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POTENTIAL LIMESTONE SOURCES IN THE DEVIL'S SLIDE-MORGAN REGION

Prepared for
Ideal Basic Industries
Devil's Slide Plant
Morgan, Utah

by

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EXECUTIVE SUMMARY

Nine limestone-bearing formations in the Devil's Slide-Morgan region were examined for possible cement quality limestone. Six of these formations were visited in the field and samples were collected from five of these. Only the Devil's Slide unit of the Twin Creek Limestone exposed in tributaries to Lost Creek, ten miles northeast of the cement plant, was found to contain high quality limestone. One-half million to one million tons of 48.7 percent CaO rock may be mineable in the Lost Creek Canyon area. Further study of the area is recommended especially if the high quality rock in the Kathryn Claims area is unavailable.

The Cambrian limestone located north of Morgan, Utah may contain thick limestone beds. Limestone is currently produced from an equivalent formation in central Utah. However, locked gates and restricted access prevented a field check of the exposures north of Morgan, and poor road conditions would be a production problem.

INTRODUCTION

A regional study of potential limestone resource rocks within a twenty-mile radius of the Devil's Slide cement plant was carried out to locate possible sources in addition to those studied in detail at Powder Hollow and the Kathryn Claims. This study consisted of a literature search to identify formations and exposures of limestone with resource potential and a brief field visit to examine the exposures. Where the rock appeared favorable samples were collected for geochemical analysis.

Potential limestone formations in the northern Wasatch Mountains, where the Devil's Slide plant is located, are Cambrian to Jurassic in age. In this region, these rocks are unconformably overlain and covered by Cretaceous and Tertiary conglomerate, sandstone and volcanic rocks (Hintze, 1980). Accessible exposures of limestone within twenty miles of the Devil's Slide plant are, therefore, limited to rocks exposed in two belts: first, rocks which are exposed along Weber Canyon from the Devil's Slide plant to Morgan, Utah and extending north from Morgan; and second, the Twin Creek Limestone, which is exposed along the bottom of Lost Creek Canyon, northeast of Devil's Slide (Hintze, 1980).

LIMESTONE FORMATIONS

Ten limestone-bearing formations are exposed between Morgan, Utah and the Devil's Slide plant. These formations generally strike north-south with a regional dip to the east. The oldest rocks are, therefore, exposed north of Morgan, Utah, with younger formations exposed progressively to the east (Mullens and Laraway, 1964; 1973). Two of these formations, the Humbug Formation and the Doughnut Formation, were examined in detail in the Kathryn Claims study (Sibbett, 1984) and will not be discussed further.

Cambrian Limestone

A Cambrian limestone formation 640 feet thick is exposed starting about two miles north of Morgan, Utah and continuing several miles to the north (Mullens and Laraway, 1973). The formation is described as thin-bedded grayish-black limestone interbedded with calcareous siltstone. The Cambrian stratigraphic section was measured a few miles to the north along these exposures at Durst Peak by Eardley (1944) and Coody (1957). The measured section presented below apparently includes the Cambrian to Devonian dolomite formation which overlies the Cambrian limestone.

Table 1

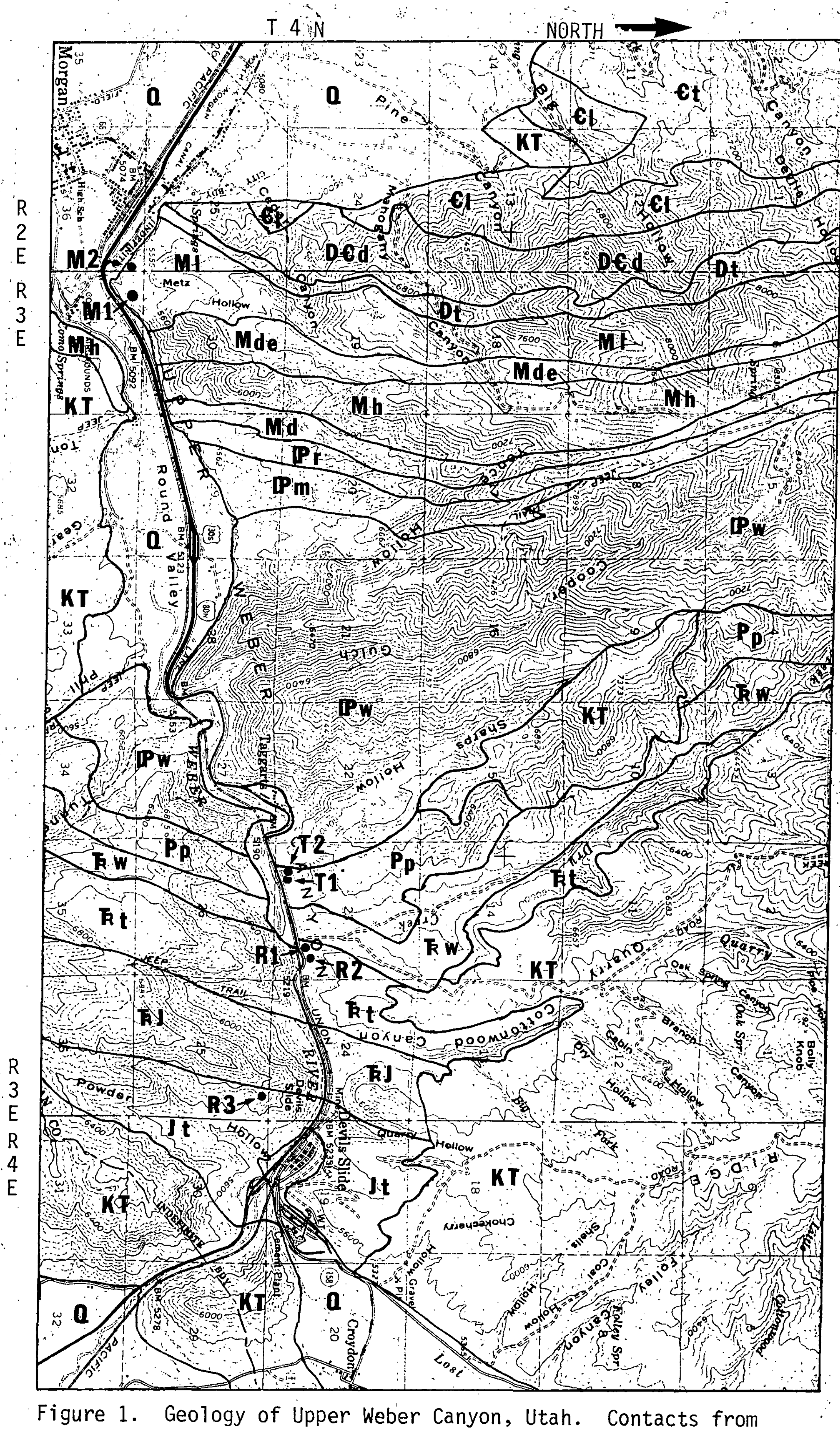
Type Section of Cambrian Limestone and Devonian Dolomite

Unit Number	Description	Thickness (feet)
13	Limestone, dark gray at bottom becoming light gray at top. Vermicular (Bluebird type)	100±
12	Shale, tan thin-bedded	20
11	Dolomite, white on weathered surface, gray on fresh surface. Wavy fine laminations (Lynch dolomite type). Becomes darker and vermicular at top	50
10	Limestone, dark and pisolitic at bottom, overlain by gray and mottled limestone, and this in turn overlain by dark-gray limestone with irregular calcite veinlets	50

Unit Number	Description	Thickness (feet)
9	Shale, tan thin-bedded. A sandy limestone in middle contains hematite pseudomorphs after pyrite	35
8	Limestone, vermicular (Bluebird type)	40
7	Dolomite, white, laminated (Lynch dolomite type). Vermicular limestone of Bluebird type in middle with some black chert nodules	100
6	Limestone, vermicular (Bluebird type). More massive bedded at top than bottom	175
5	Limestone edgewise conglomerate with some beds of mottled or banded limestone and also some beds of gray shale with 1/2-inch concretions	30
4	Shale, olive-gray, splintery, interbedded with thin blue-gray mottled limestone	100
3	Limestone, dark-gray to black with conspicuous irregular mudstone bands and mottles of lighter tan. Blotchy in part. Some beds have sandylike weathered surface (Hartmann type)	150
2	Shale and platey limestone, generally light gray-blue. Some limestones have yellowish blotches. A porous black sandstone probably near bottom	425
1	Limestone, dark gray-blue, banded, mottled and lumpy (Hartmann type). Large oölites and pisolites in lower part	100
	Conformable on Ophir shale	
	Total thickness	1375±

The measured section indicates several thick limestone beds. Also Hintze (1980) correlates the Cambrian limestone in the area with the Maxfield Limestone, which is the resource formation at the Leamington, Utah cement plant in central Utah. The lower 675 feet, units 1, 2 and 3 of the measured section comprise the Cambrian limestone as mapped by Mullens and Laraway (1973), and units 4 through 13 have been mapped as dolomite (DCd) on Fig. 1. Eardley (1944) lists the two thick limestone units 6 and 13 as "Bluebird type" and defines the Bluebird type as dark-gray dolomite or limestone.

The Cambrian limestone formation was selected for a field check. However, it was learned in Morgan, Utah that the wide exposures in Big Hollow and Pine Canyon (sections 12 and 13, T4N, R2E) are owned by Dee and Leland Kippen of Porterville, Utah. The owners have locked gates on all access roads into the area and limit access to paying hunters. An access road is present



EXPLANATION

Q	Quaternary
KT	Cretaceous and Tertiary
Jt	Twin Creek Ls
TR J	Nugget Sandstone and Ankareh Fm
TR t	Thaynes Ls
TR w	Woodside and Dinwoody Fm
Pp	Park City Fm
ℙw	Weber Quartzite
ℙm	Morgan Fm
ℙr	Round Valley Ls
Md	Doughnut Fm
Mh	Humbug Fm
Mde	Desert Ls
Ml	Lodgepole Ls
Dt	Three Forks Fm
DꞒd	Dolomite
Ꞓl	Cambrian Ls
Ꞓt	Tintic Quartzite
R1→•	Sample Location

Figure 1. Geology of Upper Weber Canyon, Utah. Contacts from Mullens and Laraway (1964, 1973). Scale 1:62,500.

further to the northwest, up Spring Hollow and Devils Hollow (Fig. 1) but this may cross the same property owner's land and would require about four miles of dirt road haulage. In light of the legal access problem and the poor condition of dirt roads in the area, it was decided the potential of producing a resource from the Cambrian limestone did not justify further effort at this time, therefore a field check was not made. This possible resource formation should be noted, however, if future needs require reconsideration of source rocks in the area.

The Cambrian limestone exposure continues for about eight miles north of Morgan, Utah. Cambrian limestone is exposed eight miles northeast of Huntsville, northeast of Causey Reservoir (Hintze, 1980). Extensive exposures of Cambrian limestone are also present to the north, east of Cache Valley (Williams, 1958). Access roads are a problem in both of these areas and haulage distance to the Devil's Slide plant is too great. Development of possible resource rock to the north and east of Huntsville would probably require a new plant site closer to these areas.

Three Forks Formation

The Devonian Three Forks Formation overlies the Cambrian limestone and dolomite formations (Mullens and Laraway, 1973). The Three Forks Formation consists of interbedded sandstone, siltstone, shale, conglomerate and limestone. The limestone units in the formation are up to 44 feet thick (Schick, 1955) and the formation is described as structurally incompetent (Mullens and Laraway, 1973). Both of these factors suggest that pure limetone beds thick enough to be of interest as a cement resource are not present in the Three Forks Formation.

Lodgepole Limestone

The Mississippian Lodgepole Limestone overlies the Three Forks Formation and forms a wide exposure one-half mile northeast of Morgan, Utah (Fig. 1). The Lodgepole Limestone consists of dark-gray limestone to dolomitic limestone about 800 feet thick (Laraway, 1958). This formation was examined and sampled in Metz Hollow as one of the four areas in the first part of this study (Sibbett, 1984). Two chip samples were collected, each across a 30-foot thickness of beds, at one location in about the middle of the formation and the other in the upper half of the formation (IB-M1 and IB-M2, Fig 1). Analyses of these samples indicated that the beds are dolomitic (Table 2), however the formation was considered further during the regional study because of its thickness.

Eardley (1944) measured the Lodgepole Limestone in the Durst Mountain area, Laraway (1958) measured it in Camp Kiesel Canyon and Schick (1955) examined the formation north of Morgan. All three referred to the formation as the Madison Limestone. Eardley (1944) and Schick (1955) described the lower 200 feet as dolomitic with 50 feet of argillaceous limestone above. Laraway (1958) describes the upper 120 feet of the formation as dolomitic to dolomite. Sample IB-M2 was collected in about the middle of the formation and contained 18% MgO. It was, therefore, concluded that the entire formation is probably dolomitic. A sample traverse across the formation would be required to explore for any low magnesium zones. Such detailed sampling is beyond the scope of the regional study and none is recommended at this time because of the reported dolomitic character of the formation and the availability of high quality rock in other formations.

TABLE 2

ICP Analysis of Samples from Formations in the Devil's Slide-Morgan, Utah Region (Percent Oxide)

Sample #	CaO	MgO	Al_2O_3	Fe_2O_3	K_2O	Na_2O	PO_4
IB-M1	45.18	3.22	0.209	0.232	0.062	0.014	0.018
IB-M2	31.08	18.01	0.604	0.365	0.196	0.036	0.005
IB-T1	21.21	15.67	1.22	1.28	0.348	0.073	0.960
IB-T2	34.48	6.26	0.460	0.178	0.144	0.023	0.284
IB-R1	31.55	1.63	3.50	1.47	0.648	0.870	0.455
IB-R2	32.55	1.60	3.45	1.46	0.673	0.857	0.479
IB-R3	43.68*	1.01	1.75	0.752	0.233	0.449	0.043
IB-R4	49.34	0.777	0.661	0.429	0.162	0.031	<0.009
IB-R5	48.05	1.21	0.652	0.476	0.137	0.047	<0.009

* Average CaO value for two replicate analyses.

Deseret Limestone

The Deseret Limestone overlies the Lodgepole Limestone (Fig. 1). This 500- to 600-foot thick formation was examined by Eardley (1944) and referred to as unit 1 of his Brazer Formation, which included the overlying Humbug and Doughnut Formations. The formation is described as sandstone with "a few limestone beds intercalated" (Eardley, 1944). Mullens and Laraway (1973) describe the Deseret Limestone as limestone and dolomite interbedded with sandstone and containing zones of shale and chert. No thick limestone units could be observed from Weber Canyon. Available data therefore suggest that the Deseret Limestone does not contain significant limestone beds and the formation was not field checked.

Round Valley Limestone

The Pennsylvanian Round Valley Limestone overlies the Doughnut Formation and is described as 400 feet of light-gray limestone containing nodules and seams of chert and beds of limestone conglomerate (Mullens and Laraway, 1973). In response to this favorable description, the formation was examined closely in the field but not measured during mapping of the Kathryn Claims area. Field examination found abundant chert clasts and quartz sand in the conglomerate, abundant tan to orange chert in most limestone beds and indications of shale partings throughout the formation. Sadlick (1955) measured and described the Round Valley Limestone about a mile north of where it was mapped in the Kathryn Claims area and his measured section is included here as Table 3.

Table 3

Type Section of the Round Valley Limestone Measured in N. 1/2 sec. 20, T4N, R3E, approximately 2 miles northeast of Morgan, Utah.
(Sadlick, 1955)

Unit Number	Description	Thickness (feet)
36	Silty limestone, grayish orange pink, in beds more than 2 feet thick, about 50 percent sand grains	8.5
35	Calcilutite* (limestone or dolomite), light gray, contains milky-white chert nodules up to 3 inches in diameter.	4.5
34	Siltstone, grayish orange pink, in thick beds, portions weather light brown.	3.5
33	Calcilutite, light gray and grayish red purple, contains black chert nodules in lower half and milky-white nodules in upper half.	33.0
32	Saccharoidal limestone, light gray, weathers to an arenaceous appearance.	2.0
31	Interbedded arenaceous calcilutite and sandstone.	17.0
30	Calcilutite, medium gray, poorly exposed.	34.0
29	Covered with light brown soil, taped across drainage ditch.	11.2
28	Dip slope covered with light gray calcilutite some of which is partly in place.	10.0
27	Calcilutite, medium gray weathers very light gray; portions have an arenaceous appearance on weathered surface.	9.7
26	Calcilutite, light gray; contains milky-white chert nodules parallel to bedding; nodules are irregular in shape and average 3 inches in diameter.	11.6
25	Calcilutite, light gray, poorly exposed on dip slope.	20.0
24	Calcilutite, light gray, very poorly exposed on dip slope.	32.5
23	Calcilutite, light gray, dense, begins to form dip slope.	29.0
22	Arenaceous calcilutite, light reddish purple.	1.0
21	Interbedded siltstone and very fine-grained sandstone, light brownish gray.	14.8
20	Interbedded siltstone and very fine-grained sandstone in 2-inch thick beds.	2.0
19	Calcilutite, light gray, in beds about 2 feet thick.	9.0
18.	Calcilutite, light gray, very hard, dense.	6.2
17	Milky-white chert and light gray calcilutite in equal amounts.	1.0
16	Calcilutite, medium gray.	1.0
15	Calcilutite, light gray, contains 2 one-foot thick resistant beds and pale reddish brown very fine-grained sandstone.	6.0
14	Same as underlying beds, except chert nodules are larger and unit is less resistant to weathering.	2.0
13	Calcilutite, light gray, very hard, dense, contains milky-white chert nodules.	5.0
12	Covered.	5.0
11	Calcilutite, medium gray, weathers to a smooth, light gray ledge.	1.0

Unit Number	Description	Thickness (feet)
10	Sandstone, medium gray, very fine-grained.	2.0
9	Poorly exposed, probably light gray calcilutite.	23.2
8	Saccharoidal limestone, light gray.	3.5
7	Calcilutite, light gray, cherty, in beds less than 1-foot thick, slope-forming.	9.2
6	Calcilutite, medium gray, saccharoidal in part, poorly exposed.	4.5
5	Covered.	7.9
4	Calcilutite, light gray, partly saccharoidal (granular sugarlike texture).	1.0
3	Covered.	3.5
2	Calcilutite, pale red and light brownish gray.	2.0
1	Argillaceous calcilutite, medium light gray. In places there is nodular, cherty limestone, limestone breccia and arenaceous limestone.	57.0
	Total thickness	394.3

* Calcilutite - limestone or dolomite composed of calcareous rock flour.

The only thick limestone zone evident in this measured section consists of units number 23 through 28, 81 feet thick, 197 feet above the base of the formation. A light gray limestone free of chert was noted in about this position in the northwest 1/4 of section 29, T4N, R3E. The limestone bed was poorly exposed but seemed to thin to the north and south in the map area and was not sampled. This eighty-foot limestone bed is only a few hundred feet east of the much thicker, high qualilty Doughnut Formation in the Kathryn Claims area (Sibbett, 1984), and would have the same ownership and transport problems. Further study of Round Valley Limestone as a separate resource does not seem warranted. However, if the Doughnut Formation is developed as a resource, the Round Valley Limestone could be examined more closely and sampled at that time if additional reserves were desired.

Park City Formation

The Permian Park City Formation is the next formation to the east and up section which contains limestone beds (Fig. 1). The Park City Formation consists of limestone, phosphatic mudstone and dolomite. The formation's exposure trends north across Weber Canyon one-half mile east of Taggarts (Mullens and Laraway, 1964). A complete measured stratigraphic section for the area was not found in the literature but Eardley (1944) describes the middle of the formation as containing limestone with great masses of chert and sandy limestone interbedded with siltstone and shale. Hintze (1980) shows the Park City Formation in the region as consisting of thin limestone interbedded with siltstone. Mullens and Laraway (1964), however, describe the formation as containing thick-bedded limestone. During examination of the Taggarts area, two 30-foot chip samples were collected across a thick exposure of calcareous beds directly east of the Weber Quartzite (Fig. 1). These samples, IB-T1 and IB-T2 in Table 2, contained high MgO content and low CaO content. The only other limestone bed exposed in the formation crops out about 1000 feet east of the sampled location. This second limestone is about 40 feet thick and effervesed only weakly with dilute hydrochloric acid. The bed is therefore assumed to be dolomitic. No further study of the Park City Formation is recommended.

Thaynes Limestone

The 2200-foot thick Triassic Thaynes Limestone is exposed about 2 miles west of the Devil's Slide plant (Fig. 1). A detailed measure section of the formation in Weber Canyon is presented by Smith (1969). The measured section shows the formation to consist of interbedded siltstone, shale and limestone with the thickest limestone unit only 42 feet thick. Some limestone beds are described as dolomitic (Smith, 1969). Exposures just east of the mouth of Dry

Creek along the old highway looked encouraging, however, and two chip samples were collected across the 330 feet thick limestone-appearing zone. Analyses of the 100-foot chip samples, IB-R1 and IB-R2 are given in Table 2. The low CaO content, averaging 32%, and hard nature of the beds suggest that the rock is silty. Based on the analyses, the Thaynes Limestone is not of resource quality and no further study of the formation is recommended.

Slide Rock Member of Twin Creek Limestone

During mapping of the Twin Creek Limestone in Powder Hollow, the Slide Rock Member (different from the Devil's Slide unit) was found to be present high on the hill to the west of the main production zone (Sibbett, 1984). The Slide Rock Member was mapped but not sampled with the other limestone beds because it is thinner and much higher up the hill than the known production unit, the Watton Canyon Member. Analyses of rock quality indicated that rocks of higher CaO content than the thick Watton Canyon and Rich Members would be important as "sweeteners" for production from Powder Hollow. Therefore, the Slide Rock Member in Powder Hollow was sampled as part of the regional study.

The Slide Rock Member is about 90 feet thick in Powder Hollow, dips 80 degrees and consists of medium- to thin-bedded micrite. One chip sample, IB-R3, was collected across the limestone bed where it is exposed 2000 feet southwest of the Devil's Slide (Fig. 1). The analysis is listed in Table 2. The single chip sample indicates the Slide Rock Member could provide additional reserves for general production but the 43.68 percent CaO content is too low to be used as a "sweetener".

Twin Creek Limestone in Lost Creek Canyon

The Twin Creek Limestone is exposed in Lost Creek Canyon and its tributaries six miles and further northeast of the Devil's Slide plant

(Hintze, 1980; Clark, 1919). Although the exposure of Twin Creek Limestone in Powder Hollow is closer, available tonnage of high quality rock such as the Devil's Slide unit is limited in Powder Hollow. Therefore, a reconnaissance examination of the Twin Creek Limestone in Lost Creek Canyon was made to check for favorable exposures of the Devil's Slide unit. Most of the area mapped as Twin Creek Limestone by Clark (1919) consists of the shale to sandstone portion of the formation overlain on an angular unconformity by Cretaceous to Tertiary clastic rocks (Hintze, 1980). The micrite beds of the thick Watton Canyon Member and the thinner oolitic Devil's Slide unit are exposed in Stokes Canyon and Paradise Canyon and these outcrops are sketched on Figure 2. A thick limestone unit is also exposed on the east side of Lost Creek Canyon, just south of the dam (Fig. 2), but the Devil's Slide unit was not evident near the dam. Field examination in Toone Canyon failed to find the Watton Canyon Member or the Devil's Slide unit continuing to the south. Hintze (1980) shows a fault cutting off the Twin Creek Limestone to the southeast in Toone Canyon.

A brief visit was made to the outcrops in Paradise Canyon and samples IB-R4 and IB-R5 were collected (Fig. 2). The outcrop sampled by IB-R4 is a thick-bedded, resistant oolite which is believed to be the Devil's Slide unit. The outcrop sampled by IB-R5 is also oolitic but medium to thin bedded. The section may be repeated here as at the Devil's Slide Plant.

Analyses IB-R4 and IB-R5 from the Lost Creek area are listed in Table 2. Both samples from Paradise Canyon are high quality rock (49.34 percent and 48.05 percent CaO), and therefore the outcrops probably are the Devil's Slide unit. Unfortunately, both exposures dip steeply and the oolite beds were estimated in the field to be about 50 feet thick. If both exposures could be

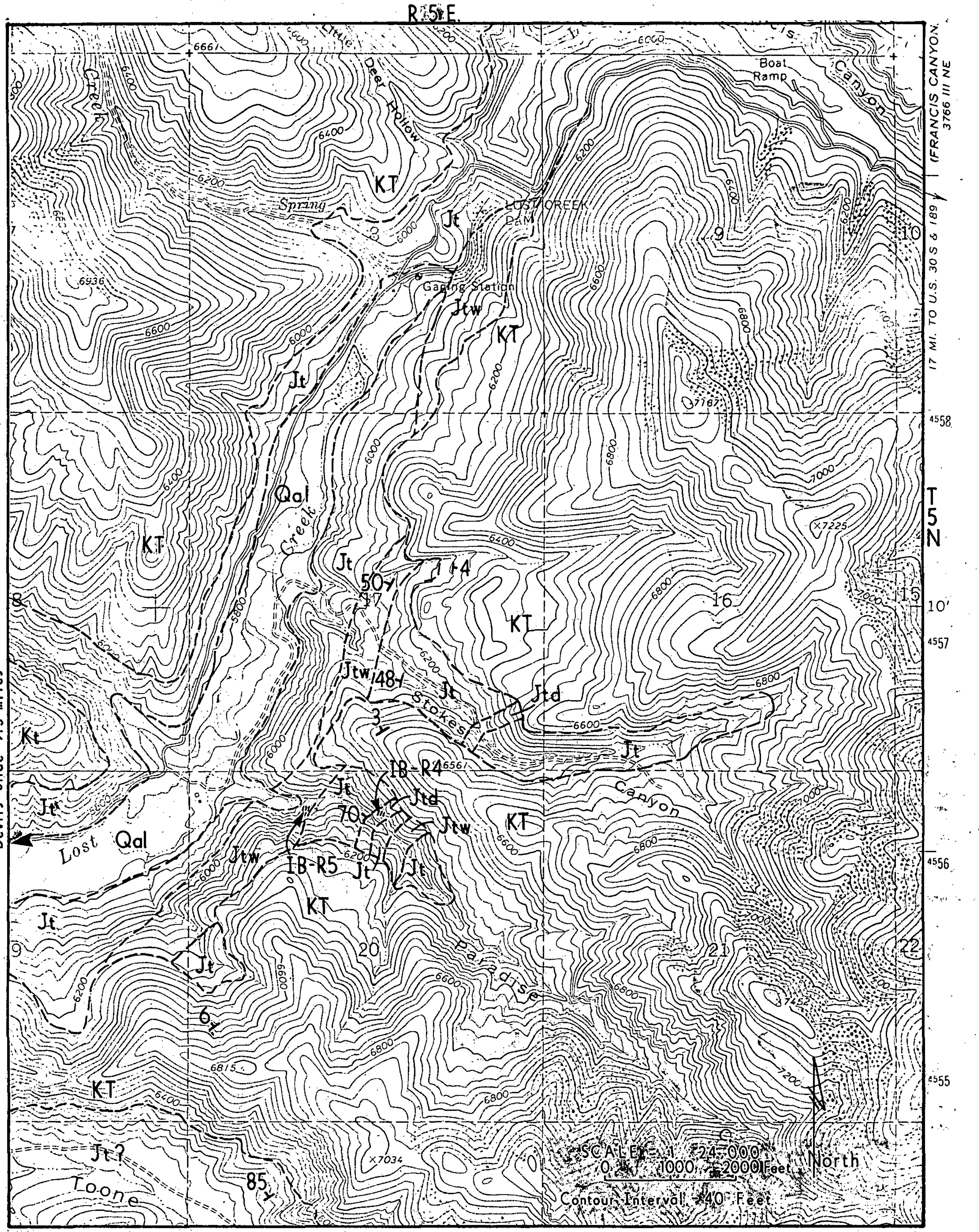


Figure 2. Twin Creek Limestone exposures in Lost Creek Canyon. Qal-alluvium, KT-Cretaceous and Tertiary conglomerates, Jt-Twin Creek Ls. shale, Jtw-Watton Canyon Member, Jtd-Devil's Slide limestone unit. KT contact from Clark (1919), Jtw and Ttd contacts sketched from field visit.

mined to a depth of 50 feet along 1000 feet of strike, about half a million tons of high quality rock could be produced from Paradise Canyon. A comparable amount may be exposed in Stokes Canyon (Fig. 2). This area is 10 miles from the Devil's Slide Plant, but it is generally downhill and the road is fairly good, although unpaved in part.

Recommendations for further study of this high quality but low tonnage potential resource are made in light of the other possible sources of high quality rock in the region. The Humbug and Doughnut Formations in the Kathryn Claims area are preferrable from a resource standpoint, but if this resource becomes unavailable or overpriced, the Devil's Slide unit in Lost Creek Canyon could be an alternative source.

AREAS RECOMMENDED FOR FURTHER STUDY

The Twin Creek Limestone exposures in Lost Creek Canyon are recommended for further study if the Doughnut Formation is not available for high quality rock or an additional source is desired. The next step in evaluating the Lost Creek Canyon area would be detailed geologic mapping, measuring stratigraphic sections and sampling in Stokes and Paradise Canyons. The study would be comparable to the study done in Powder Hollow (Sibbett, 1984) and would provide a better indication of resource quality and quantity that may be available in Paradise and Stokes Canyons. The ownership and availability of the possible resource should be determined before the study is started.

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APPENDIX

Thirty-seven element ICP analyses of samples.

Samples are arranged in the same order as in Table 1.

LIMESTONES

29 IB-M-1

ELEMENT			CONCENTRATION
NA	% OX.		0.014
K	% OX.		0.062
CA	% OX.		45.18
MG	% OX.		3.22
FE	% OX.		0.232
AL	% OX.		0.209
SI	% OX.	<	3.21
TI	% OX.		0.009
P	% OX.		0.018
SR	PPM		447
BA	% OX.		0.006
V	PPM	<	500
CR	PPM	<	4.00
MN	% OX.		0.002
CO	PPM	<	2.00
NI	PPM	<	10.0
CU	PPM	<	10.0
MO	PPM	<	100
PB	PPM	<	20.0
ZN	PPM		21
CD	PPM	<	10.0
AG	PPM	<	4.00
AU	PPM	<	16.0
AS	PPM	<	50.0
SB	PPM	<	60.0
BI	PPM	<	200
U	PPM	<	5000
TE	PPM	<	100
SN	PPM	<	10.0
W	PPM	<	2400
LI	PPM	<	4.00
BE	PPM	<	1.00
B	PPM	<	800
ZR	PPM	<	10.0
LA	PPM	<	10.0
CE	PPM	<	20.0
TH	PPM	<	300
	TOTAL		52.161

LIMESTONE SAMPLES

30 IB-M-2

ELEMENT			CONCENTRATION
NA	% OX.		0.036
K	% OX.		0.196
CA	% OX.		31.08
MG	% OX.		18.01
FE	% OX.		0.365
AL	% OX.		0.604
SI	% OX.	<	3.21
TI	% OX.		0.024
P	% OX.	<	0.005
SR	PPM		51
BA	% OX.		0.004
V	PPM	<	500
CR	PPM		22
MN	% OX.		0.004
CO	PPM	<	2.00
NI	PPM		13
CU	PPM	<	10.0
MO	PPM	<	100
PB	PPM	<	20.0
ZN	PPM		35
CD	PPM	<	10.0
AG	PPM	<	4.00
AU	PPM	<	16.0
AS	PPM	<	50.0
SB	PPM	<	60.0
BI	PPM	<	200
U	PPM	<	5000
TE	PPM	<	100
SN	PPM	<	10.0
W	PPM	<	2400
LI	PPM	<	4.00
BE	PPM	<	1.00
B	PPM	<	800
ZR	PPM	<	10.0
LA	PPM		16
CE	PPM	<	20.0
TH	PPM	<	300
	TOTAL		53.533

15 IB-T-1

ELEMENT		CONCENTRATION
NA	% OX.	0.073
K	% OX.	0.348
CA	% OX.	21.21
MG	% OX.	15.67
FE	% OX.	1.28
AL	% OX.	1.22
SI	% OX.	< 3.21
TI	% OX.	0.050
P	% OX.	0.960
SR	PPM	79
BA	% OX.	0.005
V	PPM	< 500
CR	PPM	82
MN	% OX.	0.013
CO	PPM	3
NI	PPM	13
CU	PPM	20
MO	PPM	< 100
PB	PPM	< 20.0
ZN	PPM	49
CD	PPM	< 10.0
AG	PPM	< 4.00
AU	PPM	< 16.0
AS	PPM	< 50.0
SB	PPM	< 60.0
BI	PPM	210
U	PPM	< 5000
TE	PPM	< 100
SN	PPM	< 10.0
W	PPM	< 2400
LI	PPM	5
BE	PPM	< 1.00
B	PPM	< 800
ZR	PPM	< 10.0
LA	PPM	29
CE	PPM	< 20.0
TH	PPM	< 300
	TOTAL	44.040

LIMESTONES

16 IB-T-2

ELEMENT		CONCENTRATION
NA	% OX.	0.023
K	% OX.	0.144
CA	% OX.	34.48
MG	% OX.	6.26
FE	% OX.	0.178
AL	% OX.	0.460
SI	% OX.	< 3.21
TI	% OX.	0.029
P	% OX.	0.284
SR	PPM	56
BA	% OX.	0.006
V	PPM	< 500
CR	PPM	17
MN	% OX.	0.012
CO	PPM	< 2.00
NI	PPM	< 10.0
CU	PPM	< 10.0
MO	PPM	< 100
PB	PPM	< 20.0
ZN	PPM	23
CD	PPM	< 10.0
AG	PPM	< 4.00
AU	PPM	< 16.0
AS	PPM	< 50.0
SB	PPM	< 60.0
BI	PPM	< 200
U	PPM	< 5000
TE	PPM	< 100
SN	PPM	< 10.0
W	PPM	< 2400
LI	PPM	< 4.00
BE	PPM	< 1.00
B	PPM	< 800
ZR	PPM	< 10.0
LA	PPM	21
CE	PPM	< 20.0
TH	PPM	< 300
	TOTAL	45.092

LIMESTONES

28 IB R-1

ELEMENT			CONCENTRATION
NA	% OX.		0.870
K	% OX.		0.648
CA	% OX.		31.55
MG	% OX.		1.63
FE	% OX.		1.47
AL	% OX.		3.50
SI	% OX.	<	3.21
TI	% OX.		0.123
P	% OX.		0.455
SR	PPM		160
BA	% OX.		0.022
V	PPM	<	500
CR	PPM		15
MN	% OX.		0.227
CO	PPM		5
NI	PPM	<	10.0
CU	PPM	<	10.0
MO	PPM	<	100
PB	PPM	<	20.0
ZN	PPM		13
CD	PPM	<	10.0
AG	PPM	<	4.00
AU	PPM	<	8.00
AS	PPM	<	50.0
SB	PPM	<	60.0
BI	PPM	<	200
U	PPM	<	5000
TE	PPM	<	100
SN	PPM	<	10.0
W	PPM	<	2400
LI	PPM		8
BE	PPM	<	1.00
B	PPM	<	800
ZR	PPM		22
LA	PPM		19
CE	PPM		33
TH	PPM	<	300
	TOTAL		43.694

LIMESTONES

29 IB R-2

ELEMENT			CONCENTRATION
NA	% OX.		0.857
K	% OX.		0.673
CA	% OX.		32.39
MG	% OX.		1.60
FE	% OX.		1.46
AL	% OX.		3.45
SI	% OX.	<	3.21
TI	% OX.		0.131
P	% OX.		0.479
SR	PPM		143
BA	% OX.		0.015
V	PPM	<	500
CR	PPM		16
MN	% OX.		0.347
CO	PPM		4
NI	PPM	<	10.0
CU	PPM	<	10.0
MO	PPM	<	100
PB	PPM	<	20.0
ZN	PPM		13
CD	PPM	<	10.0
AG	PPM	<	4.00
AU	PPM	<	8.00
AS	PPM	<	50.0
SB	PPM	<	60.0
BI	PPM	<	200
U	PPM	<	5000
TE	PPM	<	100
SN	PPM	<	10.0
W	PPM	<	2400
LI	PPM		9
BE	PPM	<	1.00
B	PPM	<	800
ZR	PPM		21
LA	PPM		19
CE	PPM		34
TH	PPM	<	300
	TOTAL		44.610

LIMESTONES

30 IB R-3

ELEMENT			CONCENTRATION
NA	% OX.		0.449
K	% OX.		0.233
CA	% OX.		43.93
MG	% OX.		1.01
FE	% OX.		0.752
AL	% OX.		1.75
SI	% OX.	<	6.42
TI	% OX.		0.064
P	% OX.		0.043
SR	PPM		305
BA	% OX.		0.018
V	PPM	<	1000
CR	PPM	<	8.00
MN	% OX.		0.028
CO	PPM	<	4.00
NI	PPM	<	20.0
CU	PPM	<	20.0
MO	PPM	<	200
PB	PPM	<	40.0
ZN	PPM		55
CD	PPM	<	20.0
AG	PPM	<	8.00
AU	PPM	<	16.0
AS	PPM	<	100
SB	PPM	<	120
BI	PPM	<	400
U	PPM	<	10000
TE	PPM	<	200
SN	PPM	<	20.0
W	PPM	<	4800
LI	PPM	<	8.00
BE	PPM	<	2.00
B	PPM	<	1600
ZR	PPM	<	20.0
LA	PPM		26
CE	PPM	<	40.0
TH	PPM	<	600
	TOTAL		54.700

LIMESTONES

31 IB R-3(R)

ELEMENT			CONCENTRATION
NA	% OX.		0.443
K	% OX.		0.227
CA	% OX.		43.43
MG	% OX.		1.01
FE	% OX.		0.746
AL	% OX.		1.65
SI	% OX.	<	6.42
TI	% OX.		0.062
P	% OX.		0.034
SR	PPM		300
BA	% OX.		0.017
V	PPM	<	1000
CR	PPM	<	8.00
MN	% OX.		0.028
CO	PPM	<	4.00
NI	PPM	<	20.0
CU	PPM	<	20.0
MO	PPM	<	200
PB	PPM	<	40.0
ZN	PPM		46
CD	PPM	<	20.0
AG	PPM	<	8.00
AU	PPM	<	16.0
AS	PPM	<	100
SB	PPM	<	120
BI	PPM	<	400
U	PPM	<	10000
TE	PPM	<	200
SN	PPM	<	20.0
W	PPM	<	4800
LI	PPM	<	8.00
BE	PPM	<	2.00
B	PPM	<	1600
ZR	PPM	<	20.0
LA	PPM		26
CE	PPM	<	40.0
TH	PPM	<	600
	TOTAL		54.066

LIMESTONES

32 IB R-4

ELEMENT			CONCENTRATION
NA	% OX.		0.031
K	% OX.		0.162
CA	% OX.		49.34
MG	% OX.		0.777
FE	% OX.		0.429
AL	% OX.		0.661
SI	% OX.	<	6.42
TI	% OX.		0.023
P	% OX.	<	0.009
SR	PPM		308
BA	% OX.		0.010
V	PPM	<	1000
CR	PPM	<	8.00
MN	% OX.		0.015
CO	PPM	<	4.00
NI	PPM	<	20.0
CU	PPM	<	20.0
MO	PPM	<	200
PB	PPM	<	40.0
ZN	PPM		30
CD	PPM	<	20.0
AG	PPM	<	8.00
AU	PPM	<	16.0
AS	PPM	<	100
SB	PPM	<	120
BI	PPM	<	400
U	PPM	<	10000
TE	PPM	<	200
SN	PPM	<	20.0
W	PPM	<	4800
LI	PPM	<	8.00
BE	PPM	<	2.00
B	PPM	<	1600
ZR	PPM	<	20.0
LA	PPM		21
CE	PPM	<	40.0
TH	PPM	<	600
	TOTAL		57.871

LIMESTONES

33 IB R-5

ELEMENT			CONCENTRATION
NA	% OX.		0.047
K	% OX.		0.137
CA	% OX.		48.05
MG	% OX.		1.21
FE	% OX.		0.476
AL	% OX.		0.652
SI	% OX.	<	6.42
TI	% OX.		0.026
P	% OX.	<	0.009
SR	PPM		318
BA	% OX.		0.010
V	PPM	<	1000
CR	PPM	<	8.00
MN	% OX.		0.013
CO	PPM	<	4.00
NI	PPM	<	20.0
CU	PPM	<	20.0
MO	PPM	<	200
PB	PPM	<	40.0
ZN	PPM		60
CD	PPM	<	20.0
AG	PPM	<	8.00
AU	PPM	<	16.0
AS	PPM	<	100
SB	PPM	<	120
BI	PPM	<	400
U	PPM	<	10000
TE	PPM	<	200
SN	PPM	<	20.0
W	PPM	<	4800
LI	PPM	<	8.00
BE	PPM	<	2.00
B	PPM	<	1600
ZR	PPM	<	20.0
LA	PPM	<	20.0
CE	PPM	<	40.0
TH	PPM	<	600
	TOTAL		57.042