



SD Department of Transportation  
Office of Research

Supplementary Report 5

Feasibility of Mining of Selected Pozzolans

# Development of a Type IP Cement

Study SD91-11  
Final Report

Prepared by  
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16. Abstract  A detailed assessment of the mineability of ten potential locations of pozzolans was made. The deposits are all volcanic ash beds within the Lakota Formation, a cretaceous sedimentary rock which crops out as a hogback, which encircles the Black Hills. The most favorable deposit is located about 10 miles south of the Cement Plant at Rapid City. There is very little overburden. The deposit is over 30 ft. thick, and could produce 1 million tons from an area less than 10 acres.					
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## Supplemental Report

### Task 9 - Feasibility of Mining

S.D. Department of Transportation  
Project SD-01-11  
"Development of a Type IP Cement"

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## INTRODUCTION

Because of the excellent pozzolanic qualities of sample LK-1 as described in earlier sections of this report, a detailed assessment of potential locations of deposits similar to LK-1 were made. Most of the field work was conducted in the summer of 1993 by Tim Thomure and Perry Rahn.

LK-1 is an outcrop of a portion of the Lakota Formation on Skyline Drive in Rapid City. The deposit appears to be volcanic ash (partially "welded tuff") deposited into water (a lake or swamp) which existed in Cretaceous time. Unlike other pozzolan deposits in Italy and elsewhere, the deposits in the Lakota Formation are not continuous beds, but appear to be ash that was reworked by water. As a result, the deposits have numerous "facies", i.e. they are not continuous laterally for any great extent.

This section of the report describes other locations where outcrops similar to LK-1 and LK-2 were found. The feasibility of mining is given for each location.

## SITE DESCRIPTION

Figure 1 is a geologic map of the Black Hills showing the location of Lakota sites studied in detail. LK-1 and LK-2 are locations which were studied as part of the original reconnaissance investigations, and the mineralogy and chemistry are described in previous sections of this report. The other 8 locales are Lakota outcrops which are potential pozzolan outcrops.

LK-1 and LK-2 are considered to be reworked volcanic ash. In Cretaceous time, widespread volcanic eruptions presumably occurred hundreds of miles to the west, and the ash fell over the landscape. In low areas such as ox-bow lakes and swamps, the ash accumulated to several tens of feet thick, partly because ash washed off adjacent higher lands.

The ten sites shown on Figure 1 were located primarily by aerial photograph inspection. Most of the Lakota Formation outcrops (the "hogback" area) is grass and tree covered with poor exposures. Along the canyons of some streams ("water gaps") there are some good exposures. Some outcrops contain ash beds, other outcrops show none. The only way to definitely know the extent of ash beds in the Lakota would be by

extensive test drilling which is beyond the scope of this investigation.

Each of the 10 locales were evaluated as to mineability. Table 1 summarizes the data. A detailed topographic map, and, where appropriate, a stratigraphic section and geologic cross-section was prepared for each site.

#### Site #1 (Sturgis 7 1/2' quadrangle)

A 20 ft thick bed of ash occurs near the crest of a hill north of Sturgis (Fig. 2 and 3). The bed has no lateral extent; it is only an erosional remnant. Hence no mining is feasible.

#### Site #2 (Sturgis 7 1/2' quadrangle)

Along Spring Creek, near Eden School, a power substation excavation shows the same ash bed as Site #1. It appears to be 10 ft thick (Fig. 4). Based on the geologic cross-section (Fig. 5) there is considerable overburden on top of this unit.

#### Site #3 (Tilford 7 1/2' quadrangle)

This exposure along Morris Creek (Fig. 6) consists of an unusual small pinnacle of ash and limestone (Fig. 7), as well as a larger outcrop to the north (Fig. 8).

#### LK-1 (Rapid City E 7 1/2' quadrangle)

This location (Fig. 9) supplied a sample which had the best pozzolanic qualities out of 26 samples studied in the initial reconnaissance part of this study. There is at least 48 ft of ash (Fig. 10), with not much overburden (Fig. 11). Unfortunately the outcrop is in the middle of Rapid City in a recreational area (along Skyline Drive) where it is very unlikely any mining would ever become a reality.

#### LK-2 (Rapid City E 7 1/2' quadrangle)

The same ash bed as LK-1 crops out along the south side of the "gap" in Rapid City. It does not appear to be as thick here as LK-1 (Fig. 12), and has much greater overburden (Fig. 13).

#### Site #4 (Hermosa NW 7 1/2' quadrangle)

This local along Billover Creek (Fig. 14) has two ash beds totaling 19' thick (Fig. 15), and the overburden averages about 60 ft thick (Fig. 16).

#### Site #5 (Hermosa NW 7 1/2' quadrangle)

This site along Walt Smith Creek is about 17 ft thick (Fig. 17), and has about 80 ft of overburden (Fig. 18)



#### Site #6 (Hermosa NW 7 1/2' quadrangle)

Sites #6 and #7 are located on Hart Ranch, a new private recreational area (Fig. 19). The sites are over a mile SW of the main campground area. Site #6 was spotted on the aerial photographs, but field inspection revealed no ash beds (Fig. 20)

#### Site #7 (Hermosa NW 7 1/2' quadrangle)

This site showed silicified ash cropping out over a large acreage. The ash is resistant to erosion and small waterfalls and potholes were present in the ephemeral drainages. The ash is about 30 ft thick (Fig. 21) and has almost no overburden (Fig. 22) over an area of at least 50 acres.

#### Site #8 (Edgemont NW 7 1/2' quadrangle)

This site is far removed from the Cement Plant (Fig. 23), but is the only ash locale seen in the southern Black Hills. Although the bed is 20 ft thick, (Fig. 24) it has considerable overburden (Fig. 25).

### MINEABILITY

All of the above 10 locales were studied to determine their mining feasibility. Table 1 shows a summary of the data.

It was determined that one million tons should be a practical size of deposit. A sample of LK-2 was determined to have a in-situ specific gravity of  $2.64 \text{ gm/cm}^3$  ( $162 \text{ lbs/ft}^3$ ). Therefore, for 1 ft thick deposit, in order to produce  $10^6$  tons it would be necessary to mine an area of 280 acres. Table 1 shows the acreage necessary to produce  $10^6$  tons of pozzolan for each locale. From this point of view the most favorable sites are LK-1 and #7, which require only mining 5.8 and 9.4 acres, respectively.

Based on the geologic cross-sections and the topographic maps, each site was studied to determine the average thickness of overburden necessary to be excavated over the ash bed. The area studied for overburden is the acreage necessary to produce  $10^6$  tons of pozzolan. The ratio of overburden thickness to pozzolan thickness was determined (Column E). The most favorable deposit is #7, which has very little overburden.

It is beyond the scope of this report to make a detailed assessment of all factors involved in the possible mining of pozzolan. Some of the most important factors are discussed below:

#### Land availability

All 10 sites are on private land. No attempt was made to discuss this report with the landowners. Presumably the sites could be acquired for mining.

### Transportation

Table 1 shows that LK-1 and 2 are only 1 mile from the Cement Plant and hence would present the lowest transportation cost. However, the sites are in Rapid City and almost certainly would not be mined due to environmental factors.

The next most favorable site is #7 which is 10 air miles from the cement plant. There would have to be a 1 mile access road constructed to Rt. 79.

### Mining and Beneficiation

All of the 10 locales could probably be mined with conventional open pit excavation. However Site #7 seems to be silicified, and may require blasting.

No attempt is made in this report to determine if the ash beds are consistent pozzolanic qualities over the entire extent of the locale described. [Indeed, no further lab work was conducted on these additional sites to see if their pozzolanic qualities measured up to LK-1 or LK-2.] Some locales (LK-2) have interbedded sandstones and would present a problem in mining in that the pozzolan would have to be separated from the sandstone. Others seem somewhat uniform and could be easily mined.

At LK-7, 9.4 acres would be required to produce  $10^6$  tons of pozzolan (Table 1). In 1992, the state cement plant produced 754,000 tons of cement. We can assume that 10% of cement produced will be blended with pozzolan, and the blend would contain 10% pozzolan. Therefore 7,540 tons of tons of pozzolan would be required annually. At LK-7, mining this amount would require about 0.1 acre annually.

### Environmental Factors

All the 10 sites have environmental factors which would cause an impediment to mining. For example, LK-1 and LK-2 are in Rapid City, and the noise and dust would certainly preclude mining. The most favorable locale, site #7, is far-removed from human habitation. It is over 1 mile to the nearest residence. It could be mined with minimal impact on water resources since it is only drained by ephemeral streams. It would be up to Hart Ranch and adjoining landowners to decide how mining would least impact on their ranching and recreational activities.

## SUMMARY

This research is a reconnaissance evaluation of the feasibility of mining deposits which have pozzolanic qualities. The investigation is confined to the Lakota Formation. To gain a more complete understanding of the occurrence of these deposits, it is necessary to have extensive test drilling which is beyond the scope of this investigation.

With the exception of LK-1 and LK-2, the pozzolanic qualities of the other Lakota locales are not known. If the 8 other Lakota sites prove to be as good as LK-1 and LK-2, then it is obvious that Site #7 is the best place to mine because it is thick, has little overburden, and would cause relatively little environmental impact. Assuming no blasting is required, it could probably be mined for approximately \$3/ton. Transportation costs would be approximately \$3/ton based on a one-way haulage distance of about 15 miles. If the landowners do the mining, no land acquisition is necessary; if the deposit is leased or purchased from the landowner by a mining company, land acquisition costs would be additional. If beneficiation, crushing, seiving, washing, or calcining is necessary, this would also be an additional cost.



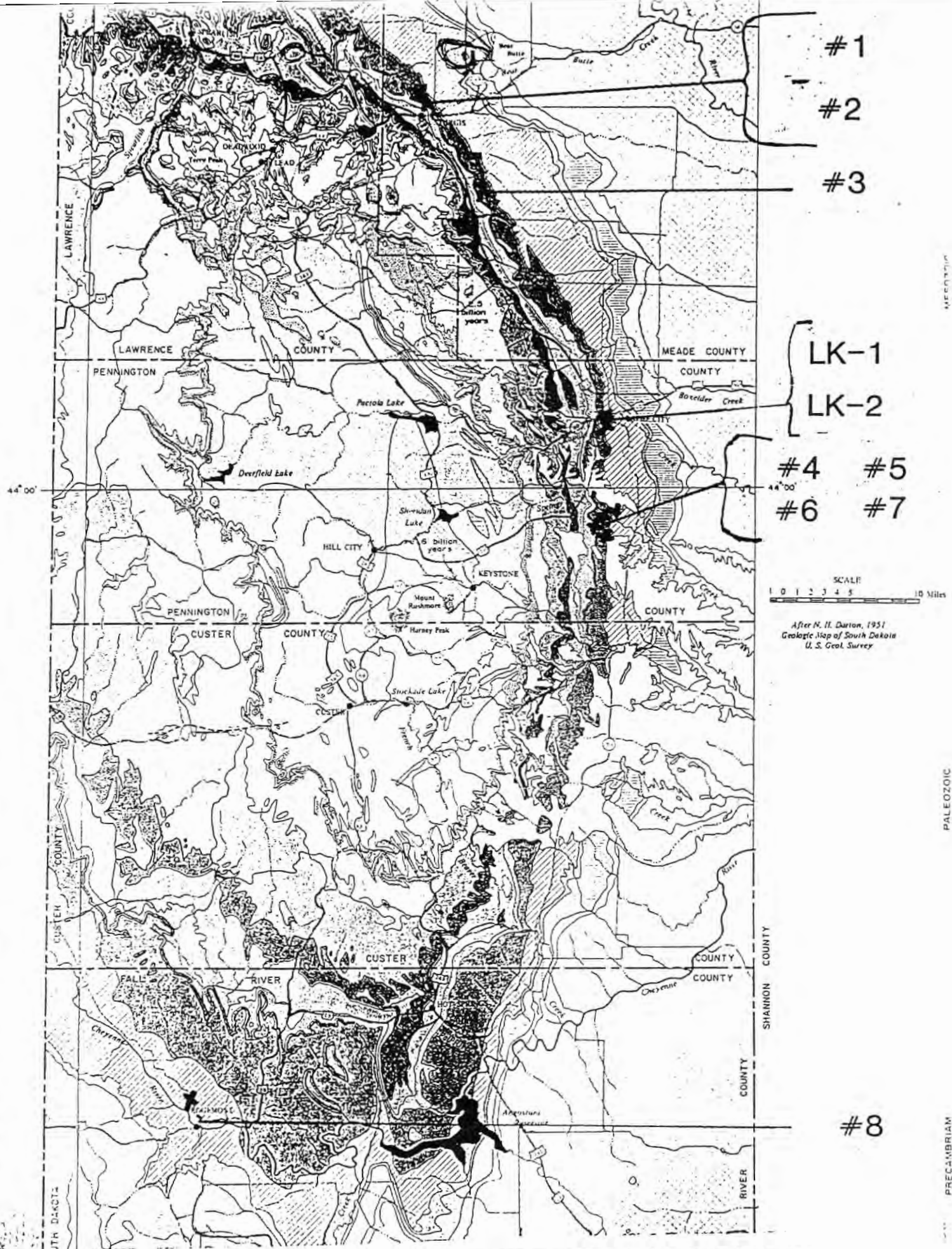


Figure 1. Geologic map of the Black Hills showing the location of the ten potential pozzolan sites.



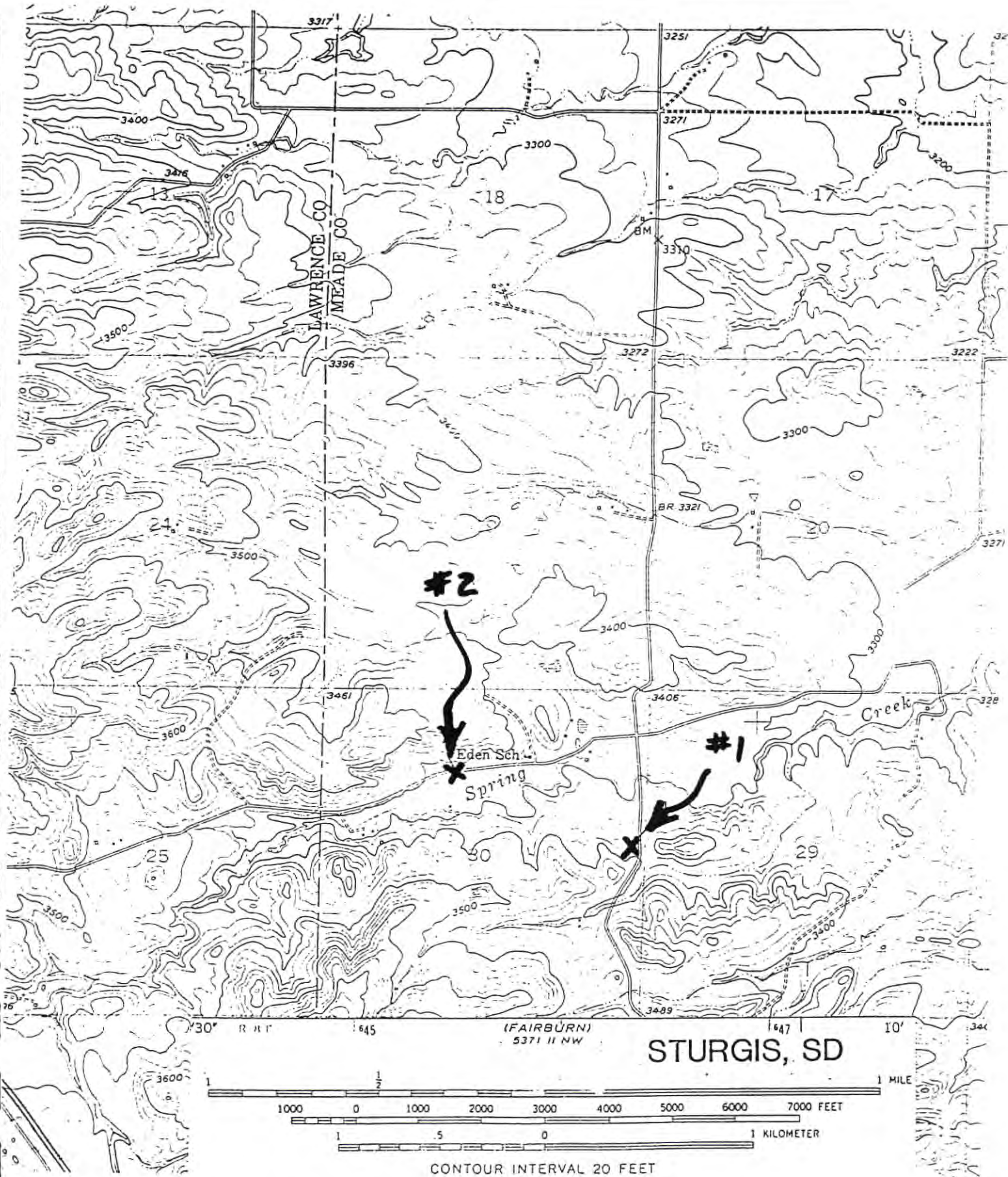
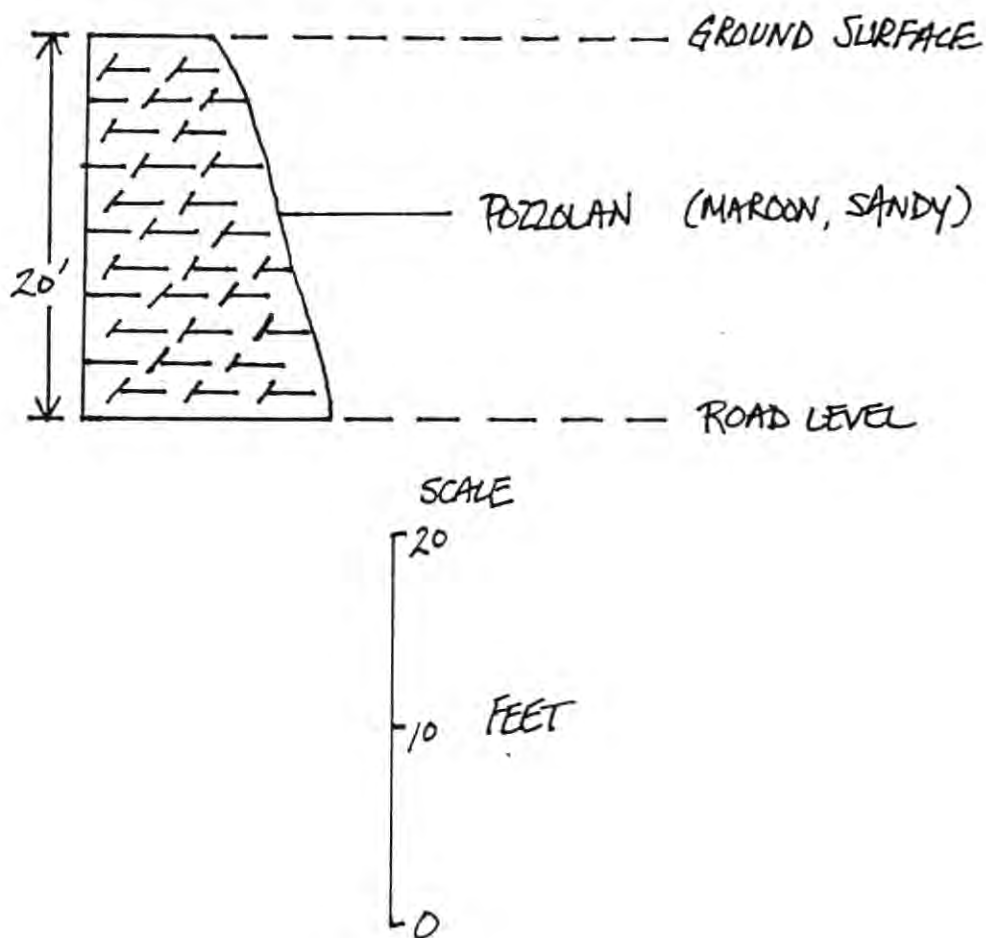


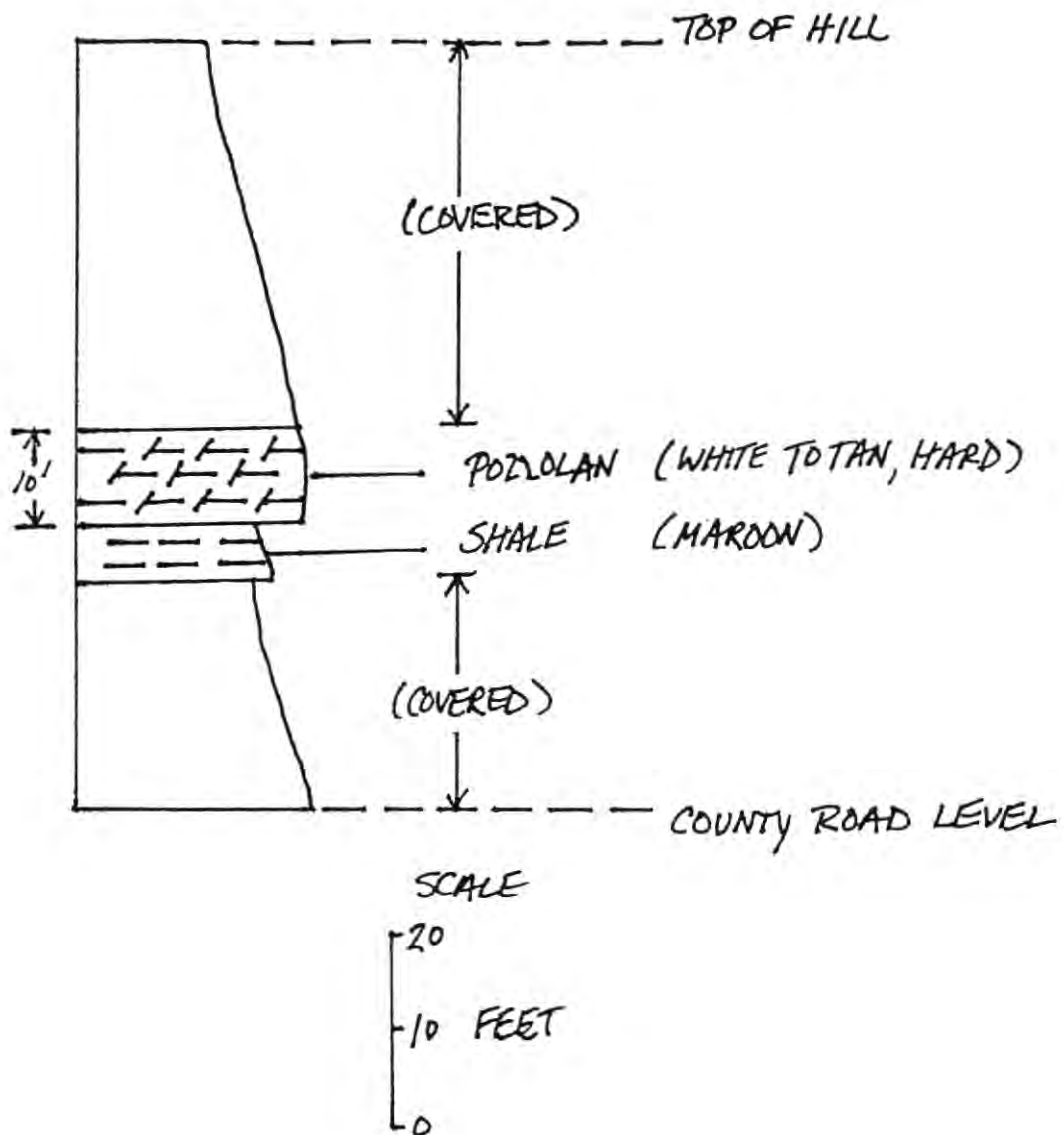
Figure 2.

Portion of the Sturgis 7 1/2' topographic map showing the location of Site #1 and #2.



# 1 (STURGIS)

Figure 3. Measured section of Site #1.



#2 (STURGIS)

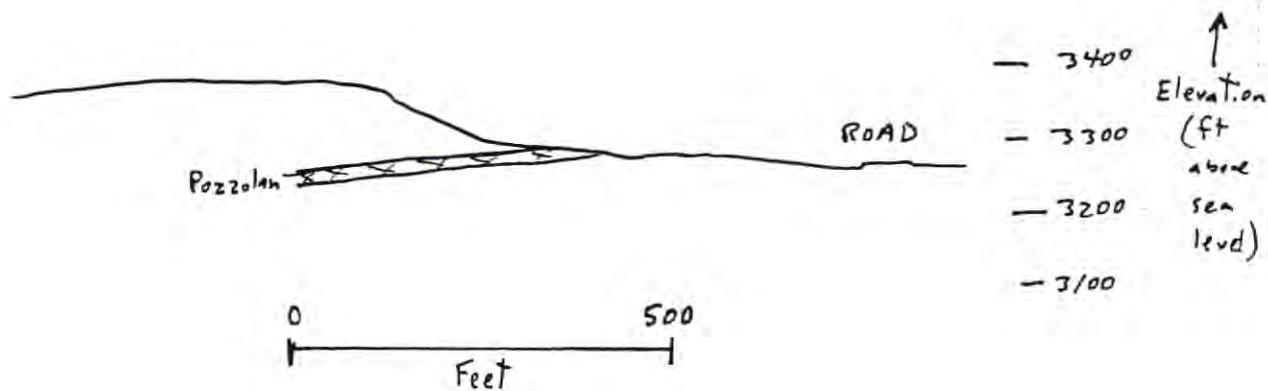
Figure 4.

Measured section of Site #2.



N

S



#2 Sturgis

Figure 5. Geologic cross-section of Site #2.



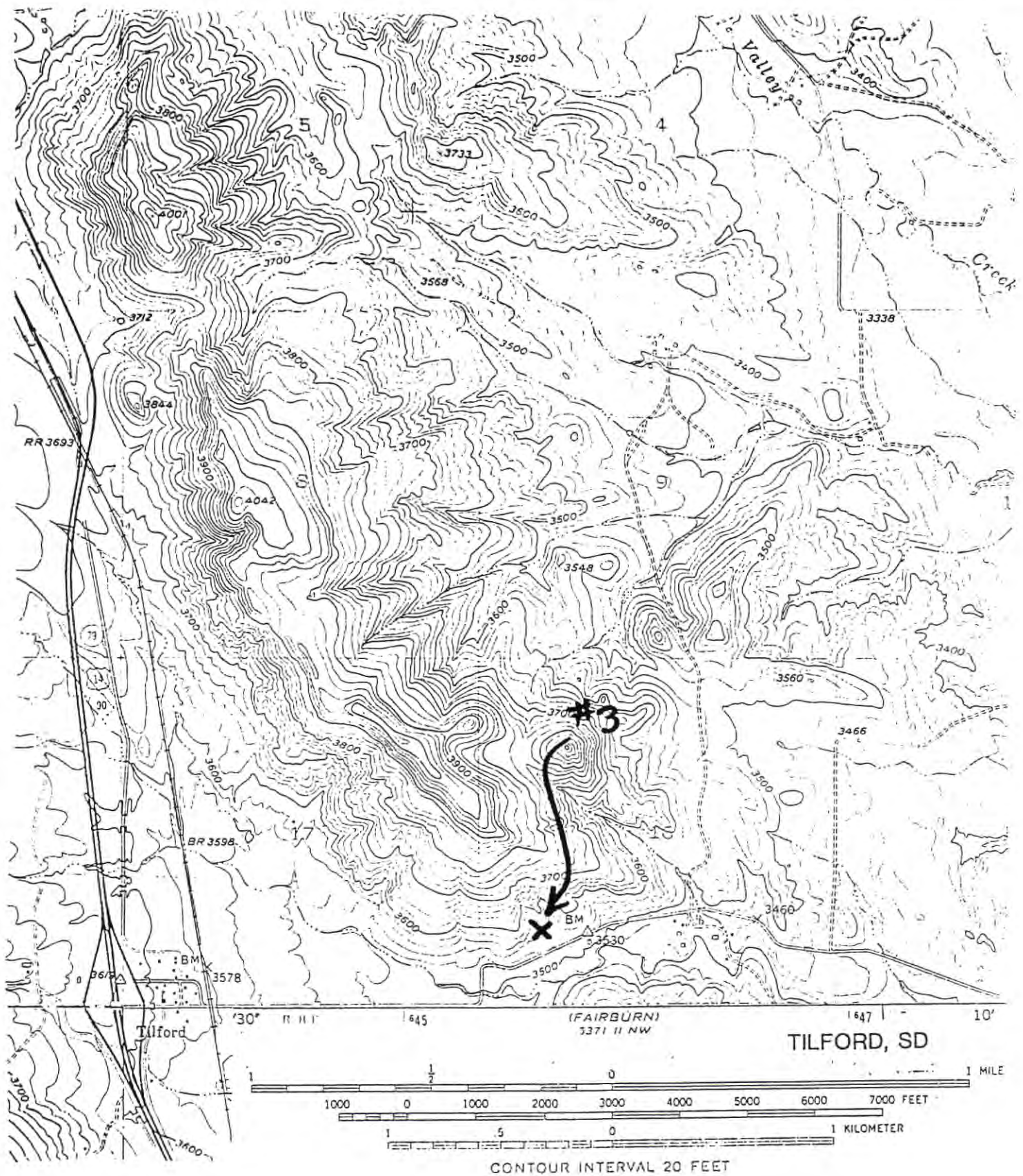
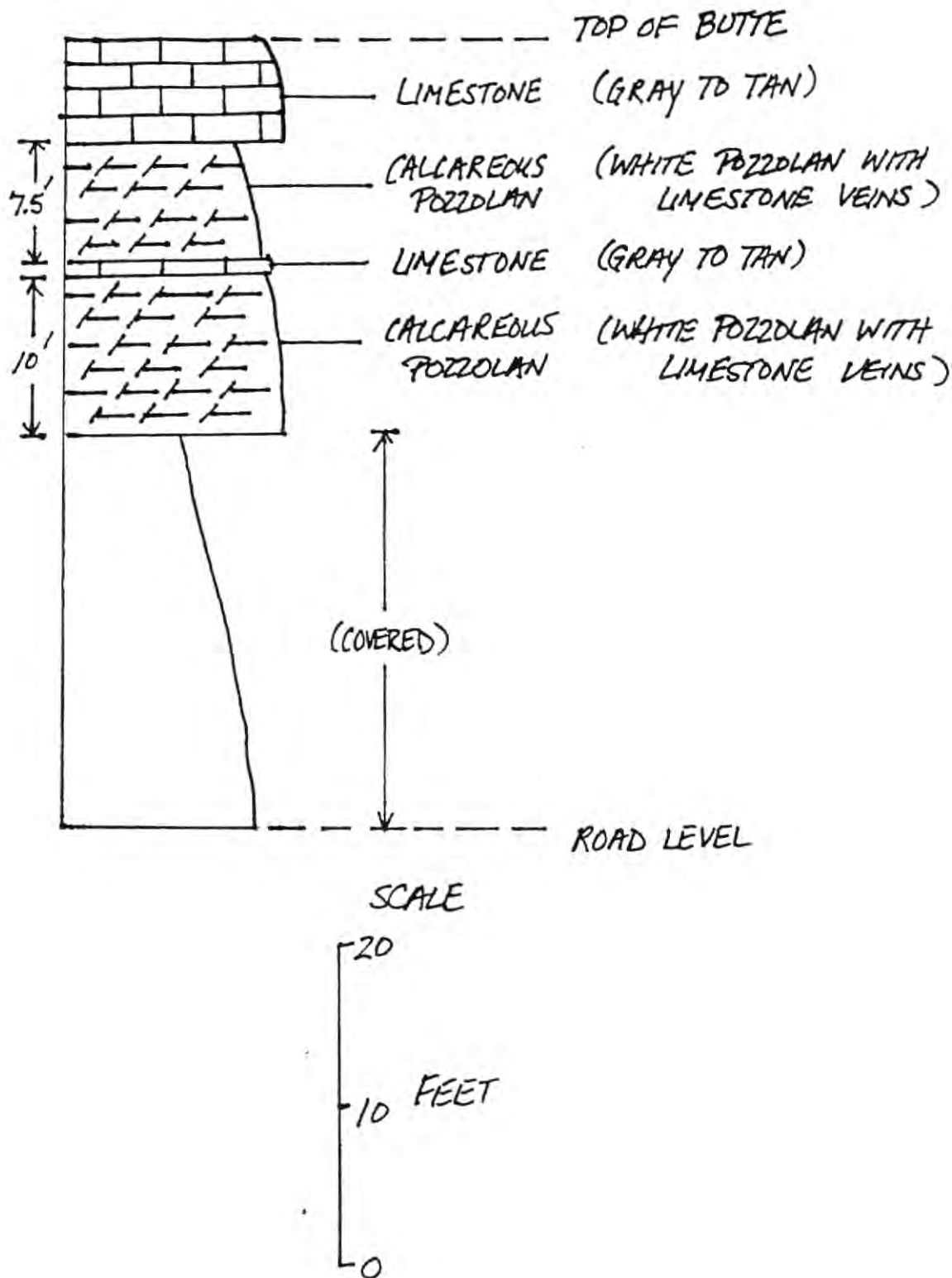


Figure 6.

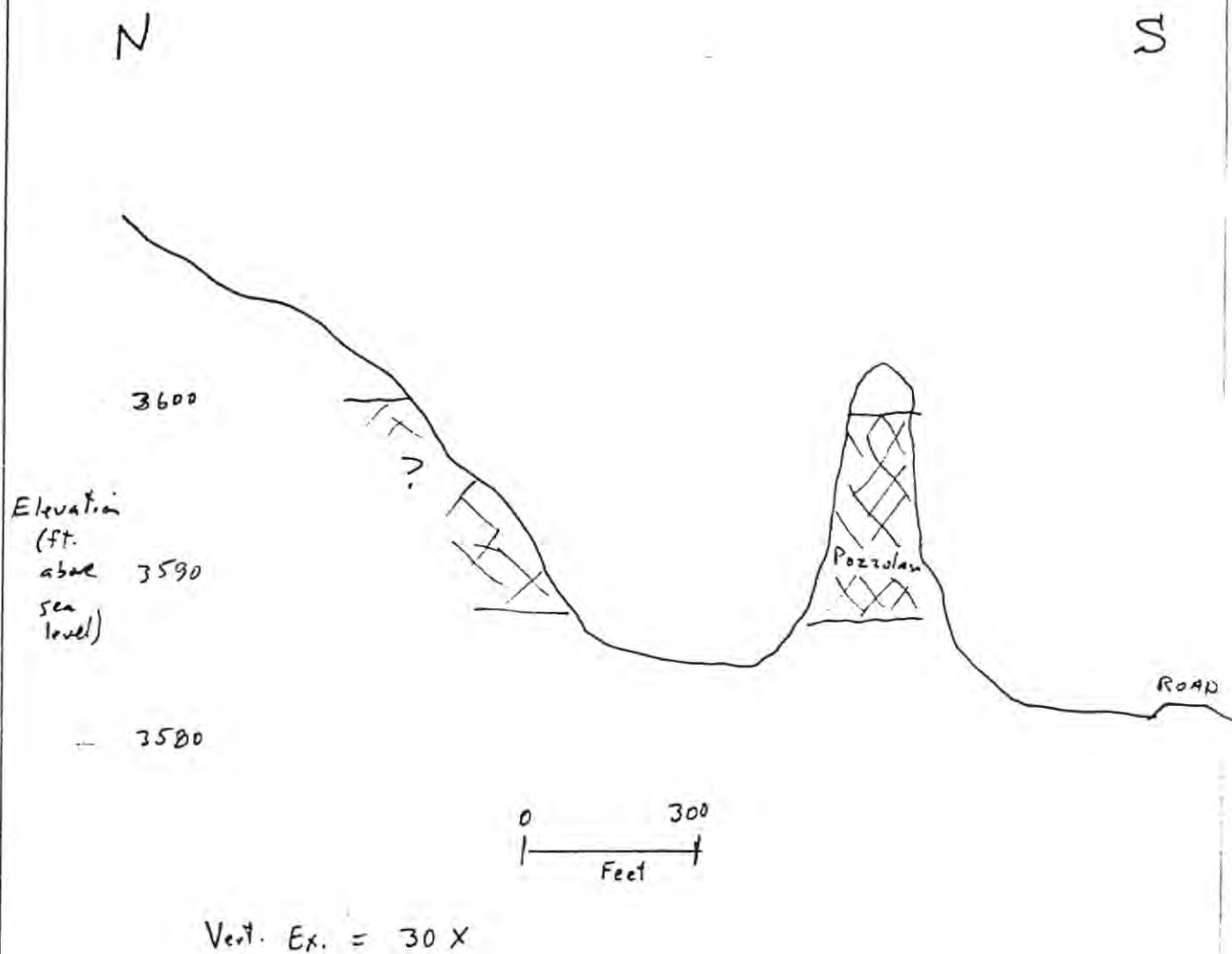
Portion of the Tilford 7 1/2' quadrangle showing the location of site #3.



#3 (TILFORD)

Figure 7.

Measured section of Site #3.



#3 Tilford

Figure 8.

Geologic cross-section of Site #3.







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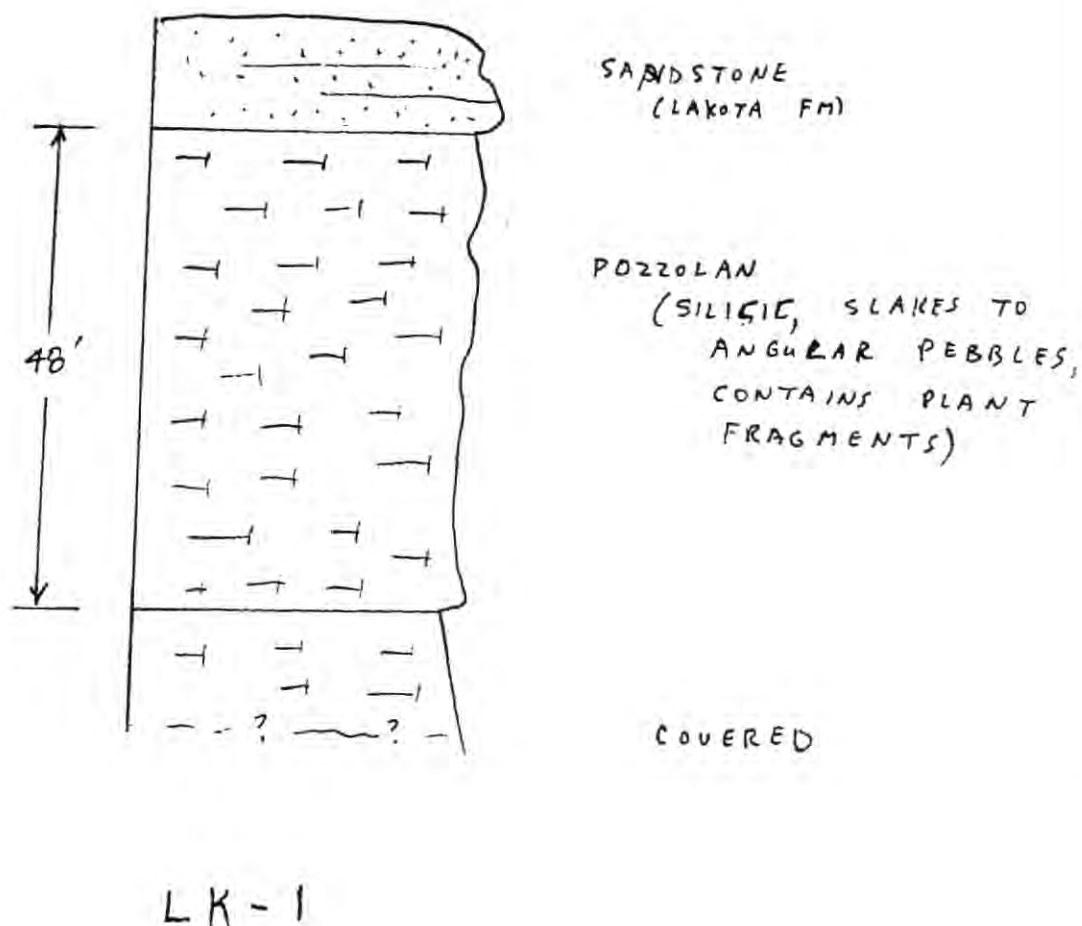


Figure 10.

Measured Section of LK-1.

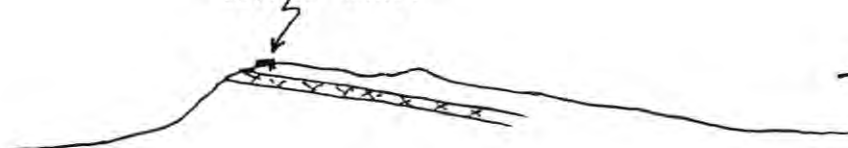
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22-142 100 SHEETS  
22-144 200 SHEETS



W

E

SKYLINE DRIVE

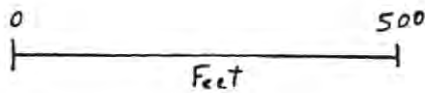


— 3500

— 3250

— 3000

↑  
Elevation  
(ft  
above  
sea  
level)



LK-1

Figure 11. Geologic cross-section of LK-1.

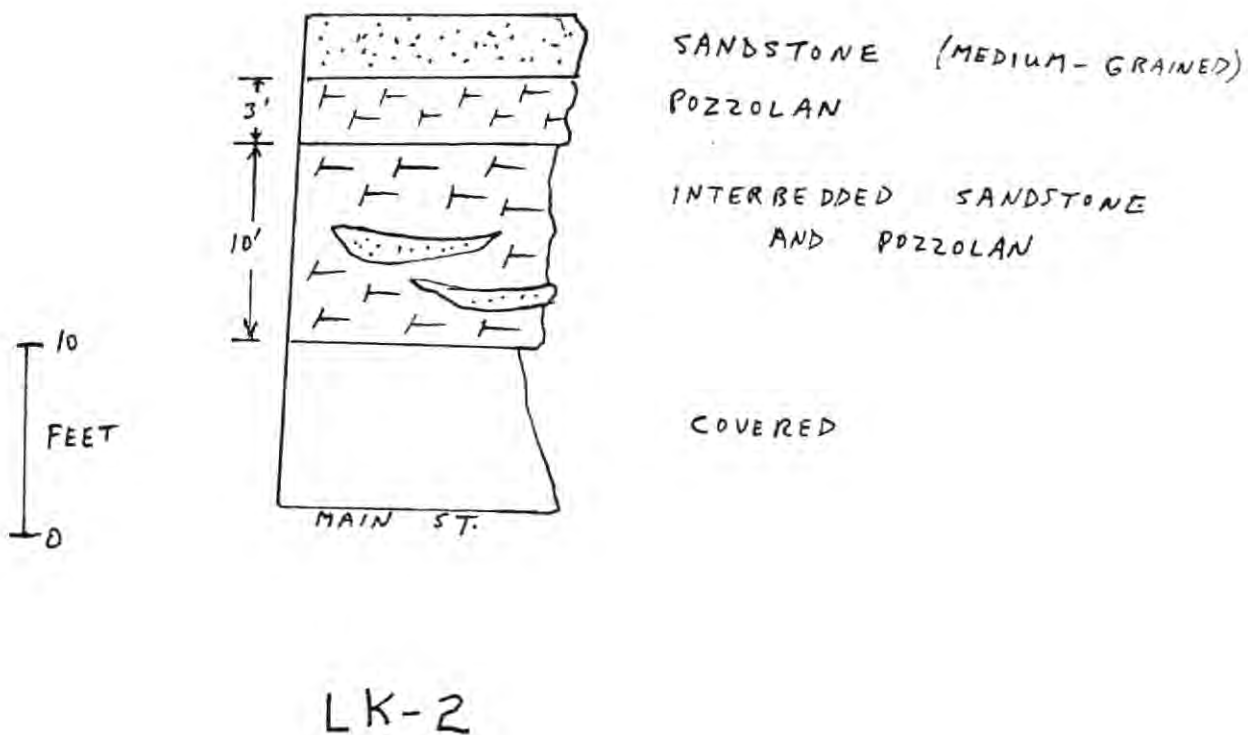


Figure 12.

Measured section of LK-2.

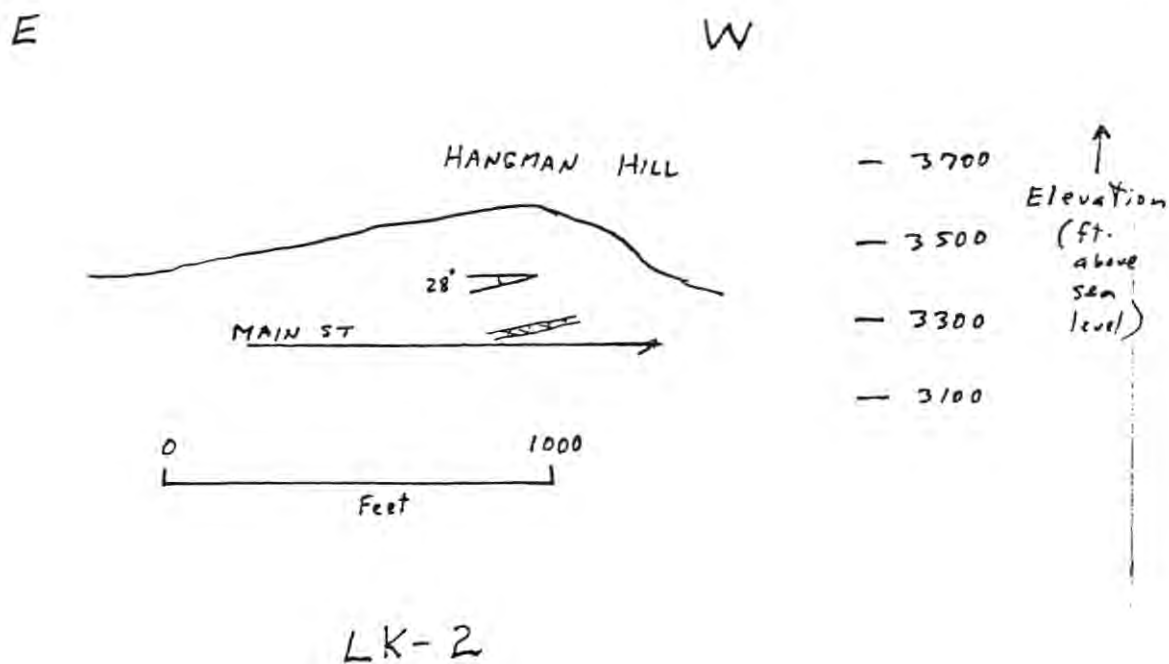
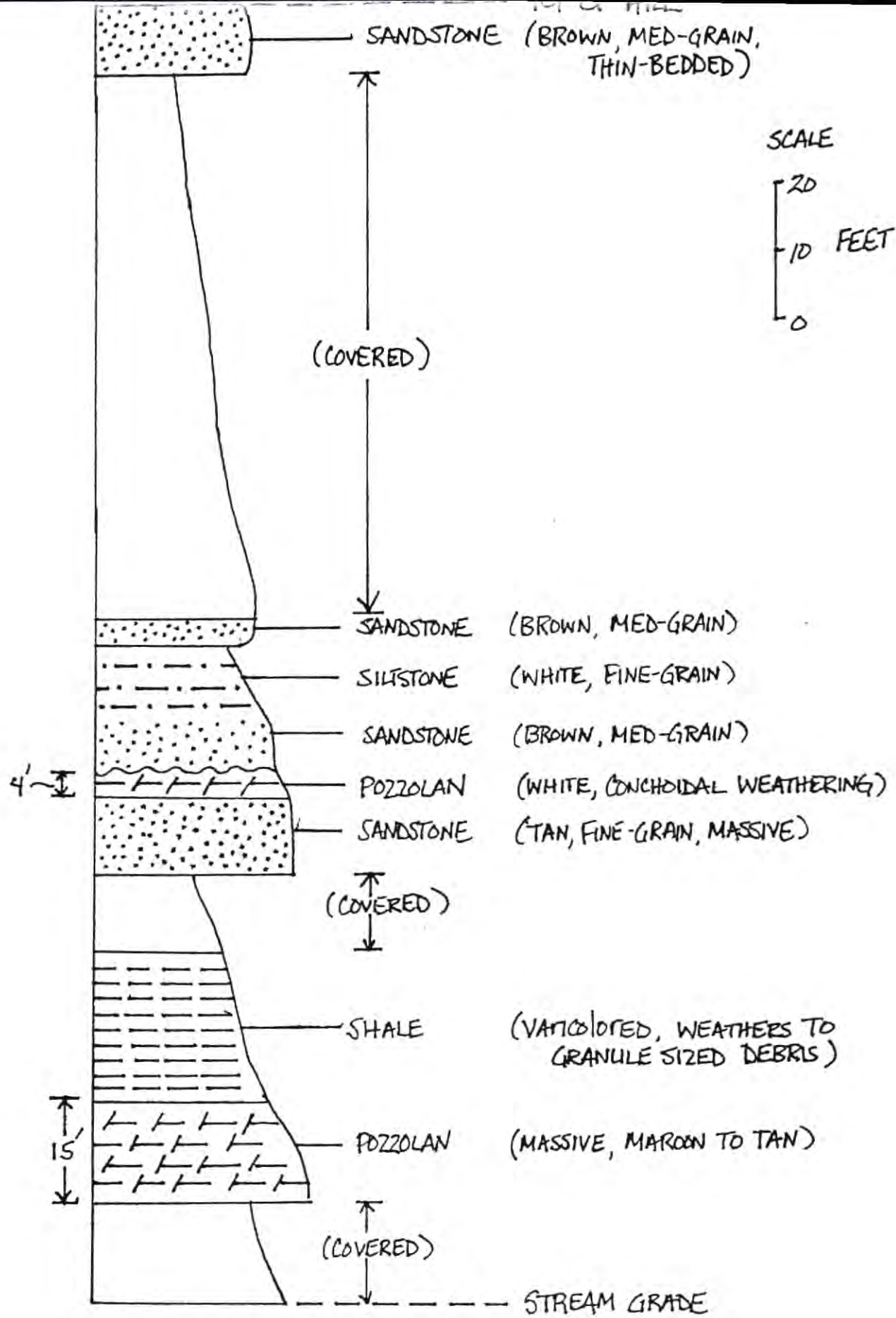


Figure 13.

Geologic cross-section of LK-2.





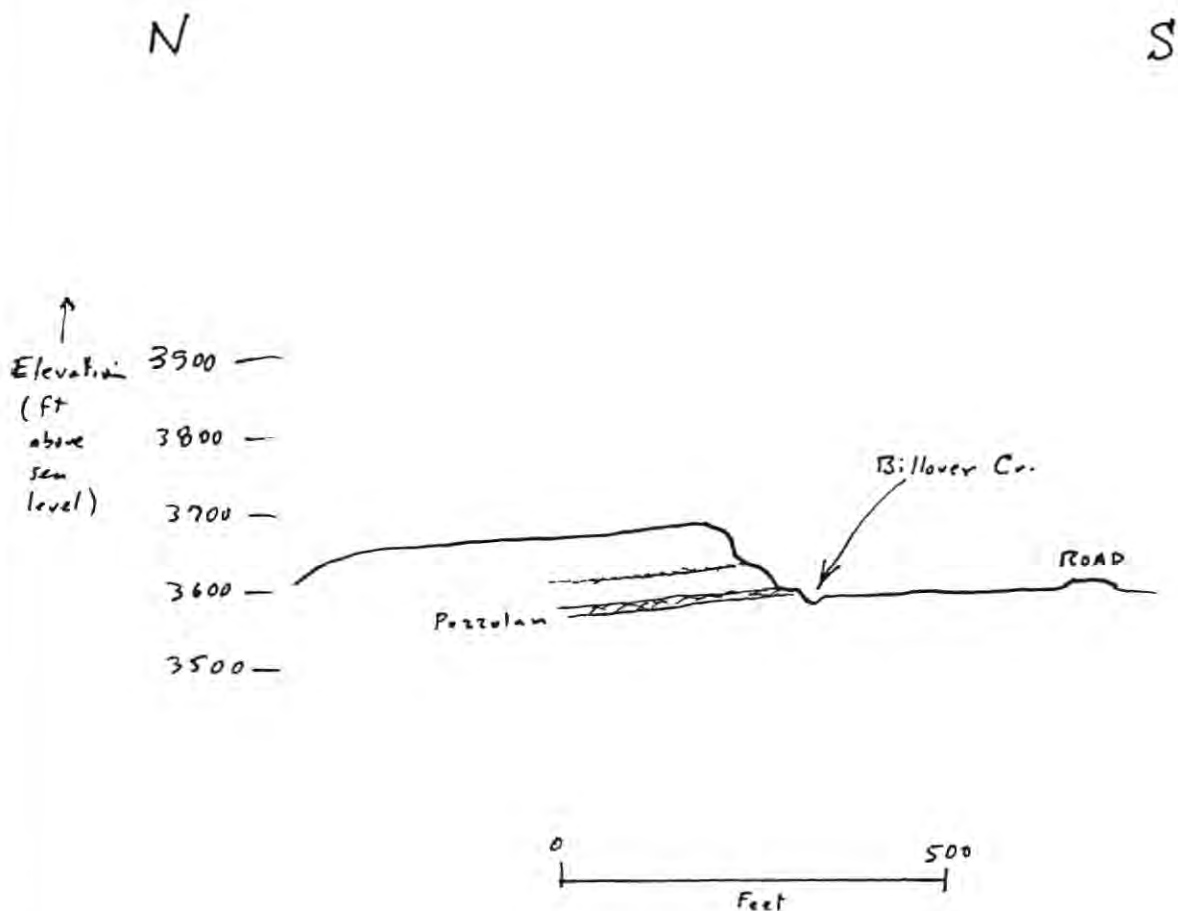


# #4 (HERMOSA NW)

Figure 15.

Measured section of Site #4.

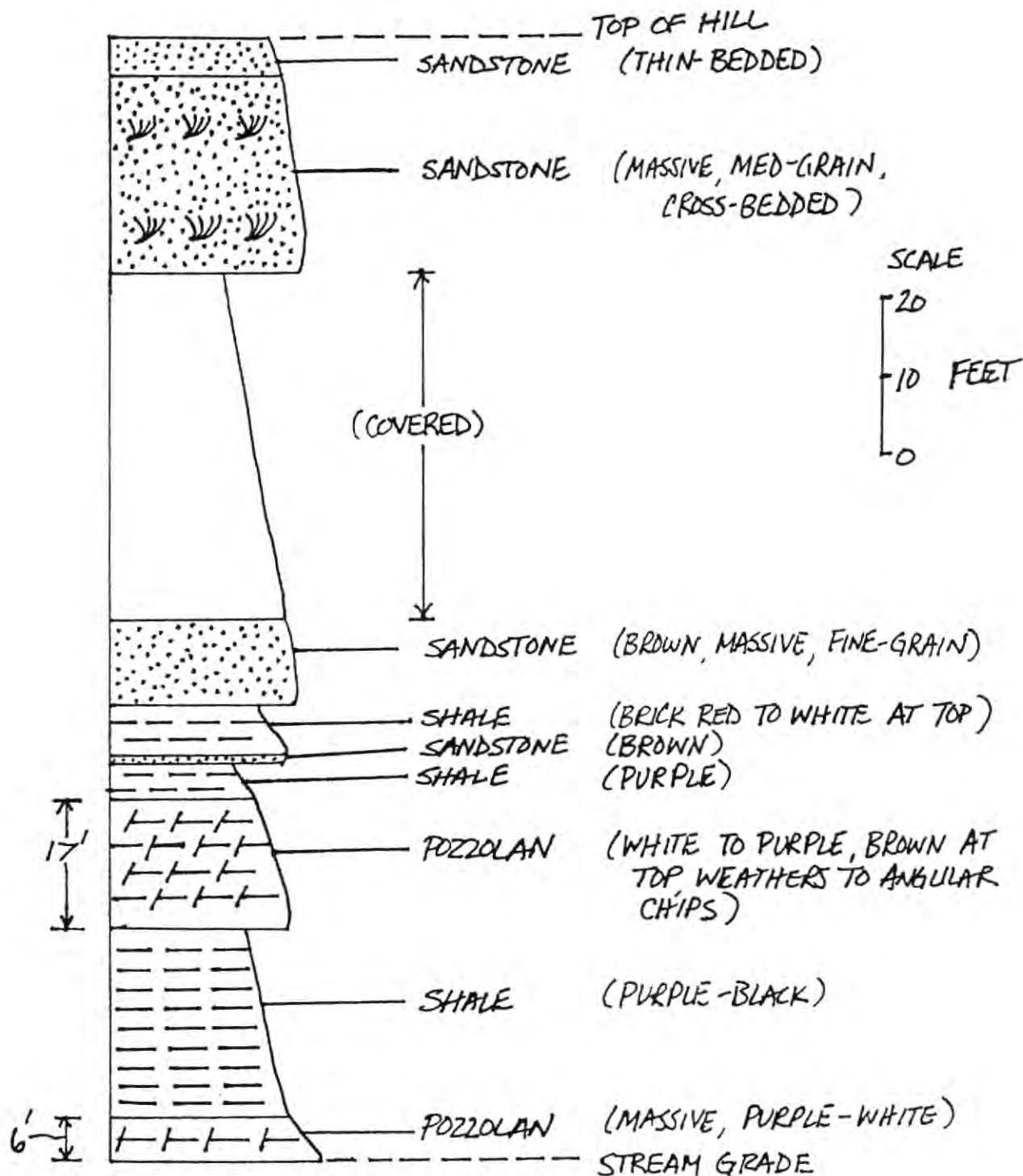




# 4 Hermosa NW

Figure 16.

Geologic cross-section of Site #4.



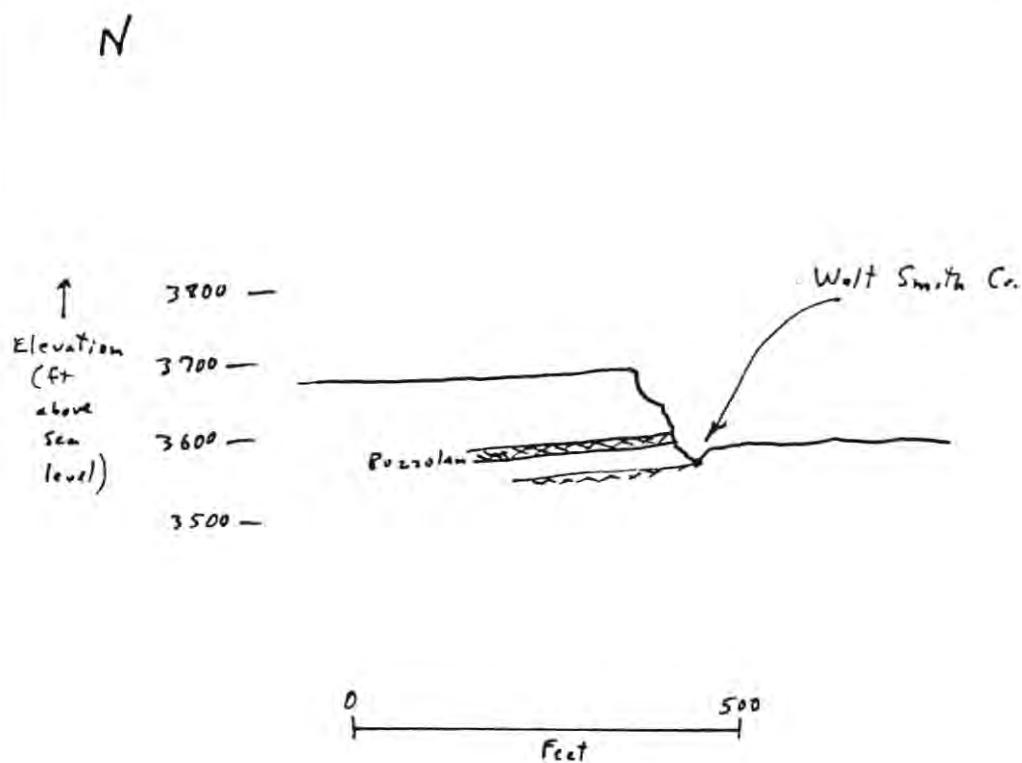
## #5 (HERMOSA NW)

Figure 17.

Measured section of Site #5.



22-141 50 SHEETS  
22-142 100 SHEETS  
22-144 200 SHEETS



# 5 Hermosa NW

Figure 18. Geologic cross-section of Site #5.

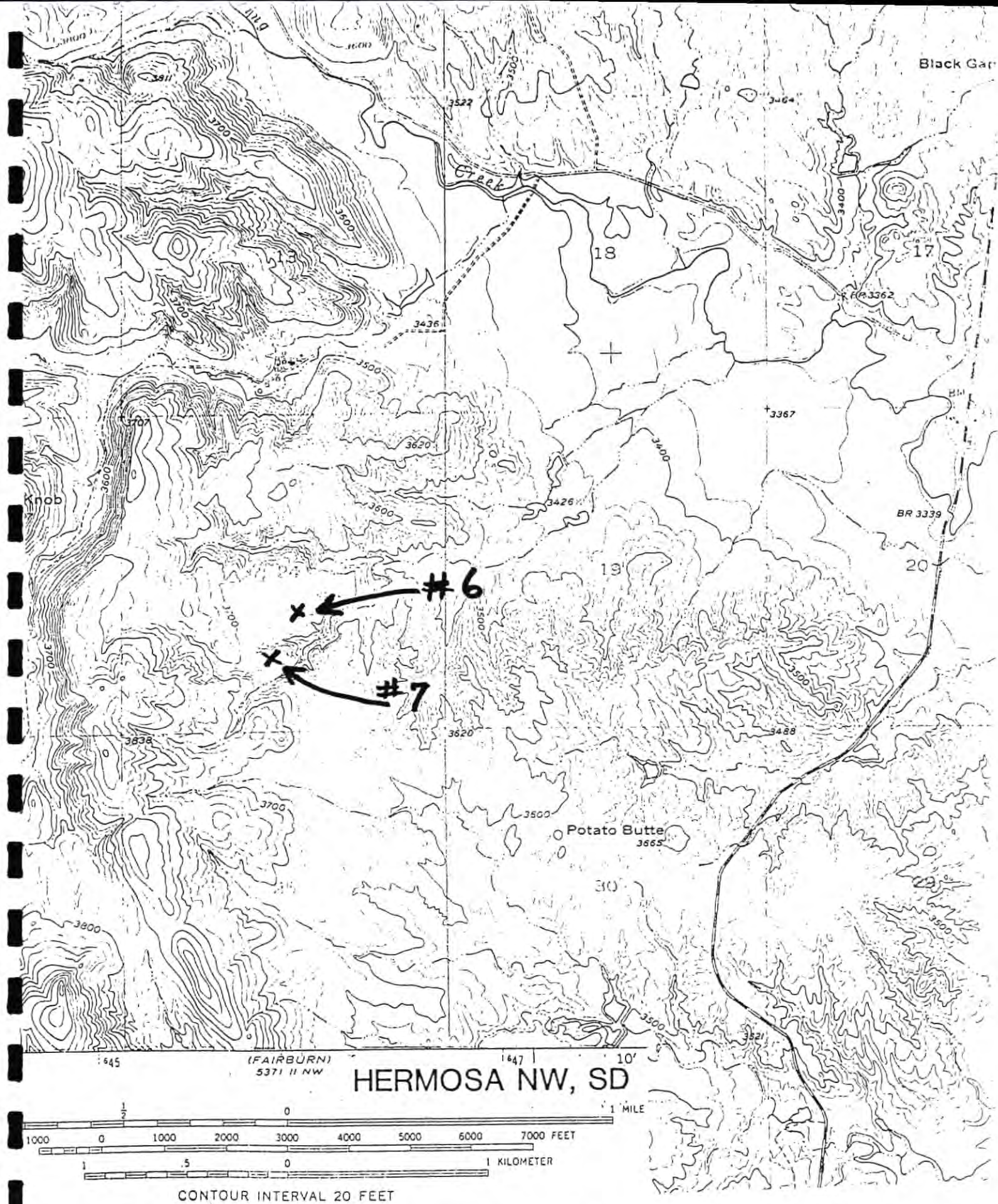
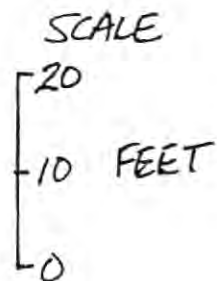
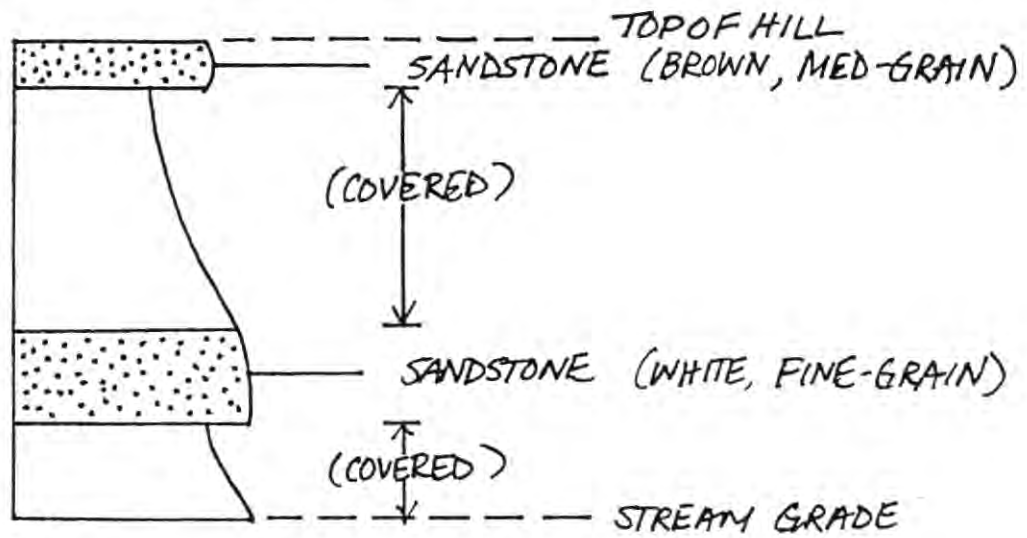


Figure 19.

Portion of the Hermosa NW 7 1/2' topographic map showing the location of Site #6 and #7.

WEST FACING NORTH (195°)

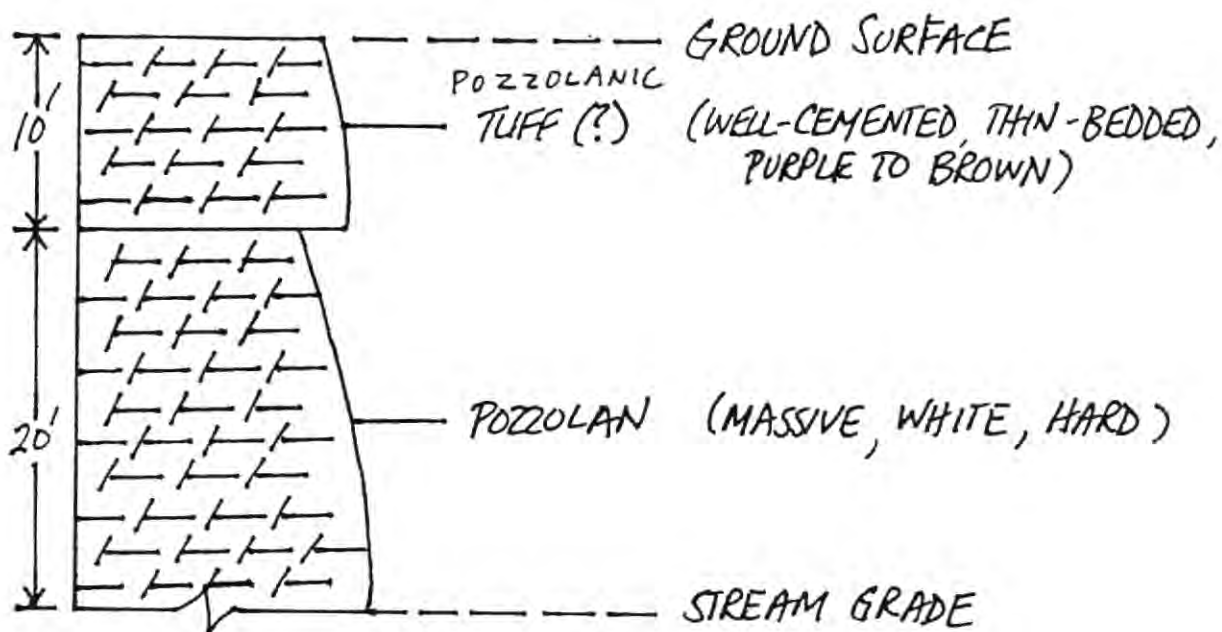


#6 (HERMOSA. NW)

Figure 20.

Measured section of Site #6.



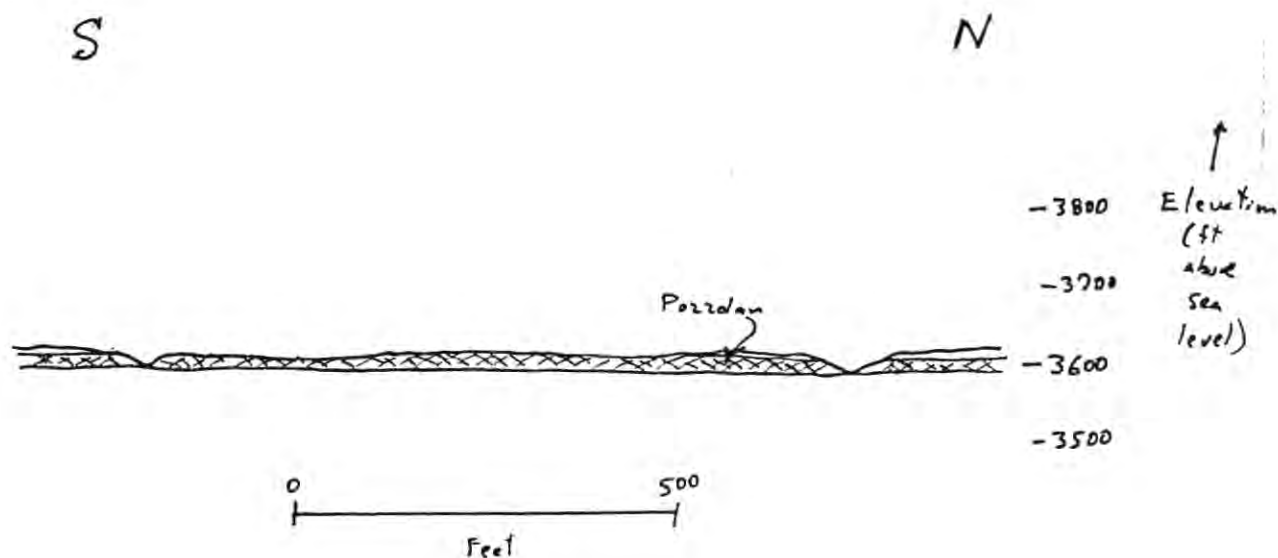


#7 (HERMOSA NW)

Figure 21.

Measured section of Site #7.

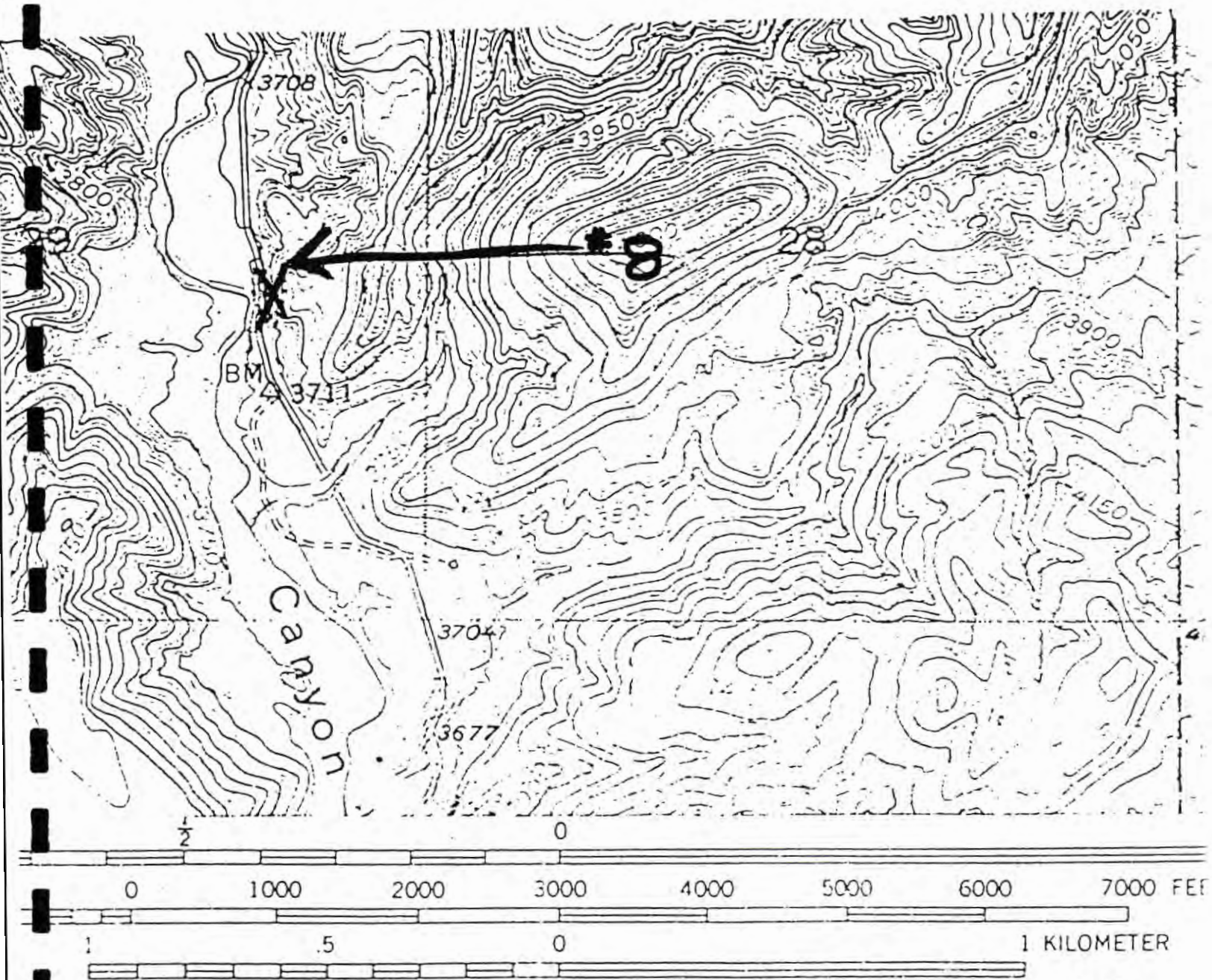
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22-144 200 SHEETS



#7 Hermosa NW

Figure 22. Geologic cross-section of Site #7.



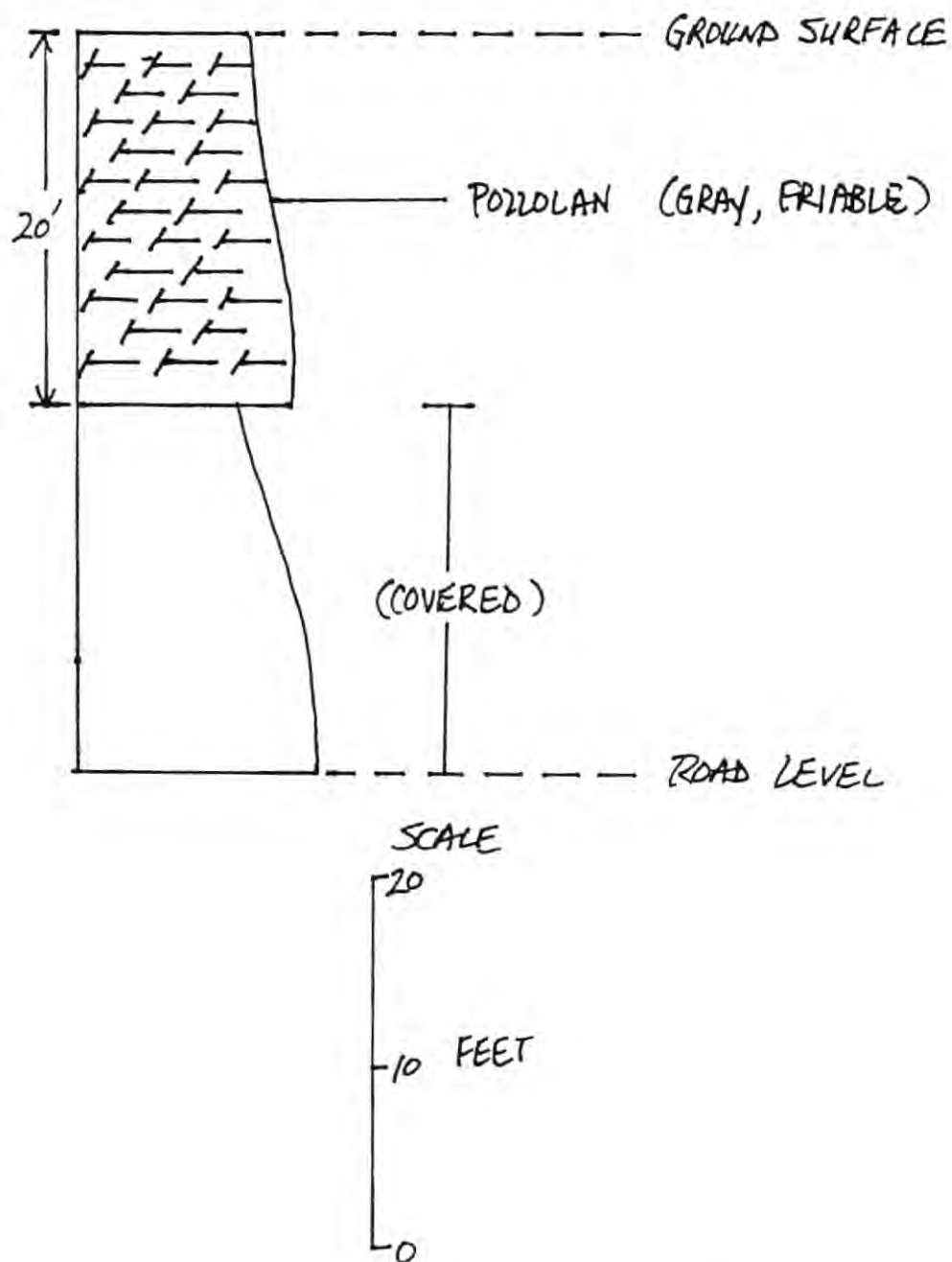


**EDGEMONT NW**

CONTOUR INTERVAL 10 FEET

Figure 23.

Portion of the Edgemont NW 7 1/2' quadrangle showing the location of Site #8.



#8 (EDGEMONT NW)

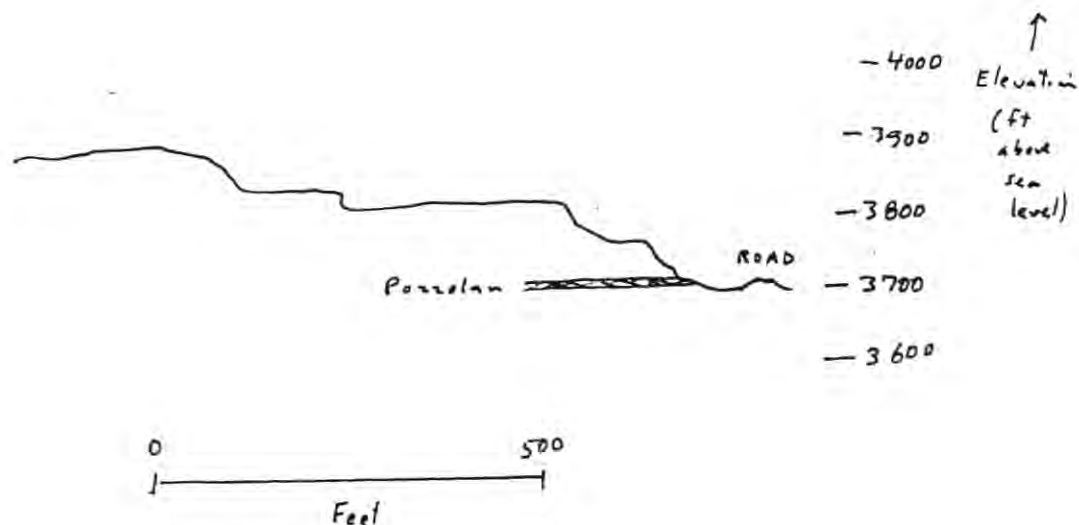
Figure 24.

Measured section of site #8.



E

W



#8 Edgemont NW

Figure 25.

Geologic cross-section of Site #8.

Table 1. Summary Table for mineat<sub>Y</sub> TABLE

Site No.	A Location (7 1/2' quadrangle)	Overburden/Thickness				F Distance to Cement Plant (miles)	Comments
		B Pozzolan thickness ft.	C Area necessary to mine 10 <sup>6</sup> tons pozzolan <sup>(1)</sup> (acres)	D Approx. Ave. overburden thickness on (C) area (ft)	E Ratio D/B		
#1	Sturgis	>20	(Total value of pozzolan is low)				
#2	Sturgis	10	28	100	10/1	30	
#3	Tilford	17 1/2	16	100	6/1	20	
LK-1	Rapid City E	40+	5.8	60	1.2/1	1	
LK-2	Rapid City E	~10	28	200	20/1	1	
#4	Hermosa NW	19	15	100	5.3/1	14	
#5	Hermosa NW	>23	12	80	3.5/1	13	
#6	Hermosa NW	0	(No pozzolan detected)				
#7	Hermosa NW	>30	9.4	15	0.5/1	10	Blasting may be necessary
#8	Edgemont NW	20	14	100	5/1	68	

(1) Assume density = 162 lbs/ft<sup>3</sup>