

SOURCE OF THE EVAN'S MOUND OBSIDIAN

by

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## ABSTRACT

Excavations of the Evan's Mound by the University of Utah Anthropology Department reveal that the site inhabitants frequently used obsidian to fashion projectile points and other tools. The nearest obsidian sources are 45 miles northwest and 55 miles west of the site. Samples from these two obsidian locations and 43 samples from the Evan's site were analyzed for Na, La, Sm, Rb, Sr, Zr, Ca, and Fe by a combination of instrumental neutron activation and X-ray fluorescence analytical techniques. Analytical results demonstrated that the two source areas were chemically distinct and that 38 of the 43 analyzed site samples were from the two sampled source areas. No stratigraphic bias of source material occurred in the mound, showing that both sources were used by the inhabitants throughout the occupational period of the site. Procurement of the obsidian can be correlated with hypothesized hunting habits of the occupants.

## INTRODUCTION

The University of California at Los Angeles, Southern Utah State College, and the University of Utah have intermittently excavated Evan's mound during the last two decades. These excavations have revealed that obsidian was a common knapping material at the site. During the 1970-1973 excavation seasons, 1489 chipped stone artifacts were recovered from the mound. Over 1100 of the artifacts are chert and chalcedony, while the remaining 370 are obsidian. Thus, obsidian constitutes one-fourth of the excavated chipped stone artifacts in an area where only chert and chalcedony are locally available.

"Persistent rumors and local legends placed the source somewhere near the town of Modena about 85 miles to the west on the Utah-Nevada border," (Weide, 1970). However, upon examination of local artifact collections, Weide located a source of obsidian in Wild Horse Canyon which is in the Mineral Mountains some 45 miles due north of the Evan's site. Based upon hand specimen and microscopic comparisons, he deduced that the obsidian at Wild Horse Canyon was identical to material collected at Parowan, Paragonah, and Evan's Mound.

The purpose of this study is to identify the source or sources of the site obsidian using modern analytical correlation techniques. The last decade has seen numerous advances in instrumental neutron activation analysis techniques, which have allowed obsidian artifacts to be chemi-

cally matched with their source (Cann and Renfrew, 1964; Parks and Tieh, 1966; Renfrew, 1966; Frison et al., 1968; Gordus et al., 1968; Wright et al., 1968; Griffin et al., 1969; Condie and Blaxland, 1970). By analyzing potential source area and site obsidians for selected elements, it should be possible to determine where the ancient inhabitants obtained obsidian.

#### THE EVANS SITE

The following description of the site is summarized from The Evans Site, a special report of the University of Utah Anthropology Department by Michael Berry, 1972. The Evans site is located in the Parowan Valley of southwestern Utah (Fig. 1). The valley is within the eastern edge of the Great Basin physiographic province. The Hurricane Cliffs, to the east, define the western rim of the Colorado Plateau, while the Black Mountains, Red Hills, and Gray Hills separate the valley from the Escalante Desert to the west.

Aboriginal-occupation of the valley was concentrated along three perennial streams which originate in the Piute Highlands above the Hurricane Cliffs. The Evans Mound is situated approximately two miles north of Summit, Utah, on an ancient channel of Summit Creek. The mound is approximately 300 feet long (SW-NE), and 160 feet wide (SE-NW), and rises a maximum of 7 feet above ground level.

The inhabitants of the site are classified under the Parowan variant of the Fremont culture (Marwitt, 1970).

The Parowan variant is divided into the Summit phase (early)



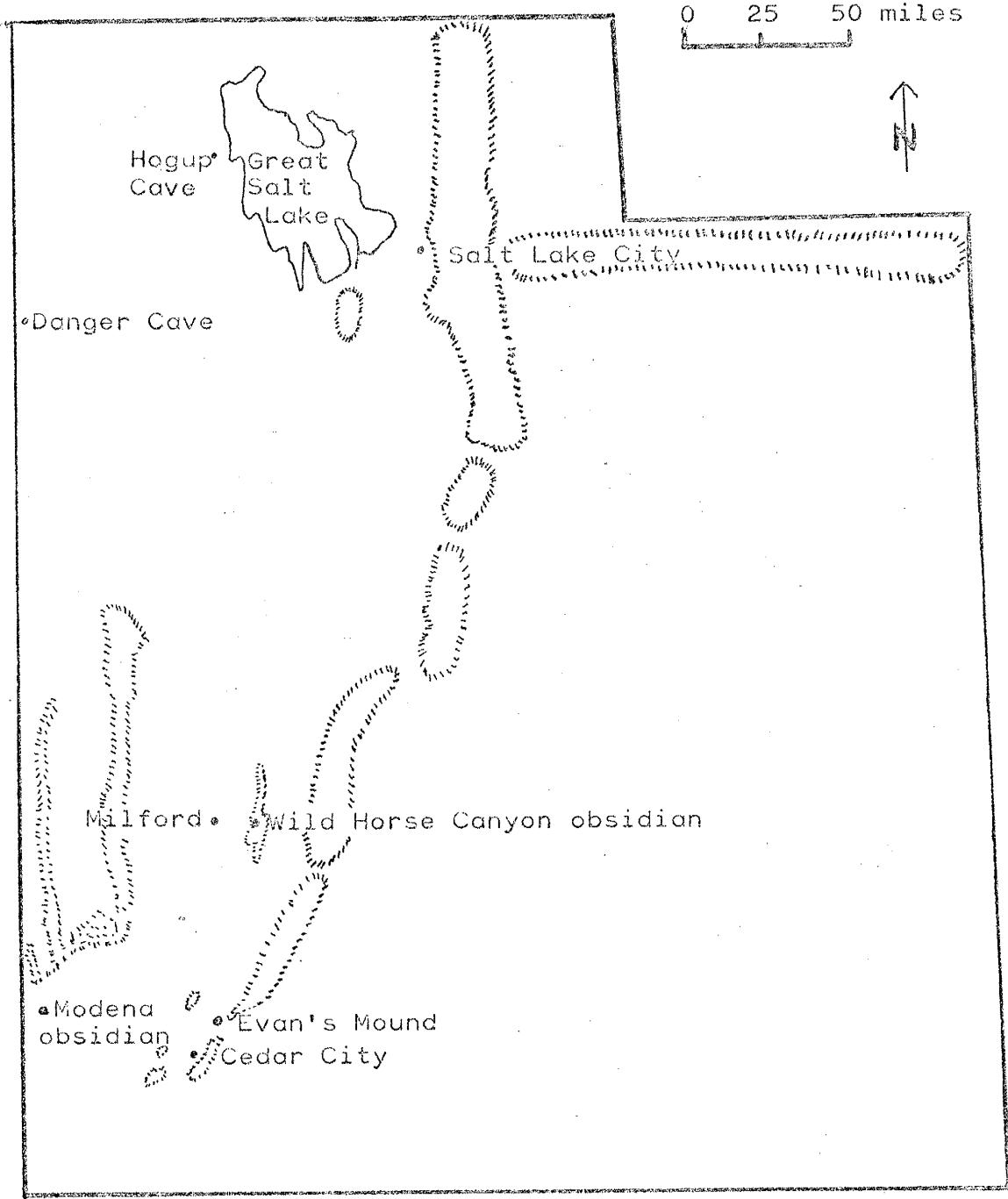


Figure 1 Map of Utah

and the Paragonah phase (late). Both phases are represented at the site.

The inhabitants of the site lived in simple pit-house dwellings. They were both farmers and hunters. Their agricultural practices were limited to raising corn and beans. Seed gathering was also an important part of their life. Mule deer, pronghorn antelope, mountain sheep, and rabbits accounted for nearly all of their meat supply.

Six radiocarbon dates, eleven archeomagnetic determinations, and the presence of intrusive pottery types brackets the occupational period of the site between approximately A.D. 1050 and A.D. 1150.

#### SOURCE AREAS

##### Modena

Abundant obsidian occurs around the town of Modena, Utah, 55 miles west of the Evans site on the Utah-Nevada border (Fig. 1). The boulder to gravel size nodules are often caliche coated and are found mixed with ancient river gravels. The source of these nodules is uncertain, but their large size and lack of weathering or transport features indicates they have not been transported far from their original source. Perhaps the original source has been eroded.

The area sampled is approximately one mile southeast of town where a dirt road cuts through a dry wash overlain by a basalt flow. About thirty nodules were selected at random and ten of these later were chosen for analysis. Abundant chippings and occasional broken tools indicate

the area's use as a quarry. The areal extent of the nodules is unknown but probably does not exceed several square miles in the vicinity of the town.

The obsidian is nonvesicular and has no macroscopic crystallites. Because it is a homogeneous glass it is excellent for knapping purposes. Large pieces are black, while smaller chips appear gray and are translucent to transparent. All degrees of fluidal banding occur in hand specimens. Some pieces are nearly transparent and clear, while other pieces are almost entirely banded and opaque.

Microscopically the glassy groundmass contains abundant globulite, margarite, and cumulite crystallites. Trichite crystallites are sparse. Minute tridymite and feldspar skeleton crystals also are present. Some of the tridymite crystals are in the form of wedge-shaped twins. Planar concentrations of the crystallites form the fluidal banding. Trace amounts of microscopic phenocrysts also occur. These consist of biotite, magnetite or ilmenite, and quartz. Many of the phenocrysts are partially resorbed and some are aligned parallel to the fluidal banding.

#### Wild Horse Canyon

Wild Horse Canyon is in the Mineral Mountains approximately 45 miles north of the Evans Site, and about 15 miles east of Milford, Utah (Fig. 1). The study by David Weide (1970) erroneously reports Ranch Canyon (directly south of Wild Horse Canyon) as the location of the obsidian. The Ranch Canyon obsidian is a black glass with numerous macro-

scopic crystallites. These crystallites render the obsidian unsuitable for knapping purposes.

Wild Horse Canyon has a series of three obsidian flows interbedded with tuff and highly weathered perlite. The flows are five to fifteen feet thick and the sequence is capped by a vesicular rhyolite flow. The obsidians are black with varying degrees of fluidal banding. Small chips are translucent to transparent. Small amounts of a reddish-brown and a red-black breccia-type glass also occur. The latter type appears to have formed in fractured or shrinkage zones in the flow in which the iron was oxidized and the glass later welded. The front of the flow is an immense talus pile of worked and unworked obsidian fragments. Chipping flakes and unfinished artifacts litter the surrounding area for over a mile from the canyon.

Microscopically the glassy groundmass contains numerous globulite, cumulite, and longulite crystallites. Planar concentrations of these crystallites form the fluidal banding present in many of the obsidians. In hand specimen, some of the glass appears milky or cloudy, which is caused by randomly oriented concentrations of the microscopic crystallites.

Microphenocrysts compose up to one per cent of the obsidian. These include rounded quartz phenocrysts with undulatory extinction, enstatite or hypersthene, and tridymite, the latter which often occurs as wedge-shaped twins. Minute feldspar phenocrysts may also be present.

The flows were sampled in a vertical section and other samples were chosen to represent the wide range of colors and flow textures which occur. Of the 22 samples collected, 11 were selected for chemical analysis.

#### SAMPLE SELECTION AND PREPARATION

##### Site Samples

The Evans site samples were selected from excavated material classified as unfinished thin bifaces, miscellaneous worked fragments, and chipping waste. No finished artifacts such as knives, drills, or points were tested since they would have been destroyed by preparation for analysis. Samples were chosen to obtain as complete a stratigraphic representation from the site as possible. Table 1 lists the position of the samples in the mound with reference to Fig. 2, the composite profile of the mound. The table also indicates whether the samples are from the Paragonah or Summit phases. The 43 samples selected for analysis exhibited a wide range of color combinations and fluidal banding.

To prepare the samples for analysis, they were first cleaned with acetone to remove the india ink field specimen numbers. They were then reduced to a fine powder by grinding them sequentially in a ceramic-plated jaw crusher, a ceramic-plated rotary grinder, and in a Fisher mortar grinder with an agate mortar and pestle. For X-ray fluorescence analysis, a 6:1 rock powder to bakelite mixture (usually three grams rock powder to one-half gram bakelite) was homogenized in a

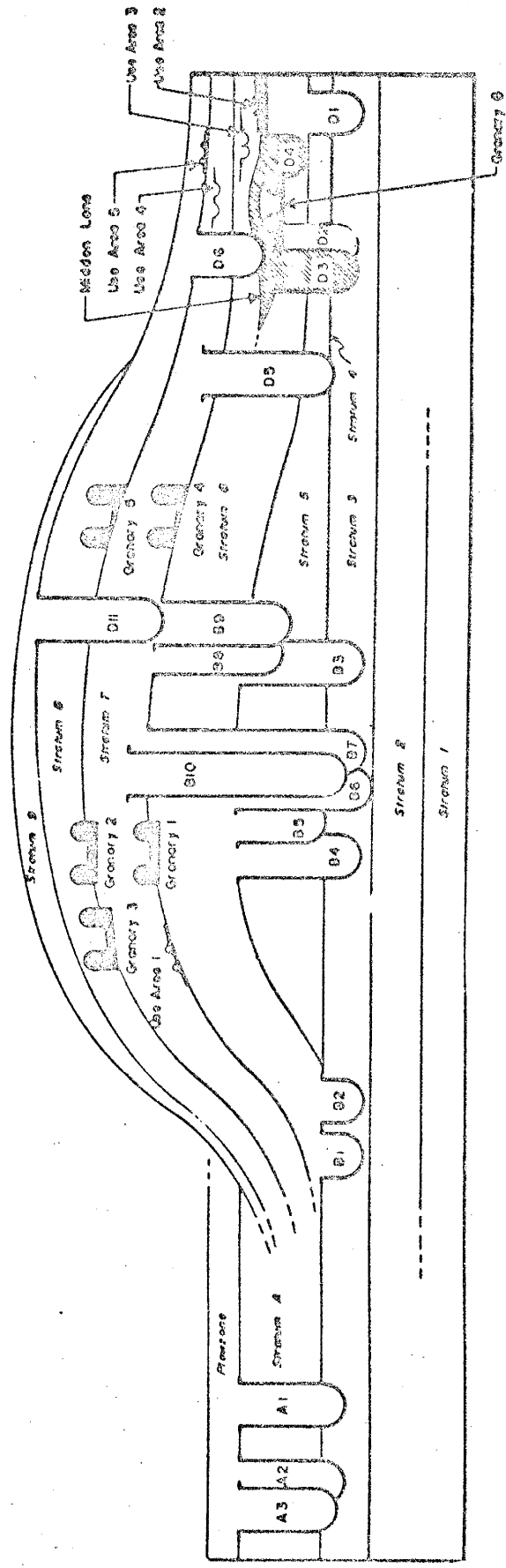


Figure 2

Composite profile of the Evans Mound. Reproduced from The Evans Site by Michael Berry, 1972.

TABLE 1

EVANS SITE SAMPLES

Analytical Number	F.S. <sup>1</sup> Number	Site Area <sup>2</sup> -Phase	Stratigraphic <sup>3</sup> Level
E01	1016-5	A-P	A3
E02	1019-137	A-P	A3
E03	902-4	A-P	A2
E04	976-7	A-P	A1
E05	976-9	A-P	A1
E06	947-18	A-P	A1
E07	985-6	B-S	B1
E08	955-1	B-S	B1
E09	372-29	B-P	9
E10	859-354	B-P	8/9 <sup>4</sup>
E11	658-26	B-P	8/9
E12	272-46	B-P	8/9
E13	319-40	B-P	8
E14	326-81	B-P	8
E15	319-44	B-P	8
E16	382-23	B-P	7
E17	547-25	B-P	7
E18	339-46	B-P	7
E19	441-18	B-S	6
E20	570-37	B-S	B4
E21	435-42	B-S	B5
E22	421-34	B-S	B5
E23	508-46	B-S	B6
E24	493-103	B-S	B6
E25	647-59	B-S	B7
E26	640-22	B-S	B3
E27	768-5	B-S	B8
E28	787-50	B-S	B8
E29	746-80	B-S	B9
E30	746-83	B-S	B9
E31	298-45	D-P	8/9

<sup>1</sup>All field specimen numbers are prefixed by 42IN40.

<sup>2</sup>P denotes sample from Paragonah phase, S from Summit phase.

<sup>3</sup>Numbers prefixed by letters indicate specific pit-house structures.

<sup>4</sup>8/9 denotes that strata 8 and 9 were indistinguishable.

TABLE 1 continued

Analytical Number	F.S. Number	Site Area -Phase	Stratigraphic Level
E32	669-89	D-P	7
E33	829-128	D-P	7
E34	890-132	D-P	7
E35	911-30	D-P	7
E36	757-58	D-S	6
E37	901-74	D-S	5
E38	807-71	D-S	5
E39	857-71	D-S	5
E40	644-69	D-S	D2
E41	645-29	D-S	D2
E42	559-70	D-S	D2
E43	644-70	D-S	D2

Spex ball mixer. The mixture was then poured into an aluminum Spex cap and pelletized under  $10,000 \text{ kg/cm}^2$  pressure in a heated steel jacket. The result is a very durable pellet which will last indefinitely.

For instrumental neutron activation analysis, a  $0.5000 \pm 0.0200$  gram sample was weighed out in a small polyethylene vial. The sample weight was recorded and the vial sealed with a soldering gun.

#### Source Samples

Quarry samples were carefully chipped to remove any caliche coating or weathered material. They were then broken into smaller pieces using a sledgehammer and a steel plate. After further size reduction in a large jaw crusher with steel plates, they were prepared in the same way as the site samples. All the samples were prepared in a consistent manner under similar conditions.



## ANALYTICAL PROCEDURE

Previous studies of other obsidian flows have shown that some elements have comparatively small intraflow variations and large interflow variations, which makes them prime candidates for correlation purposes (Renfrew, 1966; Gordus et al., 1968). Gordus et al. (1968) analyzed over 1000 obsidian samples from 60 flows and found that Mn, La, Sm, and Sc were ideal elements for characterizing obsidians. From their data Na and Rb also appeared to be significant elements for correlation purposes. Renfrew et al. (1966) studied obsidians from the Near East and found that Zr and Ba were useful elements. Other works have shown that obsidians do not have a wide range in major element content and usually these elements are not useful for correlation studies. In view of these findings Mn, La, Sm, Sc, Na, Rb, Ba, and Zr were considered for analysis. The final selection of elements was limited by the analytical equipment available at New Mexico Tech. It was necessary that large numbers of samples could be analyzed quickly and accurately, therefore La, Sm, Na, Zr, and Rb were initially chosen. Strontium was added to these because it is easily and accurately analyzed with Rb. If these elements failed to provide adequate correlation data, more elements could be analyzed for subsequently. An opportunity also arose to analyze the source samples for the major elements. This revealed that Ca and Fe concentrations were quite distinct for each source area, so the site samples were also analyzed for Ca and Fe. Of

the eight elements for which all samples were analyzed, Sm, Sr, Fe and Ca concentrations were significantly different for each source area, while Rb overlap was minimal. Lanthanum, Zr, and Na concentrations showed considerable overlap between the two source areas.

Sodium, La, and Sm concentrations were determined using a Canberra GeLi crystal by instrumental neutron activation techniques. For the sodium determination, samples were irradiated for five minutes at 30 kilowatts in the reactor core at Sandia Laboratories in Albuquerque, New Mexico. Samples were counted within two days after irradiation. Each sample was counted for 200 seconds employing the  $^{24}\text{Na}$  gamma-ray peak. The USGS standard G2 and a standard obsidian O-16 (Gordon, 1968) were included to compute Na concentration from specific activity. Lanthanum and Sm determinations were made by irradiating the samples 30 minutes at 300 kilowatts. Only 25 samples could be irradiated at one time. Irradiated samples were counted for 4000 seconds each using the  $^{140}\text{La}$  and  $^{153}\text{Sm}$  gamma-ray peaks. Sample concentrations were calculated relative to G2 and O-16 element concentrations.

Silica, Ti, Al, Mg, K, Ca, Fe, Zr, Sr, and Rb were determined using a Norelco X-ray fluorescence unit. The major element concentrations were calculated from a plot of concentrations versus counts/second. The curve on the plot was fitted by a computer program using analytical data from the rock standards listed in Table 2. Rubidium, Sr, and Zr concentrations were calculated relative to the standards G2 and O-16. The mass absorption coefficients of the samples were

TABLE 2

## ROCK STANDARD VALUES USED TO CALCULATE SAMPLE CONCENTRATIONS

Element	G2	GSP	GH	O-16	JG	GA	AGV
SiO <sub>2</sub>	69.11	67.38	75.80	74.05	72.24	69.90	58.99
TiO <sub>2</sub>	0.50	0.66	0.08	0.26	0.26	0.38	1.04
Al <sub>2</sub> O <sub>3</sub>	15.40	15.25	12.50	13.74	14.21	14.50	17.25
Fe <sub>2</sub> O <sub>3</sub>	2.65	4.33	1.34	1.54	2.21	2.83	6.76
MgO	0.76	0.96	0.03	0.02	0.73	0.95	1.53
CaO	1.94	2.02	0.69	0.62	2.18	2.45	4.90
Na <sub>2</sub> O	4.07	2.80	3.85	4.02	3.39	3.55	4.26
K <sub>2</sub> O	4.51	5.53	4.76	4.89	3.96	4.03	2.89
Rb	168	254	390	109	186	175	67
Sr	479	233	10	23	184	305	657
Zr	300	500	160	225	160	140	225
La	90	180	25	40	25	36	35
Sm	7.3	27.0		6.2	4.6		6.0

Note: Major elements are listed in weight %, trace elements in ppm.

determined from standards with known mass absorption coefficients (Reynolds, 1963). For more detailed information on analytical procedures see Condie, 1967; Condie et al., 1970; Condie and Lo, 1971; Condie and Barsky, 1972; and Barsky and Condie, 1975.

## ANALYTICAL RESULTS

Tables 3 and 4 list the major and trace element data for the source and site samples. The results have an associated analytical error of approximately  $\pm 5\%$  (Condie and Blaxland, 1970). Table 2 lists the element concentrations of the standards used in the analyses.

TABLE 3

## MAJOR ELEMENT DATA FOR SOURCE AREAS

Sample Number	SiO <sub>2</sub>	TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Total Fe <sub>2</sub> O <sub>3</sub>	CaO	Na <sub>2</sub> O	K <sub>2</sub> O
MODENA SAMPLES							
M01	74.99	0.13	14.99	0.68	0.62	3.17	4.88
M02	76.57	0.12	13.54	0.70	0.63	3.16	4.75
M03	75.96	0.14	14.12	0.69	0.64	3.31	4.62
M04	75.77	0.13	14.26	0.71	0.65	3.18	4.77
M05	75.89	0.13	14.13	0.74	0.65	3.25	4.69
M06	76.95	0.13	12.88	0.72	0.63	3.38	4.78
M07	74.67	0.14	15.45	0.71	0.63	3.23	4.63
M08	75.01	0.14	15.17	0.68	0.59	3.23	4.64
M09	77.58	0.13	12.30	0.70	0.63	3.37	4.77
M10	76.84	0.13	13.19	0.71	0.62	3.31	4.67
mean	76.02	0.13	14.00	0.70	0.63	3.26	4.72
WILD HORSE CANYON SAMPLES							
WH03	78.39	0.15	11.73	0.54	0.48	3.52	4.66
WH04	76.35	0.15	14.02	0.51	0.47	3.47	4.50
WH08	77.31	0.14	12.91	0.52	0.47	3.57	4.54
WH09	75.41	0.13	15.08	0.52	0.48	3.42	4.44
WH11	76.80	0.13	13.54	0.52	0.48	3.51	4.51
WH12	77.51	0.14	12.69	0.52	0.49	3.52	4.60
WH14	78.30	0.14	11.88	0.53	0.50	3.47	4.64
WH17	78.69	0.15	11.42	0.53	0.49	3.49	4.70
WH18	75.54	0.13	15.19	0.50	0.48	3.09	4.55
WH19	79.20	0.14	10.88	0.55	0.49	3.50	4.70
WH20	78.29	0.14	11.79	0.54	0.49	3.62	4.59
mean	77.44	0.14	12.83	0.53	0.48	3.47	4.58

Note: Data is corrected to total 99.50 wt.%. All MgO values were below the detectibility limit of 0.03%.

TABLE 4

## EVANS SITE AND SOURCE AREA SAMPLE CONCENTRATIONS

Sample No.	La ppm.	Sm ppm.	Rb ppm.	Sr ppm.	Zr ppm.	Na <sub>2</sub> O wt.%	Fe <sub>2</sub> O <sub>3</sub> wt.%	CaO wt.%
Modena Samples								
M01	52	6.0	177	69	65	3.15	0.68	0.62
M02	48	5.7	173	67	62	3.15	0.70	0.63
M03	52	5.6	173	68	67	3.33	0.69	0.64
M04	55	6.0	173	66	42	3.14	0.71	0.65
M05	46	5.8	173	66	80	3.23	0.74	0.65
M06	56	6.0	174	71	82	3.37	0.72	0.63
M07	62	6.1	175	70	85	3.25	0.71	0.63
M08	49	5.7	175	71	85	3.28	0.68	0.59
M09	59	6.0	175	71	86	3.37	0.71	0.63
M10	59	6.1	170	68	77	3.31	0.70	0.62
Wild Horse Canyon Samples								
WH03	57	3.9	157	32	70	3.50	0.54	0.48
WH04	59	3.8	163	34	80	3.57	0.51	0.47
WH08	54	3.8	163	32	82	3.60	0.52	0.47
WH09	53	3.8	165	34	97	3.52	0.52	0.48
WH11	48	3.8	162	32	86	3.56	0.52	0.48
WH12	53	3.8	162	33	82	3.51	0.52	0.49
WH14	59	4.0	164	36	75	3.40	0.53	0.50
WH17	54	3.7	164	33	71	3.44	0.53	0.49
WH18	50	3.7	165	35	79	3.21	0.50	0.48
WH19	56	3.8	167	33	68	3.46	0.55	0.49
WH20	48	3.9	164	35	76	3.59	0.54	0.49
Evans Site Samples								
E01	45	3.8				3.42		
E02	59	6.7				3.67		
E03	46	3.8	163	32	76	3.45	0.54	0.51
E04	48	5.6				3.35		
E05	46	4.0				3.38		
E06	47	5.8	172	68	94	3.14	0.70	0.63
E07	46	3.8	169	33	77	3.56	0.57	0.52
E08	56	5.8	170	71	94	3.26	0.72	0.65
E09	42	3.5	162	31	83	3.45	0.57	0.52

\*Blank spaces indicate that not enough sample was available for X-ray fluorescence analysis.

TABLE 4 continued

Sample No.	La ppm.	Sm ppm.	Rb ppm.	Sr ppm.	Zr ppm.	Na <sub>2</sub> O wt.%	Fe <sub>2</sub> O <sub>3</sub> wt.%	CaO wt.%
E10	39	3.6	164	30	87	3.42	0.53	0.52
E11	43	3.5	165	31	84	3.53	0.54	0.53
E12	49	3.6	163	29	86	3.55	0.54	0.52
E13	44	3.4	161	29	85	3.38	0.55	0.52
E14	37	3.5	157	29	89	3.46	0.55	0.52
E15	43	5.1	171	62	101	3.16	0.70	0.64
E16	46	3.7	166	38	83	3.24	0.54	0.52
E17	41	3.4	167	35	86	3.37	0.53	0.52
E18	38	3.4	164	33	83	3.33	0.53	0.52
E19	39	3.3	171	36	82	3.32	0.57	0.52
E20	11	5.7	220	4	70	3.72	0.67	0.67
E21	45	3.6				3.44		
E22	48	4.9	154	50	112	3.32	0.62	0.53
E23	52	5.8	173	68	108	3.33	0.72	0.63
E24	41	3.6	162	32	95	3.46	0.55	0.50
E25	41	3.6	162	32	91	3.46	0.55	0.52
E26	76	8.9	130	111	272	3.91	0.64	0.73
E27	45	3.6	167	31	79	3.19	0.55	0.52
E28	50	3.8	166	29	89	3.46	0.55	0.51
E29	51	5.4	139	50	136	3.39	0.91	0.57
E30	51	5.9	170	64	89	3.20	0.72	0.65
E31	44	3.6	166	31	81	3.29	0.55	0.52
E32	53	3.8	162	29	66	3.37	0.54	0.52
E33	51	5.7	178	69	99	3.09	0.70	0.63
E34	49	3.8	169	30	95	3.34	0.55	0.51
E35	45	3.9	169	34	83	3.36	0.54	0.51
E36	44	3.6	169	30	90	3.36	0.55	0.52
E37	52	5.8	178	68	95	3.17	0.70	0.63
E38	48	5.8				3.29		
E39	56	5.8	177	68	90	3.33	0.70	0.61
E40	43	3.8	163	29	72	3.30	0.55	0.51
E41	52	4.0	164	30	86	3.34	0.54	0.51
E42	55	6.0	171	65	102	3.19	0.71	0.62
E43	43	3.6	160	32	88	3.36	0.55	0.50

TABLE 5

MEAN AND RANGE OF ELEMENT VALUES FOR SOURCE AND SITE SAMPLES

Element	Modena Source Samples	Site Samples From Modena <sup>1</sup>	Wild Horse Source Samples	Site Samples From Wild Horse <sup>2</sup>
La ppm.				
Mean	54	51	54	44
Range	46-62	43-56	48-59	37-53
Sm ppm.				
Mean	5.9	5.7	3.8	3.7
Range	5.6-6.1	5.1-6.0	3.7-4.0	3.4-4.0
Rb ppm.				
Mean	174	175	163	165
Range	170-175	170-178	157-167	157-171
Sr ppm.				
Mean	69	67	34	31
Range	66-71	62-71	32-36	29-38
Zr ppm.				
Mean	73	96	79	84
Range	42-86	89-108	68-97	66-95
Na <sub>2</sub> O wt. %				
Mean	3.26	3.23	3.47	3.39
Range	3.14-3.37	3.14-3.35	3.21-3.60	3.19-3.56
Fe <sub>2</sub> O <sub>3</sub> wt. %				
Mean	0.70	0.71	0.53	0.55
Range	0.68-0.74	0.70-0.72	0.50-0.55	0.53-0.57
CaO wt. %				
Mean	0.63	0.63	0.48	0.52
Range	0.59-0.65	0.61-0.65	0.47-0.50	0.51-0.53

<sup>1</sup> Includes samples E: 4, 6, 8, 15, 23, 30, 33, 37, 38, 39, 42.

<sup>2</sup> Includes samples E: 1, 3, 5, 7, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 21, 24, 25, 27, 28, 31, 32, 34, 35, 36, 40, 41, 43.

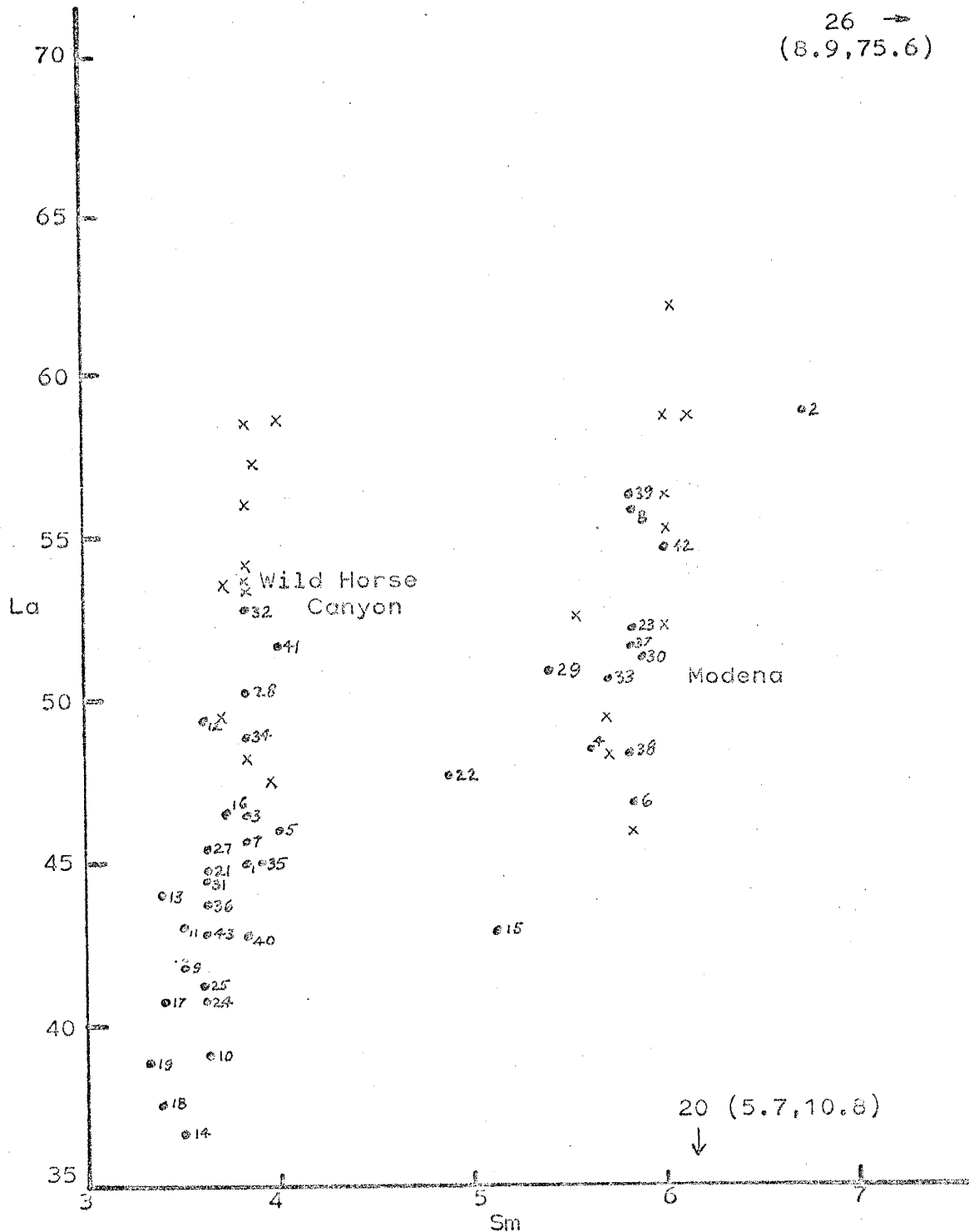


Figure 3

La (ppm) versus Sm (ppm) in site samples (numbered dots) and source samples (x's)



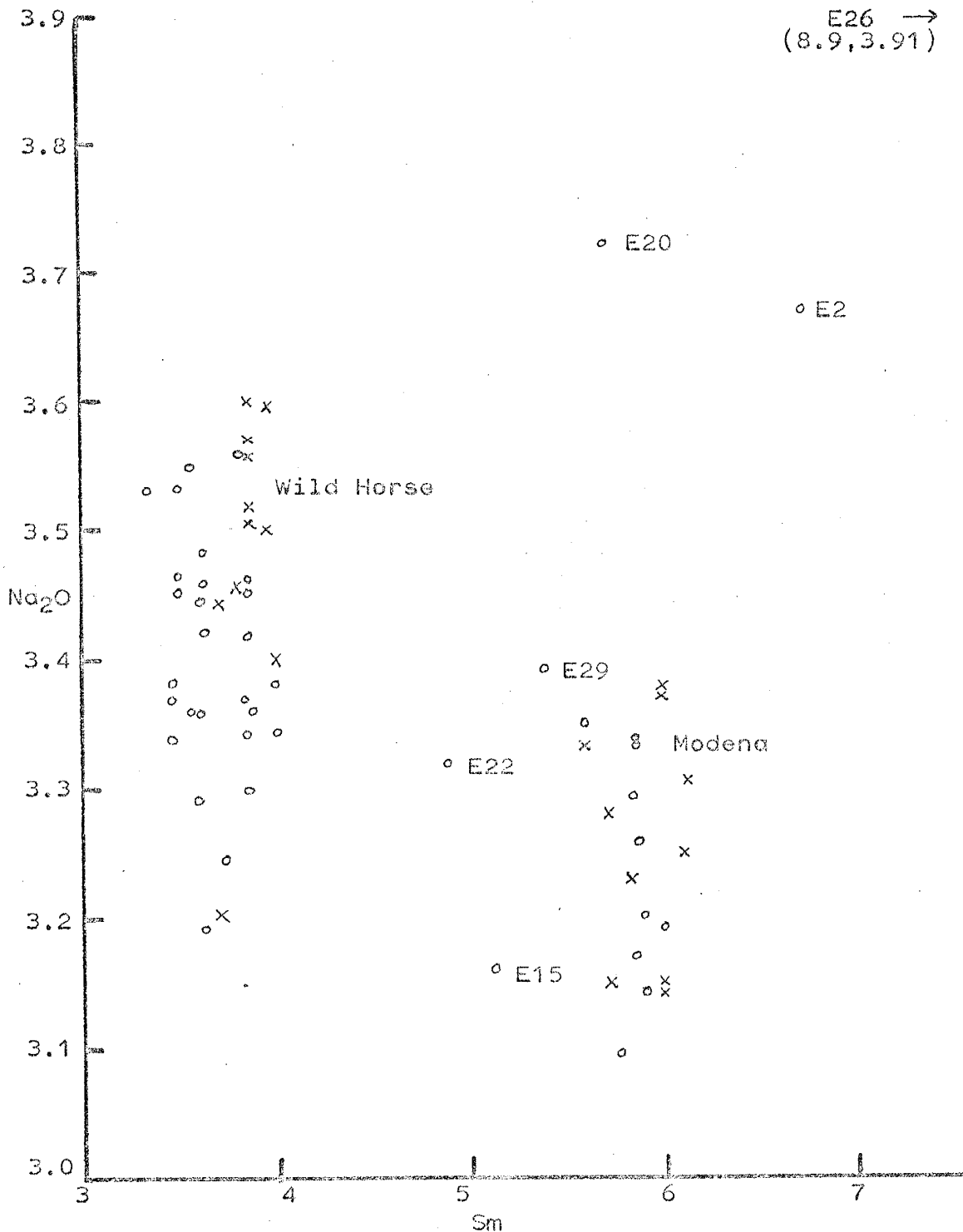


Figure 4

Na<sub>2</sub>O (wt.%) versus Sm (ppm) in site samples (circles) and source samples (x's)

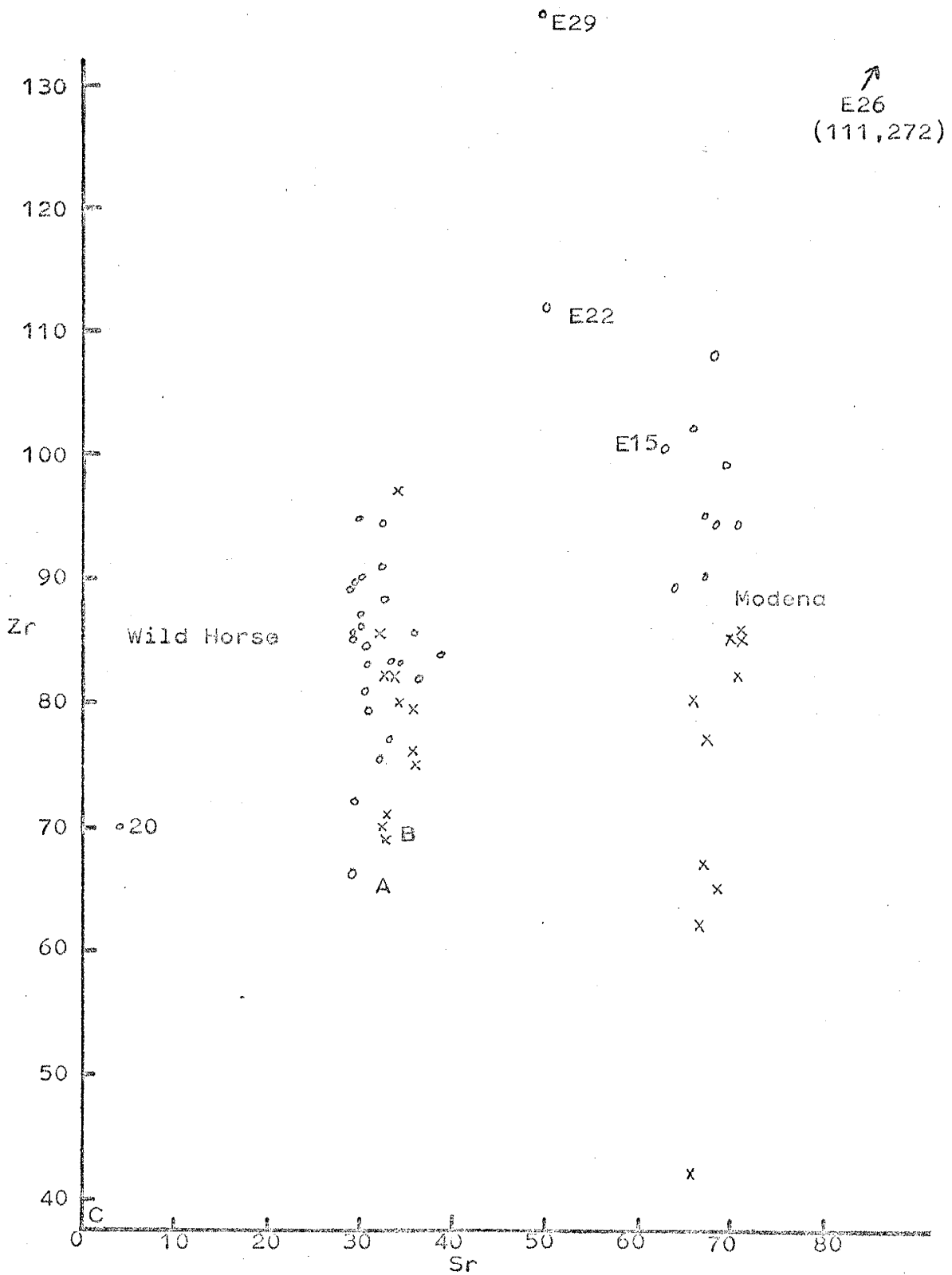


Figure 5

Zr (ppm) versus Sr (ppm) in site samples (circles) and source samples (x's). Samples A, B, and C (near origin) were analyzed by Condie and Blaxland (1970). See text, p. 25.

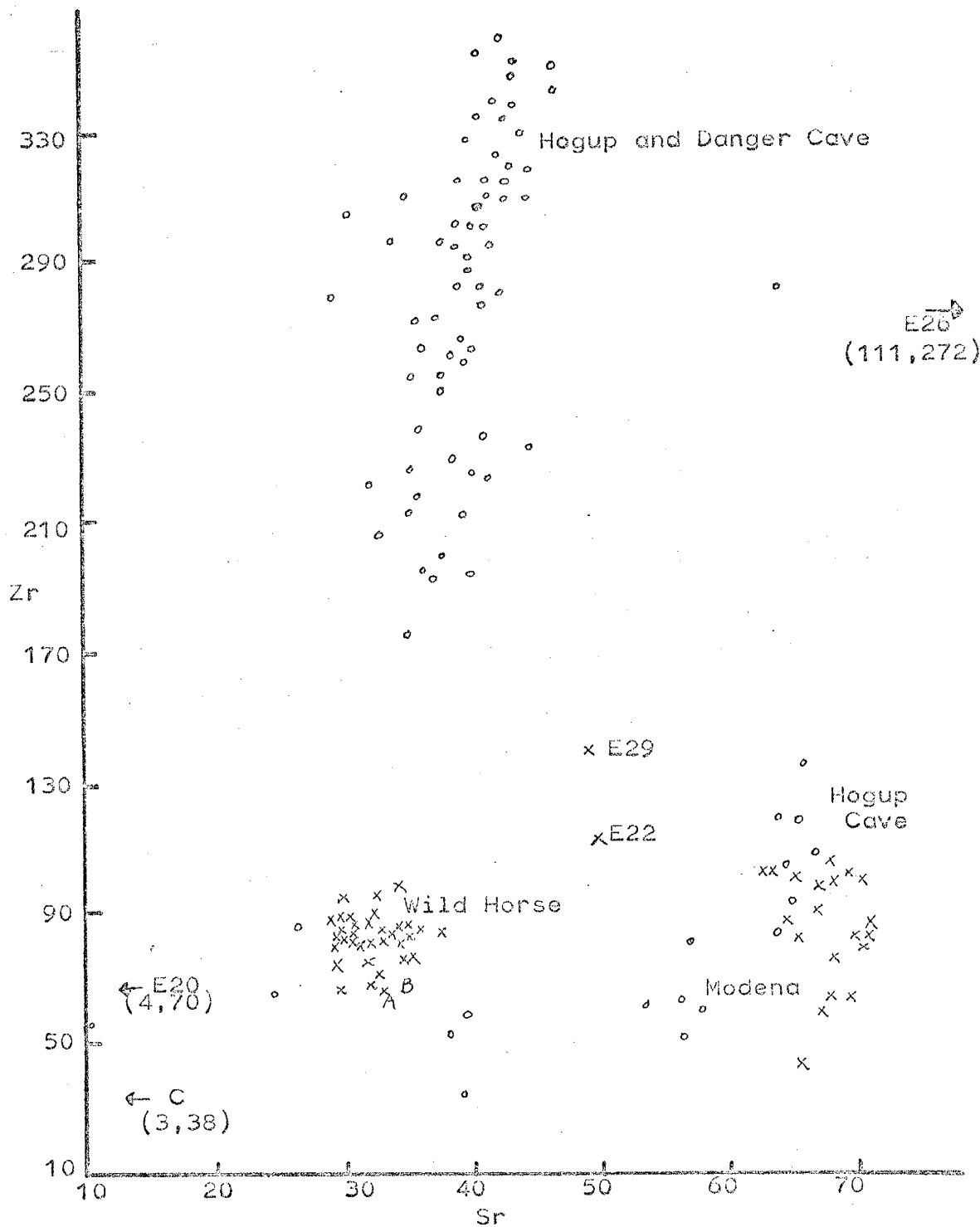


Figure 6

Zr (ppm) versus Sr (ppm) in Hogup and Danger Cave samples (circles) and in Evans Site samples (x's)

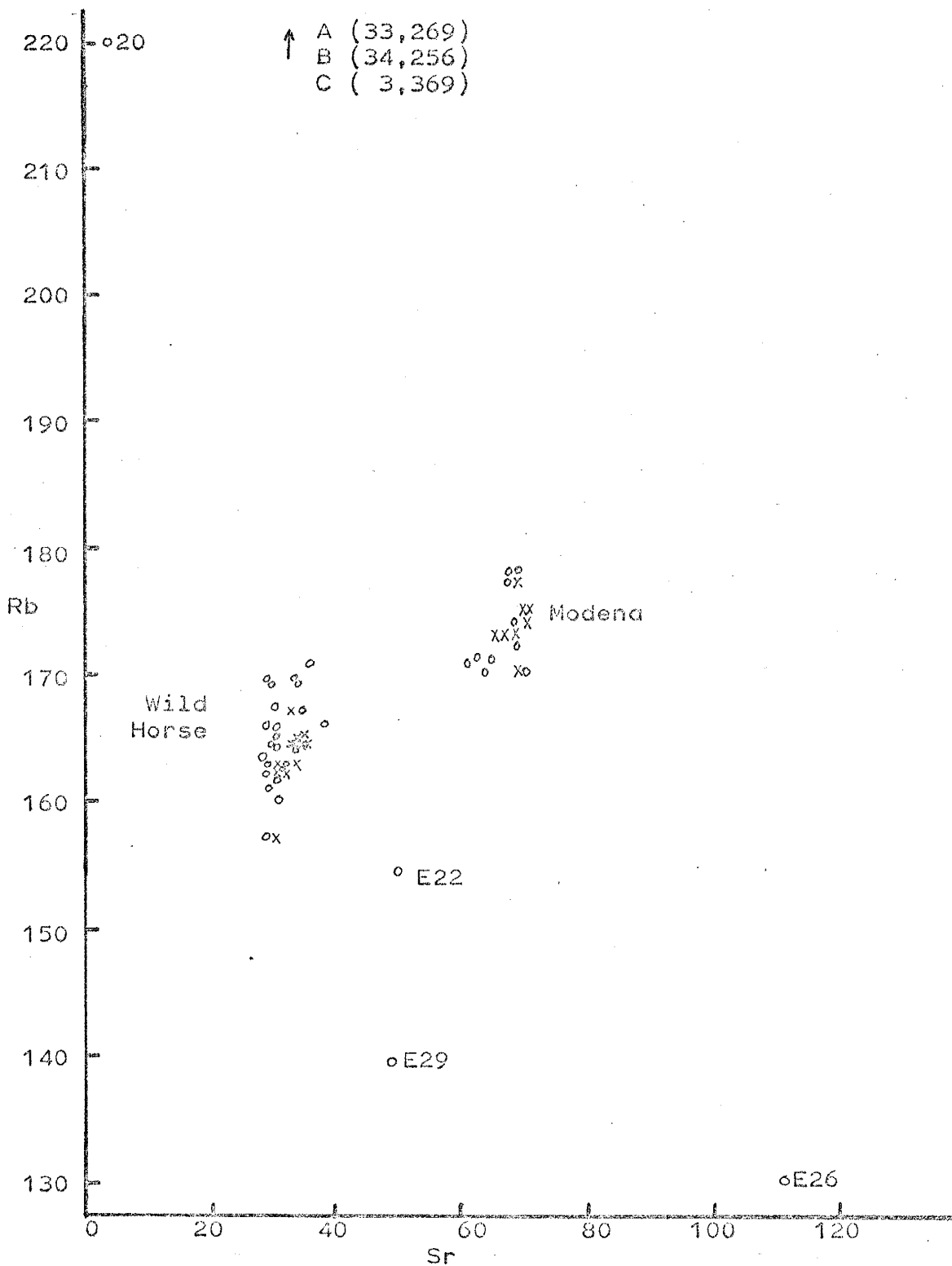


Figure 7

Rb (ppm) versus Sr (ppm) in site samples (circles) and source samples (x's)

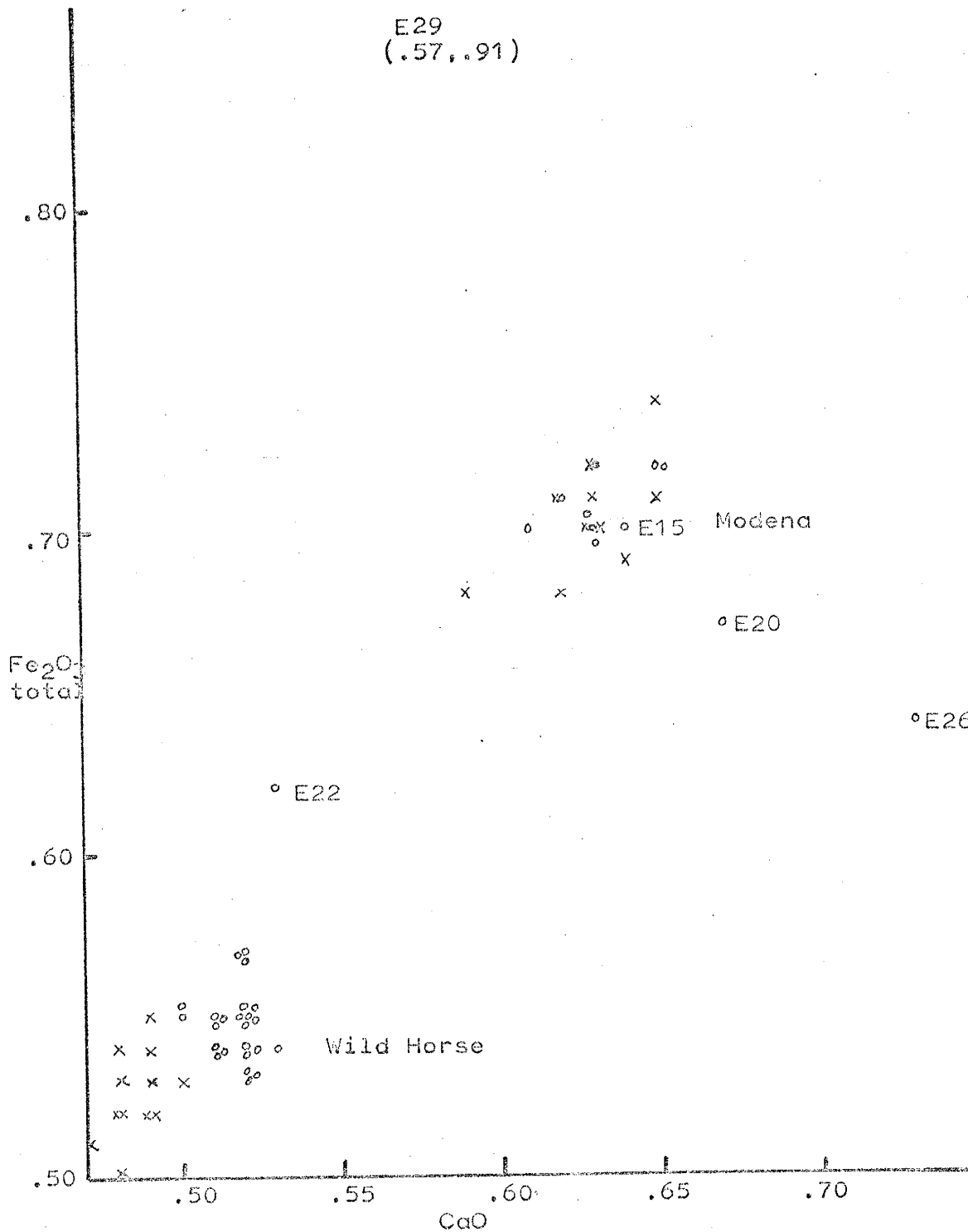


Figure 8

Fe<sub>2</sub>O<sub>3</sub> (wt.%) versus CaO (wt.%) in site samples (circles) and source samples (x's)

The La versus Sm diagram (Fig. 3) shows a distinct clustering of points for each source area. From this figure and the other plots, site samples can be assigned to the Modena area, Wild Horse Canyon area, or to a group with an unknown origin. Samples E: 4,6,8,15,23,30,33,37,38,39, and 42 are defined as part of the Modena obsidian. E15 is slightly depleted in La and Sm but clearly falls within the Modena group on the plots of the other elements. Site samples identified as part of the Wild Horse Canyon obsidian are E: 1,3,5,7,9,10,11,12,13,14,16,17,18,19,21,24,25,27,28, 31,32,34,35,36,40,41, and 43. Site samples E: 2,20,22,26, and 29 are from unknown sources. It should be noted that none of these samples have similar element concentrations for all of the elements analyzed, suggesting that these five samples represent five separate, unknown source areas.

The La concentrations in the site samples assigned to the Wild Horse Canyon site are lower than those observed in the Wild Horse Canyon source obsidian. La content of the Wild Horse Canyon site samples is 44 ppm compared to 54 ppm for the source samples (Table 5). The Modena mean La concentrations are much closer at 52 ppm for site samples and 54 ppm for source samples. All the source and site samples were treated in a consistent manner during sample preparation, analysis, and data reduction. Any bias depleting the Wild Horse Canyon site samples in La would also deplete the Modena site samples, since all samples were prepared, tested, and reduced using the same procedures. Any natural chemical depletion within the mound should have also depleted the Modena

obsidians which were admixed in with the Wild Horse Canyon obsidian in the site. The plot shows that the Modena site samples are not low in La compared to the source samples. The obsidians from Wild Horse Canyon were fresh and unaltered, suggesting that no depletion or enrichment occurred in the flows. The apparent La depletion in the Wild Horse Canyon source samples, therefore seems unexplainable at this time.

Figure 4 is a  $\text{Na}_2\text{O}$  versus Sm diagram. The distribution of the samples is the same as in the previous figure with the same 27 samples belonging to the Wild Horse Canyon group, 11 samples to the Modena group, and 5 samples of unknown origin.

The Zr versus Sr diagram (Fig. 5) also exhibits the same distribution of samples. Samples A and B are obsidian collected from the Wild Horse Canyon flows. They were collected and analyzed by Condie and Blaxland (1970) in their study of obsidians from Danger and Hogup Caves in northwestern Utah. These authors also collected and analyzed sample C which is from an outcrop east of Black Rock, Utah, about 23 miles north of Wild Horse Canyon. None of the site samples with an unknown origin are from this location.

Figure 6 shows the Zr versus Sr data for the samples from Hogup and Danger Caves (from Condie and Blaxland, 1970) plotted with data from this study. It is clear that the major source of obsidian for Hogup and Danger Caves is not from the Wild Horse Canyon or the Modena areas. The cave samples are much higher in Zr content than either of the

latter source areas. The 280 ppm Zr range in the cave samples seems anomalous for a single flow. The Modena source may be present as several samples in Hogup Cave. Hogup Cave is approximately 250 miles north of Modena, Utah (Fig. 1).

There is an apparent enrichment of Zr in the Evan's site samples with respect to the Modena source samples. Following the same line of reasoning as with the La depletion, the cause of the Zr enrichment is also unknown.

The Rb versus Sr diagram (Fig. 7) again shows the typical distribution of the site points about the source area points. The Rb values for samples "A" and "B" are about 100 ppm higher than my values. Since intraflow variation studies (Laidley and McKay, 1971; Condie and Hayslip, 1974) indicate that a given source should not show such a wide range in Rb concentration, it appears that the Rb analyses reported by Condie and Bloxland are in error. The Sr and Zr results, however, agree well between the two studies.

The  $\text{Fe}_2\text{O}_3$  versus CaO diagram (Fig. 8) shows the characteristic grouping of site points about the two source areas. There is a slight enrichment of CaO in site samples as compared with the Wild Horse Canyon source samples. Again the cause of this apparent enrichment is unknown. In the other diagrams, samples E22 and E29 appear to be closely spaced enough to come from the same source. However, their large  $\text{Fe}_2\text{O}_3$  concentration differences seems to exclude this possibility.



Summarizing, the trace element distributions suggest that of the 43 Evans site samples analyzed, 27 are from the Wild Horse Canyon flows, 11 are from the Modena source area, and 5 have an unknown origin. Table 5 lists the comparative means and ranges for the source and site samples. Except for the La, Zr, and CaO anomalies previously noted, the means and ranges of the source and site samples compare very well with each other.

Table 6 lists intraflow and interflow variations of published obsidian analyses. The numbers listed are rounded off to the nearest percent. The relative deviation is one standard deviation times 100 divided by the mean. In addition to the intraflow variations listed, Condie and Hayslip (1975) found that Medicine Lake obsidians had major element intraflow variations of less than or equal to 5%, with 5-15% variation for trace elements. Eruptive groups had major element variations of 2-12% and trace element variations of 10-30%. Condie and Hayslip defined an eruptive group as "a closely related group of flows (or flows and pyroclastics) which exhibits compositional coherency." The Wild Horse Canyon flows would be an example of an eruptive group. Condie and Hayslip's variation ranges agree well with the values in Table 6.

In this study,  $\text{Fe}_2\text{O}_3$ , CaO, Sm, and Sr were the most significant elements in correlating Evans site and source samples. These elements also have a small intraflow variation and a large interflow variation.

TABLE 6

## ELEMENT VARIATION IN OBSIDIANS

	Intraflow Variations			Interflow Variations			
	Big Glass OF <sup>1</sup>	Glass Mtn. <sup>2</sup>	Wild Horse Canyon	Modena	Wild Horse -Modena <sup>3</sup>	Misc. <sup>4</sup> Sources	Misc. Sources
SiO <sub>2</sub>	1		2	1	0	3	
TiO <sub>2</sub>	1		7	8	7	36	
Al <sub>2</sub> O <sub>3</sub>	1		9	7	6	5	
Fe <sub>2</sub> O <sub>3</sub>	1	6	2	3	19	57	63 <sup>5</sup>
Total							
MnO	1	8					
MgO	3						
CaO	2		2	3	20	29	
Na <sub>2</sub> O	2	4	3	3	5	16	17 <sup>5</sup>
K <sub>2</sub> O	1		2	2	2	8	
Rb	3	9	2	1	5		33 <sup>6</sup>
Zn	10						
La		7	7	9	0		49 <sup>6</sup>
Sc		8					
Sm		8	3	3	31		48 <sup>6</sup>
Zr			10	19	5		55 <sup>7</sup>
Sr			3	3	46		60 <sup>7</sup>

Note: All values are relative deviation, rounded off to the nearest percent.

<sup>1</sup>Data from Laidley and McKay, 1971, Big Obsidian Flow, Oregon.

<sup>2</sup>Data from Gordus et al., 1968, Glass Mountain, California.

<sup>3</sup>Interflow variations using Modena and Wild Horse Canyon data.

<sup>4</sup>Interflow variations using data from Laidley and McKay, 1971 (Big Obsidian Flow, Oregon), Gordus et al., 1968 (O-16 standard obsidian, Oregon), Condie and Hayslip, 1975 (Big Glass Mountain rhyolite, California) and from Wild Horse Canyon and Modena obsidians.

<sup>5</sup>Includes data sources 4 and 6

<sup>6</sup>Interflow variations using data from number 4 above and from Gordus et al., 1968 (Obsidian Cliff, Wyoming), Cerro de las Navajas, Mexico, Glass Mountain, California, Nappa Valley, California, Mono Lake, California, and Cougar Mountain, California.

<sup>7</sup>Same data as 4, minus Big Obsidian Flow data by Laidley and McKay, 1971.

Interflow variations in Table 6 were calculated using data from combinations of different flows. This was necessary because the same elements were not determined for all of the obsidians. The interflow variation is significantly larger than the intraflow variation for  $TiO_2$ ,  $Fe_2O_3$ , and  $CaO$ , indicating these elements potential to differentiate obsidians between regions. Previous studies commonly have concentrated on trace elements in obsidians, and have not analyzed the samples for major elements. However, the results of this study indicate that Ti, Fe, and Ca may be useful for differentiating obsidians from different regions.

Figure 9 is a diagram of Sm (ppm) versus La (ppm) concentrations in selected obsidians from the United States and Mexico. The diagram illustrates the significance of La and Sm to differentiate obsidians on an interregional basis. By determining major and trace elements for obsidian flows, it should be possible to differentiate one obsidian flow from any other obsidian flow. The results of this study demonstrate that the Wild Horse Canyon area and Modena area obsidians are the major source of obsidian for the Evans site, and that no other interpretation is likely, except as discussed below.

It is possible that there are other obsidians in the region that originated from the same magma, or similar magmas, as the Modena or Wild Horse Canyon obsidians. By tapping such a magma, obsidian indistinguishable from the known sources could be produced. No detailed geologic

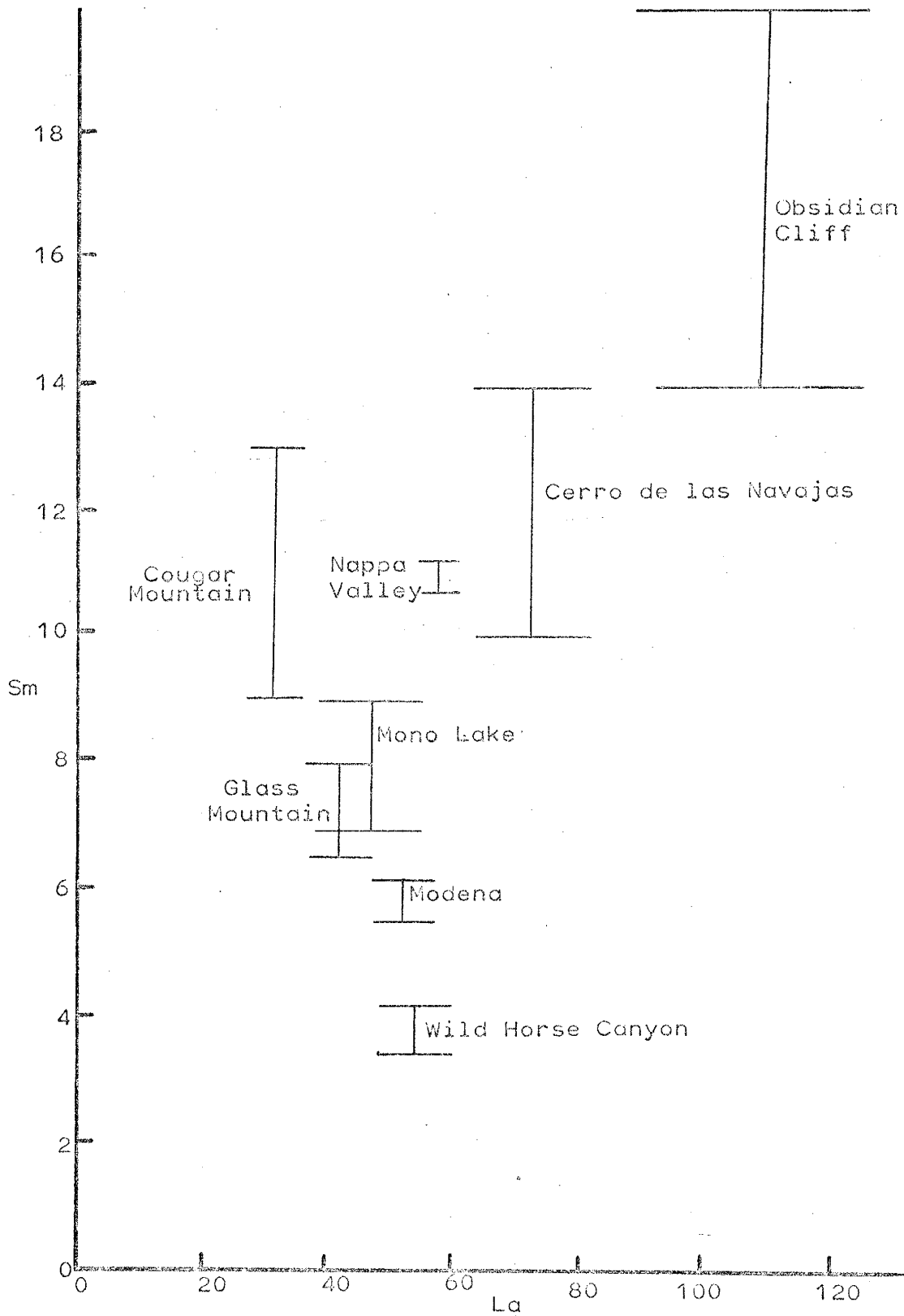


Figure 9

Sm (ppm) versus La (ppm) for obsidians in the United States and Mexico. Data from Gordus et al., 1968, and this study.

mapping has been done in the Modena area. The areal extent and source of the nodules are not known. The nodules show no evidence of having been transported very far. Many nodules are large in size, as big as five inches in diameter, and have not been exposed long enough even to have their glassy appearance dulled. The areal extent of exposed nodules is probably limited to within a few miles of the primary source. Abundant chipping debris and broken artifacts in the immediate vicinity of the nodules show that the obsidian was extensively used by ancient inhabitants of the area.

Detailed geologic mapping has been done in the Mineral Mountains, the most recent of which was by P.W. Lipman, P.D. Rowley, and J.S. Pallister of the U.S. Geological Survey. A telephone conversation with Peter Rowley on September 26, 1975, revealed that an obsidian flow was located in Negro Mag Wash, some two miles north of Wild Horse Canyon. Abundant chipping debris was reported in the area. Rowley reported no other obsidian flows were found in the area during their study.

The Negro Mag Wash flow is likely to be from the same source as the Wild Horse Canyon flow. If this obsidian is chemically indistinguishable from that of Wild Horse Canyon, the Evans site samples could be from either the Wild Horse Canyon or Negro Mag Wash localities. For archeological implications this is no more meaningful than identifying a single source. The purpose of the study was to determine the source or sources of the Evans site obsidian in terms

of specific source areas. The available data indicate that the site obsidian was obtained from the Mineral Mountains and Modena, but clearly is not from Black Rock, Utah or from a distant source such as Obsidian Cliff in Yellowstone Park.

Table 7 shows the distribution of site samples, by source area and site phase, in the stratigraphy of the mound. The lack of any stratigraphic bias demonstrates that both source areas were used by the inhabitants throughout the occupational period of the mound. Conclusions on the stratigraphic distribution of the samples of unknown origin are unwarranted. Since there are only five such samples in the study, any conclusions would be tenuous.

#### OBSIDIAN PROCUREMENT BY SITE INHABITANTS

Life at the Evans site is thought to have centered around farming, seed gathering, hunting, and procurement of technological materials (Berry, 1972). Obsidian probably was collected on hunting trips since it is doubtful that the Indians would walk 45 miles for a few pieces of obsidian when chert and chalcedony were abundant locally.

Mountain sheep, mule deer, and pronghorn antelope represent over 80% of the dressed meat consumed at the Evans site (Smith, 1972). The minimum count of these animals at the site during the occupational period is 16 sheep, 33 deer, and 22 antelope, for a total of 71 animals. The minimum count was determined by counting the maximum number of either the right or left mandible, calcaneus, scapula, or ulna bones. Sheep and deer were probably found near the edges of

TABLE 7

DISTRIBUTION OF SOURCE MATERIAL IN EVANS SITE

Stratigraphic Level	Wild Horse Canyon Samples	Modena Samples	Unknown Origin Samples
<u>Area A</u>	PPP	PP	P
<u>Area B</u>			
8/9	PPP		
9	P		
8	PP	P	
7	PPSSS	S	S
6	SSS	S	SSS
B1	S	S	
<u>Area D</u>			
8/9	P		
7	PPP	P	
6	SSSS	S	
5		SSS	

Note: P is a sample from Paragonah phase, S is a sample from Summit phase.

and in the mountains to the east of the site while antelope may have been hunted in the Escalante Desert to the west of the site. Thus, if obsidian was collected on hunting trips there should be a relationship between the amount of Modena obsidian and the number of antelope killed, and a relationship between the amount of Wild Horse Canyon obsidian collected and the number of sheep and deer killed. Modena and Wild Horse Canyon obsidian account for 38 of the 43 site samples tested. Of the 38 samples, Modena samples are 29% and Wild Horse Canyon samples are 71% of the obsidian excavated at the site. Of the three types of animals, antelope represent 31% of the minimum count, while the sheep and deer are the other 69%. While obsidian probably was not collected

everytime an animal was killed, these figures do substantiate the hypothesis that the source of the site obsidian is a function of the inhabitant's hunting habits.

Closer examination of the hypothesis reveals several inherent weaknesses. The minimum count of faunal remains and the proportions of Wild Horse Canyon versus Modena obsidian are based on a very small excavated population sample compared to the actual material occurring at the mound. When choosing Evans site samples for analyses, samples exhibiting a wide range of colors and flow characteristics were picked. Numerous pieces of flowbanded red obsidian and the red-black breccia type glass were chosen to see if the change in colors might also indicate changes in chemical composition. Since the red or breccia-type glass only occurs at Wild Horse Canyon, the selection of samples was unknowingly biased in favor of Wild Horse Canyon. Of the 43 samples chosen for analysis, 14 were a red or red-black obsidian. Therefore, the hypothesis is statistically weak and subject to modification by further analyses of site obsidian.

#### CONCLUSIONS

The Wild Horse Canyon area and Modena area obsidians are the major sources of obsidian which were utilized at the Evans site, and probably for the rest of the Parowan valley. Very minor amounts of obsidian are from undetermined source areas. The major source of obsidian for Danger and Hogup caves was not utilized by inhabitants of the Evans site. Only a few of the Hogup cave samples match Modena or



Wild Horse Canyon material, therefore the Hogup and Danger Cave occupants probably had access to a nearer source of obsidian in northeastern Nevada or northwestern Utah. The major source of obsidian for these cave sites has not been located.

Additional work is needed to locate and analyze obsidian from other potential sources for comparison with material from the numerous excavated archeological sites in Utah. Such studies may reveal obsidian distribution patterns of importance to current hypotheses on prehistoric man in the Great Basin.

REFERENCES

- Barsky, C.K. and Condie, K.C.  
1975 "Geochemical Evolution of the Early Eruptions at the Medicine Lake Volcanic Center, Northern California." In preparation.
- Berry, M.S.  
1972 The Evans Site. University of Utah Department of Anthropology Special Report. Salt Lake City.
- Cann, J.R. and Renfrew, C.  
1964 "The Characterization of Obsidian and Its Application to the Mediterranean Region." Proceedings of the Prehistoric Society, Vol. 30, pp. 111-33. London.
- Condie, K.C.  
1967 "Petrology of the Late Precambrian Tillite Association in Northern Utah," Geological Society of America Bulletin, Vol. 78, No. 11, pp. 1317-44. Boulder.
- Condie, K.C. and Blaxland, A.B.  
1970 "Sources of Obsidian in Hogup and Danger Caves." University of Utah Anthropological Paper No. 93, Appendix IX. Salt Lake City.
- Condie, K.C., Macke, J.E. and Reimer, T.O.  
1970 "Petrology and Geochemistry of Early Precambrian Graywackes From the Fig Tree Group." Bull. Geol. Soc. Amer. 81, pp. 2759-76.
- Condie, K.C. and Lo, H.H.  
1971 "Trace Element Geochemistry of the Louis Lake Batholith of Early Precambrian Age, Wyoming." Geochim. Cosmochim. Acta 35, pp. 1099-1119.
- Condie, K.C. and Barsky, C.K.  
1972 "Origin of Quarternary Basalts From the Black Rock Desert Region, Utah." Bull. Geol. Soc. Amer. 83, pp. 333-52.
- Condie, K.C. and Hayslip, D.L.  
1975 "Young Bimodal Volcanism At Medicine Lake Volcanic Center, Northern California." Geochim. Cosmochim. Acta 39.
- Frison, G. and others  
1968 "Neutron Activation Analysis of Obsidian: An Example of Its Relevance to Northwestern Plains Archeology." The Plains Anthropologist. Lincoln.

- Gordon, G.E. and others  
1968 "Instrumental Activation Analysis of Standard Rocks With High Resolution Detectors." Geo-chimica Cosmochimica Acta 32, pp. 369-96.
- Gordus, A.A., Wright, G.A. and Griffin, J.B.  
1968 "Characterization of Obsidian Sources by Neutron Activation Analysis." Science, Vol. 161, pp. 382-84. Washington.
- Griffin, J.B., Gordus, A.A., and Wright, G.A.  
1969 "Identification of the Sources of Hopewellian Obsidian in the Middle West." American Antiquity, Vol. 34, No. 1, pp. 1-14. Washington, D.C.
- Laidley, R.A. and McKay, D.S.  
1971 "Geochemical Examination of Obsidians From Newberry Caldera, Oregon." Contr. Mineral and Petrol. 30, pp. 336-42.
- Marwitt, J.P.  
1971 "Median Village and Fremont Culture Regional Variation." University of Utah Anthropological Paper, No. 95. Salt Lake City.
- Parks, G.A. and Tieh, T.T.  
1966 "Identifying the Geographical Source of Artifact Obsidian." Nature, Vol. 211, No. 5046, pp. 289-90. London.
- Renfrew, C., Cann, J.R., and Dixon, J.E.  
1966 "Obsidian and Early Cultural Contact in the Near East." Proceedings of the Prehistoric Society, Vol. 32, pp. 30-72. London.
- Reynolds, R.C., Jr.  
1963 "Matrix Corrections in Trace Element Analysis by X-ray Fluorescence." American Mineralogist, Vol. 48, Nos. 9 & 10, pp. 1133-43. Washington, D.C.
- Smith, J.H.  
1972 "Faunal Remains From the Evans Mound Site." University of Utah Anthropology Department Special Report, Appendix III. Salt Lake City.
- Weide, D.L.  
1970 "The Geology and Geography of the Parowan and Cedar Valley Region, Iron County, Utah." University of Utah Anthropological Papers No. 95, Appendix III. Salt Lake City.

Wright, G.A., Griffin, J.B. and Gordus, A.A.  
1968 "Preliminary Report on Obsidian Samples From  
Veratic Rockshelter, Idaho," Occasional Papers  
of the Idaho State Museum. Pocatello.

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