

Geological Inventory Field Procedures

Version 1

August 14, 2002

Compiled by Glenn Mutti

CRMO

Introduction:

The following document is a written protocol that describes how the collection of geological field data for inventory purposes should be carried out at Craters of the Moon National Monument.

Equipment:

In the summer of 2002, the equipment used included a Trimble GeoExplorer 3, 100m measuring tape, a Suunto clinometer, a Brunton compass, field notebook, and a Kodak DC 5000 digital camera. Software used in the office included GPS Pathfinder Office 2.80, Arcview 3.2, ThumbsPlus 5.1, and Microsoft Internet Explorer.

Required Attributes for all Features

Required attributes for all features being mapped include date, genesis, mapping geologist, feature type, ID number, UTM coordinates, elevation, the lava type surrounding the feature, the accuracy of the measurement, and the number of photographs taken of each feature. Each of these attributes will now be examined. In addition to entering this data on the GPS unit, it should also be manually entered into the geoinventory field data notebook (for backup purposes).

Date:

This is the date on which the feature was inventoried. It will automatically be recorded when using the geoinventory data dictionary.

Point/Line/Area Genesis:

In the field, the attribute that will automatically be recorded (when using the geology data dictionary) is "Field." If a feature is mapped on GIS by only using aerial photos, this attribute column of the feature should be filled in as "Photo." If a line or area feature was initially drawn using GIS but its accuracy was then studied/improved (or vice versa in rare instances) in the field, genesis column in the attribute table of that feature should have "Photo & Field Checked" filled in.

Geologist: This attribute records the mapping geologist's name. If the mapping geologist's name is not entered on the data dictionary menu, the choice "other" should be chosen and in "Comments" they should specify their name.

Feature Type:

This attribute has been entered to create a more user-friendly database. In this field, one must enter the type of feature that is being mapped.

ID Number:

For all features being mapped, they must be assigned an identification number. This is a six digit number, with the first two digits indicating the type of feature and the last four digits acting as a specific number that refers to only the feature site that is being mapped. The feature digit code is as follows:

Tumuli: 010000
Pressure Ridge: 020000
Pressure Plateau: 030000
Squeeze Up: 040000
Inflation Pit: 050000
Pit Crater: 060000
Lava Pond/Lake: 070000
Rafted Block: 080000
Spatter Cone: 090000
Hornito: 100000
Spatter Rampart: 110000
Fissure/Open Crack Rift Set: 120000
Tree Mold: 130000
Dike: 140000
Fault: 150000
Miscellaneous Point: 160000
Rock Cairn: 170000

All geologic features mapped as geologic lines or areas must be associated with a point feature and have the same ID number. The associated point feature will store the area/line feature's attributes. The reason it is necessary that the area/line feature and the point feature have the same ID number is so that on ArcView the attributes stored with the point feature can be joined (based on ID number) to the attributes associated with its line/area feature. The minimum length of a feature needed so that it will be mapped as a line is 100m. The foreseeable point feature fields where a line association may be needed are pressure ridges, spatter ramparts, fissure/open crack rift sets, dikes, and faults. Foreseeable point feature fields where an area association may be needed are pressure plateaus, inflation pits, pit craters, lava ponds/lakes, squeeze up fields (for instance, on a lava lake), and rafted blocks, which all must have a minimum area equivalent to that of a circle with a 50m diameter (1962.5 m²). The criterion determining whether or not any of the above listed point features are mapped with an associated line/area file will be discussed in the measurement specification section for each feature field.

UTM Coordinates:

UTM Coordinates will automatically be stored by the GPS unit (Trimble GeoExplorer 3c at the time of this writing) when a file in the geoinventory data dictionary is opened. However, the UTM coordinates also need to be copied

onto the field data sheets. For a point feature, the minimum number of UTM data points that need to be collected is 120 with a maximum PDOP of 6.

Elevation:

The elevation of a feature must be recorded in the geoinventory data dictionary so that the elevation will be displayed in a GIS attribute table. Elevation measurements should always be recorded in feet.

Lava Type Surrounding the Feature:

The lava type that a feature is composed of and surrounded by defines the feature's lava type. If the rock type of the mapped feature is misrepresentative of the rock type within the feature's immediate vicinity, the surrounding lava type recorded should be the rock type that the feature overlays/is enveloped by. The lava type surrounding a feature must be recorded and has been categorized into the following options:

a'a
shelly pahoehoe
slabby pahoehoe
spiny pahoehoe
pahoehoe
blocky
cinder
spatter
composite
country rock

The composite lava type can be used when either the surrounding area is composed primarily of cinders and bombs or when several different rock types surround the feature. When "composite" is chosen, the proportion of different lava types (or cinders and bomb types) should be indicated in "Comments." field.

Three different and confusing case scenarios that occur when determining lava type follow:

Scenario 1: A bomb that contains a xenolith is discovered on top of a spiny pahoehoe flow. Since the xenolith is by definition not a local rock, the lava type encasing the xenolith should be recorded (however, in "Comments" the xenolith rock type should be noted). The surrounding lava type chosen would be composite (because "bomb" is not one of the rock types that appears on the menu) and it should be noted that the xenolith is in a bomb and the type of bomb (if discernable) should be recorded.

Scenario 2: A rafted block (which by definition is a volcanic fragment that was caught up in a lava flow and detached from its source) whose source was a crater wall (composed of spatter, cinders, and bombs) is found surrounded by cinders in Devil's Orchard. Although the block wasn't

rafted on the cinders (most likely it was rafted on an underlying trachyandesite flow), the surrounding lava type chosen should be cinder because that is the only visible lava type surrounding the block.

Scenario 3: A hornito is discovered that is composed of spatter and surrounded by shelly pahoehoe. The surrounding lava type chosen should be shelly pahoehoe because hornitos (by definition) are composed of spatter and thus, rather than identifying what the feature is composed of (which is known), the lava type surrounding the feature should be chosen.

Measurement Accuracy:

This field tells if the dimensions and measurements recorded are actual measurements or if they are estimates.

Number of photographs taken:

The number of photographs taken of a feature must be recorded in this field.

Optional Attributes for all Features

Fields that are optional but listed for all features include notable features and comments. The only features for which comments are required are faults and miscellaneous points.

Notable Features:

Notable features include remarkable geologic, biologic, and archaeological features that are noticed on/in/with the geologic feature being inventoried. A list of abbreviated features follow.

+Geologic

- glassy surface: GGS
- tachlyte: GT
- unusual color: GUC
- notable soil occurrence: GNSO
- water hole: GWH
- snow/ice accumulation: GSA or GIC
- mineral deposit: GMD

+Biologic

- ferns: BF
- moss: BM
- insects present: BIP
- bird nest: BBN
- animal nest/burrow (not including bird): BAN
- skeletons/bones: BS or BB
- dung middens: BDM

+Archaeological

- Rock chippings: ARC
- rock rings: ARR
- large bones in caves: ABC
- wall carvings/paintings: AWC or AWP

Features that are notable but do not fall into the above codes should be described with text. Features that are coded can have more in depth specifications recorded in text.

Comments:

This field is used if certain data collected does not fall into the defined compartments made for this study. It can also be used to comment on any aspect of the feature.

Feature Specific Attributes and Measurement Specifications

The following is a list of all features being inventoried and the attributes that apply to each feature. Included with this information are specifications on how to measure features and the criterion for determining if features are large enough to be recorded. All measurements are to be taken in meters. Only features that are not mapped on a USGS geological map should be recorded (however, if the feature was mapped incorrectly in the opinion of the mapping geologist, they can remap the feature with their personal interpretation). Attributes followed by an asterisk (*) are fields whose completion is required. Each feature has a specific field data sheet from which the dimensions that need recording for each feature can be quickly obtained in the field.

Tumuli

+Recording Criterion:

Tumuli's maximum height must be equal or greater than 3m. To define a feature as a tumuli rather than a pressure ridge, the width of the inflation feature must be greater than 2/3 of the its length.

-Maximum Height Observable*

Maximum height of the tumuli from the base (the edge of the incline) to its top.

-Typical Base Diameter*

Width perpendicular to the tension fracture.

-Typical Fracture Width

The most representative width of the central tension fracture at the top of the tumuli.

-Typical Fracture Depth

The most representative depth of the central tension fracture. If there are exceptionally deep areas within a fracture, those depths can be recorded in comments.

Pressure Ridge

+Recording Criterion:

- Average ridge height must be at least 3m for a length of at least 10m above surrounding topography.
- Typical Height*
Most representative height of the pressure ridge from the base (the edge of the incline) to its top.
 - Typical Width*
Most representative width of pressure ridge, from incline edge to incline edge.
 - Length*
Length of the pressure ridge from incline edge to incline edge.
 - Long Axis Trend
If a linear pressure ridge (without significant bending), then the trend of the long axis should be measured in azimuth degrees.
 - Typical Fracture Width
Typical tension fracture width at the pressure ridge top
 - Typical Fracture Depth
The most representative depth of the central tension fracture. If there are exceptionally deep areas within a fracture, those depths can be recorded in comments.

Pressure Plateau

- +Recording Criterion:
Average height of plateau must be at least 3m above surrounding topography.
- Apparent Thickness of Plateau*
Apparent thickness of plateau at measurement sight, measured from base of incline to inflation top.
- Area of Pressure Plateau
Can be determined either by creating a GPS polygon or by using aerial photos/dogqs; generally will not be determined in the field.

Squeeze up

- +Recording Criterion:
Any squeeze up should be mapped that flowed down the side of a pressure ridge; squeezed up within fractures and exhibit interesting shapes (e.g. hollow pipe); squeeze ups on lava ponds etc.
- Coincident feature*
Menu listing possible features from which the squeeze up was extruded from. Menu includes tumuli, pressure ridge, pressure plateau, lava pond, and other. If "other" is chosen, the structure must be explained in the "Comments" field.
- Shape*
Menu listing possible shapes of squeeze ups, including pipe (cylindrical, and note of whether it is hollow or not should be made in comments), candy kiss (looks like a Hershey's kiss), flow down (squeeze up running down the side of a ridge), bulbous (has a pronounced bulb-shaped

swelling), explosion (a rare squeeze up that has the skin of an exploded squeeze up still present), blob (no distinct shape), and not described. If “not described” is chosen, the shape must be described in the “Comments” field.

-Condition*

A menu where options include: Pristine (if the feature shows little/no natural or human damage), Some Deterioration/Damage (if the feature shows an observable amount of deterioration/damage), and Vandal/>50% destroyed (if the feature has excessive human damage or if more than half of the feature has deteriorated naturally). If significant human damage is apparent, this should be noted in “Comments.”

Inflation Pit

+Recording Criterion:

An inflation pit's typical diameter must be at least 10m and its maximum depth must be greater than 3m.

-Typical Rim Diameter*

Most representative diameter of inflation pit, from rim to rim.

-Maximum Depth*

Maximum depth of inflation pit, from deepest part of pit to the most representative rim level.

-Number of Distinct Inflation Steps*

If several different inflation steps are apparent (from a stair-like pattern of inflation) this should be recorded as it may indicate different flow pulses.

Pit Crater

+Recording Criterion:

A pit crater with an average diameter of equal or greater than 10m and a minimum depth of 3m.

-Typical Rim Diameter*

Most representative diameter of pit crater, from rim to rim.

-Maximum Depth*

Height from deepest part of crater up to the most representative rim level.

Lava Pond/Lake

+Recording Criterion:

Any found lava pond (e.g. Big Sink) with an average diameter equal to 30m or greater should be mapped.

-Typical Levee Height

Most representative height of levee from the edge of the levee incline on the non-pond side of the levee.

-Levee Thickness at Base

Thickness of the levee from the pond edge to the other side of the levee where initial levee inclination begins.

-Area of Lava Pond

This field can either be calculated on GIS after mapping the pond as a polygon, or it can be estimated off of aerial photos/doqqs.

Rafted Block

+Recording Criterion:

A rafted block that is longer than 10.00m and has a maximum height of 3m or greater should have its location recorded.

-Maximum Height*

Maximum height of block observed, from base to top. If trachyandesite is observable at the base, make note of this in comments.

-Typical Width*

Most representative width of block.

-Length*

Length of the rafted block.

-Long Axis Azimuth

Azimuth measure of the long axis of the block.

-Slickensides*

If slickensides are noticed on block, answer “yes”. If block was identified with aerial photos, write “aerial” in the slickensides column. An example of slickensides that have been found in CRMO can be viewed in the geodictionary photos.

Spatter Cone

+Recording Criterion:

Any spatter cone discovered should be mapped. When mapping a cluster of cones as one point, specify in “Notable Features” how the recorded base and vent diameter were determined (measurement is average of all members, measurement is only of the most prominent member, etc).

-Maximum Height*

The height from the base to the top of the spatter cone. The spatter cone base is defined as the edge of the spatter incline.

-Typical Base Diameter*

The most representative diameter of the spatter cone’s base (this could be calculated by averaging the long and short axis of the spatter cone if it is oblong).

-Typical Vent Diameter*

The most representative diameter of the spatter cone’s vent. If vent leads down to a chamber (snow is at the bottom or the bottom is not visible), note this in comments.

-Condition*

A menu where options include: Pristine (if the feature shows little/no natural or human damage), Some Deterioration/Damage (if the feature shows an observable amount of deterioration/damage), and Vandal/>50% destroyed (if the feature has excessive human damage or if more than half of the feature has deteriorated naturally). If significant human damage is apparent, this should be noted in “Comments.”

Hornito

+Recording Criterion:

Any hornito discovered should be mapped. When mapping a cluster of hornitos as one point, specify in "Notable Features" how the recorded base and vent diameter were determined (measurement is average of all members, measurement is only of the most prominent member, etc).

-Maximum Height*

The height from the base to the top of the hornito. The hornito base is defined as the edge of the spatter incline.

-Typical Base Diameter*

The most representative diameter of the hornito's base (this could be calculated by averaging the long and short axis of the hornito if it is oblong).

-Typical Vent Diameter*

The most representative diameter of the hornito's vent.

-Dribblet Spire*

A menu where if the hornito is not a dribblet spire, then "N" should be selected. If a feature is a dribblet spire, then the type needs to be classified. The types include:

- Scaley
- Ornate
- Necked
- Pyramid
- Undefined hunk
- Composite
- Other

Prototypes of each kind of dribblet spire can be found in the geodictionary photo folder.

The reasoning involved when naming a feature a dribblet spire, squeeze up, or hornito is often gray. A small hornito (one that cannot be mistaken for a common spatter cone) without a vent is the most basic criterion for a hornito to be a dribblet spire. If a small hornito was the probable origin for local ejecta/cinder deposits, then it is just a hornito and not considered a dribblet spire. Large ventless hornitos (for example, one 3m tall with a base diameter of 7m) are not considered "undefined hunk" dribblet spires because dribblet spires are typically defined as a smaller feature than our hypothetical hornito. If a squeeze up is very small (less than .20 cm tall) but still displays a neck or an ornate lava texture, it should be considered a "not-described" squeeze up.

-Condition*

A menu where options include: Pristine (if the feature shows little/no natural or human damage), Some Deterioration/Damage (if the feature shows an observable amount of deterioration/damage), and Vandal/>50% destroyed (if the feature has excessive human damage or if more than half

of the feature has deteriorated naturally). If significant human damage is apparent, this should be noted in "Comments."

Spatter Rampart

+Recording Criterion:

Any rampart with an average height greater than or equal to 2m over a length of 10m or greater should be recorded. Spatter ramparts are almost always paired, but if an individual spatter hill is found, this should be mapped as a rampart, but noted in "Comments."

-Typical Height*

The most representative height along the entire length of the spatter rampart. Measurement should be taken from the edge of the spatter incline.

-Typical Width*

The most representative width of the rampart pair, measured from the edges of the spatter inclines, across the fissure.

-Length*

Length over which the spatter rampart that is greater than 2m tall.

-Azimuth of Eruptive Fissure*

The trend of the eruptive fissure measured in azimuth degrees.

Fissure/Open Crack Rift Set

+Recording Criterion:

Crack/Fissure must be at least 30m long to be mapped.

-Length*

Length of crack.

-Typical Width*

The most representative width of a crack along its entire length.

-Typical Depth

The most representative depth of a crack along its entire length. If there are exceptionally deep areas within a crack, those depths could be recorded in comments.

-Azimuth of fissure*

The trend of the crack/fissure measured in azimuth degrees.

-Number of Sets Observable*

Total number of cracks with similar trends within the same area (~50m perpendicular to the trend of the main crack) of the crack being mapped, including the mapped crack.

-Eruptive Fissure*

If fissure was eruptive and has spatter ramparts or is the likely source of other eruptive material in the area, then select "Yes."

Tree Mold

+Recording Criterion:

Any tree mold discovered should be mapped.

-Vertical/Horizontal*

- Menu with a vertical option (if the tree mold is vertical) and a horizontal option (if the tree mold is horizontal).
- Depth/Length*
The maximum depth (if vertical) or the maximum length (if horizontal) of the tree mold.
 - Typical Width*
The most representative width of the tree mold.
 - Number of Limbs*
The number of limbs evident that are associated with the tree mold.
 - Condition*
A menu where options include: Pristine (if the feature shows little/no natural or human damage), Some Deterioration/Damage (if the feature shows an observable amount of deterioration/damage), and Vandal/>50% destroyed (if the feature has excessive human damage or if more than half of the feature has deteriorated naturally). If significant human damage is apparent, this should be noted in "Comments."
 - Tire Track Texture*
A menu where if the tree mold displays a tire track texture, then "yes" would be selected.

Dike

- +Recording Criterion:
Any dike discovered should be mapped.
- Rheologic Properties*
A description of the intruding rock to explain how it was determined that a dike is present.
- Strike
The axis trend of the dike, in azimuth, if observable.
- Dip Angle
Dip angle of dike, if observable.
- Dip Direction
Compass direction that the dike is dipping.
- Length
Length of the dike exposed on the ground surface.
- Depth
Height/depth of a dike if it is traceable in cross-section, e.g. if the dike is on some type of wall.
- Typical Dike Width
The most representative dike width observable.

Fault

- +Recording Criterion:
Any recognizable fault should be mapped.
- Fault Type
Menu of different fault types to choose: includes normal, reverse, transform, normal oblique slip, and reverse oblique slip.

-Strike

The axis trend of the fault, in azimuth, if observable.

-Dip Angle

Dip angle of fault, if observable.

-Dip Direction

Compass direction that the fault is dipping.

-Length Exposed

Length of traceable fault.

-Comments*

Comments are required to explain how the presence of the fault was determined.

Miscellaneous Point

+Recording Criterion:

Any geologically remarkable feature (examples include xenoliths, spectacular pahoehoe ropes, remarkable bombs, well formed lava blisters, spectacular glass formations, lava channels, white powder accumulate, pumice fragments (aside from small fragments on Paisley Cone and North Crater Cone)), spectacular biological feature, or any archaeological feature fall into this category. Notable features on previously mapped features (by USGS) that were not originally commented on can also be mapped as a miscellaneous point.

-Comments*

Required to tell what the feature being recorded is.

-Fields 1,2,3, and 4

Optional numeric fields to enter any dimension data of the feature.

-Explanation of Fields 1-4

Required to know what the measured dimensions in Fields 1-4 represent.

Rock Cairn

+Recording Criterion:

Any cairn encountered off of present trails should be mapped.

-Cairn Height*

Measurement of the cairn's height from the bottom of the rock pile.

-Reason for Cairn*

Categories are feature (such as a cave), trail (if it is obviously marking a trail), and unknown.