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**PARTICIPATION IN THE CREEDE SCIENTIFIC DRILLING PROJECT
AS ON-SITE PRINCIPAL INVESTIGATOR**

**Final Report
Grant No. DE-FG02-91ER14207**

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June 1992

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PARTICIPATION IN THE CREEDE SCIENTIFIC DRILLING PROJECT
AS ON-SITE PRINCIPAL INVESTIGATOR

Late in 1991, the U.S. Geological Survey (USGS), in partnership with the National Science Foundation (NSF) and the Department of Energy (DOE) completed two intermediate-depth coreholes in the moat of the 26 m.y.-old Creede caldera in southern Colorado (Fig. 1) as part of the U.S. Base Program of Continental Scientific Drilling. Chief Scientist for the project was (and remains) Philip M. Bethke (USGS, Reston, VA). Thomas H. Moses, Jr. (USGS, Menlo Park, CA) served as Chief Engineer. Jeffrey B. Hulen, University of Utah Research Institute (UURI), was funded by the DOE's Office of Basic Energy Sciences to work closely with these key individuals in the role of on-site Principal Investigator (P.I.); Wayne Campbell (USGS, Reston) was assistant on-site P.I. Tonto Drilling Services of Salt Lake City, Utah (Wayne Beaupre, Supervisor) completed the actual coring. Six additional drill-site geoscientists (F. Gay, N. Foley, D. Hayba, A. Hopkins, D. Larsen, and R. Streufert) were essential for core logging and curation, and undertook additional responsibilities to be elaborated later in this report. This on-site management team was responsible for ensuring that the project's scientific and technical objectives were smoothly and successfully achieved. Cores obtained from the project are currently under detailed investigation by 23 Principal Investigators representing 12 U.S. institutions. Additional investigators with ideas for further work on the Creede cores are encouraged to participate, and should contact Chief Scientist Philip Bethke at the USGS in Reston, VA.

FIGURE 1. LOCATION MAP, CREEDE SCIENTIFIC DRILLING PROJECT

Scientific questions addressed by the Creede Scientific Drilling Project were as follows (Bethke et al., 1992): (1) Did the lacustrine sedimentary sequence filling the moat of Creede caldera serve as reservoir for the moderately-saline aqueous fluids which scavenged and then transported silver and base metals to ore-depositional sites for the rich epithermal deposits of the Creede mining district (Fig. 1)?; (2) what were the chemical and isotopic compositions of these fluids prior to their entry into the Creede fracture (later vein) system; (3) how did these chemical and isotopic compositions evolve in transit to the ore-depositional site?; (4) how did the Creede caldera form and evolve?; (5) what is the present thermal regime in Creede caldera moat? ...the paleothermal regime?; (5) what are the hydrologic transport properties of the moat sedimentary rocks?; (6) what diagenetic or hydrothermal veins disrupt the moat sedimentary sequence, and what do their paragenetic relationships, mineralogic compositions, fluid-inclusion characteristics, and stable-isotope systematics reveal about evolution of the Creede hydrothermal system?

Two Creede caldera moat drill holes were completed for this project. The deepest (725 m), CCM-2 or Airport 1-6 (Fig. 1) was completed in the central portion of the moat along strike with the Creede district epithermal vein complex, partially on the premise that fractures extending southward from what was to become the district would have guided moat fluids as they entered the Creede hydrothermal system. A second hole (CCM-1, or Hosselkus 1-10; Fig. 2) was drilled to a depth of 375 m about 4 km to the west, well away from major paleohydrothermal fluid flow and hopefully free of

hydrothermal overprints so as to provide background material to compare with possibly altered core from CCM-2.

The two holes were drilled by Tonto Drilling services, working 24 hours per day in two 12-hour shifts. The Tonto Drilling team included veterans of past scientific and geothermal drilling projects such as Jeff Riley, Justin Semadeni, and Jerry Gillespie. Under the direction of Wayne Beaupre, Tonto obtained better than 99% core recovery for both the Creede holes; individual cores reaching more than 10 ft in length were frequently retrieved, assuring a wealth of solid sample for concerned Principal Investigators.

An on-site science team consisting of the individuals listed above complemented Tonto's superb efforts by providing round-the-clock core logging, fluid sampling, and drill-site monitoring and supervision. The team worked in shifts staggered slightly from Tonto's schedule. The principal job of the on-site science team was careful curation, labeling, boxing, and logging of the cores after provision of same by the Tonto drilling crew. Depending on drilling rate, this task required either a two-person or three-person team -- the latter particularly when drilling was trouble-free, the rocks were competent but soft, and drilling rates exceeded 150 ft per day.

Upon reception at the rig from Tonto personnel, each core was carefully washed to remove drilling fluids, dried (with a portable, hand-held, forced-air heater), marked, and oriented, so that should an unlikely accident occur, the individual pieces could be readily re-assembled. The cores were then boxed, and logged in detail at

a scale of 1" = 1 ft, with attention to lithology, fracturing, mineralization, organic-matter content, alteration, and sedimentary structures. Prior to the project, at the suggestion of computer expert Wayne Campbell, a suite of representative rock samples from Creede caldera and vicinity were assigned standard numbers, so that their counterparts in core could be categorized quickly and efficiently for subsequent computer-assisted illustration. These logs were abstracted to prepare the summary logs shown in Appendix 2.

Additional on-site activities pertaining to core included collection of special samples for certain P.I.'s as well as laboratory natural gamma and magnetic-susceptibility logging for provision of ground truth to aid in interpretation of actual down-hole gamma and magnetic susceptibility logs. Special samples included those tightly foil-wrapped and waxed to preserve natural formation fluids, and those containing particularly large amounts of organic debris. The above-ground geophysical logging of the core was carried out as time permitted; rapidly-retrieved core required full-time attention to the more important geologic logging described above. In support of detailed studies to be carried out later by the broader Creede scientific consortium, samples of all drilling fluids and additives were systematically collected and retrieved -- for example, each time a new load of drilling water was obtained from the Creede culinary water supply. Actual water samples were also retrieved from several moat aquifers for those carrying out hydrogeochemical studies in support of the project. As an interesting aside, a high-level aquifer in Rio Grande gravel

deposits in CCM-2 was discovered to produce copious quantities of water which the town of Creede may use to supplement its existing culinary water supplies.

Besides carrying out the duties specified above, the on-site science team arranged and monitored site visits by scientific and other parties, and kept the town of Creede apprised of new developments in the project (such as the discovery of potential culinary water in CCM-2). Prior to drilling, we conducted a town meeting during which the project's objectives, schedule, etc. were presented to the attendees. "Open-houses" were also held at the drill site so that people from Creede could observe drilling and related scientific activities in progress and ask questions of the on-site scientific, engineering, and drilling staff.

The two holes have already provided a wealth of new information about the Creede caldera moat and fluids residing in it at the time of formation. Through detailed studies of the core and fluids retrieved during this project, in combination with geophysical logging and other allied projects, Principal Investigators are beginning to uncover hitherto unknown facets of the Creede district's tectonic, volcanic, and hydrothermal histories.

Both Creede moat coreholes penetrated principally the moat-filling sedimentary sequence of the Creede caldera (Appendix 1) -- the lacustrine facies of the Creede Formation. CCM-1 (Fig. 1) drilled through 375 m of Creede Formation and 55 m of caldera-wall landslide breccias. CCM-2 (Fig. 2) penetrated 500 m of Creede Formation and 225 m of breccias, zeolitized tuffs, and

miscellaneous epiclastic debris. In both holes, the Creede Formation comprises principally finely-laminated to thinly bedded, zeolitized tuffaceous siltstone and sandstone probably deposited by sublacustrine turbidites. Locally interrupting this sequence are debris-flow breccias up to 15 m thick, possible subaqueous felsic pyroclastic flow rocks, and subaqueous felsic fallout tuffs. The Creede Formation in the upper third of each hole hosts conspicuous, rice-grain-shaped calcite pseudomorphs after the cold-water-precipitated hydrous calcium carbonate ikaite. Disseminated pyrite in minute quantities is ubiquitous in the Creede in both holes; and a few laminae are dominated by this sulfide. In the Snowshoe Mountain ignimbrite intersected in the lower portion of CCM-2 (Appendix 1), calcium carbonate-pyrite-clay veins are common; a few of these are prominently open and host well-developed pyrite stalactites enveloped by bladed calcite. These and other critical features of the core as observed on-site during the drilling project are recorded in the summary logs of Appendix 1.

REFERENCES

Bethke, P.M., Lipman, P.W., Barton, P.B., Jr., Daniels, J.J., Foley, N.K., and Hayba, D.O., 1987, Research drilling in the mineralized hydrothermal system at Creede, Colorado: Research Proposal Submitted to DOSECC, Inc., 129 p.

Bethke, P.M., Hulen, J.B., Moses, T.H., Jr., and Campbell, W.R., 1992, Research drilling the moat of the 26 Ma Creede caldera, San Juan Mountains, SW Colorado, USA (abs.): Paris, Int. Symp. on Continental Sci. Drilling.

Hulen, J.B., 1991, Proposal for participation in the Creede Scientific Drilling Project as On-Site Principal Investigator: Proposal to U.S. Dept. of Energy, Office of Basic Energy Sciences, 17 p.

APPENDIX 1

Creede Scientific Drilling Project
(USGS - NSF - DOE)

**Field Geologic Log Summaries (1 in. = 12 ft.)
for Coreholes CCM-2 (Airport 1-6) and
CCM-1 (Hosselkus 1-10)**

Jeffrey B. Hulen
University of Utah Research Institute

prepared from 1 in. = 1.5 ft.-scale on-site geologic logs by

P.M. Bethke
W.R. Campbell
N. Foley
F.E. Gay
D.O. Hayba
A.J. Hopkins
J.B. Hulen
D. Larsen
R. Streufert

Explanation for Sedimentary Structure Symbols

Calcite pseudomorphs after ikaite(?); so-called "rice grain" structures
Convolute stratification
Normally graded bedding (arrow shows thickness for thicker intervals)
Reverse graded bedding
Symmetrically graded bedding
Load structures
Flame structures
Injection structures
Algal mounds (?)
Unidirectional ripples
Penecontemporaneous fault
Rip-up clast
Calcareous concretion
Autoclast
(ANY OF THESE) Scour & fill structure
Cross-bedding
Burrow(?)
Plant fossil
Mudcracks

= VEINLETS

Acknowledgement: Funding for Hulen's participation in the Creede Scientific Drilling Project was provided by the U.S. Department of Energy, Office of Basic Energy Sciences, Grant No. DE-FG02-91ER14207

DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
	GRAIN SIZE FLAKE SAND GRAVEL COBBLE BOULDER	ALTERATION INTENSITY WMS	CARBONATE CEMENT WMS	ORGANIC CONTENT WMS	Veining & Vug Filling WMS	VEIN MARKS	DISSEMINATED PYRITE	SEPMENTARY STRUCTURES				
0'												0-50': INTERSTRATIFIED SANDY PEBBLE TO COBBLE GRAVEL & PEBBLY MED.-V. CRS. GRAINED SAND DEPOSITED BY THE RIO GRANDE; PEBBLES AND COBBLES ARE SUBROLINDED TO ROUNDED; MANY ROCK TYPES REPRESENTED, INCL. FELSIC- TO BASIC-COMPOSITION PORPHYRITIC FLOW RX, WELDED FELSIC- TO INTERMEDIATE COMPOSITION ASH-FLOW TUFF; MINOR SANDSTONE, PROBABLY DERIVED FR. THE CREEDE FM. (JUST THE SS); ARGILLACEOUS TO SILTY SOIL HORIZON "UPPER 1.0 FT
10'												
20'												
30'												
40'												
50'												
60'												
70'												
80'												
90'												
100'												<p>50-100': SANDY PEBBLE TO COBBLE GRAVELS, AS ABOVE; UNCONSOLIDATED, HIGHLY POROUS; COBBLE SIZE APPARENTLY INCREASES DOWNWARD; SPENKER DRILLING REPORTS THIS INTERVAL AS AN EXCELLENT AQUIFER; COBBLE COMPOSITION AS ABOVE (ALSO IN BOTH INTERVALS) PEBBLES & COBBLES OF PRECAMBRIAN BIOTITE SCHIST & GRANITE. ONE SCHIST COBBLE OBSERVED TO BE GLACIALLY STRIATED.</p> <p>*NOTE: FOOTAGES APPROXIMATE ABOVE 135': CUTTINGS ONLY - NO CORE</p> <p>* 90-100': POSSIBLE UNCONSOLIDATED SAND HORIZON</p>

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by JEFF HULEN

Date OCTOBER 24-26, 1991
(ABSTRACTED BY JBH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by: DAN HAYBA, JEFF HULEN
FRAN GAY, RANDY STRELIFERT
DAN LARSEN
Date 10/29/91

(ABSTRACTED BY JSH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by FRANK GAY
DAN HAYBA
RANDY STRELIFERT
Date 10/29/91 - 10/30/91
(ABSTRACTED BY JEH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

Logged by DAN LARSEN, FRAN GAY

(ABSTRACTED BY JCH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by JEFF HULEN
DAN LARSEN
DAN HAYBA
FRAN GAY
Date NOV. 2-4, 1991
(ABSTRACTED BY JSH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by FRANK GUY
DAN HAYBA
JEFF HULEN

Date NOV. 4, 1991

(ABSTRACTED BY JBH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by JAN HAYEN
JEFF HULEN
FRAN GAY
Date NOVEMBER 4-5, 1991
(RESTRICTED BY JSM)

RUN NO. (BOX NO.) LOGGERS CHANGE	DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
		GRAIN SIZE RANGE	ALTERATION INTENSITY	CARBONATE CEMENT	ORGANIC CONTENT	Vein & Vug Filling	VEIN MINERALS	CALCITE	TITANITE	PISS	PYRITE	SECONDARY STRUCTURE	
64 (61, 62)	700'												TO 700.9': SANDSTONE & BEDDED TUFF
65 (61, 62)	710'												700.9 - 703.9': PEBBLY TUFFACEOUS SS; ABUNDANT AUTOCLASTS
66 (61, 62)	720'												703.9 - 708.8': SS & REWORKED TUFF
67 (61, 62)	730'												708.8 - 718.1': REWORKED, SILTY-SANDY FINE-ASH TUFF, SPARSELY SCATTERED PEBBLE-SIZE PUMICE THROUGHOUT
68 (61, 62)	740'												718.1 - 731.9': INTERSTRATIFIED, LAMINA- TED TO THIN-BEDDED, GEN. VF-F GR SILTY SS & REWORKED, SILTY-SANDY TUFF, AS ABOVE
69 (61, 62)	750'												731.9 - 747.1': INTERSTRATIFIED, LAMI- NATED TO THINLY INTERBEDDED TUF- FACEOUS VF-F G SS & PALE ORANGE TO CREAM-COLORED CALCIUM CAR- BONATE
70 (66, 67)	760'												747.1 - 752.8': INTERBEDDED COARSE PEBBLY SS TO SANDY CGL. & REWORKED TUFF
71 (67, 68)	770'												752.8 - 760.1': SAME AS 731.9 - 747.1'
72 (68, 69)	780'												760.1 - 763': SAME AS 747.1 - 752.8'
73 (69, 70)	790'												763 - 781.5': SAME AS 718.1 - 731.9': EXCEPT SCATTERED LAMINAE & THIN BEDS OF CALCIUM CARBONATE
74 (70, 71)	800'												781.5 - 784.7': SAME AS 747.1 - 752.8'
													784.7 - 790.1': SAME AS 731.9 - 747.1'
													790.1 - 794.4': SAME AS 718.1 - 731.9'
													794.4 - 796.9': SAME AS 731.9 - 747.1'
													796.9 - 894.2': SAME AS 718.1 - 731.9'

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by: JEFF HULLEN
DAN HAYBA
FRAN GAY

Date: NOVEMBER 5, 1991
(ABSTRACTED BY JSH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by FRAN GAY PHIL BETHKE JEFF HOLEN
Date NOVEMBER 5-6, 1991

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

JEFF HULEN
FRAN GAY
Logged by PHIL BETHKE
WAYNE CAMPBELL
Date NOVEMBER 6, 1991
(ABSTRACTED BY JEB)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

FRAN GAY
WAYNE CAMPBELL

Date NOVEMBER 6, 1991
(ABSTRACTED BY JEH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by: JEFF HULEN
PHIL BETHKE
FRAN GAY
WAYNE CAMPBELL
Date: NOVEMBER 6-7, 1992
(ABSTRACTED BY JSH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by RANDY STREUFERT
WAYNE CAMPBELL

Date NOVEMBER 7, 1991
(ABSTRACTED BY JBH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by DAN O'HAYES
JEFF HULEN
WAYNE CAMPBELL
RANDY STRELFERT
Date NOVEMBER 7 & 8, 1991
(ABSTRACTED BY JSH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by JEFF HULEN
DAN HAYBA
ZANDY STRELFERT

Date NOVEMBER 8, 1992
(ABSTRACTED BY JPH)

RUN NO. (BOX NO.) LOGGING CHANGE	DEPTH	GRAPHIC LOGS												Lithology	NOTES & DESCRIPTIONS
		GRAIN SIZE RANGE	ALTERATION INTENSITY	ALU. TYPE	SILICIFICATION	CARBONATE CEMENT	ORGANIC CONTENT	Veining & Vug Filling	VEIN MIN. FILL	PRITE	DISS. PYRITE	DEFORMED STRUCTURES			
		SILT SAND GRAVEL PEBBLE Boulder	WMS	ARGILLIC	SILICIFICATION	CARBONATE CEMENT	ORGANIC CONTENT	WMS	WMS	CALCITE	VEIN MIN. FILL	PRITE	DISS. PYRITE	DEFORMED STRUCTURES	
	1500'														TO 1555.4': GENERALLY LAMINATED TO THIN-BEDDED, INTERSTRATIFIED REWORKED SILTY-SANDY FINE-ASH TUFF AND TUFFACEOUS, EPICLASTIC, SILTY, GEN. VF-F GR. SANDSTONE
	1510'														
	1520'														
	1530'														• ANALYSE ? VULTS. 1529.4-1531
	1540'														BEDS DIP 3°
	1550'														BEDS DIP 2°
	1560'														▲ 1555.4-1558.6' INTERLAMINATED SS & CALCIUM CARBONATE
	1570'														▲ 1558.6-1564.7': INTERBEDDED, MATRIX-SUPPORTED CGL. (DEBRIS FLOW?), SS & TR. CALCIUM CARBONATE.
	1580'														▲ 1564.7-1570.6': REWORKED, SILTY TO SANDY FINE-ASH FALLOUT TUFF
	1590'														▲ 1570.6-1580.5: INTERBEDDED MED-CRS.-GR. SS, SANDY PEBBLE CGL. & ALTERED FINE-ASH & PUMICE-BEARING REWORKED TUFF BEDS; PROMINENT SCOUR & FILL.
	1600'														▲ 1580.5-1584': HIGHLY TUFFACEOUS, EPICLASTIC PEBBLY SANDSTONE.
															▲ 1584-1587.6': FINE-ASH TUFF BEDS SEP. BY A PEBBLY SS. BED
															▲ 1587.6-1602.2': INTERBEDDED TUFFACEOUS PEBBLY SS, FINE-ASH TUFF; PROM. LOW- X X-BEDDING, LOCAL SCOUR & FILL.

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by WAYNE CAMPBELL
RANDY STRELFERT
PAUL HAYDA
JEFF HOLEN

Date NOVEMBER 6-9, 1991
(ABSTRACTED BY JPH)

RUL. NO. (BOX NO.) # LOCATIONS CHINING	DEPTH	GRAPHIC LOGS												Lithology	NOTES & DESCRIPTIONS
		GRAIN SIZE RANGE	ALTERATION INTENSITY	ALTERATION TYPE	SILICIFICATION WMS	CARBONATE CEMENT WMS	ORGANIC CONTENT WMS	Veining & Vug Filling WMS	VEIN MINES	DISSEMINA- TED PYRITE	SEDIMENTARY STRUCTURE				
159 (158, 159)	1600'														1602-1606.6': TUFFACEOUS, SILTY, VFG 95 SEQUENCE, LAM.-THIN-BEDDED, MUCH PENETRANT, FALL- TING, "FLOATING" PLUMULE; IN PART POSSIBLY OF PYRO- CLASTIC SURGE ORIGIN.
	1610'														1606.6-1608.5': POLYMYCTIC, MATRIX- TO CLAST-SUPPORTED BR; TUFFACEOUS MATRIX, ABUND. WEL- DED TUFF CLASTS
160 (159, 160)	1620'														1608.5-1637.9': MONOMICTIC BRECCIA: SAND- TO COBBLE-SIZED ANGULAR CLASTS OF FLINTY, DENSELY WELDED, FLUIDAL-APPEARING ASH-FLOW TUFF IN A SILICIFIED ROCK-FLOUR MATRIX; CLASTS APPARENTLY > 95% DENSELY WELDED, GRANOPHYRICALLY XLZD. TERT. WILLOW CK. MEMBER OF THE CARPENTER RIDGE TUFF; IDENTICAL IN APPEARANCE TO THE BRECCIA ENCOUNTERED BETW. 1204.4-1241.9 FT. IN DRILLHOLE CCM-1: IN THIS HOLE (CCM-2) THE ROCK IS QUITE VUGGY - VUGS ARE LINED W/FINE-XLN. PYRITE.
161 (159)	1630'														1637.9-1648.9': TUFFACEOUS, MATRIX- SUPPORTED BRECCIA, POLYMYCT, W/ABUND. PLUMULE; EITHER NON-WEL- DED LITHIC-RICH ASH-FLOW TUFF OR A DEBRIS- FLOW BRECCIA W/ SIMILAR COMPOSITION & TEXTURE.
162 (160)	1640'														1648.9-1671': TUFFACEOUS, MATRIX- SUPPORTED CONGLOMERATE, SIMI- LAR TO ABOVE, BUT CLASTS DISTINC- TLY MORE ROUNDED; ALSO INTER- MITTENT SAND STRINGERS; REMINI- SCENT OF AN ALLUVIAL FAN SE- QUENCE.
163 (160)	1650'														
164 (161)	1660'														
165 (162)	1670'														1671-1681.4': INTERBEDDED, SILTY TO SANDY, CLAST- TO MATRIX-SUPPOR- TED CONGLOMERATE & FINE- TO COARSE-GRAINED PEBBLY SAND- STONE; DEFINITE BEDDING.
166 (163)	1680'														1681.4-1795.5': MONOMICT BRECCIA, SAME AS 1608.3-1637.9' EXCEPT AS NOTED BELOW.
167 (164)	1690'														PROBABLE WARM (67.5°F + 5-10°F?) AQUIFER
168 (165)	1700'														* 1697-1700.6': AT LEAST 7-10% ANGULAR VUG POROSITY; VUGS LINED W/F. XLN. PYRITE.

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by: JEFF HULEN
DAN HAYDA
DAN LARSEN
RANDY STRELFERT

Date NOV. 9, 1991

(ABSTRACTED BY 184)

RUN NO. (BOX NO.) # LOGGERS CHANGE	DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
		GRAVEL SIZE RANGE	ALTERATION INTENSITY	ARGILLIC	SILICIFICATION	ORGANIC CONTENT	Veining & Vug Filling	VEIN MINERALS	CLAY	DISSEMINATED MINERALS	SEDIMENTARY STRUCTURES		
1700	169 (167, 166)												TO 1795': MONOMICT BX CONSISTING >95% OF DENSELY WELDED PELTIC ASH-FLOW TUFF (SEE PREVIOUS PAGE FOR DESCRIPTION)
1710	170 (168, 167)												
1720	171 (170, 169)												* 1721.3-1722.2': STRONG GREEN CLAY/CARBONATE ALTERATION
1730	172 (171, 170)												* 1725-1731': GREENISH CLAY LINES MUGS: WIPY
1740	173 (172, 171)												
1750	174 (173, 172)												
1760	175 (174, 173)												
1770	176 (175, 174)												* 1782.1-1786': GREENISH CLAY, AS ABOVE
1780	177 (176, 175)												
1790	178 (177, 176)												← DRILLING INDUCED?
1800	179 (178, 177)												← IN PART POSSIBLY DRILLING INDUCED 1795-1805.6': MATRIX-SUPPORTED, TUFFACEOUS BX & CGL.

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by DAN LARSEN
RANDY STRELFERT

Date NOV 9, 1991

(ABSTRACTED BY 184)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by JEFF HULEN
DAN LARSEN
ANDY HOPKINS
RANDY STREUFERT
Date 11/10/91
(ABSTRACTED BY JBH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by RANDY STRELIFERT
JEFF HULEN
DAN HAYBA
ANDY HOPKINS
Date NOVEMBER 10, 11, 1991
(ABSTRACTED BY JBH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by: JEFF HULEN
ANDY HOPKINS
DAN LARSEN
RANDY STRELFERT
Date NOVEMBER 11, 1991
(ABSTRACTED BY JSH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by ZAN LARSEN & WAYNE CAMPBELL

Date NOVEMBER 12, 1991
(ABSTRACTED BY JPH)

DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
	GRAIN SIZE RANGE	ALTERATION INTENSITY	AL. INT. %	WMS	WMS	WMS	WMS	WMS	WMS	WMS		
	SAND GRAVEL COBBLES Boulders	WMS	WMS	WMS	WMS	WMS	WMS	WMS	WMS	WMS		
2200'												TO 2223': FELSIC, BIOTITE & CLINOPYROX- ENE-BEARING, MODERATELY TO DENSE- LY WELDED ASH-FLOW TUFF; SNOW- SHOE MTN. IGNIMBRITE; CALCITE-PY- RITE VEINLETS COMMON & INCREASINGLY ABUNDANT BELOW 2250': BLADED CALCITE LOCALLY PRESENT.
2210'												
2220'												
2230'												
2240'												
2250'												* 2246.8-2247.6' IN VEINLETS: BOTRYOIDAL CARBONATE w/ COATINGS OF SUGARY-TEXTURED GRAYISH-GREEN MINERAL: ALSO SOME PLATY CALCITE XLS. UP TO 2X3 CM.
2260'												
2270'												* ALSO QTZ IN VENTS 2270.3-2270.5'
2280'												CALCITE + PYRITE VEINING INCREASES
2290'												* MESOPRECCIA 2276.5-2277'
2300'												

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by DAN LARSEN
RANDY STRELFERT
WAYNE CAMPBELL
ANDY HOPKINS

Date NOVEMBER 12, 1991

(ABSTRACTED BY JSH)

CORE RUN NO. (BOX NO.)	DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
		GRAIN SIZE RANGE	ALTERATION INTENSITY	ACT. TYPE	WMS	WMS	Vein & Vug Filling	VEIN MINERALS	VEIN MINERALS	SEDIMENTARY STRUCTURES			
2300	2300'												<p>TO 2323': SNOWSHOE MTN. IGNEIMBRITE, AS ABOVE; CONTINUED CALCITE-PYRITE VEINING, INTENSE BELOW 2310'</p> <p>* 2305.7' & 2314-2320': PYRITE STALACTITES IN VEINLETS - THE STALACTITES PRE-DATE BLADED CALCITE. @ 2305.7', THE STALACTITES SHOW THIS TEXTURE:</p> <p>BLADED CALCITE CRYSTALS</p>
2310	2310'												
2320	2320'												
2323	2323'												
(TOTAL DEPTH)													

CREEDE CALDERA
MOAT DRILL HOLE NO. 2

SUMMARY
CORE LOG

Logged by WAYNE CAMPBELL & ANDY HOPKINS
Date NOVEMBER 13, 1991
(ABSTRACTED BY JPH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

Logged by: DAN HAYBL, JEFF HULEN, PHIL BETHKE, DAN LARSEN
Date: 10/8/91 (ABSTRACTED BY JEH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

JEFF HULEN PHIL BETHKE
DAN HAYBA
DAN LARSEN
Logged by _____
Date 10/8 & 10/9/91
(ABSTRACTED BY JAH)

DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
	GRAIN SIZE RANGE	ALT. INTENSITY	ALT. INTENSITY	ALT. INTENSITY	ALT. INTENSITY	ALT. INTENSITY	ALT. INTENSITY	ALT. INTENSITY	ALT. INTENSITY	ALT. INTENSITY		
200'												201-213.8': Alternating intervals of lam to thin-bdd, silty vt-fg ss & same except w/ up to 15% (vol.) interstratified finely laminated, commonly crenulated calcium carbonate lamellae
210'												213.8-237.4': Interstratified, laminated to thin-bedded silty fg to vtfg ss; ss is immature, w/abund. detrital bte, probable plinice, volc. lithic sand grains; prominent load casts, flame structures, normally graded bedding & convolute bedding (origin as turbidites probable)
220'												• 235.35': probable 1 cm thick fallout tuff • possible burrow at 225.5'
230'												237.4-239.9': same as 191.5-201'
240'												239.9-241.2': same as 213.8-237.4 w/ a few thin calcium carb. interbeds
250'												241.2-246.4': same as 191.5-201' but highly convoluted and w/ carbonate laminae disrupted to form platy subclasts
260'												246.4-248.5': fine-gr ss, thin-bdd
270'												248.5-252.7': same as 191.5-201'
280'												252.7-284.8': silty to sandy matrix-supported conglomerate to breccia; probable debris-flow origin; angular to subrounded clasts of dominantly porphyritic volcanic rock embedded in an immature silty to sandy matrix rich in detrital biotite; scattered sltst. & ss. rip-up clasts; matrix is probably tuffaceous; scattered thin beds of massive to lam. or thin-bdd ss.
290'												• 276.6-277.5': massive crs-gr sandstone
300'												284.8-287.3': interstrat. lam.-thin-bdd. silty fg to vtfg. ss, same as 213.8-237.4'
												287.3-291.3': same as 191.5-201'
												291.3-296.45': same as 213.8-237.4'
												296.45-299': massive, normally graded pebbly crs-gr to f.gr. ss. (immature)

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

Logged by DAN LARSEN, RANDY STRELFERT, NORA FOLEY, DAN HAYBA, JEFF HULEN

Date 10/9-10/19/91

(ABSTRACTED BY JSH)

DEPTH	GRAPHIC LOGS											NOTES & DESCRIPTIONS
	GRAIN SIZE RANGE	ALUMINUM INTENSITY	GRANULARITY	CARBONATE CONTENT	ORGANIC CONTENT	Veinings & Vug Filling	VEIN MINERALS	CHLORITE	DISS. PYRITE	SEDIMENTARY STRUCTURES	Lithology	
300'												299-324': Sandstone, lt.-med. gray, silty, vfg to crs. gr., interbedded to finely interbedded; common thin graded beds; common load & flame structures; ss is immature, w/ abundant, app. little weathered bte., sand-size volc. lithic & pumice clasts
310'												
320'												
330'												324-329.4': Sandstone, immature, conspicuously graded. 329.4-331.7: ss, same as 299-324'
340'												331.7-342': Silty to sandy reworked fallout tuff, lt.-med. greenish-gray; convoluted but vague bedding; apparently altered but probably diagenetically; NOTE DISS. PYRITE
350'												242-336.5's Sandstone, laminated to thin-bedded, immature, same as 299-324' w/ common graded bedding, load structures, flame structures, & scattered convolute-stratified horizons (probably deposited from turbidity currents; note scattered calcareous concretions,
360'												
370'												→ APPEARS TO BECOME MORE TUFFACEOUS W/ DEPTH
380'												• 374.9-376.0': massive, normally graded, crs-fine gr. immature sandstone.
390'												336.5-455.6': INTERSTRATIFIED SILTY VFG-FG SANDSTONE & SUBORDINATE SILTY TO SANDY REWORKED TUFF; LAMINATED TO THIN-BEDDED OVERALL; COMMON FINE-SCALE NORMAL GRADED BEDDING, CONVOLUTE STRATIFICATION, INJECTION STRUCTURES, FLAME STRUCTURES, RIP-UP CLASTS.
400'												

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

Logged by JEFF HULEN, DON HAYBA,
DAN LARSEN, RANDY
STREUFERT, NORA FOLEY
Date 10/13/91 (ABSTRACTED BY JFH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

Logged by DAN HAYBA, JEFF HULEN,
NORA FOLEY, RANDY STRELFERT
Date 10/13-10/14/91
(ABSTRACTED BY JBH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

JEFF HULEN
DAN HAYDA
Logged by RANDY STRELFERT
DAN LARSEN
Date 10/13-10/14/91
ABSTRACTED BY JEFF HULEN

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

RANDY STRELFERT
DAN LARSEN
Logged by JEFF HULEN
DAN HAYBA
Date 10/14-10/15/91
(ABSTRACTED BY J. HULEN)

DEPTH	GRAPHIC LOGS										NOTES & DESCRIPTIONS
	GRAIN SIZE RANGE	GRAIN SHAPE	GRAIN SURFACE	GRAIN BOUNDARY	ALTRATION INTENSITY	LABORATE CEMENT	Fracturing	Veining & Vug Filling	VEN MINERALS	DISSOL. PORE	
700'											... to 742.7': See previous page
710'											
720'											
730'											
740'											
750'											742.7-750.4': Silty, massive, light gray-green, reworked fallout tuff (fine ask)
760'											
770'											750.4-820.7': Interstratified, laminated to thin-bedded, silty vf9 to fg sandstone w/ subordinate interbeds/interlaminations of buff to v. lt. gray silty reworked fallout tuff (fine ask); common fine-scale graded bedding—bases of some of these are pebbly coarse sand; common load, flame, and injection structures & rip-up clasts; a very monotonous sequence.
780'											
790'											
800'											

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

DAN LARSEN
RANDY STREUFERT
Logged by DAN HAYBA
JEFF HULEN
Date 10/15/91
(ABSTRACTED BY J. HULEN)

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

JEFF HULEN
DAN HAYBA
DAN LARSEN
Logged by RANDY STRELFERT
Date 10/15-10/16/91
(ABSTRACTED)
BY JBH

DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
	GRAIN SIZE RANGE SAND GRAVEL PEBBLES COBBLES Boulders	ALTERATION INTENSITY WMS	ALTN. SILICIFICATION CLAYIFICATION CHALKIFICATION	LAGGERS CEMENT	ORGANIC CONTENT WMS	Veining & Vug Filling WMS	VEIN MINERALS CALCITE	Pyrite	SEDIMENTARY STRUCTURES			
900											TO 978.3: SEE PREVIOUS PAGE	
910												
920												
930												
940												
950												
960												
970												
980											978.3-999.4: INTERBEDDED FINE TO CRS-GR. PEBBLY SS, SILTY TO SANDY CGL, & SILTY TO SANDY REWORKED FALLOUT TUFF.	
990												
1000											999.4-1002.9: REWORKED FALLOUT TUFF	

CREEDE CALDERA
MOAT DRILL HOLE NO. —

SUMMARY
CORE LOG
(FIELD SHEET)

Logged by: RANDY STREUFERT
DAN LARSEN
JEFF HULEN
WAYNE CAMPBELL
Date 10/10-17/91 (ABSTRACTED BY JBH)

DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
	GRAIN SIZE RANGE WMS GRAINULE PEBBLE COBBLE	ALTERATION WMS	CLASTIC SIGNIFICATION WMS	CARBONATE CEMENT WMS	ORGANIC CONTENT WMS	Veining & Vug Filling WMS	VEIN MINERAL WMS	DISSEMINATED PIRATE WMS	SEDIMENTARY STRUCTURES WMS			
1000'												1002.9-1022.1': INTERBEDDED COARSE PEBBLY SS, SILTY TO SANDY CONGLOMERATE, & SILTY TO SANDY REWORKED FALLOUT TUFF; NOTE PROMINENT SCOUR-AND-FILL TEXTURES; ROCK HAS THE APPEARANCE OF A FLUVIAL SEQUENCE
1010'												
1020'												1022.1-1026.1': SILTY, M.G., MOSTLY MASSIVE SANDSTONE.
1030'												
1040'												1026.1-1047.8': SAME AS 1002.9-1022.1'; SCOUR AND FILL STRUCTURES EVEN MORE PREVALENT; ALSO LOW-ANGLE X-BEDDING.
1050'												
1060'												1047.8-1050': FAULT ZONE; GOUGE & BK W/ CARBONATE & CHLORITE FILLING BETWEEN CLASTS.
1070'												
1080'												1050-1060': SAME AS 1002.9-1022.1'
1090'												
1100'												* 1070.2-1082.3': "RUBBLIZED" ZONE W/ 2 CM WIDE CALCITE VEIN SUB-// TO CORE AXIS.
												1060-1066.8': INTERBEDDED SILTY TO SANDY PEBBLE CGL'S./BX'S. & FINE-CRS GR PEBBLY SANDSTONES.
												1066.8-1070.8': SILTY TO SANDY, MATRIX-SUPPORTED PEBBLE TO COBBLE CONGLOMERATE.
												1070.8-1125.8': SAME AS 1060-1066.8'
												* NOTE ABUNDANT SCOUR & FILL STRUCTURES

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

Logged by: DAN LARSEN
RANDY STREUFERT
DAN HAYDA
JEFF HULEN
WAYNE CAMPBELL
Date 10/17/91 (ABSTRACTED BY JEH)

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

Wayne Campbell
Logged by DAN LARSEN
JEFF HULEN
Date 10/17-10/18/91
(ABSTRACTED BY JEL)

DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
	GRAIN SIZE RANGE	ALTERATION INTENSITY	AL. INT.	AL. EXT.	AL. TYPE	VEIN FILLING	VEIN MATRIX	CHLORITE	DIAGEN. PYRITE			
1200'												... TO 1202.2': SEE PREVIOUS PAGE.
1200'												1202.2-1204.4': MASSIVE, CRS-GR. IMMATURE SS; SHARP BUT IRREGULAR CONTACT W/ UNDERLYING BX
1210'												1204.4-1241.9': BRECCIA, MONOMICTIC, INTENSELY ALTERED; ANGULAR CLASTS RANGING FR. SAND TO COBBLE SIZE EMBEDDED IN A SILICIFIED, SILT- TO POSSIBLY CLAY-SIZED MATRIX; CLASTS ARE >99% DENSELY WELDED, TERTIARY WILLOW CK. ASH-FLOW TUFF; FLUIDAL, EUTAXITIC FOLIATION IN THESE CONSPICUOUSLY ROTATED; CLASTS APPEAR SILICIFIED, F-XLN, BUT ALSO CONTAIN PINKISH K-SPAR; MATRIX V. SILICIFIED; MINOR CHLORITE & CELADONITE IN CLASTS & MATRIX; BX VARIES DOWNHOLE FROM CLAST- TO MATRIX-SUPPORTED; ANGULAR VUGS IN MATRIX (UP TO 6 MM. DIA. & 5 VOL. % OF ROCK) COMMONLY CONTAIN PURE WHITE KAOLIN
1220'												AMONG POSSIBLE ORIGINS: (1) HYDROTHERMAL BX; (2) CALDERA-COLLAPSE BX W/ SILICIFIED MATRIX OF ROCK-FLOUR & ASH; (3) A LARGE (MEGA-) CLAST WITHIN A CALDERA-COLLAPSE BRECCIA (P.L.)
1230'												1241.9-1245.7': LITHIC-RICH, NON-WELDED ASH-FLOW TUFF; DISTINCTIVE MED. BROWNISH-ORANGE COLOR, CONSPICUOUS PUMICE
1240'												1245.7-1247.6': CLAST-SUPPORTED PEBBLE- TO COBBLE BX, TUFFACEOUS, ORIGIN UNKNOWN- APPEARS TO INTRUDE OVER- & UNDERLYING ASH-FLOW TUFF
1250'												1247.6-1250.9': SAME AS 1241.9-1245.7'
1250'												1250.9-1254.1': TUFFACEOUS, UNSORTED MATRIX-SUPPORTED BRECCIA; CLASTS ANGULAR TO SUBROUNDED, DOMINANTLY DENSELY WELDED ASH-FLOW TUFF W/ SUBORDINATE PORPHYRIC FLOW (?) ROCK
1260'												1254.1-1256.8': MONOMICTIC BX ESSENTIALLY SAME AS 1254.1-1241.9', EXC. SMALLER CLASTS, MORE NON-WILLOW CREEK TUFF CLASTS.
1260'												1256.8-1263': SAME AS 1250.9-1254.1'
1270'												1263-1268.2': SIMILAR TO 1254.1-1256.8', EXC. MORE CLASTS OF PYRIC FLOW (?) ROCK, MORE CELADONITE/CHLORITE.
1280'												1268.2-1293.3': TUFFACEOUS MATRIX-SUPPORTED BRECCIA W/ PEBBLES & COBBLES OF PRINCIPALLY THE WILLOW CREEK MEMBER OF THE CARPENTER RIDGE TUFF. (DENSELY WELDED, W/ FLUIDAL-APPEARING EUTAXITIC FOLIATION. ROCK COULD BE A TUFFACEOUS DEBRIS FLOW OR A NEAR-VENT, LITHIC-RICH, NON-WELDED ASH-FLOW TUFF
1290'												
1300'												1293.3-1303.2': SILICIFIED MONOMICTIC BRECCIA, SAME AS (APPARENTLY) 1204.4-1241.9', EXC. LOCALLY CRUSHED & SHEARED.

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

Logged by: DAN LARSEN
WAYNE CAMPBELL
JEFF HULEN
Date: 10/18-10/19/91
(ABSTRACTED BY JBH)

DEPTH	GRAPHIC LOGS										Lithology	NOTES & DESCRIPTIONS
	GRAIN SIZE RANGE SAND GRAVEL PEBBLE COBBLE	ALTERATION INTENSITY WMS	VEINING & VUG FILLING WMS	VEIN MINERALS CALCITE SODIUM CHLORIDE	DISSEMINATED MINERALS							
1300'												... TO 1303.2': SEE PREVIOUS PAGE
												1303.2-1305.3: SAME AS 1268.2-1293.3'
												1305.3-1307.5: ASH-FLOW TUFF; ABUNDANT PLUMICE; POSSIBLY A LARGE CLAST.
1310'												1307.5-1325.5': TUFFACEOUS, MATRIX-SUPPORTED BRECCIA, SAME AS 1268.2-1293.3'
1320'												
												1325.5-1327.5': ASH-FLOW TUFF (CLAST?), SAME AS 1305.3-1307.5' EXC. MORE LITHICS.
1330'												1327.5-1371.5' (TD): TUFFACEOUS, MATRIX-SUPPORTED BRECCIA, W/ PEBBLE, COBBLE, & RARE BOULDER-SIZE ANGULAR TO SUBROUNDED CLASTS EMBEDDED IN A HIGHLY TUFFACEOUS MATRIX; MOST CLASTS APPEAR TO BE WELDED TUFFS OF THE WILLOW CK. MEMBER OF THE CARPENTER RIDGE TUFF, THE CAMPBELL MTN. MEMBER, THE WAGON PARK TUFF (?), & THE MAMMOTH MTN. TUFF, & SOME PORPHYRITIC FELSIC- TO INTERMEDIATE-COMPOSITION FLOW ROCKS.
1340'												* BELOW ~ 1342', PLUMICE BECOMES MUCH MORE ABUNDANT & CONSPICUOUS.
1350'												
1360'												(JSH) * STRONGLY SUSPECT THIS ROCK IS A LITHIC-RICH, NON-WELDED ASH-FLOW TUFF, BUT IT COULD BE A TEXTURALLY SIMILAR DEBRIS-FLOW DEPOSIT.
1370'												
1371.5' (TOTAL DEPTH)												

CREEDE CALDERA
MOAT DRILL HOLE NO. 1

SUMMARY
CORE LOG
(FIELD SHEET)

Wayne Campbell
Dan Larsen
Logged by JEFF HULEN
Date 10/19/91
(ABSTRACTED BY JSH)

END

**DATE
FILMED**

3 / 25 / 93