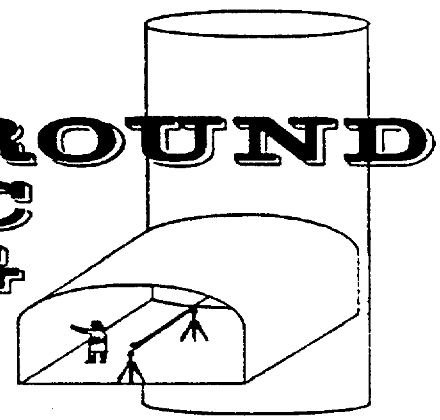
YUCCA MOUNTAIN PROJECT

EXPLORATORY SHAFT FACILITY

TECHNICAL PROCEDURE

FOR

UNDERGROUND GEOLOGIC MAPPING



SHAFT MAPPING

Prepared by

U.S. Geological Survey
and
Bureau of Reclamation

for

The Department of Energy

USGS/USBR TECHNICAL PROCEDURE YMP-USBR-GP-31, Rev 0

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UNDERGROUND GEOLOGIC MAPPING
SHAFT MAPPING

1.0 PURPOSE

To assure the accuracy, validity, and applicability of the methods to perform Underground Geologic Mapping of drifts of the Exploratory Shaft Facility (ESF) of the Yucca Mountain Project (YMP), this procedure provides a guide for USGS and USBR personnel and their contractors to perform the described activity. From this procedure, the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) can evaluate these activities for meeting the requirements of the YMP, and competent, trained personnel can reproduce the work.

This procedure describes the components of the work, the principles of the work, the principles of the methods used, and their limits. It also describes the detailed methods to be used for calibration, operation and performance verification of any equipment. In addition, it defines the requirements for data acceptance, documentation, and control; and it provides a means of data traceability.

2.0 SCOPE OF COMPLIANCE

2.1 This procedure applies to all USGS or USBR personnel and contractor personnel who may perform work referred to in Para. 1.0, or use data obtained from this procedure if it is deemed to potentially affect public heath and safety as related to a nuclear waste repository.

2.2 All data derived from this procedure that are presented to support licensing of the YMP repository, and any equipment calibrations or recalibrations that may be required shall be in accordance with this technical procedure. Variations are allowed only if and when this procedure is formally revised, or otherwise modified, as described in Section 8.

3.0 PERSONNEL RESPONSIBILITIES

The Principal Investigator (PI) is responsible for assuring full compliance with this procedure. Per QMP-2.02 and QMP-2.03, the PI shall require that all personnel assigned to work under this procedure shall have the necessary technical training, experience, and personnel skills to adequately perform this procedure; and they shall have a working knowledge of the USGS or USBR QA Manual. Responsibilities of others including the reviewer(s), contributing investigators, and officers are described in Para. 4, QMP-5.01.

Principal Investigator - The geologist who is responsible for Underground Geologic Mapping at the ESF. He is responsible for assuring all phases of geologic mapping in the ESF are executed according to the technical procedures. He oversees the Project and Principal Geologists and assures smooth flow of data from all the Principal Geologists.

Principal Geologist - These geologists are responsible for data collection and transport of the data from the ESF to Denver for data reduction. The Principal Geologists work in conjunction with the project geologist to coordinate the mapping effort. They also work with the photogrammetry technicians during photogrammetric data reduction to produce as-built geologic maps and cross-sections of the ESF.

Project Geologist - Geologist stationed at the site, who is responsible for data reduction at the site and coordinating mapping sessions with the construction contractor. The Project Geologist is responsible for staffing coordination at the ESF Site, assuring that geology crews are present when needed to insure no loss of mapping data. The Project Geologist also provides information to other experimenters and DOE at the site. He is responsible for calibration of geologic mapping instruments at the NTS.

Site Geologists - Geologists responsible for geologic data collection at the headings of each excavation and data reduction at the ESF. These geologists will perform the actual detail line surveys and collect samples. Site geologists are responsible for assuring technical procedures are followed at the data collection point in the field. The site geologists are also responsible for transporting equipment to the mapping location and properly assembled. Site geologists will inspect the cleaned walls and determine if cleaning is adequate for geologic mapping. The site geologists will assure the Foundation Acceptance Form (check) is properly completed by all parties.

Assistant Geologist - Assists or performs mapping duties under the supervison of the Site Geologist.

4.0 DETAILED PROCEDURE

This procedure serves as a guide for geologic mapping to be done in the shafts of the Exploratory Shaft Facility. USGS hydrologists and geologists will use the structural, stratigraphic, and lithologic information gathered during this procedure for scientific characterization of Yucca Mountain.

4.1 OBJECTIVE:

This procedure will be used for geologic mapping of the shafts of the Exploratory Shaft Facility. These procedures will serve as a guide for USGS and USBR geologists and contractor personnel performing the mapping and sampling in the ESF shafts. This procedure, when combined with technical procedures YMP-USBR-32 and YMP-USBR-34 will provide an extremely accurate, expandable data base containing information regarding the geologic conditions exposed in the shafts of the ESF. This system provides rapid and relatively easy access to the data base for YMP experimenters other than those directly involved in the mapping.

4.2 METHODS USED:

Full-periphery, close-range photogrammetric mapping utilizing surveyed control targets will be used to produce maps of the shafts. Photographic data will be collected underground using a metric camera which is positioned on a telescoping camera mount. After photography, geologists will perform detail line surveys and any necessary conventional mapping to record information which cannot be gathered photogrammetrically. USGS/USBR geologists will also collect mineral infilling and lithologic samples for use by a variety of experimenters. Stereophotographs will be processed in Denver, Colorado using a Kern DSR-11 analytical plotter under Technical Procedure YMP-USBR-34, R0. Geologic data obtained from photogrammetric analysis of the photos will be combined with the information recorded during the detailed line surveys and conventional mapping.

4.2.1 PREPARATION FOR MAPPING

4.2.1.1 Contractor Coordination - The Project Geologist shall monitor the construction progress to coordinate a time for geologic mapping which causes the least interference with the shaft-sinking contractor and permit the maximum exposure of shaft wall allowed by safety. The geology mapping crew must have clean rock walls, unobstructed by chain-link fabric. Rock bolt reinforcement is allowable however, and will not significantly hamper mapping of a particular section of shaft. If the Project Geologist and the shaft-sinking contractor's representative determine that the rock conditions warrant that no more than one

Underground Geologic Mapping

Shaft Mapping Logic

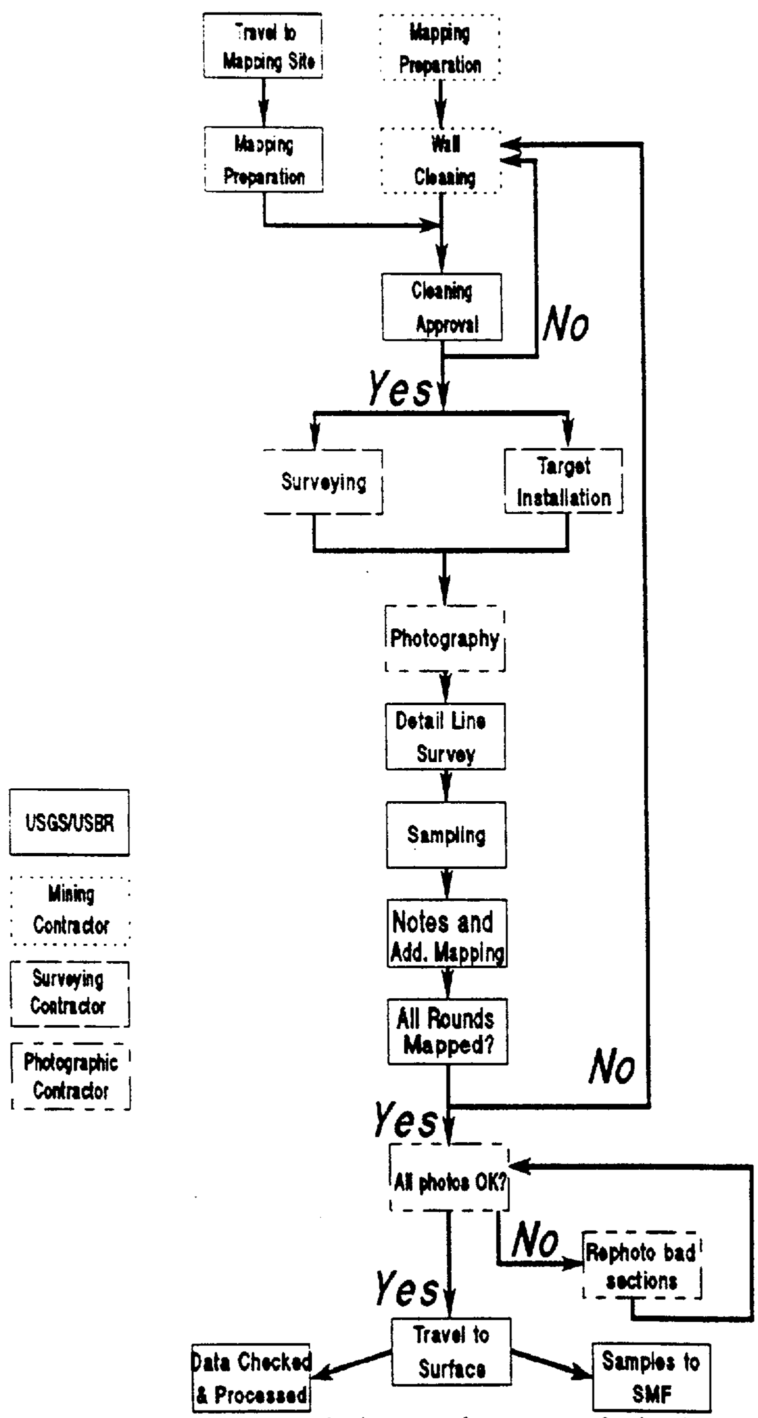

Figure 1 - Flowchart showing how geologic mapping proceeds in the shaft

blast round may be left without chain-link fabric, then geologic mapping will be done one round at a time until the rock becomes competent enough to support multiple rounds. The contractor will not be allowed to place any chain-link fabric until the rock on which the chain-link is to be placed has been mapped.

The Project Geologist or representative will notify the surveying contractor and photographic subcontractor that the shaft is ready for geologic mapping. The Project Geologist will provide the excavation contractors, as well as the mapping crew a minimum of one hour notice before mapping is to begin. On shifts where the Project Geologist is not present at the ESF, the site geologist shall assume the responsibility for coordinating geologic mapping with both the construction contractor and the support contractors (surveying and photographic).

4.2.1.2 Assembly of Equipment

4.2.1.2.1 Calibration Check - The site geologist or assistant shall check each piece of mapping equipment requiring calibration to make sure that its calibration is current. Instruments and equipment requiring calibration are designated in section 5.0 CALIBRATION REQUIREMENTS on page 37.

4.2.1.2.2 Checklist - Before leaving the ESF surface facility, the site geologist and assistant geologist shall use a checklist of equipment required to complete the work at the interval to be mapped (see Attachment #1 - Checklist). The site geologist shall ensure that the surveyors and photographers are present with their equipment and ready to begin work.

4.2.1.3 Travel to Shaft Bottom - Geologists, photographer, and surveyors (if not already present) shall proceed to the lower working deck of the galloway using standard transport procedures established by the shaft-sinking contractor. The shaft contractor shall assist as needed in loading and unloading the equipment required for the mapping.

4.2.1.4 Clearing of Obstructions - As soon as the contractor and the geologist concur that geologic mapping will be done at a particular time, a miner or miners will begin removing equipment and obstructions from the lower galloway deck. When the photographs for mapping are taken, no more than 20° of the periphery of the shaft, or more than 5° in any one quadrant of the shaft periphery shall be obstructed when viewed from the center of the shaft. Utility lines, ladders, and handrails must be removed prior to photography. The portion of the brattice that extends below the middle galloway deck and obstructs the camera field of view shall also be removed.

4.2.1.4.1 Wall Cleaning - The shaft-sinking contractor will be required to clean the walls thoroughly before geologic mapping. All loose, encrusted, or "plastered on" materials must be removed from the rock surface to be mapped while introducing a minimum amount of water into the shaft. Proper cleaning of the walls is important since the geologic mapping relies on good exposure of the rock on the shaft wall. Water must be kept to a minimum to prevent contamination of other experiments. The contractor shall be responsible for providing all wall-cleaning equipment. Washing will be accomplished utilizing an air-water blowpipe as shown in drawing OA-46-33 or PI approved equivalent. Prototype testing has shown (Harris, 1988) that the blowpipe will provide adequate cleaning when used at correct flows and pressures. The design of the blowpipe is such that both the flow of air and the flow of water to the nozzle can be easily controlled by the operator.

Prototype testing indicates using the blowpipe specified above and a 2-inch hose between the main compressed air line (4-inch diameter) provides most efficient operation when the water flow is adjusted to approximately 2 gallons-per-minute with an air pressure of 80-100 lb/in^2. The air flow valve on the blowpipe should be adjusted so that the water propelled from the nozzle is in a mist form. If too much air is introduced into the blowpipe, the water flow will be too low to clean effectively.

4.2.1.4.2 Lighting - The shaft contractor shall set-up adequate lighting prior to the beginning of mapping, and shall maintain the lighting throughout each particular mapping session. "Adequate lighting" shall mean sufficient light to allow geologists to clearly observe the rock on the excavation walls. The contractor will not be required to provide sufficient lighting for the stereophotography as flash strobes will be used to assure correct exposure.

4.2.1.4.3 Galloway Set-up for Mapping - Prior to mapping, the contractor will prepare the lower working floor of the galloway for setup of the mapping camera pedestal (drawing OA-46- ___). The pedestal must be installed in the center of the shaft, requiring the shaft-sinking contractor to install a secure cover over the muck bucket well that is stiff enough for accurate surveying from the mapping pedestal. The bucket well cover shall be drilled and tapped to accept the leveling base for the mapping pedestal

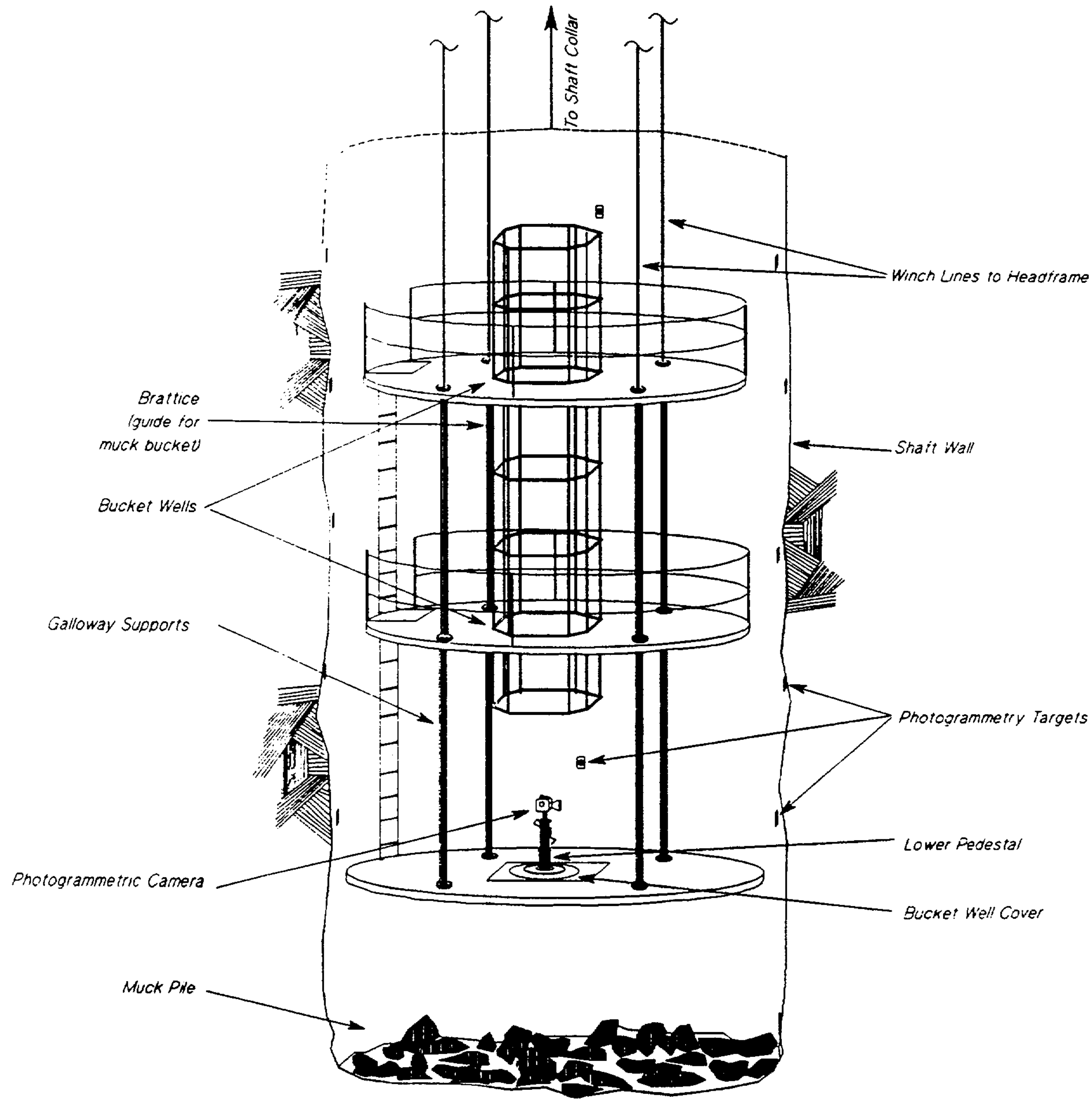

Figure 2 - Isometric drawing of the shaft sinking galloway with the mapping pedestal installed.

(drawing OA-46-___). The contractor shall also prepare the working floor extensions for installation after photography at that elevation is completed. After each round of photography is completed, the contractor should deploy the deck extensions where necessary to allow the geologists close access to the wall.

4.2.1.4.4 Galloway Positioning

a. Initial - Prior to the beginning of a particular mapping session, the shaft-sinking contractor shall move the galloway up or down the shaft such that the lowest working floor of the galloway is approximately 2.1m $\pm$2cm below the last elevation to which geologic mapping has been completed, and the galloway secured utilizing stabilizing jacks against the walls. As discussed in section 4.2.9, the elevation where previous mapping ceased will be clearly marked on the shaft wall and the information transferred to the contractor at the end the previous mapping session. The contractor shall position the galloway such that the first round of photographs will overlap those of the mapping. When the site geologist arrives, he will check to make sure the galloway is correctly positioned to assure overlap with the previous round. This information shall be checked and noted on the Mapping Preparation Acceptance Form (see Form 1, Figure 3). The galloway will be repositioned after the first round of mapping is completed as discussed in section 4.2.1.4.5.b.

b. During mapping - After the first round of geologic mapping, the galloway will be lowered for mapping of the next lower section of shaft. The geologists will be present to assure that sufficient overlap between mapping rounds is maintained. The galloway should be lowered 2.1m $\pm$2cm to provide adequate overlap. The geologist should check that the shaft wall has been adequately cleaned to insure clear photographs of the wall. The contractor shall be responsible for setup and moving of the galloway between mapping rounds. This includes removing handrails and any other equipment installed during mapping of a previous round during that shift which would obstruct the view of the wall. A separate mapping preparation acceptance form will be filled out for each mapping round in each shift.

4.2.1.4.6 Reference Surveying - Methods for locating the mapping pedestal and photogrammetry targets are included in Holmes & Narver technical

USGS/USBR-TECHNICAL PROCEDURE-YMP-USBR-GP-31 & 32, RO

FORM - 1 *Underground Geologic Mapping*

MAPPING PREPARATION ACCEPTANCE FORM

TIME ________ DATE __________

EXCAVATION_______________

BLAST ROUND #______ DEPTH _______ (ft)

ELEVATION*________ (ft)

	INITIALS
Galloway or Platform Positioning	___ (USGS/USBR)
Wall Cleaning	___ (USGS/USBR)
Reference Surveying	___ SURVEYING CONTRACTOR
Lighting	___ (USGS/USBR)
Excavation Clear of Obstructions	___ (USGS/USBR)

Geologist_________________
(signature required for approval)

Note: Do not leave blanks; use NA where appropriate

* Use bottom deck elevation in shaft, laser elevation in drift

Figure 3 - Mapping Preparation Acceptance Form

procedure NNWSI-017???. After initial positioning of the galloway, surveyors will install a reference-point target. The surveyors should provide the geologists with the three-dimensional coordinates of the reference point as soon as possible. The target will be marked with an "N" in a letter at least one-inch tall handwritten on the target with a bold felt-tip marker. The elevation to the nearest 0.1 ft shall also be written clearly on the target. The lettering shall not obscure the cross-hairs of the targets. The target shall be attached to the wall in the same fashion as the photogrammetry targets in section 4.2.2.3. The reference point target may be installed as part of 4.2.1.4.7, below.

4.2.1.4.7 Installation of Camera Pedestal - After survey control has been established the telescoping camera mount will be installed. The mount consists of two parts; the lower pedestal with an adjustable centering and levelling base, and the upper pedestal which has mounts for surveyors' total station, the photogrammetric camera, and the flash units (dwg. __________).

The lower pedestal is mounted first. The surveyors shall use an oriented laser beam or other means to locate the center of the shaft such that the lower camera pedestal can be installed within 1 cm of the center of the shaft. The lower pedestal is equipped with a large bulls-eye level accurate to within 10 minutes of arc. The level is located in a machined recess in the top of the lower pedestal. The lower pedestal is equipped with a pair of aluminum disks which have levelling and centering bolts which screw into the contractors bucket well cover (see drawing OA-46-____). These bolts are used to both level and center the lower pedestal. To install the lower pedestal, geologists should attach the pedestal to the upper disk with four 5/8" bolts. The levelling screws are adjusted until the bubble in the bulls-eye level is centered. Nuts and washers are then tightened down on top of the disk where the levelling screws extend upward through the upper plate to secure the disk once it has been levelled. The lower disk is centered using the centering screws on the hold down dogs attached to the contractor's bucket well cover. The surveyors will assist in determining the center of the shaft and assuring the pedestal is correctly located. The end flanges of the pedestals are machined parallel so that when the lower pedestal is levelled, the upper pedestal will be centered and leveled when attached.

After levelling and centering the lower pedestal, the bull's-eye level is removed from the machined recess, the centering ring is installed and the upper pedestal is attached with four bolts. The appropriate adapters and/or mounts can then be attached to the top of the mapping pedestal. The height of the telescoping pedestal can be varied as needed to set the photogrammetry targets using the attached cranks.

4.2.2 ESTABLISHING PHOTOGRAMMETRY AND LINE SURVEY CONTROL - Once the mapping pedestal has been installed, the surveyors will mount their instrument on the pedestal, and orient and locate the instrument. The surveyors will then use the instrument in conjunction with an integral laser and electronic distance meter (EDM) to determine the locations of the photogrammetry control points. This will be done by setting the instrument at pre-determined angles and gluing a control point on the wall at the point where the laser intersects the wall. These target locations will be approximately every 60° around the shaft, and will be spaced every .95m vertically.

4.2.2.1 Numbering of Photogrammetry Targets - Each photogrammetry control target will be marked with a unique number using a bold, black indelible marker. The number on the top of the target will have the elevation of the target to the nearest foot. The bottom of the target will have the shaft number (S-1 or S-2) and the number of the individual target in the each round (1-6). The numbers should be approximately 2-3 cm tall in the spaces on the top and bottom of the target.

4.2.2.2 Attaching Photogrammetry Targets to Excavated Walls - After the targets have been numbered, the photogrammetry targets will be installed on the shaft wall at the points where the survey laser beams intersect the walls. About 5 cm^3 of GE Silglaze N No. SCS 2597 silicone adhesive are applied to the back of the target and the target stuck on the rock wall, positioned with the laser beam centered on the cross-hairs of the target bull's-eye. The target should be oriented with the target facing the center of the shaft. When the laser beam falls on a fracture surface or other oblique surface, a resin hemisphere should first be glued to the rock surface, and the target attached to the hemisphere (see Figure 4). The flat side of the hemisphere should be against the rock to assure maximum adhesion. The photogrammetry target should be glued to the curved side of the hemisphere such that the target approximately faces the center of the shaft. It is important that targets face the center of the shaft so they are clearly visible in the stereophotographs. Angling the targets more than 15° from a shaft tangent will make locating them difficult in the photogrammetry laboratory.

4.2.2.3 Installation of Laser Azimuth Pointer - After the photogrammetry targets are attached and located on the walls, the surveyors shall remove the surveying

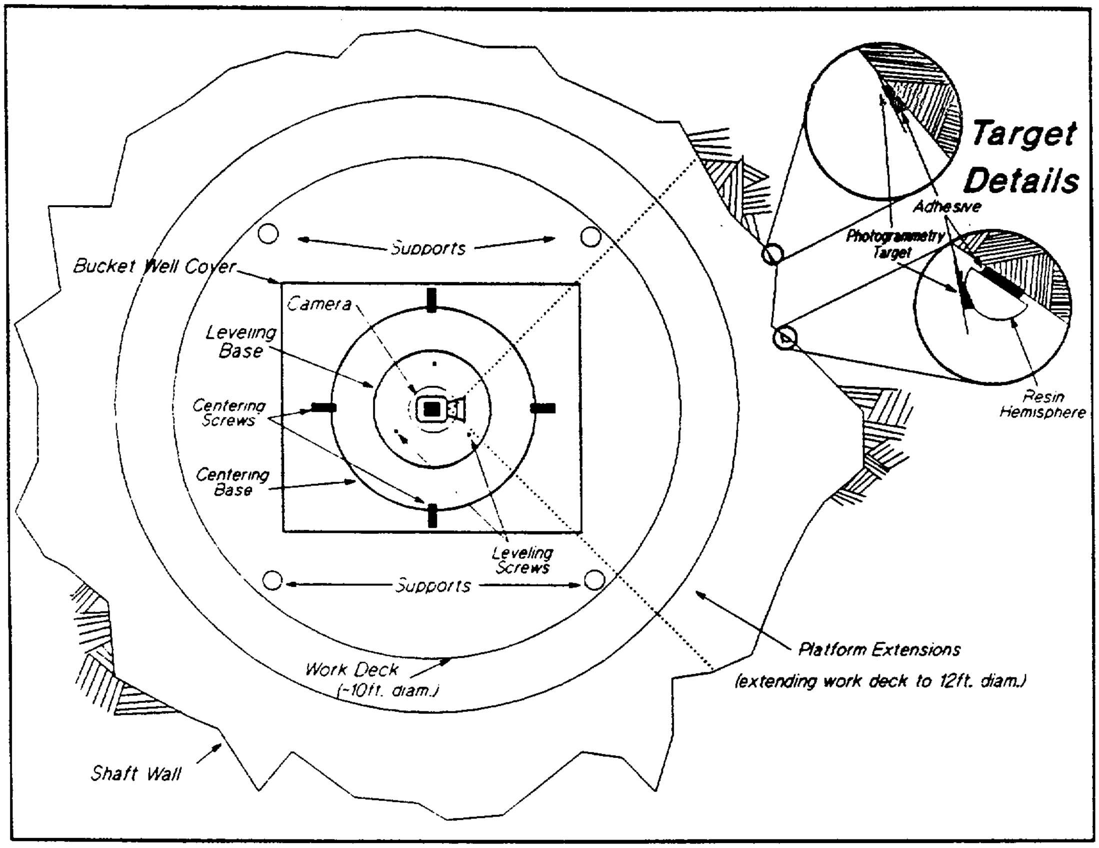

Figure 4 - Diagrammatic Plan View of the lower galloway deck with detail showing photogrammetry target placement.

instrument and mount from the mapping pedestal and the geologists shall install the laser azimuth pointer (LAP) on the pedestal. After the LAP is installed, the pointer base must be zeroed to north. This is done by first releasing the base lock (see drawing OA-46-__). The laser is then turned on and the beam placed on the reference target. With the laser kept centered on the target, the surveying base of the LAP is set to 0°, and the base locked. The height of the laser beam may also be adjusted if necessary to make sure the beam is at the same elevation as the reference target by adjusting the telescoping mount.

4.2.2.4 Marking of Fractures for the Detailed Line Survey - Once the LAP is properly installed, the laser pointer can be used to locate individual fractures along the wall. The LAP is rotated clockwise until the laser beam is on the first of the discontinuities to be recorded during the detailed line survey. All geologic features that intersect the datum line are described with the exception of fractures less than 30 cm long (unless of special interest). The features are numbered starting at one, progressing in a clockwise direction (looking down). Each feature is numbered sequentially on the rock with a black, indelible felt-tip pen. Discontinuities exposed as linear features are marked with a number with an arrow to the feature, if necessary, for clarity. Features which are exposed as planar surfaces are marked with a circled number. The geologist should ensure that all fracture numbers are visible from the center of the shaft and will be distinguishable in the stereophotos.

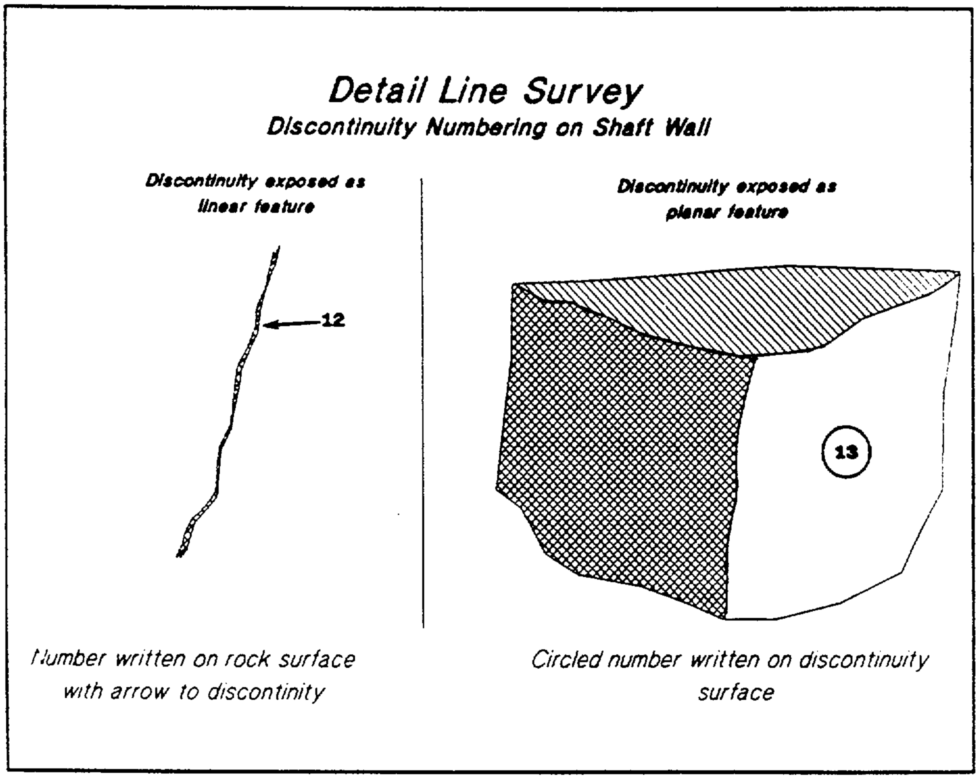

Figure 5 - Examples of how discontinuities are marked before photography.

4.2.3 STEREOPHOTOGRAPHY - Stereophotography is the primary means for recording the condition of the excavated rock in the shafts. The photographs will be processed in the photogrammetric laboratory to determine characteristics of the various geologic features as well as make full-periphery maps and cross-sections of the shafts. Prior to taking any stereophotos, the wall of the shaft must be properly marked to delineate all fractures as discussed in 4.2.2.4 above, and the locations of all recoverable samples marked prior to removing any samples from wall. In addition, all photogrammetric targets should in place and properly numbered.

4.2.3.1 Tagging of Samples - When possible, prior to the taking of stereophotos, the geologists should examine the shaft wall and determine where rock and mineral samples should be taken. A Sample Management Facility (SMF) bar code sticker should be affixed to the samples while the samples are still in place. The number of each sample shall be entered on the top of the page of sample stickers, along with all the other information required on the form (see Figure - 9, page 27). The sample must not be removed from the wall until after the photographs are taken. Refer to section 4.2.6 for information regarding sampling procedures.

4.2.3.2 Set-up of Camera - After marking the fractures and samples, the LAP should be removed from the mapping pedestal and replaced with the camera. The mount is oriented so that camera position 1 directly faces the North reference target set by the surveyors in section 4.2.1.4.6. To check this orientation the geologist or photographer should install the Rollei 6006 camera on the mount and center the target in the center of the viewfinder. The telescoping pedestal can be rotated by loosening the four bolts holding the mount to the lower pedestal. The camera is mounted on its side to facilitate mounting the film positives in the analytical plotter.

4.2.3.3 Set-up and Testing of Flash Units - While the geologists and surveyors are setting up and aligning the mapping and surveying equipment, the photographers should be setting up and testing the camera and flash equipment. The Speedotron 103CC flash units are attached to the flash bars on the camera mount. A Speedotron 1205 power supply will be used to power the flash units. The shaft sinking contractor must provide 120V, 60hz power to the lower galloway deck to run the power supply. The photographer is responsible for providing and attaching sync cords and adapters for synchronizing the camera with the flash units. The photographer shall test fire the light units at least twice prior to initiating stereophotography.

4.2.3.4 Photographing of Walls - The miner or laborer should remove the appropriate galloway handrails while the photographer is setting up the camera.

The first step in photographing the walls is loading Kodak Vericolor III VPS 120 or VPS 220 into the appropriate film magazine of the camera. Care should be taken at this point to insure that the film is correctly threaded through clips of the magazine. Failure to properly load the film may results in loss of photographic data. To load the film, push the magazine drawslide as far as it will go in the direction of the

»magazine change« arrow. This closes the drawslide window. Hold the camera upside down and press the unlocking knobs on the side of the magazine. Open the magazine back and remove the film cartridge. Pull out the red clip and insert the film spool in accordance with the symbol. Keep the paper leader lined up straight and thread into the empty spool, winding on until the arrow mark is exactly on the white pointer. Insert the tear-off tab from the film box in the holder on the film spool side. Fit the film cartridge into the magazine, with the film spool near the |═| mark and the empty spool near the |—| mark. Be careful to position the film leader over the holding spring of the film pressure plate; threading under this spring occurs automatically. Close the back and lock firmly on both sides.

The film magazine is then installed on the camera back and the magazine drawslide is pushed all the way down. When the drawslide is fully depressed, the DIN/ASA setting information will be visible: the dial should be set to DIN/ASA value being used - in the case of VPS 220 or 120, 160 ASA. The indicator dial on the magazine should also be set to this value. Set the control switch to »S« and depress the shutter release button. This will advance the film to the first frame. When the film comes into position for taking a photograph, the counter indicates frame 1. If the »1« does not appear, press the release button again.

The camera is then re-mounted on the telescoping pedestal. The PC sync cord must be plugged into the PC jack on the side of the camera before the camera is installed on the mount. The camera is slipped into the mount from the front, and the retaining screw tightened. The upper part of the mount is pivoted so that the camera is facing the #1 position. The camera positions have been stamped into the edge of the camera mount on the top of the camera pedestal.

Before photographing of the wall begins, the geologist should prepare a placard to be placed at the bottom of the #1 photo in each round. The placard will be approximately 8" X 16" and shall have white moveable letters on a black background. The placard information shall include the following:

1) Excavation Name - ES-1 or ES-2

2) Date - The date of mapping in this format: mm/dd/yy

3) Elevation - Elevation of the mapping floor as determined by the surveyors to the nearest 0.1 foot.

4) Geologist - The first initial and last name, such as D. Smith.

5) Photographer - The first initial and last name.

6) Time - Time to the nearest 5 minutes in military format, such as 1915.

The geologist and photographer should work together to assure that the placard is visible in all first photographs for each round. If the geologist feels the placard is obscuring the view of an important geologic feature, he may move the placard to one side, as long as the placard is still clearly visible in the photo.

The lens cap should be removed from the camera and the wall visible through the viewfinder checked to make sure it is centered on the reference target (first photo only) installed in procedure 4.2.1.4.6. When the camera is centered on the reference target, 6 other photogrammetry targets should be visible in the viewfinder. The actual size of the viewed area is approximately 10% larger than that seen through the viewfinder, so targets visible in the viewfinder will always be present on the film. Before exposing the first photograph, the photographer should check to make sure the shutter speed is set on 125 (1/125th of a second) and the lens aperture at F11 for correct exposure. If the galloway is at the correct height and the photo is correctly centered, the camera should be about 1.05 m off the floor. The power pack should be checked to make sure it is on and charged. A square, lighted button on the top left of the power supply labelled "**READY**" should be illuminated. The rocker switch labelled "**MODEL**" should be on. This will provide general lighting of the walls during preparation for photography, and will allow the photographer to adjust the flash reflectors to prevent areas of uneven lighting. When the photographer is ready to shoot the photo, the "**MODEL**" switch should be turned off and other personnel should turn their headlamps away from the area to be photographed to prevent bright spots in the photo. The photographer should depress the shutter release to take the photo, watching both flash units to make sure they fire. After the first photo is taken, the camera is rotated 60° to the right to the next click stop of the photo mount. The next photograph is taken at this location in the same manner as the first. After the second photo, photos are taken in the same manner every 60° around the shaft. The miner may remove and replace handrails as necessary to assure they are not visible in the photos. If the photographer observes that the flash units did not fire, he should simply re-shoot the photo without rotating the camera.

When a round of photos (6) is completed, the camera pedestal is raised 0.95 meter and another round of photos taken. The first photo of the second round is centered between two vertical rows of photogrammetry targets and directly above the reference target in the first round. The reference target should be visible in the lower center of the #1 photo of the second round. The second photo round is taken in similar fashion to the first round, beginning with position #1 and proceeding clockwise around the shaft. After the second round is completed, the pedestal is lowered and the camera removed from the pedestal and temporarily stored in the padded camera case. The laser azimuth pointer is then installed on the mapping pedestal, and the base of the goniometer zeroed to the reference target. The goniometer is used to perform detailed line surveys on the wall. After the line surveys are completed (see 4.2.4 below), and sampling is completed, the galloway should be lowered 1.9 m (6.0 ft). After lowering the galloway, the pedestal will be re-centered and set-up again as discussed above.

4.2.4 DETAIL LINE SURVEY - Traditional detail line survey (DLS) mapping consists of mapping a traverse across an outcrop, cutslope, or other rock exposure. The traverse is established using a measuring tape stretched across the rock surface. The location of each geologic feature or discontinuity which intersects the traverse is then recorded along with the feature's characteristics. The USGS/USBR will use DLS information from this type of survey to provide data which cannot effectively be gathered by photogrammetry such as types of mineralization and small-scale fracture roughness.

In the ESF, detail line surveys will be done by using a laser to establish the datum line on the wall of the excavation rather than a measuring tape. In the shafts, horizontal detail line surveys will be done using the Laser Azimuth Pointer (LAP). Since the distance around the perimeter of the shaft will vary from round to round, and it is difficult to stretch a tape around the inside of a cylinder, the laser will locate each feature by azimuth from the center of the shaft rather than circumferential distance. The pointer is aimed at the feature and the azimuthal location of the feature recorded instead of a distance. This will allow the feature to be easily located by azimuth on the full periphery maps of the shaft developed by the photographs. After the location of the feature is recorded, the azimuth, dip, aperture, mineral infilling, and roughness of each feature will be manually measured and recorded. This information will be used to complement the data generated by photogrammetric and conventional mapping.

4.2.4.1 Installation of Laser Azimuth Pointer - The LAP is installed on the previously leveled and centered mapping pedestal. The LAP is normally horizontal, but if significant features will be missed by a horizontal line, the LAP can be positioned at an angle with pertinent alignment data recorded. Also, a vertical traverse can be run if necessary. The laser beam is aligned with the north mark provided by the surveyors and a photogrammetry control target is marked with the detail line survey elevation and affixed to the wall centered on the pointer mark. The laser pointer base lock is then loosened and the azimuth ring zero degree mark is aligned with the zero mark on the vernier. The base lock is then tightened and all subsequent readings are true bearings from the center of the shaft.

4.2.4.2 Recording of Geologic Features along Datum Line - All geologic discontinuities that intersect the datum line are described with the exception of fractures less than 30 cm long. Any anomalous fractures less than 30 cm are described. The traverse is run starting at zero (north) progressing in a clockwise direction with increasing azimuth. The individual features are recorded on Form 2, Detail Line Survey - Shafts (see Figure 6) with each feature azimuth recorded where first encountered on the traverse. Each blank should be filled, either with data or a dash where no data is available. Entries are explained below:

a. Feature # - The feature column header has a space for the DLS elevation. This designator applies to the elevation of the target and is recorded only once. Each feature is numbered sequentially on the rock with a black, indelible felt-tip pen. As per section 4.2.2.4., discontinuities which are exposed as linear features are marked with a number with an arrow to the feature. Features exposed as planar surfaces are marked with a circled number. The number is entered in the feature column.

b. Feature Type - The feature type standard abbreviation is entered (see Attachment 3 for Detail Line Survey abbreviations).

c. Bearing or Location - The bearing or location of the feature is recorded where first encountered by the traverse. Azimuth should be recorded to nearest minute (for transit base instruments) or .01 degree (for digital

YUCCA MOUNTAIN PROJECT–Underground Geologic Mapping Form 2 - Sheet ___ of ___

Detailed Line Survey – SHAFTS Depth ______ Round______ Date _______ Geologists________________

Elevation______________ Photographer _____________ Survey Party Chief __________

Feature #	Feature Type	Bearing or Location	Strike	Dip	Aperture	Mineralization			Plunge	Fracture Roughness	Ends	Comments
						Deg.	Composition	Thickness	Direction Amount			

Note: Do not leave blanks; use NA etc. where appropriate

Figure 6 - Form 2, Detail Line Survey - Shafts

instruments).

d. Strike and Dip - Strikes and dips should be recorded to the nearest degree.

e. Aperture - Aperture is the open, unfilled distance between the sides of a fracture. The spacing is measured using calipers, feeler gauges, or a taper gauge, as appropriate. Aperture should be recorded to a 0.01 mm.

f. Mineralization Deg - The mineralization degree is an estimated percentage of the fracture surface covered with a particular mineral. Figures 7 & 8 are a guide for estimating the percentages.

g. Mineralization Composition - The name of each mineral on the fracture surface is entered. If the composition is not known, the mineral should be described in the Comments column or field book.

h. Mineralization Thickness - the thickness of the minerals deposited in or on the fracture is measured with the appropriate device (calipers, etc.) and recorded to 0.01 mm.

i. Plunge - The plunge of any slickensides is entered in this column. The plunge of other linear features can be entered in the Comments column or field book. Plunge is recorded with both amount and direction.

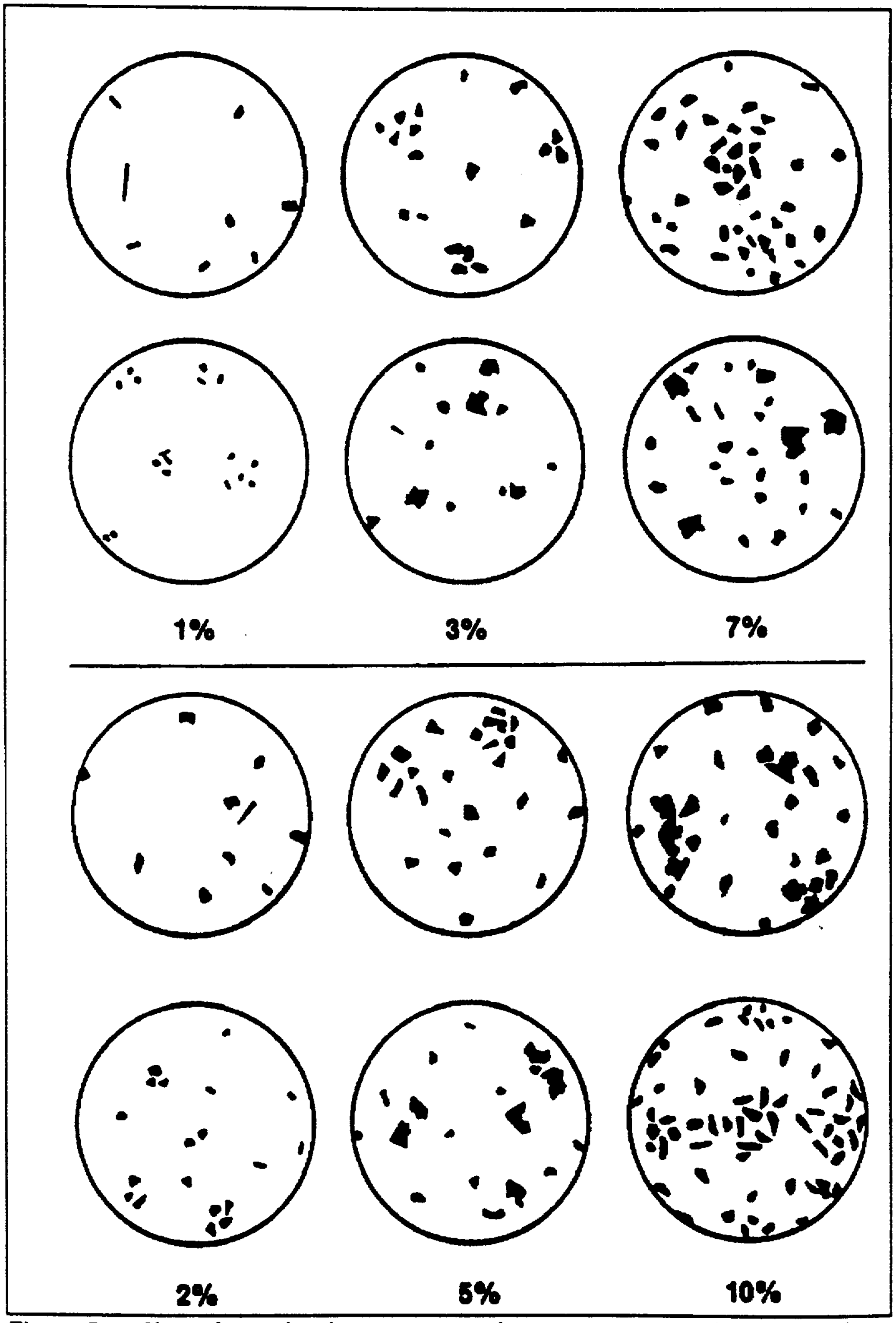

Figure 7 - Chart for estimating percent volume or coverage (Reprinted from *Journal of Sedimentary Petrography*, vol. 25, n. 3, p. 229-234, Sept. 1955).

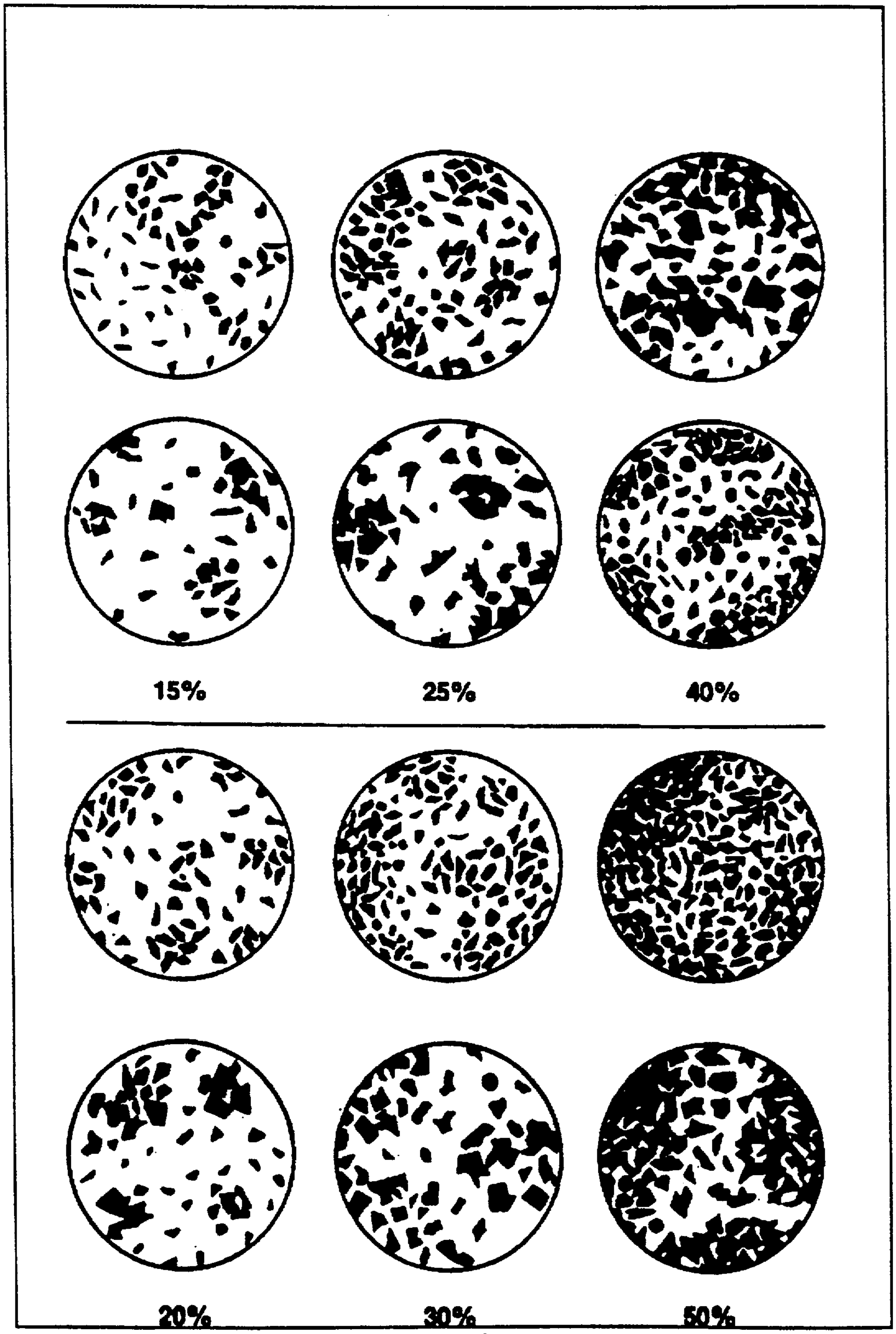

Figure 8 - Chart for estimating percent volume or coverage.

j. Fracture Roughness - Small-scale roughness of the fracture surfaces can be recorded by one of two methods. A shape copier is held normal to the fracture surface and gently pressed onto the surface until the impression of the surface is visible in the copier. The shape of the copier is then compared with a sheet of known roughness curves and values. The value is then entered in the box on the sheet. Where the roughness varies, or does not fit a single roughness curve, a range may be entered, such as 32-48.

A digital roughness gage is presently under development which may replace the shape copier method. The digital roughness gage (DRG) is placed on the fracture surface, and the sensor pin moved across the surface. The gage will then give a digital readout of the roughness of the surface. This number is then recorded on the data sheet.

k. Ends - The number of fracture terminations that are visible to the mapper is recorded in this column. If the mapper can see the end of the fracture trace in both directions along the trace on the wall, the number 2 is recorded. If one termination is visible (either terminating at another fracture, or just pinching out) the number 1 is recorded. If the fracture extends beyond the mapper's view in both directions, 0 is recorded.

l. Comments - Items or characteristics of the fracture that are not adequately covered in the previous columns are to be described in this column or in a field book (described below).

4.2.5 GEOLOGIC NOTES - Items or geologic information that are not adequately covered using photogrammetric or detail line survey mapping are to be described in 4 3/4 x 7 1/2-inch field books. Examples of the types of data to be recorded (but not limited to) are: lithologic changes, contacts, thickness and descriptions of fault zones, sketch maps, and construction data such as poorly standing ground or support problems. Entries should be dated at the beginning, along with the time the entry is begun, and the elevation and azimuth of features or conditions being described. The mappers must sign the page after completion of entries.

4.2.6 SAMPLING - Samples will be collected routinely and for specific features. All samples are to be transferred to a representative from the Sample Management Facility (SMF) when the mapping team reaches the surface. An SMF Sample Collection Report (Form AP6.3Q-5-10/21/88 or revision, Figure 9) should be filled out for each sample collected. Samples are to be tracked using the bar code system

YUCCA MOUNTAIN PROJECT SAMPLE MANAGEMENT FACILITY

SAMPLE COLLECTION REPORT	BTPSMF7-1 5/89

Date Sample Collected	5-12-91	Page 1 of 1
Sample Collector	R. Smith	
Organization	USBR	
Collector's Sample ID	3375-227	

SPC00001051

Type of sample (*circle*): (rock) muck soil liquid gas
other (*specify*): ____________

Type of site (*Circle all appropriate entries*)

SURFACE:	ESF: (Shaft) Drift
trench outcrop borehole other	borehole muck pile (in place) other

Collection Location:
ES-1, elev. 3375', az. 227°

SAMPLE: weight________, volume________, dimensions____________

FIELD PHOTOS (*circle*): prints slides instant prints video (photogrammetry) NA

STORAGE REQUIREMENTS: None

REMARKS: None

SAMPLE TRANSFER TO SMF (*Check one*) ☐ Yes ☐ No

Person Releasing Custody	Date	Person Accepting Custody	Date

SMF USE

STORAGE LOCATION: Area____________ Unit____________
Date Stored____________ Time Stored____________
Verified By____________ Date____________

Figure 9 - SMF Sample Collection Report

used by the SMF with the appropriate bar code sticker affixed to the form. All samples are to be bagged in a muslin sample bag. The corresponding sample bar code is placed inside the bag, attached to the sample tag on the bag, and the same bar code applied to a field book page with a brief entry describing the sample. The label is to be attached before the samples are removed from the wall, and before photography. If the sample later is determined not appropriate or ruined during removal from the wall, the reason for the samples' loss should be entered into the field book. The words, "destroyed during collection" are entered on the SMF Sample Collection Report in the remarks area. If a sample is taken after photography, the location should be noted in the field book, the appropriate information entered on the SMF form, and a polaroid photo taken showing the area where the sample was collected.

4.2.6.1 Record Samples - A record sample is to be collected from each mapping round (approximately 6 feet) or at any significant change in lithology, etc. The samples should be representative of the wall rock. In areas where the lithology varies over a short distance, more than one sample per mapping round should be taken as appropriate. The sample should be approximately grapefruit size (about 500 cm^3).

Sample locations are to be marked with the appropriate bar code number sticker stuck to the back of a 2" X 3" plastic label, and the label glued to the sample with 5-minute epoxy. The sample number is determined by listing the elevation and azimuth from where the sample is taken: for example, 3375-227. Both portions of the number should be rounded to the nearest whole number. If for any reason, the number is incorrectly written on the label, the label should be discarded. The geologist may use any tool at his disposal to remove the sample, taking care not to damage. The samples are placed in canvas bags. One of the bar code tags should be stuck to the liner of the bag near the top, and the bag sealed. Another of the bar code tags should be applied to the label of the bag along with the date, location from which the sample was removed (elevation and azimuth), and the name of the sampler. The sample will be transferred to a representative of the SMF at the surface under section 4.2.10 of this procedure.

4.2.6.2 Mineral Infilling Samples - Samples of mineral infillings will be collected for Los Alamos National Laboratories. A sample of each mineral infilling materials visible along the various fractures within each round should be taken if practicable. The samples should also be representative of the thickness of the mineral infillings. The samples should have a minimum size of approximately 4 in^2 (20 cm^2) of the material coating a fracture surface. The sample may be removed by the use of a pry bar, rock pick, or spatula, etc., depending on the configuration of the deposit. It is desirable to remove a portion of the wall rock with the mineral sample to assure that all mineral coatings on the fracture are sampled. Also mineral infillings on both sides of fracture should be sampled where possible. To avoid any contamination of the sample, a bar code tag will not be affixed directly to the sample, but a bar code sticker should be affixed to the inside and outside of the sample bag, and the location, date, and sampler should be entered into the field notes. The sample will be placed first in small sliding closure ("ziplock") plastic bag, and then both place within a 6" X 6" bubble pack bag and sealed. An SMF sample collection report should be filled out for each of the infilling samples with special note that the sample is taken for LANL. The samples will be transferred to a representative of the SMF for temporary storage as explained in section 4.2.10 of this procedure.

4.2.6.3 Oriented Samples - Oriented samples will occasionally be taken for various experimenters as requested through the PI. Samples of rock which may contain geopetals will be collected for Los Alamos National Laboratory. These samples should have a photogrammetry target affixed to them face down prior to photography. The orientation tag should be attached with 5-minute epoxy. The GE Silglaze N adhesive used to glue photogrammetry targets should not be used because the adhesive will not hold the tag when the sample is placed in the sample bag. The target should be oriented with the long edge at the top and horizontal (i.e., top edge parallel to strike of the sample surface). An SMF Bar Code sticker should be affixed to the target. The strike of the top edge of the target and the dip of the target face should be written with indelible felt tip marker on the face of the target. The sample should be labelled in the same manner as the mineral infilling samples described in section 4.2.6.2.. The target on the sample will provide the experimenter with a rough orientation. The exact orientation of the sample will be determined in the analytical plotter laboratory during photogrammetric mapping.

4.2.6.4 Close-up Photographs (Polaroid) - The geologist may, at his discretion, take polaroid photos of the walls or geologic features. The photos may be entered into the permanent record by affixing the photo into the field notes by either double-sided tape or by gluing the photo into the notes. Special features in the photo may be noted by writing directly on the photo with a felt-tip marker. Only photos which are entered into the geologist's field notes shall be considered part of the permanent record. Geologists with the proper NTS security clearance may also take 35mm photos of any geologic feature . These photos may be given to Pan Am for processing when the roll is complete.

4.2.7 MOVING OF GALLOWAY - If the height of the shaft interval being mapped is greater than 2m, and operations covered in sections 4.2.1.4.5 through 4.2.6 are completed, the geologists will instruct the miner to have the galloway lowered. The galloway should be lowered 2.1m to achieve the proper photo overlap. This distance may be measured in any manner acceptable to both the mining contractor and the geologist, but the movement must be 2.1m $\pm$ 2cm. Once the galloway is correctly lowered, the geologists should remove the LAP, and the surveyors re-set their instrument on the pedestal.

4.2.8 MAPPING OF SUBSEQUENT ROUNDS - Each of these steps should be repeated as needed to complete mapping at the new galloway level. After the surveyors orient the instrument, they will set the photogrammetry targets in their proper locations. The entire mapping process can then be repeated including: numbering and setting photogrammetry points, labelling targets, marking and removing samples, detail line surveys, and note taking. This process is repeated until all the exposed geology to be mapped has been photographed and sampled. The project or site geologist will determine when enough of the shaft wall has been mapped to prevent any loss of data as the shaft is lined. The site geologist should arrange his mapping such that the first mapping round adequately overlaps the last geology round mapped. The bottom round mapped should extend sufficiently far down the shaft to ensure that any concrete placed does not obscure last mapping round. Since the concrete cannot be placed near the bottom of the shaft, the geologist should have no difficulty in extending mapping low enough to ensure adequate overlap with the next mapping round.

4.2.8.1 Send Exposed Film to Surface - As soon as all exposed rock surfaces to be mapped have been photographed, the exposed film should be sent to the surface for developing. When the photography is complete, the mappers inform Pan Am that photography is completed, and the film is being sent to the surface. The film should be packaged in a waterproof and dustproof case and sent to the surface immediately. Alternatively, the Pan Am photographer with the mapping team may immediately carry the film to the surface. When the film reaches the surface, the Pan Am representative should call down the shaft and confirm that the film has been received. The Pan Am representative should then immediately develop the film. If the film development and coverage is correct, the geologist at the shaft bottom should immediately be informed. If the development or positioning is incorrect, the interval will be re-photographed. The geologist should return to mapping as needed, but should not dismantle the mapping equipment or leave the galloway until the film has been successfully developed.

4.2.8.2 Mark Bottom of Last Photographed Round - After the mapping is complete, the geologist should paint a fluorescent orange stripe on the rock wall at the bottom of the interval mapped. The paint stripe should extend around the shaft perimeter, and will indicate where mapping ended. When the following geologist sets up the galloway to begin mapping he must make sure that the orange line is visible in the top photo.

4.2.9 COMPLETION OF MAPPING

4.2.9.1 Complete Mapping of the Final Round - After the film is sent to the surface for processing, the sampling and detailed line survey should be completed. Any general notes on should be added at this time.

4.2.9.2 Confirm Film Development with Surface - Current planning indicates that the concrete placement for the shaft lining will usually occur immediately after geologic mapping. When mapping does immediately precede shaft lining, the successful development of the stereophotographs must be confirmed before the geologist leaves the bottom of the shaft. Once the film development is complete at Pan Am's laboratory, the Pan Am representative must examine each of the photos to confirm adequate exposure of each frame. If a blank frame is visible on the negative strip, the target numbers should be examined in the following frame to see if the photo has been re-shot. Each photo should be examined to insure the exposure is adequate to produce an acceptable or replaced film positive. Each exposure of every roll of film must be acceptable or replaced since the photos are a primary source of data. If any exposures are unacceptable, the development of all the rolls of film from that particular mapping session should befinished, and then the results called called to the heading. This process is necessary to ensure that no data are lost if a photo failure occurs.

4.2.9.3 If Film Development Successful, Dismantle Equipment - If all photos have been successfully developed, the geologic mapping equipment should be dismantled and returned to the ground surface. All equipment should be properly stowed.

4.2.9.4 If Film Development Unsuccessful, Re-photograph - If one or more of the photos are unacceptable, and the unsatisfactory photos have not been re-shot on the original roll, the photographs will have to be re-taken. All six photographs should be taken whenever a photo is found to be unacceptable. The camera mount, camera, and strobe units should be re-installed on the platform, and the entire ring of photos should be photographed. When re-taking photographs, the photo placard should be used to indicate that the photos are retakes. This is designated by entering the word "Retake" on the placard along with the normal exposure information as discussed in section 4.2.3.4. The locations where samples have been removed from the wall should also be marked when re-photographing. This should be done by marking the sample number on the back of a photogrammetry control target and gluing the target to the wall by the method described in section 4.2.2.2. When all re-takes have been completed, the film should again be sent in a film transit case to the surface. The film should be transferred as before (section 4.2.8.1). Confirmation of successful development of the photos must be obtained before leaving the shaft bottom. If the photos are unacceptable, the photos should again be re-shot and the crew remain in the shaft until acceptable photos have been taken of the entire mapped section, ad infinitum.

4.2.9.5 Return to Surface - Once successful photos have been acquired, the mapping team can return to the surface. All equipment should be properly stored in transit cases and all samples brought to the surface. The SMF can be informed before the mapping leaves the shaft bottom and inform them that the mapping crew is leaving the shaft and will have samples ready for transfer at the surface.

4.2.10 TRANSFER OF SAMPLES TO SMF PERSONNEL - When the surface is reached, the SMF (if this has not already been done from the shaft bottom) should be informed that samples are ready for transfer. When the SMF representative arrives at the ESF, all bar coded samples should be transferred to the SMF reps, including those collected for LANL. Samples collected for LANL will be stored at the SMF until LANL reps collects the samples. Record samples will be transferred to the SMF for archival storage. The geologist will transfer the samples and the SMF Sample Collection Reports (Form AP6.3Q-5-10/21/88 or revision). This transfer should take place at the ESF (rather than Area 25) as soon as the mapping crew reaches the surface. The SMF will be responsible for safe handling of the samples beyond the ESF.

4.2.11 RETURN TO AE BUILDING AND PROCESS DATA - After samples have been transferred to the SMF representatives at the shaft collar, the mapping gear should be stowed at the geology trailer on the ESF pad. Any exposed rolls of 35mm film should be transferred to Pan Am representatives at this time. The crew may then return to the AE building and process the data from the detail line surveys.

4.2.10 TRANSFER OF SAMPLES TO SMF PERSONNEL - When the geologist reaches the surface, he should contact the SMF (if this has not already been done from the heading) and inform them that samples are ready for transfer. When the SMF representative arrives at the ESF, all bar coded samples should be transferred, including those collected for LANL. Samples collected for LANL will be stored at the SMF until LANL reps collects the samples. Record samples will be transferred to the SMF for archival storage. The geologist will transfer the samples and the SMF Sample Collection Reports (Form AP6.3Q-5-10/21/88 or revision). This transfer should take place at the ESF, rather than Area 25, as soon as the mapping crew reaches the surface. The SMF will be responsible for safe handling of the samples beyond the ESF.

4.2.11 RETURN TO AE BUILDING AND PROCESS DATA - After samples have been transferred to the SMF representatives at the shaft collar, the mapping gear should be stowed at the geology trailer at the ESF pad. Any exposed rolls of 35mm film should be transferred to Pan Am representatives at this time. The crew may then return to the AE building and process the data from the detail line surveys.

4.2.12 TRANSFER AND ARCHIVING OF DATA - On a weekly basis, stereophotographs and raw data will be hand carried to Denver by the principal geologists. Stereophotographs will include film positives and contact color prints from the negatives of all excavation walls photographed during the week ending on the Saturday immediately preceeding the day of data transfer. Pan Am photography will store the negatives, film positives, and color prints from midnight Friday through the following Friday midnight. The following table shows the number of sets of each type of photographic media and where they shall reside after the weekly data occurs:

TYPE OF MEDIA	# OF COPIES	LOCATION AFTER DATA TRANSFER
Original Negatives	1	Las Vegas Records Center
Film positives	3	1 set at Photogrammetry Lab in Denver, CO 1 set at Pan Am Photography 1 set at Las Vegas, NV, Record Center
Contact color prints	2	1 set at Photogrammetry Lab in Denver, CO 1 set at Las Vegas, NV, Record Center

On the Sunday of the data transfer, the outgoing Principal Geologist shall contact a designated representative of Pan Am Photography to arrange face-to-face transfer of all photographic data for the week the geologist has been at the site. This transfer should take place before noon on the Sunday after the last of the photo data has been collected. Since the data collection period ends at midnight on Friday, this will allow Pan Am 30 hours to process any photos collected late on Friday (as well as any photos yet unfinished) before the transfer takes place. A Data Transfer Form (figure -11) and Records Center Form must be filled out by both parties at the time of the transfer. The original Form will stay with the package of photos and data throughout the trip to Denver. In addition to the Data Transfer Form, the principal geologist must record the end mapping station of each ESF heading. The end station should be easily obtained from either the photos (each photogrammetry target will be numbered with the drift stationing), the geologist's field notebook, or the "Geology Mapping Team Log Book" (see section 4.___, p.__).

After the Data Transfer Form is completed, the project geologist shall be responsible for delivering one set of photos and data to the Vegas Records Center during the week following the transfer. The Las Vegas Records Center requires that a separate form be completed for introduction of information into the center (form TBD).

Photos and data to be used in the Denver photogrammetry lab will be hand carried to Denver by the principal geologist. The data shall be placed in travelling pouch and handled as carry-on luggage (<u>not</u> checked with baggage). If the principal geologist returns to Denver via surface transportation, the pouch should be protected from heat and cold during the trip to Denver.

Upon arrival in Denver, the principal geologist should hand carry the photos and data to the photogrammetry lab as soon as practicable. At the lab, the package of photos and data will be signed over to one of the photogrammetry lab representatives. The same Data Transfer Form used to transfer photos from Pan Am Photography and data from the mapping team at the NTS, will also be used to document the receipt of the photos at the photogrammetry lab. A designated representative of the photogrammetry lab should check to make sure all the reported photos and data are indeed in the travelling pouch before signing in the material. Once received, the photogrammetry laboratory is solely responsible for handling, storage, maintenance of the photos and data until they are transferred to the SAIC records center in Golden, Colorado. The photos and data will be processed and maintained at the photogrammetry laboratory in accordance with policies set forth in USGS Technical Procedure YMP-USBR-GP-34, R0.

The principal geologist will alternate with three other principal geologists who will each spend one week at the site and three weeks in Denver. While in Denver, the principal geologists will work with the photogrammetrists and photogrammetry technicians developing full-periphery geologic maps of the drifts (and shafts) which were photographed during their most recent visits to the ESF. In addition to map work, the geologists should work on updating geologic sections and the geologic data base which will provide information to other experimenters and scientists on the Yucca Mountain Project.

When his three weeks are completed, each of the principal geologists will return to the NTS on Sunday and carry drafts of the completed geologic maps and processed geologic data to the project site geologists for their review and comments. The incoming geologist must find out from either the outgoing principal geologist or the project geologist the end mapping station of each ESF heading during the previous mapping period. End mapping stations should be recorded in the "Geology Mapping Team Log Book". These stations will become the beginning stations for the following week's mapping. The principal geologist will spend the week at the site supervising (along with the project geologist) underground geologic mapping data collection.

4.3 ALTERNATIVE METHODS CONSIDERED:

1. **Conventional Sketch Mapping**: Traditionally, underground openings have been mapped by measuring and sketching the geologic features on a pre-printed field

Page ____ of ____ USGS/USBR TECHNICAL PROCEDURE YMP-USBR-GP-31&323, R0

Yucca Mountain Project – UNDERGROUND GEOLOGIC MAPPING

Photo & Data Transfer Form

Person Carrying Data ____________________ Date Leaving NTS __________
Name

Data Enclosed Collected from ________________ to ________________
Start Date End Date

Photos Received from ______________________________
Photo Contractor Representative

Excavation ____________________
Photo Numbers ____________________ through ____________________
Elevation/Station ____________________ through ____________________

Type of Data (circle one): Floppy Disk, Hard Copy
Photo Type (circle one): Film Positives, Prints
Film Size (circle one): 220, 120, 35mm, Polaroid

Excavation ____________________
Photo Numbers ____________________ through ____________________
Elevation/Station ____________________ through ____________________
Type of Data (circle one): Floppy Disk, Hard Copy
Photo Type (circle one): Film Positives, Prints
Film Size (circle one): 220, 120, 35mm, Polaroid

Data Received by ____________________ Date ____________________

Location ____________________________ Organization____________________

Figure 10 - Data Transfer Form

sheet. Conventional sketch mapping was compared to photogrammetric mapping in terms of cost, accuracy, reproducibility, and expandability during prototype testing. Scott (1987) discussed the advantages and disadvantages of the two methods.

2. **Photomosaic Mapping** : Photomosaics have also been assembled to do geologic mapping. Photomosaic mapping was compared to photogrammetric mapping in terms of cost, accuracy, reproducibility, and expandability during prototype testing. Scott (1987) discussed the advantages and disadvantages of the two methods.

3. **Carpenter's Shape Copier** : Fracture roughnesses have been measured using carpenter's shape copiers to record the shape of a fracture. The shape is traced onto a field sheet, and the tracing is digitized or compared to known curves. The digital roughness gage allows rapid digital readout directly of the fracture roughness, without the interim steps.

4. **Brunton Compass** : Traditionally, the Brunton Compass has been used for measuring the attitudes of geologic features. In the ESF, the rock has significant magnetic anomalies which can cause erroneous readings on a magnetic compass. Also, the presence of steel mining equipment and ground support makes the use of a magnetic compass unreliable. The geological gyrocompass developed for ESF mapping does not rely on the Earth's natural magnetic field for reference.

4.4 MATERIALS/EQUIPMENT REQUIRED; Following is a list of equipment required for mapping in the shaft:

4.4.1 Surveying and Laser Alignment Equipment

Equipment Description	Number Required
Mapping (Telescoping) Pedestal (dwg. OA-46-_	1
Pyramid Beam Splitter (dwg. OA-46-_)	1
Laser Azimuth Pointer (dwg. OA-46-_)	1
Photogrammetry Targets (dwg. OA-46-_)	12
Photogrammetry Target Mounts (dwg. OA-46-31)	8
Adhesive, GE Silglaze N, Bronze color, No. SCS 2597	2
Adhesive Gun, for 8 1/2-inch adhesive tubes	1
Epoxy, 5-minute, Devcon, 5 oz. tubes	3

4.4.2 CAMERA EQUIPMENT

Camera Mount (dwg. OA-46-_)	1
Camera, Rollei 6006, with 40mm Distagon lens, 45° prism viewpiece, 120 or 220 film magazine, and remote release	1
Film magazine, for Rollei 6006 camera, 6x6/220, Rollei No. 760 071 or 6x6/120, Rollei No. 760 070	2

Spare film insert in plastic case, Rollei No. 760 075	1
Spare Ni-Cad power pack for Rollei 6006 camera, Rollei No. 208 953	1
Speedotron No. 1205 power supply, 1200 watt-second photoflash power units with 3 power channels	1
Speedotron No. 103CC color corrected light units	2
7" Universal Reflector, Speedotron, for No. 1205 light unit	2
Flash tube protective cover, for Speedotron No. 1205 light unit	2
Sync extension cord, for Speedotron No. 1205 light unit	2
Camera Case, aluminum shell, 21 in. long x 17 in. high x 7½in. thick, Zero Halliburton, silver, No. 121-106	1
Film, Color negative, 220 or 120, Kodak Vericolor III, VPS 220 or 120	8 rolls

4.4.3 DETAILED LINE SURVEY EQUIPMENT

Electronic Digital Caliper - English and metric readout, equipped with output capabilities for computer interface, LCD display, stainless steel, 0 to 6-inch range, battery operated, accuracy .0001 in. or .001 mm, with case Starrett No. 722Z-6/150 mm	1
Adapter and Disc to allow interface between Starrett No. 722Z digital caliper and IBM-PC compatible computer, Starrett No. 722H	1

Thickness Gages, 13 leaves (.03, .04, .05, .06, .07, .08, .09, .10, .15, .20, .30, .40, .50 mm), leaf sizes - 12.7 mm to 7 mm X 77 mm, stainless steel, with locking device, Starrett No. 173MAT	1
Taper Gage, English and metric, range .010 to .150 in. and 0.3 to 4 mm, tool steel, Starrett No. 270.	1
Digital Roughness Gage (dwg. OA-46-__)	1
Geological Gyrocompass (dwg. OA-46-__)	1
Carpenter's Shape Copier	1
Form 2, "Detailed Line Survey Form"	30

4.4.4 GENERAL GEOLOGIC MAPPING EQUIPMENT

Mapping Vest, Filson	1
Field Notebook, K & E "Rite in the Rain", Level Field Book, No. B8143	1
Measuring tape, metric, 3m	1
Pocket scale, 1:125, metric	1
Form 1, "Mapping Preparation Approval Form"	4
Sample Collection Bags, Canvas, with sewn on sample identification tag	15
Mineralogical Sample Bags, zip-closure, 4" X 4", plastic	20
Bubble-pack Bags, 6" X 6", plastic	20

4.5 <u>ASSUMPTIONS AFFECTING THE PROCEDURE:</u> To be Determined

4.6 <u>DATA INFORMATION:</u>

4.6.1 DICSONTINUITY DATA FROM DETAIL LINE SURVEYS

4.6.2 DESCRIPTION OF SAMPLES

4.6.3 GEOLOGIC NOTES

5.0 CALIBRATION REQUIREMENTS

Calibration is required as a part of this technical procedure. All surveying instruments and cameras used to obtain photogrammetric data will be calibrated in compliance with the Instrument Calibration Procedure (YMP-USBR-QMP 12.01) prior to obtaining data that will be used to support licensing the YMP Project.

5.1 <u>CALIBRATION RESPONSIBILITY:</u> The PI is responsible for calibrations required by this procedure. Calibration will be in accordance with procedures described or referenced in Para. 5.2. Maintenance of all calibration records described in Para. 5.3 may be done by a contributing investigator under the supervision of the PI.

5.2 <u>CALIBRATION PROCEDURE:</u> The following instruments require calibration:

1) Surveying equipment - Wild 4000 total station
Will be calibrated by H & N according to procedures NNWSI-017 and ________.

2) Right-angle prism goniometer
Will be calibrated by comparison with a standard setup.

3) Brunton compass (Inclinometer)
Will be calibrated by comparison with a standard.

4) Mapping camera - Rollei 6006

Will be calibrated using a camera test frame according to procedure USGS-GP-___, R0.

5) Geological Gyrocompass
Will be calibrated by comparison with a known bearing.

6) Pyramid beam splitter
Will be calibrated by comparison with a standard test station.

5.3 CALIBRATION RECORDS: Calibration data will be entered in field notebooks. These notebooks will be maintained as described in the Document Control Procedure (YMP-USBR-QMP- 6.01) and stored in accordance with the QA Records Management Procedure (YMP-USBR-17.01). Minimum data will include instrument type, identification and location, calibration procedure used, its date, the standard used, its range and accuracy, recalibration due date, responsible division subunit, any pertinent observations and the name of the person calibrating the instrument. Calibration entries shall be signed and dated by the person performing the calibration and filed with the QA Office.

5.4 LABELING OF EQUIPMENT CALIBRATION STATUS: In compliance with YMP-USBR-QMP-12.01, a sticker must be affixed to each piece of equipment used in this procedure denoting the calibration status according to one of the following three categories:

a) Equipment identification, date calibrated, date recalibration is due, procedure number and calibrator;

b) Equipment identification, "OPERATOR TO CALIBRATE", and the procedure number; or

c) Equipment identification and "NO CALIBRATION REQUIRED".

6.0 IDENTIFICATION AND CONTROL OF SAMPLES

Samples will be collected as part 4.2.6 of this procedure.

6.1 SAMPLE IDENTIFICATION: As part of the data records and documentation, and in compliance with QMP-8.01, and section 4.2.6.1 all record samples will be identified by a sample number marked on a 2" X 3" plastic tag with a bar code number affixed to the tag. The sample number will be written on the tag with an indelible marking pen. The sample numbering system will conform to Para. 4.2.6.1.

Samples collected for LANL under sections 4.2.6.2 and 4.2.6.3 of this procedure will be marked with a bar code number and assigned and independent sample number. This sample number will be affixed to the sample bag rather than the sample to prevent contamination. The sample numbering system will conform to Para. 4.2.6.1.

6.2 CONTROL AND STORAGE: In compliance with QMP-8.01, the collected and identified samples shall be stored in the Sample Management Facility, Area 25, NTS. The PI, principal geologists, project geologist, and site geologists shall have access to all the samples collected under the requirements of section 4.2.6.1 of this procedure, and shall follow the procedures designated in SMF technical procedure ________________. Samples taken for LANL under sections 4.2.6.2 and 4.2.6.3 of this procedure may be accessed only by the PI's (or their representatives) for which those samples have been collected.

7.0 QUALITY ASSURANCE RECORDS

All information collected and recorded under this procedure that is to be used in support of the YMP Project licensing process is required to be a part of the official USGS record. Input needed to process the information as a record includes: title or description, subject, originator, date of the document, and whether it is an original, a revision or an addendum. Specific items from this procedure that will constitute a record are field notebooks, field sheets, and magnetic recording media.

7.1 NOTEBOOKS: Notebooks or other organized documentation will be prepared as appropriate by the PI or a contributing investigator to record data from this procedure and shall include any information considered by the originator to be pertinent. When data are kept in loose-leaf form, each page will be numbered consecutively and chronologically. All documents will be signed or initialed and dated by the investigator on a daily basis when entries are made. Any revisions will be lined out, initialed, and dated.

7.2 COLLECTED DATA: All data collected and the applicability of methods used in this procedure will be reviewed and cosigned by a peer or supervisor of the investigator knowledgeable with the objectives of this procedure in accordance with YMP-USBR-QMP-6.01, Para. 4.2.2; and as such are acceptable and meaningful data that meet appropriate quantitative and qualitative acceptance criteria. Unacceptable data shall be identified appropriate to the form of the data.

8.0 MODIFICATIONS

When field modifications become necessary, per Para. 4.8, QMP- 5.05, the PI shall fully document the changes, submit the documentation for the same review signature and distribution process as for the original procedure, and indicate whether the change should result in a subsequent revision to the technical procedure. The documentation will be reviewed within 30 days.

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10.0 ATTACHMENTS

ATTACHMENT #1

MAPPING EQUIPMENT LIST

Equipment Description	Number Required
Mapping (Telescoping) Pedestal	1
Pyramid Beam Splitter	1
Laser Azimuth Pointer	1
Photogrammetry Targets	12
Photogrammetry Target Mounts	8
Adhesive, GE Silglaze N	2
Adhesive Gun	1
Epoxy, 5-minute	3

Camera Equipment

Camera Mount	1
Camera, Rollei 6006	1
Film magazine for Rollei 6006 camera, 6x6/220	2
Spare film insert in plastic case	1
Spare Ni-Cad power pack for Rollei 6006 camera,	1
Speedotron No. 1205 power supply	1
Speedotron No. 103CC light units	2
7" Reflector, for light unit	2
Flash tube protective cover for light units	2
Sync extension cord for light units	2
Film, 220 or 120, Kodak Vericolor III, VPS 220 or 120	8 rolls

Detailed Line Survey Equipment

Electronic Digital Caliper	1
Adapter and interface Disc	1
Thickness Gages	1
Taper Gage	1
Digital Roughness Gage	1
Geological Gyrocompass	1
Carpenter's Shape Copier	1
Form 2, "Detailed Line Survey Form"	30

General Geologic Mapping Equipment

Mapping Vest	1
Field Notebook Level Field Book	1
Measuring tape	1
Pocket scale, 1:125, metric	1
Form 1, "Mapping Preparation Approval Form"	4
Sample Collection Bags	15
Mineralogical Sample Bags, zip-closure, 4" X 4", plastic	20
Bubble-pack Bags, 6" X 6", plastic	20

ATTACHMENT #2

STANDARD ABBREVIATIONS

A

about	abt
above	abv
absent	abs
abundant	abnt
accessory	acces
acicular	acic
agglomerate	agim
alluvium	alv
altered (-ing)	altg
amorphous	amor
amount	amt
amphibole	amp
analcite	anal
and	&
angular	ang
anhedral	anhd
aphanitic	aph
apparent	apr
appears	aprs
approximate(ly)	aprox
argillaceous	arg
arkose(-ic)	ark
ash-fall	afa
ash-flow	afl
associated	assoc
at	
authigenic	authg
average	av
axiolitic	axtc

B

band(ed)	bnd
barrel(s)	bbl
basalt	bas
bed(ded)	bd
bedding	bdg
becomes(-ing)	bcm
bentonite(-ic)	bent
biotite	biot
black(ish)	bk
bleached	bich
blade(d)	bld
bleb	blb
blocky(y)	blk
blue(-ish)	bl
bomb	bm
boring(-ed)	bor
bottom	bot
boulder	bldr
branching	brhg
break	brk
breccia(ted)	brec
bright	bri
brittle	brit
brown(ish)	brn
broken	brkn
bronze	brz
bubble	bubl
buff	bu

C

calcite(-areous)	calc
cavity	cav
cement(ed)	cmt
center(ed)	ctr
chalcedony	chal
chert(y)	cht
chlorite(-ic)	chlor

circulation(-ate)	circ
clastic	clas
clay(ey)	cl
clean	cln
clear	clr
cleavage	clvg
cluster(ed)	clus
coarse(ly)	c
coating(-ed)	cota
cobble	colb
color(ed)	col
common	com
compact	cmpt
compare	cf.
competence(-ent)	comp
concentric	cncn
conchoidal	conch
concretion	conc
conglomerate(-ic)	cgl
consolidated	consol
conspicuous	conspic
contract	ctc
contorted	cntrt
core	c
covered	cov
cream	crm
crenulation(-ed)	cren
crevice	crev
cross-bedding(-ed)	xbd
cross-lamination(-ed)	xstrat
crystal(line)	xl
crystallization	x/z
cube(-ic)	cub
cuttings	ctgs

D

dacite	dac
darker	dk
debris	deb
decreasing(-ing)	decr
dendritic	dend
dense(ly)	dns
description	desc
determine	dtrm
detritus(-al)	dtrl
devitrified	dvit
diagonal	diag
diameter	dia
difference(-ent)	dif
discontinuous	dcont
displacement	disp
disseminated	dism
distinct	dist
distorted	dstrt
disturbed	distb
dominant	dom
drilling	drig
drusy	drsy
dusky	dsky

E

earthy	ea
effervescent	efv
elevation	elev
elliptical	elip
elongate	elong
embedded	embd
enlarged	enl
equant	eqnt
equivalent	equiv
especially	esp
euhedral	euhed
eutaxitic	eutax
even	evn
excellent	ex
exposure(-osed)	exp
extrusion(-ed)	extr

F

facet(ed)	fac
faint	fnt
fair(ly)	fr
fault(ed)	flt
feldspar(-athic)	fld
felsite	fls
ferruginous	ferr
fibrous	fib
figured	fig
filling	fill
fine(ly)	f
fissile	fis
flaggy	flgy
flat(tened)	flat
foliated	fol
formation	fm
fracture(d)	frac
fragment(ed)	frag
frequent	freq
fresh	frs
friable	fri
fringe(-ing)	frg
frosted	fros

G

gabbro	gab
generally	gen
geopetal	gept
glass(y)	gl
glauconite	glau
gloss(y)	glos
good	gd
gouged	goug
grading(-es,-ed)	grd
grain(ed)	gr
granule(-ar,-ated)	gran
gravel	gvl
gray(ish)	gy
greasy	gsy
green(ish)	gn
gritty	grty
gypsum	gyp

H

hackly	hky
hard	hd
heavy	hvy
hematite(-itic)	hem
heterogeneous	hetr
hexagonal	hex
high(ly)	hi
homogeneous	hom
horizontal	hor
hornblende	hbld

I

igneous	ig
imbedded	imbd
impression	imp
inclusion(-ded)	incl
increase(-ing)	incr
indistinct	indst
indurated	ind
inside diameter	I.D.
insoluble	insl
interbedded	intbd
intercalated	intcl
interfingered	intfr
intergranular	intgran
intergrown	intgwn
interval	intvl
intrusion(-ive)	intr
iridescent	irid
iron(stone)	fe(st)
irregular	ireg

J

jasper	jasp
joint(ed)	jt

K

kaolin	kao

L

lamina(ted)	lam
lapilli(stone)	lap(st)
large(r)	lrg
latite	lat
lava	lva
lavender	lav
layer(ed)	lyr
leached	lchd
lenticular	len
light(er)	lt
limonite(-itic)	lmn
lithology,lithic	lith
lithophysae(-al)	lthph
little	ltl
local	loc
long	lg
loop	lp
loose	lse
lower	low
lumpy	lmpy
luster	lst

M

magnetite(-ic)	mag
marble(-ized)	mbl
maroon	mar
massive	mas
material,matter	mat
matrix	mtx
maximum	max
medium	med
member	mbr
metaphorphic(-osed)	meta
mica(ceous)	mic
microcrystalline	mcxl
microgained	mcgr
middle	mid
milky	mky
mineral(ized)	mnrl
minimum	min
minor	mnr
minute	mnut
moderate	mod
mold(ic)	mol
mosaic	mos
mottling(-ed)	mot
mudstone	md(st)
muscovite	musc

N

natural	nat
near	nr
no,non-	n
nodule	nod
numerous	num

O

object	obj
occasional	occ
ochre	och
odor	od
olive	olv
opaque	op
open	opn
orange(-ish)	orng
outside diameter	O.D.
overgrowth	ovght

oxidized	ox

P

paper(y)	pap
part(ly),partial	pt
particle	par
patch(y)	pch
pearly	prly
pebble(-y)	pbl
pellet	pel
phenocryst	phen
pink(ish)	pk
pisolite(-itic)	piso
pitted	pit
plagioclase	plag
platy	plty
polished	pol
polyvinyl chloride	PVC
poor(ly)	p
porosity, porous	por
possible(-ly)	pos
preserved	pres
primary	prim
probably	prob
prominent	prom
pseudo-	psdo
pumice	pum
purple	purp
pyrite(-ized)	pyr
pyroclast(ic)	pyrcls
pyrolusite	MnO2
pyroxene	prx

Q

quartz	qtz
quartzose	qtzs

R

radiate(-ing)	rad
radiaxial	radax
range(-ing)	rng
rare	rr
recemented	recem
recovery(-ed)	rec
red(dish)	re
regular	reg
remains	rmn
replacement(-d)	repl
residue(-al)	resd
resinous	rsns
reworked	resk
rhomb(ic)	rhmb
rhyolite	rhyl
rich	rch
ripple	rip
rock	rk
rounded	rnd
rubble(-ly)	rbl

S

salt & pepper	s&p
same as above	a.a.,",do
sample	spl
sand(y)	sd
sanidine	san
scarce	scs
scattered	scat
sealed	sld
secondary	sec
section	sect
sediment(ary)	sed
shape(d)	shp
shard	shd
shear	shr
sidewall core	S.W.C.
siliceous	sil
silicic	silc

silky	slky
silt(stone)	slt(st)
similar	sim
size	sz
slabby	slab
slate(-y)	sl
slickenside	sks
slight	sli
small(er)	s
smooth	sm
soft	sft
solution	sol
somewhat	smwt
sorting(-ed)	srtg
speck(-led)	spk
sparse	sps
sphene	sphe
spherulite	sphr
spongy	spgy
spot(ty,ted)	sp
stain(-ed,ing)	stn
stone	st
strata(ified)	strat
streak	strk
striated	stri
stringer	strg
structure	struc
sub-	sb-
surface	surf
surge	surg

T

tabular	tab
tan(nish)	tn
texture(d)	tex
thermal(ly)	thml
thick	thk
thin	thn
throughout	thru
tight(ly)	ti
top	tp
total depth	T.D.
tough	tgh
trace	tr
translucent	trnsl
transparent	trnsp
tubular	tub
tuff(aceous)	tuf
type(-ical)	typ

U

unconformity(-able)	unconf
unconsolidated	uncons
underlying	undly
uniform	uni
upper	up

V

vapor phase	vap
variation(-able)	var
variegated	vgt
vein	vn
verticle	vert
very	v
vesicle(-ular)	ves
violet	vi
vitrious(-ic)	vit
vitrophyre	vitph
volcanic	volc
vug(gy)	vug

W

water	wrt
wavy	wvy
waxy	wxy
weak	wk
weathered	wthr

welded	wld
well	w
white(-ish)	wh
with	w/
without	w/o

Y

yellow(ish)	yel

Z

zeolite(-ized)	zeol
zircon	zr
zone	zn

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[7]NRC documents, regulations, GTP's, etc.

[8]Uncontrolled DOE management plans to be furnished to the NRC under separate cover.

[9]Study Plans in preparation, will be furnished to the NRC upon approval.