unit in the mine has a strike of N. 80° E., and a dip of 20-25° NW. That much faulting has occurred in the area is evident from the many small displacements visible near the mine portal. The clay varies in color from light gray to dark with thin interbedded, red and yellow iron oxide bands and layers. The clay zone is overlain by a medium-bedded, medium-gray limestone. The bearing of the adit is N. 60° W., but since it is badly caved near the entrance, the extent of the workings was not determined. Apparently the adit was opened at the clay outcrop, and farther in it probably follows the strike of the beds. (See table II for data of tests on the samples taken from the north wall.)

The Chamberlain Bluebird No. 1 claim is located 200 yards southeast of the mine portal of the Chamberlain clay mine. The exposed twenty-five-foot clay beds strike and dip about 20° to the northeast. The clay and the overlying limestone unit are lithologically identical with that found in the mine. The underlying unit was not visible because the lower portion of the clay bed has not yet been exposed. (See table II for test data on the samples taken at intervals across the open cut.)

The Chamberlain Bluebird No. 2 claim in Wells Canyon is in the SE 1/4 of section 27. Although the attitude differs to the extent that the beds are horizontal, the clay unit in this claim has

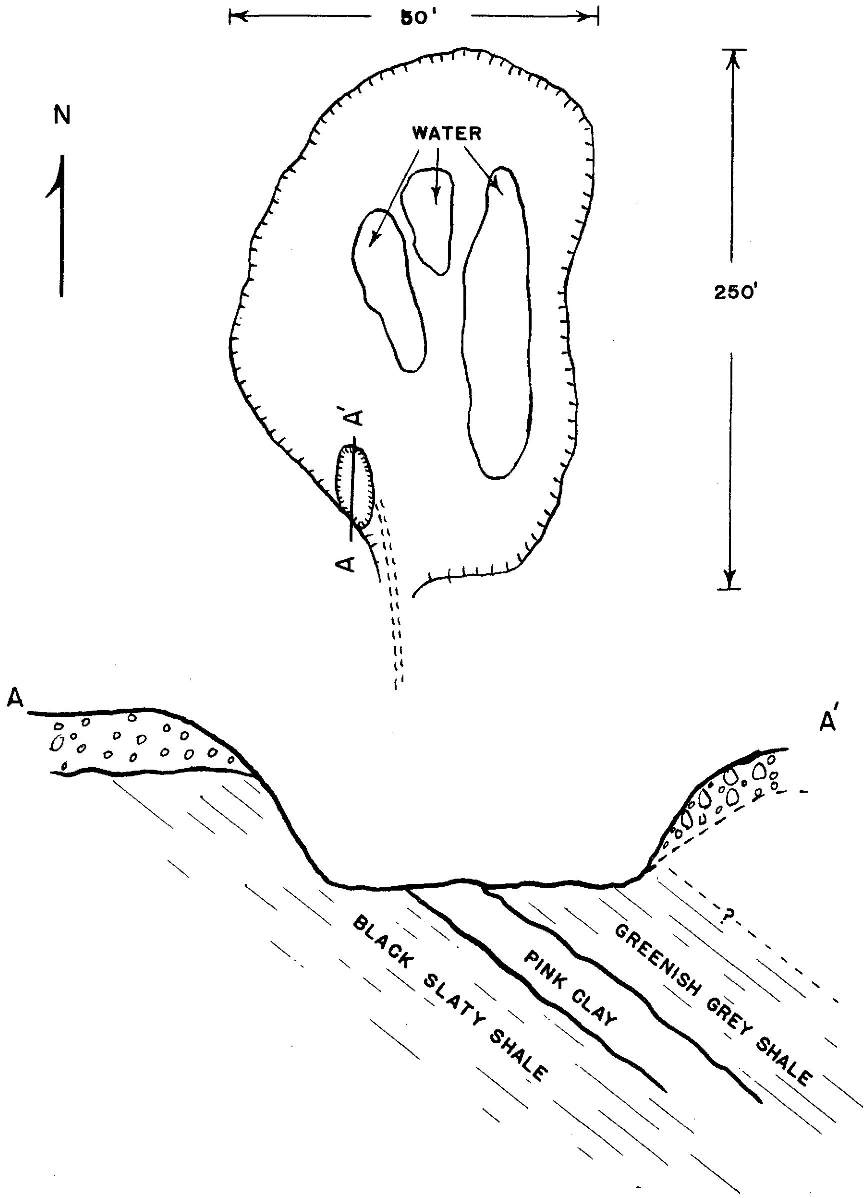


FIG. 10 OUTLINE AND CROSS SECTION
BLACK DIAMOND CLAY PIT
NEAR FAIRFIELD, UTAH.

been correlated lithologically with that in the Bluebird No. 1 and is thought to be a continuation of the unit exposed there. Removal of the overburden in a small cut about 150 feet long, for assessment purposes, comprises the only development work done on the claim. Table II contains data of the tests made on the samples taken at regular intervals across the pit.

The abandoned Black Diamond claim, formerly operated by the Interstate Brick Company, is in Manning Canyon of the Oquirrh Mountains. This canyon is a strike valley formed along the outcrop of the shale formation named after the canyon (Gilluly, 1932, p. 31). The clay shale is predominantly greenish gray to black plastic, noncalcareous and iron stained. The strike varies from N. 50° to 60° W., and dips 20° to 30° NE. Because the overburden has been removed only in the area of the clay shale zone, the overlying and underlying units are covered with alluvium and are not visible. The exposed clay shale is about fifty feet thick and was worked from an open pit 250 feet long and 150 feet wide. Data on tests of a composite sample taken from the claim are found in table II. (See fig. 11.)

The Interstate Brick Company clay mine is located about five miles west of Fairfield, Utah, about half a mile west of the Utah County line in Tooele County near Five Mile Pass. Lithologic description of the clay is based on examination of samples brought to the surface during regular mining operations. (See fig. 17.) The clay is of the greenish-gray, plastic, noncalcareous type. None of the units adjacent to the clay zone are exposed and the attitude was not accurately determined, but a general east-west strike with dip 20-30° to the south is indicated. Recent stripping has exposed large volumes of good clay and apparently the underground operations will soon be abandoned. Data on the samples tested are found in table II.

The Utah Fire Clay Company mine is near the Five Mile Pass Interstate Brick Company mine described

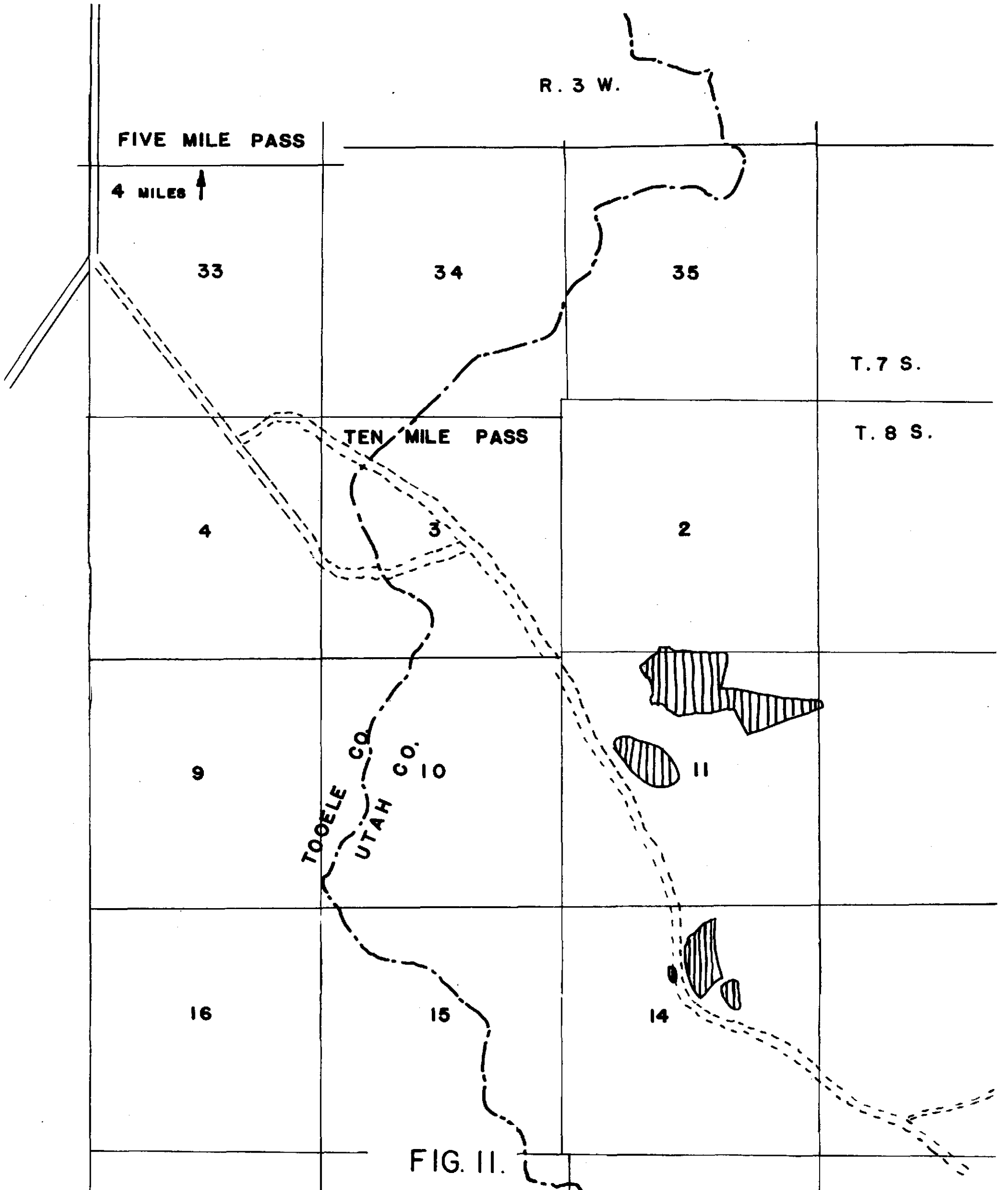


FIG. 11.

MANNING CANYON SHALE
SOUTH OF FIVE MILE PASS

OUTCROP OF MANNING CANYON LIMESTONE MEMBER
(COVERED SHALES ARE ADJACENT)

(AFTER BJARNSON AND DONEY, 1953)

above. The same conditions were encountered and results determined as in the above investigation. The mine is currently on a part-time operation basis and, according to Mr. Meyer of the Utah Fire Clay Company, the total production from this mine and the Clinton pit in the Beverly Hills is approximately 12,000 tons per year. This figure represents the approximate annual workings of the Utah Fire Clay Company in Utah County as the Clinton pit and the Five Mile Pass mine are the only deposits currently being exploited. Mining operations have been active intermittently since 1926. See table II for data on the tests made on a composite sample.

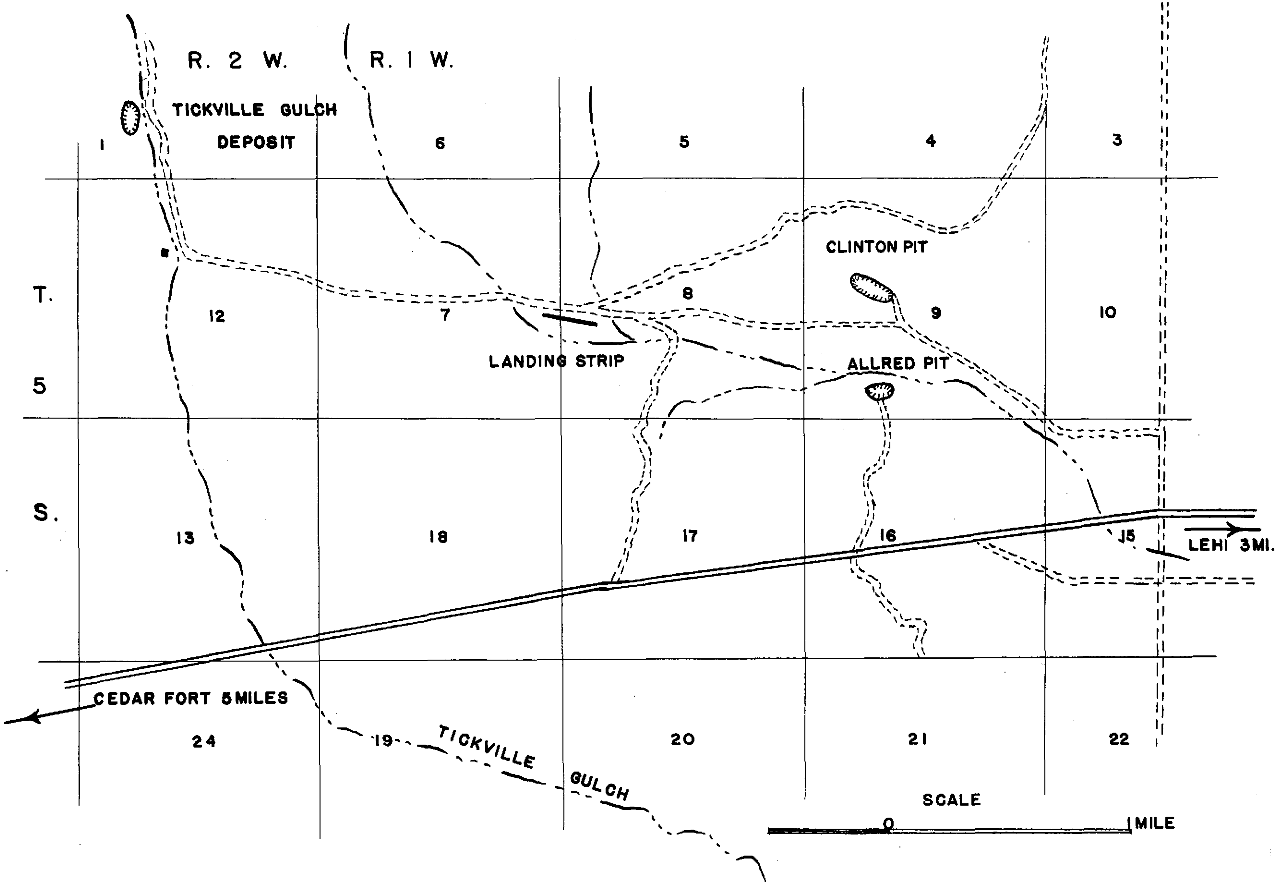
The Manning Canyon shale and adjacent lithologic units outcrop in the Boulter Mountains south of Five Mile Pass. Locations of likely shallow Manning Canyon shale deposits (with little alluvial cover) are shown in figure 11. To date prospecting activity has been limited to the northernmost areas only.

Deposit	Unfired Color	Fired Color		Linear Shrinkage	
		Cone 2	Cone 8	Cone 2	Cone 8
Don Chamberlain Clay Mine	lt. to dk. gray	pale yel.gr. 5Y4/1	slt. mot.pl. org. 10R7/2	6.0	2.5
Don Chamberlain Bluebird #1	lt. to dk. gray	yel.gr. 5Y8/1	very pale org. 10YR8/2	8.5	10.0
Don Chamberlain Bluebird #2	lt. to dk. gray	pale brn. 5YR5/2	mot. brn. gr. 5YR4/1	0.0	0.0
Interstate Brick Co. Black Diamond Claim	greenish gray	gr.red 10R4/2		5.0	
Interstate Brick Co. Five Mile Pass Clay Mine	greenish gray	yel. brn. 10YR7/2	mot. yel. brn. 10YR7/2	5.0	5.0
Utah Fire Clay Co. Mine	greenish gray	pale brn. 5YR5/2		7.0	

TABLE II

Porosity		Bloating			
Cone 2	Cone 8	Cone 2	Cone 8	P.C.E.	Evaluation
8.0	16.3	very slt.			Abandoned
3.0	5.3	very slt.			Mining too difficult for small quantity present
13.2	19.8	mod.	much	-20	Possible large quantity
9.4		slt.		-20	Possible large quantity
14.5	11.5	none	slight	-23	Structural clay products
24.1		very slt.		+23	Structural clay products

MANNING CANYON SHALE OF FIVE MILE PASS AREA



LOCATION MAP
FIG. 12 CLAY DEPOSITS OF THE BEVERLY HILLS AREA
NEAR LEHI, UTAH.

BEVERLY HILLS AREA

Extensive outcrops of Manning Canyon shale occur between the Lake Mountains and the Oquirrh Mountains in the area designated as the Beverly Hills. (Mapped by Madsen, 1952.)

The Clinton deposit, about five miles west and two miles north of Lehi in sections 8 and 9, T. 5 S., R. 1 W., S.L.B. & M., is operated by the Utah Fire Clay Company of Salt Lake City. Mining in the large deposit (over half a mile long and 50-100 feet wide) has been carried on for over fifty years and is easily the biggest single operation in the county. The vertical beds strike N. 75° E. The clay shale here is greenish gray with much rust-brown material interbedded. The typical disc-like concretions are also abundant. At depth and in lenses the typical black clay is found.

The best clay member in this deposit is about fifty feet thick, although its incompetency has caused much thickening and thinning. The wall rock consists of pink shales and dark limestones with narrow strips of white clays interbedded with them. See figure 12 for location, figure 13 for cross section, and table III for properties of the clay in this bed.

Across the valley to the south about a mile from the Clinton deposit is an opening in what appears to be Manning Canyon shale.

This deposit, owned by Mr. Aaron Allred of Lehi, has seen limited operation by the Interstate Brick Company. The clay face is exposed for 100 feet, but since the deposit is covered by thick alluvium, it is extremely doubtful if it ever will be a big producer. See table III.

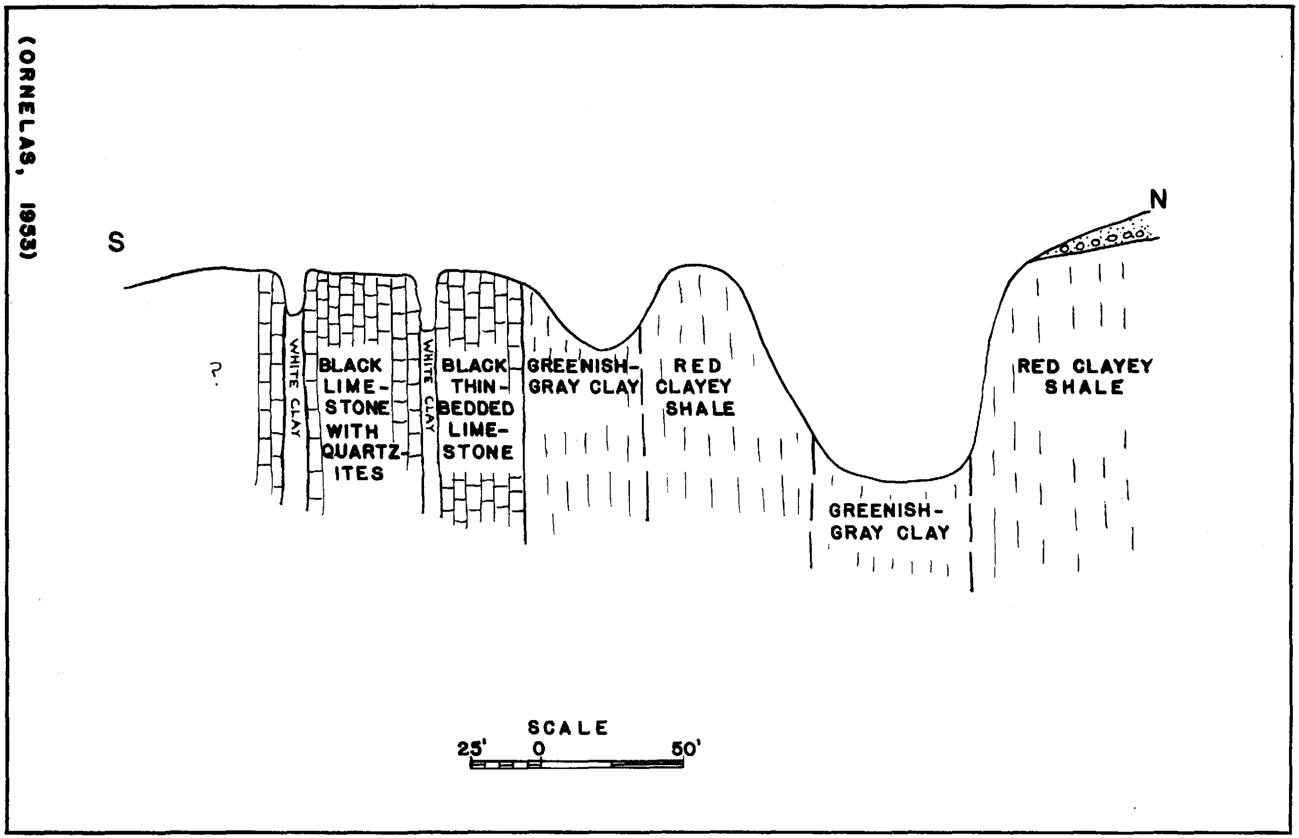


FIG.13 DIAGRAMMATIC SECTION OF CLINTON CLAY PIT, BEVERLY HILLS, UTAH

PAYSON CANYON

The Manning Canyon formation is exposed on both sides of Payson Canyon as indicated in figure 14. The narrow outcrop nearest the mouth does not show the shale members of the formation, these probably having been covered by the thrusts and other movements in the neighborhood.

As mapped by Brown (1950) the eastern outcrop is more extensive although the actual clay shale members are covered by soil and vegetation.

POLE CANYON (WASATCH MOUNTAINS)

This strike valley (see fig. 15) is very similar to Manning, Pole, and West Canyons in the Oquirrh Range in that its existence is due to the presence of easily eroded Manning Canyon shale.

Numerous outcrops of dark-gray clay shale have been exposed by road and aquaduct excavations throughout the length of the valley. The clay is plastic, rather soft, and for the most part noncalcareous although thin calcareous units are found. Limonitic units and evidence of pyrite concretions are also present. The bedding is not uniform and exhibits much variation in attitude and thickness.

Tests made on one sample collected near the mouth of the canyon (half a mile south of U. S. Highway 189) showed the clay shale to bloat and to fuse by cone 2.

A very large amount of the clay shale can be anticipated from the floor of this canyon which extends some six to eight miles up and to the south. It is considered likely that some of this area may contain clay of higher quality than tested at the mouth of the canyon.

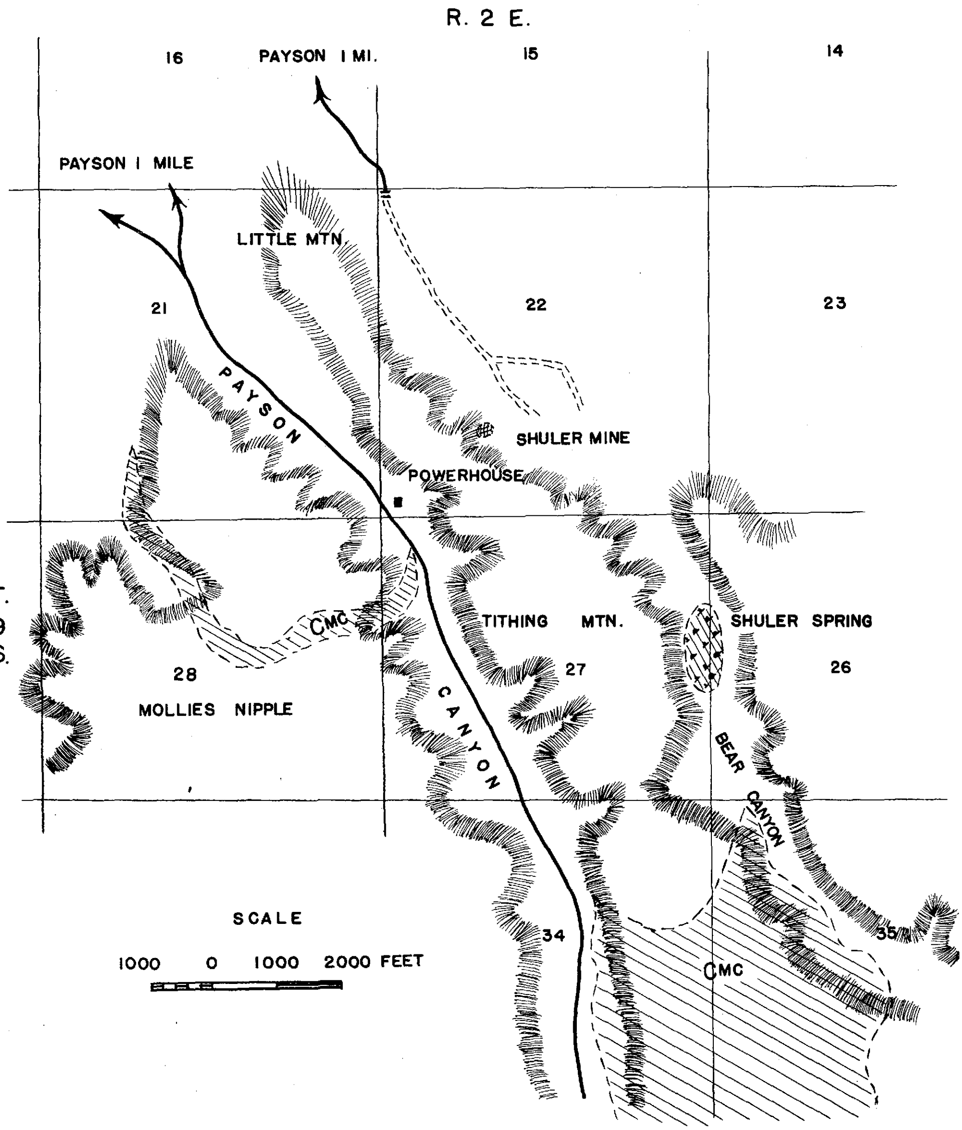
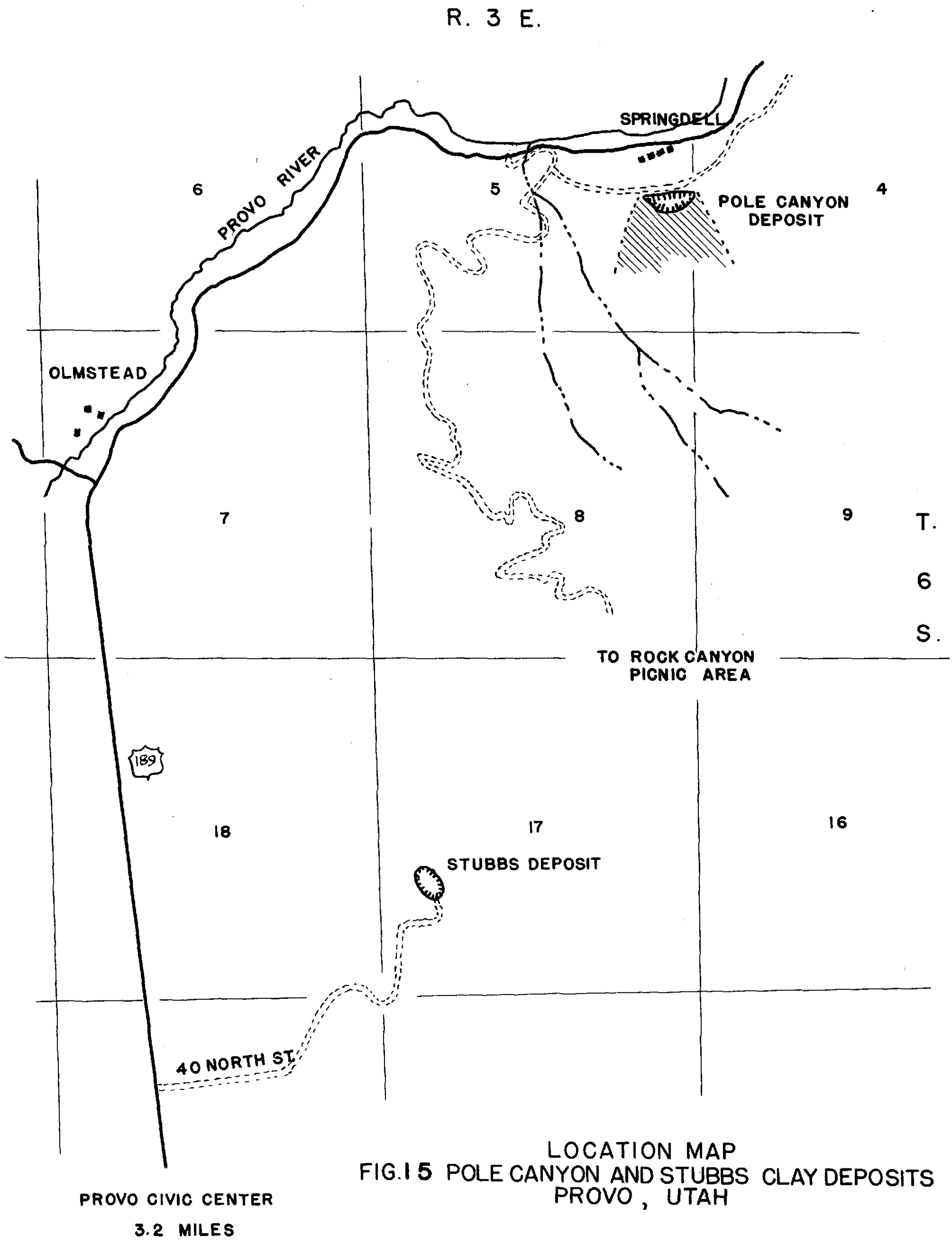


FIG.14 CLAY DEPOSITS NEAR PAYSON, UTAH

(IN PART AFTER BROWN, 1950.)



LOCATION MAP
FIG.15 POLE CANYON AND STUBBS CLAY DEPOSITS
PROVO, UTAH

Deposit	Unfired Color	Fired Color and Shrinkage		
		Cone 04	Cone 2	Cone 8
Allred	gray	pink gray 1.0%	yellow gray 6.5%	
Clinton	greenish gray	orange pink 10R8/2 0.0%	very pale orange 10YR8/2 2.5%	very pale orange 10YR8/2 5.0%
Pole Canyon	lead gray	grayish orange 10YR7/4 0.0%	black (glass)	

TABLE III. MANNING CANYON SHALE OF

Porosity			Bloating	
Cone 04	Cone 2	Cone 8	Cone 2	Evaluation
25.0%	0.0		none	Possible brick clay; some production
27.6%	20.8%	16.3%	none	Important for brick, tile, sewer pipe
38.2%			none	Not developed
BEVERLY HILLS AND POLE CANYON AREAS				

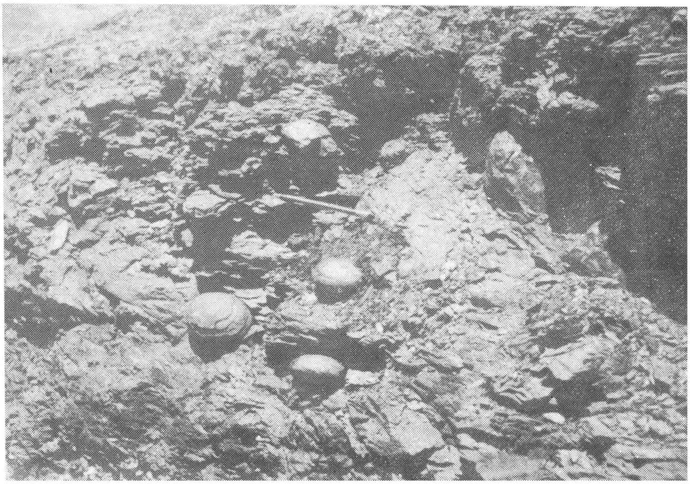


Figure 16. Black pyritic concretions abundant in Manning Canyon shale formation.

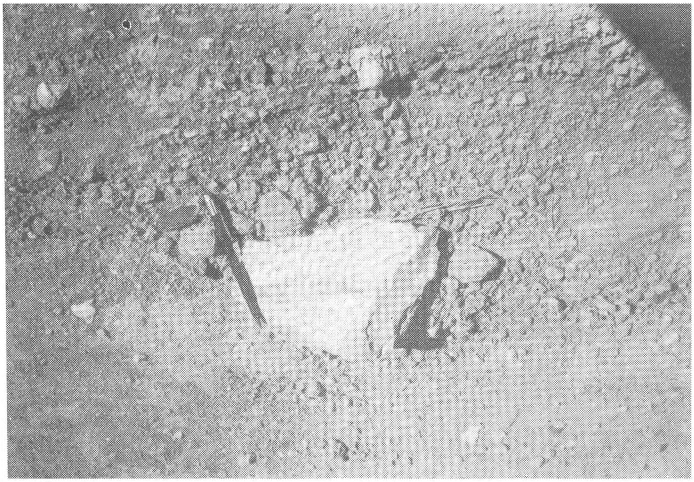


Figure 17. Lepidodendron scales in clay taken from Interstate Five Mile Pass mine.

WEATHERING OF MANNING CANYON SHALE

As noted in the statements concerning the ndividual deposits, the black clay portions of his formation are everywhere poorer in quality than heir lighter-colored counterparts. Observation hows that unaltered pyrite is an important acces- ory of the black clays and firing experience shows he harmful bloating and color effects that result.

Concretions and other lithologic evidence all oint to a common origin for both the black clays nd the lighter gray and brown clays. The blacks ncountered in the Manning Canyon Black Diamond eposit at the surface and in other pits at depth re similar to each other.

The explanation for the black shales at the urface in the strike valleys seems to be twofold. xidation has been impeded by the presence of the airly high water table in the bottom of the valley; ence the little alteration never has produced much lay of high quality. Erosion has been rapid on he soft shale in the bottom of the valley and has ended to remove most, if not all, of the newly ormed high-grade clay. The opposite of these two ffects is found where the water table is low and rosion is at a minimum. This would seem to indicate ood Manning Canyon shale deposits on the flats and oor ones on the slopes. Specifically, the outlook or canyon deposits such as Pole, Payson, and Manning anyons would be poor while those on Lake Mountain, t Five Mile Pass and some of those at the Boulter ountains would be better.

The possibility of hydrothermal alteration as means of producing the light-colored clay should ot be lightly dismissed. Considerable evidence xists, particularly in the Five Mile Pass area, f the action of hydrothermal solutions on lime- tones and shales. Recent exploratory excavations n the area have uncovered interesting evidence.

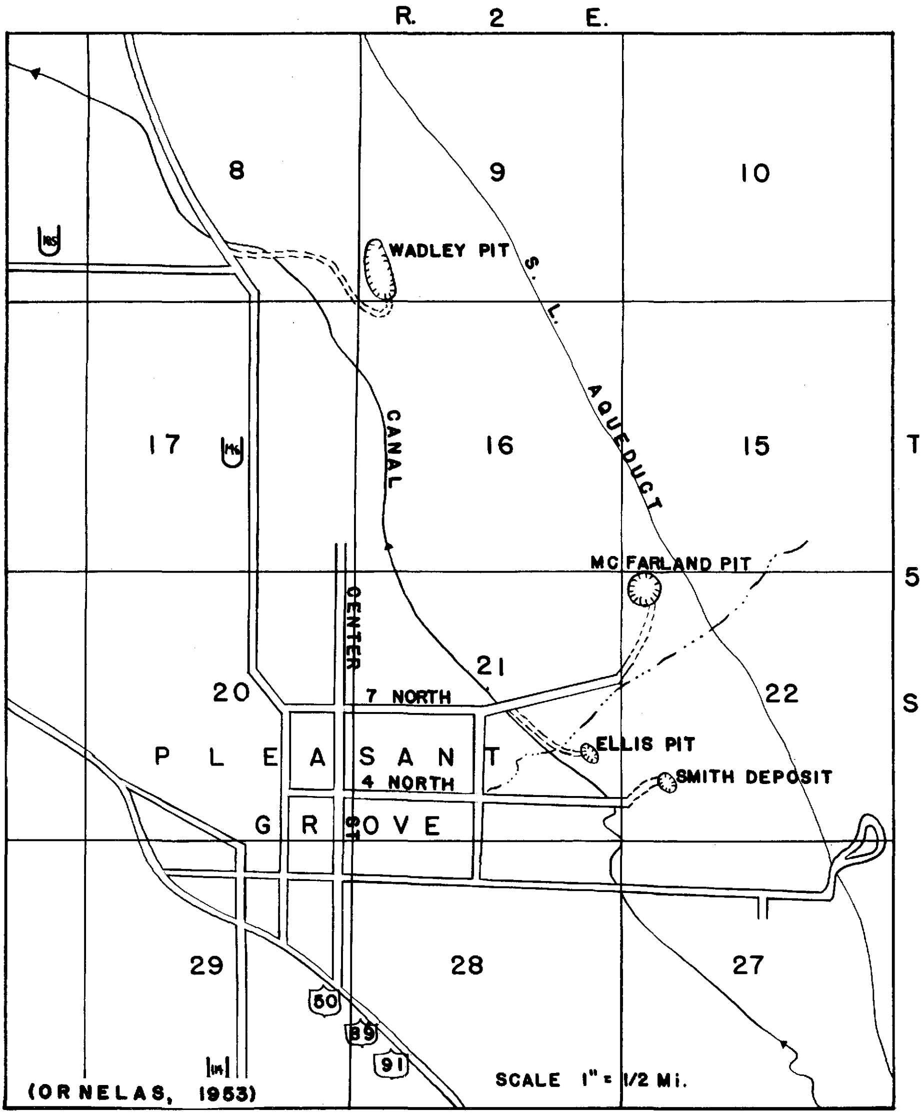


FIG. 18 CLAY DEPOSITS NEAR PLEASANT GROVE, UTAH

G R E A T   B L U E   F O R M A T I O N

(LONG TRAIL SHALE FORMATION)

GENERAL GEOLOGY

A number of writers have described the prominent shale member of the Great Blue formation. Spurr (1895) first noted the shale as a 100-foot bed in the 5,000-foot Great Blue limestone formation in the Mercur mining district. The shale was described as being black, carbonaceous and calcareous.

The Long Trail shale was so named by Gilluly (1932) after its 85-foot exposure in Long Trail Gulch in Ophir Canyon in the Oquirrh Mountains. Fossil evidence points to the Mississippian age for the entire Great Blue formation.

More recently, other writers (Calderwood, Bullock, and Smith, all in 1951) have described the shale belonging to the Great Blue formation in the Lake Mountains area although the Long Trail shale member as such was not identified.

Along the Wasatch Mountain Front a number of good exposures of the Long Trail shale member are found. An 85-foot-thick shale, 675 feet above the base of the Great Blue limestone was so described by Baker, et al. (1949).

At least two shale members have been located in the Great Blue limestone and some difference of opinion exists as to the correct identification of the actual Long Trail member from place to place. Incompetency, cover, and structural changes make positive identification and correlation difficult. In this report all shales of the Great Blue limestone formation are considered as Long Trail shale.

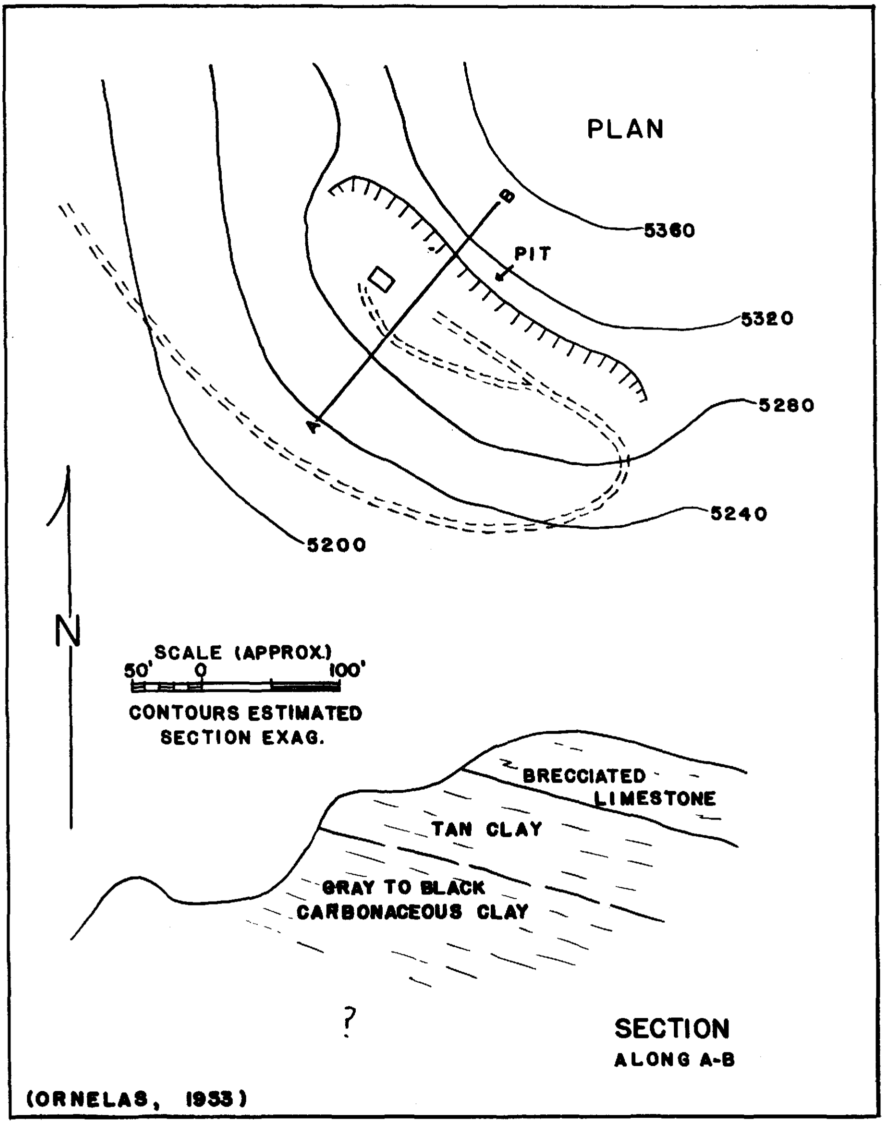


FIG. 19 DIAGRAMMATIC SKETCHES OF WADLEY CLAY PIT, PLEASANT GROVE, UTAH

PLEASANT GROVE AREA

The largest exposure of the Long Trail shale appears in the Wasatch Front in and near Pleasant Grove where three pits have been opened for commercial development. See figure 18 for one location of these deposits. The deposits lie along the strike of the Great Blue formation just above the Provo Lake Bonneville level.

The clay in the three deposits is very similar and, even with the variations observed, it is easily identified as being typical of the Long Trail member. It is lead to greenish gray to black in color, largely noncalcareous, plastic, soft, and carbonaceous. Locally, small seams of selenite crystals are observed. Tests of these deposits are reported in table IV.

McFarland deposit: Two pits approximately 150 feet in length have been opened on the property of Mr. John McFarland, although very little clay appears to have been shipped from either.

Smith deposit: Mr. Carl D. Smith of Pleasant Grove has several exploratory openings on his property, but no recent shipments have been made.

Wadley deposit: The largest of the exposures in this area is on the Wadley property. Shipments have been made sporadically for many years and currently are approximately two carloads of clay per year. All of this has gone to California. Figure 19 shows sketches of this pit.

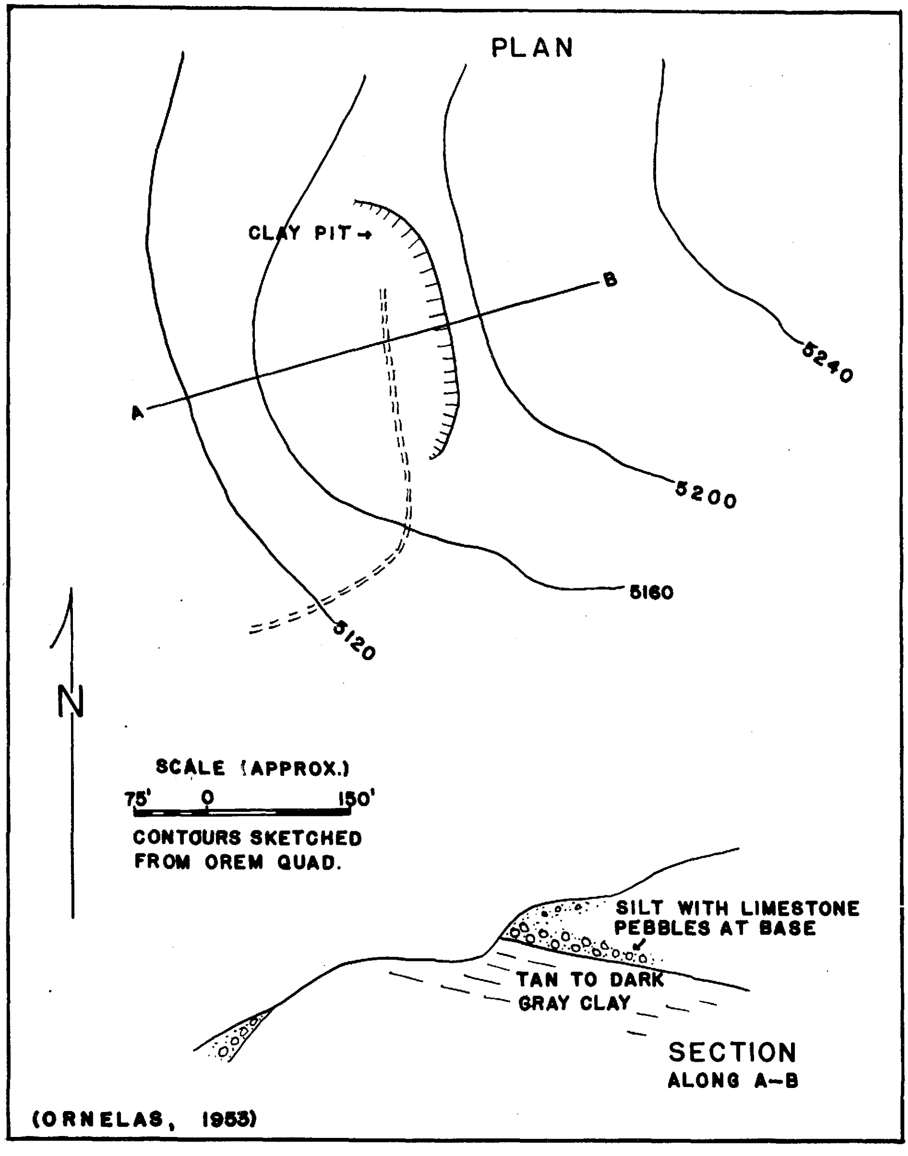


FIG. 20 STUBBS CLAY PIT, PROVO, UTAH

EDGEMONT AREA

A clay shale bed very similar to those in the vicinity of Pleasant Grove has been an important supplier in the area immediately north of Provo. Mr. Lloyd Stubbs owns the deposit one mile east of the Edgemont L. D. S. chapel on 40th North Street, Provo, Utah. See figure 15 for locations.

The bedding of the deposit is very obscure and direct evidence of its Long Trail shale origin is not readily available. There appears to be some evidence of landslide type of movement from higher on the slopes, and it is possible that this bed is of another formation (e. g., Manning Canyon shale). Location at the base of the mountain and the lithology point to the Long Trail shale origin.

OTHER LOCATIONS

There are several possible outcrops of the Great Blue limestone and its Long Trail shale member in Utah County although the above were the only ones investigated in this study. Drilling and other detailed work would be required to uncover other beds of economic importance. Areas where such investigation might prove profitable include extensions north and south along the strike of the deposits described above and also on the Lake Mountains.

A small outcrop of the Long Trail member, possibly indicative of a significant deposit, has been mapped by Proctor in Chiulos Canyon in the NW 1/2, section 29, T. 9 S., R. 2 W., in the Allen's Ranch quadrangle.

Deposit	Unfired Color	Fired Color and Linear Shrinkage		
		Cone 04	Cone 2	Cone 6
McFar-land	lead-gray	lt.brn. 5YR 6/4 1.5%	brown-gray 5YR 4/1 5%	
Smith (com-posite)	green-gray to black	pale red-brn. 10 R 5/4 3.3%		grayish brown 5 YR 3/2 3.3%
Wadley	black	lt.brn. 5YR 6/4 2.5%	pale brown 5YR 3/2 5.0%	
	gray	lt.brn. 5YR 6/4 0%	grayish red 10 R 4/2 0%	
Stubbs (com-posite)	varied	red-orange 10 R 6/6 3.3%		brown-gray 5 YR 4/1 3.3%

TABLE IV

Porosity			Bloating			Evaluation
Cone 04	Cone 2	Cone 6	Cone 04	Cone 2	Cone 6	
27.8	14.4		none	slight		Abandoned due to proximity to aqueduct.
23.4		15.7	none		much	No shipments.
24.1	7.7		none	moder-ate		Brick clay.
37.4	28.6		none	none		
26.4		20.0	none	moder-ate		Brick clay.
LONG TRAIL SHALE DEPOSITS						

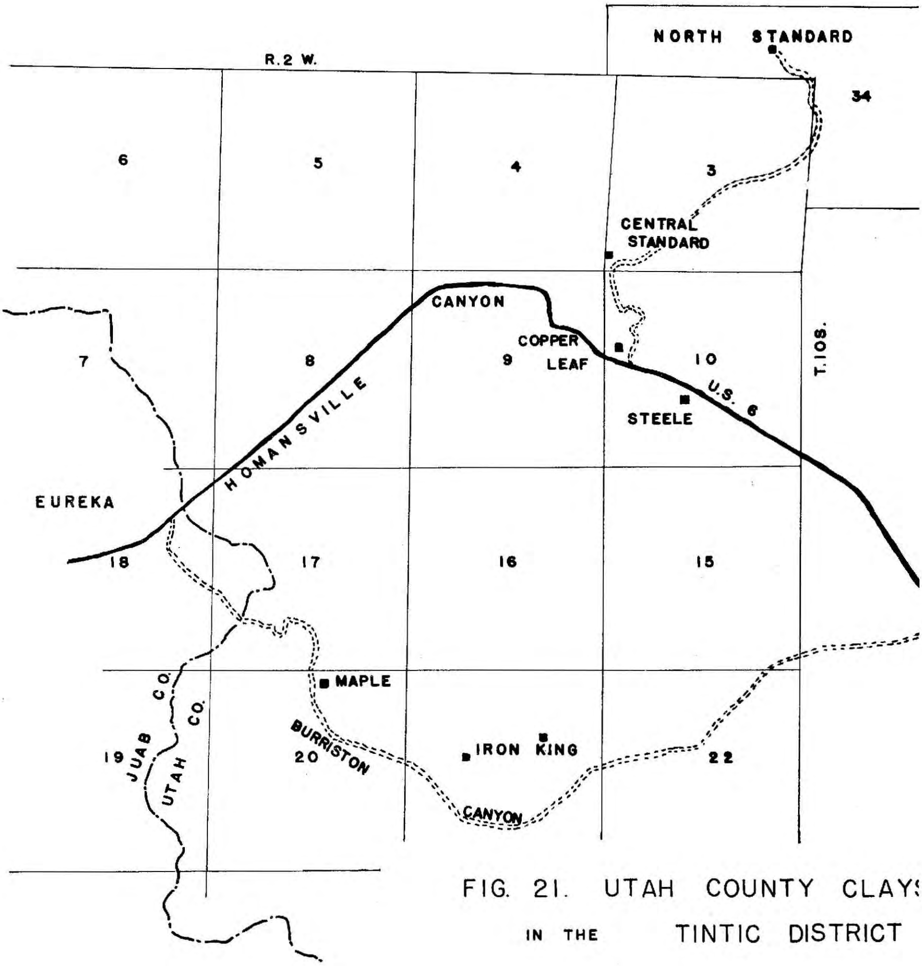


FIG. 21. UTAH COUNTY CLAYS IN THE TINTIC DISTRICT

PRIMARY CLAYS

GENERAL

Clay minerals are recognized as being chiefly the result of alteration of some primary or predecessor material. Transportation and redeposition of clays often proceeds to make shale deposits such as those already described and other sedimentary clay deposits. Where the clay minerals have not been transported after alteration, many characteristics of the parent rocks remain in the deposit. Such residues are termed primary or alteration deposits. In this class will be considered mainly those deposits which owe their clay content to the work of magmatic solutions. No attempt is here made to evaluate the complete genesis of the altered product.

Magmatic waters are the proved medium and agent for deposition of many metallic ore deposits and it is not unusual to find clay minerals accumulated as one phase of a general regional deposition.

Utah and neighboring counties have many examples of ore deposition controlled by hydrothermal solutions. One of the most famous of these is the East Tintic mining district surrounding the city of Eureka, Utah. A number of excellent accounts of the ore deposition in this area are available (see Butler, et al., 1920; and Lovering, 1949).

Briefly, the mechanism by which clay is deposited is this: A suitable host or parent rock such as volcanic ash or one of several types of sedimentary rock must be present. Faulting and/or folding may accompany or precede intrusion by magma at depth. Solutions of water heavily charged with soluble materials will rise along fissures, bedding planes, intrusive contact zones, etc. Silica may be removed and water may be added to the host, changing it to clay mineral matter. Ideally, a large volume of a host rock would be altered to form a homogeneous mass of clay. Such is not the usual case, however, and the capricious nature of the solutions precludes uniformity. This becomes important for the clay miner who is accustomed to mining large quantities of uniform quality clay and is unable to do so in many of the Utah County alteration deposits. Undesirable impurities from quartz to magnetite may be present in varying amounts.

Most of the ore bodies of the Tintic district ie in Juab County just west of Utah County. The ery valuable and productive Dragon clay mine is o located. This now famous mine was originally marginal iron mine, but more recently it has been rominent as one of the nation's chief sources of he clay mineral, halloysite. Halloysite from the ragon mine possesses properties which are not avorable to ceramic use, but it has other properties hich make it very valuable for use as a petroleum-racking catalyst. Thousands of tons of Dragon alloysite are shipped annually to the Filtrol orporation processing plant in Salt Lake City. ecause of the interest in the Dragon mine in recent ears, prospecting has been very active even in the tah County area for clays of the same type. Only hose investigated within Utah County are reported erein. These may be located on the map of figure 1.

Maple claim: Owned by Mr. Clarence Loose of rovo, this claim is in the NE 1/4 of section 20, . 10 S., R. 2 W., S. L. B. & M., in Burriston Canyon bout 2 miles east of Eureka.

Halloysite and montmorillonite are the minerals resent. The color is light to greenish gray with any limonitic blebs and lenses.

A shaft sunk into the exposed halloysite has hown only a small, almost spherical deposit of ather pure halloysite of uneconomic significance to e present. A large amount of more impure halloysite s also present, but it is also of no proved economic ignificance.

Volcanic evidences abound in the immediate icinity and, with the montmorillonite found, it is educed that the halloysite is the result of altera-ion of volcanic material by ascending hydrothermal olutions.

Iron King mines: (See fig. 21.) Iron, copper, lead, and manganese were originally mined from this area although the mines have long since been closed. Accessory kaolinite and halloysite mixed with the ore minerals are found in the contact zone and in mineralized fissures in the sedimentary rock. This occurrence of clay is not of economic significance due to the intermixture of iron and other impurities.

Steele deposit: The Steele brothers of Goshen have opened an intrusive-sediment contact zone three miles east of Eureka on U.S. Highway 6. Two small adits have revealed some attention to clay minerals but nothing of value. Halloysite appears to be at least one of the alteration products.

Central Standard mine: A jasperoid-halloysite-montmorillonite rock is exposed in an opening 300 yards south of the Central Standard mine shaft. This material is overlain mainly by weathered extrusive flows and presumably the rising hydrothermal solutions brought about the alteration. The impure nature of the products precludes economic importance.

Burriston claim: On the southeast fringe of the East Tintic mining district is one of the larger halloysite deposits visited. A claim owned by Ray and Floyd Burriston has been located in Government Canyon in southern Goshen Valley, 10 miles south of Goshen.

The clay material is plastic, soft, and non-calcareous halloysite very similar to the poorer quality found at the Dragon mine. It is locally light green to rust brown and yellow in color.

The body of clay forms the footwall to an east-west dike which dips 75° S. Clay has been removed from beneath the dike for 20 feet down dip and for twice that distance along the strike. Overburden has been removed in several places (100 to 200 feet along the strike) revealing the same clay bed as already exposed by development. The intrusive-limestone contact appears to have localized the alteration in this area. The bed is not thick and the difficulties of removal coupled with the poor quality show no economic significance at present.

Copper Leaf shaft: (Section 4, T. 10 S., R. 2 W.) Halloysite has been discovered at the base of a volcanic flow about a quarter of a mile northwest of the Copper Leaf shaft.

North Standard mine: (Section 34, T. 9 S., R. 2 W.) Halloysite has also been found in a fissure alteration zone in a small canyon just north of the shaft. An altered tuff just northwest of the shaft has been used for a decorative stone.

FOX HILLS

The largest and most widely studied halloysite deposit in Utah County is that in sections 20 and 29, T. 7 S., R. 1 W., S. L. B. & M., located just south of Soldiers Pass in the Fox Hills at the southern end of the Lake Mountains. The clay in this deposit is white although bands of reds and purples have discolored much of it. The bands are not parallel to the bedding of the deposit and give it a pseudo-cross-bedded appearance in places. It has been definitely identified by differential thermal analysis and electron microscopy as being halloysite. The white clay readily washes from the quartz and other detrital matter with which it has been deposited.

Recent core drillings by Filtrol Corporation have revealed interbedded limestones and clay over an area which is more than one and one-half miles long (north to south) and three quarters of a mile wide (east to west). In this area there are many outcrops of the clay and the present evidence points to several lenses of halloysite as being present. The clay horizons vary from three to fifteen feet in thickness, although in most places they are about eight feet thick.

The limestones present are apparently of the fresh-water type and are largely soft and porous, even in some cases being little more than tufa. Travertine-like deposits are also present. No fossils have been found in the limestones which have, nevertheless, been tentatively dated with the Salt Lake formation.

Several views have been expressed as to possible origin of this unusual clay occurrence. Crawford and Buranek (1948) hold that volcanic ash deposits have been altered by ground water in the present location. Sharp and Stringham (1950) lean to a sedimentary origin for the clay bed with iron staining due to ground water at a later date. Bullock (1951) believes as Crawford and Buranek except that hydrothermal solutions were responsible.

More recent information (1953 and 1954), primarily that gained by Mr. R. L. Root, then geologist for 'iltrol Corporation, more or less substantiates the ;harp and Stringham view with the addition that at .east two and possibly many separate sedimentary de- ›osits contributed to the present Fox clay.

A sedimentary origin is supported by the detri- ›al grains of quartz which account for as much as 'orty percent of the mass of the clay material and ›y the nature of the true bedding which is conform- .ble with the interbedded limestones. No actual vol- :anic ash has been found in the immediate area al- ·hough basalt flows do lie within the general 'icinity.

The tufas and travertines point to possible hot pring activity although the noncalcareous nature of he clay material would seem to preclude a close con- .ection.

In the absence of further evidence it seems ›roper to conclude that a sedimentary deposit (or eposits) of more or less altered material collected n the present location. The origin of the sediments s not inferred and this does not preclude an igneous rigin for them. Subsequent water movement (of not ·ver moderate temperatures) through the deposit has ltered the material to its present condition. Be- ides the pseudo-bedding type of colored bands in the lay, the unsorted nature of the fine clay and the oarse sand supports the view of alteration after eposition.

Crawford and Buranek (1948) report at least rial use of the Fox clay in Washington, California, nd Utah in the manufacture of brick and as foundry and binder. The present writer has beneficiated the lay, i. e., removed the sand impurities and has ob- ained a product not greatly unlike in ceramic behav- or the very plastic sedimentary kaolins of Florida. 'he Zellerbach Paper Company of Portland, Oregon, in- icates that the clay closely approaches standards or paper-grade clay. The Filtrol Corporation has een very much interested in the clay for use as a atalyst but apparently has no current plans for ex- ·loitation. Even though of fairly large tonnage, it ppears that the Fox Clay is of more academic in- erest than economic.

MISCELLANEOUS PRIMARY DEPOSITS

A number of rock alteration areas have come to the writer's attention and have been visited during the course of this investigation. None of these appear to have economic significance due to the very limited quantity of uniformly usable clay. The occurrences visited, often at the behest of a prospector-owner, range upward from one which had a total of about 25 pounds of halloysite in one very small pocket along a fault zone.

Tickville Gulch claim: A. O. Acerson of Riverton has located a claim on an altered volcanic flow in Tickville Gulch, section 1, T. 5 S., R. 2 W., S. L. B. & M. (See fig. 12.) The clay is siliceous and bentonitic, supporting the view that it is an alteration of perlite which is abundant in the immediate area. Glassy perlite fragments are encountered within a foot of the surface and, although not proved, it appears that unaltered perlite would underly the clay occurrence. Although the exposure extends over nearly an acre, the total quantity is not large.

Belmont deposit: Sometime prior to 1950 the late Mr. Sidney Belmont of Provo acquired a fairly large deposit in section 18, T. 11 S., R. 1 W., S. L. B. & M., eight miles southwest of Goshen. The clay material is soft, plastic, pinkish gray in color. Montmorillonite and sericite are present and may account for most of the clay minerals. No stratification is apparent. An impermeable silty shale bed above probably served as a dam for rising hydrothermal solutions which altered volcanic material.

Chamberlain claim: Mr. Don Chamberlain has discovered a clay outcrop in section 33, T. 6 S., R. 3 W., S. L. B. & M.

The clay material is largely white to light gray in color although it contains stringers of red iron oxides. It is nonplastic and ash-like, and appears as a definite primary alteration product. No adjacent stratigraphic units are visible at the top of a low hill where this bed is exposed. Only a small area has been exposed and it is not known how extensive this deposit may be.

Mineralogically the clay material was found by differential thermal analysis to be kaolin with a large amount of quartz as accessory. The material did not shrink nor bloat even at cone 8, and it burned white. The porosity at cone 8 was about 42%.

<u>Shuler Spring area</u>: Just east of Payson Canyon, three miles southeast of Payson in sections 26 and 27, T. 9 S., R. 2 E., S. L. B. & M., is the area known locally as the "Goose Nest." The clay exposure is about one and one-half miles south of the Shuler Ranch. See figure 14.

The Payson Creek overflow has cut a thirty- to forty-foot gully through the unconsolidated valley fill and has exposed at the bottom an altered soil horizon which probably predates Lake Bonneville deposition (Brown, 1950). The clay material of the old soil is white to grayish green in color. Part of it is slightly calcareous. The darker colored clay is very plastic.

Upon firing to cone 04 a composite sample became orange pink with no shrinkage and high porosity. At cone 2 it fused readily indicating a very impure nature. Differential thermal analysis indicated a high calcium montmorillonite content.

<u>Alpine area</u>: A saprolite occurrence of similar origin to that of the Shuler Spring area was first studied by Hunt et al. (1949), on the Alpine-Draper road in sections 11 and 14, T. 4 S., R. 1 E., S. L. B. & M.

Many small lenses of very impure clay-like material may be seen in fresh road cuts in the area. These are largely calcareous with volcanic and limestone pebbles common. Also intermixed in places are the local gravels and silts. No economic significance can be attributed to these clays due to small volume and to their very impure nature.

Boulter Mountains: Several scattered clay occurrences have been noted in the Boulter Mountains north of Eureka and the Tintic district. H. W. Stroud of Salt Lake City has located four claims in sections 10 and 15, T. 9 S., R. 3 W., S. L. B. & M.

Examination of the clay from these claims shows halloysite and montmorillonite associated with calcareous and siliceous impurities. An overlying volcanic rock appears to have been the parent of these alteration products.

Shuler mine: A different type of clay-like material was discovered by Mr. Keith Shuler two miles southeast of Payson in SW 1/4, section 22, T. 9 S., R. 2 E., S. L. B. & M. He has opened a fault zone into the northeast end of Tithing Mountain on a strike of N. 40° E. See figure 14.

The clay material is white to reddish yellow in color and is plastic when wet. Mineralogically (differential thermal analysis), the material contains mostly quartz with some small amount of kaolin. It appears to be just an altered fault gouge with gradation on the walls to brecciated limestone. Brown (1950) located this fault in the Oquirrh formation.

Acerson claim (Lake Mountains): A very small occurrence of halloysite with calcareous and siliceous material was discovered by Mr. A. O. Acerson of Riverton, Utah, in the Cedar Hills area on the west flank of Lake Mountains in section 32, T. 6 S., R. 1 W., S. L. B. & M., about two miles north of the William Prince Company pumice pit.

Aside from the apparent difference in mineralogy, this fault zone occurrence is almost exactly like that of the Shuler mine (above) and is of no economic significance from the clay standpoint.

A fairly good grade of halloysite was encountered but no more than 25 pounds of it was obtained during the extensive surface and shallow depth (3-4 feet) exploration along the fault. It is doubted that much more of the halloysite would be found even with extensive drilling. The brecciated fault zone extends up to 30 feet but is much narrower in most places.

SOUTHEASTERN UTAH COUNTY

SHALES

A number of shales, interbedded with sandstones and limestones, occur in the flat-lying Colorado Plateau portion of Utah County. Spieker (1949) has detailed much of this area and his report was the basis of the exploration here. Paleocene and Eocene times are represented in North Horn, Colton, and Green River formations and each of these was found to contain shale members. Sampling in this area was done just along U. S. Highway 50-6 between Millfork (Utah County) and Castlegate (Carbon County.

The shales vary through a wide range of colors and textures. Many very calcareous and many sandy shales were seen and not reported.

Eight locations of noncalcareous shales were sampled and tested. These were tan to red to black in color and all were somewhat silty. They occurred in beds from three to several hundred feet in thickness.

At cone 04 these shales burn light brown to orange and do not shrink. Bloating and fusion occur by cone 2.

These shales, although not of brick-making quality, might easily be used for a bloated clay product such as haydite.

L A C U S T R I N E A N D A L L U V I A L C L A Y S

Reworked clay materials may become deposited through the action of streams and lakes. Many such deposits resulted in Utah County coincidentally with Lake Bonneville.

Though not much in the way of separate deposition, the saprolites (ancient soil remnants) found in Payson Canyon (Shuler Spring area) and in the Alpine area (reported above) are probably related to Lake Bonneville.

At least three commercial deposits have been worked from the recent lake and stream deposits in Utah Valley.

Ellis deposit: In 1950 Mr. Martell Ellis operated a small brick yard at the site of a clay deposit two miles east of Pleasant Grove in the SE 1/4 section 21, T. 5 S., R. 2 E., S. L. B. & M. See figure 18.

The clay is tannish brown with yellow and brown streaks. It weathers a light-tan color and fires, at cone 04, to a light-brown color. Differential thermal analysis shows this material to be primarily calcium carbonate and quartz with very little clay mineral.

The deposit, opened up 165 feet long, 70 feet wide, and 10 feet deep, is flat lying and well stratified. Texturally, it is a silty clay to a shaly siltstone with rounded quartzite and limestone pebbles and granules.

Provo Brick and Tile Company: This company has been established at the site of two fair-sized lacustrine-alluvial lenses in the E 1/2 section 36, T. 6 S., R. 2 E., at 14th North and 2nd West in Provo.

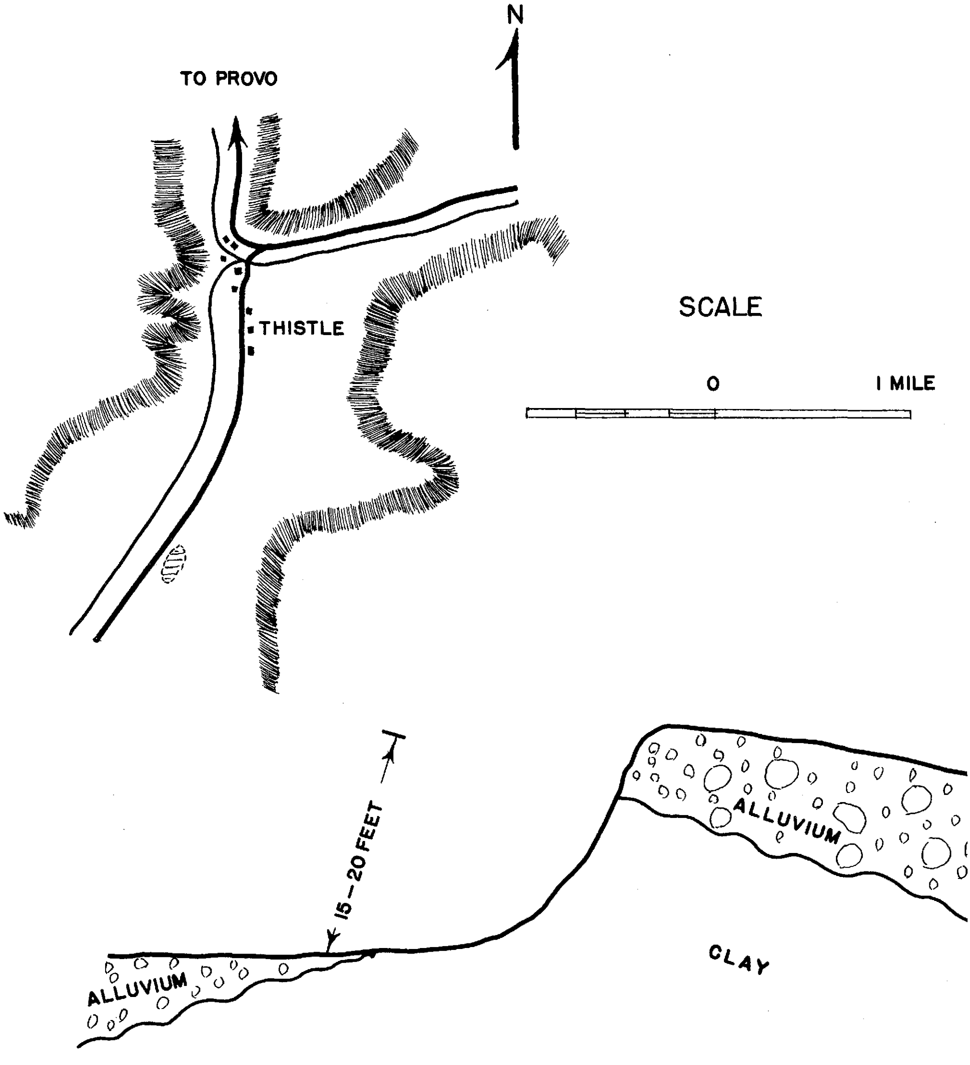


FIG. 22 LOCATION MAP AND CROSS SECTION
CLAY DEPOSIT 1 MILE SOUTH
THISTLE, UTAH.

The clay material is very similar to that of ıe Ellis deposit although it is somewhat more Lastic. It fuses completely before cone 6, indiating much impurity. The one lens in present peration has exposed clay for 1,500 feet by 180 eet and 10 to 20 feet in depth.

This clay is mixed with other clays in the anufacture of common building brick.

Ironton: The Ironton Works of the Columbia-eneva Steel Division, U. S. Steel Corporation, otains small quantities of similar clay from the onneville terraces just east of its plant south f Provo. This clay is used for mudding up doors n the coke ovens.

Spanish Fork Canyon and Thistle, Utah areas: wo clay occurrences adjacent to Highway 89, one t Diamond Fork and the other just south of Thistle unction (see fig. 22), are probably of alluvial rigin.

The Diamond Fork deposit is located in the 1/2 section 17, T. 9 S., R. 4 E., S. L. B. & M., bout 200 feet north of the highway in a road cut. ne small lens of plastic, silty clay material grades nto coarser alluvium on all sides.

One mile south of Thistle on the highway right f way in the SE 1/4 section 32, T. 9 S., R. 4 E., . L. B. & M., is another plastic, silty pocket of lay. It has been reported (Harris, 1953) that his material is a lithotope of the Flagstaff formaion and that it outcrops throughout the area. xtent of this deposit is unknown.

Though plastic, firing tests do not show a arge amount of clay mineral to be present and here was no shrinkage even at cone 8. Differential hermal analysis indicated a large amount of quartz nd a small amount of kaolinite and some calcite.

C L A Y   P R O D U C T I O N

I N   U T A H   C O U N T Y

Listed below are the latest figures available on the production of clay in Utah County:

	Utah County		State Total	
Year	Short Tons	Value	Short Tons	Value
1949	114,934	$272,806	251,509	$ 646,520
1950	51,126	176,022	303,078	933,196
1951	38,892	137,104	293,688	1,277,763
1952	32,882	85,452	180,066	1,115,642
1953	46,240	128,598	245,420	1,561,515
1954	44,430	128,263	277,511	2,061,932

Companies known to mine and/or ship clay from Utah County during the years covered above:

Roger Cedarstrom Company, Lehi.
Western Fire Clay Company, Salt Lake City.
R. D. Wadley Clay Company, Pleasant Grove.
George A. Lewis, Lehi.
Florence Powell, Lehi.
Utah Fire Clay Company, Salt Lake City.
Interstate Brick Company, Salt Lake City.
Provo Brick and Tile Company, Provo.

(The above information was furnished by the U. S. Bureau of Mines.)

SUMMARY AND CONCLUSIONS

Of the several dozen known occurrences of clay in Utah County only a small number are considered of economic significance. The Manning Canyon shale formation has been the most productive in the past and some of these deposits show promise of continuing to be important in the future. Potential areas of new production, at present unproved, are indicated for south of Five Mile Pass.

The Long Trail shalé continues tc produce brick clay from at least two pits although other deposits remain unworked at present. The clay generally is poorer and of lesser quantity than the more important Manning Canyon shale. The future for this type is less bright than for the clay from the Manning Canyon shale formation.

Primary clays, with halloysite the most sought-after mineral, are found in several small deposits and the only one of significant size, the Fox clay, has not proved as yet to be economical.

Lacustrine-alluvial clays of near Lake Bonneville time are being used in the production of common brick. Several more such deposits probably could be found should the need arise for this low-quality clay.

Other clay occurrences studied are definitely marginal, at least from the standpoint of actual clay mineral content, and, except for bloating characteristics of the shales, in the southeast part of the county, the deposits are of no economic significance.

The future looks fairly bright for production of clays, at least for brick, structural clay products, and low-heat duty refractory use in Utah County. One would not be realistic in predicting a big increase in production even though growth should parallel population and building trends rather closely.

APPENDIX A

C L A Y   M I N E R A L S

All of the clay minerals are of extremely fine particle size, so small that very high-powered electron microscopes are required to distinguish a distinctive shape for the individual crystals. All of the clay minerals are formed of sheets or layers of oxides and the crystals which result generally are very much like the familiar mica flakes only they are very much smaller.

Shape, size, composition, and both physical and chemical behavior differ from mineral to mineral. The differences in clay minerals are the result of several factors which include original material, environment, and subsequent alteration. The table below indicates some of these differences (after Ries, 1949):

Name	Chemical Formula	Remarks
Kaolinite	$Al_2O_3.2SiO_2.2H_2O$	Most common clay mineral; important in eastern kaolin deposits; paper clay, whitewares, etc.
Dickite Nacrite	Same	Uncommon; both of hydrothermal origin.
Halloysite	Same and $Al_2O_3.2SiO.4H_2O$	Rather uncommon; found as very small tubes formed from rolled up sheet of the crystal.
Allophane	Approximately the same.	Amorphous; no crystal structure.
Montmorillonite	$(Mg, Ca)O.Al_2O_3.5SiO_2nH_2O$	May adsorb sodium and then swells greatly; or may adsorb calcium; altered volcanic glass; clay is also called bentonite.
Illite	$K_2O-MgO-Al_2O_3-SiO_2-H_2O$ in various amounts.	Common mineral in shales.

APPENDIX B

C L A Y   P R O S P E C T I N G   I N   U T A H

THE OUTLOOK

Utah is not endowed with a rich geologic inheritance of possible clay deposits. Fortunately, however, Utah does have ample clays for its own and Idaho's present structural clay products industries although even these medium-grade deposits are not inexhaustable. More of these need to be discovered and at least placed in a ready reserve for when they are needed.

Special clays, such as the halloysite now being mined in large quantities at the Dragon mine, will likely continue to be in demand. The premium price placed on these clays is a good incentive for further prospecting.

Refractory clay is the chief clay product imported into Utah, and recent work has uncovered at least two possible sources in Utah. One of these, the clay lenses of the Dakota sandstone formation, outcrops widely in southeastern Utah. Wise uranium and other prospectors will keep a watchful eye on deposits of this formation.

Primary kaolin deposits offer some hope for refractory clay although those so far discovered have serious drawbacks.

HOW TO PROSPECT FOR CLAY

Methods used in clay prospecting do not differ much from those used for other minerals. Prospectors should be cautioned to collect as samples representative quantities of any deposit discovered rather than the high-grade, selected examples usually brought in.

Very few clay materials containing any free calcium carbonate have any value as clays; hence prospectors will save much time and effort by testing in the field each clay occurrence for carbonate. The simplest method involves placing a drop of dilute hydrochloric (also called muriatic) acid on the sample and observing effervescence (bubbling) of the carbon dioxide. Only the soluble carbonates will do this, so a display is a negative sign for a good clay. The concentrated acid purchased in a drug store should be diluted down to one-tenth strength with water.

Drilling below the impure surface soils is often advisable to locate hidden but suspected clay deposits. At least one Utah firm employs this method and has been quite successful with an inexpensive lightweight drilling rig.

For rocky country or for more information, it is necessary to use heavier drilling rigs and earth movers of various types as the situation dictates.

APPENDIX C

CLAY TESTING FACILITIES

Several facilities are available for the evaluation of clays in the state. Chief among these are the universities, followed by the major clay manufacturing plants.

The Ceramic Engineering Department, University of Utah, has the best equipped laboratory for this purpose. There, under the auspices of the Utah Engineering Experiment Station, all known tests on clays can be made, including plasticity, beneficiation, firing, x-ray, differential thermal analysis, and electron micrographic tests. No charge is made for the simpler tests, although where much labor and/or equipment must be used, these must be accounted for.

The Geology Department, Brigham Young University, has facilities to make most tests to determine economic value of clays. Equipment includes differential thermal apparatus for mineralogical analysis and pyrometrical cone equivalent furnace for fusing (firing) tests. Tests are made at the Brigham Young University as trained personnel are available to make them.

Persons submitting samples to industrial concerns can expect to learn if their clay is of interest to that company and little else.

APPENDIX D

SELENIUM AND FLUORINE CONTENT

A number of samples of the bedded deposits collected for ceramic ests were also analysed for selenium and fluorine content under the irection of D. A. Greenwood, Utah State Agricultural College. The elenium and fluorine determinations were made by Reuel Lamborn and arold M. Nielsen of the Chemistry Section of the Utah Agricultural xperiment Station, Logan, Utah. The results of these analyses are abulated below.

That these two elements are present is not at all surprising lthough the specific amount present is not easily related to simi- ar clays elsewhere due to lack of such data.

Most of the bedded clays of Utah County actually possess less elenium and fluorine than is reported by Mason (1952) as being the verage of these elements in the earth's crust. Values over the verage are related to solubility of the elements and enrichment by aters carrying them. The much higher values found for selenium in he Stubbs pit and for fluorine from Five Mile Pass deserve further nvestigation before conclusions relating to this preliminary analysis re drawn.

Deposit	Selenium	Fluorine
	(parts per million)	
Earth's crust (average)	0.09	300
Manning Canyon shale		
Interstate #1	0.02	220
Interstate #2	0.42	260
Powell	0.38	240
Clinton	0.29	235
Allred	0.38	368
Jack Rabbit	0.02	240
Overcross	0.28	300
Cedarstrom	0.14	400
Wiley Canyon	0.00	290
Pole Canyon	0.08	790
Black Diamond	0.00	450
Chamberlain mine	0.30	850
Chamberlain claim	0.00	450
Utah Fire Clay	0.01	1070
Interstate (Five Mile Pass)	0.00	910
Bluebird #1	0.00	870
Bluebird #2	1.23	1500
Long Trail shale		
McFarland	0.05	450
Wadley	0.22	500
Stubbs	9.5	380
Smith	0.98	680

APPENDIX E

P Y R O M E T R I C   C O N E S

Reactions which take place in clays as they are fired to high temperatures are primarily functions of the total heat added and the rate at which the heat is added. Temperature alone is not sufficient measure of the reaction. Because of the complexity of the reaction rate dependencies, a simplified comparison method is used widely for clay testing and throughout the ceramic industry for firing of ceramic bodies.

A very reproducible set of compositions each of which fuses after a certain time-temperature treatment is used for the comparison. To recognize a degree of fusion each of the various numbered compositions is formed into small narrow triangular pyramids (called cones) and a number of these are mounted on a clay plaque (base) at an angle of 82° with the horizontal. Standard numbered cones are available commercially. During subsequent heating, the most fusible cone first bends over and the tip touches the plaque, then the second one, etc.

When testing a clay of unknown fusion characteristics, cones of the clay are arranged in a cone plaque with several numbered standard cones. The plaque is put in a furnace and heated on a definite schedule until the unknown clay cone bends over. The unknown clay is said to have a pyrometric cone equivalent corresponding to the number of the standard cone which bends over with it.

Examples of Temperature Limits

for Standard Cones

Cone No.	Fired Slowly 20° C. per hour		Fired Rapidly 150° C. per hour	
	°C	°F	°C	°F
022	585	1085	605	1121
021	595	1103	615	1139
020	625	1157	650	1202
⋮	⋮	⋮	⋮	⋮
04	1050	1922	1060	1940
03	1080	1976	1115	2039
02	1095	2003	1125	2057
01	1110	2030	1145	2093
1	1125	2057	1160	2120
2	1135	2075	1165	2129
3	1145	2093	1170	2138
4	1165	2129	1190	2174
5	1180	2156	1205	2201
6	1190	2174	1230	2246
7	1210	2210	1250	2282
8	1225	2237	1260	2300
9	1250	2282	1285	2345

Cone No.	Fired rapidly 100° C. per hour	
⋮	°C	°F
23	1580	2876
24	1595	2903
⋮	⋮	⋮
40	1885	3425
41	1970	3578
42	2015	3659

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