GREAT BASIN TOOL-STONE SOURCES

The NDOT Obsidian and Tool-Stone Sourcing Project: 2002 Progress Report.

by

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THE TOOL-STONE SOURCE IDENTIFICATION PROJECT: 2002 Progress Report.

The Cultural Resource Section (CRS) of the Nevada Department of Transportation (NDOT), Environmental Services Division, has had a program of obsidian studies since the late 1970's. Subsequently, the department has been actively involved in cooperative research programs with X-ray fluorescence (XRF), Neutron Activation Analysis, trace element analysis, and hydration laboratories. The author has been involved in sourcing studies since the late 1960's and has an abiding interest in flintknapping and replication studies since exposure to the late Drs. Don E. Crabtree and Earl H. Swanson, maintained by the work of Jim Woods and Gene Titmus.

This is an ongoing research project. If you have information on tool-stone sources, trace element analysis, or hydration studies that would contribute to this document, or if you have comments, remarks, or requests for data or copies, please contact:

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The NDOT source identification program was developed to locate, identify, and characterize major tool-stone (especially obsidian, welded tuff, vitrophyre, ignimbrite, etc., . . .) sources. This characterization is known variously as sourcing, source analysis, XRF and NAA analysis, and trace element analysis. The program began at a project-specific level. Later it expanded to a broader, statewide level. It has since been expanded to include sources that are found in sites around the entire Great Basin Culture Area.

The program included the following:

1. a. Sponsorship of nondestructive trace element analysis of artifacts and source samples,
   b. Sponsorship of the hydration analysis of artifacts,
   c. Sponsorship of laboratory experiments on induced hydration of source samples,
2. a. Placement of instruments to develop basic environmental data, and
   b. Monitoring and recovery of these instruments, and
   c. Sponsorship of analysis of these instruments, and
3. Field location and sampling of primary material sources (many of which were previously unknown and/or unrecorded), and
4. Functioning as a clearinghouse for source data.

The regional scope required to address tool-stone sourcing research problems articulated nicely with the statewide responsibilities of NDOT and the total NDOT CRS program. This scope also articulated nicely with the author's interest, experience, and research on prehistoric Great Basin and Columbia Plateau tool-stone, trade, and lithic technology. This report presents the results of the combined program to date (March 19, 2009).

In the early stages of this program, artifacts were collected and submitted to various laboratories and individuals for XRF source data analysis. Analysis often included hydration analysis on a project specific basis. The result of this analysis usually was a letter report from the laboratory, to NDOT. NDOT provided the funding for this project specific sourcing and hydration analysis, along with the resulting report. The information was rather haphazardly distributed.

By the early 1980s, as more effort went to the problem, we recognized that large gaps existed in the database and more extensive research was needed. In cooperation with other institutions and individuals, new samples were collected and other sources identified, often because of a direct request from a cooperating researcher. Since NDOT Cultural Resource Section (archaeological survey) crews cover most of the state and have opportunities to gather data that other laboratories do not, this cooperative effort worked well. By compiling source data from different labs and projects, we could recognize source locations that were not in the existing database. We were also able to match isolated XRF data with the appropriate obsidian source location.

By the 1990's we recognized the need for a document summarizing the research and providing a list of sources and data on the trace element analysis. The Great Basin Tool-Stone Sources report was the result. Descriptions, legal descriptions, and sometimes, directions and personal observations were also included. Large-scale maps showing the distribution of sources are included in the 2002 revision.

Unfortunately, non-project-specific samples and records provided by NDOT to the sourcing labs were unfunded samples. Due to the unfunded nature of these samples, the destination lab often did not provide us with a report on their analysis. We are still attempting to obtain some of these results for future publication. This report should not be considered a comprehensive presentation of all existing data. It is instead, a summary presentation of all reasonably available data. This report includes samples submitted, but for which we received no analysis data, to avoid future duplication.

In the late 1990's our data was incorporated into an Internet website maintained by Dr. Craig Skinner (Northwest Research Obsidian Laboratory) and Dr. Michael Glascock (Missouri University Research Reactor, Archaeometry Laboratory http://www.missouri.edu/~murrwww/archlab.html for the International Association for Obsidian Studies. This site, to found on the Internet at the Northwest Research Obsidian Studies Laboratory web page http://obsidianlab.com contains the World Obsidian Source Catalog, a worldwide reference to obsidian and obsidian sources. It also has links to literature sources.

Another good source of information is the International Association for Obsidian Studies (IAOS, Department of Anthropology, San Jose State University, San Jose CA 95192-0113). They provide members with a PC compatible diskette containing their Obsidian Bibliography. Their website is http://www.peak.org/obsidian/index.html and also has information and links to the sites above and to other sites. The U.S.G.S. Nevada office has an online Open File Report - USGS Open-File Report, 99-523 Moyer, Lorre A. Preliminary digital map of cryptocrystalline occurrences in northern Nevada. Maximum recommended scale 1:750,000. USGS Open-file report no. 99-523, pub. 1999. Access: http://geopubs.wr.usgs.gov/open-file/of99-523/ (the web site keeps changing, so use a search engine). This report uses data from this source study and includes maps of distribution.

Trace Element Analysis.

The data from the laboratories usually comes as a letter report, such as the following example.

X-Ray Fluorescence Methods

> "Analyses were completed using a Spectrace 5000 energy dispersive X-ray fluorescence system. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9keV X-rays (at 1000 counts per second) in an area 30mm². Signals from the spectrometer are amplified and filtered by a time variant pulse processor, and sent to a 100 MHz Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a Rh target, and 4 mil Be window. The tube is driven by a 50 kV 1mA high voltage power supply, providing a voltage range of 6 to 50 kV".
>
> For analysis of the elements zinc (Zn), gallium (Ga), lead (Pb), thorium (Th), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb), the Rh x-ray tube is operated at 30 kV, .30 mA (pulsed), with a .127 mm Pd filter. Analytical lines used are: Zn (K-alpha), Ga (K-alpha), Pb (L-alpha), Th (L-alpha), Rb (K-alpha), Sr (K-alpha), Y (K-alpha), Zr (K-alpha) and Nb (K-alpha). Scanning period is 200 seconds live-time in an air path. Trace-element intensities for the Zn-Nb series elements are converted to parts-per-million (ppm) by weight using a least squares polynomial fit routine. Ppm values may vary according to specimen mass and nature of the surface of the sample. All samples are scanned as unmodified rock specimens (not powder)."

X-Ray Fluorescence Results

> "Analytical results are given in the following table. Of eleven specimens from the four Elko County sites, eight specimens are characteristic of the Brown's Bench chemical group. The remaining three specimens are divided among two unidentified chemical groups (unknown A and unknown B). Two of the specimens from 26ES855 are characteristic of the Crow Spring obsidian and the third represents an unknown source (unknown C). . . ." (Jackson and Davis letter

report, 1992).

Hydration Analysis.

Friedman and Smith (1960) reported on observations regarding the index of refraction (RI) in obsidian. They noticed that the RI was higher on hydrated surfaces than on un-weathered surfaces of obsidian thin sections. Thin sections are a standard geologic technique for studying rock samples. Small slices of stone are carefully ground and polished, then mounted onto a slide using balsam and polished again. This resulting thin section is then observed under a variety of microscopes and the minerals described and analyzed. It was during this analysis that the RI led them to discover the hydration rind. Friedman and Smith described this hydration rind as a diffusion front. Obsidian is totally dehydrated by the intense heat that forms it. A nodule is only exposed to weathering at its surface. Obsidian has the unique ability to absorb water from the atmosphere. When the nodule is broken, for instance by a prehistoric flintknapper, the fresh surface begins to hydrate and the hydration clock is started. The moisture produces a diffusion front that has a different RI than the rest of the rock. The act of making an artifact begins the hydration clock.

Trace element composition as per cent weight.

SiO_2	Al_2O_3	Na_2O_3	K_2O	Fe^2O_3	CaO	MgO	TiO_2
77.2	12.89	3.98	4.72	0.51	0.44	0.07	0.16

Some basic ideas are involved in the development of hydration dating. The hydration rind increases as a non-linear function of time. It is a diffusion front of water. It is independent of relative humidity. Obsidian is totally dry, so it will absorb water from any source, air, soil, or stream. The chemical composition of the obsidian affects the hydration rate. The temperature environment affects the rate. Higher temperatures hydrate faster.

Before hydration dating can be attempted, several things must be considered. The storage history of the artifact must be known. If it were stored in an overheated museum basement, this would affect the rate. The ground temperature must also be known, or at least estimated from the best available data. The chemical composition of the obsidian must also be known.

The hydration rate is strongly affected by three things, infrared radiation/temperature, trace element composition and mechanical variables. These are often interdependent. If the ratios of sodium and aluminum are increased relative to silica, the absorptivity of infrared radiation increases and the hydration rate increases. Implied in this is the idea that surface material hydrates faster than buried materials. Mechanical features such as the density of cracks per cubic millimeter affects the rate. A major problem NDOT has experienced is related to these cracks. The more cracks, the more access to water, therefore the faster the obsidian hydrates. Another problem is that the cracks penetrate the diffusion front. The laboratory technician has difficulty deciding which is the hydration rind and which is a crack rind. Sometimes there are several apparent rinds, thoroughly confusing the issue.

Further research revealed that the trace element composition was often consistent within a particular source or portion of a source. Ericson (1975) hypothesized that obsidian from different sources might hydrate at different rates within a given geographical region. He developed a range of rates for California and western Nevada sources. He used neutron activation analysis to compare trace elements. He analyzed obsidian artifacts associated with carbon dates and developed preliminary hydration rates for ten sources including Mt. Hicks, Pine Grove Hills, and the Bodie Hills.

The technique used by Ericson follows:

> "Hydration measurements were made on the obsidian artefacts [sic] using the following procedure. Single obsidian sections were cut from each specimen with a Felke Di-Met (Model II-B) saw using a 3½ in. diamond-charged, brass saw blade, ground optically flat with silicon carbide No. 400 and aluminium [sic] oxide No. 95 grits on a flat plate, mounted on a petrographic slide with Lakeside plastic cement, ground on the other side to a thickness of 0.003 in., and covered with a glass cover slide using Canada balsam. The obsidian hydration rims were measured at 537.5 magnification, using a calibrated Leitz micrometer eyepiece mounted in an American Optical petrographic microscope. Measurements were taken at three to four different points with five readings per point. The results of these observations were averaged for each thin section. The 'pooled' standard deviation for each thin section was 0.2 microns, which included the three components of variability, namely (1) hydration rim variability, (2) instrument error and (3) observer error . . . " (Ericson 1975:153).

Hydration rate data is often presented in the format used in <u>Mohlab Technical Report No. 21</u> (Michels 1983a): "Compositional characterization of the sample was accomplished by means of atomic absorption spectroscopy and is expressed in %/wt. values: . . . "

> <u>Induced Hydration Experiment</u>
> "The quarry sample was fractured by percussion and nine small freshly-surfaced

flakes were selected for induced hydration in a one-liter, thermoregulated reaction bomb containing 500 ml of de-ionized water. The results are given in MOHLAB Table 1."

Mohlab Table 1

Sample Number	Temp.	Duration	Micron Value	Standard Deviation
01	200°C	0.5 day	1.83µ	±0.04µ
02	200°C	1 day	2.80µ	±0.08µ
03	200°C	2 days	3.55µ	±0.04µ
04	200°C	4 days	5.17µ	±0.04µ
05	200°C	6 days	6.48µ	±0.08µ
06	250°C	4 days	14.64µ	±0.08µ
07	225°C	4 days	8.60µ	±0.10µ
08	175°C	4 days	2.53µ	±0.07µ
09	150°C	4 days	1.32µ	±0.04µ

Hydration measurements were taken (after thin sectioning) under transmitted, cross-polarized light by means of an optical microscope equipped with a 100X oil immersion objective and a Vicker's image-splitting eyepiece.
(Michels 1983a: 1-2).

"The hydration rate is a diffusion process and obeys the equation suggested by Friedman and Smith (1960): $\mathbf{x^2 = Kt}$ where **x** is the thickness of the hydration layer, **K** is the hydration rate, and **t** is the time. The hydration rate is temperature dependent and follows the Arrhenius equation given by:

$$\mathbf{k = Ae^{-E/RT}} \text{ or (working equation) } \mathbf{k' = k \exp (E/R\ (^1/_T - {}^1/_{T'}))}$$

= 6.82²/day (hydration rate @ **T**)

k' = unknown (hydration rate @ **T'**)

A = hydration constant

E = 88960 J/mol (activation energy)

R = 8.317 J/mol^{-1}°C^{-1} (gas constant)

T = 473.16°K (200°C)

T' = 285.19°K (effective hydration temperature for Pine Valley, Nevada.

By performing trace element analysis on a series of artifacts, not only are the artifacts characterized but eventually the source as well. The same applies to hydration rates. Once a sample is traced to a source, then the hydration rate for that source must be developed. Part of the development of a hydration rate involves the determination of the effective hydration temperature for given sites. Using **T**, above, samples are heat-soaked for a predetermined amount of time (0.5 to 6 days) and the hydration rind measured. Linear regression analysis results in a rate, **k**, above. This daily rate is converted to a kiloyear (1000 years) or Ky rate. The actual hydration rim or rind measurement is multiplied by the rate to figure out time.

The effective hydration temperature (EHT) for Pine Valley, Nevada was estimated to be 285.19°K. The EHT for the Pole Line site, 26MN406, was estimated from weather station reports to be 281.61°K. Ambrose cells placed at the site (Michels 1992) suggest an EHT of 285.69°K-285.84°K. This is a maximum difference of 4.23°K or 1.5%.

The working equation produces a hydration rate roughly $0.84\mu^2$/ky for Mt. Hicks obsidian at the Pine Valley and Pole Line sites. Radiocarbon dating from the Pole Line site suggests that a rate between $0.51\mu^2$/ka and $0.53\mu^2$/ka would be more in agreement, but inappropriate. At this time hydration dating is limited to relative, rather than absolute dating, at least in the areas we have analyzed. This is part of the reason NDOT supports this research. Debate regarding the potential usefulness of this technique continues (Obsidian Hydration Chronology in the Inyo-Mono Region, Society for California Archaeology, April 1999, Sacramento)

Neutron Activation Analysis

"Previous characterization studies of obsidian from Nevada and the surrounding Great Basin region have been limited to the technique of x-ray fluorescence (XRF) analysis. This has been due to the greater availability and lower cost of XRF, and the fact that researchers with experience in XRF have conducted this research …the small number of elements measured and XRF's inability to measure certain highly diagnostic trace elements limits the usefulness of compositional data from XRF to regional investigations rather than global studies of greater current interest to geochemists. In addition, archaeologists concerned with the long range movement of obsidian materials may fin XRF data inadequate to differentiate between hundreds of possible sources." "…Samples were crushed between cleaned tool steel plates to produce a number of interior fragments weighing 50 to 100 mg each. Aliquots weighing about 100 mg were weighed into high-density polyethylene vials for short irradiation. At the same time, aliquots of about 300 mg were weighed into high-purity quartz vials used for long irradiations. Along with the unknown samples, reference standard of SRM-278 Obsidian Rock and SRM-1633a Coal Fly Ash were likewise prepared." "…neutron activation analysis of archaeological samples consists of two irradiations and a total of three measurements … (Glascock and Ambroz letter report, July 27, 1996)
See the following overview for details.

"An Overview of Neutron Activation Analysis

by Michael D. Glascock
Missouri University Research Reactor

Introduction

Neutron activation analysis (NAA) is a sensitive analytical technique useful for performing both qualitative and quantitative multi-element analysis of major, minor, and trace elements in samples from almost every conceivable field of scientific or technical interest. For many elements and applications, NAA offers sensitivities that are superior to those attainable by other methods, on the order of parts per billion or better. In addition, because of its accuracy and reliability, NAA is generally recognized as the "referee method" of choice when new procedures are being developed or when other methods yield results that do not agree. Worldwide application of NAA is so widespread it is estimated that approximately 100,000 samples undergo analysis each year.

Neutron activation analysis was discovered in 1936 when Hevesy and Levi found that samples containing certain rare earth elements became highly radioactive after exposure to a source of neutrons. From this observation, they quickly recognized the potential of employing nuclear reactions on samples followed by measurement of the induced radioactivity to facilitate both qualitative and quantitative identification of the elements present in the samples.

The basic essentials required to carry out an analysis of samples by NAA are a source of neutrons, instrumentation suitable for detecting gamma rays, and a detailed knowledge of the reactions that occur when neutrons interact with target nuclei. Brief descriptions of the NAA method, reactor neutron sources, and gamma-ray detection are given below.

The NAA Method

The sequence of events occurring during the most common type of nuclear reaction used for NAA, namely the neutron capture or (n,gamma) reaction, is illustrated in Figure 1. When a neutron interacts with the target nucleus via a non-elastic collision, a compound nucleus forms in an excited state. The excitation energy of the compound nucleus is due to the binding energy of the neutron with the nucleus. The compound nucleus will almost instantaneously de-excite into a more stable configuration through emission of one or more characteristic prompt gamma rays. In many cases, this new configuration yields a radioactive nucleus which also de-excites (or decays) by emission of one or more characteristic delayed gamma rays, but at a much slower rate according to the unique half-life of the radioactive nucleus. Depending upon the particular radioactive species, half-lives can range from fractions of a second to several years.

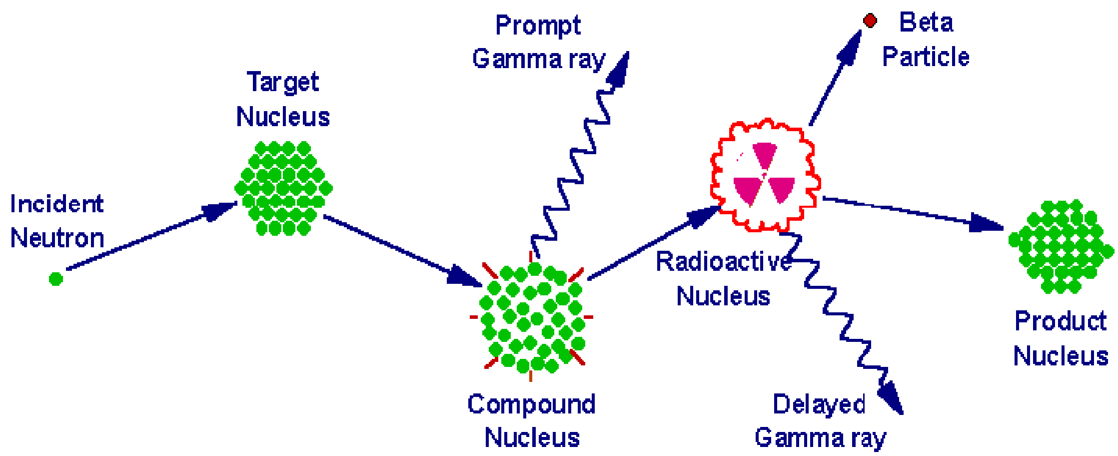


Fig. 1. Diagram illustrating the process of neutron capture by a target nucleus followed by the emission of gamma rays.

In principle, therefore, with respect to the time of measurement, NAA falls into two categories: (1) prompt gamma-ray neutron activation analysis (PGNAA), where measurements take place during irradiation, or (2) delayed gamma-ray neutron activation analysis (DGNAA), where the measurements follow radioactive decay. The latter operational mode is more common; thus, when one mentions NAA it is generally assumed that measurement of the delayed gamma rays is intended. About 70% of the elements have properties suitable for measurement by NAA.

Neutrons

Although there are several types of neutron sources (reactors, accelerators, and radioisotopic neutron emitters) one can use for NAA, nuclear reactors with their high fluxes of neutrons from uranium fission offer the highest available sensitivities for most elements. Different types of reactors and different positions within a reactor can vary considerably with regard to their neutron energy distributions and fluxes due to the materials used to moderate (or reduce the energies of) the primary fission neutrons. However, as shown in Figure 2, most neutron energy distributions are quite broad and consist of three principal components (thermal, epithermal, and fast).

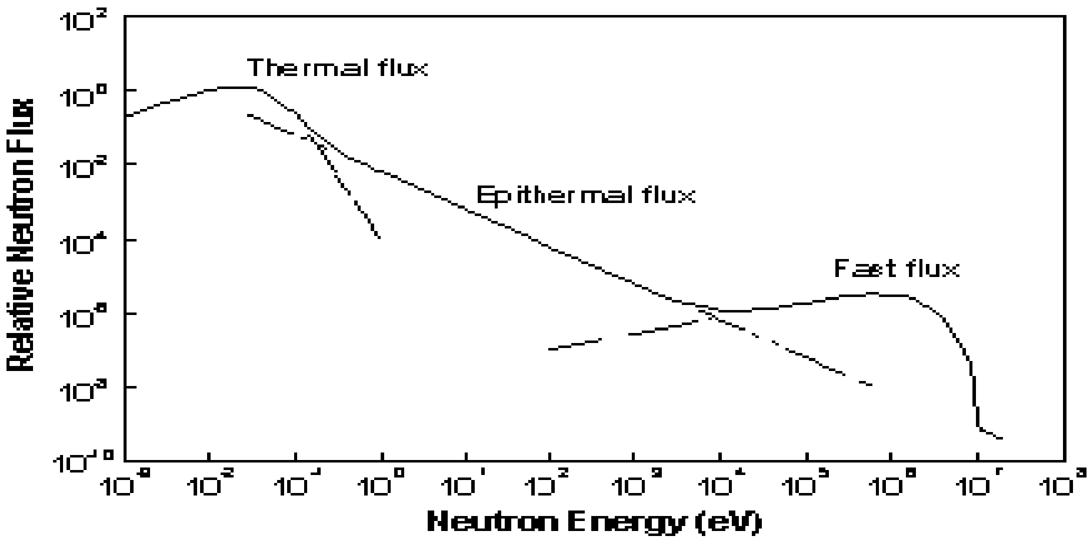


Fig. 2. A typical reactor neutron energy spectrum showing the various components used to describe the neutron energy regions.

The thermal neutron component consists of low-energy neutrons (energies below 0.5 eV) in thermal equilibrium with atoms in the reactor's moderator. At room temperature, the energy spectrum of thermal neutrons is best described by a Maxwell-Boltzmann distribution with a mean energy of 0.025 eV and a most probable velocity of 2200 m/s. In most reactor irradiation positions, 90-95% of the neutrons that bombard a sample are thermal neutrons. In general, a one-megawatt reactor has a peak thermal neutron flux of approximately 1E13 neutrons per square centimeter per second.

The epithermal neutron component consists of neutrons (energies from 0.5 eV to about 0.5 MeV) which have been only partially moderated. A cadmium foil 1 mm thick absorbs all thermal neutrons but will allow epithermal and fast neutrons above 0.5 eV in energy to pass through. In a typical unshielded reactor irradiation position, the epithermal neutron flux represents about 2% the total neutron flux. Both thermal and epithermal neutrons induce (n,gamma) reactions on target nuclei. An NAA technique that employs only epithermal neutrons to induce (n,gamma) reactions by irradiating the samples being analyzed inside either cadmium or boron shields is called epithermal neutron activation analysis (ENAA).

The fast neutron component of the neutron spectrum (energies above 0.5 MeV) consists of the primary fission neutrons which still have much of their original energy following fission. Fast neutrons contribute very little to the (n,gamma) reaction, but instead induce nuclear reactions where the ejection of one or more nuclear particles - (n,p), (n,n'), and (n,2n) - are prevalent. In a typical reactor irradiation position, about 5% of the total flux consists of fast neutrons. An NAA technique that employs nuclear reactions induced by fast neutrons is called fast neutron activation analysis (FNAA).

Prompt vs. Delayed NAA

As mentioned earlier, the NAA technique can be categorized according to whether gamma rays are measured during neutron irradiation (PGNAA) or at some time after the end of the irradiation (DGNAA). The PGNAA technique is generally performed by using a beam of neutrons extracted through a reactor beam port. Fluxes on samples irradiated in beams are on the order of one million times lower than on samples inside a reactor but detectors can be placed very close to the sample compensating for much of the loss in sensitivity due to flux. The PGNAA technique is most applicable to elements with extremely high neutron capture cross-sections (B, Cd, Sm, and Gd); elements which decay too rapidly to be measured by DGNAA; elements that produce only stable isotopes; or elements with weak decay gamma-ray intensities.

DGNAA (sometimes called conventional NAA) is useful for the vast majority of elements that produce radioactive nuclides. The technique is flexible with respect to time such that the sensitivity for a long-lived radionuclide that suffers from an interference by a shorter-lived radionuclide can be improved by waiting for the short-lived radionuclide to decay. This selectivity is a key advantage of DGNAA over other analytical methods.

Instrumental vs. Radiochemical NAA

With the use of automated sample handling, gamma-ray measurement with solid-state detectors, and computerized data processing it is generally possible to simultaneously measure more than thirty elements in most sample types without chemical processing. The application of purely instrumental procedures is commonly called instrumental neutron activation analysis (INAA) and is one of NAA's most important advantages over other analytical techniques. If chemical separations are done to samples after irradiation to remove interferences or to concentrate the radioisotope of interest, the technique is called radiochemical neutron activation analysis (RNAA). The latter technique is performed infrequently due to its high labor cost.

Measurement of Gamma Rays

The instrumentation used to measure gamma rays from radioactive samples generally consists of a semiconductor detector, associated electronics, and a computer-based, multi-channel analyzer (MCA/computer). Most NAA labs operate one or more hyperpure or intrinsic germanium (HPGe) detectors which operate at liquid nitrogen temperatures (77 degrees K) by mounting the germanium crystal in a vacuum cryostat, thermally connected to a copper rod or "cold finger". Although HPGe detectors come in many different designs and sizes, the most common type of detector is the coaxial detector which in NAA is useful for measurement of gamma-rays with energies over the range from about 60 keV to 3.0 MeV.

The two most important performance characteristics requiring consideration when purchasing a new HPGe detector are resolution and efficiency. Other characteristics to consider are peak shape, peak-to-Compton ratio, crystal dimensions or shape, and price.

The detector's resolution is a measure of its ability to separate closely spaced peaks in a spectrum. In general, detector resolution is specified in terms of the full width at half maximum (FWHM) of the 122-keV photopeak of Co-57 and the 1332-keV photopeak of Co-60. For most NAA applications, a detector with 1.0-keV resolution or below at 122 keV and 1.8 keV or below at 1332 keV is sufficient.

Detector efficiency depends on the energy of the measured radiation, the solid angle between sample and detector crystal, and the active volume of the crystal. A larger volume detector will have a higher efficiency. In general, detector efficiency is measured relative to a 3-inch by 3-inch sodium iodide detector using a Co-60 source (1332-keV gamma ray) at a distance of 25 cm from the crystal face. A general rule of thumb for germanium detectors is 1 percent efficiency per each 5 cc of active volume. As detector volume increases, the detector resolution gradually decreases. For most NAA applications, an HPGe detector of 15-30 percent efficiency is adequate.

Typical gamma-ray spectra from an irradiated pottery specimen are shown in Figures 3-5 using two different irradiation and measurement procedures.

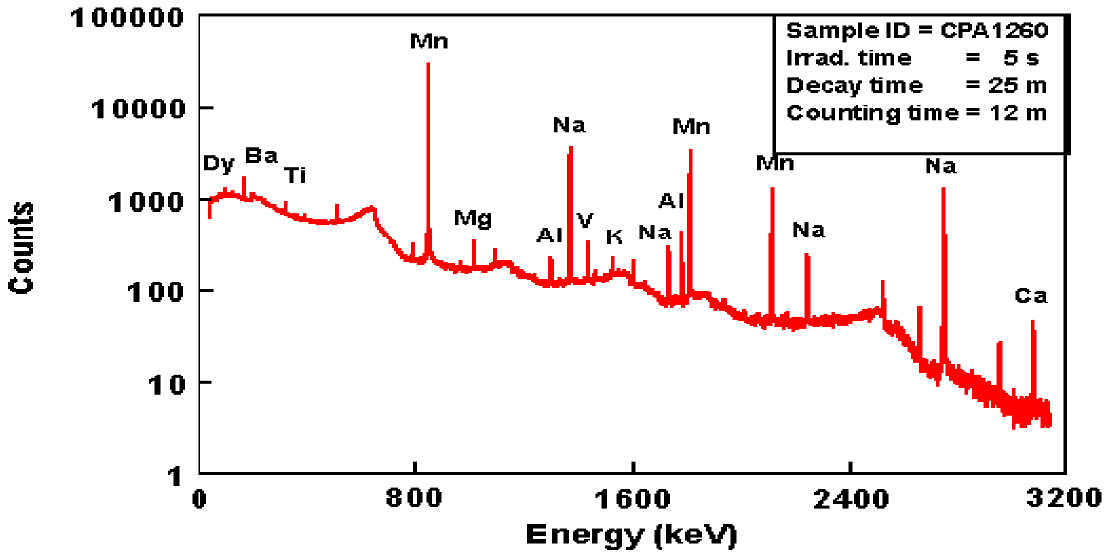


Fig. 3. Gamma-ray spectrum showing several short-lived elements measured in a sample of pottery irradiated for 5 seconds, decayed for 25 minutes, and counted for 12 minutes with an HPGe detector.

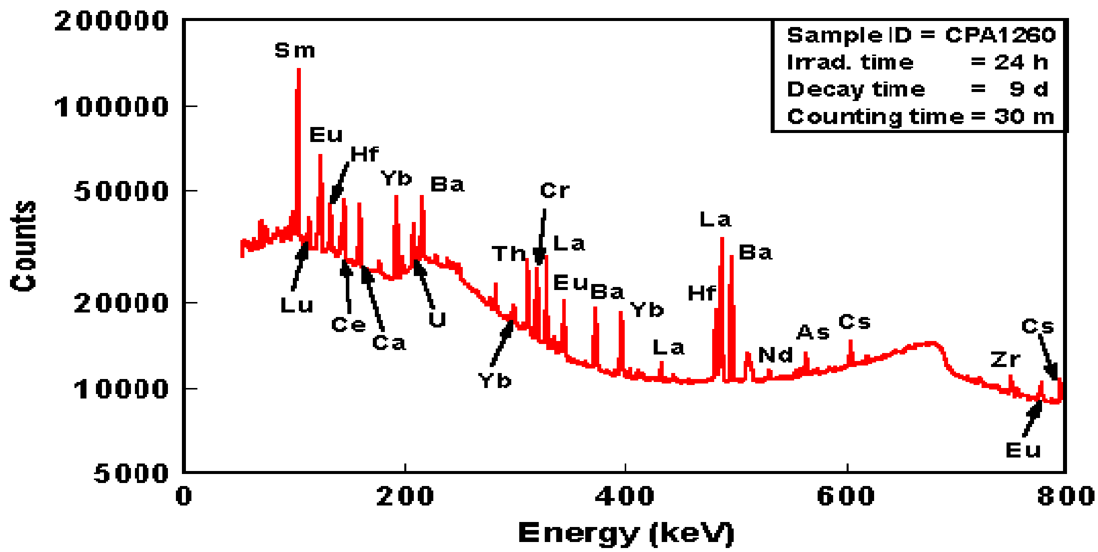


Fig. 4. Gamma-ray spectrum from 0 to 800 keV showing medium- and long-lived elements measured in a sample of pottery irradiated for 24 hours, decayed for 9 days, and counted for 30 minutes on a HPGe detector.

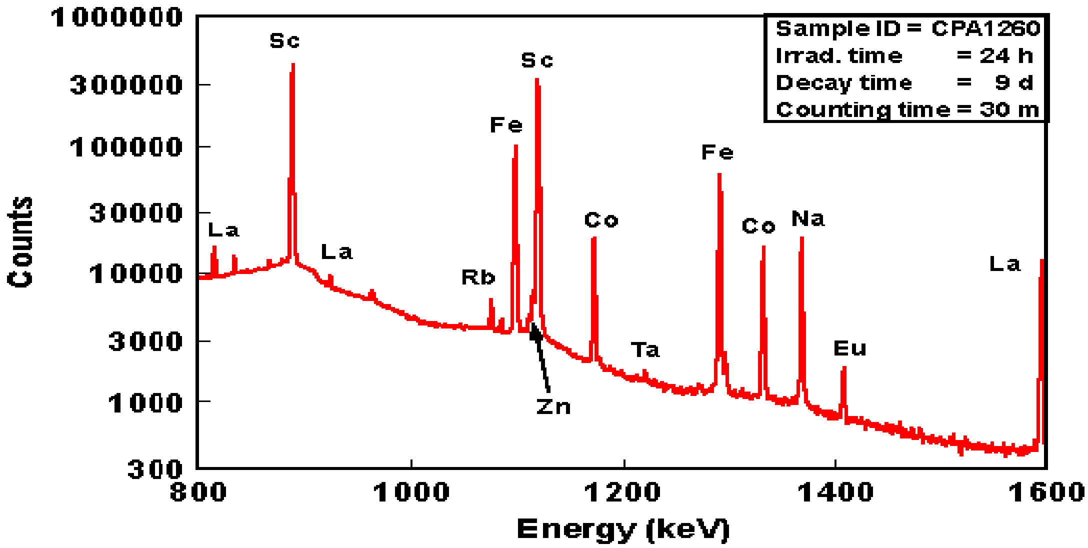


Fig. 5. Gamma-ray spectrum from 800 to 1600 keV showing medium- and long-lived elements measured in a sample of pottery irradiated for 24 hours, decayed for 9 days, and counted for 30 minutes on a HPGe detector.

Using Gamma-ray Counts to Calculate Element Concentration

The procedure generally used to calculate concentration (i.e., ppm of element) in the unknown sample is to irradiate the unknown sample and a comparator standard containing a known amount of the element of interest together in the reactor. If the unknown sample and the comparator standard are both measured on the same detector, then one needs to correct the difference in decay between the two. One usually decay corrects the measured counts (or activity) for both samples back to the end of irradiation using the half-life of the measured isotope. The equation used to calculate the mass of an element in the unknown sample relative to the comparator standard is

$$\frac{A_{sam}}{A_{std}} = \frac{m_{sam}}{m_{std}} \frac{(e^{-\lambda T_d})_{sam}}{(e^{-\lambda T_d})_{std}}$$

where A = activity of the sample (sam) and standard (std), m = mass of the element, λ = decay constant for the isotope and T_d = decay time. When performing short irradiations, the irradiation, decay and counting times are normally fixed the same for all samples and standards such that the time dependent factors cancel. Thus the above equation simplifies into

$$c_{sam} = c_{std} \frac{W_{std}}{W_{sam}} \frac{A_{sam}}{A_{std}}$$

where c = concentration of the element and W = weight of the sample and standard.

Sensitivities Available by NAA

The sensitivities for NAA are dependent upon the irradiation parameters (i.e., neutron flux, irradiation and decay times), measurement conditions (i.e., measurement time, detector efficiency), nuclear parameters of the elements being measured (i.e., isotope abundance, neutron cross-section, half-life, and gamma-ray abundance). The accuracy of an individual NAA determination usually ranges between 1 to 10 percent of the reported value. Table I lists the approximate sensitivities for determination of elements assuming interference free spectra.

Table I. Estimated detection limits for INAA using decay gamma rays. Assuming irradiation in a reactor neutron flux of $1x10^{13}$ n cm^{-2} s^{-1}.

Sensitivity (picograms)	Elements
1	Dy, Eu
1 - 10	In, Lu, Mn
10 - 100	Au, Ho, Ir, Re, Sm, W
100 - 1E3	Ag, Ar, As, Br, Cl, Co, Cs, Cu, Er, Ga, Hf, I, La, Sb, Sc, Se, Ta, Tb, Th, Tm, U, V, Yb
1E3 - 1E4	Al, Ba, Cd, Ce, Cr, Hg, Kr, Gd, Ge, Mo, Na, Nd, Ni, Os, Pd, Rb, Rh, Ru, Sr, Te, Zn, Zr
1E4 - 1E5	Bi, Ca, K, Mg, P, Pt, Si, Sn, Ti, Tl, Xe, Y
1E5 - 1E6	F, Fe, Nb, Ne
1E7	Pb, S

Copied from the Missouri University Research Reactor website
http://www.missouri.edu/~glascock/naa_over.htm

RESEARCH DESIGN .

This Research Design is applicable to any NDOT project involving obsidian or vitrophyre (a technical term for, large and small, and to those involving sources of other tool-stone that are regional in distribution. Obsidian sourcing is, although scientific in scope and methods, still somewhat haphazard. The location of many obsidian sources is problematical. Existing publication of known sources is haphazard and the analysis of artifacts for trace elements is not done often enough. This research is an effort to redress some of those problems.

1. Until just a few years ago, conventional wisdom was such that "everyone knew" there

were only a few obsidian sources. As their actual abundance became apparent, hundreds and thousands of localities were identified. Can we identify the number and location of available sources?

2. Particular obsidian sources may be associated with particular technological manufacturing techniques or artifact types. Can we show any such associations and recognize the cause?

3. Obsidian comes in a variety of colors and textures. Can these be used to visually identify or separate obsidian from different sources used by Great Basin Indians?

4. A premise of the NDOT obsidian-sourcing project is that essential material, such as obsidian, is too universally important to be restricted by tribal boundaries. Obsidian trade should, and does, transcend the official ethnographic boundaries of tribal groups. By studying the distribution of obsidian from specific sources, it should be possible to trace this valuable commodity outward from the source. This in turn gives us a region that must have had a commodity traded in return (i.e., shell, acorns, chert, baskets, etc,...). What patterns of distribution (trade) have been identified by this work?

SITES AND SOURCES INVESTIGATED

Ring Road - 26WA1696, 26WA1697 . The Ring Road project was the first major project undertaken by the NDOT internal archaeology program (Cultural Resource Section, Environmental Services Division). It involved the excavation of several sites in the northwestern Truckee Meadows, near Reno. Artifacts from sites excavated by the Ring Road project (26WA1696, 1697) were sent to Mr. Lee Sappington (Bowers Laboratory of Anthropology, University of Idaho, Moscow and Washington State University, Laboratory of Anthropology) for analysis.

> These artifacts represented a source not in the database (Sappington, personal communication, 1980). No written report was received by NDOT.

Acme Playa - 26MN540 . The Acme Playa site was a multi-component hearth complex in a valley northeast of Mono Lake. Radiocarbon dates ranged from 780 BP to 5,000 BP (Moore 1986:61, 63, 92). Seven artifacts, 26Mn540-90 through 96, were sent to Dr. Richard Hughes for sourcing (ibid, Appendix I: 106). Mt. Hicks source samples were provided to Dr. Hughes, Dr. Michels, and to Mr. Sappington.

> One biface/Elko projectile point tip, 26Mn540-90 was made from obsidian of the Garfield Hills geochemical type (Hughes 1983c). This is called the "Hawthorne Source" by Sappington (1981b), and "Hawthorne" by Tuohy (Hughes 1984:Fig. 10). An Elko Series projectile point, 26Mn540-96 was made of Queen obsidian, from the Truman Meadows/Truman Canyon/Queen Valley area southeast of Mono Lake. The remaining 5

artifacts, flakes and biface fragments, were made from the Mt. Hicks geochemical type, from a source north of Mono Lake. See Table One for trace element analysis.

The trace element analysis suggests that the inhabitants of this site traded with or went to areas along the fringe of the Mono Basin, 80 kilometers to the west.

Some materials were sent to the UCLA Obsidian labs for hydration analysis. The sandblasted surface of these artifacts resulted in unreadable hydration rims (Kaufman, personal communication). The surface had numerous multiple microscopic cracks that produced confusing overlapping hydration rinds.

Pole Line Project - 26MN406 . Twelve obsidian artifacts from a dated hearth/House floor were sent to Dr. Hughes for sourcing. This house was in the Anchorite Hills, near Mono Lake and very close to the Mt. Hicks source (Matranga 1982). There was evidence of pine nut processing, hunting, and tool making. Eleven artifacts were Mt. Hicks obsidian, and one (E-3) was unknown. The proximity of the Mt. Hicks source (15 kilometers) caused it to dominate the tool-stone inventory. Mt. Hicks ejecta also naturally occurred on the surface of the site as small pebbles. Later, further work was done at this site (Matranga 1992). Again, the Mt. Hicks source dominated in eight out of eight items sampled (see Table Eight, this report).

CORRECTIVE NOTE: The calculated hydration rim calendar dates reported for the 26MN406 artifacts above, using rates of 0.515 to $0.53\mu^2$ average between 2930±70BP and 3059±71BP or 3,000 years ago (Green various; NDOT MN 80-177T; Matranga 1993; and Moore 1995: Table Two, Three, and Four) is not a valid date. The established rate is and has always been the $0.84\mu^2$ rate developed by Michels of Mohlab.

The artifacts from 26MN406 are associated with Radiocarbon dates WSU-2660 (2780 ±110BP, Tree-ring corrected to 2960±110), and with Beta-4914 (2880±85BP, Tree-ring corrected to 3085±90). There was a remarkable agreement between the carbon dates and the hydration dates. One of the closest I have ever seen. Unfortunately, the rates were calculated by ignoring the established rate and developing a new rate using the radiocarbon dates and the Friedman and Smith (1960) hydration rate calculation $x^2 = kt$. In this calculation, x is the hydration thickness, k is the hydration rate, and t is equal to time. There already was an established rate for Mt. Hicks obsidian, but Green chose to ignore it in favor of the calculation based on the radiocarbon date. Consequently, the 3,000-year hydration calendar dates, above, are the result of a circular argument (The carbon date was used to determine a rate based on the rim thickness. This rate was then used to calculate the hydration date based on the rim thickness). The reported calendar hydration dates, above, are then not based on the hydration rate but on the carbon dates. They are invalid.

Induced hydration rates were determined by Michels (Mohlab No. 21). Two thermal cells (Ambrose cells #305 & 306) were placed at 26MN406 in 1991 and retrieved in 1992. The results indicate an Effective Hydration Temperature for Mohlab #305 of 285.69°K/12.53°C and for Mohlab #306 of 285.84K/12.68°C (Michels 1992, personal communication). Instead of the hydration rates reported by Green (0.515 to $0.53\mu^2$), the rate was determined to be virtually identical to that from the Mt. Hicks obsidian at the Pine Valley site, or $0.84\mu^2$. This data invalidated the reported hydration dates from 26MN406. The originally calculated hydration rim calendar dates above, averaging 3,000 B.P., based on hydration rim thicknesses of 1.20µ to 1.28µ change to an average of about 1,800 B.P.

(Using the formula “$x^2 = kt$”,
if $x=1.2$, $x^2=1.2^2$ or 1.44,
and $k=0.84$, $1.44/0.84= 1.7142857$ or 1,714 B.P.;
and if $x=1.28$, then $x^2=1.6384$,
and $k=0.84$, then $1.6384/0.84=1.9504761$ or 1,951 B.P.

Unfortunately, this new hydration date of 1800 years± disagrees with the carbon date of 3000±.

Steamboat Hills - 26WA1414 . This site was primarily a workshop for a local tool-stone called "Steamboat Sinter", a hydrothermally deposited siliceous travertine from the Steamboat Hot Springs between Reno and Carson City. The locally quarried material was heat treated at this site in a series of eleven hearth areas. Most of the debitage was the local CCS/sinter. There were smaller amounts of obsidian tools and flakes.

Fifty obsidian artifacts (mostly pressure flakes) were sent to Dr. Richard Hughes for sourcing (Table Five). Of the fifty artifacts submitted, twenty-one were from Mt. Hicks, four were from the Bodie Hills, and three were C.B. Concrete (source specimens were provided by NDOT). Nine artifacts were from unknown sources. Thirteen specimens require additional elemental analyses. Twelve of these resemble the Bodie Hills or Pine Grove Hills sources, but Ba and Ce concentration values would be required for determination. One specimen has concentrations of Rb, Sr, Y, Zr, and Nb that overlap with several geochemical sources from northwestern Nevada (Seven Troughs/Majuba).

This dominance of non-local or exotic sources would appear to show a pattern of preference for exotic tool stone by the people from the Steamboat area; roughly, 76% of the artifacts were made from exotic obsidian, even though a local source (C.B. Concrete) was within fifteen miles. A similar pattern occurred at a site on the south shore of Washoe Lake at 26WA3316 (NDOT WA88-020T). Simple flake tools and *ad hoc* tools were made from locally available material, but elaborately flaked tools and points were made from imported material. The data suggest extensive trade or travel throughout western Nevada and the Mono Basin, in California.

There were also radical differences in the hydration rim measurements between the UCLA OTS and Mohlab readings (see Table Five).

Pine Valley - 26EU48, 26EU51. The artifact hydration dates from 26EU48 and 26EU51, plus that of the house floor at 26MN406, are shown in Dr. Joseph Michels @ Mohlab, Invoice #82, January 18, 1983 (Table Six, below). The obsidian artifacts from these sites came from sources in Paradise Valley, north of Winnemucca, Nevada and about 120 miles northwest of the site, and from the Mt. Hicks, and Pine Grove Hills sources, near the Mono Basin (200 miles southwest). Another artifact came from the Duck Flat source (180 miles west of the site). This supports the idea of extensive trade networks throughout the Great Basin. The Pine Valley sites are in ethnographic Western Shoshone territory, but the sources are in traditional ethnographic Northern Paiute territory. This may be ethnographic error, or represent changing occupancy or different land use patterns through time.

White River, SR 318 artifacts. Two bifaces were collected from SR 318 and analyzed by Dr. Jackson: One was assigned to the Kane Springs source, in this case probably also the nearest source; The other was assigned to an unknown source (See Table One). There are no sources in our combined databases matching that artifact. However, there is a close fit to a Great Basin stem fragment (26NY5996/2) collected from the northeast shore of Pluvial Lake Railroad (Railroad Valley, SR 379). Rubidium and Niobarium match closely at 190.4/194.282 and 27.8/30.629ppm. Strontium and Yttrium are also close at 121.4/126.062 and 31.6/32.496ppm. Zirconium is 27.8/30.629ppm. These variations are within the range of deviation. The other elements were quite different. Both artifacts probably come from a source that remains to be characterized. It probably lies between Railroad Valley and the White River Narrows. The Grant Range divides the two site areas. Dr. Hughes has been investigating glassy sources in the area (1994).

Fish Lake Valley artifacts. Three obsidian bifaces and one basalt Great Basin Stemmed Series point submitted for analysis (NDOT letter 1/27/88, and PO# 37051 dated 1/8/88). The samples were sent to Dr. Hughes.

Clayton Valley/Silverpeak nodular float source and SR 265 ES 9.0, "The Crater" basalt source sample, submitted to Dr. Hughes with the Fish Lake Valley artifacts, above.

Tonopah Lake - 26ES685. Great Basin Stemmed Series point stems were collected for analysis. They were near a prominent rock outcrop on the shores of Pluvial Lake Tonopah. The stems were made from the nearby Silverpeak obsidian (Hughes letter 11/6/87). Hydration rims were measured, but the sandblasted surface rendered them unreadable (Origer letter 12/3/87). See Table Seven for trace element analysis.

Basalt Pit . Source sample sent to Hughes (NDOT letter 6/8/88). This was a sample of pebble-sized obsidian nodules from just east of Montgomery Pass. It is probably related, as ejecta, to the Queen/Truman Meadows source.

I-80 Material pit, Pershing County - 26PE814 . Five projectile points were collected and sent to Dr. Jackson for analysis (NDOT PE 085-88P). They represented three known sources, Majuba (three projectile points), Bordwell Spring (one point), and Pinto Peak (one point). The Majuba (A.K.A. Seven Troughs) source was near the project area, but the Bordwell Spring and Pinto Peak sources are between Summit Lake and the California border. This suggests that there was trade between the Humboldt River near Lovelock, Nevada and the source area near Surprise Valley, California.

> NOTE: Some researchers try to develop visual characteristics to identify obsidian sources in the field or lab, without requiring laboratory analyses. In our experience, this usually does not work. Many of the proponents of visual sourcing have worked around the Casa Diablo source complex. Experience in other areas usually dissuades them. In the case of the artifacts from 26PE814, samples were visually identified as opaque, mahogany, and translucent grey. They were separated by color. The opaque samples came from both Bordwell Spring and Mt. Majuba. The translucent material came from the Pinto Peak source. The Majuba source also produced the mahogany obsidian. The field catalog lumps the samples together by visual characteristics, which would result in attribution to the wrong source.

Dufurrena Grade - 26HU1746. Seven artifacts and fifteen source samples (NDOT HU90-038T) were analyzed by Dr. Tom Jackson of Biosystems Analysis. They were assigned to two geochemical types that occur on the site (NDOT HU90-038T). Some of the samples were opaque and some were mahogany. They were assumed to be from different geochemical sources or events. As it developed, they were from two events, but not what we expected. Both events also occurred as nodular float on the site. One of the types (Group A) had both opaque and mahogany variants. We attempted visual identification but the opaque material occurs as both Group A and as Group B. The mahogany material was visually distinct, but chemically identical to the opaque. A larger sample might show the occurrence of mahogany in both events, also. There were differences in trace elements between visually similar groups (Table Nine). This was another site where visual identification failed, while trace element analysis successfully identified samples.

Railroad Valley - 26NY5996. Two Great Basin Stemmed Series point base fragments were sent to Jackson for analysis. They were assigned to an unknown source (Table Nine).

Spring Valley - 26WP1998 . A projectile point was analyzed and assigned to an unknown source. The trace element analysis data from Table Nine resembles Topaz Mountain and Black Rock Utah sources (Nelson and Holmes 1979:73). The rubidium amounts are much higher in

Utah than in Nevada sources (see Table One, Table Seven, Table Nine, Table Ten, and Table Eleven). This is an area where partial attribution might be possible.

Lathrop Wells. Samples of nodular float were collected by NDOT and analyzed by Biosystems Analysis. These nodules represented an unknown source (Table Nine: Nye-1 through Nye-10).

Kane Springs. Source Samples were collected from the slopes of the southern Meadow Valley Mountains, about twelve miles south of Kane Springs. They were analyzed by Biosystems Analysis as source samples (Table Eleven).

CB Concrete. Source samples were collected and analyzed by Biosystems Analysis (Table Eleven).

Sutro Springs. Source samples were collected and analyzed by Biosystems Analysis (Table Eleven).

Garrison Site . In the early 1950's, when the site was first excavated, trace element analysis was not routinely done by archaeologists. It states in the report "Geologists were also helpful in locating for us the native sources of stone and materials used in the manufacture of artifacts. Thus we are able to say that the brown-flecked obsidian so well represented at the site by chips and projectile points came from an outcropping in the Confusion Range approximately 40 miles from our site" (Taylor 1954:6). The BLM Ely Office contacted NDOT and asked for sponsorship for the trace element analysis of a surface collection from the Garrison Site (Zancanella, personal communication). Three Utah sources were identified (Table Eight): the Black Rock Area, Beaver Mountains, Utah (about sixty miles west of the site, and about twenty miles west of the purported source in the Confusion Range); Schoo Mine/Wild Horse Canyon, Mineral Mountain Range, Utah (about eighty miles southeast of the site); and the Modena Area, Utah (about eighty miles south of the site). It is unsure if any of these samples were the "brown-flecked obsidian" mentioned in the report, but none of them were from the Confusion Range.

Double H Mountains Obsidian Procurement Area. A series of obsidian sources were identified in the Double H Mountains (Table Eleven). These include outcrop and float sources. Some of them produce a distinctive olive green material. This material is one that we had been seeking for more than a decade. The data, below, needs to be placed into a data base format. Sources from this area include:

Pretty Creek
A Pretty Creek source sample was sent to Dr. Richard Hughes 4/13/88. This is a blue/green obsidian/tuff from T.44N., R.35E., Sec. 33, on the Thacker Pass 15' Quad. An amateur collection at Boise State University contains as many as 200 points collected from the Upper Quinn River, made from this material. Most of them are the grey-green type.

Hoppin Spring
A float sample from Hoppin Spring, in T.43N., R.35E., Sec. 24, on the Orovada, Nev. 15' map, was sent to Richard Hughes with our letter of 6/8/88.

Double H Mine Pit
An outcrop sample from the Double H Mine Pit source, in T.43N., R.35E., Sec.3, was sent to Richard Hughes with our letter of 6/8/88.

Thacker Pass
A float sample from the Thacker Pass source, in T.44N., R.35E., Sec. 17, was sent to Dr. Tom Jackson on 6/15/91 (Table Eleven).

QOA Source
A sample from the QOA float source was sent to Dr. Tom Jackson on 6/15/91 (Table Eleven).

Sentinel Rock
A sample of the outcrop in T.44N., R.36E., Sec. 19 on the Sentinel Rock, Nev. 7.5' map, was sent to Dr. Tom Jackson on 6/15/91 (Table Eleven).

Double H Float
A sample was sent to Dr. Tom Jackson on 6/15/91 (Table Eleven).

XRF SUMMARY

Obsidian studies for which the NDOT has provided source samples, maps, artifacts, or funding for trace element analysis and hydration research include, ...

1 Schoo Mine, Black Rock, Wild Horse Canyon, Topaz Mountain, and Modena Utah. Obsidian from these sources are found in Nevada, at the Garrison site, and in the Panaca Summit site complexes.

2 Owyhee (Toy Pass), and Brown's Bench, Idaho. Obsidian from these sources occurs in the Pine Valley area, and in minor surveys in northern Nevada. Brown’s Bench material occurs into Butte and Long Valleys (Beck and Jones 1990:241; Jones and Beck 1990:90)

3 Kane Springs Wash, Sarcobatus Flat/Tolicha Wash/Obsidian Butte, Oreana, Seven Troughs, Paradise Valley, Santa Rosa Mountains/Red Hills, Sentinel Peak, Double H Mountains, Dolly Varden Basin, Poker Brown Wash, Massacre Creek, Catnip, Idaho Canyon, Vya, Duck Flat, Chimney Creek Reservoir, Flowery

Range, C B Concrete, Mt. Hicks, Pine Grove Hills, Queen, Hawthorne, and Queen imposter/Silverpeak, Clayton Valley in Nevada. These sources occur in minor survey areas, Pine Valley, Pole Line, Acme Playa, Sheldon Antelope Range, Washoe Lake, Steamboat area sites.

4 Bodie Hills, Lookout Mountain, Casa Diablo in California. Some of these sources occur in the Pole Line, Steamboat Hills, and Washoe Lake sites

5 Ring Road artifacts were subjected to trace element analysis (sourcing) and hydration analysis.

6 Pine Valley artifacts were sourced and both induced hydration and hydration dating performed.

7 Pole Line artifacts were sourced, induced hydration, and hydration dating performed

8 Washoe Lake artifacts/flakes were sourced. Most of the more elaborate tools, i.e. bifaces and projectile points, were made from exotic obsidians from the Mammoth/Mono area. While local C. B. Concrete obsidian was used for simple tools.

9 Garrison Site. Since XRF analysis was not being performed when the Garrison site was excavated, they assumed that the obsidian came from sources in Utah. NDOT attempted to determine the exact sources for a sample of artifacts on the disturbed surface of the site. See Table Eight. Mark Kodak is also engaged in research on the Garrison Site, and other sites nearby. His XRF data will also be included in his report.

10 26WA1414 artifacts were sourced and analyzed for hydration dates.

11 Acme Playa artifacts were sourced and hydration dated.

12 Dufurrena Grade artifacts were sourced. Local obsidian sent as source sample.

13 Numerous artifacts, especially Great Basin Stemmed Point stem fragments, have been sent for source and hydration analysis. They are usually too patinated for hydration rim analysis. The sources are usually local. Exceptions to this occur. An example would be at the Pine Valley sites, where Mt. Hicks' obsidian occurs nearly 200 miles from the source. It is not uncommon for good raw material to travel hundreds of miles/kilometers.

As a matter of policy, NDOT Cultural Resource Section survey crews (archaeologists) routinely collect source samples and artifacts for trace element studies. When time permits, source samples are collected from around the state and submitted for analysis.

TRACE ELEMENT ANALYSIS TABLES

The following tables show the results of various trace element analyses. Source and attribution data is included with each table.

TABLE ONE . Trace Element Analysis Hawthorne Source and SR 318 Artifacts . Data from Hughes letter reports to NDOT dated March 1, 1983 and July 18, 1989

Table One										
Item #	Pb	Th	Zn	Ga	Rb	Sr	Y	Zr	Nb	Source
SR 318-A Artifact			44.9± 11.3	18.1± 5.0	205.3± 5.8	34.6±3. 0	31.1±2. 6	144.2± 4.6	26.9 ±3.6	Kane Springs
SR 318-B Artifact			112.9±7 .9	19.3± 4.7	190.4± 5.6	121.4± 3.4	31.6±2. 5	156.7± 4.6	27.8±3. 5	unknown
Hawthorne Source Sample	29.7± 4.5	16.4±5. 1	*** La 18.1± 1.5**	*** Ce 40.3± 5.2**	181.7± 3.7	63.7±3. 2	17.4±3. 5	84.8±2. 7	13.9±2. 1	Hawthorne source sample
* Non-standard elements are placed in otherwise empty columns and marked with an asterisk.										

TABLE TWO . Trace Element and Hydration Analysis . Trace element (%/wt.) and hydration analysis (microns per 1000 years [µ/ka]) from Mohlab to NDOT. Mohlab Technical Reports (MTR) and Radiocarbon laboratory number indicated.

Table Two										
Item #	SiO_2	Al_2O_3	Na_2O	K_2O	$FE_2O_3^T$	CaO	MgO	TiO_2	Radio-carbon date (C^{14})	Hydration Rate/ 1000 years
Pine Grove Hills @ Pine Valley 26EU48	76.4	13.46	3.97	4.72	0.51	0.71	0.07	0.16	MTR 22	0.59µ
Pine Grove Hills @ Mono Lake 26MN406									**WSU2660** 2780 ±110 BP **Beta-4914** 2880±85 BP	0.53µ
Mt. Hicks @ Pine Valley	77.2	12.89	3.98	4.72	0.51	0.44	0.07	0.16	MTR 21	0.84µ

TABLE THREE
Trace Element Analysis 26ES685
Great Basin Stemmed Series point bases (stems) from the margin of Pluvial Lake Tonopah in Esmeralda County. Data from Hughes letter report November 6, 1987

Item #	Zn	Ga	Rb	Sr	Y	Zr	Nb	Fe/Mn	Source (chemical type)
26ES685-1	46.9 ±9.3	13.1 ±6.4	149.7 ±5.4	89.3 ±3.2	14.8 ±2.9	182.4 ±4.7	15.4 ±3.5	46.6	Casa Diablo
26ES685-2	61.3 ±7.4	15.0 ±5.1	169.9 ±5.4	19.4 ±2.9	30.7 ±2.4	133.7 ±4.4	36.3 ±3.5	19.2	Queen imposter
26ES685-3	52.3 ±8.3	21.4 ±4.1	177.4 ±5.6	20.6 ±2.9	28.8 ±2.5	146.7 ±4.6	35.7 ±3.6		Queen impostor
26ES685-4	46.9 ±8.1	13.4 ±5.7	148.2 ±5.4	112.0 ±3.3	17.9 ±2.6	188.5 ±4.7	12.6 ±3.5		Casa Diablo

TABLE FOUR
Garrison Site Trace Element Analysis (ppm)

Data from Hughes letter report dated July 18, 1989. All sources are located in Utah.

Item #	Zn	Ga	Rb	Sr	Y	Zr	Nb	Fe/Mn	Source chemical type
Basin #2a	69.8 ±11.8	18.7 ±7.1	264.3 ±7.5	13.5 ±3.2	52.7 ±3.2	104.3 ±4.9	30.7 ±4.2		Black Rock Area
Basin #2b	51.9 ±8.9	18.9 ±4.5	269.9 ±5.8	11.6 ±2.9	50.0 ±2.4	93.1 ± 4.2	26.3 ±3.5		Black Rock Area
Basin #2c	40.9 ±12.0	23.6 ±4.3	206.4 ±5.8	45.2 ±3.0	25.6 ±2.6	122.9 ±4.5	26.4 ±3.6		Schoo Mine/ Wild Horse Canyon
Basin #2d	48.3 ±8.6	15.3 ±5.0	166.2 ±5.3	55.4 ±2.9	24.5 ±2.4	120.2 ±4.3	23.8 ±3.4		Unknown
Mound #1a	34.9 ±14.4	20.8 ±4.5	188.4 ±5.6	37.5 ±2.9	23.3 ±2.5	109.9 ±4.4	21.6 ±3.5		Schoo Mine /Wild Horse Canyon
Mound #1b	47.0 ±9.8	13.3 ±7.1	200.9 ±5.6	42.2 ±2.9	21.7 ±2.5	114.7 ±4.4	24.3 ±3.5		Schoo Mine /Wild Horse Canyon

Mound #1c	58.6 ±8.7	14.4 ±6.4	197.1 ±5.6	45.4 ±2.9	22.5 ±2.5	111.5 ±4.4	27.5 ±3.5		Schoo Mine /Wild Horse Canyon
Mound #1d	59.1 ±10.0	17.7 ±5.6	211.2 ±6.0	41.2 ±3.1	24.0 ±2.8	118.4 ±4.6	21.2 ±3.7		Schoo Mine /Wild Horse Canyon
Mound #1e	62.9 ±11.0	20.6 ±5.7	283.1 ±7.0	11.1 ±3.2	54.2 ±3.0	102.4 ±4.7	31.2 ±3.9		Black Rock Area
Mound #1f	60.9 ±10.0	15.6 ±6.8	202.3 ±6.0	42.0 ±3.1	25.5 ±2.7	118.6 ±4.6	22.9 ±3.7		Schoo Mine /Wild Horse Canyon
Mound #2a	60.5 ±8.8	22.1 ±4.4	262.2 ±5.8	09.8 ±2.9	53.1 ±2.4	100.3 ±4.2	30.2 ±3.5		Black Rock Area
Mound #2b	38.4 ±13.1	14.0 ±7.0	188.8 ±5.5	40.2 ±2.9	23.6 ±2.5	112.1 ±4.4	26.2 ±3.5		Schoo Mine /Wild Horse Canyon
Mound #2h	57.8 ±10.8	24.7 ±4.8	280.3 ±6.5	12.2 ±3.0	54.8 ±2.7	99.0 ±4.5	35.7 ±3.7		Black Rock Area
Mound #3a	60.9 ±10.8	16.4 ±6.7	260.1 ±6.7	11.5 ±3.1	50.5 ±2.9	99.3 ±4.6	24.6 ±3.9		Black Rock Area
Mound #3b	46.2 ±10.4	15.8 ±5.8	176.7 ±5.7	39.4 ±3.0	21.4 ±2.6	109.3 ±4.4	22.7 ±3.6		Schoo Mine/ Wild Horse Canyon
Mound #3c	64.1 ±7.6	19.1 ±4.4	186.3 ±5.5	40.9 ±2.9	25.1 ±2.4	116.5 ±4.3	29.4 ±3.4		Schoo Mine /Wild Horse Canyon
Mound #4/ Basin 1a	54.6 ±11.3	26.1 ±4.8	215.6 ±6.0	87.9 ±3.3	29.4 ±2.7	136.3 ±4.7	22.4 ±3.7		Modena Area
Mound #4/ Basin 1b	57.7 ±9.3	10.9 ±13.7	187.7 ±5.6	40.7 ±2.9	25.8 ±2.5	109.2 ±4.4	30.5 ±3.5		Schoo Mine /Wild Horse Canyon

Mound #4/ Basin 1c	64. 5±10.0	20.6 ±5.1	205.8 ±6.1	41.5 ±3.1	27.0 ±2.8	117.4 ±4.6	27.3 ±3.7		Schoo Mine /Wild Horse Canyon
Mound #4/ Basin 1d	55.4 ±10.4	17.4 ±5.9	207.1 ±6.0	85.8 ±3.4	33.7 ±2.6	125.7 ±4.7	23.1 ±3.7		Modena Area
Mound #4/ Basin 1e	61.3 ±9.8	20.8 ±5.1	216.3 ±6.0	42.3 ±3.1	27.8 ±2.7	124.6 ±4.6	23.3 ±3.7		Schoo Mine /Wild Horse Canyon
Mound #5/ Basin 3a	57.1 ±10.1	22.8 ±4.8	292.0 ±5.9	08.7 ±2.9	58.1 ±2.4	102.8 ±4.2	35.6 ±3.4		Black Rock Area
Mound #5 Basin 3b	48.1 ±13.1	25.9 ±5.2	263.8 ±6.3	12.0 ±3.0	50.2 ±2.6	98.5 ±4.4	28.8 ±3.6		Black Rock Area
Mound #5 Basin 3c	51.7 ±12.7	18.4 ±6.5	257.6 ±6.2	12.8 ±3.0	49.3 ±2.6	103.5 ±4.4	28.4 ±3.6		Black Rock Area
Mound #5/ Basin 3d	54.0 ±10.6	18.9 ±5.4	187.0 ±5.6	40.9 ±3.0	26.2 ±2.5	116.9 ±4.4	26.5 ±3.5		Schoo Mine /Wild Horse Canyon
Mound #5/ Basin 3e	41.4 ±14.1	21.7 ±5.2	253.0 ±6.1	11.1 ±3.0	52.5 ±2.6	95.5 ±4.4	28.8 ±3.6		Black Rock Area
Mound #5/ Basin 3f	53.3± 11.9	25.4 ±4.9	270.3 ±6.4	17.7 ±2.9	53.3 ±2.7	100.8 ±4.5	32.0 ±3.7		Black Rock Area
Mound #5/ Basin 3g	47.6± 12.0	15.5 ±6.8	205.4 ±5.9	47.2 ±3.0	24.7 ±2.6	129.7 ±4.5	22.1 ±3.6		Schoo Mine /Wild Horse Canyon
Mound #5/ Basin 3h	60.2± 11.3	16.3 ±6.6	274.8 ±6.6	16.0 ±3.0	47.8 ±2.8	98.0 ±4.5	30.8 ±3.8		Black Rock Area
Mound #5/ Basin 3i	47.3± 12.2	21.1 ±5.9	208.3 ±5.9	40.5 ±3.0	25.3 ±2.7	116.5 ±4.6	29.6 ±3.6		Schoo Mine /Wild Horse Canyon
Mound #2c	46.0± 11.1	22.8 ±4.5	252.8 ±5.9	14.3 ±2.9	51.9 ±2.5	106.0 ±4.3	27.0 ±3.5		Black Rock Area
Mound #2d	63.3± 8.9	22.7 ±4.4	284.5 ±6.2	10.8 ±3.0	52.1 ±2.6	98.7 ±4.3	29.7 ±3.6		Black Rock Area

Mound #2e	50.5± 10.5	17.5 ±5.6	197.4 ±5.8	42.6 ±3.0	24.2 ±2.7	116.5 ±4.5	22.5 ±3.6		Schoo Mine /Wild Horse Canyon
Mound #2f	39.8± 14.7	15.3 ±7.0	191.1 ±6.0	44.3 ±3.1	27.0 ±2.7	120.3 ±4.7	20.9 ±3.8		Schoo Mine /Wild Horse Canyon
Mound #2g	68.7± 10.8	24.2 ±5.2	291.2 ±7.0	08.3 ±3.4	54.6 ±2.9	103.3 ±4.6	30.6 ±3.9		Black Rock Area

TABLE FIVE TRACE ELEMENT ANALYSIS (PPM) 26HU1746 Data from Jackson letter report dated 10 April, 1991.								
Item #	Pb	Th	Rb	Sr	Y	Zr	Nb	S.G.T
Note: Trace element composition for artifacts from 26HU1746 are identical to source samples found at the site location. Group B material resembles Hughes' Massacre Lake/Guano Valley source geochemical type (S.G.T).								
26Hu1746/01-01 Denio/ Dufurrena Grade site	22.477 ± 2.9801	27.051 ± 2.3433	218.237 ± 2.6146	21.765 ± 5.5656	41.829 ± 1.8845	143.249 ± 7.087	27.116 ± 1.7756	Group A
26Hu1746/02-04	35.455 ± 2.8592	28.447 ± 2.1507	222.799 ± 2.3634	2.219 ± 5.627	92.407 ± 1.8618	591.917 ± 7.3109	32.105 ± 1.6733	Group B
26Hu1746/04-03	30.519 ± 3.0009	24.780 ± 2.2686	213.377 ± 2.4853	2.410 ± 5.629	88.414 ± 1.9692	574.245 ± 7.3811	31.608 ± 1.7645	Group B
26Hu1746/11-04	25.050 ± 2.6668	24.937 ± 2.0359	210.995 ± 2.2463	21.320 ± 5.5404	41.055 ± 1.6646	143.024 ± 7.0195	27.126 ± 1.5803	Group A
26Hu1746/19-1	33.270 ± 2.9899	24.015 ± 2.2003	222.145 ± 2.4591	3.413 ± 5.5702	87.290 ± 1.9203	580.574 ± 7.3661	30.926 ± 1.7366	Group B
26Hu1746/22-01	36.030 ± 2.8156	26.954 ± 2.1360	222.952 ± 2.3280	1.610 ± 5.8345	88.356 ± 1.8390	596.715 ± 7.2900	33.620 ± 1.6418	Group B
26Hu1746/22-02	34.046 ± 2.7615	27.627 ± 2.0229	205.014 ± 2.2463	3.103 ± 5.5563	83.402 ± 1.7908	565.352 ± 7.2580	29.888 ± 1.6339	Group B
26Hu1746/S1 Denio/ Dufurrena Grade Source sample	29.707 ± 2.9219	21.433 ± 2.1829	212.677 ± 2.2481	ND	87.175 ± 1.7933	573.706 ± 7.2421	33.194 ± 1.6227	on-site S.G.T B
26Hu1746 /S2 Source sample	25.613 ± 2.8275	29.147 ± 2.1533	236.546 ± 2.3660	26.763 ± 5.5477	43.535 ± 1.7311	151.296 ± 7.0354	23.360 ± 1.6399	on-site S.G.T A
26Hu1746/S3 Source sample	32.417 ± 2.7774	24.952 ± 2.0826	217.915 ± 2.2225	ND	88.872 ± 1.7646	590.058 ± 7.2323	32.996 ± 1.5944	on-site S.G.T B
26Hu1746/S4 Source sample	25.666 ± 2.7173	28.901 ± 2.0949	219.024 ± 2.3326	21.332 ± 5.5484	41.317 ± 1.7228	144.558 ± 7.0343	27.537 ± 1.6273	on-site S.G.T A
26Hu1746/S5 Source sample	36.242 ± 2.8053	21.190 ± 2.1038	226.737 ± 2.3052	2.877 ± 5.5668	93.337 ± 1.8139	601.163 ± 7.2783	27.627 ± 1.6314	on-site S.G.T B

26Hu1746/S6 Source sample	34.142 ± 2.8497	29.285 ± 2.0928	214.580 ± 2.3244	2.124 ± 5.6273	86.495 ± 1.8428	587.301 ± 7.2969	28.954 ± 1.6746	on-site S.G.T B
26Hu1746/S7 Source sample	25.022 ± 2.6604	26.521 ± 2.0078	219.937 ± 2.2563	21.761 ± 5.5426	40.773 ± 1.6710	144.862 ± 7.0191	28.051 ± 1.5843	on-site S.G.T A
26Hu1746/S8 Source sample	35.791 ± 2.7677	25.256 ± 2.0747	224.414 ± 2.2728	ND	90.786 ± 1.7951	596.368 ± 7.2590	28.832 ± 1.6218	on-site S.G.T B
26Hu1746/S9 Source sample	34.883 ± 2.7426	27.959 ± 2.0268	221.478 ± 2.2403	3.011 ± 5.5543	88.377 ± 1.7724	594.510 ± 7.2420	32.722 ± 1.5959	on-site S.G.T B
26Hu1746/S10 Source sample	31.598 ± 2.7849	28.347 ± 2.0159	208.747 ± 2.2383	1.821 ± 5.6729	86.330 ± 1.7870	574.938 ± 7.2515	33.538 ± 1.6178	on-site S.G.T B
26Hu1746/S11 Source sample	31.915 ± 2.8907	24.817 ± 2.1567	226.211 ± 2.3757	2.580 ± 5.5824	89.214 ± 1.8702	598.429 ± 7.3199	32.419 ± 1.6717	on-site S.G.T B
26Hu1746/S12 Source sample	32.643 ± 2.7163	24.660 ± 2.0099	212.517 ± 2.2146	2.208 ± 5.5927	90.770 ± 1.7577	583.944 ± 7.2338	30.120 ± 1.5990	on-site S.G.T B
26Hu1746/S13 Source sample	34.409 ± 2.7506	33.651 ± 2.0050	213.462 ± 2.2506	2.366 ± 5.5873	87.831 ± 1.7877	574.222 ± 7.2562	32.341 ± 1.6185	on-site S.G.T B
26Hu1746/S14 Source sample	22.698 ± 2.6752	26.799 ± 1.9912	213.828 ± 2.2527	22.255 ± 5.5406	40.439 ± 1.6763	140.886 ± 7.0214	27.324 ± 1.5873	on-site S.G.T A
26Hu1746/S15 Source sample	35.007 ± 2.7455	32.114 ± 2.0133	221.700 ± 2.2454	2.699 ± 5.5664	89.379 ± 1.7775	590.762 ± 7.2486	33.071 ± 1.5968	on-site S.G.T B
26Mn406/00A-1 Pole Line House	36.840 ± 2.6572	22.571 ± 1.9905	153.584 ± 2.0805	23.054 ± 5.5437	12.925 ± 1.6361	88.935 ± 7.0080	20.224 ± 1.5836	Mt. Hicks
26Mn406/00A-2	34.305 ± 2.6942	17.952 ± 1.9813	160.040 ± 2.0615	22.468 ± 5.5404	14.073 ± 1.6081	90.681 ± 7.0002	20.685 ± 1.5465	Mt. Hicks
26Mn406/00A-3	40.178 ± 2.9716	31.771 ± 2.2246	164.668 ± 2.4110	27.213 ± 5.5675	13.191 ± 1.8468	93.564 ± 7.0695	19.155 ± 1.7899	Mt. Hicks
26Mn406/00B-1	36.770 ± 2.6738	20.479 ± 1.9797	160.322 ± 2.0827	24.869 ± 5.5431	13.540 ± 1.6246	91.000 ± 7.0031	21.374 ± 1.5531	Mt. Hicks

26Mn406/00B -2	33.543 ± 2.6770	20.356 ± 1.9532	154.150 ± 2.0332	24.054 ± 5.5404	13.525 ± 1.6005	90.148 ± 6.9964	20.443 ± 1.5446	Mt. Hicks
26Mn406/00B -3	35.227 ± 2.8059	27.929 ± 2.0767	171.993 ± 2.2216	25.146 ± 5.5519	14.497 ± 1.6976	94.342 ± 7.0261	19.884 ± 1.6434	Mt. Hicks
26Mn406-55	32.294 ± 2.8436	23.307 ± 2.1253	152.043 ± 2.1058	22.879 ± 5.5491	15.338 ± 1.6294	87.639 ± 7.0097	21.416 ± 1.5807	Mt. Hicks
26Mn406-56	33.456 ± 2.6650	20.438 ± 2.0024	172.896 ± 2.0963	18.509 ± 5.5385	21.296 ± 1.6285	132.362 ± 7.0118	37.252 ± 1.5813	Queen
26Pe814-A1	22.591 ± 2.6520	14.772 ± 1.9342	151.515 ± 2.0394	117.196 ± 5.6111	20.568 ± 1.5986	170.940 ± 7.0338	10.056± 1.5420	Majuba
26Pe814-A2	35.495 ± 2.8947	22.174 ± 2.0147	188.660 ± 2.2028	1.660 ± 5.7746	88.354 ± 1.7845	490.870 ± 7.2110	28.468 ± 1.6160	Pinto Peak
26Pe814-B1	28.669 ± 2.9143	13.614 ± 2.0514	153.566 ± 2.1998	2.203 ± 5.6214	59.229 ± 1.7846	381.872 ± 7.2060	19.854 ± 1.6809	Bordwell Spring
26Pe814-B2	23.953 ± 2.6668	15.045 ± 1.9862	155.739 ± 2.0867	119.695 ± 5.6166	18.508 ± 1.6199	172.877 ± 7.0430	11.805 ± 1.5488	Ma-juba
26Pe814-C	27.369 ± 2.7277	18.611 ± 1.9972	164.594 ± 2.2145	123.626 ± 5.6477	20.824 ± 1.6873	181.023 ± 7.0759	12.065 ± 1.6263	Ma-juba
26Ny5996/1 Great Basin point stem	31.014 ± 2.7520	20.957 ± 2.1322	187.306 ± 2.1521	38.180 ± 5.5559	18.635 ± 1.6487	119.124 ± 7.0097	22.640 ± 1.5587	Not in data base
26Ny5996/2 Great Basin point stem	25.380 ± 2.7032	16.778 ± 2.0708	194.282 ± 2.1934	123.062 ± 5.6255	32.496 ± 1.6609	168.500 ± 7.0440	30.629 ± 1.5825	Not in data base
26Wp 1998 Isolated point	36.850 ± 3.0297	22.730 ± 2.4998	387.357 ± 3.4611	1.612 ± 6.0839	81.508 ± 2.2549	87.661 ± 7.0898	18.663 ± 1.8706	Not in data base
Nye-1 Lathrop Wells nodular float	25.268 ± 2.6479	25.577 ± 2.0605	195.702 ± 2.1493	84.482 ± 5.5821	26.235 ± 1.6328	218.577 ± 7.0477	27.519 ± 1.5580	source sample
Nye-2	27.883 ± 2.6349	32.707 ± 2.0418	203.043 ± 2.2049	81.061 ± 5.5846	29.193 ± 1.6457	224.677 ± 7.0613	27.736 ± 1.5724	source sample
Nye-3	27.553 ± 2.7023	32.519 ± 2.0947	204.181 ± 2.2645	81.859 ± 5.5926	25.763 ± 1.6921	225.219 ± 7.0758	25.486 ± 1.6250	source sample
Nye-4	32.324 ± 2.7647	31.086 ± 2.1753	222.661 ± 2.3608	83.914 ± 5.6049	27.114 ± 1.7143	228.618 ± 7.0921	27.489 ± 1.6395	source sample

Nye-5	25.957 ± 2.6871	29.001 ± 2.1080	198.993 ± 2.2732	85.091 ± 5.5986	28.196 ± 1.6826	220.360 ± 7.0752	25.677 ± 1.6226	source sample
Nye-6	27.952 ± 2.7356	30.178 ± 2.1803	203.599 ± 2.3392	81.102 ± 1.7356	25.102 ± 1.7356	220.950 ± 7.0966	28.696 ± 1.6662	source sample
Nye-7	29.377 ± 2.6557	32.953 ± 2.0877	209.421 ± 2.2503	83.728 ± 5.5896	27.570 ± 1.6712	224.971 ± 7.0687	28.523 ± 1.0687	source sample
Nye-8	28.385 ± 2.7245	33.793 ± 2.1141	210.094 ± 2.2810	81.224 ± 5.5932	28.607 ± 1.6857	228.378 ± 7.0788	30.378 ± 1.6193	source sample
Nye-9	27.237 ± 2.5897	30.387 ± 1.9864	204.268 ± 2.1285	78.970 ± 5.5733	26.207 ± 1.6084	221.312 ± 7.0398	28.257 ± 1.5280	source sample
Nye-10	28.046 ± 2.8210	33.260 ± 2.2904	223.971 ± 2.4888	88.010 ± 5.6250	28.119 ± 1.8150	233.997 ± 7.1319	32.144 ± 1.7269	source sample

TABLE SIX
XRF ANALYSIS FOR ASSORTED NEVADA SITES .
Data from Dr. Tom Jackson (BIOSYSTEMS ANALYSIS INC.) Letter Reports to NDOT, 1991, 1992

Sample#	ZN	GA	PB	TH	RB	SR	Y	ZR	NB	SOURCE
26Ek5165	These artifacts are from a site with Shoshone pottery, near the Franklin River in the north end of the Ruby Valley, Nevada.									
1 ±	53.9 5.7	15.2 3.4	31.2 2.9	40.0 4.1	218.8 2.7	48.0 6.6	66.0 1.8	434.6 6.3	42.5 2.4	Browns Bench
2 ±	45.8 5.1	18.8 2.8	27.7 2.4	22.4 3.3	124.2 2.3	72.9 6.6	32.5 1.6	103.6 6.0	12.6 2.6	unknown A
3 ±	67.8 4.8	18.8 2.8	28.6 2.3	36.4 3.6	214.9 2.5	54.8 6.6	61.3 1.7	449.3 6.3	48.7 2.2	Browns Bench
4 ±	37.5 4.3	11.4 2.2	30.2 1.9	20.6 2.8	123.6 2.1	72.0 6.6	33.9 1.4	103.6 5.9	14.3 2.3	unknown A
26Ek5797	These artifacts are from a site with Desert Side-notch Series points, near Elko, Nevada.									
1 ±	59.1 4.9	25.7 2.7	36.4 2.2	42.4 3.6	218.9 2.6	54.4 6.6	66.9 1.7	454.3 6.3	42.6 2.3	Browns Bench
2 ±	70.2 4.8	23.7 2.5	28.6 2.3	37.2 3.6	231.0 2.6	52.2 6.6	67.7 1.7	433.7 6.3	48.0 2.3	Browns Bench
26Ek5798	These artifacts are from a site with Elko Series points in the Goshute Valley, Nevada.									
1 ±	67.9 4.8	12.8 2.6	33.2 2.1	36.6 3.6	220.2 2.6	57.1 6.6	62.8 1.8	459.3 6.4	49.2 2.3	Browns Bench
2 ±	59.8 4.8	22.9 2.6	34.5 2.2	42.1 3.5	237.4 2.6	58.3 6.6	68.1 1.7	483.1 6.3	51.3 2.2	Browns Bench
26Ek5799	These artifacts are from a site with Great Basin Stemmed Series points on a terrace above Pluvial Lake Bonneville, near Wendover, Utah/Nevada.									
1 ±	116.2 5.0	21.4 2.4	27.0 2.1	32.0 3.3	215.7 2.5	53.2 6.5	60.8 1.7	441.0 6.3	46.8 2.2	Browns Bench
2 ±	69.2 4.6	20.7 2.3	32.4 1.9	36.5 3.2	226.4 2.4	49.8 6.5	66.5 1.6	437.2 6.2	51.8 2.1	Browns Bench
3 ±	87.6 4.6	18.9 2.4	34.4 2.1	35.3 3.2	181.9 2.4	75.0 6.6	67.4 1.6	580.8 6.4	61.4 2.2	unknown B
26Es855	These artifacts are from the playa resulting from the desiccation of Pluvial Lake Tonopah, near Millers, Nevada.									

1 ±	25.5 4.5	18.3 2.0	22.8 1.9	27.2 3.0	206.4 2.4	12.9 6.5	25.2 1.5	109.7 5.9	32.9 2.1	Crow Springs
2 ±	43.4 4.2	16.7 2.1	35.7 1.9	28.4 3.1	318.5 2.6	5.2 6.9	44.7 1.6	119.1 5.9	42.5 2.1	unknown C
3 ±	27.3 4.4	20.6 2.0	28.8 1.7	35.6 3.0	264.5 2.5	11.3 6.5	19.0 1.5	110.5 5.9	37.8 2.1	Crow Springs
26Hu2219	These artifacts are from site 26HU2219, containing Humboldt and Elko Series points. It is on the west shore of Continental Lake, near Denio, Nevada.									
1 ±	139.8 4.8	23.8 2.2	36.0 2.1	25.8 2.9	220.3 2.4	6.3 6.6	89.4 1.6	544.4 6.3	38.7 2.1	Group B
2 ±	135.1 5.5	18.5 3.2	30.1 2.8	31.4 3.5	217.0 2.4	4.8 7.7	83.9 1.6	532.7 6.3	33.8 2.2	Group B
3 ±	46.9 4.8	20.6 2.5	19.6 2.2	16.1 2.7	147.5 2.2	138.7 6.6	20.2 1.5	167.6 6.0	11.8 2.4	unknown D
4 ±	134.4 5.3	19.6 2.8	33.6 2.4	28.1 3.1	208.9 2.0	00.0 00.0	84.7 1.7	523.4 6.4	36.1 2.2	Group B
5 ±	134.1 5.1	21.4 2.7	37.7 2.3	32.4 3.1	211.4 2.5	7.0 6.6	84.4 1.7	537.3 6.4	39.6 2.2	Group B
CrNV-1-2641	unknown provenience.									
1 ±	70.1 4.5	18.9 2.5	32.7 2.1	36.7 3.4	220.9 2.5	48.1 6.5	62.9 1.7	416.6 6.2	47.5 2.2	Browns Bench
SR490-White Pine County	This artifact was an isolated biface-thinning-flake from east of the Hercules Gap, near Ely, Nevada.									
1 ±	68.6 4.9	32.3 2.6	34.3 2.3	20.1 3.1	384.7 3.3	6.1 6.7	77.6 1.9	96.8 6.0	24.0 2.4	unknown E
Calibration	These are the readings for the standard reference. They are included for calibration.									
RGM-1	38.9 3.9	14.8 1.9	23.7 1.7	17.1 2.3	145.7 2.0	105.3 6.6	23.5 1.3	214.6 6.0	6.0 2.8	standard
NOTE: unknown A, B, C, D, E are unknown sources. Discrimination is hypothetical.										

The following, Table Seven, contains data on trace element concentration values for nodular float sources that were collected from sources within the State of Nevada.

TABLE SEVEN
TRACE ELEMENT CONCENTRATION VALUES FOR NODULES FROM NEVADA FLOAT SOURCES .
Data from Dr. Tom Jackson (BIOSYSTEMS ANALYSIS INC.) letter reports to NDOT, 1992.

Sample #	ZN	GA	PB	TH	RB	SR	Y	ZR	NB	Source Attribution
Jackpot	Float nodules collected from south of Jackpot on US 93 Elko County, Nevada.									
1 ±	60.2 5.3	13.3 3.1	36.8 2.4	40.6 3.7	210.9 2.5	51.9 6.6	62.3 1.7	439.2 6.2	48.5 2.2	Browns Bench (BB)
2 ±	53.5 4.9	20.5 2.7	29.6 2.4	41.0 3.6	214.3 2.5	51.1 6.5	62.5 1.6	437.0 6.2	44.5 2.2	BB
3 ±	60.8 4.2	15.6 2.3	28.5 2.0	35.4 3.1	211.4 2.3	47.2 6.5	59.3 1.5	402.0 6.1	47.9 2.1	BB
4 ±	72.1 4.4	23.0 2.4	30.3 2.1	39.4 3.3	219.2 2.4	50.1 6.5	63.5 1.6	439.4 6.2	49.7 2.2	BB
5 ±	57.6 4.3	25.6 2.3	33.8 2.0	34.2 3.1	210.4 2.3	51.8 6.5	64.6 1.5	434.9 6.2	45.8 2.1	BB
6 ±	65.0 4.9	24.3 2.7	31.5 2.3	32.5 3.8	226.2 2.8	51.4 6.6	63.0 1.8	435.7 6.4	45.2 2.4	BB
7 ±	67.4 5.5	20.7 3.1	30.8 2.6	42.4 4.2	218.2 2.9	54.1 6.6	62.0 2.0	448.4 6.5	44.2 2.6	BB
8 ±	60.9 4.3	18.5 2.4	34.0 2.0	43.2 3.3	221.4 2.4	50.1 6.5	64.1 1.6	409.3 6.2	45.7 2.2	BB
9 ±	50.1 4.7	25.3 2.5	33.8 2.1	38.8 3.6	219.6 2.6	49.3 6.6	61.7 1.7	420.2 6.3	47.5 2.3	BB
10 ±	55.5 4.5	20.0 2.4	26.2 2.1	31.6 3.4	208.1 2.5	46.4 6.5	61.9 1.7	401.8 6.2	51.1 2.3	BB
11 ±	64.4 5.9	18.5 3.5	29.8 3.0	34.5 4.4	225.0 3.2	54.1 6.6	59.5 2.1	424.6 6.6	46.2 2.8	BB
13 ±	67.0 5.0	15.1 3.0	30.2 2.5	38.8 4.1	226.5 2.9	54.0 6.6	68.8 2.0	426.6 6.5	49.0 2.6	BB
14 ±	63.9 4.6	15.4 2.4	27.3 2.1	34.6 3.3	217.3 2.5	54.6 6.5	65.3 1.6	455.5 6.3	47.2 2.2	BB

15 ±	65.0 4.7	26.0 2.7	31.8 2.2	33.6 3.4	209.0 2.6	47.8 6.6	62.6 1.7	439.1 6.3	46.8 2.3	BB
16 ±	56.8 4.8	19.6 2.6	29.6 2.3	36.3 3.6	205.5 2.6	45.7 6.6	65.3 1.7	407.8 6.3	44.9 2.4	BB
RGM	Reference standard - This sample is run for calibration purposes.									
1 ±	39.1 3.9	15.1 1.9	20.4 1.7	15.5 2.3	150.2 2.0	105.2 6.6	24.0 1.3	215.7 6.0	7.5 2.5	Reference Standard
Double H	Double H Mountains float and outcrop sources, near Orovada on SR 293, Humboldt County, Nevada.									
HH-1	Sentinel Rock outcrop source (26Hu1989). Green and black banded nodules from the north side of a road cut at SR 293 HU 15.0									
1 ±	200.9 6.7	17.6 3.7	45.1 3.4	28.5 3.9	209.0 2.7	8.7 6.7	88.5 1.9	486.4 6.5	36.8 2.4	source sample
2 ±	205.8 6.1	29.7 3.2	44.4 2.9	28.1 3.4	219.4 2.5	5.6 6.9	93.9 1.8	516.1 6.4	37.0 2.3	source sample
3 ±	196.0 6.8	33.8 3.5	42.6 3.2	26.6 3.8	204.3 2.8	4.5 9.9	92.4 2.0	497.2 6.6	37.1 2.5	source sample
4 ±	186.3 5.6	24.1 2.8	39.7 2.6	22.7 3.1	205.4 2.4	6.9 6.6	94.2 1.7	505.3 6.3	39.0 2.2	source sample
5 ±	186.1 5.7	23.6 2.8	41.5 2.6	24.8 3.0	203.4 2.5	6.4 6.7	94.7 1.8	503.7 6.4	39.6 2.2	source sample
6 ±	191.5 5.7	22.9 2.7	46.4 2.4	29.6 3.1	199.2 2.5	9.8 6.6	93.0 1.7	486.9 6.4	33.7 2.3	source sample
7 ±	192.9 5.7	27.2 2.6	47.9 2.4	29.9 3.0	216.3 2.5	6.6 6.7	93.4 1.8	513.8 6.4	34.9 2.3	source sample
HH-2	Sentinel Rock outcrop source (26Hu1989). Black nodules from the south side of a road cut at SR 293 HU 15.0									
1 ±	179.7 5.3	17.0 2.5	41.8 2.3	22.4 2.8	200.6 2.4	6.1 6.7	89.6 1.6	486.6 6.3	40.1 2.1	source sample
2 ±	199.8 6.1	23.9 2.8	48.7 2.6	31.0 3.2	216.8 2.7	4.8 7.8	94.5 1.9	508.2 6.5	35.2 2.4	source sample
5 ±	190.1 6.6	15.4 3.0	41.1 2.9	26.4 3.5	191.9 2.8	5.0 7.6	89.8 2.0	487.7 6.6	32.4 2.6	source sample
6 ±	208.2 7.6	15.6 3.7	38.0 3.6	28.7 4.1	193.1 3.2	5.7 7.2	89.2 2.4	469.2 6.9	35.2 3.0	source sample

HH-3	Kings River Road float source (26Hu2935). Broken nodules and spalls from the east side of SR 293 HU 20.3.									
1 ±	184.0 5.4	24.7 2.5	40. 2.3	28.3 2.8	200.0 2.4	5.2 6.9	87.0 1.7	473.0 6.3	36.1 2.2	source sample
2 ±	199.8 6.0	27.8 2.8	40.4 2.6	21.7 3.1	204.2 2.6	8.1 6.6	94.2 1.9	482.2 6.5	35.5 2.4	source sample
3 ±	203.1 6.6	29.3 3.1	46.1 2.8	22.8 3.4	214.2 2.8	5.7 7.0	94.7 2.0	509.1 6.6	42.3 2.6	source sample
4 ±	187.9 5.6	28.5 2.7	41.2 2.4	28.9 3.0	214.7 2.5	6.3 6.7	89.2 1.7	478.1 6.3	34.0 2.2	source sample
5 ±	200.2 5.6	26.7 2.6	39.5 2.5	23.5 3.0	202.4 2.5	5.2 7.1	91.0 1.7	484.1 6.3	32.6 2.3	source sample
6 ±	237.6 6.2	36.7 2.8	49.6 2.6	33.6 3.2	224.8 2.6	5.5 6.9	96.9 1.8	516.3 6.4	33.4 2.3	source sample
8 ±	160.1 5.4	27.2 2.5	34.3 2.4	19.5 2.9	179.2 2.4	7.4 6.6	81.7 1.7	435.7 6.3	29.6 2.2	source sample
9 ±	176.2 6.1	21.2 2.8	35.6 2.6	23.9 3.3	192.6 2.6	5.4 7.1	87.1 1.9	466.1 6.5	35.5 2.5	source sample
10 ±	154.6 6.3	17.6 2.9	34.3 2.8	21.4 3.3	182.0 2.7	4.6 8.5	84.3 2.0	443.8 6.5	29.7 2.6	source sample
HH-4	QOA float source (26Hu2934). Taken from a buried layer of Quaternary Older Alluvium (QOA) east of SR 293 HU 22.5.									
1 ±	207.7 5.9	19.9 2.6	50.3 2.6	28.9 3.0	221.5 2.6	6.8 6.6	99.2 1.8	519.0 6.4	36.0 2.3	source sample
2 ±	189.5 5.1	27.0 2.4	40.1 2.2	24.2 2.8	204.1 2.4	5.9 6.7	94.0 1.6	501.9 6.3	36.7 2.1	source sample
4 ±	196.0 5.2	24.4 2.4	42.3 2.3	26.8 2.8	208.1 2.3	5.5 6.8	94.5 1.6	499.5 6.2	39.4 2.1	source sample
5 ±	210.8 5.9	28.8 2.7	48.1 2.5	24.3 3.1	217.8 2.6	5.5 6.9	96.3 1.8	513.0 6.4	38.2 2.3	source sample
6 ±	195.5 5.6	29.8 2.6	46.0 2.4	25.2 3.0	201.3 2.5	5.3 7.0	94.5+ 1.8	496.6 6.4	30.8 2.3	source sample
7 ±	197.6 5.6	28.1 2.6	41.5 2.4	27.5 3.0	214.1 2.4	6.2 6.7	92.5 1.7	490.1 6.3	37.3 2.2	source sample
8 ±	184.9 5.9	26.1 2.7	40.7 2.6	28.0 3.0	206.8 2.5	6.1 6.7	90.9 1.8	484.9 6.4	33.8 2.3	source sample

9 ±	197.4 6.1	19.4 2.9	44.2 2.6	28.1 3.2	208.9 2.7	6.2 6.7	95.4 1.9	497.6 6.5	38.1 2.4	source sample
10 ±	184.6 5.3	30.4 2.4	44.0 2.3	25.6 2.9	194.7 2.4	4.1 35.8	94.6 1.7	489.5 36.3	35.9 6.3	source sample
RGM	Reference standard. Included for calibration purposes.									
1 ±	35.9 4.0	15.2 1.8	22.2 1.7	13.6 2.3	145.3 2.0	104.6 6.6	24.4 1.3	215.8 6.0	8.6 2.3	source sample
HH-5	Nodular float collected from alluvium below Hoppin Spring.									
1 ±	191.9 6.5	31.8 2.9	43.1 2.7	26.0 3.4	203.4 2.7	4.3 12.5	92.7 1.9	486.4 6.5	34.3 2.5	source sample
2 ±	182.1 6.5	26.4 3.1	36.5 2.8	19.9 3.4	196.5 2.8	5.9 6.9	84.1 2.0	463.7 6.6	39.2 2.5	source sample
3 ±	174.7 6.2	22.0 3.0	38.3 2.8	25.5 3.5	196.2 2.7	4.0 47.2	85.9 1.9	473.5 6.5	31.7 2.5	source sample
4 ±	185.4 6.3	26.3 2.9	45.2 2.6	26.5 3.3	209.7 2.7	6.8 6.7	95.5 1.9	482.4 6.5	35.6 2.4	source sample
5 ±	164.7 5.8	27.1 2.7	42.2 2.5	17.8 3.0	181.9 2.6	35.4 6.5	86.9 1.8	444.4 6.4	33.7 2.3	source sample
6 ±	187.4 6.0	28.4 2.7	43.0 2.5	22.3 3.1	212.9 2.6	5.3 7.0	93.2 1.8	485.6 6.4	38.8 2.3	source sample
NOTE: Notice the similarity of values for the Double H Mountains material. Sample HH-1 appeared green. Sample HH-2 appeared black. Sample HH-1 and 2 are from within 100' of each other in a road cut through an outcrop. The other samples are as much as ten miles apart. Sample HH-4 appeared to be air fall ejecta from a different event. Sample HH-3 and 5 were alluvial float.										
RGM	Reference standard. Included for calibration purposes.									
1 ±	34.7 4.0	16.4 1.9	24.1 1.7	17.1 2.3	148.4 2.0	104.5 6.6	24.1 1.3	212.6 6.0	8.3 2.3	source sample
Kane Springs	Nodular float collected from the Meadow Valley Mountains (southeast) side of Kane Springs Wash near US 93 Lincoln County.									
1 ±	48.6 5.7	24.5 3.3	23.4 2.7	24.3 3.9	187.6 2.9	19.0 6.6	50.3 1.9	187.8 6.2	38.4 2.6	source sample
2 ±	39.2 4.6	15.9 2.3	20.0 2.1	23.9 2.9	191.0 2.3	42.0 6.5	34.4 1.5	158.5 6.0	27.4 2.1	source sample
3 ±	35.7 4.0	16.7 2.0	24.5 1.7	30.2 2.8	203.8 2.2	36.0 6.5	38.9 1.4	155.5 5.9	27.3 2.0	source sample

4 ±	38.6 4.2	17.6 2.1	224.3 1.8	25.8 3.0	200.2 2.4	35.4 6.5	39.7 1.5	153.0 6.0	27.7 2.2	source sample
5 ±	44.9 5.3	24.4 2.9	26.8 2.4	31.8 3.9	198.9 2.9	45.3 6.6	38.6 1.9	169.8 6.1	25.6 2.6	source sample
6 ±	48.5 4.2	24.2 2.1	24.1 1.8	26.6 2.9	204.8 2.4	44.2 6.5	38.5 1.5	168.0 6.0	23.7 2.2	source sample
7 ±	43.0 4.1	23.9 2.1	24.2 1.8	26.7 2.9	225.7 2.4	8.9 6.5	41.5 1.5	126.2 5.9	29.5 2.1	source sample
8 ±	48.4 4.4	17.6 2.4	27.0 2.0	28.3 3.2	214.4 2.6	44.6 6.6	38.7 1.6	164.9 6.0	26.5 2.3	source sample
9 ±	53.1 4.3	24.3 2.2	30.1 1.8	26.9 2.9	188.3 2.4	17.7 6.5	53.8 1.5	189.9 6.0	37.4 2.2	source sample
RGM	Reference standard. Included for calibration purposes.									
1	34.7 4.0	16.4 1.9	24.1 1.7	17.1 2.3	148.4 2.0	104.5 6.6	24.1 1.3	212.6 6.0	8.3 2.3	Reference Standard
CB Concrete	Nodular outcrop source in ash in a cinder cone being mined for cement. Virginia Range south of Reno near US 395, Washoe County.									
1 ±	39.3 4.0	9.6 1.9	21.8 1.8	16.1 2.4	137.3 2.1	86.5 6.6	17.8 1.4	102.3 5.9	14.0 2.2	source sample
2 ±	51.4 3.9	14.0 2.0	26.6 1.7	16.6 2.4	155.4 2.1	92.6 6.6	15.8 1.4	106.7 5.9	12.4 2.2	source sample
3 ±	46.3 4.3	22.0 2.1	24.1 1.9	16.5 2.6	145.0 2.2	85.6 6.6	16.6 1.5	104.9 5.9	11.3 2.4	source sample
4 ±	39.4 4.4	16.5 2.0	22.9 1.8	15.8 2.5	143.1 2.2	88.1 6.6	18.9 1.4	100.5 5.9	12.5 2.3	source sample
5 ±	45.7 4.0	14.9 1.9	22.7 1.8	19.0 2.5	152.1 2.1	91.7 6.6	17.2 1.4	105.6 5.9	13.3 2.2	source sample
6 ±	43.0 4.2	17.8 2.0	22.8 1.9	14.0 2.5	143.6 2.1	87.0 6.6	15.5 1.5	102.3 5.9	14.6 2.2	source sample
7 ±	45.0 3.9	13.0 1.8	19.3 1.7	13.9 2.3	138.1 2.0	89.2 6.5	17.8 1.3	100.6 5.9	17.3 2.0	source sample
8 ±	43.2 3.9	11.8 1.8	23.2 1.6	13.8 2.3	144.7 2.0	87.6 6.5	16.0 1.4	102.7 5.9	12.2 2.2	source sample
9 ±	38.3 3.9	14.5 1.8	24.0 1.7	15.4 2.2	137.9 2.0	86.9 6.5	17.3 1.3	102.0 5.9	11.5 2.2	source sample

10 ±	42.6 4.6	14.5 2.4	24.7 2.0	16.6 2.8	139.5 2.3	89.6 6.6	17.5 1.6	100.8 6.0	13.2 2.5	source sample
11 ±	46.5 3.9	10.8 1.8	25.5 1.7	17.5 2.4	140.2 2.1	85.7 6.5	17.3 1.4	99.5 5.9	17.4 2.1	source sample
12 ±	41.4 4.1	15.2 2.0	21.7 1.9	13.6 2.5	145.7 2.1	88.4 6.6	18.1 1.4	99.8 5.9	13.5 2.3	source sample
13 ±	38.9 4.5	18.4 2.1	21.1 1.9	17.8 2.6	135.0 2.2	836. 6.6	16.0 1.5	100.4 6.0	13.6 2.4	source sample
14 ±	49.1 4.3	18.3 2.1	24.5 1.9	16.6 2.7	141.0 2.2	82.8 6.6	16.3 1.5	100.7 6.0	16.1 2.3	source sample
Sutro Springs	Nodular outcrop source in volcanic ash in a cinder cone being mined for cement manufacturing. Flowery Range (Virginia Range) east of Dayton on US 50.									
1 ±	38.9 4.7	11.4 2.5	25.5 2.2	13.4 2.6	140.6 2.1	79.5 6.6	16.6 1.4	88.4 5.9	17.6 2.1	source sample
2 ±	43.8 4.4	15.5 2.4	30.2 2.1	13.1 2.5	148.8 2.2	82.4 6.6	16.6 1.5	90.0 5.9	25.5 2.1	source sample
3 ±	42.6 4.7	11.3 2.5	29.4 2.3	9.6 2.5	149.8 2.3	83.6 6.6	18.4 1.5	91.7 6.0	23.3 2.3	source sample
4 ±	40.7 4.3	17.5 2.2	31.3 2.0	12.0 2.3	144.2 2.1	79.9 6.6	19.2 1.4	87.5 5.9	24.3 2.0	source sample
5 ±	45.2 4.3	13.0 2.3	25.2 2.1	9.5 2.4	139.2 2.1	80.6 6.6	18.4 1.4	80.9 5.8	25.5 2.1	source sample
6 ±	39.4 4.1	14.3 2.0	29.9 1.8	9.3 2.2	141.2 2.1	81.9 6.5	18.4 1.4	86.7 5.9	20.4 2.1	source sample
7 ±	46.4 4.0	16.7 2.0	25.9 1.9	12.0 2.2	138.6 2.0	78.2 6.5	16.7 1.4	88.5 5.9	24.2 2.0	source sample
8 ±	40.1 4.0	13.5 2.0	25.9 1.8	9.1 2.1	138.4 2.0	80.4 6.5	16.3 1.3	88.0 5.9	18.6 2.0	source sample
9 ±	39.4 4.2	17.0 2.2	30.2 1.9	13.4 2.4	142.9 2.2	79.8 6.6	16.5 1.5	88.2 5.9	22.5 2.1	source sample
10 ±	45.1 4.1	16.3 2.2	26.9 1.9	8.9 2.2	143.9 2.1	84.1 6.6	18.3 1.4	89.5 5.9	21.8 2.1	source sample
11 ±	39.7 4.1	15.8 2.0	24.4 2.0	11.3 2.3	143.0 2.1	77.8 6.5	19.3 1.4	87.3 5.9	19.5 2.1	source sample
12 ±	43.3 4.1	15.9 2.1	24.3 2.0	12.5 2.4	138.3 2.1	76.2 6.6	14.9 1.5	84.7 5.9	22.4 2.2	source sample

13 ±	39.0 4.6	21.5 2.5	28.7 2.2	12.2 2.6	150.2 2.3	80.4 6.6	15.7 1.6	88.5 6.0	24.7 2.3	source sample
14 ±	35.3 4.2	13.7 2.1	28.2 1.9	10.2 2.3	145.6 2.1	80.5 6.6	18.3 1.4	87.2 5.9	23.0 2.0	source sample
15 ±	42.7 4.1	15.2 2.2	29.3 1.9	10.2 2.3	141.5 2.1	80.3 6.6	17.6 1.4	88.3 5.9	25.8 2.1	source sample
RGM	Reference Standard. Included for calibration purposes.									
1 ±	37.4 4.0	15.7 1.9	21.6 1.8	14.6 2.3	145.6 2.0	103.1 6.6	24.6 1.3	211.1 6.0	8.0 2.4	Reference Standard

TABLE EIGHT
TRACE ELEMENT ANALYSIS OF BUTTE VALLEY OBSIDIAN (in ppm).
Taken from Jones & Beck, Journal of California & Great Basin Anthropology Vol. 12, No. 1, 1990:91, Table 2.

Sample and numbers of items analyzed (n=)	Rb	Sr	Y	Zr	Source Attribution
Float "a" (n=10) ±	160.7 8.2	315.6 9.4	23.9 1.4	117.4 3.4	Butte Mountain Float source
Artifacts "b" (n=41) ±	165.4 8.0	324.8 13.9	24.2 1.7	117.5 5.3	Butte Mountain
Browns Bench (n=28) ±	211.2 11.7	50.6 2.7	56.4 3.1	456.3 21.1	Browns Bench
A (n=5) ±	175.6 7.8	67.0 4.9	61.2 2.5	556.9 27.1	unknown A
B (n=10) ±	192.1 5.8	125.2 5.0	32.6 1.9	164.0 5.0	unknown B
C (n=7) ±	230.9 5.8	25.7 2.1	58.6 2.9	371.0 10.0	unknown C
D (n=2) ±	210.7 8.2	27.0 1.3	29.3 0.6	102.5 2.6	unknown D
E (n=1) ±	151.9	126.4	23.4	162.3	unknown E
F (n=4) ±	192.9 5.6	106.7 4.6	15.3 1.2	104.8 5.0	unknown F
G (n=11) ±	193.9 11.1	77.6 4.3	27.2 4.5	119.7 10.9	unknown G
H (n=1) ±	194.0	43.1	25.2	111.9	unknown H
I (n=2) ±	336.6 4.8	5.7 2.6	40.0 1.1	113.5 15.7	unknown I
J (n=2) ±	437.2 12.4	7.3 0.1	46.8 0.2	148.0 2.6	unknown J
K (n=1) ±	170.6	89.6	25.4	145.0	unknown K

SUMMARY AND CONCLUSIONS - NDOT XRF AND TRACE ELEMENT ANALYSIS SOURCING PROGRAM

The NDOT obsidian-sourcing program has several goals. The primary goal is the identification and location of obsidian and other tool-stone sources as part of understanding the Ancient Peoples of the Great Basin. Second, is the publication of new trace element and hydration analyses, both for sources and for artifacts from archaeological sites. Third, is the observation of patterning. Whether there are associations between materials and artifact types (such as the apparent strong association between basalt and Great Basin Stemmed points), between time periods and material types, between cultural Groups, material types, and artifact types. The following remarks address some of our conclusions.

The Ring Road data, gathered in the 1970S but not finished until the 1990S, showed that there were more sources in the western Nevada area than previously recognized, and that there was a need to locate and identify these sources.

This progress report on the NDOT obsidian-sourcing project, lists more than 300 obsidian (welded tuff, vitrophyre, ignimbrite) sources in Nevada and adjacent portions of the surrounding states. The identification of these sources is a major step in tracking the movements of the prehistoric inhabitants of the area. This tracking is an essential ingredient in the study of their settlement and subsistence patterns. Although some eastern Nevada sources are not characterized in this document, that is an artifact of the process of information dissemination. Many sources have been collected and submitted for analysis but the results have not been available to us, or have not appeared in the regional literature. That is one of the problems this document is trying to alleviate.

Trace element analysis through X-ray fluorescence analysis is a useful and nondestructive tool for this process. Neutron Activation Analysis is becoming more common. Most of the available sources are now identified, although a few are still under analysis. Some previously separated sources have been recognized as minor variants within larger geochemical groups. Our emphasis should shift to a focus on correlations and patterns of exchange.

Aboriginal preference for exotic tool-stone for curated objects.

The Acme Playa data showed preference for finer (fewer flaws, greater clarity, more homogenous, exotic) obsidian in the manufacture of finished tools. Utilized flakes and other simple flake tools were made from local materials - the on-site Garfield Hills/Hawthorne Source. Large projectile points were made from Truman Meadows obsidian. Sites in the Steamboat Hills and at Washoe Lake share this pattern. Acme Playa and the Pole Line also showed that even when people lived on top of obsidian float sources (Hawthorne Source, Mt. Hicks), they had artifacts made from other sources (Truman Meadows, Mt. Hicks, Majuba, Pine Grove Hills, and Bodie). An obvious tautology is that people use local tool-stone to manufacture tools. Less obvious is the idea that utilitarian objects are made from the nearest available resource, while curated objects are made from more exotic, imported materials.

The Steamboat Hills project showed that Mono Basin obsidian traveled to the north as well as to the northeast. A definite preference for exotic obsidian in curated and finished tools was strongly demonstrated. The presence of obsidian from local, Mono Basin, and other (probably Seven Troughs/Majuba) sources was demonstrated. Obsidian apparently travels across ethnographic tribal and linguistic boundaries. This may suggest that this distribution be more a result of trade than travel. Thus the question of which mechanisms are responsible for its distribution becomes more complicated. With more data, it may become possible to sort this distribution through time and space, and see if there are associations between linguistic/cultural Groups and sources. Tentative identification to a general source area (when exact attribution was not possible) uses partial clustering of trace element attributes. Later research verifies this identification. From this it is possible to see that sources from a related series of vents produce similar suites of trace elements.

The Pine Valley project showed that exotic materials that came from several distant and widely separated sources (Mono Basin, Paradise Valley, Duck Flat) coexisted in eastern Nevada sites. Here, tool-stone from ethnographic Washoe and Northern Paiute territories was found in Western Shoshone site areas. Whether this shows trade, fluctuation in territory through time, travel, or other influences is unknown. Trade appears most likely.

Artifacts from 26Pe814, near Lovelock, showed that although there was a close local obsidian source (Majuba), tool-stone traveled long distances from other sources (Bordwell Spring and Pinto Peak), near the California border.

Hydration dating of surface artifacts

The Pole Line project showed a problem with trying to use radiocarbon dates to develop hydration rates. Induced hydration studies by XRF laboratories reduced the proposed hydration dates by more than half, bringing the rate in line with that already established for other nearby sources. Attempting to bring the hydration rate in line with the radiocarbon date produced a rate much faster than that found by laboratory induction. Here, hydration studies produced more problems than results: the radiocarbon dates average 3,000 B.P., while the hydration dates average closer to 1,700 B.P., a 1,300-year discrepancy. This is an area that should be the focus of the next round of research questions.

The Tonopah Lake data showed that Western Stemmed Tradition artifacts were also made from local obsidian, in this case, Silver Peak/Clayton. Weathering and sandblasting rendered the hydration rims unreadable.

A finding from the Acme Playa site and others was the difficulty of trying to read hydration rinds on obsidian artifacts from the more desert-like areas of the Great Basin. Surface weathering and sandblasting removes hydration rinds and restarts the hydration clock. Researchers in California have had much better results in hydration dating surface artifacts than we have had in Nevada. Some of our surface artifacts have four or more overlapping and intersecting rinds and cracks, which produce problematical results.

Besides these difficulties, we also found that sending samples to different hydration laboratories produces contradictory results. Interpretations of hydration rind thickness differed considerably. The Nevada experience has not been favorable regarding hydration dating of surface artifacts.

Association of tool-stone sources with reduction techniques or artifact types.

Artifacts from 26Hu1746, west of Denio, show that bipolar flake production processed the local obsidian. The bipolar technique is similar to rested percussion, but the blow is struck into the middle of the potential platform area, rather than the edge. The blow is more like that of a novice flintknapper, who does not know how to direct the force. The result is chunks and splinters rather than flakes. Shear forces overwhelm the fracture forces, producing a piece that lacks the normal signs of conchoidal fracture (bulbs, cones, etc., . . .). When the bipolar technique is properly done, some of these sheared chunks are complete cross-sections through the pebble. This allows a finished artifact to be almost as large as the original pebble nodule. These chunks are more like a slice through the nodule than a flake. Another characteristic flake results when the shearing force spreads less interacting with the compression forces and producing several wedges, or "orange-peel flakes". These have a more obtuse edge than a flake and are more useful as simple tools (Crabtree 1982:5-6; 1973). Although some small nodules from 26Hu1746 were sometimes broken by rested percussion, the dominant technique was usually bipolar reduction. There was almost no freehand reduction. Artifacts from this site were primarily from on-site nodular tool-stone sources, the exception being chert tools.

Certain obsidian sources do appear to be associated with particular technological manufacturing techniques. This is shown in northwestern Nevada and Northeastern California, where generally small size obsidian nodules require bipolar, or at least rested percussion, reduction techniques for efficient processing. The large size of the outcrops around Mono Lake (Lookout Mountain, Bodie Hills, Mt. Hicks, etc., . . .) allows the production of large slabs and bifaces. These were exported as trade blanks. Bifaces from the Mono Basin can be traced over trails through the Sierra Nevada Mountains for the two thousand year period of the Mono Basin material dominance. Mono Basin obsidian occurs near Elko, Nevada.

In addition, people of a time period may prefer a particular material. This is the case at the Silver Site (26HU2515) on the Upper Quinn River, where green obsidian points from the Humboldt Series dominate the archaeological record. Beck and Jones (1990) have found similar patterns with Western Stemmed Tradition artifacts in east-central Nevada.

Artifacts from the Garrison Site, near Garrison, Utah show affinities with sources in other Fremont site areas near Modena, the Beaver Mountains, and in the Black Rock Area, Utah. These findings contradicted the conclusions of Taylor (1954:6) regarding the source for the site.

Visual identification of obsidian tool-stone sources.

The analysis of artifacts from 26Pe814 showed that visual identification of the obsidian sources was unreliable.

Site 26Hu1746 is another area where visual identification of the local obsidian did not result in correct source attribution. There were two sources represented as float on the site (Group “A” and “B”). There were two colors of obsidian from the inventory of the site (mahogany and opaque black). We thought that the mahogany was from one source and the opaque black was from another. We were wrong. Group "A" had both opaque and mahogany obsidian. Group "B" had only opaque.

Different outcrops and float from the Double H Mountains produce beautiful gray-green, green, purple, or blue material. As a result, the tool-stone is very distinctive, unfortunately not distinctive enough. Trace element comparison by XRF of these beautiful examples with mundane black nodules from the same source area showed only minor variation and failed to show distinctive characteristics. Perhaps NAA or some other future technique will differentiate these sources.

Source attribution based on partial correlation.

Some artifacts had trace elements that did not match a specific source but did resemble sources from a general area. They can be tentatively assigned to the region, but should later be compared to updated source data for verification. Generally, source attribution is based on a close fit of three or more trace elements. Artifacts from the Steamboat Hills resemble tool-stone from the Majuba source area, in several elements.

Further research shows that there are often multiple geochemical events within a particular source. 26Hu1746 is a site in a nodular float source with nodules from two similar geochemical sources.

There is also a tendency for unknown sources from sites within geographic areas to have affinities or partial trace element correlations with each other. The White River and Railroad Valley sites, for example. These sites are only one mountain range apart. This is a case where there may still be unknown sources nearby that remain to be identified.

There is also a tendency toward regional clustering in tool-stone source use. Northwestern Nevada sources tend to occur in northwestern sites (due to association with Northern Paiute groups?). A wide diagonal band, from the Mono Basin to east of Elko, uses both Mono Basin and Paradise Valley tool-stone (Shoshone?), but Mono tool-stone also occurs in ethnographic Washoe territory near Reno. The northeastern part of the state, from Elko eastward, uses mostly Browns Bench (Idaho) tool-stone. Southern Nevada uses local sources (Southern Paiutes?). Southeastern and eastern Nevada sites contain western Utah sources (Anasazi? Fremont?). Southern Idaho sources account for some obsidian found at sites north of the Humboldt River. The mapping process discussed below may further refine this tendency.

Further research directions.

Part of the continuing investigation in XRF and trade, involves plotting sites and their tool-stone sources on combined California, Oregon, Idaho, Utah, and Nevada 1:500,000 scale maps (see below). This labor-intensive project may give more detailed data on the directions of travel for the various tool-stones. Don Tuohy has done some work on "Early Man" points from Nevada (In, Hughes 1984:193-221, Figure 11.). His work shows that this is a complex pattern to analyze. It may turn out that more data will obscure patterns rather than making them clearer.

It has been disappointing that we do not understand the mechanism of trade. One assumption has been that the tool-stone was traded for perishables. We have been unable to confirm this assumption. We have not recognized trade commodities, even though there is evidence for trade ethnographically and archaeologically.

One example of non-obsidian tool-stone trade occurs with Steamboat Sinter. This siliceous travertine can be heat treated and made into good tools. Sites near the source, and in the Truckee Meadows, were subjected to manufacturing trajectory debitage analysis. The debitage shows that finely made, Elko sized bifaces were manufactured at these sites (Matranga 1985, revised 1992). Once they reach a certain size in the manufacturing trajectory, they disappear from the archaeological record. They do not show up in local sites. The assumption is that they were traded away. We do not know where.

There is also evidence of tool-stone trade near Ely, Nevada. Lt. Simpson (1876:117) mentions a trade route trail near Hercules Gap (Gate), used between " . . . the To-sa-witch band of Sho-sho-nees, living about the Humboldt River, who yearly take this route, to trade horses with the Pahvant Indians about Fillmore." The Tosawihi opalite/chert from quarries near Battle Mountain, Nevada was also traded along this route, and obsidian from Utah came the other way. Brian Amme, of the Ely BLM Office, has shown some of this in unpublished papers and we have identified some of the obsidian samples. This is one of the few cases where we could document some trade goods.

Surface finds and isolates need to be analyzed and identified to the source as a way of examining the difference between on-site and non-site distributions. This is becoming more difficult as Federal Agencies (who control most of Nevada) develop and enforce non-collection policies.

Many more artifacts need to be sourced and subjected to hydration analysis. Cross-dated subsurface artifacts need to be compared to surface artifacts to learn the effectiveness of hydration dating on surface sites. As this is determined, we also need to concentrate on the reproducibility of these measurements. Previously published trace element analyses need to be compared for patterns missed in the initial analysis.

There is a continuing necessity for the collection of source samples to be analyzed for identification, and for variation of trace elements within sources.

LIST OF KNOWN TOOLS TONE SOURCES

This list contains recognized sources of lithic tool-stone. It is written from a Nevada perspective, but it includes multi-state sources. Most of these sources were potentially available to Great Basin Indians. The source name/names is given in capitals. Secondary names follow. The material type and its occurrence are listed, i.e. seam chalcedony, obsidian outcrop, or vitrophyre nodular float. (Even though most so-called "obsidian" is a welded tuff, glassy ignimbrite, or vitrophyre, it usually is still divided into obsidian [transparent, you can see through it] and the others [it is opaque, you cannot see through it]. Some of the obsidian is actually a silicic rhyolite ash-flow tuff). Most of these sources are obsidian or ignimbrite. If the source is also a known archaeological site, the number is given, where available. A brief discussion follows the description, and then the legal description and map name, if available to me. An asterisk (*) indicates whether I have personally verified the material and location. Boulders are larger than your head. Cobbles are between head and fist size. Pebbles are smaller than your fist.

ALASKA CANYON, WARNER MOUNTAINS, LASSEN COUNTY, CALIFORNIA. Obsidian nodules.
The material has phenocrysts and inclusions like those from Dodge Reservoir. T.43N., R.16E., Sec. 15.

AMERICAN FALLS, POWER COUNTY, IDAHO. Ignimbrite/vitrophyre outcrop. *
The material occurs in gullies and canyons that drain into the Snake River near American Falls. It grades from glassy to coarsely crystalline. It is also found on the south and east along I-15 toward Raft River. It has also been called Walcott. There are cobbles and outcrops of flawed ignimbrite/vitrophyre that contain inclusions and bombs in Power and Bonneville counties, Idaho. This is apparently the result of huge pyroclastic flows from the Owyhee Uplift. The material is related to the Picabo and/or Twin Falls volcanic fields. There is an obsidian source in Power County in T.8S., R.31E., Sec. 6, on the 1971 USGS 7.5' American Falls SW Quad.

AMARGOSA VALLEY, NYE COUNTY, NEVADA . Obsidian pebble nodule float.
The nodules are found in desert pavement on the tops of linear gravel bars, and on the slopes below. Nevada State Route 373 passes just to the east, four miles north of the California state border. Forty Mile Wash passes nearby to the west, having originated within 30 miles of Obsidian Butte on Pahute Mesa. The bars are presumed to be from old meanders of the Pleistocene and earlier Amargosa River. The material is distinct in the few samples that have been sourced, but it may be related to the Tolicha Wash/Sarcobatus Flats float from Obsidian Butte. T.17S., R.49E., Sec. 23, in the NW ¼ and elsewhere. The nodules are small, but there are not many obsidian sources nearby, so they were used. As of 2002, there was no published evidence of bipolar reduction of these nodules.

ANCHORITE HILLS, MINERAL COUNTY, NEVADA. Obsidian nodules. *
(see Mt. Hicks) This source refers to small pebbles from the Anchorite Hills, T.4N., R.29E., Sec. 28 that are probably ejecta from Mt. Hicks. Several NDOT reports deal with this area.

ANNADEL, Annadel Farms, CALIFORNIA. Reported source.
North Coast Range.

ASSHOLE MOUNTAIN, LYON COUNTY, NEVADA. Obsidian nodule outcrop.
This is a local name for the hill that is the Sutro Springs source (which see).

AUGER CREEK, LAKE COUNTY, OREGON. Obsidian nodules.
The source is at the north end of Auger Valley, next to the creek. T.30S., R.14E., Sec. 9.

BACKBONE RIDGE, SHASTA COUNTY, CALIFORNIA. Obsidian nodules.
Large mahogany, red/black/clear nodules exposed in the road cut.
This is part of the Tuscan Geochemical Group.

Seaman Gulch locality	= T.33N., R.2W., Sec. 8.
Backbone Ridge locality	= T.34N., R.2W., Sec. 8.
South Forest Camp locality	= T.34N., R.2W., Sec. 15.

BADGER CREEK, WASHOE COUNTY, NEVADA.   Obsidian nodules.
The material is bluish-grey like the Mosquito Lake source. Most of the other sources nearby are green.
The source is 2 ½ miles southeast of Bitner Butte and 1 mile west of East Spring. T.44N., R.22E., Sec. 2.

BAGDAD, BRISTOL MOUNTAINS, SAN BERNARDINO COUNTY CALIFORNIA. Nodular obsidian pebble float.
Translucent to gray-banded nodules extending for miles. T.7N., R.11E., Sec. 7 & 18; T.7N., R.10E., Sec. 12 & 13; extending to Bristol Lake.

BASQUE SPRING, TWIN FALLS COUNTY, IDAHO.   Chert.
(10OE125 & 126). Near the Patrick Ranch, up Brown's Bench Road, 17.4 miles from Three Creeks Road and 0.3 miles west to the top of a hill. T.16S., R.12E., Sec 30 or 19.

BEATTY'S BUTTE, LAKE COUNTY, OREGON. Obsidian boulder exposure.
Multi-colored obsidian exposed on the west side of the butte. T.37S., R.28E., Sec. ___.

BEAVER CREEK, OWYHEE COUNTY, IDAHO. Jasper.
(10OE91) On the north ridge overlooking Beaver Creek, extending east and west above the junction of Trap Creek and Beaver Creek, near the Brace Brothers Ranch. T.12S., R.3W., Sec. 21

BIG SOUTHERN BUTTE, BUTTE COUNTY, IDAHO. Obsidian outcrops.
The source is in Butte County, Idaho near the summit of the butte and Webb Spring, on the 1972 USGS 7.5' Big Southern Butte, Idaho Quad.   T.1N., R.29E., Sec. 1, & 14.

BIG TABLE MOUNTAIN, CENTENNIAL MOUNTAINS, IDAHO.   Obsidian boulder outcrops and quarries. * Extending over an area greater than T.13N., R.38E., Sec. 19, 20, 28, 29, 30, 33, 34 in part, and T.14N. R.38E., Sec. 2, 3, 4, 10, 11, 13, 14. This widespread outcrop of boulders and cobbles contains material described as both obsidian and vitrophyre. It has been called the Camas-Dry Creek, Bear Gulch, and Centennial source.   It has been traced to sites throughout the West and as the Group 90 source into the Mississippi Rive Valley (Ohio, Indiana, Illinois, and Wisconsin). Exploitation of this source began in the Paleo-Indian Period and continued through the Archaic (Willingham 1995).

BLACK HILLS, KLAMATH COUNTY, OREGON. Obsidian nodules.
Extensive deposits 3½ miles northwest of Spodue Mountain.

BLACK ROCK, MILLARD COUNTY, UTAH. Obsidian.

Antelope Spring	- T.24S., R.9W., Sec. 3, 11, 14, 35, and T.23S., R.9W., Sec. 2, 35, and;
Cruz	- T.23S., R.8W., Sec. 31, 28, and T.23S., R.9W., Sec. 26 and;
Black Rock	- T.24S., R.10W., Sec. 10, and;
Tabernacle	- T.23S., R.7W., Sec. 17, and;
Cove Fort	- T.24S., R.8W., Sec. 10, and;
Fillmore	- T.22S., R.9W., Sec. 11.

BLOSSOM CREEK, CALIFORNIA.
North Coast Range. Reported source, no information.

BLUE MOUNTAIN /STEEL SWAMP, MODOC COUNTY, CALIFORNIA. Obsidian cobble outcrop. The source is CA-Mod-325, and is 1½ miles southwest of the Blue Mountain lookout tower.

BLUE SPRING, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA.
Obsidian outcrop exposed in road cuts. T.46N., R.15E., Sec. 32.

BODIE HILLS, MONO COUNTY, CALIF. Obsidian outcrops and cobbles. *
The source is in Mono County, Calif. It is in T.5N., R.26E., Sec. 10, 11, 14-16, 21 & 22 on the 1958 USGS 15' Bridgeport, Calif. Quad. This source has been made famous through studies and papers in California journals. Take the Aurora Canyon road from California State Route 22, just north of Bridgeport. Go about 1¼ miles. The source is on the left. The quality of the material rivals that of the Glass Butte source in Oregon. Some of the obsidian is very glassy and almost clear. It produces a ringing sound when struck. This high-quality material was traded into central California for thousands of years.

BORAX LAKE, CALIFORNIA.
North Coast Range. Reported source, no information.

BORDWELL SPRING /SPRINGS, WASHOE COUNTY, NEVADA. Obsidian nodules.
The source is a few hundred meters west of the camp. T.39N., R.20E., Sec. 34.

BOX SPRINGS, NYE COUNTY, NEVADA. Obsidian float.
This source is reported from the Monitor Valley Playa. It is a diffuse scatter of small nodules washing out of ephemeral stream-beds. It is mentioned in Hughes' section of the Monitor Valley monograph. T.13N., R.47E., Sec. 9 or 19.

BROWN'S BENCH, TWIN FALLS AND CASSIA COUNTY, IDAHO. Vitrophyre outcrop. *
Material outcrops along the bench on the west side of Salmon Falls Reservoir. Source materials from Rock Creek and Mahogany Butte correlate closely with Brown's Bench and may be from the same pyroclastic event. T.12S., R13E., Sec. 11 of the 1979 USGS 7.5' Tuanna Butte, Idaho Quad., and T.14S., R.14E., Sec. 30 on the 1977 USGS 7.5' Brown Bench South, Idaho Quad. Pebble float has been found as far as Hollister in T.13S., R.17E., Sec. 6, and south of Jackpot, Nevada in T.46N., R.64E. This source is probably derived from the Bruneau/Jarbidge Volcanic Field. Beck and Jones (?????????) Report finding this material 240 kilometers south, in Butte and Long Valley, Nevada,

BUCK MOUNTAIN, MODOC COUNTY, CALIFORNIA. Large obsidian flow.
This is the type site for the Buck Mountain geochemical Group. T.44N., R.15E., Sec. 4.

BUTTE MOUNTAIN, WHITE PINE COUNTY, NEVADA. Nodular obsidian float. The material occurs on the west side of Butte Valley, near Robbers Roost Ridge. T.21N., R.60E., Sec. 34, 35, AND T.20N., R.60E., Sec. 1, 2.

HINES, HARNEY COUNTY, OREGON. Obsidian outcrop and boulder nodules. * The source is in Harney County, Ore. on the 1974 AMS Baker, Ore. Quad. The site is in road-cuts on the west side of the pass above Hines on the way to John Day. It is also known as the Radar Range.

BUZZARD ROOST, SHASTA COUNTY, CALIFORNIA. Obsidian nodules.
This is part of the Tuscan Geochemical Group. Multi-colored float exposed in stream channels and road cuts. This is about 3 miles southwest of Round Mountain. T.33N., R.1W., Sec. 3.

CALLAHAN OBSIDIAN FLOW, MEDICINE LAKE HIGHLAND, SISKIYOU COUNTY, CALIFORNIA. Small outcrop of black to blue/black obsidian.
T.44N., R.3E., Sec. 5.

CAMAS DRY CREEK, CAMAS COUNTY, IDAHO. Obsidian pebble float. *
The source is near Fairfield. It is in T.2S., R.15E., Sec. 36. There are other nearby vitrophyre sources that are not well located. This name is also used for the unrelated Big Table Mountain/Centennial/Bear Gulch source (which see). It is also called Dry Creek.

CASA DIABLO, MONO COUNTY, CALIF. Obsidian outcrops.
This source is just west of Crowley Lake. See Lookout Mountain, Calif.

CATNIP MOUNTAIN, WASHOE COUNTY, NEVADA. Obsidian
Reported source, no information. T.45N., R24E., Sec. 5.

C.B. CONCRETE, WASHOE COUNTY, NEVADA. Obsidian pebble nodules.
Small pebbles in volcanic ash in a cinder cone. It is mined for use in cement. T.18N., R.20E. Washoe County, Nevada. The mine can be see from the junction of US 395 and Nevada SR 341/431.

CENTENNIAL /BIG TABLE MOUNTAIN, CLARK, FREMONT, JEFFERSON, TETON IDAHO/BEAVERHEAD COUNTY, MONTANA. Obsidian.
This alluvial source occurs in Clark, Fremont, Jefferson, and Teton counties, Idaho and Beaverhead County, Montana from glaciated sources in the Centennial Mountains. See the Big Table Mountain source.

CHALK SPRING JUNCTION, MODOC COUNTY, CALIFORNIA. Obsidian pebble float.
T,39N., R.10E., Sec. 5.

CHESTERFIELD, BANNOCK COUNTY, IDAHO. Obsidian float.
The source is in Bannock County, Idaho in T.7S., R.37E., & R.38E. on the 1948 USGS 15' Portneuf Quad. It is also reported from Caribou County, Ida. in T.6S., R38E., Sec. 9 and 10, and in T.6S., R.37E. and R.38E.

CHINA CREEK, NEZ PERCE COUNTY, IDAHO. Agate nodules and seams.*
T.30N., R.4W. & R.5W., Seams of agate nodules along hillsides and road cuts on the north side of the Salmon River between China Creek and Eagle Creek. Go from Craigmont to Winchester. Take a dirt road to Forest, turn right through Soldiers Meadow Reservoir, thence down the Eagle Creek Road.

CHIMNEY CREEK RESERVOIR, HUMBOLDT COUNTY, NEVADA. Obsidian nodules. The source is in T.41N., R.43E., Sec. 9, 21 & 31 on the 1971 AMS McDermitt, Nevada quad. And in T.43N., R.39E., Sec. 15 on the 1959 USGS 15' Hinkey Summit, Nevada quad.

CONTACT, ELKO COUNTY, NEVADA. Rock crystal and seam chalcedonies.
Wells, Nevada AMS.

COGLAN BUTTES, LAKE COUNTY, OREGON. Obsidian nodules.
Purple-sheen obsidian cobbles west of Hope Well. T.33S., R.20E., Sec. 11, 14.

COSO HOT SPRINGS / COSO VOLCANIC FIELD /JOSHUA /WEST SUGARLOAF MOUNTAIN /WEST CACTUS PEAK, INYO COUNTY, CALIFORNIA. Obsidian nodules.
Elston (IMR) has studied the quarry/workshops at this source.

COUGAR BUTTE, MODOC COUNTY, CALIFORNIA. Twenty centimeter, milky grey, obsidian nodules with a pink-purple cast.
T.44N., R.4E., Sec. 13.

COUGAR MOUNTAIN, LAKE COUNTY, OREGON. Black "greasy' obsidian nodules and cobbles.
T.25S., R.15E., Sec. 14.

COW CREEK, SHASTA COUNTY, CALIFORNIA. Obsidian pebbles.
Part of the Tuscan geochemical Group. There are gray banded and mahogany materials in the stream channel. T.31N., R.3W. Sec. 16.

COWHEAD LAKE, MODOC COUNTY, CALIFORNIA. Obsidian boulder outcrop.
The source of this black, grey, and purple and black obsidian is at the south end of Cowhead Lake, Modoc County, Calif. in T.47N., R.17E., Sec 33 on the 1962 USGS 15' Fort Bidwell, Calif. quad.

CROW SPRINGS, ESMERALDA COUNTY, NEVADA. Obsidian pebbles.
The obsidian occurs in a perlite mine. It is scattered over several acres. It is mentioned in the Monitor Valley monograph. T.5N., R.39E., Sec. 32.

DAVIS CREEK, MODOC COUNTY, CALIFORNIA. Obsidian outcrops and cobbles. *
North of Alturas and south of Goose Lake, between Davis Creek and Lassen Creek, in Modoc County, California. There are more than five sources in that area. A map is available from the Davis Creek Store. These sources are on the west of the Warner Mountains. They are a part of the complex of sources in the north Warner Mountains, east of Goose Lake.

DEEP CREEK, OWYHEE COUNTY, IDAHO. Jasper.
T.12S., R.3W. (R13E?), Sec. 21 10OE92. The material comes from where the road crosses Trap Creek near a house.

DEL PRAT SPRING, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Nodular obsidian pebble and cobble float.
The material is a vitreous black, sometimes banded. It is found in the stream south of the spring. T.47N., R.15E., Sec. 32.

DENIO /DUFURRENA /VIRGIN VALLEY, HUMBOLDT COUNTY, NEVADA. Obsidian nodules.*
The ground in a large part of northern Humboldt County (and northern Washoe County) is littered for many miles with nodules from at least four geochemical events. Samples from the Dufurrena Grade site (26Hu1746) represent at least two of them. Pebbles from this area on the Sheldon Plateau and from Virgin Valley wash down into Thousand Springs Valley, through the Thousand Springs Gorge. The flats below Big Spring Table are littered for miles with cobbles in T.46N., R.26E., Sec. 23, 24, 27 to 33, and in T.46N., R.24E., Sec. 20-28, and T.46N., R.25E., Sec. 29 and 30. Other related float localities are: along

old SR 8A to VYA in T.46N., R.24E. and T.45N., R.24E. and T.44N., R.23E. and localities in T.45N., R.24E., Sec. 5 on the 1966 USGS 7.5' Catnip Mountain, Nevada Quad; and T.43N., R.23E., Sec. 34 on the 1966 USGS 7.5' Nut Mountain, Nevada Quad. near Summit Lake; and T.44N., R.27E., Sec. 1 on the 1965 USGS 15' Railroad Point Quad. These are included in Hughes" "Vya Source" and represent several geochemical events. These have been studied by Hughes, Nelson and Holmes, Jackson, and Skinner (various dates). If you take the dirt road from SR 140 HU 100 (State Route 140, Humboldt County road mile 100) south to Vya, there is a virtually continuous nodule scatter for 32 miles. There are distinctive workshop complexes where specialized bipolar reduction techniques were used to split nodules, such as the one at the top of the Dufurrena Grade (26Hu1746). That site had saddle-shaped boulders that were used as anvils in a hammer-on-anvil technique, used for splitting small pebble-size nodules. The wear on the anvil produced a tightly pecked surface, similar to acorn processing pit-marks. Attempts at visual identification of nodules from this site results in samples that lump material into the wrong geochemical type. There can be mahogany or pure black nodules from the same source. There are more chemical similarities across the colors, than within them. This source is examined in Table Nine.

DEVIL PEAK, SPRING MOUNTAINS, CLARK COUNTY, NEVADA. Marekanites ("Apache tears"), and 3-10cm obsidian nodules in Perlite deposits, near the Umpire and Picture Rock Perlite/Rhyolite mines. The West Locus contains up to 100 pebbles per square meter *in situ* in the perlite matrix. T. The East Locus has a similar density in rhyolite domes. Both localities extend for miles below the source.

DODGE RESERVOIR, WARNER MOUNTAINS, LASSEN COUNTY, CALIFORNIA. Grey obsidian cobbles with inclusions and white phenocrysts.
Near the north end of the reservoir. T.36N., R.16E., Sec. 15

DOLLY VARDEN BASIN, WASHOE COUNTY, NEVADA. Obsidian.
The source is in T.35N., R.22E., Sec. 7 on the 1955 AMS Lovelock, Nevada Quad.

DOUBLE H MOUNTAINS, HUMBOLDT COUNTY, NEVADA. Green, blue, grey, or black obsidian cobble nodules and outcrops. *
These sources are in T.43N., R.35E., Sec. 3 on the 1961 USGS 15' Thacker Pass, Nevada Quad. They occur also in the headwaters of Pretty Creek, Rock Creek, and Moonshine Canyon, Hoppin Spring, and Sentinel Rock area, with localities in T.44N., R.36E, Sec. 19 and T.43N., R.35E., Sec. 24. Obsidian is widespread in the Double H and Montana mountains. Float nodules from the sources surround the mountains. I.e., near Sod House; Titus Point; Quinn River Crossing; Sentinel Rock; upper Quinn River; and Kings River. This is part of the McDermitt Caldera, which also produces obsidian in Malheur County, Oregon and in the Santa Rosa Range, in Nevada. This high quality material was also prized for its colors and was traded extensively throughout Nevada. An amateur collection (the Schurtle Collection) housed at Boise State University contains hundreds of points from this source. An artifact of this material occurred at the Sunshine Locality, Early Man site. Shown in Table Eleven, in this report. This is another source where color was not detectable in the trace element analysis. There was no detectable chemical difference between nodules of black, or of gray-green obsidian. Olivine was suspected as the source of the green color, derived from ocean deposits that were melted into the caldera, but this was not supported by the evidence.

DOUBLE HOT SPRINGS, HUMBOLDT COUNTY, NEVADA. Obsidian.
The source is in T.36N., R.26E., Sec. 3 on the 1954 AMS Vya, Nevada quad. It may just represent debitage from a large workshop complex.

DOUBLE SPRINGS, LYON COUNTY, NEVADA. Obsidian.
This is another of the names for the Sutro Springs source, which see.

DOVE SPRINGS, OWYHEE COUNTY, IDAHO. Petrified bone, seam agates*.

Petrified bone in boulder quartzitic conglomerates, and large cobbles of thick, seam chalcedony cobbles in basins in the bed of Saylor Creek near the springs and for miles downstream. This is a part of the Glenns Ferry Formation. T.8S., R.10E., Sec. 6 in the SW ¼ of the NE ¼.

DREWS CREEK /BUTCHER FLAT, LAKE COUNTY, OREGON. Obsidian nodules.
This source is a small exposure of devitrifying obsidian nodules weathering from a knoll at the east of the Butcher Flat Reservoir. It is 2½ miles southwest of Quartz Butte.

DREWS VALLEY RANCH, LAKE COUNTY, OREGON. Obsidian nodules and perlite.
This is another devitrified obsidian nodule locality. T.38S., R.17E., Sec. 17.

DRY VALLEY, NEVADA. Obsidian.
Reported source. No information.

DUCK FLAT, WASHOE COUNTY, NEVADA. Obsidian nodules. *
The source of multi-colored obsidian is in T.37N., R.19E., Sec. 34 and T.36N., R.19E., Sec. 3.

EAST GLASS MOUNTAIN, MODOC COUNTY, CALIFORNIA. Obsidian nodules.
The material is visually identical but geochemically different from Glass Mountain obsidian. T.43N. R.4E., Sec. 1.

EAST MEDICINE LAKE, SISKIYOU COUNTY, CALIFORNIA.
Reported source, no information.

EUREKA, EUREKA COUNTY, NEVADA. Basalt *
Across from the fairgrounds on highway 50, west of town and south of the highway, are huge boulders of workable basalt. The material is dark gray, fine grained, breaks readily, and produces high quality artifacts. T. 20N., R53E., Sec. 32, 33. Traffic and weathering have produced *in-situ* spalling that resembles cultural modification.

FANDANGO VALLEY, MODOC COUNTY, CALIF. Obsidian.
Reported source. No data.

FISH LAKE VALLEY, ESMERALDA COUNTY, NEVADA. Obsidian nodules.*
These samples were collected in T.1N., R.35E., Sec. 32 and are identical to Silverpeak obsidian. An outcrop was reported near Red Mountain but has not been relocated. These samples probably represent float from this outcrop on or near Red Mountain in the Silver Peak Range. This, and other nearby obsidian sources, is chemically similar to several Mono Lake obsidian sources, especially the Queen/ Truman Canyon/Meadows source. The Fe/Mn ratios are the best separator

FISH SPRINGS, INYO COUNTY, CALIF. Obsidian
The source is near Big Pine, Calif.

FLINT CANYON, POWER COUNTY, IDAHO. Chert *
T.11S., R.30E. Sec. 22 & 14? near Molly's Nipple. The material is a blocky, poor-quality greenish CCS.

FLOWERY RANGE, LYON COUNTY, NEVADA. Obsidian nodules. *
This source is in perlite deposits in T.17N., R.22E. (26 ST 59). It is known by several names; Sutro Springs, Double Springs, Asshole Mountain . The cinder cone is being used for cement. Pebbles occur in loose layers within the layered ash deposits.

FOX MOUNTAIN, WASHOE COUNTY, NEVADA. Obsidian cobbles.

The source is in Washoe County, Nevada 1 mile SW of Fox Mountain in T.36N., R.21E., Sec. 14.

1**GARFIELD - Band of glassy nodules in ashy matrix below coarse rhyolitic rock.**

GARFIELD, MINERAL COUNTY, NEVADA. Obsidian nodular float and as nodules embedded in a poorly welded tuff. .* This is also known as the Garfield Hills, and/or the Hawthorne source.
The original recording of this source assumed that the source had been eroded away. Later study discovered that nodules were embedded in a pink welded tuff/ignimbrite layer in T.8N., R.32E., Section 36 in the S ½ of the S ½ of the SW ¼ and in T.7N., R.32E., Section 1 in the N ½ of the N ½ of the NW ¼, and in the N ½ of the NW ¼ of the NE ¼. Drive west from the center (Junction of US 95 and SR 359) of Hawthorne, Nevada on US 95 South. Go a little more than eight miles to the Garfield Flat Road (at US 95 Mn 41.2). Turn south, drive 2.2 miles, and take a jeep road southwest into a wash. After another 0.88 miles, the wash opens up into a small valley. The pinkish formation rising one half mile to your south is the source outcrop. The pink rhyolitic tuff/ignimbrite capping the hills is the parent material. The nodules are embedded in the base of the tuff and are the dark stain in the slopes below (See photographs below).. Erosion has carried the nodules into the Ammunition Depot in the Walker Lake Valley, in several areas along US 95, and into the Soda Spring Valley near Kinkaid.

The outcrop cliff/bluff extends from about N 38 degrees 30.147' x W 118 degrees 28.748 to N 38 degrees 30.113' x W 118 degrees 28.302' You can almost drive up to it. The Garfield Flat Road is a good gravel road but the jeep road is the bottom of a sandy wash, and may be washed out. The outcrop hill is shown on the Kinkaid, Nevada USGS 7.5' map. It is near the bottom of the map, below the USGS Triangulation

Station Panta 6074' and part of the outcrop also shows up on the Pamlico 7.5' map. Panta is at UTM 11 03 70 686E x 42 62 223N.

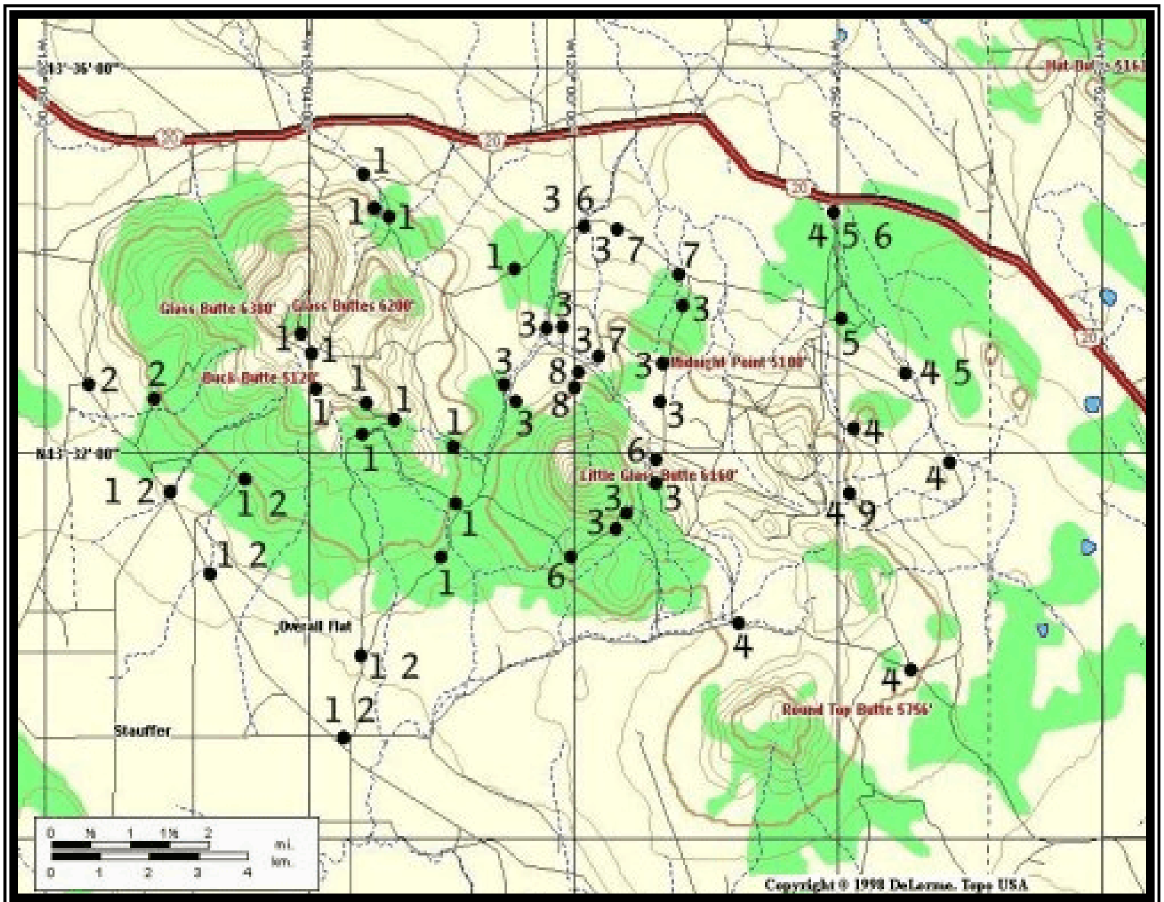
Linda Blair of the UNLV HRC tested a nearby site for the ammunition dump and found Folsom points made from Garfield obsidian. An amateur showed the late Arnie Cunningham (Turner) a Clovis biface made from this material, which came from an area on Nevada SR359 now called "Old Bomb". That is where they tested the bombs for reliability. It has been replaced by "New Bomb" but is still unsafe to walk around. I have a piece that I collected on my desk that is more than 13cm long. Most nodules are fist-size and smaller.

2GARFIELD – Nodular float washes down this valley for miles.

GLASS BUTTE /BUTTES, LAKE COUNTY, OREGON. Obsidian nodules and buried outcrops. * The material occurs as seams in draws, as float, and in cinnabar mining trenches in the buttes on the left (south) as you go west toward Bend from Burns, Oregon. There are as many as eight geochemical types represented in this one area (See photograph below). Glass Butte is noted on road signs and highway maps, and is one of the more well-known sources. It is 21 to 28 miles west of Riley Junction (US 395 & Oregon SR 20). There are numerous aboriginal quarries and workshops, and modern ones. This is a source of gem-quality obsidian in red, brown, burgundy, mottled gray, clear, black, and variations. It occurs in small pieces and in massive chunks. The material varies by locality. Some of the material is wonderful to work and approaches glass in clarity. It was featured in several of the Crabtree/ISU flintknapping films. In 1991 the Oregon Department of Transportation put up a sign for "Obsidian Road" about 28 miles west of Riley Junction. Material occurs in T.23S., R.22E., Sec. 32 & 29, and in T.23S., R.23E., Sec. 19.

GLASS MOUNTAIN, MEDICINE LAKE HIGHLAND, SISKIYOU COUNTY, CALIFORNIA. Obsidian outcrop.
Huge high-quality obsidian flow. T.44N., R.4E., Sec. 26.

GRASS VALLEY SPRING, WASHOE COUNTY, NEVADA. Obsidian cobbles. The source is in Washoe County, Nevada in T.38N., R.22E., Sec. 32 about 5 ½ miles WNW of Hog Ranch Mountain.



3**GLASS BUTTE - locations of geochemically distinct obsidian.**

GRASSHOPPER FLAT, MEDICINE LAKE HIGHLAND. SISKIYOU COUNTY, CALIFORNIA.
Milky grey and banded obsidian.
T.43N., R.2E., Sec. 35, 36. See also Lost Iron Well.

GRASSY RANCH, WASHOE COUNTY, NEVADA. Obsidian nodules.
The source is in T.41N., R.22E., Sec. 19. It is about 8 miles south southeast of Massacre Ranch.

GRAY'S CREEK, BONNEVILLE OR BINGHAM COUNTY, IDAHO. Obsidian.
This material was reported by Wyeth (in Thwaites 161 - Young 1899) on June 27th. as "...SW over a high bluff below the junction of Gray's Creek with the Mudday (sic), less than 15 miles."

GRINDSTONE BUTTE, OWYHEE COUNTY, IDAHO. Chert. *
T.7S., R.10E., Sec. 35, mixed chalcedonies in conglomerate, aboriginal quarries (See the ISUM/BLM survey report for Saylor Creek, Unit 2.)

GUANO VALLEY, LAKE COUNTY, ORE. Obsidian nodules.
This source of emerald green obsidian is in T.40S., R.27E., Sec. 27 & 28. It chemically resembles obsidian from Massacre Lake, Nevada.

JUNCTION, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Small outcrop of nodules in a devitrified ash.
Similar material and setting to Tick Rise source, black/pinky black. T.45N., R.,14E., Sec. 2.

HAGER MOUNTAIN, LAKE COUNTY, OREGON. Obsidian boulder outcrop.
The brittle, grainy black obsidian boulders were exposed in the road cut. T.30S., R.14e., Sec. 11.

HARRIS FLAT, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA.
Bluish grey, and streaked red and black, and translucent black obsidian pebbles and cobbles. T.45N., R.15E., Sec. 21.

HAWKINS /MALAD /ONEIDA, ONEIDA COUNTY, IDAHO.   Obsidian.
The Oneida source is in Oneida County, Idaho at T.11S., R.35E., Sec. 26 on the 1968 USGS 7.5' Wakley Peak, Idaho Quad. It is in a large perlite deposit in Bannock County that is accessible in T.12S., R.35E., Sec. 4. It occurs at several localities in the area. Near the Arbon Gap, it is associated with a metamorphosed lakebed tuff.

HAWTHORNE, MINERAL COUNTY, NEVADA. Obsidian/welded tuff nodules*.
This is also known as the Garfield Hills source, which see. Large pebble nodules of welded tuff occur as float in several separate localities: Just east of Hawthorne on US 95 in T.8N., R.31E., Sec. 22; at T.8N., R.32E., Sec. 18; and at T.8N., R.33E., Sec. 24- Acme Playa. The original source for the float may have eroded away. (**NOTE:** The original recording of this source assumed that the source had been eroded away. Later study discovered that nodules were embedded in a pink welded tuff/ignimbrite layer in T.8N., R.32E., Section 36, in the S ½ of the S ½ of the SW ¼ and in T.7N., R.32E., Section 1 in the N ½ of the N ½ of the NW ¼, and in the N ½ of the NW ¼ of the NE ¼. Drive west from the center (Junction of US 95 and SR 359) of Hawthorne, Nevada on US 95 South. Go a little more than eight miles to the Garfield Flat Road (US 95 Mn 41.2). Turn south, drive 2.2 miles, and take a jeep road into a wash. After another 0.88 miles, the wash opens up into a small valley. The pinkish formation rising one half mile to your south is the source outcrop. The pink rhyolitic tuff/ignimbrite capping the hills is the parent material. The nodules are embedded in the tuff and are the dark stain in the slopes below. Erosion has carried nodules northeast and northwest across US 95, several miles away.

HOG RANCH, WASHOE COUNTY, NEVADA.   Obsidian nodules.
This source is about 3½ miles north of Hog Mountain. T.36N., R.23E., Sec. 17 and 18.

HOMECAMP A, B, C, WASHOE COUNTY, NEVADA. Obsidian nodules.
This is the name of three proposed geochemical Groups on the Vya AMS 1:250,000 quad. They include: Bordwell Spring, Summit Spring Canyon, Duck Flat, Hog Ranch, South of Pinto Peak, Fox Mountain, and Grass Valley Spring, which see .

HORSE CANYON SPRING, HUMBOLDT COUNTY, NEVADA.   Obsidian nodules. The source is in T.45N., R24E. along the dirt highway (Nevada SR 8A or whatever it is now) between Horse Canyon Spring and Gooch Spring Camp along the western margin of Gooch Table in the Sheldon Antelope Range.

HORSE MOUNTAIN, LAKE COUNTY, OREGON. Vitrophyre dome.
This large dome is surrounded by dense nodules for miles. Samples have been collected from 13 miles west of US 395, 5 miles south on the Coleman Flat Road. T.28S., R.22E., Sec. 19. Nodules have been found in the Poverty Basin in T.29S., R.21E., Sec. 3,4, and in T.29S., R.22E., Sec. 10, 14, and in T.28S., R.22E., Sec 7, 8, 17, 18, and in T.28S., R.21E., Sec. 13, 14.

HUMBOLDT, HUMBOLDT COUNTY, NEVADA.   Obsidian.
The material occurs in northern Humboldt County Nevada, in the Sentinel Rock Area, in T.43N., R.35E., Sec. 3, and in T.44N., R.36E., Sec. 18 and 19.

ILLIPAH, WHITE PINE COUNTY, NEVADA .   Siliceous limestone/chert. *
The material occurs as large cobbles and fossils in 300 million year old Ely Limestone, in T.17N., R58E.,

Sec. 2 and surrounding hills. Most of the material is fractured, so it is hard to find good tools but it is there and was used aboriginally. The mountains to the north, Bald Mountain and Little Bald Mountain, toward the Ruby Marshes and on the west side of Long Valley, have numerous outcrops of metamorphic siliceous limestone, and nearby Alligator Ridge has outcrops of useable basalt. These sources are in areas of intense mining activity (1970s-2002) so many exposures have been blasted and\or removed.

INYO CRATERS, MONO COUNTY, CALIF. Obsidian.
The source is on the 1953 USGS 15' Mono Craters, Calif. Quad. Reported source, no information.

INDIAN HOT SPRINGS /BRUNEAU, OWYHEE COUNTY, IDAHO. Jasper.*
Bruneau jasper outcrops on both sides of the canyon for about 1 mile north of the access road and down-river in the Bruneau Canyon. There are terrible roads leading to the hot springs, some of which have seams of jasper. It occurs in reddish, chocolate, and "eyed" varieties up to several feet across. T.12S., R.7E., Sec. 33.

IXL, WASHOE COUNTY, NEVADA. Obsidian nodules. *
The source is about ½ mile south of the IXL Ranch in T.47N., R.22E., Sec. 32 on the 1966 USGS 7.5' Rye Creek, Nevada quad.

JAWBONE CANYON, CALIFORNIA.
Reported source, no information.

KANE SPRINGS WASH, LINCOLN COUNTY, NEVADA. Obsidian nodules.*
The material occurs as float on slopes and washes. T.11S., R.63E., Sec. 20. The road from US 93, in Lincoln County, passes through a large area of float.

KELLY MOUNTAIN, PLUMAS COUNTY, CALIFORNIA. Poor quality obsidian pebbles.
The material has many vesicles and inclusions. It is similar to Mosquito Springs material. T.30N., R.5E., Sec. 36.

KELLY CANYON, JEFFERSON COUNTY, IDAHO. Obsidian float source. *
The material occurs as pebbles and feathery swirls in alluvium above Heise Hot Spring (near Idaho Falls),, near highway 26. It has also been found in the cut above the ski area parking lot. The Kelly Canyon source is in T.4N., R.41E., Sec. 28 on the 1951 USGS 7.5" Heise, Idaho Quad. Samples that appear to represent the same source have been collected from T.12N., R.38E., Sec. 16, T.13N., R.38E., Sec. 15, and T.14N., R.45E., Sec. 2.

KIRK CANYON, BEAVER COUNTY, UTAH. Obsidian
Mineral Mountain Range. T.27S., R.9W., Sec. 27.

LASSEN CREEK, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Large outcrop on top of a hill northeast of Buck Mountain. It is at the head of Lassen Creek. Red and black, black, and purple obsidian. T.45N., R.15E., Sec. 34.

LIDY HOT SPRINGS, CLARK COUNTY, IDAHO. Chert source.*
The material occurs at and near a defunct spa on highway 22 (Dubois-Birch Creek), north toward the Tendoy Mountains. It occurs as seams and nodules.

LODGEPOLE, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Large outcrop, boulders and cobbles of obsidian.
About 1¼ miles ESE of Buck Mountain. Black, red, and red/black obsidian. T.44N., R.15E., Sec. 3.

LONG CREEK, LAKE COUNTY, OREGON. Obsidian pebbles in streambed.
Similar to Sycan Marsh/Silver Lake material.
T.31S., R.13E., Sec. 32.

LOOKOUT MOUNTAIN, MONO COUNTY, CALIFORNIA. Obsidian nodules and outcrops. *
From US 395 in Mono County, about 5 miles south of Mono Lake/Lee Vining, turn northeast onto Lookout Mountain Road. Drive to forest road #2s88 for nodules. Drive to forest road #2s08 for outcrops, partially exposed in the road cut on the SE flank of Lookout Mountain. The ledges are several meters thick and dip steeply to the north. They have been fractured by uplift and the pieces are wedged like a 3-D jigsaw puzzle. It is geochemically identical to Casa Diablo, two miles to the south. T.2S., R.27E., Sec. 36 & T.3S., R.27E., Sec. 1. The material tends to have numerous fractures lined with ash. Some of the material is so fractured as to be unusable. However some of it is quite good, several tons of which were used in a lithic manufacturing and analysis training class held by Dr. John Fagan for NDOT and USDA Forest Service employees.

LOST IRON WELL, MEDICINE LAKE HIGHLAND, SISKIYOU COUNTY, CALIFORNIA. Grey and black obsidian.
One mile east of Lost Iron Well. T.42N., R.2E., Sec. 27.

LOWER SALMON FALLS CREEK, TWIN FALLS COUNTY, NEVADA. Chalcedony.
114°-53'W/42°-35'N Twin Falls, Ida. AMS.

MAMMOTH, MONO COUNTY, CALIF.   Obsidian buried outcrop and boulder nodules on the hill behind the ranger station, on the Sawmill Cutoff road to Crestview. *   T.3S., R.27E., Sec. 2.

MANN CREEK, WASHINGTON COUNTY, IDAHO.   Chert.*
T.12N., R.5W., Sec 25 in the SW ¼. The material is on the right (east) side of US 95 about 7-8 miles north of Weiser, Idaho. IDOT borrow pit.

MARYSVALE, PIUTE COUNTY, UTAH. Obsidian
T.27S., R.4W., Sec. 24.

MASSACRE LAKE /MASSACRE CREEK, WASHOE COUNTY, NEVADA. Obsidian nodules. *
This is part of a semi-continuous float source that covers most of the Vya USGS 1:250,000 quadrangle. The Massacre Lake obsidian is chemically identical to Guano Valley, Oregon obsidian. The source is in the form of cobble float in T.43N., R.21E., Sec. 34 on the 1966 USGS 7.5' Massacre Creek, Nevada Quad. Pebbles and cobbles of this obsidian are incorporated in the road fill of the road from SR 140 to Vya, formerly referred to as Nevada 8A.

MCCOMB BUTTE, LAKE COUNTY, OREGON. Milky grey obsidian cobble and nodule outcrop.
T.34S., R.18E., Sec. 31.

MEDICINE LAKE, SISKIYOU COUNTY, CALIFORNIA.
There are more than ten sources of seven geochemical types in the Medicine Lake Highland. See specific sources.

MIDDLE FORK, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Obsidian outcrop.
The source is CA-Mod-324, and is about ¾ mile north of Plum Creek. T.45N., R.14E., Sec. 23.

MIDVALE HILL, WASHINGTON COUNTY, IDAHO. Blue/gray basalt.*
The material occurs as fine-grained, rounded, blue/gray basalt cobbles on the shoulders of the hill. Similar material occurs in outcrop layers in stacked basalt layers along the Weiser River in T.18N., R.1W.

MODENA, IRON COUNTY, UTAH/PANACA SUMMIT, LINCOLN COUNTY, NEVADA. Obsidian nodules. *
The Modena source is in Iron County, Utah at T.35S., R.19W., Sec. 12 on the 1972 USGS 7.5' *Modena, Utah* Quad. The Panaca Summit nodule source is on Nevada State Route 319, in Lincoln County, Nevada on the 1972 USGS 15' *Panaca Summit, Nevada* quad. The Blue Ridge Perlite Deposit in T.2S., R.70E. Sec. 2 is a source of perlite that produces "Apache tears". Nodules cover more tan 20 miles, between Panaca, NV and Modena, UT.

MONACHE MEADOWS, CALIF. Obsidian
Reported source, no information.

MONO CRATERS, MONO COUNTY, CALIF. Obsidian outcrop. *
The source is in Mono County, Calif. on the 1953 USGS 15' Mono Craters, Calif. quad. The road from near Lee Vining on US 395, to Benton (California 190) passes near Panum Crater, a crater with obsidian on its rim and on the plug. It is on the bench overlooking Navy Beach, at Mono Lake. It has been developed as an interpretive site. Obsidian is reported from the other craters.

MONO GLASS MOUNTAIN, MONO COUNTY, CALIF. Obsidian
This source is near the east rim of the Mono Basin. It is between the Casa Diablo, and Truman Meadows sources. Some of the material exhibits a wood-like grainy structure but it still breaks choncoidally. There is a semi-circular chain of sources around the margins of the Mono Basin. This includes the Bodie Hills, Mt. Hicks, Truman Meadows (Queen), Inyo Glass Mountain, Mono Glass Mountain, Mono Craters, and Casa Diablo. They are a result of the magma chamber that produced the Mono Basin depression. As the chamber melted and released gases, the pressure forced liquid rock to the surface. If it exited rapidly and cooled fast, it became ash and pumice. If it exited slowly and cooled slowly, it became rhyolitic lava flows. If it exited slowly but cooled rapidly, it became glassy rock (obsidian). Some of the ash flows (pyroclastic flows) remained hot enough to melt together into glassy ignimbrite (remelted ash). As the chamber melted different rock formations through time, the composition of the melt changed, resulting in chemically distinct eruptions.

MOSQUITO LAKE /MOSQUITO CREEK, WASHOE COUNTY, NEVADA. * Obsidian nodules.
The source is ¾ mile east of Gravelly Spring and ½ mile north of Mosquito Lake. The material is unlike the dominant green material found in the other nearby sources. It is a milky blue/grey. T.46N., R.19E., Sec. 34.

MOSQUITO SPRINGS, LASSEN COUNTY, CALIFORNIA. Poor quality obsidian pebbles.
The material is similar to the Kelly Mountain source. It is vesicular, with inclusions. T.29N., R.6E., Sec. 20.

MT. HICKS, MINERAL COUNTY, NEVADA. Obsidian nodules and outcrop.*
The peak of Mt. Hicks is in T5N R28E Sec. 24. There are several bands of float on the northeast and southeast. It occurs in T.5N., R.29E., Sec. 17, 18, 20, & 34 in Mineral County, Nevada on the 1962 USGS 15' Aurora, Nevada - Calif. quad. Material occurs on other parts of the mountain and on ridges to the north. There are large aboriginal quarry/workshops. An unusual feature of this source is that rock-lined house pits, that have workshops and debris fans leading from their doorways, are found on the north slope. The California State University, Stanislaus' Institute for Archaeological Research (Napton and Greathouse-Napton) excavated part of the slope leading into the Alkali Lake Valley. No report has been received on their work. Some of the material from this source and from the Bodies Hills approaches the quality of Glass Butte obsidian. Large nodules surround more than ten square miles, in a northeastern direction from Mt. Hicks and into Alkali Valley. Pebbles cover more than 40 square miles, and overlap

the Aurora Crater and Mud Springs/Fletcher sources. There are several distinct sources within 15 linear miles, including the Bodie Hills source.

MT. Majuba, PERSHING COUNTY, NEVADA. * Obsidian float.
Obsidian from a number of localities near Mt. Majuba and the Seven Troughs Mountains. T.31N., R.29E., Sec. 4. is the location of both the "Mt. Majuba" and the "Seven Troughs" obsidian samples. So far as I can find out, no one has ever found any obsidian on Mt. Majuba itself. Perhaps the name was chose because Mt. Majuba is the dominant feature on the local landscape. Nodules extend for many miles, occasionally crossing the Humboldt River.

MOUNT KONOCTI, CALIFORNIA.
North Coast Range. Reported source, no information.

MURPHY SPRINGS, OWYHEE COUNTY, IDAHO. Vitrophyre and chalcedony.
T.16S., R.10E., Sec. 29 in the SW ¼, 10 OE 197, Three miles SE of Murphy Springs.

NAPA GLASS MOUNTAIN, CALIFORNIA.
North Coast Range. Reported source, no information.

NEEDLE GRASS SPRING JUNCTION, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Small obsidian outcrop.
Several different colors; red, red/black, black. T.45N., R.15E., Sec. 29.

NELLIE SPRING, WASHOE COUNTY, NEVADA. * Ignimbrite cobbles. T.40N., R.21E., Sec. 28.
Dense, variably-colored dark ignimbrite, with ashy inclusions and crystals, from about four miles north of Pinto Peak. The material is across the main road, west of the spring. It occurs as large cobbles and small boulders.

NELSON QUARRY, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Obsidian outcrop.
Hughes (1983b: 296) reports a small high quality red and black outcrop. Buck Mountain Chemical Group. T.45N., R.14E., Sec. 12.

NEWBERRY CRATER, DESCHUTES COUNTY, OREGON. Obsidian outcrop.
This is reputed to be the largest single obsidian flow in the world.

NORTH COTTONWOOD FLAT, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Obsidian flow.
Black and pinkish black obsidian. T.46N., R.14E., Sec. 36.

NORTH FORK, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Obsidian outcrop and needles.
A large outcrop of obsidian across the North Fork of Davis Creek from the Nelson source. Buck Mountain geochemical type. T.45N., R.14E., Sec. 12.

NUT MOUNTAIN . WASHOE COUNTY, NEVADA.
Reported source, no information. T.43N., R.23E. Sec. 34.

OAT CREEK, SHASTA COUNTY, CALIFORNIA. Obsidian nodules eroding into the creek.
This is part of the Tuscan Geochemical Group. T.32N., R.3W., Sec. 26.

OBSIDIAN BUTTE, IMPERIAL COUNTY, CALIFORNIA.
Reported source, no information.

OPAL SPRING, ELKO COUNTY, NEVADA. Red chalcedony.
114°-31'W./41°-44'N. Wells, Nevada AMS

OREANA, PERSHING COUNTY, NEVADA. Obsidian nodules.
The source is in Pershing County, Nevada in T.28N., R.32E., Sec. 11 on the 1965 USGS 7.5' Oreana, Nevada Quad. Float obsidian occurs on either side of the Humboldt River. It has also been reported near Star City and Unionville. It is related to Majuba material.

OWYHEE /BROWNS /CASTLE, OWYHEE COUNTY, IDAHO. Obsidian pebble nodules.*
The Owyhee (Toy Pass) source is in Owyhee County, Idaho in T.6S., R.2W., Sec. 14 on the 1965 USGS 15' Triangle, Idaho Quad. The source is nodular pebble float, that occurs throughout northern Owyhee County, Idaho.

PANACA SUMMIT, LINCOLN COUNTY, NEVADA. *
This is nodular float and nodules in perlite deposits in T.1 and 2S., R69 and 70E., and as float throughout the area, see also Modena, Utah.

PARADISE VALLEY, HUMBOLDT COUNTY, NEVADA. obsidian nodules.*
This refers to several localities in the Santa Rosa Mountains and in the Little Humboldt River Valley. T.41N., R.43E., Sec. 31; T.42N., R.38E., Sec. 17; T.43N., R.39E., Sec. 2, 11, 14, 15, 22, 23.

PERSHING COUNTY, NEVADA. Obsidian
Reported source, no information. T.32N., R.30E., Sec. 17.

PINE GROVE HILLS, LYON COUNTY, NEVADA. Obsidian nodules.*
Scattered pebbles throughout the Pine Grove Hills. Sources at T.8N., R.25E., Sec. 8. and T9N R25E., Sec. 9/10/15/16. Pebbles occur for several miles along Nevada SR 338. They also wash down nearly into Desert Creek.

PINK LADY, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Large exposure and outcrop, iridescent silver-sheen and green-sheen. T.45N., R.15E., Sec. 32.

PINTO PEAK, WASHOE COUNTY, NEVADA. Obsidian nodules.
The source is 3 miles south of Pinto Peak in T.39N., R.21E., Sec. 17.

POKER BROWN GAP, PERSHING COUNTY, NEVADA. Obsidian.
The source was sampled by Nelson 1983 in T.32N., R.30E., Section 17. It is on the 1955 AMS Lovelock, Nevada Quad.

POKER BROWN WASH, PERSHING COUNTY, NEVADA. Obsidian.
Sampled by Nelson 1983 in Pershing County, Nevada in T.31N., R.31E., Sec. 27 on the 1971 USGS 7.5' Poker Brown, Nevada Quad., and at T.31N., R.30E., Sec. 4 & 25, and in T.31N., R.31E., Sec. 5 on the 1955 AMS Lovelock, Nevada, and in T.31N., R.32E., Sec. 11 on the 1971 USGS 7.5' Rye Patch Reservoir, Nevada Quad.

PORCUPINE SPRING, TWIN FALLS COUNTY, IDAHO. Yellow jasper.
114°-15'W/42°-07'N. Twin Falls, Ida. AMS.

PUMICE HOLE MINE, BEAVER COUNTY, UTAH. Obsidian
T.28S., R.9W., Sec. 2.

QUARTZ MOUNTAIN, DESCHUTES COUNTY, OREGON. Obsidian cobble outcrop.
Multi-colored nodules originating in a devitrified rhyolite dome complex. It is about 15 miles ESE of the Newberry Volcano. T.22S., R.15E., Sec. 33, 34.

QUEEN VALLEY, MINERAL COUNTY, NEVADA.   Obsidian nodules.*
This is probably float from the Truman Meadows /Truman Canyon outcrop source. It is reported in Mineral County, Nevada and Mono County, Calif. T.1N., R.32E., Sec. 7-9, 17, 18, and 28. Float in Fish Lake Valley, Nevada has been identified as Queen material. There is a very similar material that has been called the "Silverpeak Source", which has nearly identical chemical values, except for inverse Fe/Mg values.

RABBIT HOLE, PERSHING COUNTY, NEVADA.   Obsidian.
Reported source, probably "Majuba"/Seven Troughs material.

RABBIT SPRING, TWIN FALLS COUNTY, IDAHO.   Chalcedonies and agates.
114-38'W./42-08'N. Twin Falls, ID. AMS

RAILROAD GRADE, MEDICINE LAKE HIGHLAND, SISKIYOU COUNTY, CALIFORNIA. Small exposure of 30cm nodules of vitreous, brittle obsidian exposed in a railroad cut on the southeast of Cinder Butte. T.44N., R.4E., Sec. 2.

RAILROAD POINT, HUMBOLDT COUNTY, NEVADA.   Nodular float
This float source consists of pebbles washing from the Thousand Springs/ Virgin Valley/ Dufurrena Grade areas, being washed by Virgin Creek/Thousand Creek through the Thousand Creek Gorge, and onto the floor of Thousand Springs Valley. T.44N., R.27E., Sec. 1. Tertiary volcanism produced extensive ash deposits, which contained nodules of vitrophyre. The valleys in this area had thousands of feet of ash. Railroad Point was a lava flow that followed a riverbed through the ash. Wind and rain have eroded most of the ash onto the Black Rock Desert, leaving Railroad Point as a prominent raised feature on the landscape. The erosion also produced a flattening effect on layers of obsidian float, compressing it into a single layer on rock surfaces. The plateaus above this area have as many as four different geochemical sources lying on the modern lava surface. These sources could have been widely separated in time as well as distance. The nodules found near Railroad Point are a jumble of these sources.

RAINBOW MINES, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Angular cobbles and small boulders of black obsidian (with a pink translucence) that has a red/orange cortex. A mine has extensively disturbed the area. T.46N., R.14E., Sec. 12.

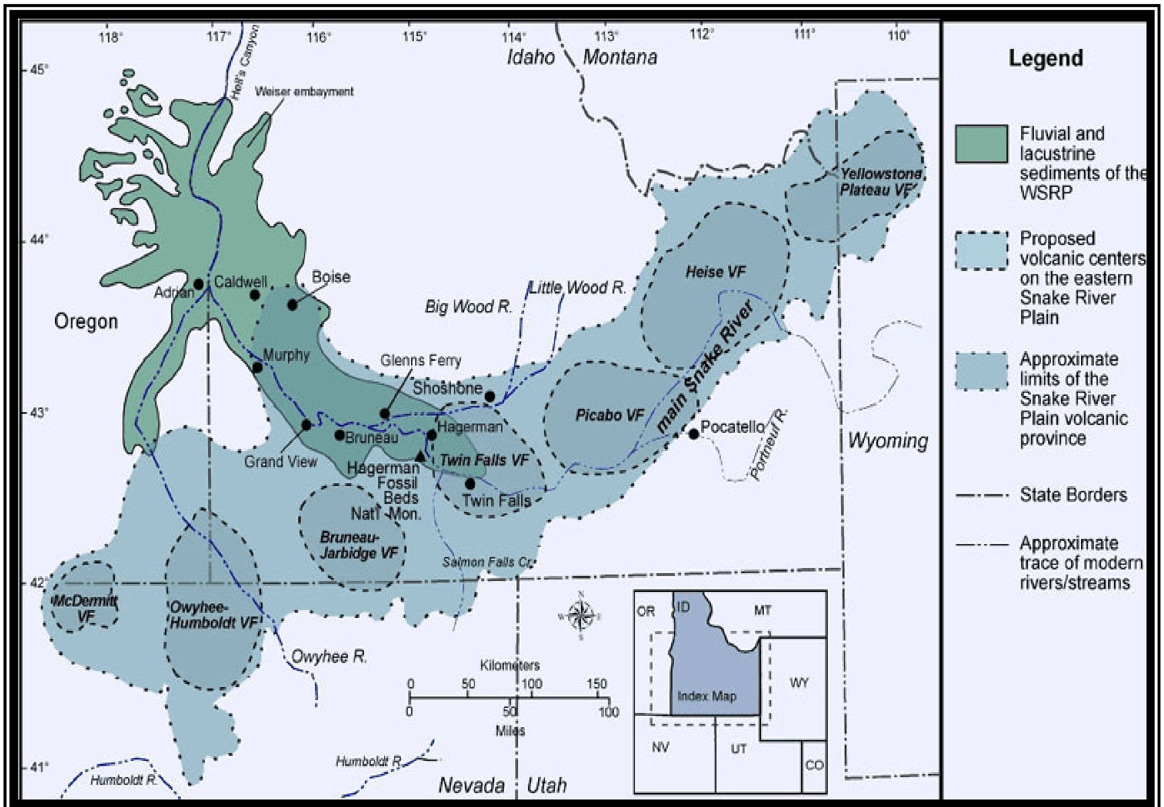
RANCHO GRANDE, ELKO COUNTY, NEVADA.   Agate and chalcedonies.
114°-08'W./41°-52'N. Wells, Nevada AMS, upper Goose Creek-Bluff Creek area.

RED SWITCHBACK, MEDICINE LAKE HIGHLAND, SISKIYOU COUNTY, CALIFORNIA.
Obsidian (red and black) outcrop.
T.45N., R.3E., Sec. 32.

REYNOLDS, OWYHEE COUNTY, IDAHO.   Obsidian nodules.
The material occurs in the upper portion of the Reynolds Creek Basin in T.3S., R4W.
RILEY /REILLY /GLASS MOUNTAIN, OREGON. Obsidian nodules.*
The source is on both sides of US 395 in a saddle about 4½/5 miles south of the junction of US 395 with Oregon SR 78 (US20), in T.24S., R.26E., Sec. 13, Harney County, Ore. It is east of the Riley Junction and Glass Butte.

ROCK CREEK, TWIN FALLS AND CASSIA COUNTIES, IDAHO. vitrophyre.*

The red, brown, and black ignimbrite occurs in the hillsides and washes above the Third Fork of Rock Creek, below Cherry Spring Road, below the West Fork and also over the mountains and below Lower Goose Creek Reservoir, near Oakley, Idaho. T.12S., R.18E., Sec. 10 & 11.



4Volcanic fields and obsidian sources, potentially associated with the Yellowstone Hot Spot. Becoming progressively younger toward the northeast.

This green obsidian source is in T.42N., R.21E., Sec. 19. It is east of Sand Spring and about 3 ½ miles south of Massacre Ranch.

SANTA ROSA MOUNTAINS, HUMBOLDT COUNTY, NEVADA. Obsidian. *
See Paradise Valley.

SARCOBATUS FLATS /TOLICHA WASH /OBSIDIAN BUTTE, NYE COUNTY, NEVADA. Obsidian nodules. *
There are several collecting localities in this area. After a few years, it was realized that they were all related. This is actually float washing down from Obsidian Butte on Pahute Mesa in the (Top Secret/closed to the public) Nellis Air Force Bombing Range and DOE Nuclear Test Site. Localities of float include T.7S., R.44E., Sec. 28 and T.8S., R.45E., Sec. 28. The presence of an outcrop is suspected at Obsidian Butte in T.7S., R.46E., Sec. 19, but the locale is closed to the public (and scholars).

SATURDAY MOUNTAIN, CUSTER COUNTY, IDAHO. Chert.*
There are surface scatters of agate and chalcedonies on Saturday Mountain, north of the Salmon River, upstream from Clayton, between Squaw Creek and Thompson Creek. This is the site of a proposed open pit mine.

SCHOOL CREEK, LAKE COUNTY, OREGON. Obsidian nodules.
An outcrop of green obsidian cobbles, about 2 miles northwest of Bald Butte

SCHOO /SCHOOL MINE, BEAVER COUNTY, UTAH. Obsidian
Mineral Mountain Range. T.27S., R.9W. Sec. 1, 2, 11, 34.

SCHADLER DITCH, MODOC COUNTY, CALIFORNIA. Obsidian.
Small nodules exposed in the ditch on the NE of Mount Bidwell. This, along with the Eightmile Creek source, are geochemically the same as the Cowhead Lake source. T.47N., R.16E., Sec. 10.

SECRET CANYON (MALAD), ONEIDA COUNTY, IDAHO. Quartzite.*
The material occurs as unsorted rocks, from pebble to house-size. It is a quartz-cemented quartzite. It is near Deep Creek/Malad. It was being used as a source of material for an IDOT crusher. Some of the aboriginal detritus looked heat-treated. This may be also called “willow Spring Quartzite”.

SEVEN TROUGHS, PERSHING COUNTY, NEVADA. Obsidian. *
In the Seven Troughs Range, in T.31N., R.29E., Sec. 4 on the 1955 AMS Lovelock, Nevada Quad. This is the same locality as the "Mt. Majuba" source, which is a misnomer. There is no obsidian on Mt. Majuba.

SILVER LAKE, LAKE COUNTY, OREGON. Greenish black obsidian cobbles and boulders.
This source is near the north end of Alder Spring Ridge. The material is similar to the Sycan Marsh material. T.30S., R.13E., Sec. 1.

SILVERPEAK/CAVE SPRING, ESMERALDA COUNTY, NEVADA. Nodular obsidian float and fractured outcrop*
The source is known from artifacts at sites in western Nevada and from the White and Sierra Nevada mountains in California. Nodular float occurs in the Clayton Valley and along State Route 265 in the bottom of the Big Smoky Valley. It can also be found along Nevada State Route 264 in Fish Lake Valley. Float samples were collected from T.2S., R.39E. And from T.1N., R.38E., Sec. 9 and 35.

A potential source outcrop was first brought to my attention by Dr. Richard Hughes in 1985. It was described as being on Red Mountain by a Lt. Lyle from notes by Gilbert, in an Army Corps of Engineers survey report (Wheeler 1871:48-49). An outcrop of fragmented and layered material was found matching their description, at Cave Spring near Red Mountain in the Silver Peak Mountains. T.2S., R.37E., Sec. 2 in the NW¼. Drive west from Silverpeak on Coyote Road (not the Nivloc Road). Go over Coyote Summit to Rhyolite Ridge. Just before the gap in the ridge, you will notice shiny-banded material at the base of the rhyolite (about ten miles from Silverpeak). It has distorted bands of fractured pyroclastic materials (pumice, rhyolite, obsidian). The nodular float specimens are better quality tool-stone than the outcrop. They are also not from the outcrop. The Cave Spring outcrop is geochemically different from the Silverpeak float, and therefore, not the source.

SOUTH GLASS MOUNTAIN, MEDICINE LAKE HIGHLAND, CALIFORNIA. Obsidian.
Trace elements are identical to Glass Mountain. T.43N., R.4E. Sec. 9.

SOUTH HANGING ROCK, WASHOE COUNTY, NEVADA. Obsidian nodules.
The emerald green obsidian source is in T.42N., R.23E., Sec. 31 & 32 at the south end of Hanging Rock Canyon and about 3 ½ miles east northeast of Stevens Camp. It is about ½ mile southwest of the IXL Ranch in the southern Guano Valley.

SOUTH OF PINTO PEAK, WASHOE COUNTY, NEVADA. Obsidian cobble float.
T.39N., R.21E., Sec. 17.

SOUTH WARNER MOUNTAINS, MODOC AND LASSEN COUNTY, CALIFORNIA. *
The Warner Mountains have more than 20 recognized obsidian sources, with 7 geochemical types.

SPODUE MOUNTAIN, KLAMATH COUNTY, OREGON. Devitrified obsidian cobbles and nodules. Black, purple/black, and black with mahogany nodules. T.34N., R.12E., Sec. 13.

SPRAGUE RIVER, KLAMATH COUNTY, OREGON. Obsidian pebble float.
T.36S., R.10E., Sec. 7.

STEVENS CAMP, WASHOE COUNTY, NEVADA. Obsidian nodules.
This green obsidian source is about 7 ½ miles east southeast of Massacre Ranch in T.41N., R.22E., Sec. 10.

STEAMBOAT HOT SPRINGS, WASHOE COUNTY, NEVADA. "Sinter"(siliceous travertine) and basalt. *
The sinter forms in thick layers around the hot springs. It is a result of minerals in suspension in the water. It is difficult to work until it has been heat-treated, then it is very tractable. Aboriginal heat treating ovens have been found at the source. The basalt occurs in nearby rhyolitic formations. It supplied tool stone as well as large hammer stones, used for quarrying the sinter. It is in the southeast quadrant of the junction of US 395 and the Mt. Rose Highway. T.18N., R20E., Sec. 28, 29, 32, 33. Much of the source has been disturbed by geothermal power plant construction.

STOCKOFF QUARRY, NORTHEASTERN OREGON. Basalt.
This source is known for workable basalt. It is mentioned in Don Tuohy and Allan Bryan's 1958 gas pipeline survey. It was Bruce Womack's MA thesis.

STONY RHYOLITE CORE, MEDICINE LAKE HIGHLAND, MODOC COUNTY, CALIFORNIA. Obsidian outcrop.
The obsidian is exposed in the base of the rhyolite one mile southeast of Yellowjacket. The material is nearly identical to the Yellowjacket source. T.44N., R.5E., Sec. 28.

SUGAR HILL /SUGAR HILL SWITCHBACK, WARNER MOUNTAINS, MODOC COUNTY, CALIF. Obsidian outcrop and float.
Black obsidian only. T.46N., R.14E., Sec. 25, 34-36, and in T.45N., R.14E., Sec. 2 on the 1962 USGS 15' Willow Ranch, Calif. quad.

SUGARLOAF BUTTE, MALHEUR COUNTY, OREGON. Obsidian.
The source is on the 1950 USGS 15' Jameson, Ore. Quad.

SUMMIT LAKE, HUMBOLDT COUNTY, NEVADA. Obsidian nodules.
T.42N., R.26E., Sec. 23 and T.42N., R.27E. Sec. 28 and 29 near Summit Lake.

SUMMIT SPRING CANYON, WASHOE COUNTY, NEVADA. Obsidian nodules.
T.37N., R.21E., Sec. 8.

SURVEYOR SPRING, LAKE COUNTY, OREGON. Obsidian cobble outcrop.
Pink obsidian outcrops from a low knoll a mile northeast of the spring. T.41S., R.23E., Sec. 11, 14.

SUTRO SPRINGS /DOUBLE SPRINGS /ASSHOLE MOUNTAIN, LYON COUNTY, NEVADA. Obsidian nodules.* Obsidian nodules and pebbles occur in layers of a poorly fused volcanic ash. The ash is being used for cement. The mine has disturbed much of the west face of the cinder cone. T.17N., R.22E., Sec. 8. It can be seen from US 50 east of Dayton.

SWORINGER BASIN, WARNER MOUNTAINS, LASSEN COUNTY, CALIFORNIA. Obsidian cobbles. The material occurs at the south end of the basin. This is also CA-Las-201. T.38N., R.16E., Sec. 12.

SYCAN MARSH / CARLON RANCH / COLD SPRING, LAKE COUNTY, OREGON. Greenish-black obsidian cobbles and nodules in road cut. Similar to Silver Lake source material. T.31S., R.13E., Sec. 34.

TEXAS SPRING, ELKO COUNTY, NEVADA.   Petrified wood, agate, chalcedony.
T.44N., R.65E. 114°33' West longitude, 41°38' North latitude, on the Wells, Nevada AMS Quad.

THREE CREEKS, OWYHEE COUNTY, IDAHO.   Vitrophyre.
Site# 10OE61, aboriginal vitrophyre quarry. Material quarried from a 1-meter ledge, near where Three Creeks Road crosses Devil Creek, and about 27.2 miles from Rogerson, Nevada. T.15S., R.12E., Sec. 22

TICK RISE, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Angular nodules and needles in ashy matrix,
T.45N., R.15E., Sec. 21.

TIMBER BUTTE /SQUAW BUTTE /WEBB CREEK, BOISE COUNTY, IDAHO. Obsidian outcrop*
The source is in Boise County, Idaho in T. 8N., R.2E., Sec. 5-7, and in Gem County Ida. in T.9 N., R.1W., Sec. 30. It occurs as a band of obsidian outcrop, and as float in the Squaw Creek Valley.

TOPAZ MOUNTAIN, JUAB COUNTY, UTAH.   Obsidian.
T.12S., R.11W. Sec. 28, 29, 31, and T.13S., R.11W., Sec. 6, 9.

TOSAWI / TOSAWIHI / BATTLE MOUNTAIN, ELKO COUNTY, NEVADA.   Chert, opalite, and meta-quartzite. *
T.37N., R.48E., Sec. 4 & 5, 116-30'W./41-15'N. McDermitt, Nevada AMS. See Elston, Raven, and Budy 1987 etc, ... for maps. A gold mine is blasting the chert/opalite to get to the gold below. This is a huge deposit of a hydrothermally altered volcanic ash. It was the major non-obsidian tool-stone source in the Great Basin. It was reputedly the reason why the White-knife Shoshone were so-called.   Initial quarrying and primary decortication is very difficult. The material is granular, very durable and tough, and it occurs in large ledges and blocks. Boulder hammer-stones, wedges, and fire quarrying were all employed in aboriginal quarrying. Once the material is reduced to smaller slabs and rough bifaces, experiments have shown that it can be heat-treated by burying it about 8-20cm under a campfire that is allowed to burn for a few hours, or overnight. There is a noticeable color change, and flakes removed after treatment are glossier than previous flakes and flake scars. It suffers a slight loss of durability after treatment, but is much easier to work. If allowed to properly cool (at least 8-12 hours) it can be removed without pot lidding, cracking or crazing. If a sample is too hot to hold barehanded, then it is probably too hot to remove the rest of the flakes. The thermal alteration changes the nature of the material into a very forgiving, much more homogenous and flake-able material. It becomes more lustrous, and the mercury/cinnabar tends to result in a pink color. Minerals with low melt temperatures, such as Calcium and Borax tend to flow and flux other minerals. There is also a stress-relieving effect. The untreated material is very tough and durable. It is suitable for rough usage in knives and other tools. The treated material is more amenable to pressure flaking and use as projectile points.

TOY PASS, OWYHEE COUNTY, IDAHO. Obsidian pebble float. *
See Owyhee, Idaho.

TRUCKEE RIVER /BOCA RESERVOIR /MARTIS CREEK, NEVADA COUNTY, CALIFORNIA.

Basalt outcrop and float. *
This material crops out in Martis Creek near Squaw Valley. It also occurs as float in Martis Valley and along the Truckee River as nodules and boulders. T.16N. R.16E. There are also outcrops around Carnelian Bay, at Lake Tahoe. It is grainy and coarse-looking but fractures with a glassy ringing sound and produces very sharp-edged tools.

TRUMAN MEADOWS/CANYON, MINERAL COUNTY, NEVADA. Obsidian. Nodular float and outcrops. This is most likely to be the parent of the Queen float source. It is reported in Mineral County, Nevada and Mono County, Calif. T.1N., R.32E., Sec. 7-9, 17, 18, and 28, and in T.1N., R.31E,.

TUCKER HILL, LAKE COUNTY, OREGON. Obsidian cobble outcrop.
The source contains bluish-grey obsidian with white phenocrysts and inclusions. It is a devitrified flow in a perlite matrix. T.34S., R.19E., Sec. 25, 36.

TWIN SPRINGS, OWYHEE COUNTY, IDAHO. Jasper.
T.13S., R.3W., Sec 27, 10OE94. On the right side of the road, 2 miles south of the Twin Springs archaeological site.

TUSCAN, SHASTA COUNTY, CALIFORNIA.
There are four separate sources in the Tuscan Formation. See specific sources.

UPPER ROSS CREEK, WARNER MOUNTAINS, MODOC COUNTY, CALIFORNIA. Large outcrop of obsidian.
Black with a pink translucence. T.46N., R.14E., Sec. 34, 35.

VALLEY OF FIRE /OVERTON ROAD, CLARK COUNTY, NEVADA. Metaquartzite.

VYA, HUMBOLDT AND WASHOE COUNTY, NEVADA. Obsidian float. *
This cobble source is known by many different names and occurs at different localities. This is float from across most of northern Washoe and Humboldt counties. Most of the USGS 1:250,000 Vya, Nevada quadrangle has float obsidian sources. The map of the identified sources looks as though it has the Measles. An area from the Dufurrena Grade on SR 140 HU 100, near Virgin Valley, to near Massacre Lakes (32 miles) is virtually a single float nodule scatter. The road through the area mentioned above, as well as the road from Vya to the vicinity of Leadville, near Gerlach, often have obsidian nodules incorporated in the roadbed. There are at least six distinct geochemical types of obsidian, at more than 16 source localities that have been analyzed (Hughes 1983b: 348).

WARNER MOUNTAINS, MODOC AND LASSEN COUNTY, CALIFORNIA. Obsidian.*
The sources are in the Warner Mountains, Modoc County, Calif. There are several different source areas (more than 20, See Hughes 1983). Some of the sources that occur on the 1962 USGS 15' Davis Creek, Calif. quad. are T.45N., R.14E., Sec. 12 & 13, and T.45N., R.15E., Sec. 21, 29, 32, & 34, and T.44N., R.15E., Sec. 3 & 4, plus several others. Some of these sources are huge obsidian layers between pumice cliffs. Blocks more than a meter in diameter are common. In other areas, the glass occurs in buried deposits, or as surface float.

WEST HORTON, KLAMATH COUNTY, OREGON. Obsidian pebble float.
Sparse pebbles north and west of Horton Reservoir. T.37S., R.11½E., Sec. 1, 2.

WHITE ROCK CANYON, NYE COUNTY, NEVADA. Obsidian nodules.
This is a scatter of small nodules in alluvium and washes. T.8S., R47E., Sec. 7 or 19.

WILD HORSE CANYON, BEAVER COUNTY, UTAH. Obsidian

Mineral Mountain Range, Beaver County. T.27S., R9W., Sec 2, 22.

WINDMILL QUARRY, WASHOE COUNTY, NEVADA. Obsidian nodules .
The emerald-green? obsidian source is south of Massacre Lake, between Massacre Creek and the state/County road (Nevada SR 8A or 34 or whatever it is this year), in T.43N., R.21E., Sec. 34. It is the same as one of the Massacre Lake sources.

WITHAM HILL/CREEK, LAKE COUNTY, OREGON. Obsidian cobble outcrop.
Emerald green obsidian is found cropping out of a small knoll 2 miles northeast of Bald Butte. T.34S., R.17E., Sec. 7.

YELLOWJACKET, MEDICINE LAKE HIGHLAND, MODOC COUNTY, CALIFORNIA. Obsidian outcrop. The material, a grey/black banded obsidian with clear streaks, is found below an ash layer. T.44N., R.5E., Sec. 21.

YELLOWSTONE NATIONAL PARK, Wyoming. Outcrop and float sources. Obsidian Cliff is the original and most well known source in the country. At one time, it was thought to be the source of any obsidian artifacts found anywhere. Although there have been many hundreds of other sources identified to date, the Yellowstone obsidian sources produce material that has been found throughout most of western and Midwestern North America, and even beyond. Within park boundaries are many recognizable sources in addition to Obsidian Cliff, they are: Crystal Springs, Obsidian Creek, Lake of the Woods, Canyon Junction, Geyser Creek, North Geyser Basin, Cougar Creek, Madison Plateau, Summit Lakes, Buffalo Lake, Boundary Creek, Kepler Cascade, West Thumb, Grassy Lake Reservoir, Wish Creek, Mt. Hancock, Fishing Bridge, Pelican Creek, and Uncle Tom Trailhead. West of the park, but still nearby, are Idaho sources near Monida Pass, Kilgore, Bear Gulch, Teton Pass, Big Table Mountain, and possibly other obsidian and ignimbrite sources.

[[NOTE]] The sources listed above are usually larger than the legal description given. The description is taken from my own research notes, from conversations with amateurs and scholars, and from references cited below.

OBSIDIAN SOURCE MAPS

The following maps and locations were developed using Delorme's Street Atlas software (www.delorme.com). The locations were plotted as well as available maps and legal descriptions would allow. They were then converted by the software to latitude and longitude. This data was then ordered by latitude and listed below.

OVERVIEW OBSIDIAN SOURCE MAP This map was printed at 1:5,600,000 to show the distribution of all of the obsidian sources known to be important to Great Basin Indians. The scale is roughly one mile = 28mm (one mile = 1.125").

The shaded areas represent the source localities. Generally, the larger the source area, the larger the gray area. This is slightly obscured by float sources such as the Obsidian Butte source on the Nevada Test Site, where the float occurs many miles from the source. In cases where the data was acquired as many individual sources, it shows up as a lot of little circles. Areas of widespread distribution, such as the Brown's Bench, Idaho source are shown as larger circles. Irregular shapes represent modifications in distribution of a previously plotted source.

REGIONAL SOURCE MAPS These maps are printed at varying scales (shown on the bottom of the individual map) to show more accurate locations . The maps were developed at much lower scales, and then expanded to include the larger geographic area. The data is available as Delorme Street Atlas 5.0 or 6.0 (SA5 or SA6) files, which can be manipulated to fine detail by your own computer (Email: nvjoe@hotmail.com).

LATITUDE AND LONGITUDE FOR OBSIDIAN SOURCES (from the Street Atlas Map).
Sorted by latitude. This is just a list of the coordinates for sources plotted by the program.

Lat. North Long. West
34.679660, -115.850837,
34.685370, -115.838294,
35.688676, -115.433697,
35.692079, -115.439628,
35.692661, -115.440783,
35.701454, -115.455015,
35.995968, -116.229400,
36.003558, -117.862375,
36.006423, -117.870096,
36.475950, -116.425552,
36.617031, -116.404554,
36.987131, -114.957256,
37.023589, -114.883578,
37.074753, -118.253641,
37.075338, -118.248909,
37.187475, -116.638788,
37.284790, -117.075321,
37.319375, -116.865114,
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37.321198, -116.864787,
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[[The names of Rob Jackson, Tom Jackson, Richard Hughes, Robert Jack, Fred Nelson, Richard Holmes, Craig Skinner, and Jonathon E. Ericson, are legendary in the field of obsidian studies. Perusing the literature under their names will produce many more references than cited here.]]