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DATE: August 29, 1988
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TO: DISTRIBUTION JNG TBH
FROM: Jamie N. Gardner and Jeffrey B. Hulen
SUBJECT: VC-2B UPDATE 13

VC-2B was spudded in late on 19 July 1988. We are using a Universal 5000 drill rig, which is among the largest and beefiest diamond drills available. It has been extremely wet in the mountains of north central New Mexico, but things are going well and we are making steady progress. In this letter, we will outline the progress of VC-2B to date and use the opportunity to update some other topics.

By 24 July 1988, PQ-size core (3.345 inches with CHD 134 rods) had been taken to 173 feet, the hole had been reamed to about 16.5 inches, and 10.75-inch casing had been cemented to 168 feet with complete returns to the surface. In early August, PQ-size core had been taken to 708 feet, the hole reamed, and 6 by 6-5/8-inch casing cemented to 690 feet with cement returns to the surface. Temperature, caliper, and televiewer logs were run in the open hole between 170 and 700 feet prior to installation of the casing. As of this date, VC-2B has penetrated to a depth below 2000 feet with the CHD 134 string and we are in the process of cementing the drill rods in as casing. After a planned break of about one week, during which time no Daily Activity Reports will be issued, we will step down to CHD 101 rods (HQ-size core, 2.50 inches in diameter). If all continues to go well, we may complete the hole to total depth with the CHD 101 string.

VC-2B is already providing a wealth of new information about the Valles caldera, its intracaldera stratigraphy and structure, and its hydrothermally altered and mineralized rocks. Much of the information we have collected is abstracted on Figure 1, a summary log of the corehole to date.

VC-2B was collared on an ancient landslide, and from the surface to a depth of 113 feet the corehole encountered coarse, unsorted, landslide debris. This deposit contained large boulders of various rock types, including one 2-meter block of unaltered limestone. Beneath the landslide, semi-consolidated, soft-sediment-deformed, epiclastic sandstone prevails to a depth of 152.5 feet. The sandstone is apparently intruded by porphyritic rhyolite and hydrothermal breccia, rock types which are intimately intermingled to a depth of 183 feet. Between that depth and 551.6 feet, the rocks are dominated by coarse, clay-rich breccias of possible debris-flow origin. These deposits are rich in red, hematitic siliciclastic rocks almost certainly derived from the Permian Abo Formation. The post-Bandelier-age Upper Tuffs (<1.12 Ma), penetrated in companion corehole VC-2A, are apparently absent at the VC-2B site. Beneath the high-level debris-flow deposits, VC-2B bored through what we believe to be the Tshirege Member of the Bandelier

Tuff to a depth of 1201.3 feet. The Tshirege in VC-2B comprises weakly to densely welded, crystal-rich rhyolite ash-flow tuff, locally highly enriched in lithic fragments. Between 1052.7 feet and 1134.2 feet, the Tshirege contains >75% lithic clasts, and these are surprisingly almost all Abo Formation sandstones, siltstones, and shales. We suspect these lithic-rich tuffs (lag breccias?) indicate proximity to an early Tshirege vent, the walls of which may be flared where it intersects the Abo. The S3 sandstone, a prominent marker horizon between the Tshirege and the underlying Otowi Member (1.45 Ma) of the Bandelier Tuff, was penetrated in VC-2B between depths of 1201.3 feet and 1221 feet. As in VC-2A, the S3 in VC-2B is a soft-sediment-deformed, intraformationally brecciated, apparently well-sorted sandstone. Beneath the S3, VC-2B remained in mostly densely welded, crystal-rich Otowi Member ash-flow tuffs. These dark grey rocks may actually contain some relict glass. Below 1700 feet, the tuffs become moderately welded and more intensely altered.

The VC-2B rocks are variably disrupted by fractures and breccias of both tectonic and hydrothermal origin. The interval 760-970 feet, for example, is cut by numerous fault zones, one of which, at 870 feet, marks the depth of total loss of drilling fluid circulation. These fault zones are highly porous intervals of gouge and breccia; the porosity has been significantly enhanced by dissolution. Voids have been leached to form irregular networks with up to at least 10% porosity. An interval in the Otowi Member, between depths of about 1300 feet and 1560 feet, is widely shattered by hydraulic fractures and cut by numerous hydrothermal breccia dikes and stringers.

The entire rock sequence penetrated by VC-2B is hydrothermally altered, although to varying intensity. The matrix of the near-surface landslide debris is pervasively altered to illite, kaolin, and pyrite, although much of the illite could be pre-landslide in age; clasts in the landslide range from highly altered to very fresh. Sandstones and debris-flow deposits beneath the landslide are widely altered to illite, phengite, calcite, and pyrite, although several Abo-rich intervals appear to be virtually unaltered. The rhyolite-hydrothermal breccia interval between 152.5 feet and 183 feet is kaolinized, sericitized, and silicified; the matrix of the hydrothermal breccia is rock flour intensely altered to quartz, ankerite, calcite, and pyrite in various combinations. The Tshirege and Otowi Member ash flows range from nearly fresh to completely altered. For example, the highly faulted and fractured Tshirege interval between about 760 feet and 970 feet is quite silicified; feldpars have been dissolved and open spaces are lined with small, euhedral, prismatic quartz crystals. The hydraulically fractured and hydrothermally brecciated Otowi between about 1300 feet and 1560 feet is laced with chlorite-sericite-calcite veinlets, even though the host rock remains relatively fresh. By contrast, the Otowi between 1560 feet and 1620 feet appears to be extremely fresh and perhaps partially glassy ignimbrite essentially devoid of secondary phases.

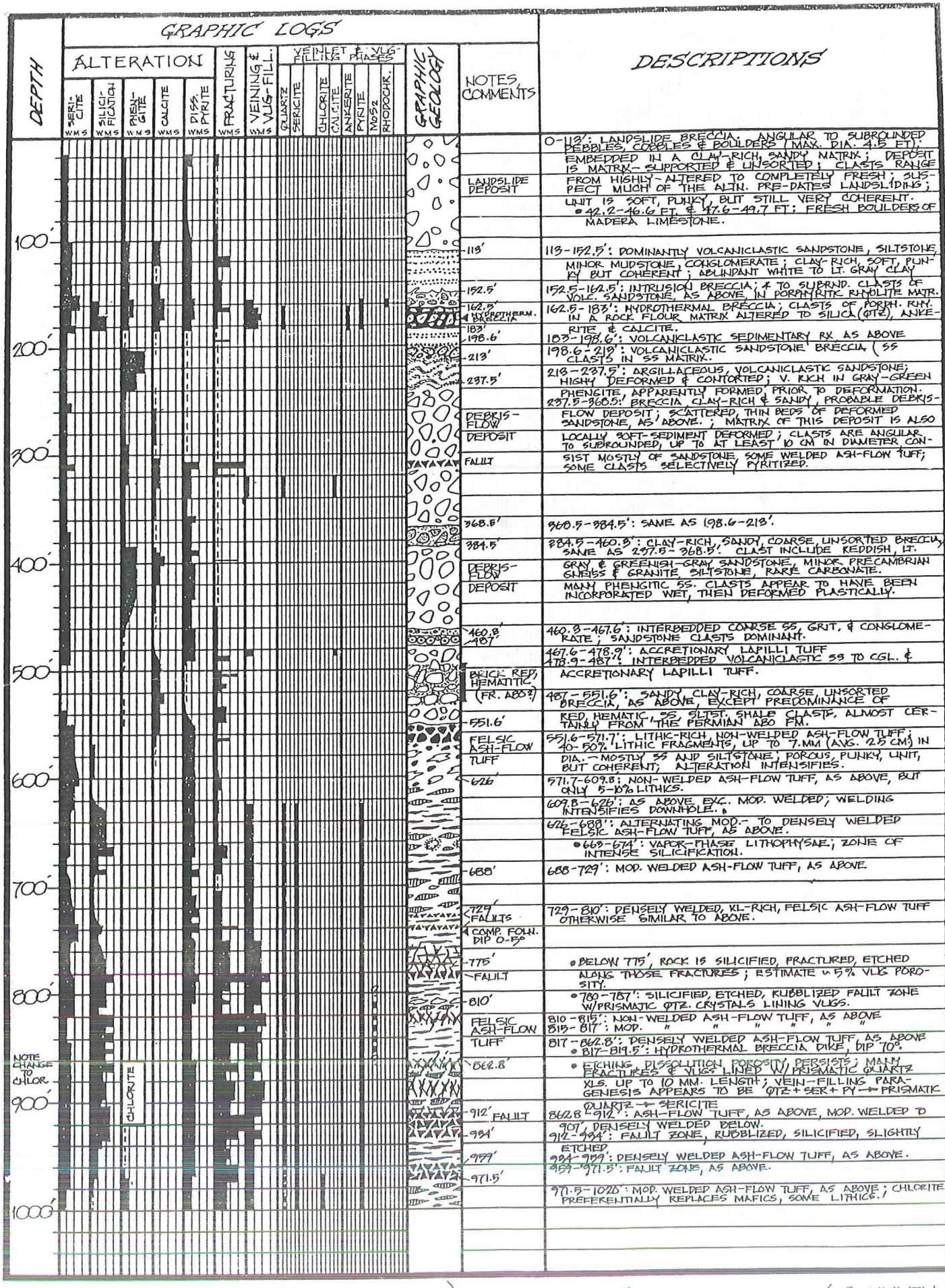
Several secondary metallic minerals, previously unreported from the Valles hydrothermal system, have been discovered in the altered rocks of VC-2B. Traces of a microcrystalline, hairlike sulfide or sulfosalt were

observed in the most highly altered portions of the high-level debris-flow/sandstone interval. We suspect that this mineral may be either stibnite, jamesonite, or boulangerite. At 1152 feet, pyrite crystals on a sericite-coated fracture are accompanied by euhedral ruby silver crystals (insufficient amount for XRD, but SEM analysis shows only silver, antimony, and sulfur). These crystals have a silvery medium gray appearance in low-intensity light, but produce a startling red internal reflection when viewed in strong sunlight. Although silver-bearing pyrites have been reported from other holes in the Valles hydrothermal system, no silver sulfides or sulfosalts have been identified. The occurrence of pyrargyrite (?) in VC-2B strengthens the similarity of the Valles system to Creede-type, epithermal silver-base metal systems.

Thus, with only about one-third of the hole completed, VC-2B is already offering an exciting wealth of research opportunities. We intend to issue at least one more summary, such as this, before completion of coring in late October. If members of the science team wish to visit the drill site while we are still coring, contact us at (505) 829-3952 or leave a message at (505) 667-7590.

JNG/JBH:maj

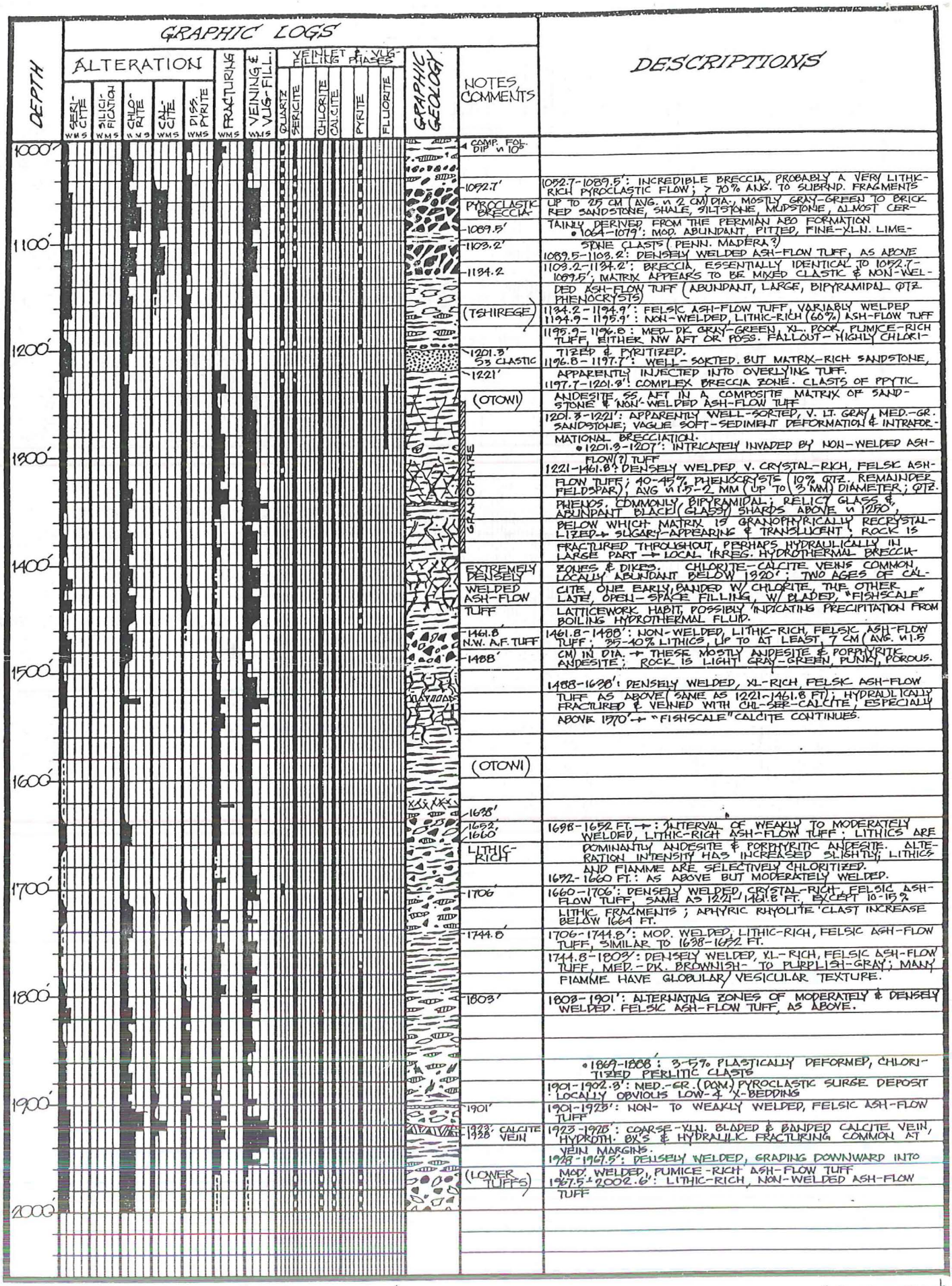
DISTRIBUTION:
See attached lists
CRM-4, MS A150
ESS-1 File



DRILL HOLE VC-2B (SUMMARY LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J. B. HULEN & J. N. GARDNER



DRILL HOLE VC-2B (SUMMARY LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

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GRAPHIC LOGS

DEPTH	ALTERATION: SERICITE WMS	ALTERATION: SILICIFICATION WMS	ALTERATION: CHLORITE WMS	ALTERATION: CALCITE WMS	ALTERATION: DISS. PYRITE WMS	FRACTURING WMS	VEINING & VUG-FILL. WMS	VEIN/FILLET & VUG-PHASES: QUARTZ	VEIN/FILLET & VUG-PHASES: SERICITE	VEIN/FILLET & VUG-PHASES: CHLORITE	VEIN/FILLET & VUG-PHASES: CALCITE	VEIN/FILLET & VUG-PHASES: PYRITE	GRAPHIC GEOLOGY	NOTES, COMMENTS	DESCRIPTIONS
2000'														(LOWER TUFFS)	2002.6' - 2030.5': DISTINCTIVE, MOD. WELDED PUMICE- & XL-POOR ASH-FLOW TUFF; SMALL (3-4 MM.) PUMICES CHLORITIZED SELECTIVELY 2030.5 - 2042.8': WKLY-MOD. WELDED ASH-FLOW TUFF 2042.8 - 2048.3': ZONE OF ABUND. PPYTIC DACITE CLASTS. 2048.3 - WEAKLY- TO NON-WELDED, LITHIC-RICH, FELSIC ASH-FLOW; FIAMME UP TO 4 CM. IN LENGTH; LITHICS MOSTLY ANDESITE, MINOR ASH-FLOW TUFF, RARE SILTSTONE & SANDSTONE.
2100'															

DRILL HOLE VC-2B (SUMMARY LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

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August 26, 1988

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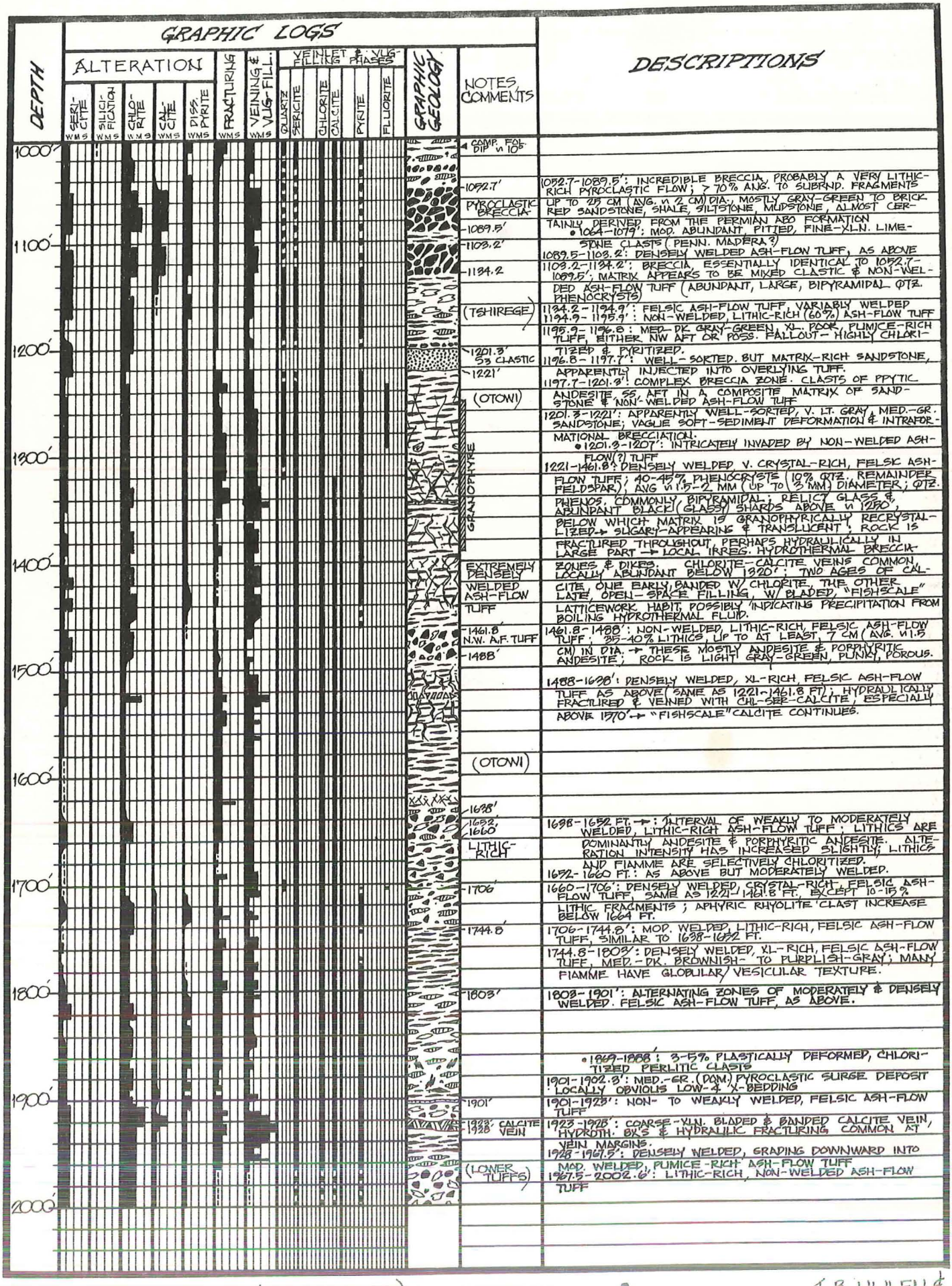
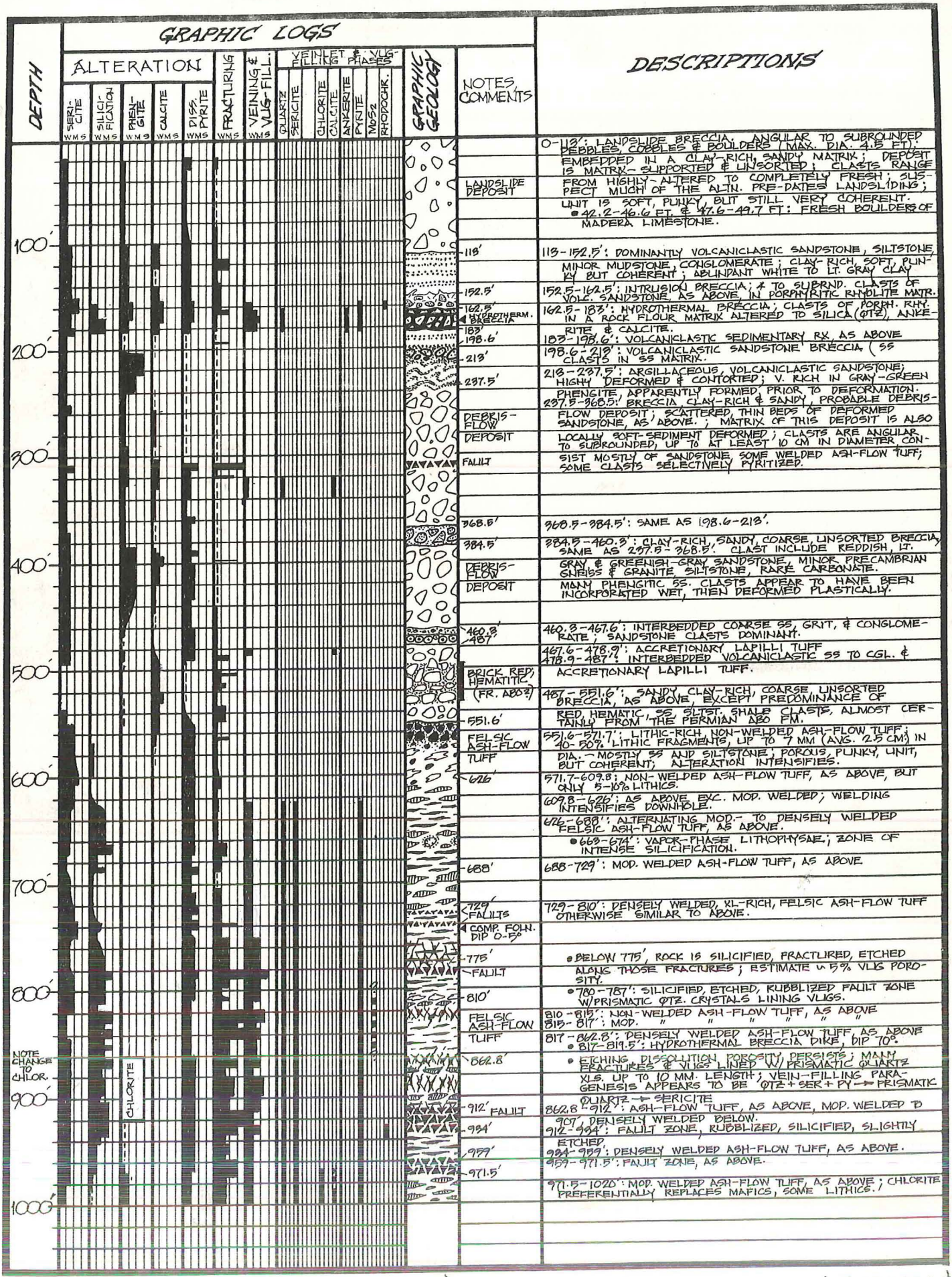


DRILL HOLE VC-2B (SUMMARY LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J. B. HULEN & J. N. GARDNER



DRILL HOLE VC-2B (SUMMARY LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

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January 31, 1989
ESS-1, Geology/Geochemistry
MS D462
(505) 667-1799

TO: DISTRIBUTION
FROM: Jamie N. Gardner and Jeffrey B. Hulen
SUBJECT: VC-2B UPDATE

At 0045 hours on 22 October, 1988, core run number 767 was withdrawn from scientific core hole VC-2b and drilling ceased with official total depth at 5780 feet. Temperature logging continued through November, and our detailed field log of the core was completed in mid-January, 1989. Copies of the completed field log will be distributed to the Science Team in February.

VC-2b passed the nominal bottom hole target of 1.75 km by about 12 meters; moreover, the deep hole objective of 200 meters into granitic rocks was surpassed by about 6 meters. We believe that with the ensuing scientific endeavors, virtually all of the major and diverse objectives of the project will be achieved. So far, the core hole has certainly been a resounding success, and the potential for continued success through the efforts of the Science Team is tremendous. Opportunities for great science abound!

THE CORE HOLE

Sandia National Laboratories' Geoscience Research Drilling Office was in charge of actual drilling operations, and a complete report on the drilling and engineering of VC-2b--progress, problems, solutions, costs, etc.--should be forthcoming from GRDO's Pete Lysne and/or Ron Jacobson. In short, however, VC-2b was continuously cored from surface to total depth with 99.2% overall core recovery. Most of the losses in recovery were in the top 100 feet of the hole in friable landslide debris. From surface to 2090 feet PQ-size core (3.345 inches in diameter) was taken; from 2090 to 5567 feet the core is HQ-size (2.5 inches in diameter); and, from 5567 feet to 5780 feet the core is NQ-size (1.875 inches in diameter). The CHD-101 rods (inner diameter 3.09 inches), with which the HQ core was taken, were cemented with a "tag" at 5567 feet. Below that the completed bore was left as open hole, about 3 inches in diameter, to total depth.

Borehole orientation surveys, run periodically through about 4600 feet, indicate the hole deviates less than one degree from vertical. During drilling, GRDO ran a number of temperature logs as well as televiewer and caliper logs in open hole between roughly 170 and 900 feet. Since completion both GRDO and Los Alamos' Hot Dry Rock group have run a number of temperature logs, monitoring thermal recovery of the hole. Attached is the most recent temperature log that we have obtained (this one by the Los Alamos group in November). Among many interesting things, this log shows maximum down hole temperature was about 295°C in early November.

Because of cost constraints, we will run no other geophysical logs in the future other than temperature. Members of the Science Team are encouraged to run additional logs in VC-2b. VC-2b is on private land, behind locked gates, with locks on the wellhead; this together with the

possibility that the well may flow hot geothermal fluids will require arranging in-hole activities through Jamie Gardner.

THE CORE

The stratigraphic succession penetrated by VC-2b generally fits the regional stratigraphy quite well. There are some oddities and coincidences, however, that render the stratigraphic assignments we use here tentative until further work can be done by the Science Team. A brief stratigraphy is as follows:

Surface to 113 feet: landslide

113 to 571 feet: caldera fill sediments and debris flows, including an apparent subvolcanic intrusive (154 to 182 ft.) intimately associated with a hydrothermal breccia, and accretionary lapilli tuffs

571 to 1200 feet: Tshirege Member of the Bandelier Tuff

1200 to 1221 feet: S-3 sandstone

1221 to 1965 feet: Otowi Member of the Bandelier Tuff

1965 to 2434 feet: lower tuffs of the Bandelier Tuff

2434 to 2619 feet: Santa Fe Group sandstone with interbedded Cochiti Formation

2619 to 4252 feet: Permian red beds and minor limestones: may include Yeso and Abo Formations; contains conglomerates with andesitic cobbles from 3298 to 3338 ft.

4252 to 5113 feet: interbedded Pennsylvanian limestones and siliciclastic rocks

5113 to 5780 feet: Precambrian (?) quartz monzonite

Alteration in VC-2b is extremely variable, but most of the core exhibits moderate chlorite-sericite alteration with phyllic/ argillic alteration to 552 feet and phyllic alteration to 970 feet. The Permian sequence is only lightly altered, but does contain intervals of intense sericitization in some once-permeable sands. Vein minerals are numerous. Some highlights include: prismatic quartz, "fish-scale" calcite, and pyrite nearly throughout the core; probable stibnite in the debris flows of the caldera fill sequence; rhodochrosite around 930 feet; ruby silver (pyrargyrite) around 1152 feet; fluorite from 1237 to 1392 feet; a bismuth telluride (tetradymite ?) around 4757 feet; galena and a yet-unidentified light rare earth element-rich mineral around 4762 feet; chalcopyrite and possible bornite around 4824 feet; beautiful euhedra of epidote below 4820 feet; and many more! Below about 4950 feet the Pennsylvanian rocks apparently exhibit the effects of thermal metamorphism with recrystallization of the limestones and some visible porphyroblastic (?) minerals.

FLUIDS

Fluid sampling and possible flow tests will began in spring 1989. Until that time, given the methods of diamond coring, it is difficult to say much about the hydrothermal system. However, a few preliminary comments are possible. Consistent with results from VC-2a, the active hydrothermal system penetrated by VC-2b has a shallow vapor-rich cap, which, when allowed, would flow mainly CO_2 and H_2S. The vapor cap is apparently stratigraphically separated from an underlying liquid-dominated zone by an interval of densely welded tuff (1500 to 1600 feet). Preliminary information suggests that the liquid zone may consist of at least two largely isolated, stacked systems. Again it appears that the separation of these systems may be stratigraphic with one in the Permian sequence and one within and below the Pennsylvanian section. The drilling of VC-2b was a bit unique in the caldera region, because we maintained drilling fluid returns (usually about 80%) for most of the hole. Attached is a plot that shows the variation of several elements in the drilling fluid returns versus depth. It appears from this plot that at least one deep zone, and possibly more, was yielding chloride-rich geothermal fluids that entered the bore and mixed with the drilling mud. Perhaps the hydrothermal system is not all as "underpressured" as previously believed.

SAMPLES

As you may well imagine, 5780 feet is a lot of core--over 1100 boxes! Consequently, there will be some changes in procedures for obtaining samples from how we in the Valles scientific drilling project have operated in the past. One major departure from past efforts is that the core will be shipped to the Grand Junction core facility almost immediately (by the end of February, 1989). For those of you unable to go to Grand Junction and sample in person, the Curator of the facility will handle your requests. These requests should be sent to:

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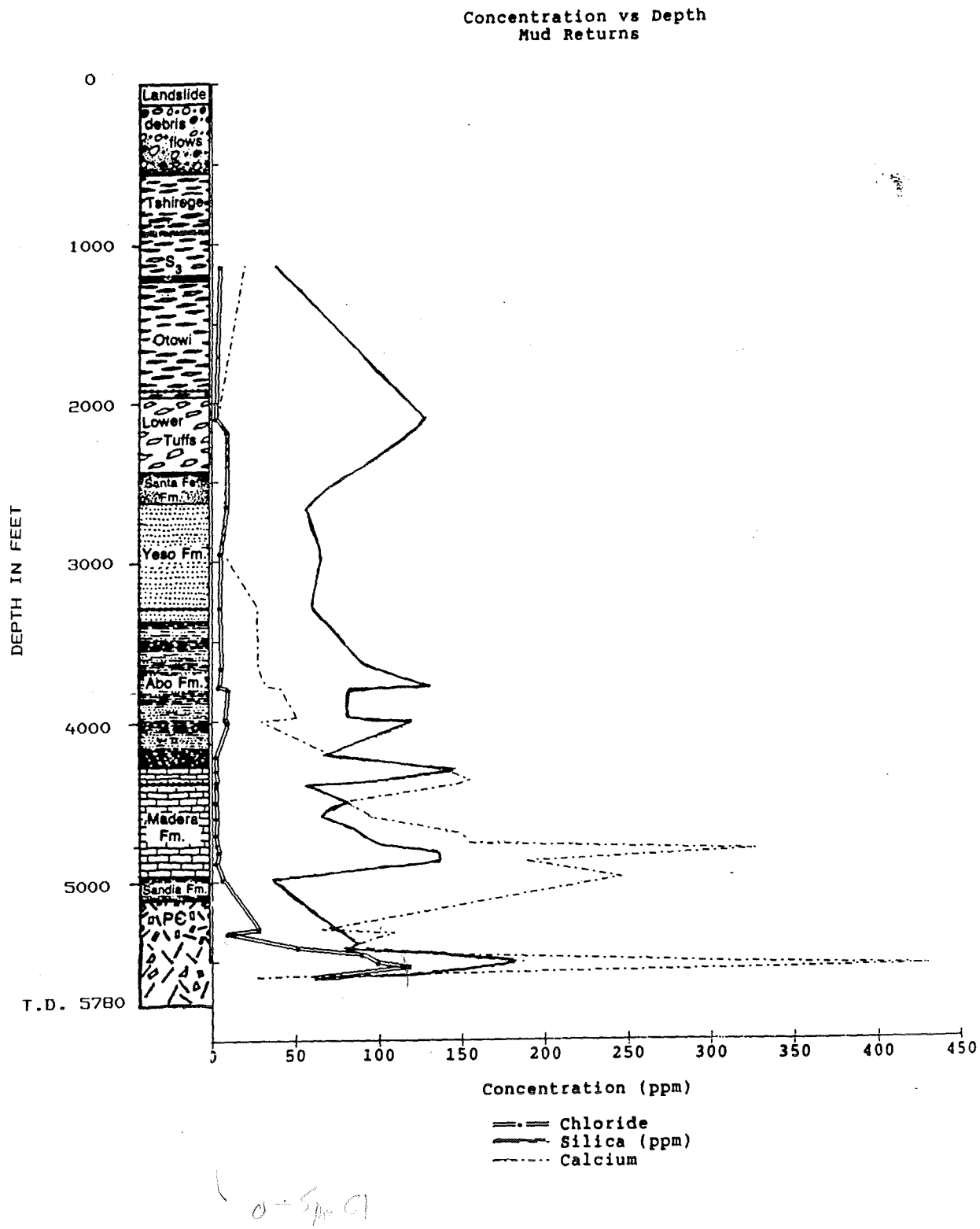
Grand Junction, CO 81502
(303) 242-8621

So that we may continue to coordinate the activities of the Science Team, we ask that when you write to the Curator with your sample request please send a copy of the letter to Jamie Gardner. There's lots of good science to be done!

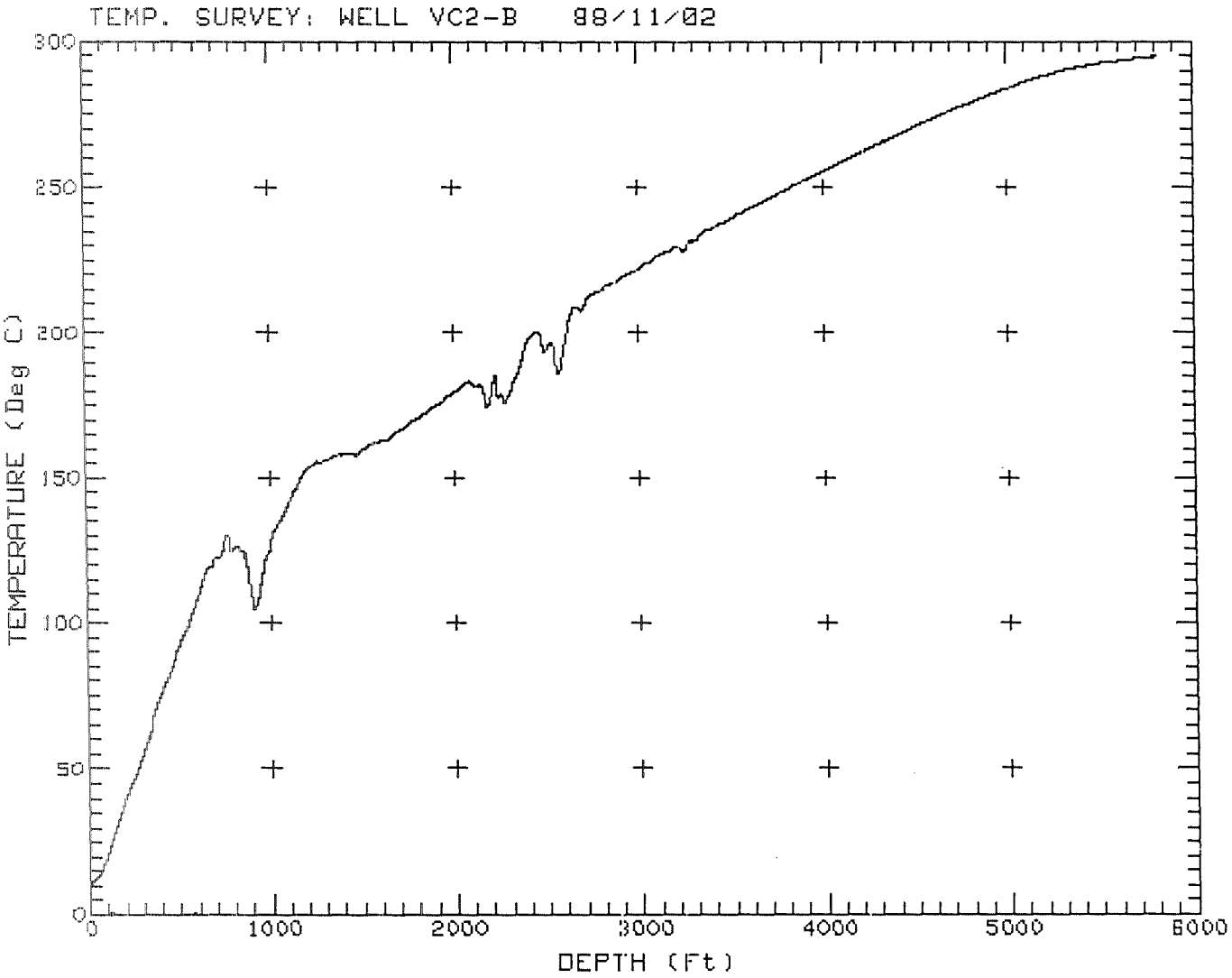
JNG/JBH:maj

Att. a/s

DISTRIBUTION:
See attached lists
CRM-4, MS A150
ESS-1 File


Concentration vs Depth
Mud Returns
0
1000
2000
3000
4000
5000
T.D. 5780
DEPTH IN FEET
Landslide
debris flows
Tshirege
S3
Otowi
Lower Tuffs
Santa Fe Fm.
Yeso Fm.
Abo Fm.
Madera Fm.
Sandia Fm.
PC
0
50
100
150
200
250
300
350
400
450
Concentration (ppm)
Chloride
Silica (ppm)
Calcium

0 - 5ppm Cl


TEMP. SURVEY: WELL VC2-B 88/11/02
TEMPERATURE (Deg C)
300
250
200
150
100
50
0
0
1000
2000
3000
4000
5000
6000
DEPTH (Ft)