GL01684

Field Geologic Log
for
Continental Scientific Drilling Program Corehole VC-2B
Valles Caldera, New Mexico

by

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March 1989

DOE/ER/13196-4
ESL-89025-TR

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ABSTRACT

VC-2B, the third Continental Scientific Drilling Program (CSDP) corehole in the Valles caldera, was completed in October 1988 at a depth of 5780 ft (1761.7 m) and a bottom-hole temperature of nearly 300°C. Drilled in the Sulphur Springs area, in the west-central portion of the caldera, VC-2B penetrated most of the thick, Valles intracaldera ignimbrite sequence as well as precaldera basement rocks ranging in age from Miocene to Precambrian. Major units intersected are as follows: 0-113.5 ft (0-34.6 m) -- landslide debris; 113.5-551.6 ft (34.6-168.2 m)-- interstratified debris-flow deposits and epiclastic sedimentary rocks (<1.12 Ma); 551.6-1196.8 ft (168.2-364.8 m) -- Tshirege Member of the Bandelier Tuff (1.12 Ma); 1196.8 -1221 ft (364.8-372.1 m) -- S_3 clastic deposits (1.45-1.12 Ma); 1221-1965.2 ft (372.1-599 m) -- Otowi Member of the Bandelier Tuff (1.45 Ma); 1965.2-2434 ft (599-741.8 m) -- Lower Tuffs (2.8 Ma, possibly as old as 3.6 Ma); 2434-2619 ft (741.8-798.2 m) -- Santa Fe Group sandstone (Miocene); 2619-3435.5 ft (798.2-1046.9 m)-- Permian Yeso Formation; 3435.5-4252 ft (1046.9-1295.9 m)-- Permian Abo Formation; 4252-4962.8 ft (1295.9-1512.6 m)-- Pennsylvanian Madera Limestone; 4962.8-5113 ft (1512.6-1558.4 m) -- Pennsylvanian Sandia Formation; 5113-5780 ft (1558.4-1761.7 m) -- Precambrian quartz monzonite.

Whereas much of the intracaldera volcanic sequence and the deep Precambrian quartz monzonite have been extensively fractured and brecciated (both tectonically and hydrothermally), intervening Paleozoic strata have undergone little structural disruption. This disparity is mirrored by the distribution and intensity of hydrothermal alteration and vein mineralization.

Rocks in the upper 800 m and lower 250 m of VC-2B are extensively altered, brecciated and veined. The Paleozoic rocks between these zones are essentially unaltered and only sparsely veined. Alteration in near-surface landslide debris is in part pre-slide in age. Below the slide, sericitic alteration -- illitic, mixed-layer illite/smectite changing with depth to illite -- prevails to a depth of about 300 m; this alteration is overprinted by kaolinization to a depth of 161.8 m. Chlorite-sericite (illite) alteration prevails between 300 and 800 m. Deep alteration is primarily propylitic, but the upper 12.5 m of the Precambrian quartz monzonite is intensely chlorite-sericitized. Near the contact with the quartz monzonite, siliciclastic rocks of the Pennsylvanian Sandia Formation have the appearance of calc-silicate hornfels, complete with large, tabular, translucent gray, sieve-textured porphyroblasts rimmed with chlorite. Preliminary petrographic examination of these rocks, however, has so far revealed no secondary phases indicative of high-temperature

thermal metamorphism; the gray porphyroblasts are anhydrite, possibly of diagenetic origin.

Hydrothermal veins and breccias are widespread in the VC-2B core, particulary in the more highly altered zones above and below the Paleozoic sequence. Identified vein minerals comprise quartz, calcite, ankerite, dolomite, fluorite, anhydrite, barite, epidote, wairakite, sericite, chlorite, hematite, and pyrite as well as rare rhodochrosite, chalcopyrite, chalcocite, sphalerite, galena, tetradymite (?), stibnite (?), and pyrargyrite. The latter two metallic minerals and rhodochrosite occur only at high elevations in the corehole; the other sulfides (and telluride?), except pyrite, are apparently confined to Paleozoic and Precambrian hosts.

The age(s) of secondary minerals in rocks below the intracaldera volcanic sequence remain(s) to be determined, but initial evidence suggests that they may be related in part to the currently or recently active Valles hydrothermal system. Homogenization temperatures for primary fluid inclusions trapped in several of these deep veins closely match current temperatures. Furthermore, several of the deeper veins apparently contributed significant amounts of chloride to the otherwise essentially chloride-free drilling mud when first encountered; if not deposited by the contemporary hydrothermal system, these veins may at least be channeling its thermal fluids. If this is so, VC-2B may have penetrated "stacked" hydrothermal cells separated by essentially impermeable Paleozoic strata.

INTRODUCTION

On October 22, 1988, Continental Scientific Drilling Program corehole VC-2B, in the Sulphur Springs area of the Valles caldera (Fig. 1), was completed at a depth of 5780 ft (1761.7 m) and a bottom-hole temperature exceeding 290°C. A collaboration involving Los Alamos National Laboratory (LANL), Sandia National Laboratories' Geoscience Research Drilling Office (GRDO), Tonto Drilling Services, and the University of Utah Research Institute (UURI), VC-2B was drilled not only to investigate, measure, and sample the high-temperature, liquid-dominated Sulphur Springs hydrothermal system (Goff et al., 1985) but in doing so to address a broad range of related scientific objectives (Hulen et al., 1988). Successful completion of the hole helps ensure that these objectives will be achieved.

Through the efforts of Tonto Drilling Services, core recovery for VC-2B was nearly 100%. The core provides the first continuous and undisturbed (as opposed to cuttings) record of the complex Valles intracaldera ignimbrite sequence and the subjacent Paleozoic to Precambrian basement. It also preserves delicate fractures, breccias, hydrothermal alteration textures, and paragenetic relationships, extremely useful (and hitherto unavailable) for reconstructing the Valles caldera's tectonic and hydrothermal history.

This report presents a detailed preliminary log of the lithology, stratigraphy, structure, hydrothermal alteration,

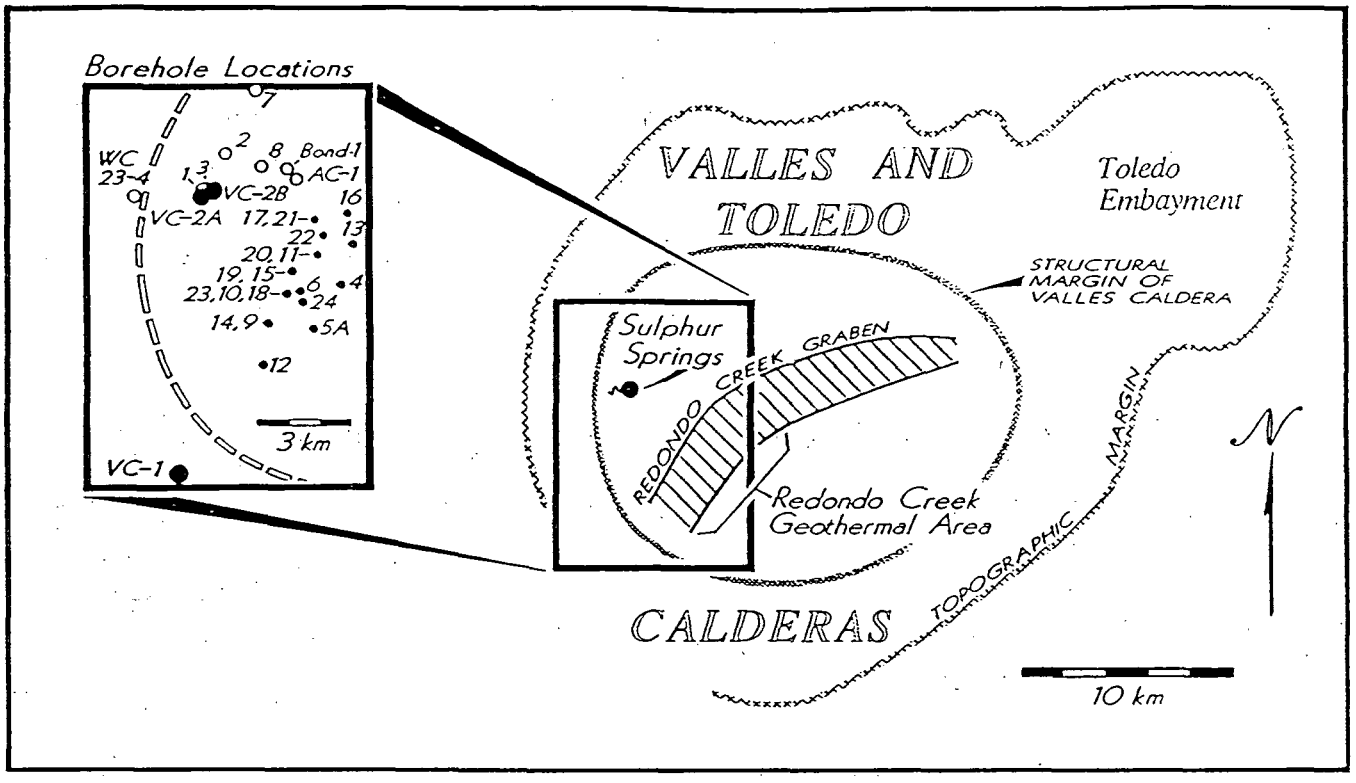


Figure 1. Location map showing positions of scientific coreholes (larger closed circles, inset at left) and geothermal wells (open circles and small, closed circles) completed to date in the Valles caldera complex.

veining, and metallic mineralization encountered in VC-2B. The log is designed to help guide the diverse research efforts of the 94 geoscientists forming the VC-2B research team (Appendix 2). Abbreviations used in the log are listed in Appendix 1.

STRATIGRAPHY AND LITHOLOGY

The intracaldera ignimbrite sequence and underlying Paleozoic to Precambrian basement penetrated by VC-2B (Fig. 2) can be correlated readily with rocks exposed within and near the Valles caldera or penetrated by previous geothermal or scientific drill holes (Fig. 1). We are reasonably confident of these correlations, but stress that their confirmation must await detailed study by the research team. Major units intersected in VC-2B are interpreted by us as follows:

Surface to 113.5 ft (34.6 m): Landslide Debris--Coarse, unsorted, generally matrix-supported breccia, with clasts up to at least 4.5 ft (1.4 m) in diameter; highly variable clast to matrix ratio; clasts represent most pre- and intracaldera lithologies; many of the clasts are red, hematitic, and appear to have been derived from the Permian Abo Formation.

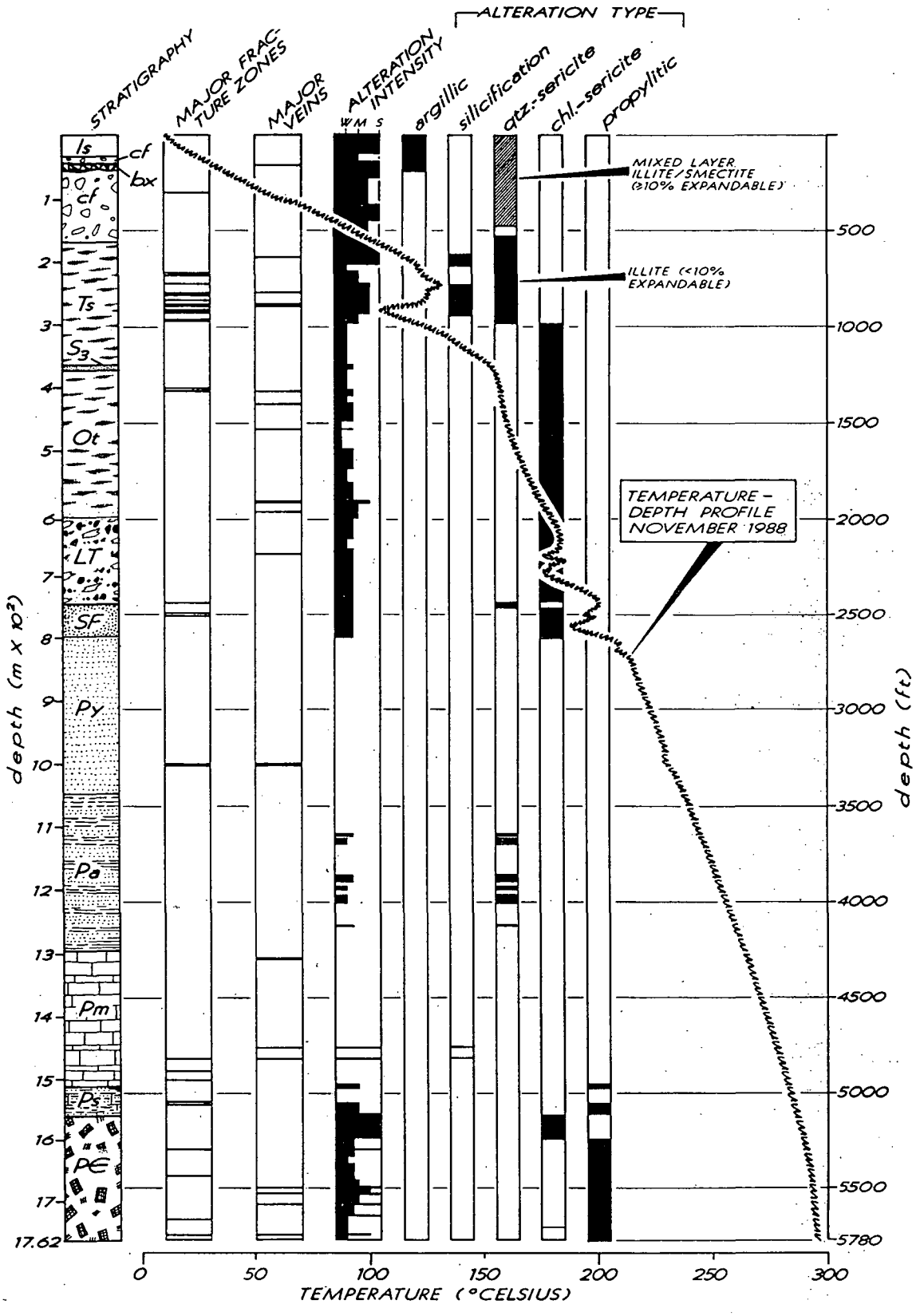


Figure 2. Summarized geologic log for CSDP corehole VC-2B, Sulphur Springs area, Valles caldera, New Mexico.
ls--limestone; cf--caldera-fill clastic rocks; bx--hydrothermal breccia and dacite porphyry; Ts--Tshirege Member of Bandelier Tuff; S_3--S_3 clastic deposits; Ot--Otowi Member of Bandelier Tuff; LT--Lower Tuffs; SF--Santa Fe Group sandstone; Py--Permian Yeso Fm; Pa--Permian Abo Fm; Pm--Penn. Madera Limestone; Ps--Penn. Sandia Fm; PC--Precambrian quartz monzonite.

113.5-551.6 ft (34.6-168.2 m): **Interstratified Debris-Flow Deposits and Epiclastic Sedimentary Rocks (< 1.12 Ma)** -- Debris-flow deposits resemble overlying landslide breccia, but are generally more monolithologic, consisting largely of sandstone clasts in a clay-rich, sandy matrix; epiclastic siltstones and sandstones are bleached, clay-rich, and commonly contorted to intraformationally brecciated; interbedded accretionary lapilli tuff and tuffaceous sandstone to conglomerate between 467.6 ft (142.5 m) and 487 ft (148.4 m); debris-flow breccia consisting entirely of red, remobilized Abo Formation shale and sandstone between 496 ft (151.2 m) and 530 ft (161.5 m); unusual dacite or andesite porphyry, with associated hydrothermal breccia, apparently intrudes this sequence between 152.2 ft (46.4 m) and 183 ft (55.8 m).

551.6-1196.8 ft (168.2-364.8 m): **Tshirege Member of the Bandelier Tuff (1.12 Ma)** -- Non- to densely welded, crystal-rich rhyolite ash-flow tuff; extremely lithic-rich intervals, 551.6-571.7 ft (168.2-174.3 m), 1030-1035.3 ft (313.9-315.5 m), 1052.7-1089.5 ft (320.8-332.1 m), and 1103.2-1134.2 ft (336.2-345.7 m); the latter two lithic breccias are strongly fines-depleted, and consist

principally of clasts derived from the Permian Abo Formation and the Pennsylvanian Madera Limestone; well-developed vapor-phase cavities from 663 ft (202.1 m) to 674 ft (205.4 m).

1196.8-1221 ft (364.8-372.1 m): **S_3 Clastic Deposits (1.45-1.12 Ma)** -- Interbedded dacite breccia, tuffaceous sandstone breccia, and sandstone; important marker horizon separating the Tshirege and Otowi Members of the Bandelier Tuff.

1221-1965.2 ft (372.1-599 m): **Otowi Member of the Bandelier Tuff (1.45 Ma)** -- Dominantly densely welded, crystal-rich, rhyolite ash-flow tuff; much of the unit is very hard, flinty in appearance; locally contains dark, relict glass; lithic-rich zone, 1461.8-1488 ft (445.5-453.5 m); mafic-appearing pumice, 1869-1888 ft (569.6-575.4 m); possible fused fallout tuff (50%+ pumice, (Guaje pumice bed?)), 1958-1965.2 ft (596.8-599 m).

1965.2-2434 ft (599-741.8 m): **Lower Tuffs (2.8 Ma?)**-- Non- to densely welded, crystal-rich and (especially) lithic-rich ash-flow tuff; commonly 20%, and locally up to 70% lithic fragments, dominantly porphyritic andesite; distinctive, micro-eutaxitic texture, 2003.3-2030.5 ft (610.6-

618.9 m), with fiamme averaging only 3-4 mm in length; extremely lithic-rich zone (lag breccia), 2209.5-2223.2 ft (673.4-677.6 m); fines-depletion (degassing) pipes prominent, 2236-2266.7 ft (681.5-690.0 m).

2434-2619 ft (741.8-798.2 m): Sandstone of the Santa Fe Group (Miocene) --Friable, porous, bleached and punky-appearing; massive to steeply cross(?)-bedded, very possibly of aeolian origin in part; highly contorted and intruded by hematitic clastic dikes, 2434-2452 ft (741.8-747.3 m); complex interval of interbedded debris-flow deposits, tuffs, carbonates (?), and sandstones, 2452-2469.5 ft (747.3-752.7 m) (possibly Miocene Cochiti Formation equivalent).

2619-3435.5 ft (798.2-1047.1 m): Permian Yeso Formation -- Dominantly hematitic, fine-grained, plane- to wavy-bedded, commonly bioturbated, locally argillaceous sandstone; anhydrite nodules and filled burrows common; thin anhydrite, limestone, and mudstone beds locally present; volcaniclastic conglomerate, 3305.5-3334 ft (1007.5-1016.2 m), with large porphyritic andesite cobbles; arkosic conglomerate with granitic

pebbles and cobbles below this sub-unit to a depth of 3358 ft (1023.5 m)

3435.5-4252 ft (1047.1-1295.9 m): Permian Abo Formation -- Interbedded hematitic arkosic mudstones and sandstones; thin limestone and dolomite interbeds as well as diagenetic calcite nodules locally present.

4252-4962.8 ft (1295.9-1512.6 m): Pennsylvanian Madera Limestone -- Interbedded, relatively pure to argillaceous limestones and siliciclastic rocks; locally very fossiliferous (brachiopods, fusulinids, corals, pelecypods); black, pyritic and possibly organic-rich shales and mudstones locally present; massive chert, 4879.5-4896.5 ft (1487.2-1492.3 m); very sulfide-rich (pyrite and sphalerite) "black" mudstone, 4941-4944.2 ft (1505.9-1506.9 m).

4962.8-5113 ft (1512.6-1558.4 m): Pennsylvanian Sandia Formation -- Dominantly interbedded mudstone, siltstone, sandstone and argillaceous to sandy limestone; much of the unit seems recrystallized.

5113-5780 ft (1558.4-1761.7 m)(total depth):

Precambrian Porphyritic Biotite (+ Hornblende) Quartz Monzonite -- Very distinctive, coarsely porphyritic, with 20-25% large potassium feldspar phenocrysts (up to 3 X 2 cm in X-section) embedded in a medium-crystalline, granitic matrix; average about 10-12% disseminated mafic minerals; original magnetite (ilmenite ?) and sphene now commonly converted to leucoxene; aplite, fine-grained granite, and granodiorite dikes locally present.

STRUCTURE

The entire stratigraphic sequence outlined above has undergone at least some structural disruption, but the effects of that disruption are highly variable; fracturing and brecciation are strongly dependent on rock type and elevation in the Valles hydrothermal system. The Bandelier Tuff, associated ignimbrites and volcaniclastic sedimentary rocks are commonly intensely fractured (Fig. 2), both tectonically and hydrothermally; the deep Precambrian basement is similarly but moderately fractured. Curiously, however, the intervening Paleozoic sedimentary sequence is overall only weakly fractured, and the Permian redbeds (Abo and Yeso Formations) remain (except for fissile shales and mudstones) essentially undisturbed.

As in corehole VC-2A, compaction foliation dips in the Tshirege and Otowi Members of the Bandelier Tuff are

essentially identical, indicating that unlike the Valles caldera, the Toledo caldera (formed simultaneously with eruption of the Otowi at 1.45 Ma) did not undergo structural resurgence; had it done so, dips presumably would be steeper in the Otowi than in the Tshirege. Curiously, compaction foliation dips throughout the Bandelier Tuff are much shallower in VC-2B (generally 10- 20^{o}) than in VC-2A (up to 50^{o}). The relatively steep dips of VC-2A are apparently due to rotation along faults rather than resurgent doming of the Valles caldera.

The most intense fracturing encountered in VC-2B is hosted by densely welded ignimbrites of the Tshirege Member of the Bandelier Tuff in the interval 775-990 ft (236.2-301.7 m). Several major fault zones (tectonic breccias) in this interval are accompanied by widespread stockwork fracturing of the affected tuffs. These faults and breccias are strongly altered, and have clearly focused high-level fluid flow in the Valles hydrothermal system.

Between 1320.5 ft (402.5m) and 1579.5 ft (481.4m), the Otowi Member of the Bandelier Tuff is extensively but moderately broken by hydraulic fracture networks and local hydrothermal breccias. Most of these are partially infilled with bladed, "fishscale" calcite, a morphology which can indicate deposition from boiling hydrothermal solutions; it is possible that the fluids responsible here for hydraulic rock rupture deposited this calcite in the resulting open spaces.

The Lower Tuffs and underlying Santa Fe Group sandstones are largely unfractured although moderately altered (Fig. 2). Permeability in these units is probably of primary origin.

Considering the location of VC-2B near the ring-fracture margin of a major caldera, the Permian Abo and (particularly) Yeso Formations are remarkably unfractured. Intervals of several hundred feet in the Yeso, in fact, are nearly devoid of fractures, and several intact cores exceeding 10 ft (3.1 m) in length were obtained from this unit. The underlying Abo is locally broken and rubblized, but primarily in fissile shales and mudstones; we suspect that these are not throughgoing tectonic features. Only one structure in the entire 1633 ft (497.7 m)-thick Permian redbed sequence has apparently guided extensive thermal fluid flow--an altered and mineralized fault centered at a depth of 3293 ft (1003.7 m)(Fig. 2).

The Pennsylvanian Madera Limestone and Sandia Formations are more fractured than the overlying Permian sequence, perhaps because of their more brittle primary textures. As a result, these units host a few more, but still widespread, hydrothermal veins.

The contact between the Sandia Formation and underlying Precambrian quartz monzonite coincides with a subhorizontal, intensely sheared "melange" of various lithologies--actually what could be described as a protomylonite--spanning the interval 5108.2-5119 ft (1556.9-1560.2 m).

This unique structure suggests the possibility that here the Paleozoic sequence may have been thrust over the Precambrian (perhaps during Laramide compression).

Although not as disrupted as the high-level ignimbrite sequence, the deep Precambrian quartz monzonite penetrated by VC-2B also hosts numerous fractures and breccias of both tectonic and hydrothermal origin. In addition, the upper 41 ft (12.5 m) of the unit is intensely altered, indicating past invasion by thermal fluids along now-healed fractures (perhaps in part developed during weathering and unloading).

ALTERATION AND MINERALIZATION

Alteration: Hydrothermal alteration and mineralization in VC-2B reflect the distribution both of secondary permeability along the fractures and breccias just described and of primary permeability in certain clastic rocks as well as non- to weakly-welded ignimbrites. Accordingly, the high-level intracaldera ignimbrite sequence and deep Precambrian basement are separated by essentially unaltered Paleozoic strata (Fig. 2). Since current temperatures in these Paleozoic rocks are more than sufficient for relatively high-grade hydrothermal alteration, the lack of that alteration most likely reflects insufficient host rock permeability. This suggests the possibility (assuming that all or most alteration encountered is related to the current or recently active Valles hydrothermal system) that the Paleozoic rocks, particularly the Permian redbeds, form a

largely impermeable barrier separating "stacked" hydrothermal cells. Hydrothermal alteration in VC-2B is most pervasive and intense from the surface to a depth of 990 ft (301.7 m). Much (though not all) of the alteration in landslide debris above 113.5 ft (34.6 m) probably predates development of the slide; in an otherwise punky, clay-rich matrix, absolutely fresh Madera limestone clasts are locally present. Between 113.5 ft (34.6 m) and 183 ft (55.8 m), epiclastic sediments, debris-flow breccias, and the dacite/andesite porphyry-hydrothermal breccia interval are strongly altered to mixed-layer illite/smectite and phengite/smectite, quartz, calcite, and kaolin; the latter mineral is particularly abundant in association with the porphyry/breccia interval. The same alteration without kaolin affects most of the debris-flow/epiclastic interval to a depth of 551.6 ft (161.8 m). Between that depth and 775 ft (236.2 m), illite is the principal secondary phase; the illite is accompanied by locally intense silicification below 735 ft (224 m). Densely welded ash-flow tuffs in the interval 775-990 ft (236.2-301.7 m) are intensely quartz-sericitized (here sericite = illite), silicified, and hydrothermally etched along fractures and between breccia clasts. This dissolution has resulted in secondary porosities locally reaching at least 10 vol.%. Note that this etched zone corresponds to a prominent reversal in the most recently obtained temperature profile (Fig. 2).

Chlorite-sericite alteration is the dominant alteration type between 990 ft (301.7 m) and 2619 ft (798.2 m). It is particulary well-developed in the Lower Tuffs and Santa Fe Group sandstones.

Paleozoic strata intersected in VC-2B are mostly unaltered, though a few coarser-grained sandstones in the Abo Formation appear to have been weakly to moderately sericitized. Clay fractions extracted from selected samples of these rocks are shown by XRD to contain abundant mixed-layer illite/smectite with up to 45% expandable interlayers, far more than would be expected at presently prevailing temperatures (e.g Hedenquist and Reid, 1985). Most of these clays are believed to represent the rocks' older, relatively low-temperature diagenetic signatures. We suspect that they have retained these signatures because of their host rocks' impermeability; even though heated to high temperatures, the clays were isolated from potassium-bearing hydrothermal fluids, and there was insufficient local potassium to effect the transformation to low-expandability illite. Alternatively, the clays were heated to these high temperatures very recently, and are even now transforming to illites at depth.

With the exception of intense chlorite-sericitization of the upper Precambrian (Fig. 2), propylitic alteration (chlorite-sericite-epidote-calcite-hematite) apparently prevails at depth in VC-2B. Intensity of this

propylitization is highly variable, but strongest in association with hydrothermal breccias and veins.

Much of the Sandia Formation below a depth of 4962 ft (1512.3 m), although tentatively included in the deep propylitic alteration zone, appears to be recrystallized and looks very much like a mottled, fine-crystalline calc-silicate rock. However, preliminary petrographic examination, XRD analysis, and electron-beam microanalysis have identified only epidote, illite, mixed-layer illite/smectite, chlorite, calcite, hematite, wairakite, and anhydrite, with no minerals characteristic of higher-temperature thermal metamorphism. The anhydrite oddly occurs as large, euhedral, sieve-textured "porphyroblasts" with chloritic rims; these may be of diagenetic origin, but, along with this entire unusual zone, deserve much more detailed investigation.

Mineralization: Mineralized veins and breccias are abundant in the VC-2B core. Mirroring the intensity of fracturing and hydrothermal alteration, they occur primarily in the intracaldera volcanic sequence and the deep Precambrian basement. Vein textures and mineral assemblages are diverse, and rather than being described exhaustively here, are catalogued in Table 1.

Based on our preliminary work, it appears that typical "epithermal" metallic vein minerals (pyrargyrite, stibnite) in VC-2B are confined to the intracaldera volcanic/sedimentary sequence. Chalcocite, chalcopyrite,

Table 1. VC-2B: Major hydrothermal vein and open-space-filling zones

DEPTH	IDENTIFIED HYDROTHERMAL VEIN AND OPEN-SPACE-FILLING MINERALS
162.5 - 166.2'	QTZ, CHALCEDONY, ANK, CAL, PY, KAOL
169.5 - 183'	QTZ, CHALCEDONY, ANK, CAL, PY, KAOL, STIBNITE?
431 - 431.8'	QTZ, CAL
819.9 - 824'	QTZ, SER, PY
881 - 897'	QTZ, SER, PY
1342.5 - 1346'	SER, CHL, CAL, PY
1350 - 1352.5'	SER, CHL, CAL, PY
1405.5 - 1405.7'	SER, CHL, CAL, PY(tr)
1414.5 - 1417'	SER, CHL, CAL, PY(tr)
1525 - 1528'	SER, CHL, CAL
1912.5 - 1932'	SER, CHL, CAL, PY
1957 - 1958'	SER, CHL, CAL, PY
3291 - 3293.5'	QTZ, SER, CHL, CAL, BARITE, ANH, SPHALERITE, CHALCOCITE
4293 - 4296.5'	QTZ, SER, CAL, CHL, PY
4325 - 4328'	CAL, PY
4565 - 4565.8'	QTZ, CAL
4687 - 4691'	CAL
4755 - 4763'	QTZ, SER, ANH, PY, TETRADYMITE(?)
4821.5 - 4829.5'	QTZ, CAL, EP, WAIRAKITE, CHALCOPYRITE, BORNITE(?)
4885.7 - 4887.7'	QTZ, CAL
4984.5 - 4997'	SER, EP, CAL, ANH, PY
5042.2 - 5043'	QTZ, SER, CAL
5061.8 - 5063'	SER, CAL, PY

TABLE 1 (continued)

5091 - 5093'	EP, CHL, CAL, PY
5303.5 - 5304'	QTZ, SER, CAL, PY
5401 - 5401.7'	QTZ, EP, CHL, CAL, PY
5403 - 5405'	QTZ, EP, CHL, CAL, PY
5447 - 5447.5'	QTZ, EP, CHL, CAL
5480.5 - 5482.7'	QTZ, EP, CHL, CAL, HEM
5485 - 5488.2'	QTZ, EP, CHL, CAL
5530 - 5335'	QTZ, EP, CHL, CAL, PY, SPHALERITE
5590.5 - 5594.3'	QTZ, SER, EP, CHL, CAL, PY
5655 - 5655.7'	QTZ, SER, EP, CHL, CAL, PY
5660.5 - 5662'	QTZ, SER, EP, CHL, CAL, PY
5730 - 5731.5'	QTZ, SER, EP, CHL, CAL, PY, CHALCOPYRITE
5750 - 5751.2'	QTZ, SER, EP, CHL, CAL, PY, CHALCOPYRITE
5756 - 5758.5'	QTZ, SER, EP, CHL, CAL, PY CHALCOPYRITE

Other zones with unusual mineralogy

927 - 934'	QTZ, SER, PY, RHODOCHROSITE
1152'	QTZ, SER, CHL, CAL, PY, PYRARGYRITE
1234 - 1240'	QTZ, SER, CHL, PY, FLUORITE
1257 - 1293.5'	QTZ, SER, CHL, PY, FLUORITE
1308 - 1314'	QTZ, SER, CHL, PY, FLUORITE
2183 - 2185'	CAL, FLUORITE

bornite (?) and other base-metal sulfides occur in veins only in Paleozoic and Precambrian rocks.

Further research is needed to determine whether or not these deep veins and associated alteration are related to the presently or recently active Valles hydrothermal system; preliminary fluid-inclusion evidence, however, suggests that they may be.

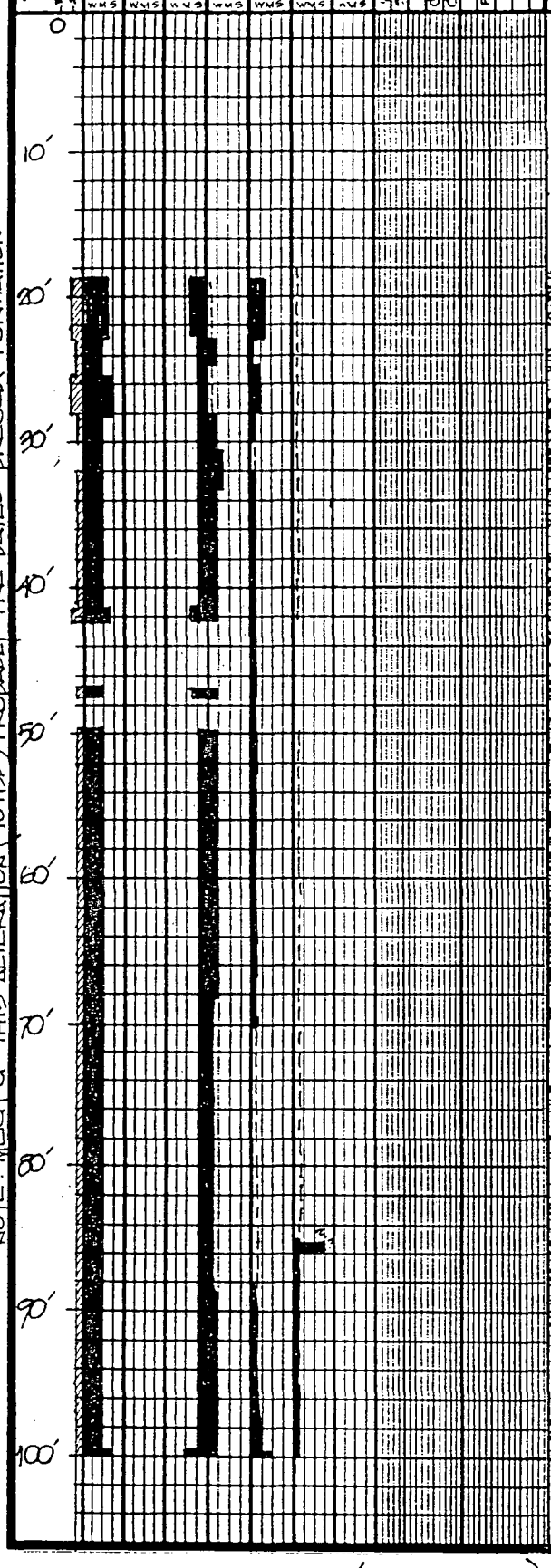
Homogenization temperatures for primary fluid inclusions in a variety of minerals from several of the deep veins are very close to presently measured temperatures (many of these samples contain coexisting primary vapor- and liquid-rich inclusions, indicating deposition from boiling hydrothermal fluids, so pressure corrections are unwarranted). While this does not conclusively prove vein mineralization from present or recent fluids, it is certainly suggestive evidence. Furthermore, many of these deep veins apparently yielded chloride-rich water to the drilling mud when first penetrated. If the veins were not deposited from presently circulating fluids, they may at least serve as contemporary fluid channels.

FIELD GEOLOGIC LOG FOR COREHOLE VC-2B

(Abbreviations listed in Table 1)

Depth Scale 1 in.=12 ft.

GRAPHIC LOGS



NOTE: MUCH OF THIS ALTERATION (TO 113.5') PROBABLY PRE-DATES BRECCIA FORMATION

DESCRIPTIONS

0-10' (RECOVERED 0.6'): EXTREMELY CLAY-RICH (STICKY), PROBABLE LANDSLIDE BRECCIA; V. LT. GRAY TO LIGHT ORANGE-BROWNISH-GRAY. MINOR DISS. GOETHITE WHICH ALSO OCCURS AS AN IRREGULARLY-DISTRIBUTED STAIN.

10-18.8: RECOVERED 0.1 (tr. 10-18): Clay-rich, sandy breccia; ≤ to subrounded clasts up to at least 6 cm in dia.; extreme heterogeneity of clasts, which include obsidian and stony rhyolite (Redondo Creek Rhyolite?) and intermediate-composition volcanics; also much variation in degree of alteration — from totally altered to fresh — suspect much of the alteration pre-dates landsliding

★ AT 18.8' CONTACT BETWEEN THE VARIABLY-ALTERED BRECCIA ABOVE & STRONGLY ALTERED BRECCIA BELOW.

18.8-30.45' Extremely clay-rich sandy, heterolithologic breccia, much more pervasively altered than above, sticky/gooey when wet; clasts up to at least 6 cm in dia.; ≤ to subrounded, including calcareous sandstone, porphyritic rhyolite, porphyritic andesite and basalt — many sandstone clasts bleached but still reddish, probably Permian Abo Formation; alteration of this deposit is intense, but in part pre-dates breccia development because alteration mineralogy & texture sometimes truncated at clast margins.

30.45-32': Fine-gr. sandstone; ~1% scattered vugs up to 1.5 x 5 mm. filled with calcite, rimmed with unknown dark material; unit appears sheared/brecciated locally @ ~60° to core axis.

32-42.1': Clay-rich sandy breccia, as above; diss. pyrite concentrated in sericitized clasts!

42.1-46.6': Limestone clast, fresh, wavy-bedded

46.6-47.6': Sandy breccia as above

47.6-49.7': Limestone clast, as above

49.7-57.1': Sandy breccia, as above; appearance of ~2% disseminated shaly clasts, dk. gray, which are selectively pyritized.

57.1-67.8': Same as above, except matrix becomes reddish-brown; suspect that this is a lobe of the landslide derived from the Abo Formation.

67.8-85.4': Sandy bx as above, but not red, hematitic; also, this sub-unit is more clast-poor & even less pyritic — intervals up to 1' FT thick with almost no clasts larger than a few mm. dia.

★ 71.5': Irreg. slip plane w/ vague slix, ~45° dip, phengite, illite on surface.

85.4-86.0': Rubble zone — probable fault

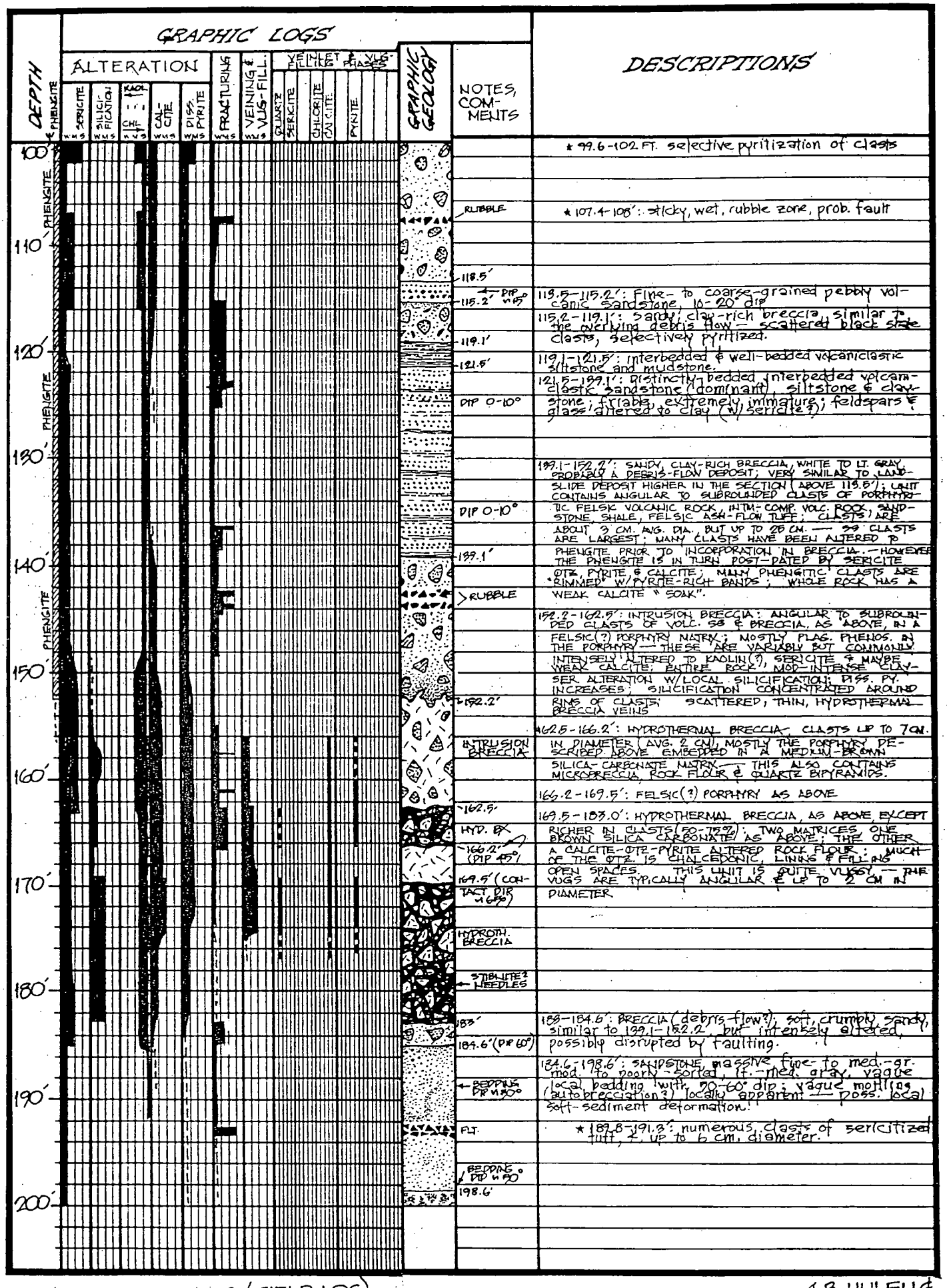
86.0-113.5': Clay-rich sandy breccia, as above, fine-grn. disseminated pyrite extremely selectively appears to post-date the matrix.

DRILL HOLE VC-28 (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. HULEN & J. GARDNER

07/23/88

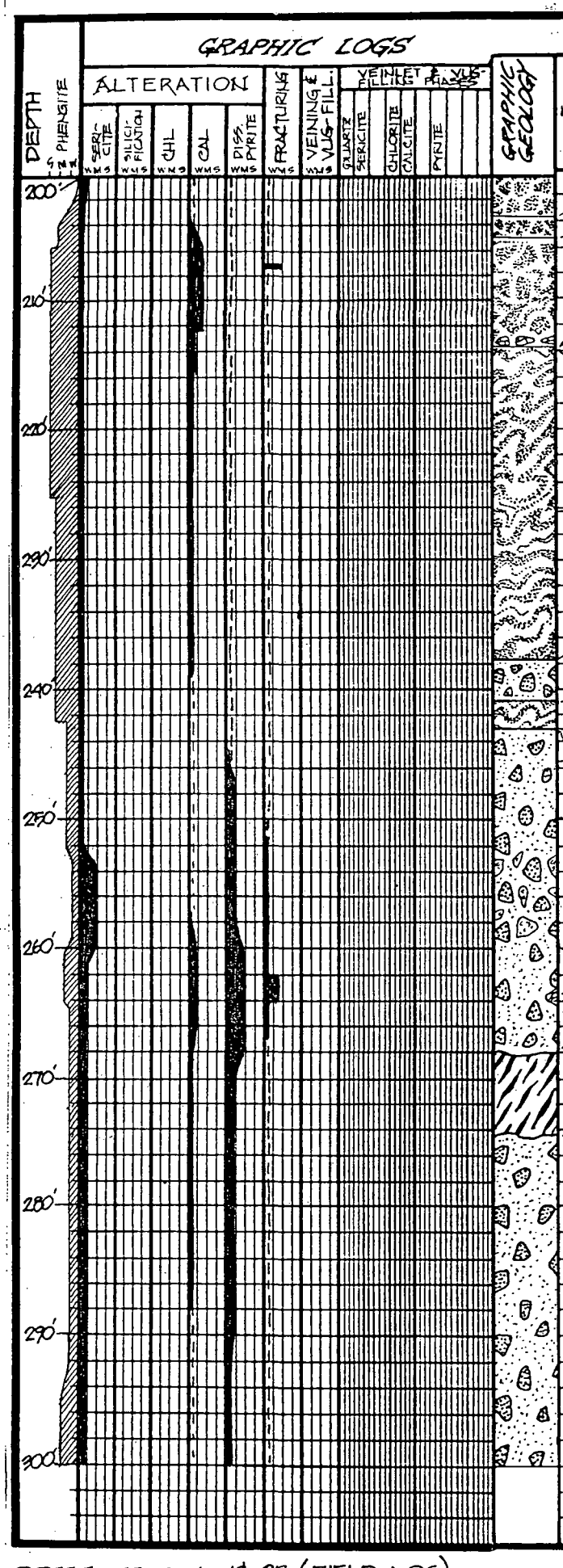


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

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

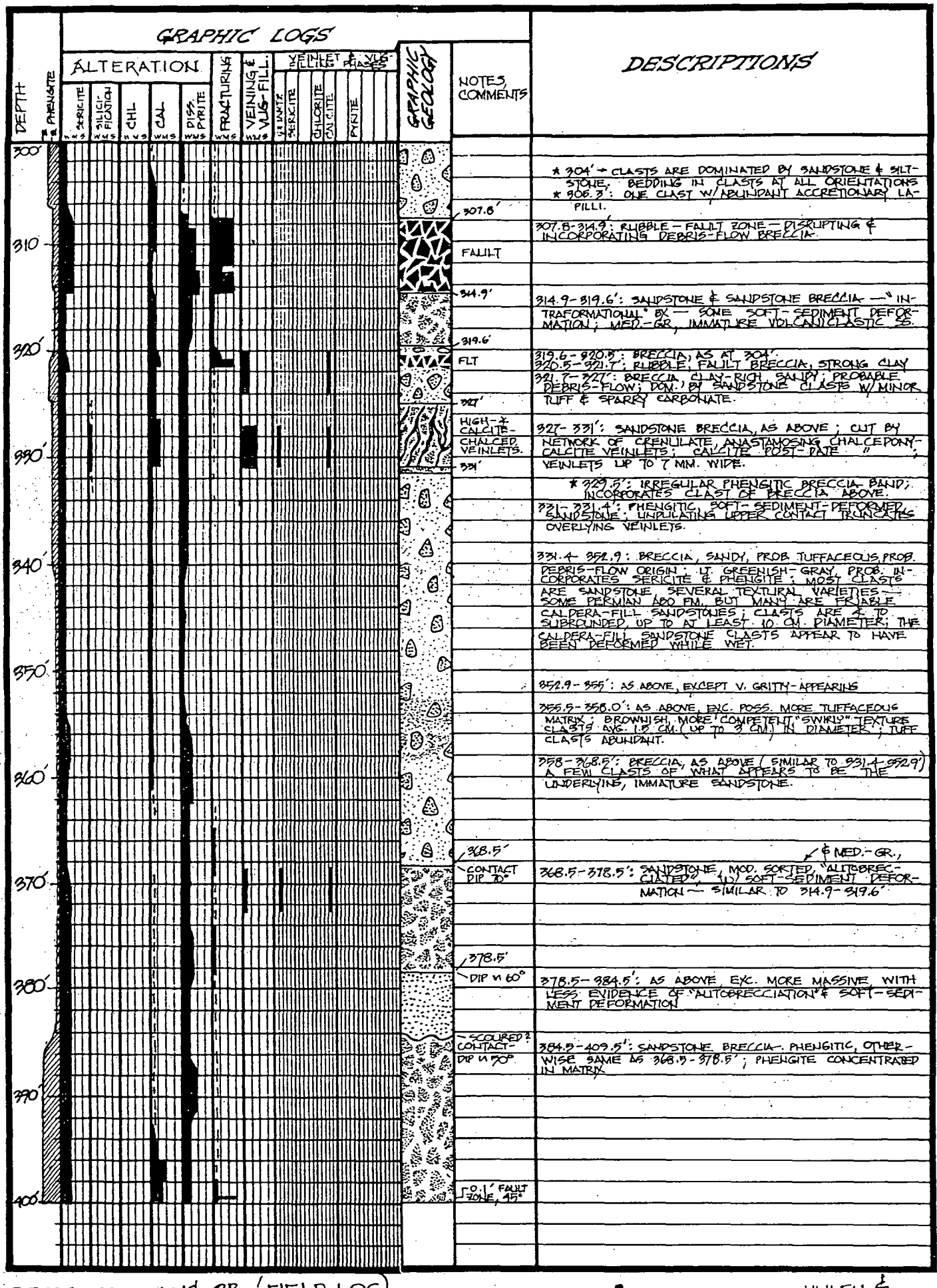
JULY 23 & 24 1988



NOTES, COMMENTS	DESCRIPTIONS
	198.6-208.7': SANDSTONE, v. lt. brownish-gray, "autobrecciated" w/ clasts of sandstone in a virtually identical matrix.
208.7'	208.7-205.2': As above, except breccia texture more apparent - this disruption appears to have occurred when the sandstone was wet.
205.2'	205.2-219.5': Bright gray-green, phengitic sandstone breccia: clasts of lt. gray-green to pinkish sandstone, angular to subrounded, embedded in a more prominently phengitic matrix; DEFINITE SWIRLY TEXTURE, ALMOST CERTAINLY SOFT-SEDIMENT DEFORMATION; SCATTERED CLASTS OF MICROXLN. TO SPARRY CALCITE
IRREG. SLIK, 45°	
219.5'	★ 212-218': More intense phengitic alteration, abundant carbonate clasts.
	★ 213-219.5': Especially clay-rich (lt. gray-grn.)
	219.5-237.5': SANDSTONE, gen. med.-gr., w/ prominent soft-sediment deformation & distinctive "swirly" texture. VERY PHENGITIC. — PHENGITE ALSO SEEMS TO PRE-DATE SOFT-SED. DEFORMATION (THINK ABOUT SOFT DISRUPTION OF HOT LAKE SEDS)
	★ 229-225': Extremely clay-rich w/ sand-size particles of phengite-altered clay.
? CRUDE BEDDING DIP W 70°	
237.5'	237.5-240.9': BRECCIA, coarse, sandy, clay-rich; ± to subround. clasts of sandstone, tuff, rare med.-gr. reddish sandstone (probably Abo Fm.)
240.9'	240.9-243': SANDSTONE, Phengitic - v. colorful, prominent "swirly" soft-sediment deformation.
243.0'	
DIP ± 45° — STIBNITE?	243-268': BRECCIA, coarse, unsorted, clay-rich, sandy; contains clasts of several different types of sandstone, including reddish & gray-green clasts from the Permian Abo Fm.; diss. pyrite becomes more prominent.
	★ @ 246': 2 MM. CLUSTER OF ACICULAR GRY CRADLE LYXLS. (STIBNITE?) 1 PIECE ※ 50-85%
	★ 258-259.6': Rich in tuff clasts
ORTHOQUARTZ CLAST	
268'	
	268-274.5': DENSELY WELDED FELSIC ASH-FLOW TUFF CLAST; FOL'N. HIGH-∠, TRUNCATED AT CLAST MARGINS.
274'	274.5-307.5': SAME AS 243-268 FT., EXC. A FEW SCATTERED CHERT CLASTS — ALSO A FEW POSSIBLE FLUVIAL SS. STRINGERS & LENSES
	★ 297.5-299.5': CONCENTRATION OF DEFORMED, PHENGITE-ALTERED CLASTS W/ VAGUE, WISPY BORDERS
	★ 299.5-301.2': CLAST OF MED.-GR. ARKOSIC SS.

DRILL HOLE VC-2B (FIELD LOG)
LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J. HULEN, J. GARDNER
07/24/88

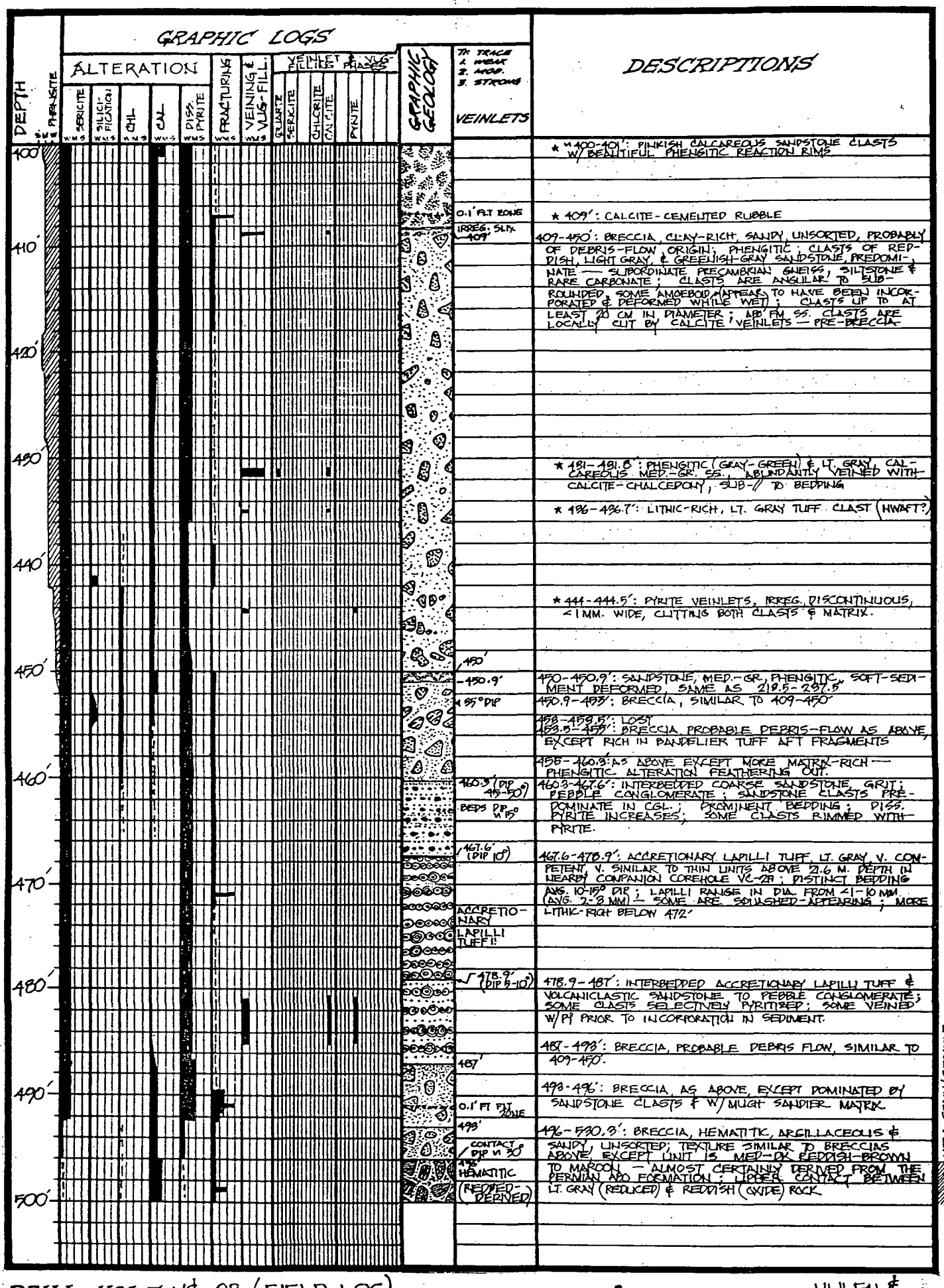


DRILL HOLE VC-2B (FIELD LOG)

LOCATION VALLES CALDERA, NEW MEXICO

LOGGED BY HULEN & GARDNER

01/28/88

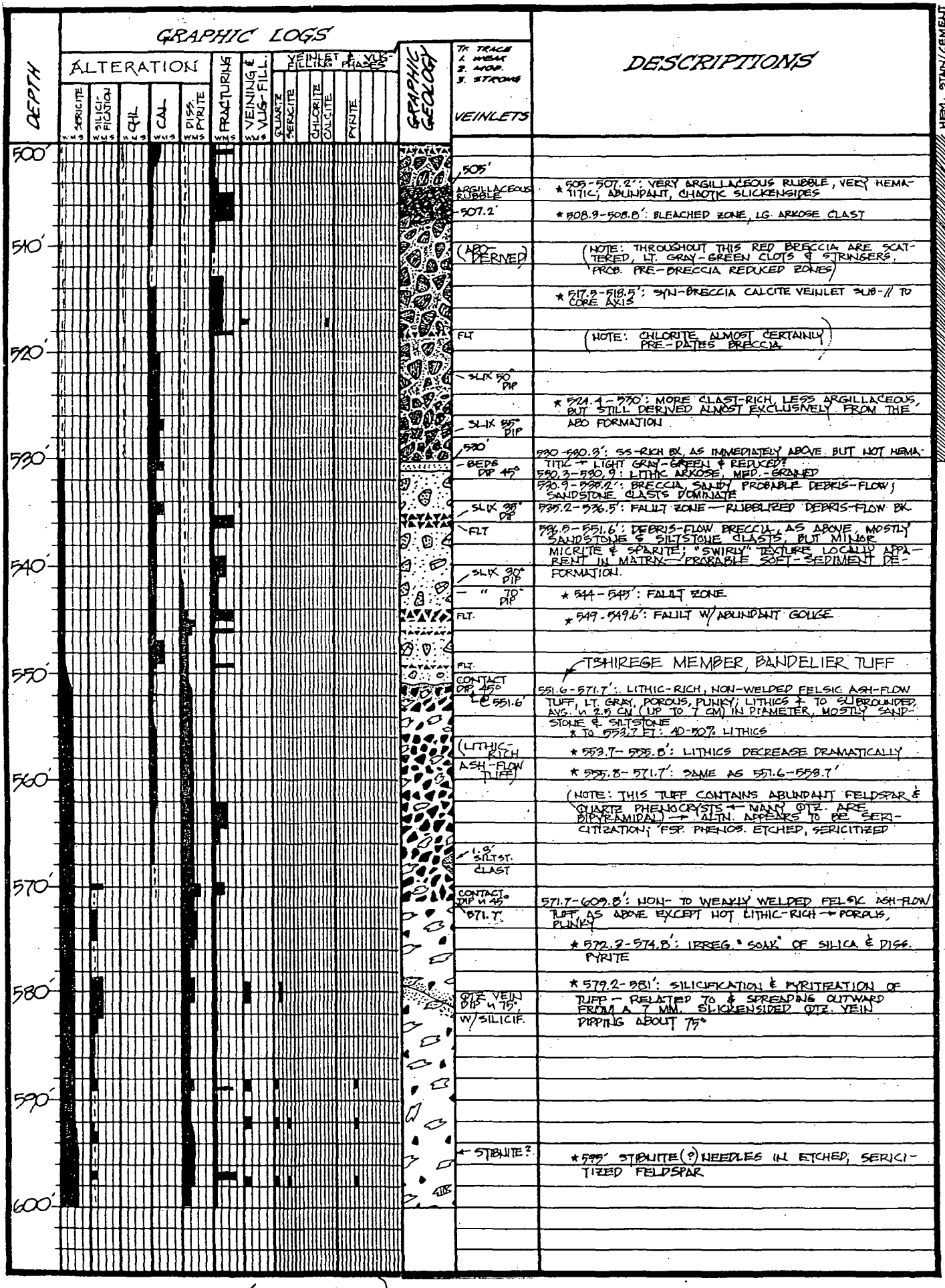


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA,

LOGGED BY HULEN & GARDNER

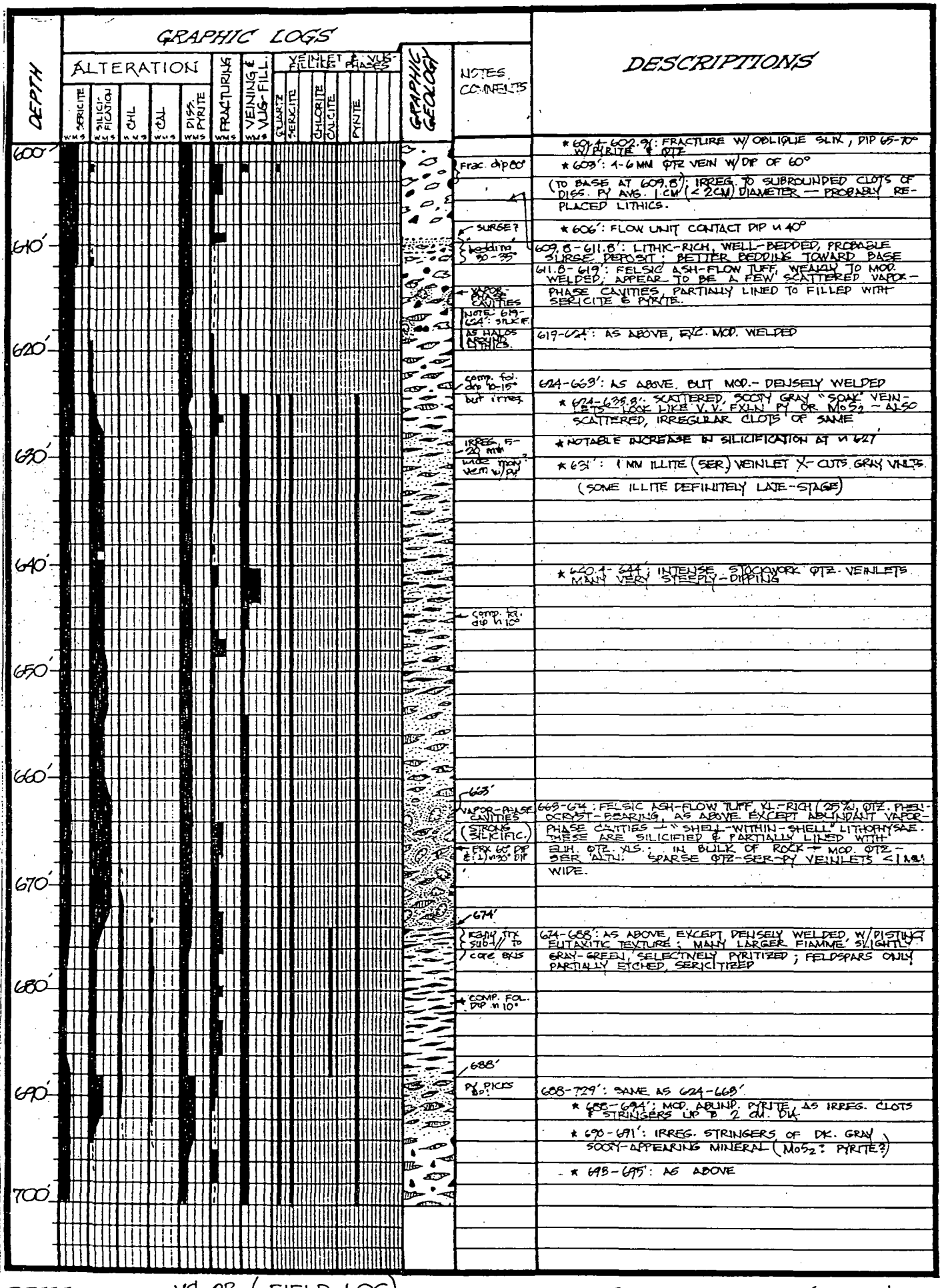
07/29/88



DRILL HOLE VC-28 (FIELD LOG)

LOCATION VALLES CALDERA, N. MEXICO

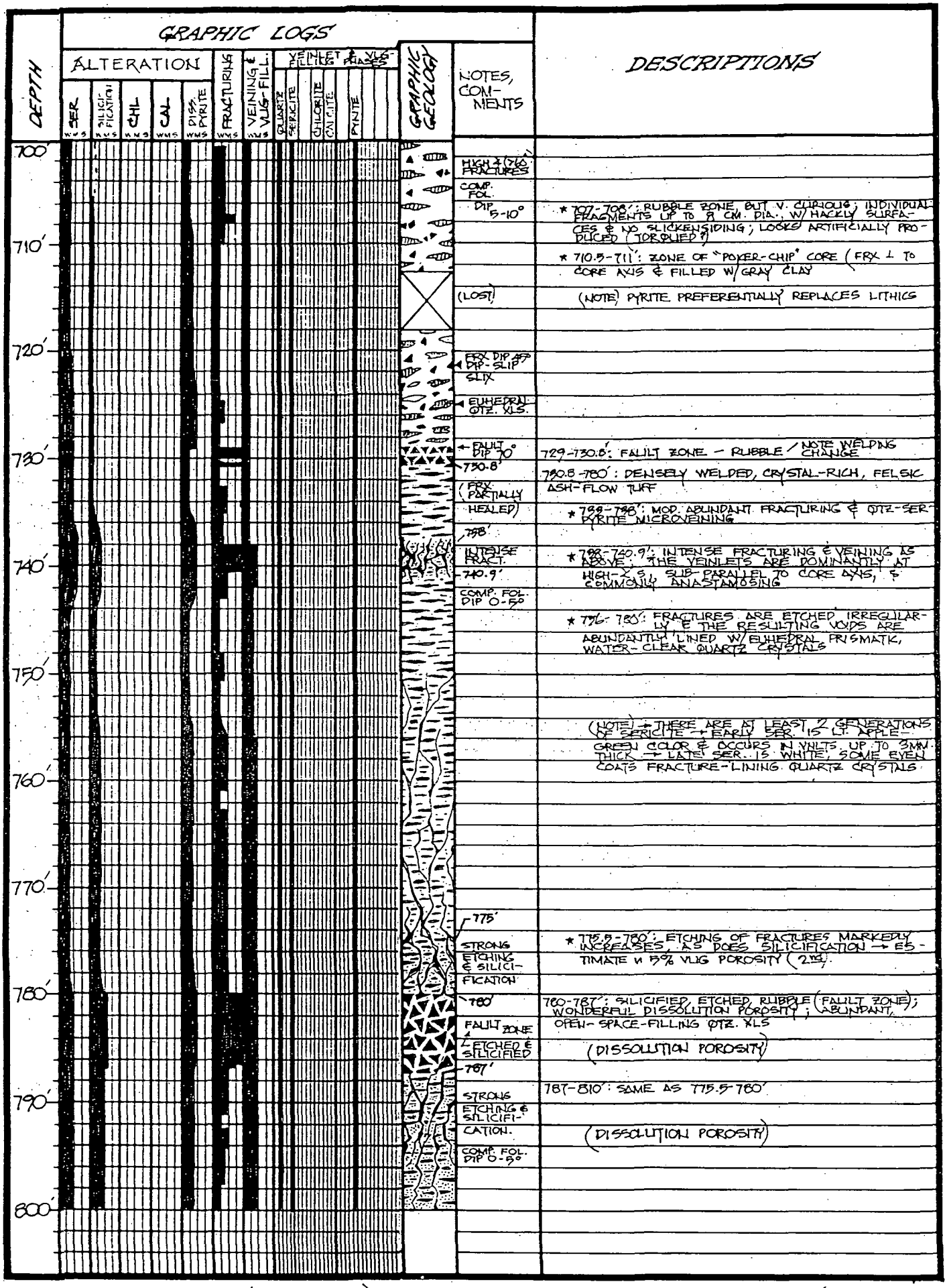
LOGGED BY J. HULEN 07/25-07/31/88



DRILL HOLE VC-2B (FIELD LOG)

LOCATION VALLES CALDERA, N. MEXICO.

LOGGED BY J. HULEN 07/31/88

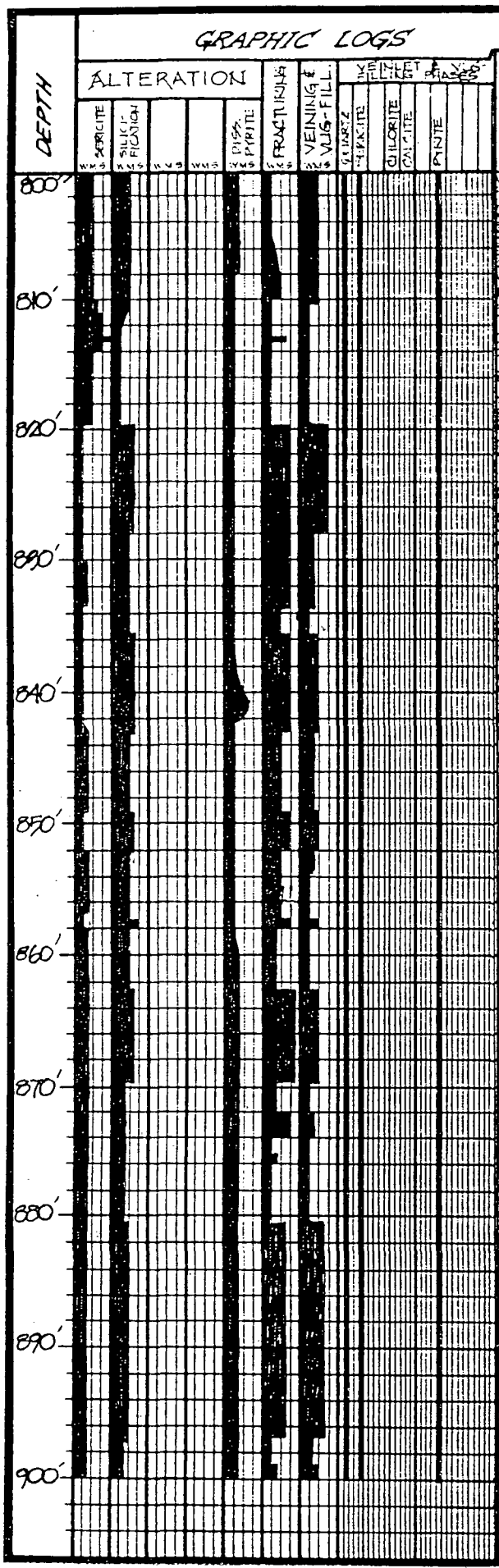


DRILL HOLE YC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J. HULEN, J. GARDNER

08/01/88



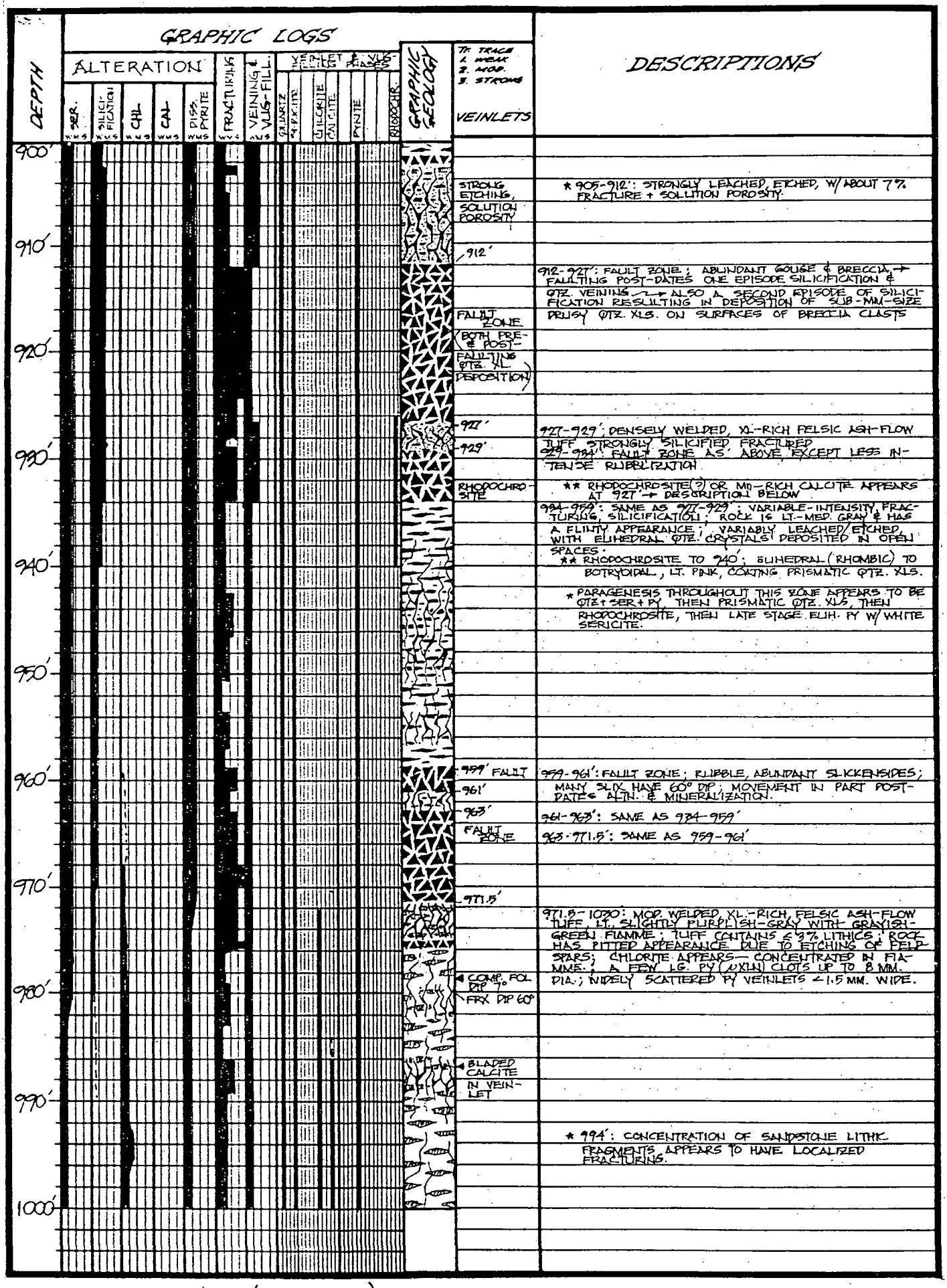
NOTES, COMMENTS	DESCRIPTIONS
LEACHED, VUGGY SILICIFIED	
810'	
	810–814': WEAKLY- TO NON-WELDED ASH-FLOW TUFF; EQUIVALENT OF OVERLYING ROCK
FRX. DIP 60 & 65°	★ 811–814': QTZ-SER ALTN. INCREASES
	★ 813–813.5': SHEARED, FRACTURED, VERY HEAVILY SERICITIZED.
HYDROTH. BRECCIA	814–817': MOD. WELDED ASH-FLOW TUFF; OTHERWISE SAME AS ABOVE.
FAULT, DIP 70°	817–819.9': HYDROTHERMAL BRECCIA DIKE AT 70°.
	819.5–820': EXTREMELY VUGGY ETCHED SILICIFIED DENSELY WELDED ASH-FLOW TUFF; EUHEDRAL, PRISMATIC QTZ. XLS. UP TO 1 CM IN DIA. IN THE VUGS
LEACHED, VUGGY; ABUNDANT QUARTZ CRYSTALS	★ 819.5–820.5': FAULT, DIP 70°
828'	828–862.8': DENSELY WELDED, CRYSTAL-RICH, FELSIC ASH-FLOW TUFF; FRACTURED, SILICIFIED, QTZ-SERICITIZED
	★ 834.5–847': FRACTURES ARE DOMINANTLY HIGH-ϕ; MOST DIPS FROM 60–70° (FULL RANGE IS 45° TO VERTICAL).
LEACHED, VUGGY	★ 838': PSEUDOMORPHIC "SHELLS OF PRISMATIC QTZ, MATTED TO FORM HOLLOW RHOMBOHEDRONS; THESE ON QTZ-SER FRACTURE COATING.
1.5 X 0.5 CM QTZ VNLT ON 75° FRAC/ VNLT	★ 847–852': 90% OF FRACTURES DIP > 70°
COMPACTION FOLN. DIP IS 0–5°	
862.8'	862.8–869.5': MOD. WELDED FELSIC ASH-FLOW TUFF, OTHERWISE SAME AS 828–862.8'; ROCK IS INTENSELY FRACTURED & ETCHED/LEACHED — A ZONE OF DISSOLUTION POROSITY. STRONG PREFERRED ORIENTATION OF FRACTURES — MOST ARE > 70° IN DIP; FRACTURE PLUS SOLUTION POROSITY IN THIS ZONE LOCALLY > 15% → AVG. ≈ 10%).
STRONG LEACHING, SOLUTION POROSITY	
869	★ VEIN/VUG MINERAL PARAGENESIS THIS ZONE IS QTZ ± SER, → PRISMATIC QTZ XLS → LATE SER.
	869.5–912': MOD.– DENSELY WELDED, XL-RICH, FELSIC ASH-FLOW TUFF
	★ 881–898': ZONE OF STRONG FRACTURING, SILICIFICATION & VEINING → SOME ETCHING BUT NOT AS INTENSE AS ABOVE. ABUNDANT QTZ-SER ± PY VEINLETS W/ EUHEDRAL QTZ. XLS. COMMONLY UP TO 10MM. IN LENGTH. MOST FRACTURE & VEINLETS NEAR-VERTICAL.
ABUNDANT QUARTZ VEINLETS	
MODERATE SOLUTION POROSITY	★ 882.5–883.5': ≈ 10 MM-WIDE, VUGGY QTZ. VEIN WITH XLS. UP TO 15 MM LONG; EUHEDRAL, PRISMATIC).

DRILL HOLE VC-2B (FIELD LOG)

LOCATION VALLES CALDERA, N. MEXICO

LOGGED BY J. HULEN, J. GARDNER

08/14/88

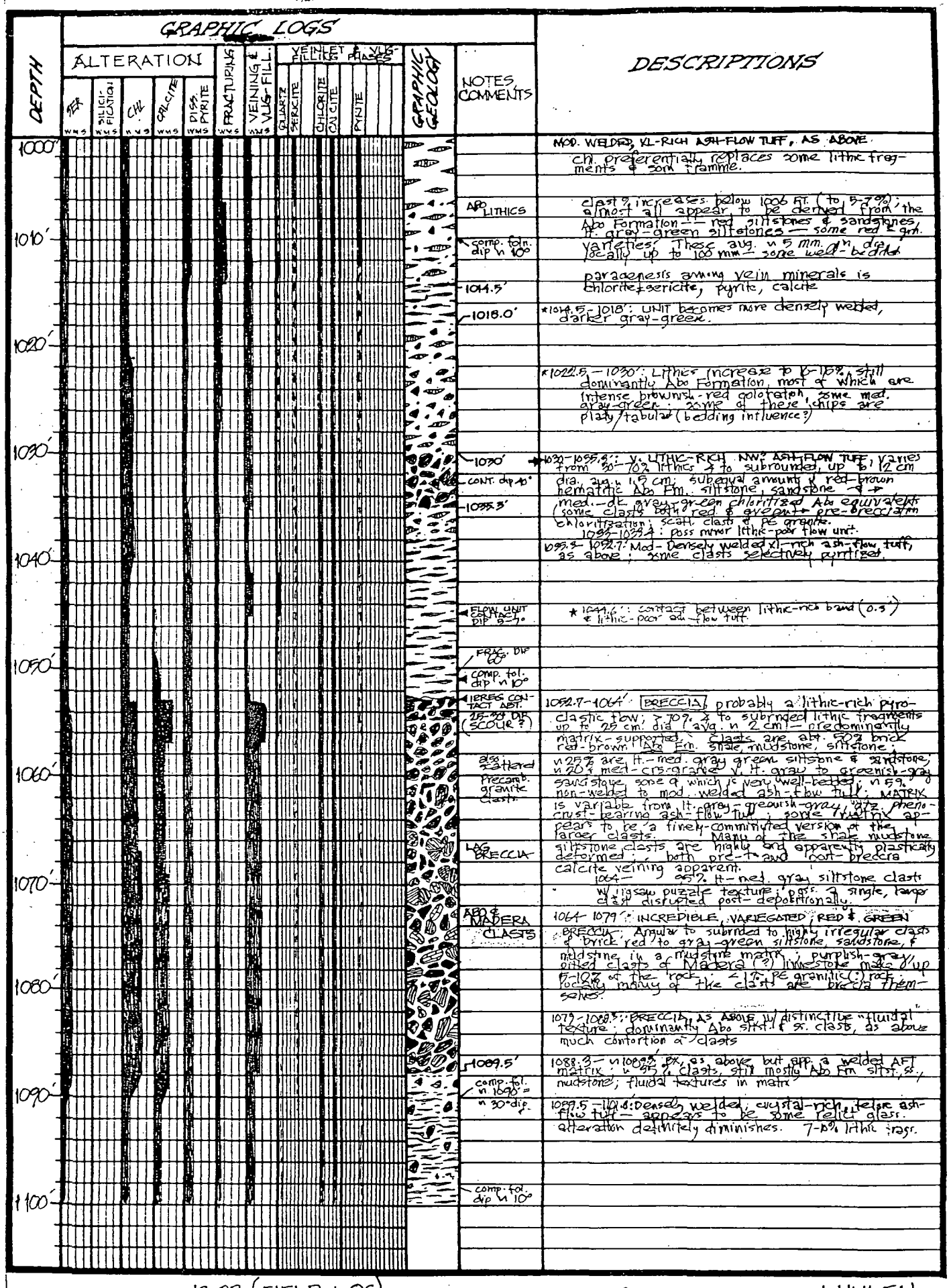


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J. HULEN, J. GARDNER

08/10/88

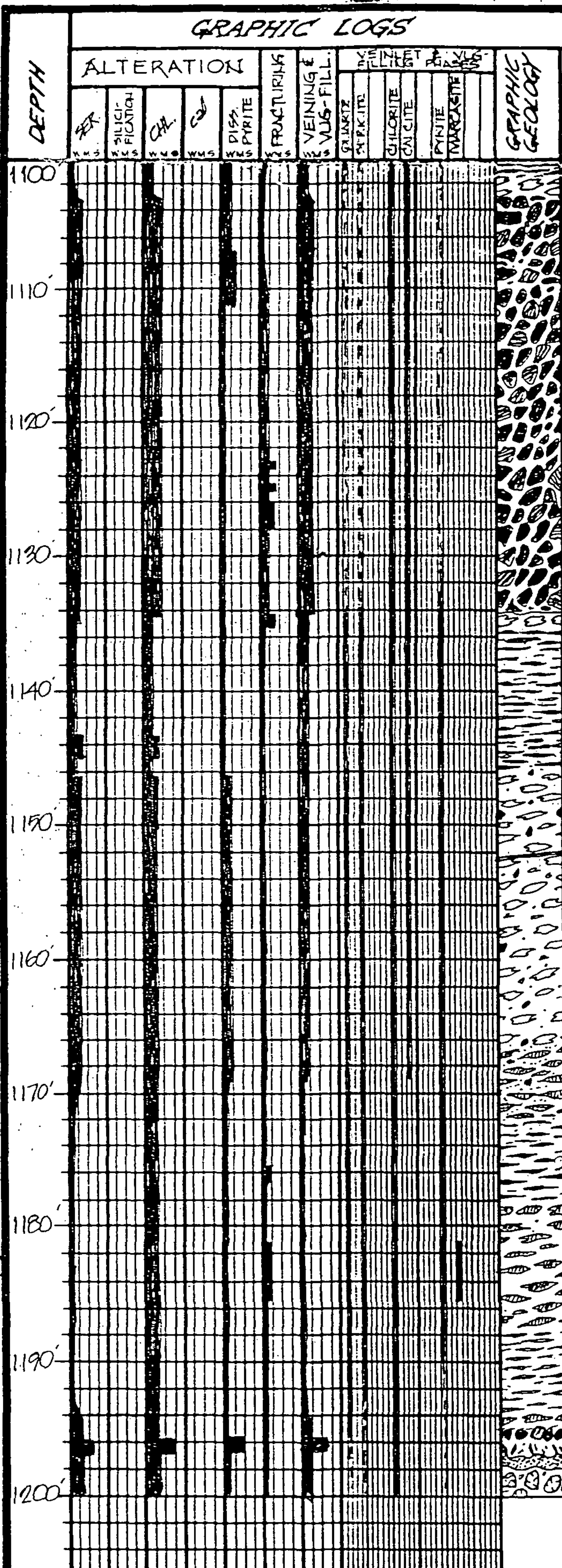


DRILL HOLE YC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. HULEN, J. GARDNER

08/12/88



DESCRIPTIONS

1101.1–1101.8': concentration of fiamme

"sinking" of vitrophyre clots into underlying tuff: – K. Wohletz –

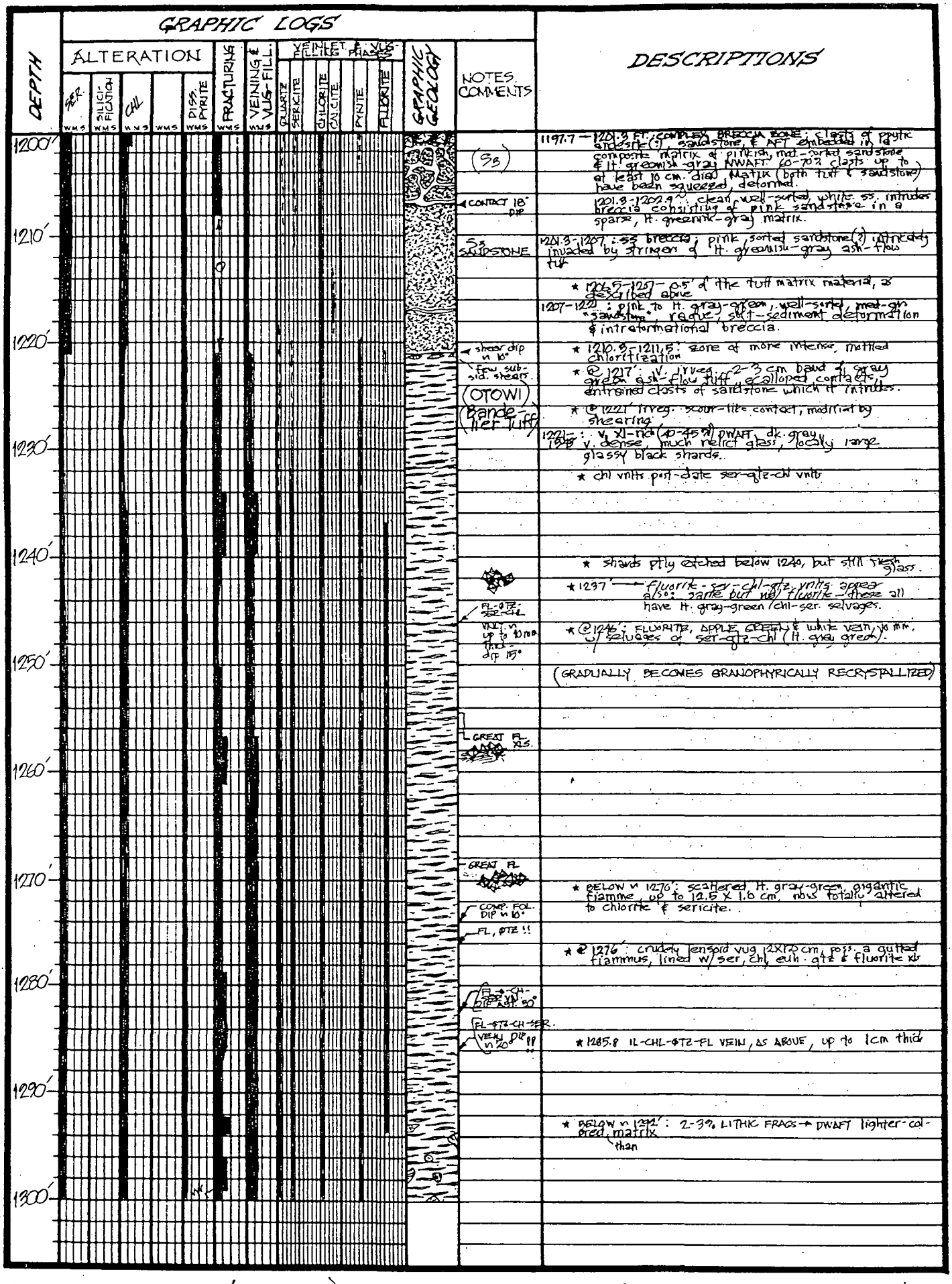
NOTES COMMENTS	DESCRIPTIONS
dip n 10° comp. fol.	DW AFT as above; 1101.8–1103.2': Non- to poorly welded tuff, otherwise same as above, – lt. pinkish-gray; lithics increase w/ depth
1103.2–1134.2'	1103.2 – PYROCL BRECCIA, ESSENTIALLY IDENTICAL TO 1052.7–1064'; dominated by clasts of Abo Fm, both brick red & gray-green; some ss., v. well-bedded; matrix appears to be mixed clastic & tuffaceous w/ abundant bipyramidal quartz phenocrysts. COARSE, UNSORTED, w/ clasts up to 25 30 cm in diameter.
Frac w/ 15–20° dip.	
BRICK-RED COLOR DOMINATES	
MOSTLY ABO-DERIVED	* note: quite possible some of the coarser ss clasts, esp. those well-bedded are from the Santa Fe Sandstone
(@1134.2) CONTACT n 35° DIP	
	1134.2–1135.2 NW lithic-rich FELSIC Ash-flow tuff, lt.–med. pinkish to purplish-gray; 10–15% lithics, up to 10 cm. dia mostly Abo ss, siltstone; (see drawing at left)
comp. foln. dip n 5°	
• GLASSY	1135.2–1166.8 DW AFT (glassy) below 1136 FT dark, slightly brownish-gray coloration w/ fiamme common dk. gray-green. Very crystal-rich (30–35% xls) – also shows bipyramidal qtz. phenos. 2–3%
bleached, lt. gray-green	–1166.5'
	1166.8– NW AFT, slightly pitted, etched, FRX enhanced by leaching.
PYRARGYRITE? PROUSTITE ??	★ @1152': QTZ-PYRITE-SER VNLT, DIP n 20°; SCATTERED MICROCRYSTALS, DK. GRAYISH-RED W/ BRILLIANT RED INTERNAL REFLECTIONS. POSSIBLE PYRARGYRITE-PROUSTITE
	• NOTE CORRELATION WITH ZONE OF NO WELDING
FRAC DIP 57°	
FRAC. DIP 78	1166.5–1172': Becomes mod. welded
	1172–1179' DWAFT, same as 1135.2–1166.8, except 40–45% phenocrysts, 7–10% of which are qtz., commonly bipyramidal
COMP. FOLN DIP n 10°	
1' ZONE MOD. WELDING	1179 – 1188 – MWAFT
	1181.4–1186: Frac/vnlt dipping n 65°, coated with gray-green ser (± chl), prismatic qtz., pyrite, & "rose-like" aggregates, up to .5 mm. in dia, consisting of flakes/plates of MARCASITE
	1188–1193.9 – DWAFT
comp foln dip n 20°	
	1193.9 – 1194.9 – MWAF
–1194.9 –1195.9	1194.9–1195.9: NW, v. lithic-rich AFT, 60% ang to subrnd. frags up to 30 mm. dia (avg. 1.5 cm) → n ½ lt. reddish well-sorted ss. n 25% pyritic, intm-comp. volc. rx. (Paliza Canyon?); n 15% massive, fxl, dk. gray-green chlorite clasts (argillite? mudstone); NW lt. gray-grn. ashy matrix w/ qtz bipyramids.
–1196.8 –1197.7	1195.9–1196.8 v. unusual, dk gray-green & med. green tuff(?) w/ stringers of injected sand(?) – think lithic in surge.
(S8)	1196.8–1197.7': v. lt. sl. pinkish-grey med-gr. well-sorted sand, app injected into overlying breccia

DRILL HOLE YC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. HULEN & J. GARDNER

08/12/88

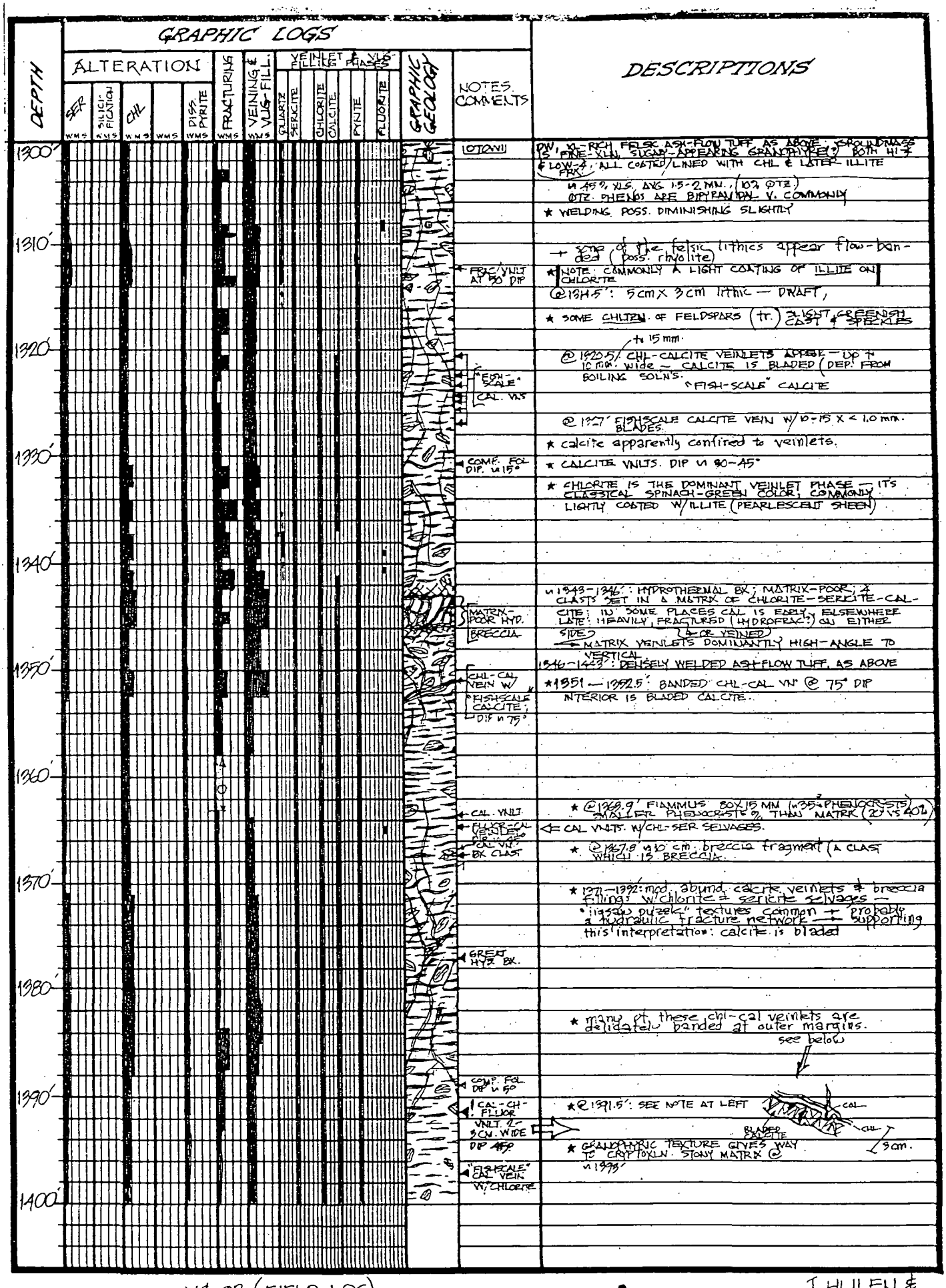


DRILL HOLE VC-2B (FIELD LOG)

LOCATION

LOGGED BY J. HULEN & J. GARDNER

AUG. 13, 1988

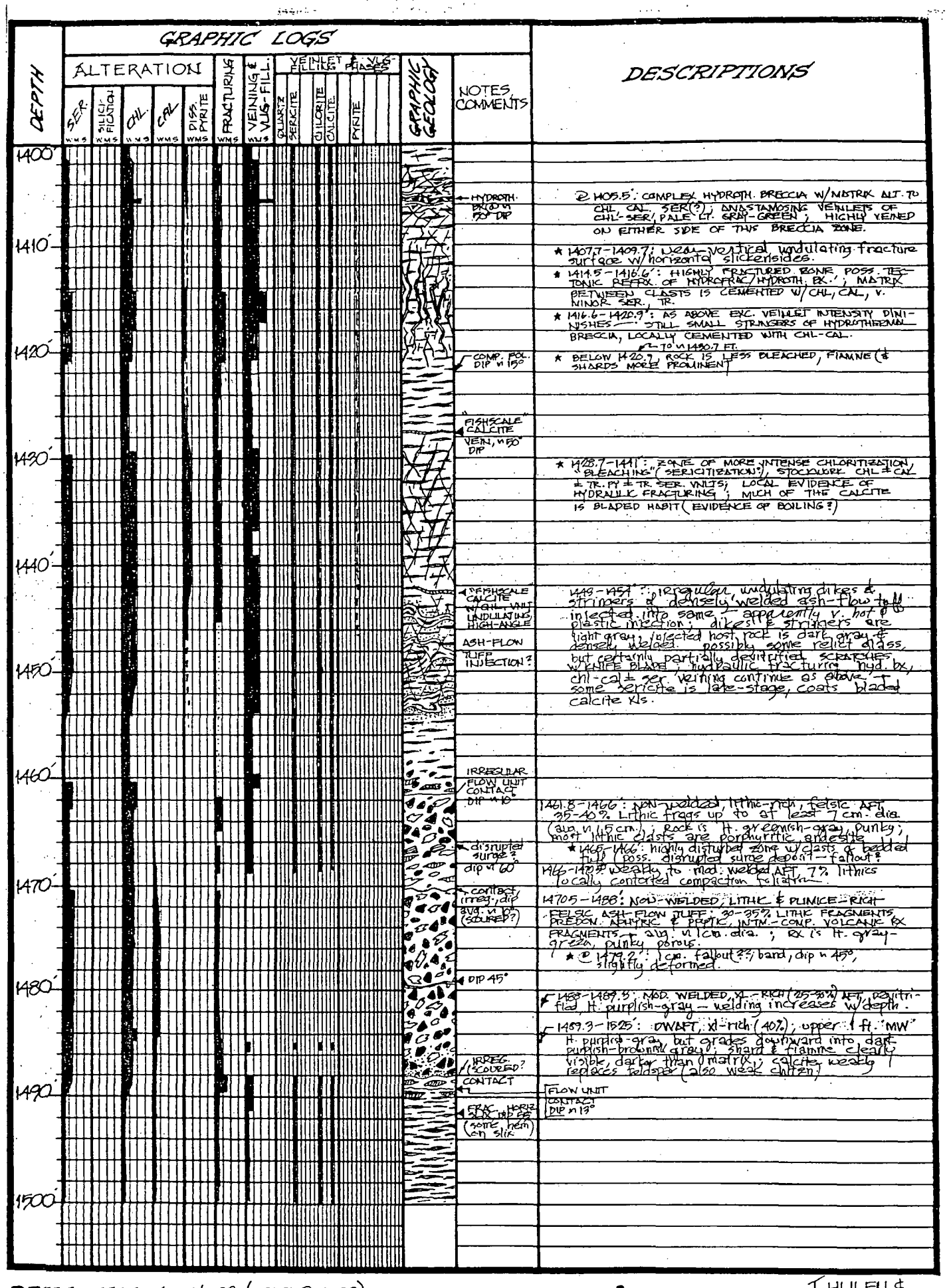


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEXICO

LOGGED BY J. HULEN & J. GARDNER

AUGUST 14 & 15 1988

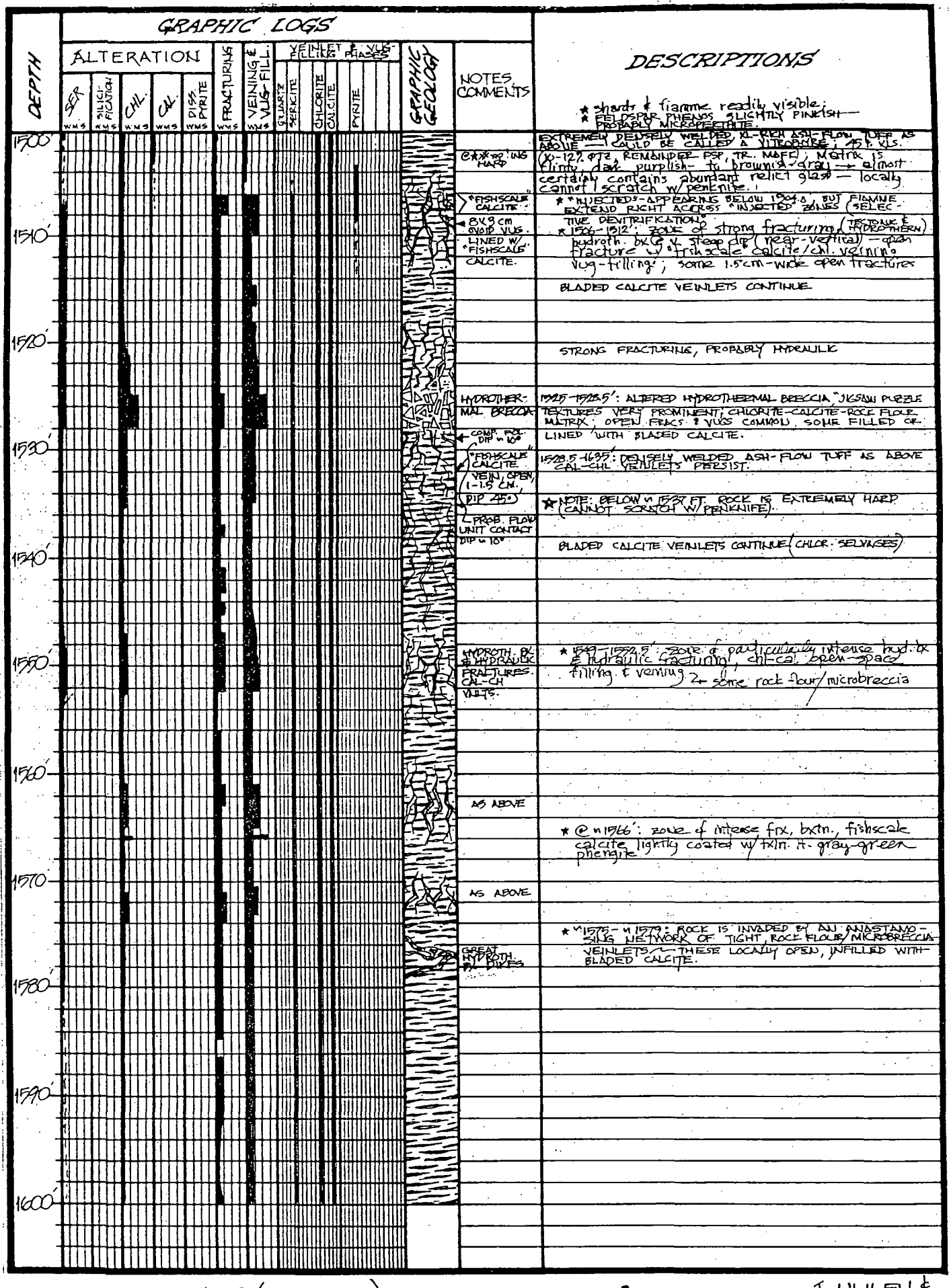


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM.

LOGGED BY J. HULEN & J. GARDNER

AUG. 15, 1988
16 & 17

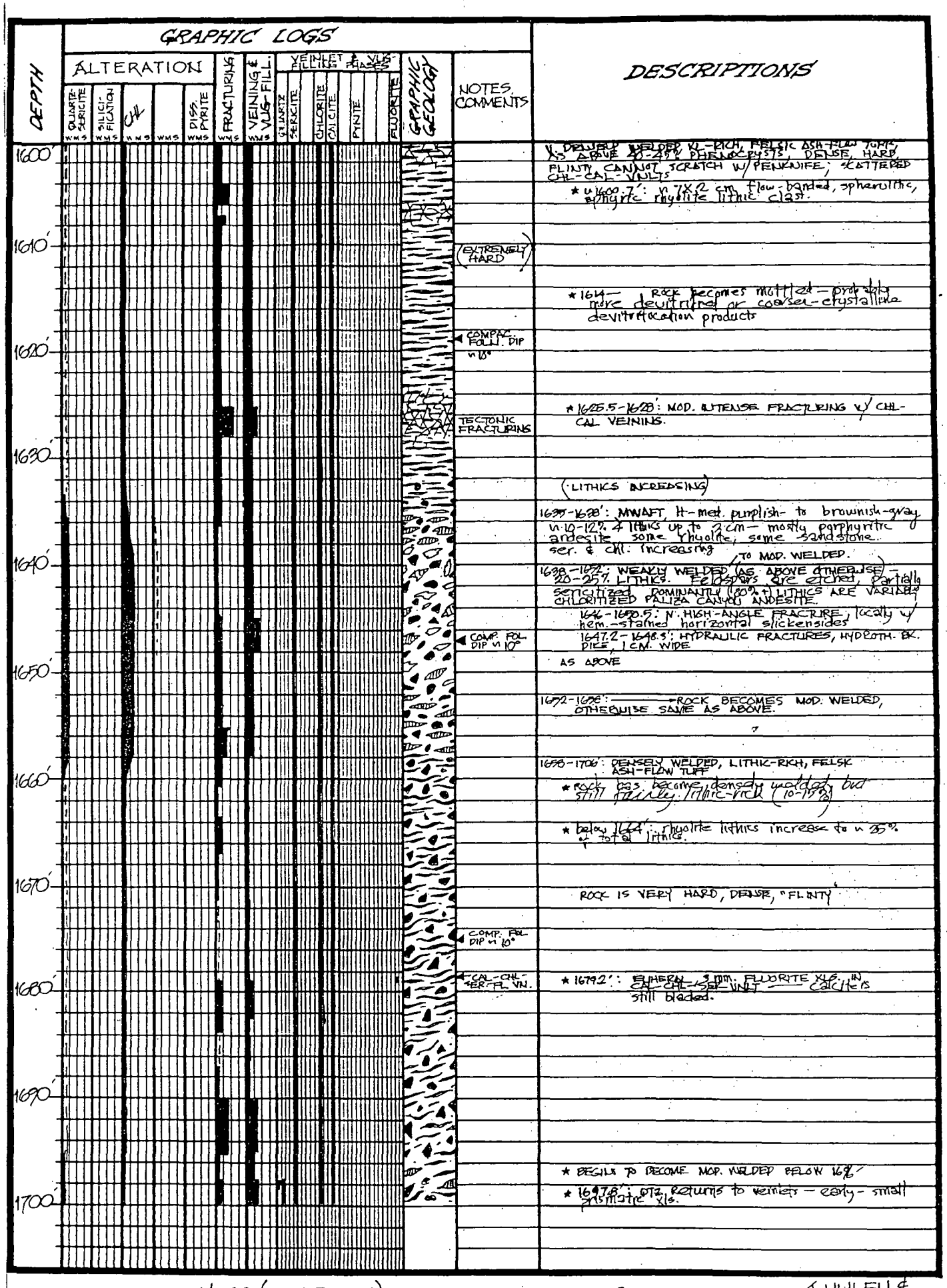


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM.

LOGGED BY J. HULEN & J. GARDNER

AUGUST 17, 1988 & 18



DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEXICO

LOGGED BY J. HULEN & J. GARDNER

AUG. 18, 1988

GRAPHIC LOGS

DEPTH	ALTERATION: SER	ALTERATION: SILICIFICATION	ALTERATION: CHL	ALTERATION: CAL	ALTERATION: DISS PYRITE	FRACTURING	VEINING & VUG-FILL	VEINLET FILLING & VUG PHASES: QUARTZ	SERICITE	CHLORITE	CALCITE	PYRITE	GRAPHIC GEOLOGY	NOTES COMMENTS	DESCRIPTIONS
1700'														CAL-CHL-SER-QTZ-PL VNLT, 45° DIP	
															1706-1744.8': MW LITHIC-RICH ASH-FLOW TUFF, R.-MED. PURPLISH-GRAY; MOTTLED TOWARD UPPER CONTACT W/ LIGHTER COLOR BELOW; FIAMME AND SOME LITHICS SELECTIVELY CHLORITIZED; VARIOUS ALTN. INTENSITY INCREASES W/ DECREASE IN WELDING.
1710'														** 1719-1718 CORE TUBE TOO HOT TO HANDLE FOR ~80 MINUTES	• @ 1706' — APPEARANCE OF BRICK-RED HEMATITIC OXIDIZED PORPHYRITIC VOLCANIC ROCK. (NOTE): BELOW 1715' ROCK IS MORE BLEACHED-APPEARING LT. PINKISH-GRAY; CHLORITIZATION INCREASES; FELDSPARS PITTED, PARTIALLY SERICITIZED.
1720'															• DISS. PY & FY IN VNLTS. RE-APPEARS @ ~1710'
														FRAC. DIP 59°	★ HABIT OF CALCITE CHANGES — MORE SOLID, PLATY, INTERGROWN WITH
															• FSP. ETCHING INCREASES BELOW 1726'
														FRAC. DIPS: 83° & 70-90	★ ROCK IS NOW LT. PINKISH-GRAY W/ DISTINCT LT. GREENISH-GRAY FIAMME; LITHICS DECREASING.
1730'															
															• 1739 ± 2 CHL-SERICITIZED PERLITE CLASTS, CELLULAR STRUCTURE CLEARLY PRESERVED; PROBABLE OPALINE SILICA PRESENT.
1740'															
															1744.8-1802.5' DENSELY WELDED XL-RICH (~20%) FELSIC A.F.T., MED.-DARK PURPLISH TO BROWNISH-GRAY MAJ. FIAMME (BUT NOT ALL) ARE CHLORITIZED → MAY HAVE GLOBULAR/VESICULAR TEXTURE; LITHICS HAVE DIMINISHED TO ~ABOUT 5%
1750'														blocky to bladed calcite	
														comp. fol. dip ~10°	
1760'															
														BLADED CALCITE	
															• BELOW ~1768 FT. — VARIABLE DIPS ON COMPACTION-FOLIATION — POST-COMPACTION FLOWAGE?
1770'														LARGE FIAMME DIP: 45°	• LITHIC % DROPS TO <1%
														COMP. FOL. DIP ~20°	• 1770': ONE LARGE FIAMME CHANGES DIP FROM 10-45°
														COMP. FOL. ~45°	• BELOW ~1775 FT. FSPS. SL. ETCHED-APPEARING, PARTIALLY SERICITIZED & CHLORITIZED.
														(PLASTIC FLOWAGE?)	
1780'														COMP. FOL. ~35°	
															• @ 1786': 5-7% QTZ. PHENOS., 30% TL. PHENOS.
														COMPACTION FOL. DIP ~25°	★ 1786.5-1787.7: COOLING BREAK — GOES FROM DENSELY TO MODERATELY WELDED.
1790'															★ 1788.5-1797.5: RK IS HIGHLY FRACTURED, VEINED W/ CHL, CAL, SER; IN THAT ORDER) 90-95% TL. PHENOS
														SLIPPERY FRACTURES	
														DOMINANTLY VERY HIGH ANGLE	• @ 1794': 5-7% QTZ. PHENOS; AVG. SIZE (EUH) ~1.5 MM. UP TO 5 MM.
1800'															COMP. FOLN. FLATTENING OUT

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

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

AUG. 19, 1988
20,

GRAPHIC LOGS

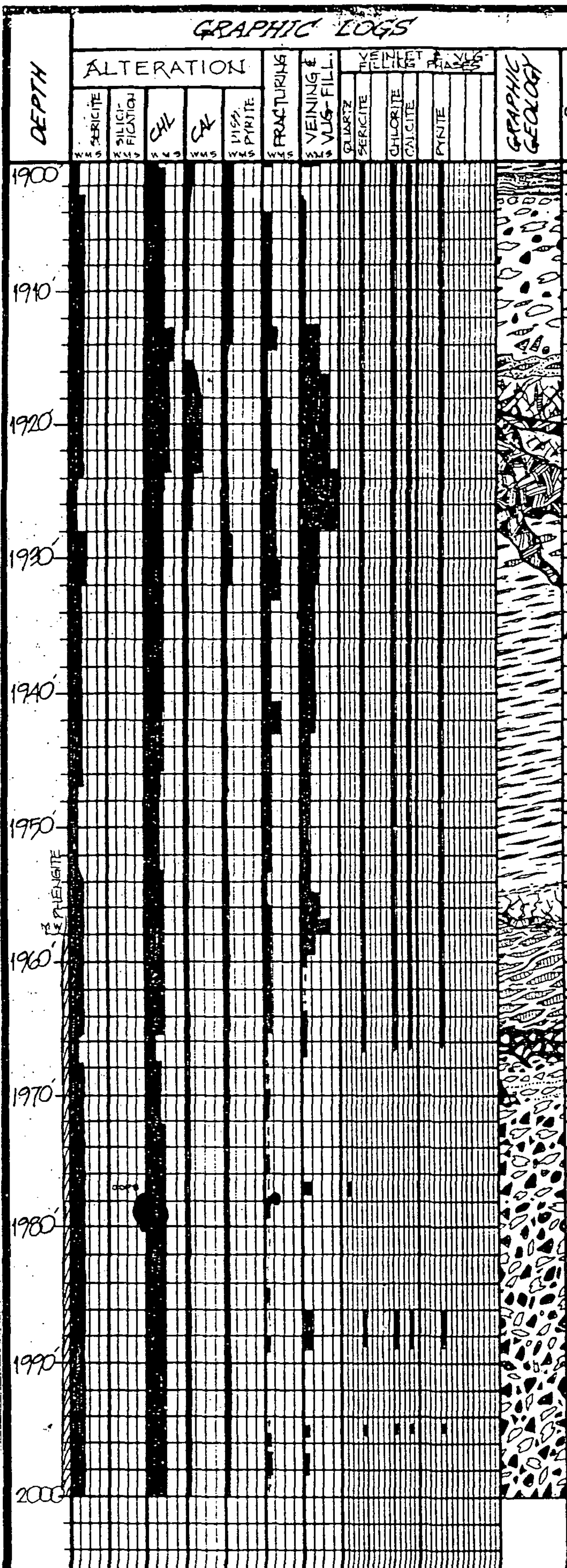
DEPTH	ALTERATION: SERICITE	ALTERATION: SILICIFICATION	ALTERATION: CHL	ALTERATION: CAL	ALTERATION: DISS. PYRITE	FRACTURING	VEINING & VUG-FILL	VEIN/FILLING & VUG PHASES: QUARTZ	SERICITE	CHLORITE	CALCITE	PYRITE	GRAPHIC GEOLOGY	NOTES COMMENTS	DESCRIPTIONS
1800'														COMP. FOL DIP ~ 10°	DWARF, AS ABOVE. 7-10% PHTZ. PHENOS. 35-40% TL. PHENOS, AVG. ~ 1.5 MM DIA. MAX. ~ 3 MM.)
													CAVED RUBBLE	NOTE	★ 1802.5-1804.5': CAVED RUBBLE EXTENSIVELY GROOVED, GROUND & SMOOTHED BY THE BIT
															1804.5-1822': MOD. WELDED, XL-RICH, FELSIC ASH-FLOW TUFF SIMILAR TO ABOVE; TL. PHENOS 25-30% QTZ. 3-5%? ETCHED FSPS.; PHENOS. AVG. ~ 1.5 MM. DIAMETER
1810'														HYDR. BX.	★ 1807.5-1808': HYDROTH. BRECCIA. CHL-CAL-SERICITE PY VEINLETS
															★ 1813.6-1823': ROCK IS bleached, appearing MORE heavily chloritized & sericitized, FSPS: etched, sericitized → also: ← ONLY ~ 20% PHENOS. (3-4% QTZ) - smaller AVG. DIA. than above & below (~1-1.5 mm)
1820'															
1830'														COMP. FOL DIP ~ 30°	1823-1892' DENSELY WELDED XL-RICH (40%) AFT AS ABOVE; ALTN. DECREASES, AS DOES FRACTURING & VEINING. CLEAR CORRELATION OF INTENSITY OF WELDING W/ INTENSITY OF ALTERATION.
															★ 1828-1829': Rock is bleached — obvious inverse relationship to high-Y frx. (Variably)
W-															1892-1896' V. complex zone of alternating, mod-welded, non-welded, & densely welded ash-flow tuff. mottled purplish- & gray-green: increase in alteration
1840'														comp. fol. dip ~ 30°	
															★ 1839.1-1841.1': zone of hydroth. bx cemented w/ chl, cal. & sericite. (V. LARGE — up to 25 mm. max. dia.)
															★ ~1845.2': 0.5-1 cm band of chlitzl. pumice (a concentration → train)
1850'														comp. fol. dip 40-50°	← for only ~ 1.5 ft.
															★ 1846-1846.3': ft. gray-green intrusive(?) pyroclastic band — see drawing at left.
														gray-grn surge(?) dip 35°	★ 1849.5': 1 cm-wide gray-green band, poss. a surge deposit (to check out!); IRREG. BLEACHING OF WALL ROCKS OUT TO A DISTANCE OF ABOUT 2 CM.
1860'															1876-1899.7': MOD. WELDED, XL-RICH, FELSIC ASH-FLOW TUFF. MED. PURPLISH-GRAY W/ SL. GREENISH TO PURPLISH-GRAY MUD. LIGHTER FIAMME ↑, 35% PHENOS TOTAL — ~5% QUARTZ
														HYDROTH. BX	★ 1866-1867': HYD. BX. healed w/ chlor. & calcite
1870'															★ 1869-1888': APPEARANCE OF CHL-RICH, MOTTLED, PLASTICALLY DEFORMED CLASTS, POSSIBLE LOCAL PERLITIC TEXTURE. SOME ARE DEFINITE FIAMME. ← ALSO LIKE THIS
															(ROCK IS CLASTS) V. CHLORITIC — MOSTLY IN FIAMME & GLASSY, PERLITIC
1880'															★ 1879' → brick red chl, hem. on frac. surface.
														COMP. FOL DIP ~ 45°	★ 1881'-0.2' zone of 65% + crystals
															★ 1884.5-1890': +5% of the chloritized mafic(?) glass blebs
1890'															★ 1896': 8 cm rounded pptic andesitic clast w/cal. vn. cut off at clast margins.
1900'															★ 1899.5 FT.: HYDRAULIC FRX; MINOR HYD. BX.

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. HULEN & J. GARDNER

AUG 21, 1988 22



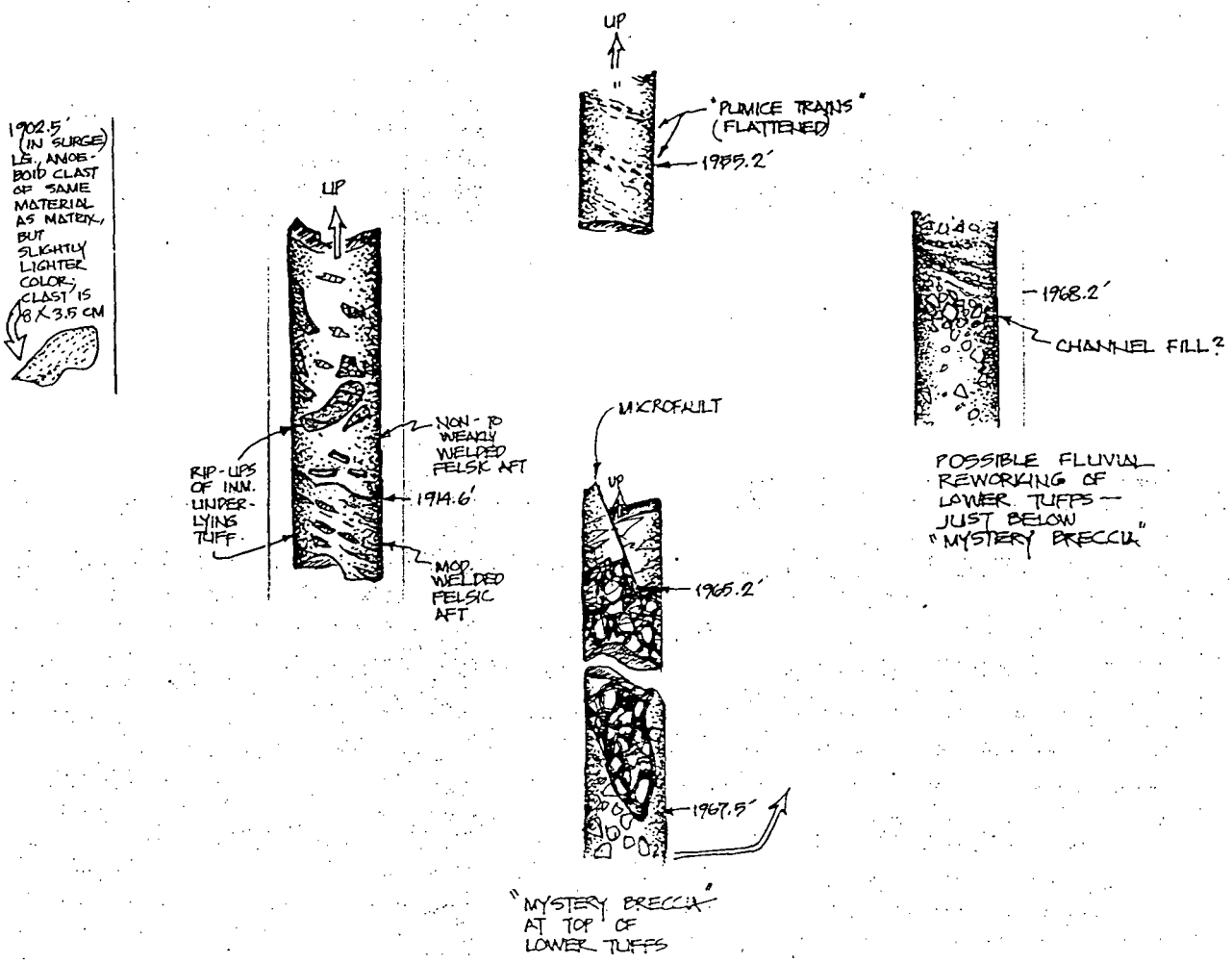
NOTES COMMENTS	DESCRIPTIONS
CONTACT DIP ~ 30°	1899.7–1901': DENSELY WELDED, XL.-RICH, FELSIC ASH-FLOW TUFF W/ HIGHLY CHLORITIZED FIAMME — RIGHT TO CONTACT
" IRREG. <10°	DEF. CONCORDANT. 1901–1902.6': PYROCLASTIC SURGE DEPOSIT, DOMINANTLY FINE-
	MED. SAND SIZE CRYSTAL & LITHIC CLASTS W/ ~15% COARSER CLASTS UP TO 4 CM AVG. ~7 MM., UPPER 0.2'
	OBVIOUS LOW ∡ X-BEDDING, VAGUE BEDDING LOCALLY PRESENT THROUGHOUT; SCATT. ACCRET. LAPILLI UP TO
	5 MM. DIA. 1902.6–1902.8': AS ABOVE BUT FINER-GRAINED SOME
COMP. FOL. ABT. 45°	FLATTENED, CONCORDANT PUMICE UP TO 2 CM. LONG. — V. OBVIOUS LOW-∡ X-BEDDING.
	1902.8–1903.1: PUMICE-RICH UNSORTED BUT POSSIBLE FALLOUT DEPOSIT, IRREG CONTACTS (LOWER & UPPER)
RIP-UPS	∡ TO ROUNDED, CHLTD. PUMICE UP TO 35 MM. DIA., IN FINE-GRAINED MATRIX; ROUNDING OF PUM. MAY ACTUALLY
	POINT TO ASH-FLOW ORIGIN. 1903.1–1914.6 SER-CHLTZD, NON- TO WEAKLY WELDED ASH-
FRX. CONT. DIP 66°	FLOW TUFF, ~3-4% QTZ. PHENOS, 12–15 OVERALL ETCHED PUMICE & FELDSPAR. ~5–7% LITHIC FRAGS.,
	ANDESITE & IGNIMBRITE → ALL CHLORITIZED
VEIN WALL DIP 78°	1914.6–1916.3': XL-POOR intensely chltzd. AFT
	1916.3–1918.3': Xl-rich DWAFT, 35% phenos (7% qtz); lt.-med. gray-green; intensely chltzd.
VEIN DIP ~80	1cm-wide chl-matrix hydroth. bx seam.
COMP. FOL DIP ~30°	1918.3–1919.5': disrupted MWAFT, microfracturing, rehealing w/ chl. uvnlts.; fiamme chltzd.; groundmass
	has pinkish cast — poss. epidote; fiamme oriented chaotically.
	1919.5–1923': AS ABOVE, exc. cut by calcite vein anastamosing calcite vein & auxiliary microveinlets;
COMP. FOL DIP ~40°	host rock intensely chltzd., laced w/ chl. µfractures.
	1923–1928': banded, bladed, calcite vein, steeply dipping, locally v. porous "fishscale" aspect — almost
	10 cm. wide — locally 10% porosity; "jigsaw puzzle" textures common at vein margins
	1928–1932': M-DWAFT, xl-rich chl-sericitized selectively chltzd. fiamme; PERLITIC-APPEARING FIAMME.
	1932–1958' AS ABOVE, BUT DENSELY WELDED: MANY FIAMME LIKE THIS →
	* @ 1947': ROCK BECOMES LESS ALTERED, has purplish-gray matrix & lt. gray-green
COMP. FOL DIP ~53°	fiamme.
	— SEE SKETCH
WELDED PUMICE TRAINS	* 1955.2–1956.2: alternating bands of v. pumice-rich & pumice-poor but distinct banding (see
CAL. VN. HIGH-∡ TO	drawing)
VERTICAL	* 1955.6–1957' highly frxd., calcite veinlets (high-∡)
(OTOWI)	1958–1965.2 MOD. WELDED, VERY PUMICE-RICH TUFF, PROB. ASH-FLOW, BUT POSS. WELDED AIR-FALL; LT. GRNISH-
(GUAJE PUMICE?)	GRAY, 50% + PUMICE — ALSO 25% XLS., INCLUDING 5–7% QTZ MUCH OF WHICH IS BIPYRAMIDAL
	* 1965.2–1967.5 MYSTERY BX; DK. GRAY MATRIX, V. ∡ CLASTS UP TO 2 CM (30–35%): 2–3 mm. app.
BEDDING 20–30°	chill margin @ upper contact; LOWER CONTACT IS VAGUE BUT APPEARS TO BE IRREG. STEEP;
BEDDING 15–20°	DOES, HOWEVER, INTRUDE(?) RX THAT'S ALMOST IDENTICAL.
	1967.5–1970': v. complicated pyroclastic flow (+surge?) interval poss.; local accumulations of fallout pumice — see
	drawing at left; well-defined bedding planes * @ ~1970 — small lobe(?) of black breccia above
	just grazed by hole.
	1970–1972.2: as above, except much finer-gr. — abundant pumice trains
(LOWER	1972.2–2002.6': V. LITHIC-RICH, NON-WELDED, ASH-FLOW TUFF PUNKY, POROUS, CHLTZD.; 30–40% LITHICS, SOME PPYTIC
TUFFS)	ANDESITE, SOME SOFT, WAXY, BLACK CLASTS; ABUND. PUMICE
	* 1995–1995.7': DWAFT LITHIC FRAGMENT

DRILL HOLE VC-2B (FIELD LOG)

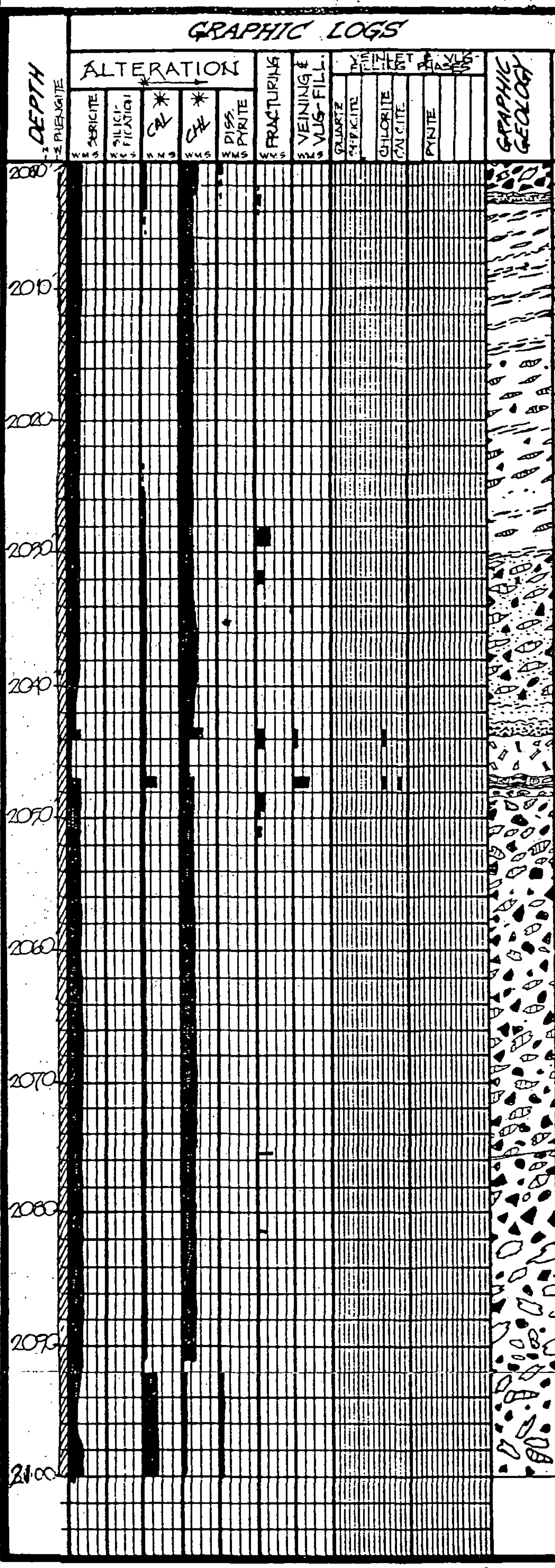
LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

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

AUG. 22, 1988



SKETCHES OF UNUSUAL FEATURES IN THE OTOWI MEMBER OF THE BANDELIER TUFF & IN THE LOWER TUFFS



NOTES COMMENTS	DESCRIPTIONS
	* NOTE: CALCITE & CHLORITE ALTERATION COLUMNS REVERSED ON THIS PAGE
	* LITHICS UP TO 10X5 CM → DOM. PPYTIC, INTM.-COMP. VOLCANIC ROCKS
◄ BEDS DIP 25°	2002.6-2003.3': WELDED SURGES(?): V. WELL-BEDDED, ALTERNATING PUMICE POOR & PUMICE-RICH BANDS 1 mm-10 mm. thick; PUMICE IS HIGHLY FLATTENED, CHLTZD.
◄ DIP 30°	2003.3-2030.5': DISTINCTIVE, PUMICE & XL-POOR, Mod. welded felsic ash-flow tuff, lt. slightly greenish-gray w/ med gray-green flamme. (flamme are gen. small (avg. 3-4 mm in length) unit has bedded aspect due to local concentrations as flattened pumice swarms, overall ~ 7-10% pumice, 5-7% (?) xls. (?) ← vague., 1-2% lithics
◄ DIP 20°	* QUARTZ PHENOS PROB. <2%, <1.5 MM.
(LOWER TUFFS)	* BEDDED ASPECT LESS APPARENT BELOW 215'. LITHICS SLIGHTLY MORE ABUNDANT BELOW 217' (3-4%)
	• (ROCK IS PUNKY, NOTABLY UNFRACTURED & UNVEINED)
◄ DIP 24°	
◄ DIP ~ 20° (PUMICE-SWARM)	2030.5-2041.4' NON- TO WEAKLY WELDED, LITHIC-BEARING (~ 7-9%) FELSIC ASH-FLOW TUFF: LT. GREENISH GRAY, PUNKY, POROUS; CLAST (LITHIC) UP TO 7 CM. DIA.; AVE. ~ 1.5 CM DIA. MANY CLASTS ARE ANDESITE & PPYTIC ANDESITE, OTHERS ARE SS, SLTST.
◄ DIP 33°	2041.4 - 2042.8 FT. XL-RICH, f.-gr., non-weakly welded, pumice-poor, quite well-bedded tuff, but prob. ash-flow.
	2042.8 - 2043.5 FT.: V. XL-RICH (76%) SURGE(??); FAINTLY BEDDED, XLS AVG. ~ 1-1.5 MM., LT. GRAY-GRN.
	2043.5 - 2046.6: PPYTIC DACITE, LT.-MED. SL. PURPLISH-GREY PROB. A LARGE CLAST
◄ FRX W/SLIX 32° DIP.	2046.6 - 2047.3': BRECCIA (PYROCLASTIC FLOW ??); CLASTS OF ppytic andesite, dacite, DWAFT in calcitic, qR. plag.-bearing matrix.
	2047.3 - 2047.8': DENSE, MED. GRAY SURGE (??) FAINT BEDDING
	2047.8 - 2048.3': BX, SAME AS 2046.6 - 2047.3'
	2048.3 - 2209.5': WEAKLY welded, v. lithic-rich, felsic ash-flow tuff; punky, lt greenish-gray; 30% lithics, avg. 1.5 cm - up to 15 cm., 4 to subrnded; mostly intermediate volcanic, some felsic AFT, rare rhyolite; some pumice (ppytic) up to 7-10 CM. in diameter; some black shale clasts
(LOWER TUFFS)	
	@ 2072.5': 2 cm. clast of water-reworked tuff w/ abund. frosted bipyramidal qtz
◄ FRX DIP 70°	* 275.7 - 276.3': fracture w/ 3-5 mm gouge, chlzd, hematized nearby chloritic pumice w/ hem. rims.
	• LITHIC % DECREASES TO ~ 15%.
	NOTE: PUMICES UP TO 4 CM. IN LENGTH
	• 2092 - wk to non welded lithic xtal rich ig. pum/flamme selectively chloritized; pockmarking & etching after felds.
	- 10-20% lithics dom P.C. and. w/ minor welded ig & ss(?); ~2100' some "mafic lithics" appear plastically defm'd; lithics up to ~ 5 cm
	- Xtal content to 2100 ~ 20%

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY HULEN & GARDNER

3 Sept 88

GRAPHIC LOGS

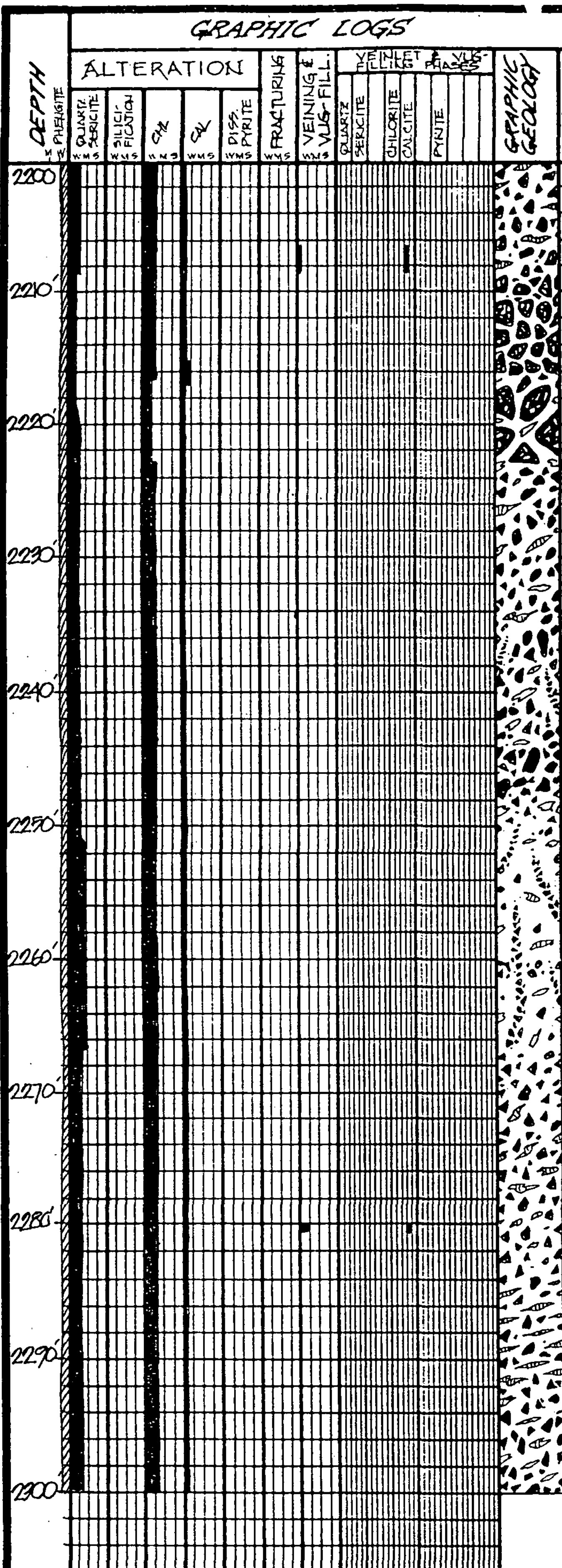
DEPTH	ALTERATION: SERICITE (W M S)	ALTERATION: SILICIFICATION (W M S)	ALTERATION: CHLORITE (W M S)	ALTERATION: CALCITE (W M S)	ALTERATION: DISS. PYRITE (W M S)	FRACTURING (W M S)	VEINING & VUG-FILL (W M S)	VEIN FILLING & VUG PHASES: QUARTZ	SERICITE	RED CLAY?	CHLORITE	CALCITE	PYRITE	FLUORITE	GRAPHIC GEOLOGY	NOTES COMMENTS	DESCRIPTIONS
2100																• comp. fol 22/20	• wk to non welded lithic Xtal rich ig., as above except @ ~2103 Xtal content incr. to 20-30%
																	• 2102 - 2105 subtle inc Abo lithics
																	• 2100 - 2122 odd mix of extremely flattened to non-defm'd pum's; non-wk welded ig. contains bi-pyr. g's fm's.
2110																	
																	• @ 2113.5 pink veining appears (called "red clay?")
																	• ~2116 trace bladey cc in vein; bladey c.c. vein ~ 0.5cm wide & ~ 4cm. long @ ~ 2117
																	• 2117 dec lithic to ~10%; still 90% P.C. and 5% ss (Abo?) 5% welded ig + pf frags.
2120																	• 2120 - 2122.5 spotty but pronounced etching of felds.
																	→ cc alt. mainly confined to chlor. fiamme
2130																	• 2132 rx becomes mod-densely welded, Lithic (10%) Xtal (20-30%) ig.
																• comp. fol 10-20°	
2140																• red fm @ 70°	• 2142 chlr. lite, but many mod welded pums still selectively chloritized & sericite? w/lite etching of felds & cc.
2150																	• red veining parallels compaction foliation w/10° to 20° dip
2160																• comp fol. 10°	• rx as above from 2132 excapt cc in lithics & fiamme subtle increase
																	• 2165.3: 6cm red (Abo) ss. clast w/1cm thick chlorite halo
2170																	• from 2173 lithics up to 10 cm; subtle incr in welding
																	• from 2175 incr. large fiamme (up to 10cm!)
2180																	• 2181 - 2185: cont 0.5 to 1 cm wide "fish scale"
																← "FISHSCALE" CALCITE W/ FLUORITE IN VEINS	calcite vein w/ green fluor. 2183-2184' prominent "pinch & swell"
2190																• COMP. FOL DIP @ 20°	
																	• pumice locally prominently etched., fps. lightly etched
2200																	

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY GARDNER, HULEN

3 Sept 88, 8 DEC. 88



NOTES COMMENTS	DESCRIPTIONS
	TO 2209.5: SAME as above
	• 2193-2195 grad. incr. from ~7 to ~20% lithics. • 2195-2204 20% lithics
COMP. FOLN. VAGUE;	• 2204-2209.5 – 25% to locally 30% ‖ dom. ppytic andesite, lesser basalt, dacite, rhyolite.
DIP 10-15°	• note: range in size from <3 mm to 6 cm & poss. larger – mostly avg. ~15 mm.
	2209.5-2223.2' very lithic-rich NWAFT; 60-70% LITHICS, angular to subrounded, 4 predominating; size range from <3 mm to cm; avg. 5-6 cm. dominantly porphyritic andesite, subordinate aphyric to porphyritic basalt; minor dacite, which is lighter gray & commonly contains hornblende & more coarsely porphyritic; minor flow-banded rhyolite; tr "snowflake"-devitrified rhyolite; some hornblende appears quite unaltered; many clasts are brecciated & hydrothermally veined prior to incorporation; some vesicular basalts contain vesicles which may be filled w/ both zeolite & calcite; some pre-AFT chl. veining of lithics.
	• @ 2213 FT: 5 cm. devitrified rhyolite w/ <1% BIPYRAMIDAL QUARTZ PHENOS. 1.5-2 MM!
	• clast color: andesite: med. to dark purplish-gray dacite: lt. greenish-gray; rhy – lt. pinkish gray.
	• 2216-2223.2': small clasts dramatically diminish, large ones increase; still ~60% clasts, but these up to 25 cm in dia. – 90% porphyritic andesite, but one is a bxtd. granitic rock (PE) ↳ & DACITE.
	2223.2-2251': LITHIC-RICH weakly to mod. welded rhy. ash-flow tuff similar to that above 2209.5'
(FINES-DEPLETION)	~30% lithic fragments, <3 mm to 7 cm., avg. ~1 cm. compositions & textures as above except as
(degassing)	noted below. • 2223.2 – ~2234: 5-10% lt. gray-green, bleached-
comp. fol. ~20°	appearing clasts of felsic volcanic rx poss. aphyric rhy – rare qtz & fsp. phenos.
	• 2237.4-2237.9': 1 irreg. 1 cm-wide zone of clast enrichment @ ~65° to core axis (DEGASSING PIPE)
	• 2239.4-2239.7': as above
LITHICS DROP TO ~20%	• 2248-2250': lithics drop grad. from 20-10%.
	2251-2266.7': REL. LITHIC-POOR (≤10%) AFT, AS ABOVE W/ ABUNDANT "DEGASSING PIPES" within which lithics reach 50%. – these pipes are irreg. >60° to core
(FINES DEPLETION PIPES) (degassing)	axis, up to 15 mm wide; matrix selectively "soaked" with calcite.
COMP. FOL. ~20°	
	• 2260-68': 20% lithics
	2266.7-2434': LITHIC-RICH AFT, SAME AS 2223.2-2251'. (FELSIC, PUNKY)
POSS. BLACK SHALE FRAGS.	
	★ 2280-80.5': 5 MM. CAL. VN., BANDED, W/ CHL. SELVAGES.
	★ 2285-91': SLIGHT increase in welding
COMPACTION FOLIATION DIP 10-20°	
ABUNDANT RHYOLITE CLASTS	★ 2292-2301': abundant rhyolitic clasts (10-15% of total clasts), lt. gray-green w/ sparse, small qtz. phenos. (Bearhead or Canovas Canyon rhy?) (Keres Group)

DRILL HOLE VC-2B (FIELD LOG)

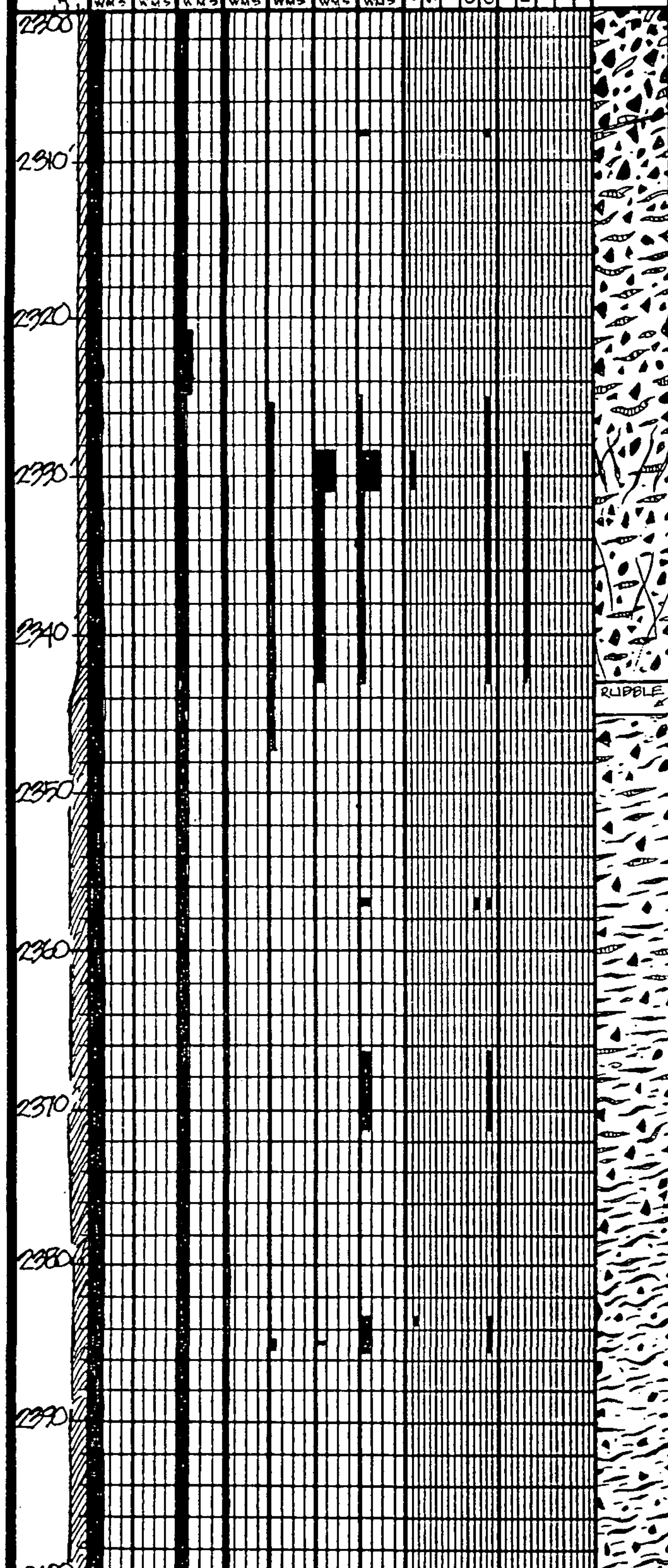
LOCATION SULPHUR SPRINGS, VALLES CALDERA

LOGGED BY HULEN, GARDNER

8 DEC. 1988

GRAPHIC LOGS

DEPTH | ALTERATION: PHENGITE, SER, SILICIFICATION, CHL, CAL, DISS. PYRITE | FRACTURING | VEINING & VUG-FILL. | VEINLET & VUG-FILLING PHASES: QUARTZ, SERICITE, CHLORITE, CALCITE, PYRITE | GRAPHIC GEOLOGY | NOTES, COMMENTS | DESCRIPTIONS

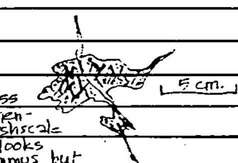


NOTES, COMMENTS

- ← "SHEAR ZONE" (~2306')
- COMPACTION FOLIATION DIP ~ 10-15° (VAGUE
- ← FRX, VEINLETS DIP 60-70° ⇑ ✓FOR CORRELATION W/ TEMP. LOG
- PROBABLE DRILL-INDUCED (RUBBLE)
- COMP. FOL DIP ~ 10°

DESCRIPTIONS

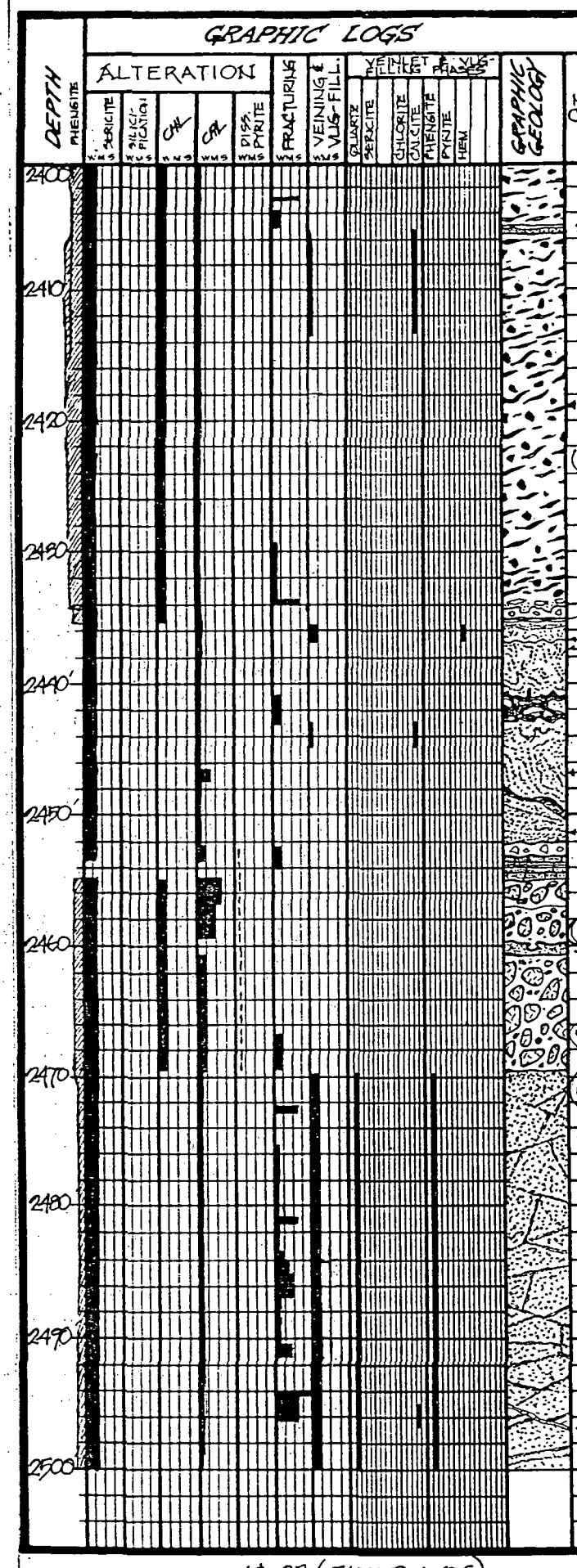
- 2306 – ~ 2311': enrichment in light grey-green rhyolite clasts, as above
- 2307.5 – 2308': IRREG. SHEAR ZONE PARTLY OCC. BY CAL VNLT. ~ 70° DIP.
- Below 2311': welding increases to mod. intensity lithics decrease to ~15% (to 2325 FT.)
- BELOW 2325': LITHICS DECREASE TO ~ 10%
- 2328.5 – 2331': zone of mod.-int. fracturing, veining – frx hackly, irreg. but most dip 60-70°; most are partially coated w/ fishscale calcite (late); brownish-gray microxln. silica, local euhedral qtz < 1mm. long; tr. pyrite only on fractures; possible trace cpy
- 2341.5 – 42.5 / 2342.5 – 2343' > "shear zones" – lower one ~ 10 mm. wide – dipping ~ 65-70°; upper – 1-3 mm. may be some hydrothermal breccia associated with both of these.
- BELOW 2345': RX becomes much greener, prob. more phengite-rich; fiamme become much more prominent. size of fiamme up to 5 X 1 cm.; lithic content 7-10%, avg 5-10 mm, locally up to 6 cm.
- ~ 2370.8 irreg. mass of chl, phengite & fishscale calcite; looks like fiammus but may be replaced & infilled lithic fragment.



DENSELY WELDED XL & LITHIC-RICH FELSIC ASH-FLOW TUFF, lt. greenish-gray, punky even though densely welded; 5-7% lithics, up to 2.5 cm (avg. ~4 mm) in dia. – these are mostly porphyritic, intermediate-composition volcanic rx, minor ss, sltst, rhyolite(?); fiamme up to 5 X 1 cm, avg ~ 2 X 1-2 mm – these are med. gray-green, much darker than matrix; some of the volc. lithics contain hematite after original mafic minerals

DRILL HOLE VC-2B (FIELD LOG)
LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J. B. HULEN & J. N. GARDNER
8 SEPT, 8-9 DEC. '88



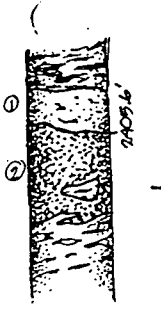
NOTES, COMMENTS	DESCRIPTIONS
	DENSELY WELDED, PUMICY ASH-FLOW TUFF, AS ABOVE
SURGE	★ 2405.5-2405.6': XL-DEFICIENT & LITHIC-DEFICIENT (<5%; <7MM) LAPILLI; SHARP UPPER CONTACT.
	★ 2405.6-2405.8': SURGE? Texturally a med.-grnd. sandstone w/ qtz, fsp, lithics + well-sorted, lt. gray scoured (or loaded?) appearing lower contact.
	① 0.1' zone of non-welded tuff, 3-4° fairly planar upper contact (& lower contact) above sandstone-like surge deposit.
COMP. FOL. DIP ∿ 20°	★ 2418.5': 10-15 cm. XL-poor band.
(LOWER TUFFS)	
	2434-2434.1': POORLY- TO MOD. WELDED ASH-FLOW TUFF, OTHERWISE SIMILAR TO ABOVE;
shear dip 20°	2434.1-2434.15': IRREG. BAND OF ALTERED FINE ASH w/n 2-3% 1 mm. XLS - mostly qtz, some feldspar
dip 85°	2434.15-2434.75': PROBABLE SURGE DEPOSIT: dense lt. brownish-gray; texturally a well-sorted, med. grained ss.
dip 80°	with suspended clasts of various rock types, subrounded to angular, up to 5 cm in dia.; clasts are predominantly andesite & sandstone" similar to the matrix; lower 5 cm vaguely plane-bedded, generally coarser grained.
	2434.75-2435': med.-crs. grn. sl. hematitic ss, contorted bedding; upper scour channel filled with darker & clast-rich sandstone.
DIP 75-90°	2435-2435.3': interbedded lithic-rich, lt. gray-green tuff & med.-gr. tuffaceous sandstone, sl. reddish.
	2435.3-2435.8': thin bedded, wavy to convolute to plane-bedded, sl. hematitic ss; soft-sed. deformation
DIP 25°	2435.8-2436.8: highly contorted, poorly sorted, fine-med. gr. hematitic (slightly), lt. reddish sandstone; scatt. silicic veinlets; some soft sed. deform.
(CARBONATE)	2436.8-2441': completely deformed (fractured/healed & soft-sediment-deformed) fine to coarse-grained sandstone
	2441-2441.4': red, contorted, fine gr. sandstone
(DEBRIS FLOWS)	2441.4-2443': red, med.-gr. sandstone breccia invading med. gr. sandstone; the breccia contains clasts
COCHITI FM. EQUIVAL.? (TUFF)	of porphyritic andesite up to 2 cm. dia. (angular) SEE DRAWING AT LEFT.
	2443-2452': Med. gr. sl. hematitic, highly soft-sed. contorted sandstone; dips range from near-horizontal to vertical.
	★ 2449-2450.5': coarse grit/breccia w/hem. matrix (same as 2441.4-2443') intrudes sandstone (concordant - may not be intrusion.
(DEBRIS FLOW)	
COCHITI FM. EQUIVAL.?	2452-2452.8': TUFF(?) lt. gray-green w/ 7% clasts - white volc. rx? fine-xln. limestone up to 15 mm. - gradational lower contact; clasts up to 4 cm, avg. 1-2 cm dia.
	2452.8-2453.6': v. fxln. lt.-med.-gray limestone, silty
(SANTA FE)	(not a clast)
	2453.6-2454.0': same as 2452-2452.8'
	2454.0-2455.2': limestone, same as 2452.8-2453.6', but grading from rel. pure to completely interfingered with tuff as above
SILICA-PHENGITE VEINLETS.	2455.2-2457.2': debris-flow? v. calcareous matrix breccia with clasts of andesite up to 15 cm, clasts of limestone as above up to 4 cm.
	2457.2-2459.3': DEBRIS-FLOW DEPOSIT, subrnd. to round clasts of andesite & pyritic andesite, rare lithi. in a very calcareous matrix → silty as well.
	2459.3-2460.3' → TUFFACEOUS SILTSTONE, lt. gray-green, ultra-fine-grained; tiny shards visible; loading at upper contact.
(SANTA FE)	2460.3-2469.5' DEBRIS-FLOW DEPOSIT, SAME AS ABOVE; ANDESITE CLASTS UP TO AT LGT. 75 CM. IN DIA.
	2469.5-2619': LITHIC-ARKOSE, LT GRAY TO BUFF, REFER TO FOLLOWING PAGE FOR DESCRIPTION!
	2475-2476.8 → CAL VNLTS, BANDED, UP TO 1 cm. WIDE, 75° dip w/ 3 cm offset of older phengite-silica "soak" veinlets dipping 10-15°.
← CALCITE VEINS	

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS
VALLES CALDERA, N.M.

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

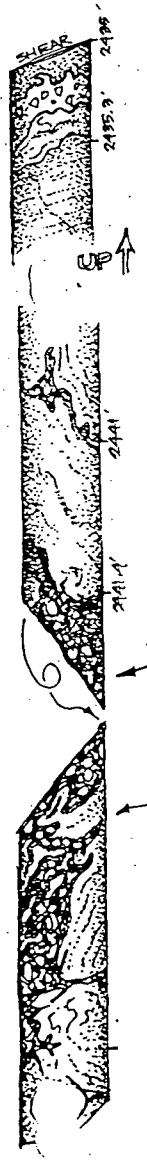
SEPT. 8, 1988



← 0.15' NON-WELDED ASH-FLOW TUFF

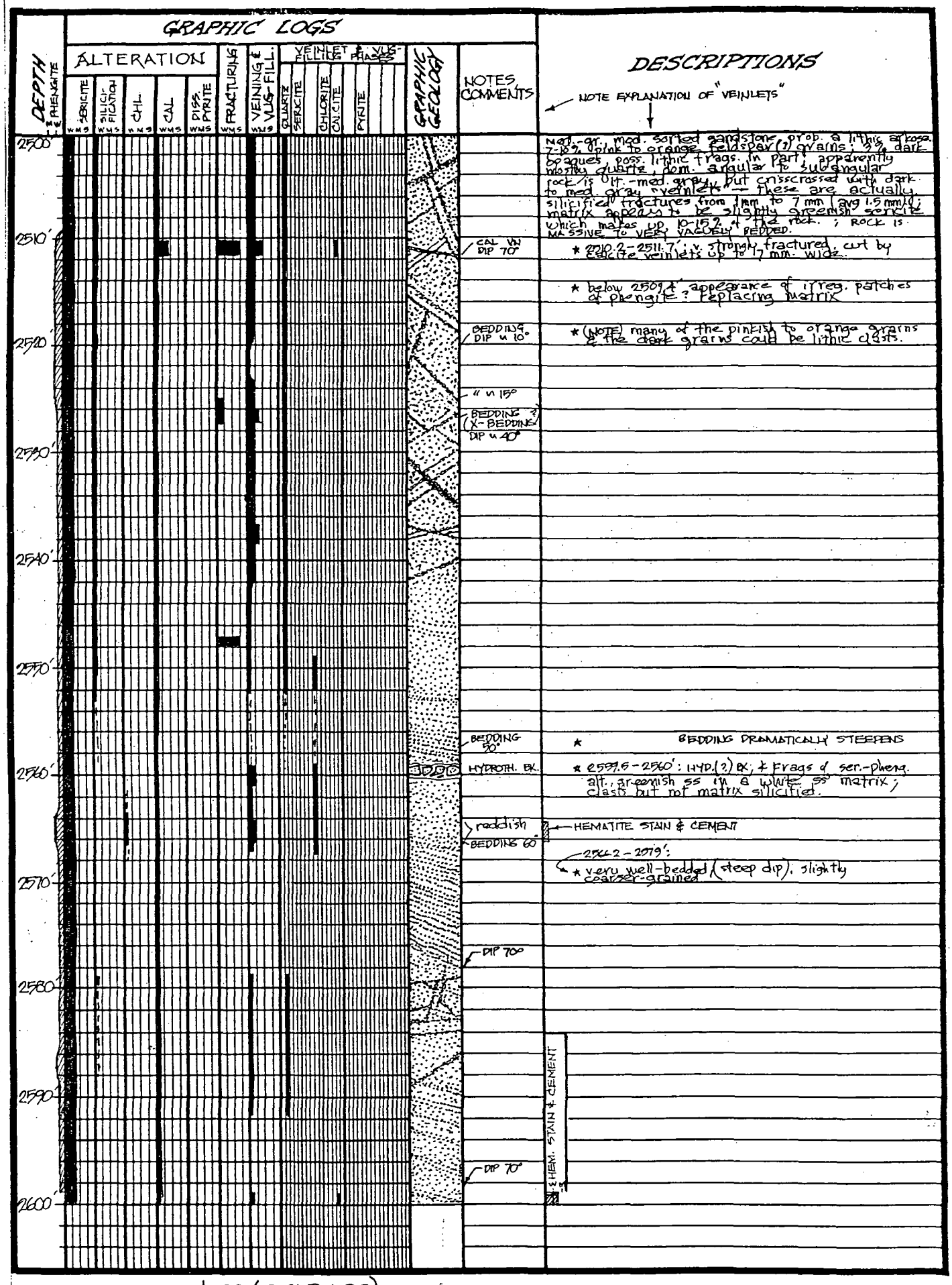
SURGE DEPOSIT "PSELIDO SANDSTONE"

SKETCHES OF UNUSUAL FEATURES IN THE LOWER TUFFS & UNDERLYING SANTA FE GROUP? SAND-STONE



HEMATITIC SANDSTONE BRECCIA WITH PORPHYRITIC ANDESITE CLASTS.

SWIRLY CONTORTED CONTACT.

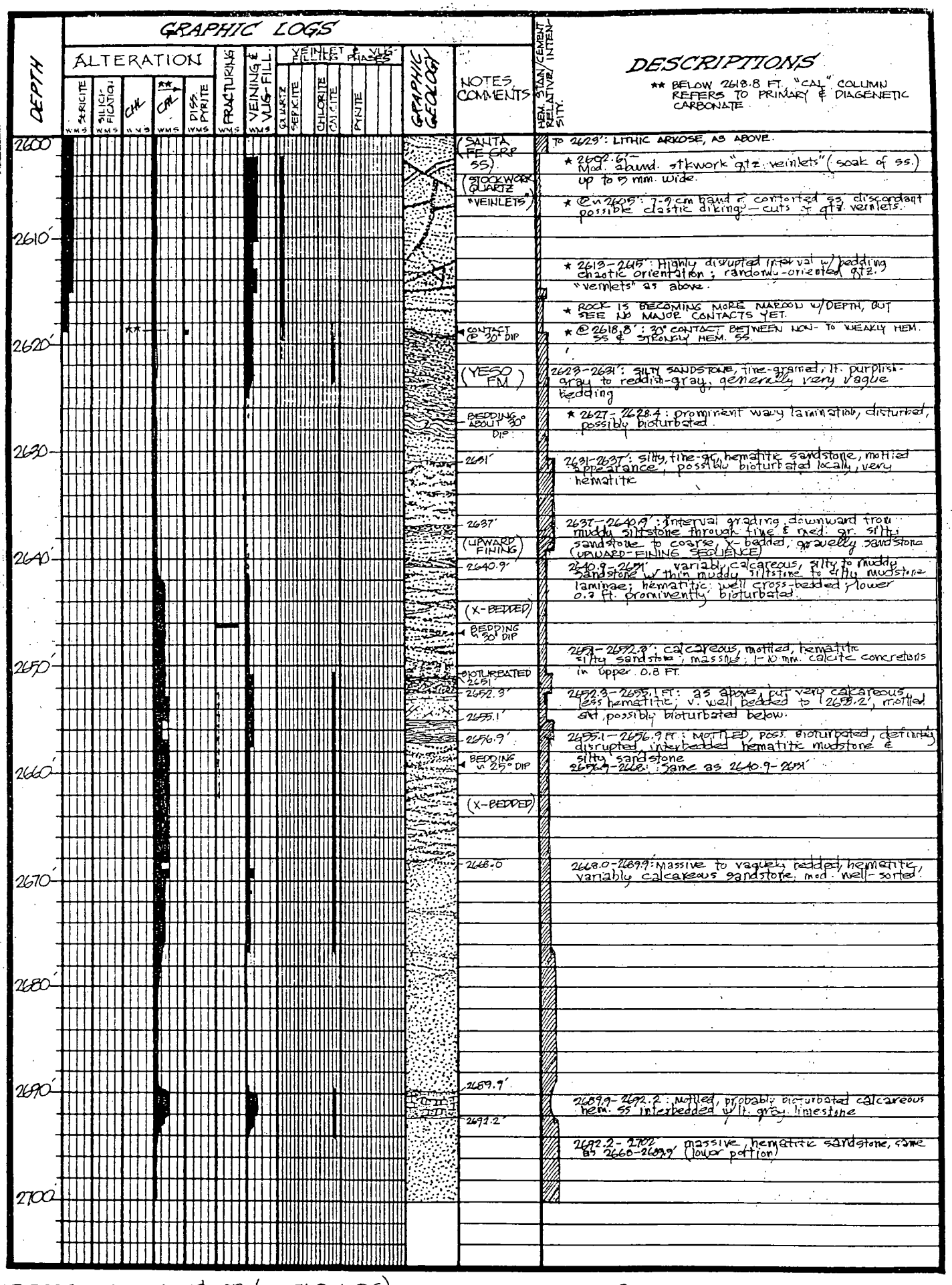


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J. B. HULEN

SEPT. 6, 1988

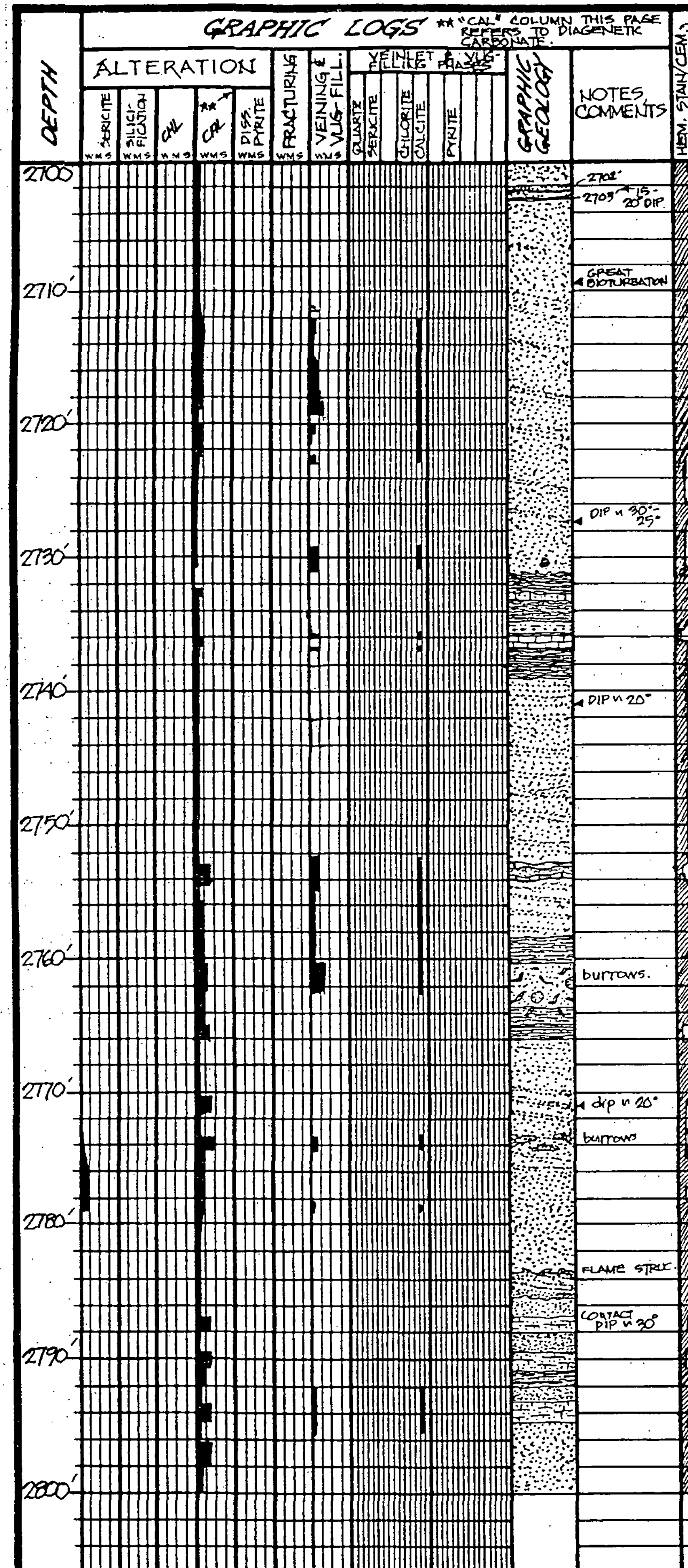


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEX.

LOGGED BY J.B. HULEN

SEPT. 6, 1988



DESCRIPTIONS

★NOTE: "VEINLETS & VUG-FILLINGS" RECORDED ON THIS PAGE ARE DOMINANTLY CALCITE NODULES & BURROW-FILLINGS OF PROBABLE DIAGENETIC ORIGIN.

MASSIVE SANDSTONE, AS ABOVE.

2702-2703: X-bedded, interbedded hem. silty ss & hem. mudstone/shale

2703-2731: Mostly massive, hematitic, silty sandstone, as above, variably calcareous.

★ 2712-2719.2': diss. irreg. lath-like to amoeboid calcite clots avg. ~ 5-7 mm Long some of these possibly filled burrows.

2731-2732.8': SILTY MUDSTONE, variegated purple and brick red; flame structure & rip-ups at lower contact

2732.8-2733.9': silty limestone weakly hematitic, wavy laminated bedding.

2733.9-2734.8': calcareous, hematitic, silty mudstone & muddy siltstone; local bioturbation

2734.8-2735.8 FT.; upward-fining ss to siltstone sequence

2735.8-2736'; laminated purple mudstone & lt. gray limestone.

2736-2736.7': lt. gray limestone

2736.7-2739.3': laminated purple mudstone and lt. gray siltstone & sandstone. ——→; wavy lamination; bioturbated (?); variably calcareous.

2739.3-2753.1': SANDSTONE, —fine—gr., massive to plane-bedded, locally X-bedded; poss. some soft-sed. deformation; hematitic.

2753.1-2754': interbedded red ss, as above, & lt. gray silty limestone; nodular-appearing wavy lamination.

2754-2758.6: same as 2739.5-2753.1 FT.

2858.6-2860.2': v. hematitic interbedded silty mudstone & muddy siltstone

2860.2-2763.8: hem, muddy to silty fine ss, bioturbated, w/abund. burrows up to 2 X 0.7 cm, filled w/ xln. calcite.

2869.8-2865: finely-laminated, red muddy siltstone, burrows as above in upper 0.9 FT

2765-2766': interbedded hem sltst/ss & lt. gray to buff silty limestone

2766-2776'; fine-gr., sl. hematitic silty ss., vaguely bedded

2776-2783.8: med.-grained, sl. hem. sandstone nearly massive

2783.8-2785.5': fine — gr. well-bedded sandstone

2785.5-2786.8: same as 2776-2783.8

2786.8-2788': calcareous, sl. hem. ss; bioturbated med-grained.

2788-2789.5': vaguely bedded hem. fine-gr. ss

2789.5-2791.0': buff, med-gr. calcareous sandstone

2791.0-2792': bioturbated, interbedded calcareous sandstone and red hematitic mudstone (laminated)

2792-2793.5': same as 2788-2789.5'.

2793.5-2795: calcareous & hem. fine gr. ss

2795-2801.3' app. massive, fine-gr., hem. ss.

★ 2796.4-2798.2: mottled-origin unknown

DRILL HOLE VC-2B (FIELD LOG)

LOCATION VALLES CALDERA, NEW MEXICO

LOGGED BY J.B. HULEN

SEPT. 7, 1988

GRAPHIC LOGS

** "CAL" COLUMN THIS PAGE REFERS TO PRIMARY & DIAGENETIC CARBONATE.

DEPTH	ALTERATION: SERICITE (WMS)	ALTERATION: SILICIFICATION (WMS)	ALTERATION: CHL (WMS)	ALTERATION: CAL ** (WMS)	ALTERATION: DISS. PYRITE (WMS)	FRACTURING (WCS)	VEINING & VUG-FILL (WCS)	VEINLET & FILLING PHASES: QUARTZ	SERICITE	SILICRITE	CALCITE	PYRITE	VUG	GRAPHIC GEOLOGY	NOTES, COMMENTS	HEM STAIN/CEMENT (REL. INTENSITY)
2800															FLAME STRUCTURE	
2810'															LIMY	
															BIOTURBATION	
2820'															LIMESTONE	
															UPWARD-FINING	
2830'																
2840'															LOADING STRUCTURES	
															UPWARD-FINING	
2850'															BEDDING DIP @ 15°	
															2857.5	
2860'															2858.5	
															LOADING, BALL STRUCTURES	
2870'															LOADING; BALL STRUCTURES	
2880'																
2890'																
2900'																

DESCRIPTIONS

★ NOTE: "VEINLETS & VUG-FILLINGS" ON THIS PAGE ARE PRINCIPALLY CALCITE NODULES & STRINGERS OF PROBABLE DIAGENETIC ORIGIN.

2801-2809.8': hem, v.f-fine gr. ss.

2809.8-2820': fine-grained sandstone, variably calcareous, massive to vaguely bedded, locally bioturbated; calcite-filled burrows are common; local flame structures & rip-ups; sparse calcite microveinlets. upper 0.4' is bright red, devoid of calcite vugs & veinlets.; local beds of lt. gray to buff limestone, as noted on graphic log

2820-2820.7': lt. gray to buff limestone, lenticular bedding; <2% thin hem. mudstone laminae

2820.7-2822.5': interbedded hem. ss, as above, & limestone, as immediately above.

2822.5-2825.1': upward-fining ss to siltstone sequence

2825.1'-2826.8': limestone lt. gray, as above; locally cracked, recealed w/cal

2826.8-2842.1': same as 2803.8-2828.5' except only sparse local filled burrows.

2842.1-2844.8': LIMESTONE, AS ABOVE, except contorted, mixed w/ about 7% hematitic sandstone & siltstone

2844.8-2857.5': SANDSTONE, same as 2826.8-2842.1

2857.5-2858.5': LIMESTONE, same as 2842.1-2844.8.

2858.5-2890': RED SANDSTONE AS ABOVE bioturbation & soft-sed. deformation. variably calcareous; ranges from fine to coarse-grained, local upward-fining character; local amoeboid "patches" of calcareous cement.

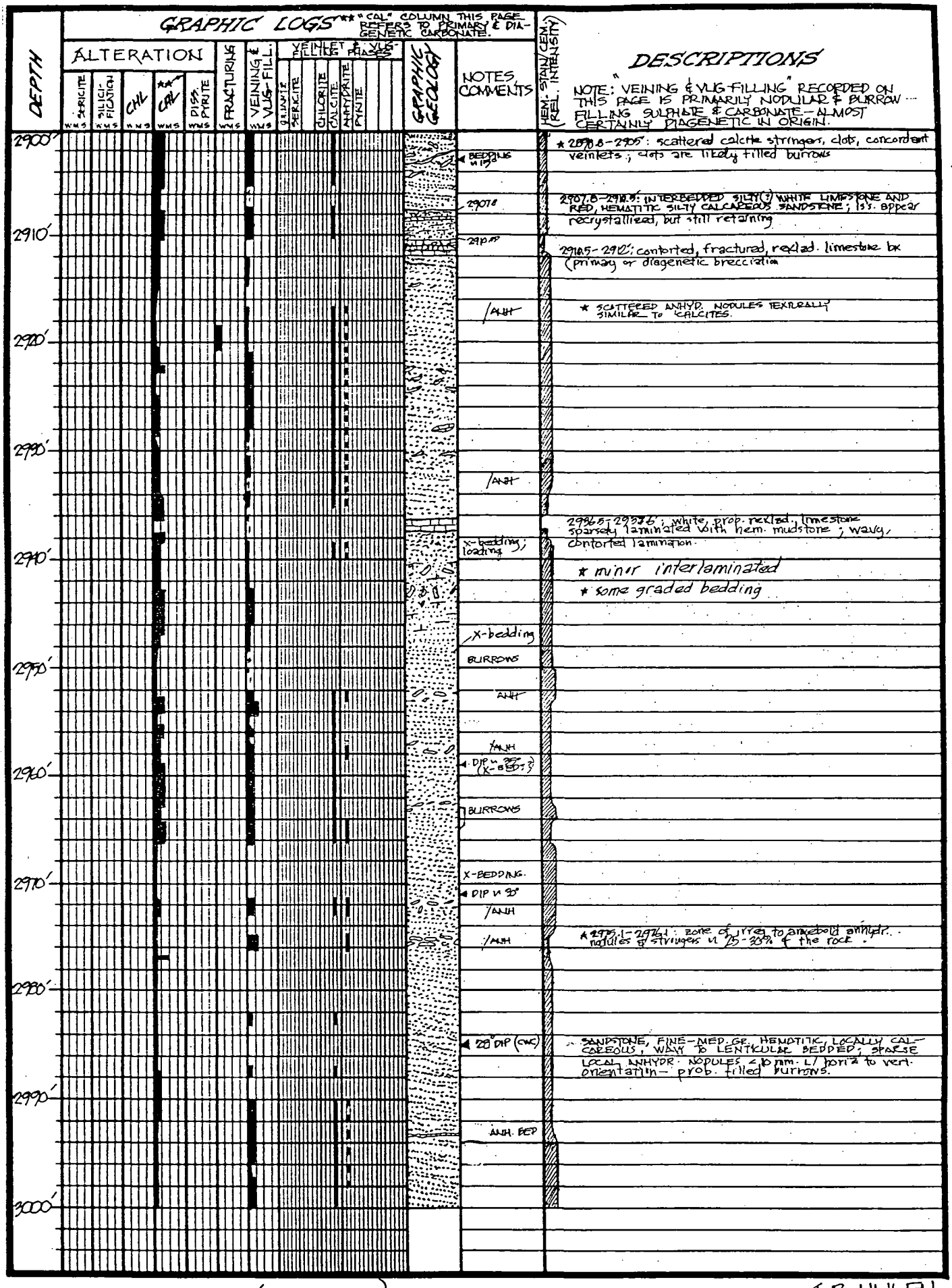
2890.9-2895.5': calcareous, hematitic sandstone, local tiny concentrations, filled burrows (calcite); mottled appearance; local wavy bedding

DRILL HOLE VC-2B (FIELD LOG)

LOCATION VALLES CALDERA, NEW MEXICO

LOGGED BY J.B. HULEN

SEPT. 7, 1988

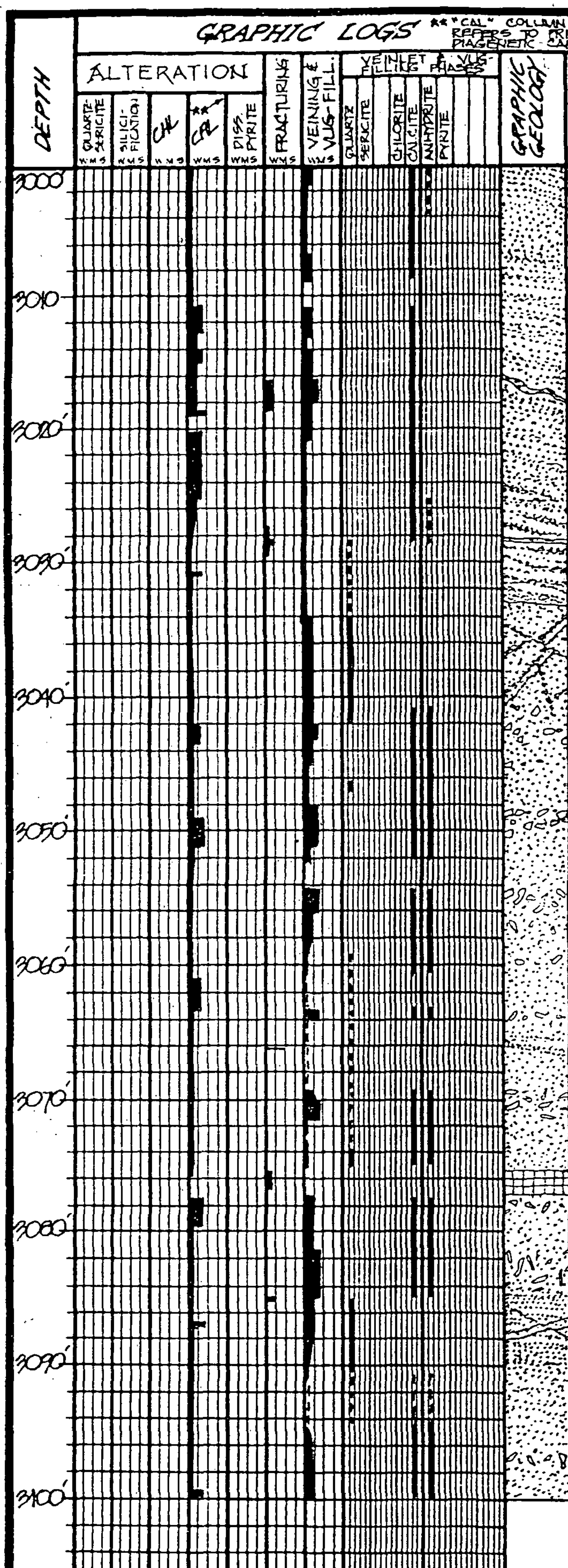


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS
VALLES CALDERA, N. MEXICO

LOGGED BY J. B. HULEN

SEPT. 9, 1988



NOTES / COMMENTS

- CAL-ANH. VEINLET.
- DIP ~ 30°
- ANH. BED.
- "SILICA SOAK" (QTZ VEINLETS)
- ANH.
- ANHYDRITE
- ANH.
- DRILLING INDUCED FRACTURES
- BEDDING PLANE SLIX DIP 25°
- ANH.
- ANHYDRITE BED
- ANH

DESCRIPTIONS

NOTE: "VEINING & VUG-FILLING" THIS PAGE IS PRIMARILY DIAGENETIC CARBONATE & SULPHATE NODULES & BURROW-FILLINGS: MINOR CALCITE & QTZ. VEINING PRESENT

★ 3009.4-3007: crsr. xln., gen. more massive ss

★ 3011.0 → curious open fractures (up to 1 mm. wide) app. caused by effect of cold drilling fluid on hot rock (thermal cracking)

★ 3016-3018: XLN. CALCITE (PLUS ANHYDRITE) VEINLET, LOCALLY OPEN. BEAUTIFUL XLS AVG. 3 MM. DIA., SOME ANH. XLS. UP TO 13 MM. LONG. → VEINLET UP TO 10 MM. WIDE.

3033.2-3075.6': SANDSTONE, LT. MAROON TO LT. BRICK RED, FINE-GR. APP. WELL-SORTED SANDSTONE PROB. A SUBARKOSE; MASSIVE TO VAGUELY BEDDED.

★ 3034-3042: stockwork "SILICA SOAK" VEINLETS UP TO 2 mm. wide (QUARTZ A)

★ 3041-3045.5 / 3049.5-3050.5: MOD. ABUND. ANHYDRITE NODULES & STRINGERS, some appear to be filled burrows, some are diagenetically disrupted strata up to 0.3 ft. thick

3075.6-3077.3': MASSIVE white anhydrite, lower 0.15' autobrecciated

3077.3-3085.1: same as 3033.2-3075.6'

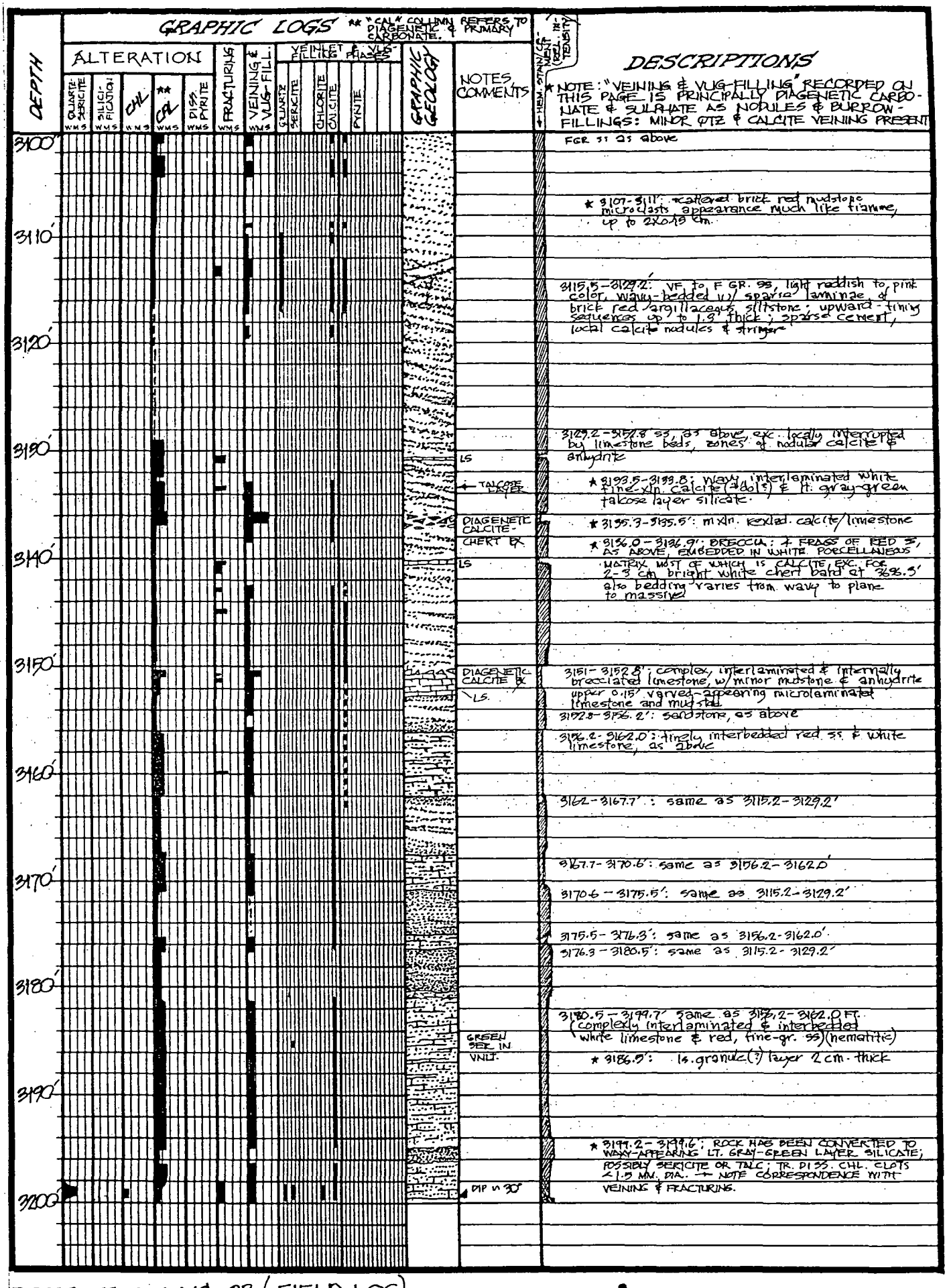
3085.1-3090: distinctly-bedded (plane to low-∠ X) hem-poor fine-gr. ss; local mudstone microclasts

3090-3115.5 SANDSTONE, fine-grained, weakly hem., massive to plane to wavy-bedded. local calcite & anhydrite nodules, local bioturbation (TIDAL FLAT?)

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEXICO

LOGGED BY J. B. HULEN
D. F. WILSON
C. W. CRISWELL
SEPT. 10, '88



FGR ss as above

★ 3107-3111': reworked brick red mudstone microclasts, appearance much like tramme, up to 2x0.5 cm.

3115.5-3129.2': VF to F GR. ss, light reddish to pink color, wavy-bedded w/ sparse laminae of brick red argillaceous siltstone; upward-fining sequences up to 1.5' thick; sparse cement, local calcite nodules & stringers

3129.2-3157.8 ss, as above, exc. locally interrupted by limestone beds, zones of nodular calcite & anhydrite

★ 3133.5-3133.8: wavy, interlaminated white fine-xln calcite (+dol?) & lt. gray-green talcose layer silicate.

★ 3135.3-3135.5': mixn. rexlzd. calcite/limestone

★ 3136.0-3136.9': BRECCIA: ± FRAGS OF RED ss, AS ABOVE, EMBEDDED IN WHITE PORCELLANEOUS MATRIX, MOST OF WHICH IS CALCITE, EXC. FOR 2-3 cm bright white chert band at 3138.5'; also bedding varies from wavy to plane to massive

3151-3152.8': complex, interlaminated & internally brecciated limestone, w/ minor mudstone & anhydrite; upper 0.1' varved-appearing microlaminated limestone and mudstone

3152.8-3156.2': sandstone, as above

3156.2-3162.0': finely interbedded red ss & white limestone, as above

3162-3167.7': same as 3115.2-3129.2'

3167.7-3170.6': same as 3156.2-3162.0'

3170.6-3175.5': same as 3115.2-3129.2'

3175.5-3176.3': same as 3156.2-3162.0'

3176.3-3180.5': same as 3115.2-3129.2'

3180.5-3199.7' same as 3152.2-3162.0 ft. (complexly interlaminated & interbedded white limestone & red, fine-gr. ss)(hematite)

★ 3186.9': ls. granule(?) layer 2 cm. thick

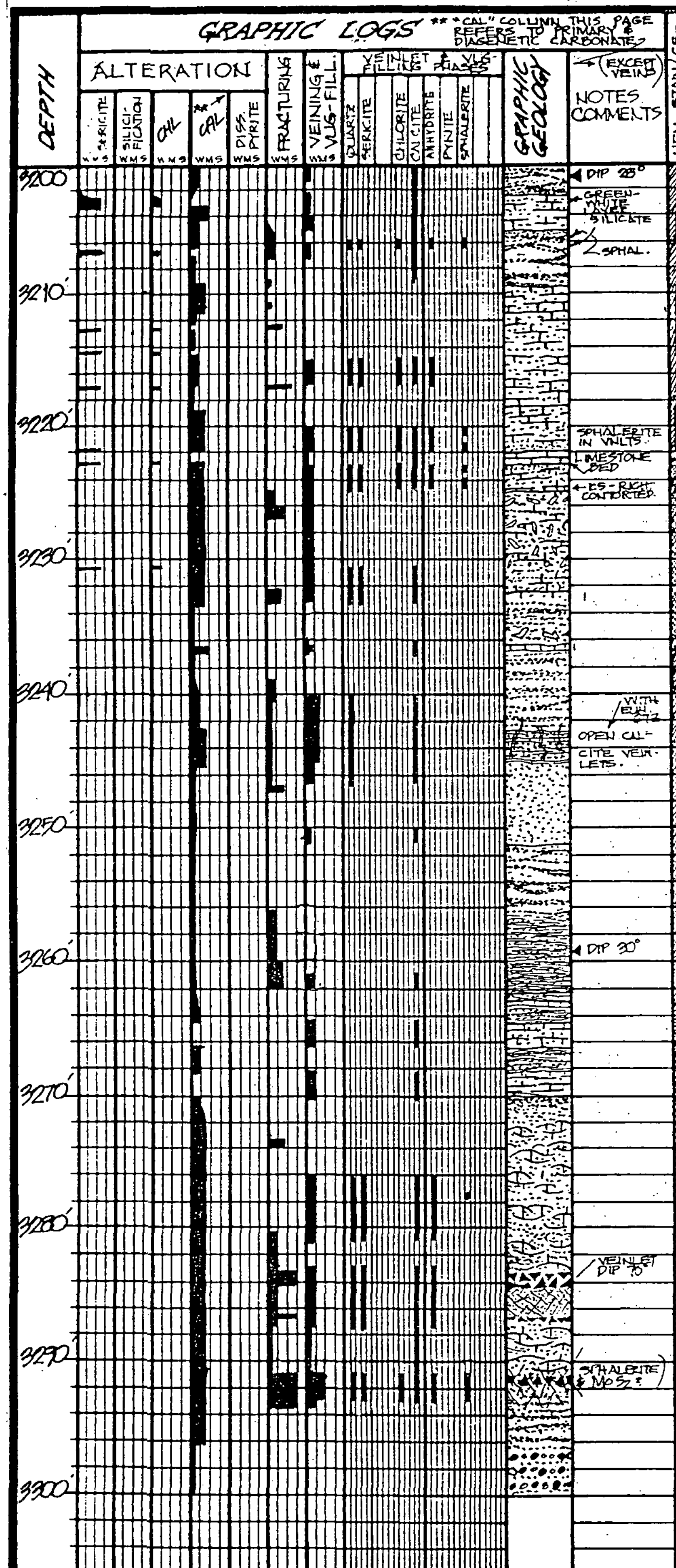
★ 3199.2-3199.6': ROCK HAS BEEN CONVERTED TO WAXY-APPEARING LT. GRAY-GREEN LAYER SILICATE; POSSIBLY SERICITE OR TALC; TR. DISS. CHL. CLOTS < 1.5 MM. DIA. → NOTE CORRESPONDENCE WITH VEINING & FRACTURING.

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J.B. HULEN

SEPT. 10, 1988



DESCRIPTIONS

SPHAL.

* 3205.7-3206.5': QTZ-CAL-ANH. VNLTS. DIP ~70-75° ONLY TRACE SPHAL. BUT DK. GRAY EUHEDRAL XLS. UP TO 0.5 MM (EUH.)

Interbedded, massive to planar to wavy-laminated red hematic FG sandstone & silty to sandy limestone (white to lt. gray). limestones commonly pseudonodular, lenticular bedded.

* note scattered beds altered intensely to lt. gray-green layer silicate — conceivably could be talc but probably is phengite or chlorite plus illite. (NOTE, 11/88 → TURNS OUT TO BE R3-ORDERED, ML ILLITE/SMECTITE)

* 3220-3222' & 3223.5-3224.7': same as 3205.7-6.5' (only tr. sphalerite → BLACKJACK.

3224.9-3233.3': SANDSTONE, fine-grained, silty, gray-purple, variably calcareous; limestone pellets(?) & filled worm burrows are common locally

3233.3-3242.7': SANDSTONE, v. f. grained, argillaceous to silty, med-dk. purplish-reddish

* 3236.5-3237.0': disrupted, contorted, interbedded/interlaminated limestone & muddy sandstone as above.

* PARTIALLY OPEN CALCITE VEINLETS UP TO 2 MM. WIDE FROM 3240' TO 3245.5'

3242.7-3248.7': Finely interlam./interbedded argillaceous hem. ss & white silty ls;

3248.7-3251.5': FGR, massive to vaguely bedded hem. SANDSTONE

3251.5-3256.3': Distinctive wavy-bedded to wavy-laminated hem. fine-gr. sandstone alternating, more clay-rich and hematite beds gen. <1-2 mm. wide with hem- & clay-poor slightly coarser layers.

3256.3-3262.3; ARGILL., V. HEM., BRICK RED FINE-GR SANDSTONE.

3262.3-3270: INTERBEDDED RED, ARGILLACEOUS SS AS ABOVE & LT. GRAY TO WHITE TO PINK HEMATITIC LIMESTONE

3270-3283.5 AS ABOVE, EXC. limy layers are nodular-appearing, w/nodules sep. by irreg. vnlts & septa of hem. ss

3283.5-3293.5' HIGHLY FRACTURED, LOCALLY FAULTED & VEINED INTERVAL → ROCK DISRUPTED IS SAME AS ABOVE

* 3283.5-3284.1; FAULT ZONE, gouge, breccia, apparently vein of qtz-calcite-anh.-ser-chl ± sp post-dating gouge

ALSO: SCATTERED < 1MM. HEXAGONAL DK. GRAY OPAQUE PLATES (MoS_2?)

* 3291-3293 FT; HEALED BX-CEMENTED BY OPEN QTZ-CALCITE-SER-CHL-ANHYDRITE VEINLETS UP TO 3 MM. WIDE INDIVIDUALLY → ZONE UP TO AT LEAST 15 MM. WIDE → SCATTERED < 1MM. SPHALERITE (BLACKJACK) XLS., APPARENTLY DEPOSITED LAST

3293.5-3296.2': Hem., vaguely bedded, fine-gr. sandstone

3296.2 - INTERBEDDED ARKOSIC GRIT & PEBBLE CONGLOMERATE (EXPLANATION NEXT PAGE)

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J.B. HULEN

SEPT. 11, 1988

GRAPHIC LOGS

** "CAL" COLUMN THIS PAGE REFERS TO PRIMARY & DIAGENETIC CARBONATE

DEPTH	ALTERATION: SERICITE WMS	ALTERATION: SILICIFICATION WMS	ALTERATION: CHL WMS	ALTERATION: ** CAL WMS	ALTERATION: DISS. PYRITE WMS	FRACTURING WMS	VEINING & VUG-FILL SWS	VEIN/VUG FILLING PHASES: QUARTZ	SERICITE	CHLORITE	CALCITE	PYRITE	HEMATITE	GRAPHIC GEOLOGY	NOTES, COMMENTS (EXC. VEINS)	HEM. STAIN & CEMENT, RELATIVE INTENSITY	DESCRIPTIONS
3300'															DIP 15–20°		
																	3305.5–3318.2': ARKOSIC CONGLOMERATE; ∠ TO RND. CLASTS UP TO 7 CM. IN DIA., BOTH PRECAMBRIAN GRANITE & GNEISS AS WELL AS DK. GRAY TO PURPLE-GRAY PORPHYRITIC ANDESITE; vague bedding @ ∩ 15°
															ANDESITE COBBLES		
3310'																	
																	* 3315–3315.5': slickensided fracture
3320'																	
																	* 3326.4–3328.4': abund. andesite cobbles up to at least 10 cm. in diameter. (also porphyritic andesite & possibly intermediate composition ash-flow tuff)
															ANDESITE COBBLES		
3330'																	
																	@ ∩ 3338' ⇨ VOLCANIC CLASTS LARGELY DISAPPEAR, TO be replaced by 95% PEGMATITIC GRANITE, MINOR GNEISS; MATRIX IS HEMATITIC SILTSTONE TO SANDSTONE CLASTS UP TO AT LEAST 10 CM. DIAMETER
3340'																	
3350'																	
3360'																	3358.2–3362.7': SANDSTONE f–med. gr., poorly-sorted, hematitic, massive to vaguely bedded. sparse granite granules & fine pebbles
															DIP ∩ 10°		3362.7–3370.9': as above, except coarser grained, scattered pebble beds up to several cm thick
3370'																	3370.9–3372.6': brick red, hem. silty mudstone/shale
																	3372.6–3385.4': SS, coarse-gr., poorly-sorted, X-bedded abundant red mudstone rip-ups up to 15 cm. long.
3380'																	
3390'																	3385.4–3390.2': FINE–MED. GR. HEM. SS, massive to finely X-bedded (toward base) sparsely bleached
																	3390.2–3396.9': SILTY, MUDSTONE, brick red, v. hematitic highly fractured w/ silk on many', poss. some thermal fracturing as well.
3400'																	3396.9–3400.5': sandstone, described next page.

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA

LOGGED BY J. HULEN, J. GARDNER

SEPT. 12, 1988

GRAPHIC LOGS

** "CAL" COLUMN THIS PAGE REFERS TO PRIMARY & DIAGENETIC CARBONATE (EXC. VEINS)

DEPTH

ALTERATION: SERICITE (WNS); SILICIFICATION (WNS); CHL (WNS); CAL ** (WNS); DISS. PYRITE (WNS)

FRACTURING (WNS)

VEINING & VUG-FILL (WNS)

VEINLET & VUG-FILLING PHASES: QUARTZ; SERICITE; CHLORITE; CALCITE; PYRITE

GRAPHIC GEOLOGY

NOTES, COMMENTS

HEMATITE STAIN & CEMENT (RELATIVE INTENSITY)

DESCRIPTIONS

3400'

SANDSTONE, med.-gr., l cm. & v. vaguely calcareous, massive, plane- & thinly X-bedded; bleached (reduced) patches v. light, slightly greenish-gray up to 10 cm. dia., bulbous to amoeboid calcite concretions (?) with some clay (?), up to 10 cm. dia., also bulbous, w/ brecciated appearance

★ @ 3405 ft.) – argillaceous, coarse sandy, punky (clasts) w/ 2 x 1 cm. smile-like vug w/ anhydrite plates up to 10 x 5 x 1 mm.

3410'

3420'

3420.8 – 3428.7': ss, med.-gr.– fining upward; abund. sand-size shale clasts (hematitic) prob. argillaceous & poorly-sorted; vague to massive bedding.

◀ DIP 10–15°

3428.7 – 3433.5': As above, but abundant pebble-size shale/mudstone rip.-up clasts up to 15 mm. highly

YESO FM

3433.5 – 3435.5': ss, same as 3420.8 – 3428.7' except highly bleached lt. gray-green.

CLASTIC DIKE

★ 3432.7 – 3434.4': CLASTIC DIKE hematitic where not bleached; sandy to silty mudstone in host of med. gr. ss. up to 1 cm. wide – see drawing at left

ABO FM

3435.5 – 3448.5': hematitic silty mudstone, highly fractured; locally common calcareous concretions, bulbous to amoeboid, up to at least 20 cm. dia.

3440'

3448.5 – 3454.6': As above except sandy – sand increases & coarsens w/ depth; lower 0.6' rich in pebbles up to 10 mm. dia

3450'

DIP ≈ 17°

3454.6 – 3467.5': Massive, calcareous, hematitic siltstone; mottled, intraformationally brecciated appearance: "MARL"; locally bleached/reduced to v. lt. slightly greenish-gray. both ir rounded, amoeboid

3460'

3467.5 – 3472.2': As above, except less calcareous, more mud-size fraction.; lower 2 ft sparse bleached/reduced spots up to 15 mm — highly rounded.

3470'

3472.2 – 3482.0': calcareous mudstone to siltstone, similar to 3454.6 – 3467.5, except less calcareous, locally more silty, also more fractured & wisely "spotted" – bleached, reduced areas up to 2 cm. – some of these have slightly darker but soft centers – some spots have double halos.

3480'

3482 – 3487.6': massive, poorly-sorted, poss. argillaceous fine-gr. sandstone

★ 3484.6 – 3485.2': bleached zone in ss. also scattered, bleached clots up to 3 cm. wide for 0.4 ft above this larger zone

3487.6 – 3495.5': med.-crs. gr. prominently X-bedded sandstone; lower 0.7 ft bleached, as is upper 2–10 mm. of underlying mudstone; heavy mineral concentration @ 3494'.

3490'

3495.5 – 3501': interbedded silty to calcareous hematitic mudstone & argillaceous, calcareous hematitic fine gr. sandstone

3500'

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

LOGGED BY J. HULEN, J. GARDNER

SEPT. 13, 1988

GRAPHIC LOGS

** CAL. COLUMN THIS PAGE REFERS TO PRIMARY (EPIGENETIC CARBONATE)

DEPTH

ALTERATION: QUARTZ-SERICITE (VWS), SILICIFICATION (VWS), CHL (VVS), CAL** (VWS), DISS. PYRITE (VWS)

FRACTURING (S, C, H)

VEINING & VUG-FILL (S, C, H)

VEINLET & VUG-FILL PHASES: QUARTZ, K-SPAR, CALCITE, ANHYDRITE, PYRITE

GRAPHIC GEOLOGY

NOTES, COMMENTS (EXC. VEINS)

DESCRIPTIONS

HEM. STAIN/CEMENT, RELATIVE INTENSITY

3500'

3510'

3520'

3530'

3540'

3550'

3560'

3570'

3580'

3590'

3600'

3501–3505.5': MOTTLED, CALCAREOUS, HEMATITIC, FGR SS, prob. argillaceous, partly silted.

many fx. dripped-on

3506.5–3513.5': argillaceous, hematitic, massive to very vaguely bedded sandstone w/ thin mudstone interbeds. Local bleached/reduced spots up to at least 10 cm. wide — amoeboid, bulbous.

3513.5–3515.8': as above exc. well X-bedded, finer gr., more argillaceous.

3515.8–3527.5': mudstone, silty, hematitic, calcareous with irregular calcite nodules, amiboid up to 4–5 cm. maximum dimension. Scattered, bleached spots, many w/ cores of organic debris.

Nodular

→ 3525.8':

3527.5 → SANDY MUDSTONE to MUDDY SANDSTONE (or siltstone), hematitic, calcareous, w/ calcite nodules as above but much less common. calcite/limestone nodules are selectively fractured but reheated; sparsely bleached as above.

Nodular

shear 40°

3535.8–3536.7': SANDSTONE BRECCIA — 2, irreg. clasts of fairly clean med-gr. ss. up to at least 1.5 cm. dia., intricately invaded by stringers of muddy hematitic sandstone

3536.7–3537': MUDSTONE-SANDSTONE BRECCIA: 2 to submm clasts of variable hem. mudstone in a matrix of clean, med. lgr. sandstone — probably a lithic arkose.; over 5–7 cm to bleached lt. gray-green.

Nodular

3537–3545.8': interbedded muddy ss & sandy to silty mudstone, locally w/ calcareous nodules same as 3527.5 to 3535.8 ft.

3545.8–3557.8': ss, f.gr. massive exc. for lower 1/2 which is plane- to low-2 X-bed; locally bleached, base is displaced 2–3 cm by fracture row occupied by calcite veinlet. Lower 3' cut by calcite veinlets up to 1 cm. wide — locally open.

VEIN 60° DIP

CALCITE VEINLETS

3557.8–3563.5': muddy, fine-gr. sandstone, locally w/ gray-green bleached spots up to at least 10 cm in dia.

★ @ ~3555 ← 0.5' zone of oolitic-appearing nodules like this (~15% of rock) centers are carbonate rich up to 1cm. in diameter.

3563.8–3571.5': interbedded sandy to silty mudstone & muddy fine-gr. ss as above.

3571.5– ss, fg, massive to vaguely bedded well-sorted.

★ 3573.6–3573.9 = sandy mudstone as above.

mudstone interbed

sandstone becomes well-bedded to 3599': prominent X-bedding, scours, possible slump structures, some rip-ups (mudstone)

CALCITE-ANHYDRITE VEINS.

← veinlets irregular, high-2, up to 3 mm. wide.

sericitized

★ 3596.8–3597.8': abundant shale/mudstone rip-ups & zone of mod. sericitization, poss. weak chlorite.

3597.8– : nodular calc. mudstone (explanation next page)

DRILL HOLE VC-2B (FIELD LOG)

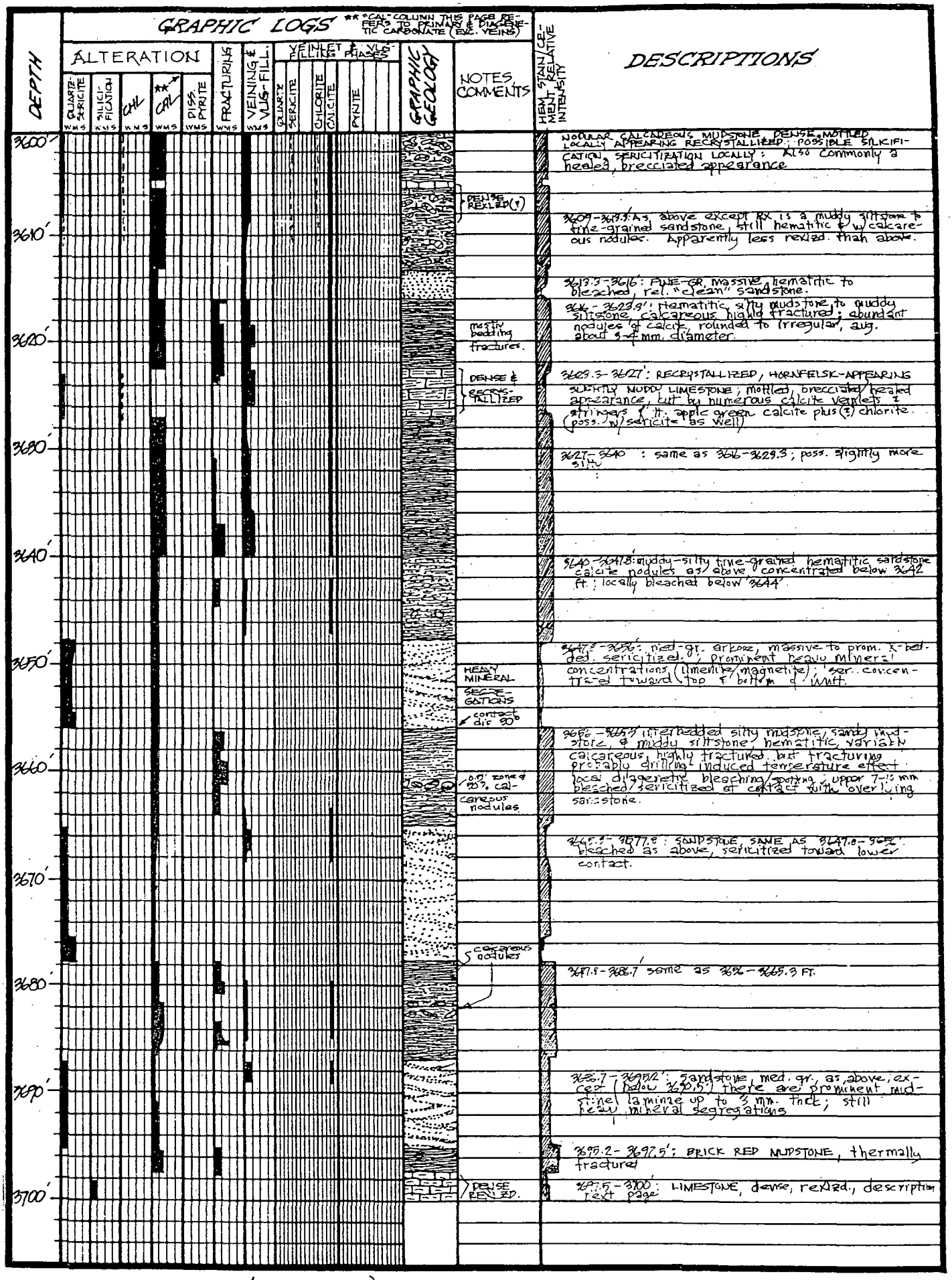
LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEXICO

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

SEPT. 19, 1988

GRAPHIC LOGS

** "CAL" COLUMN THIS PAGE REFERS TO PRIMARY & DIAGENETIC CARBONATE (EXC. VEINS)

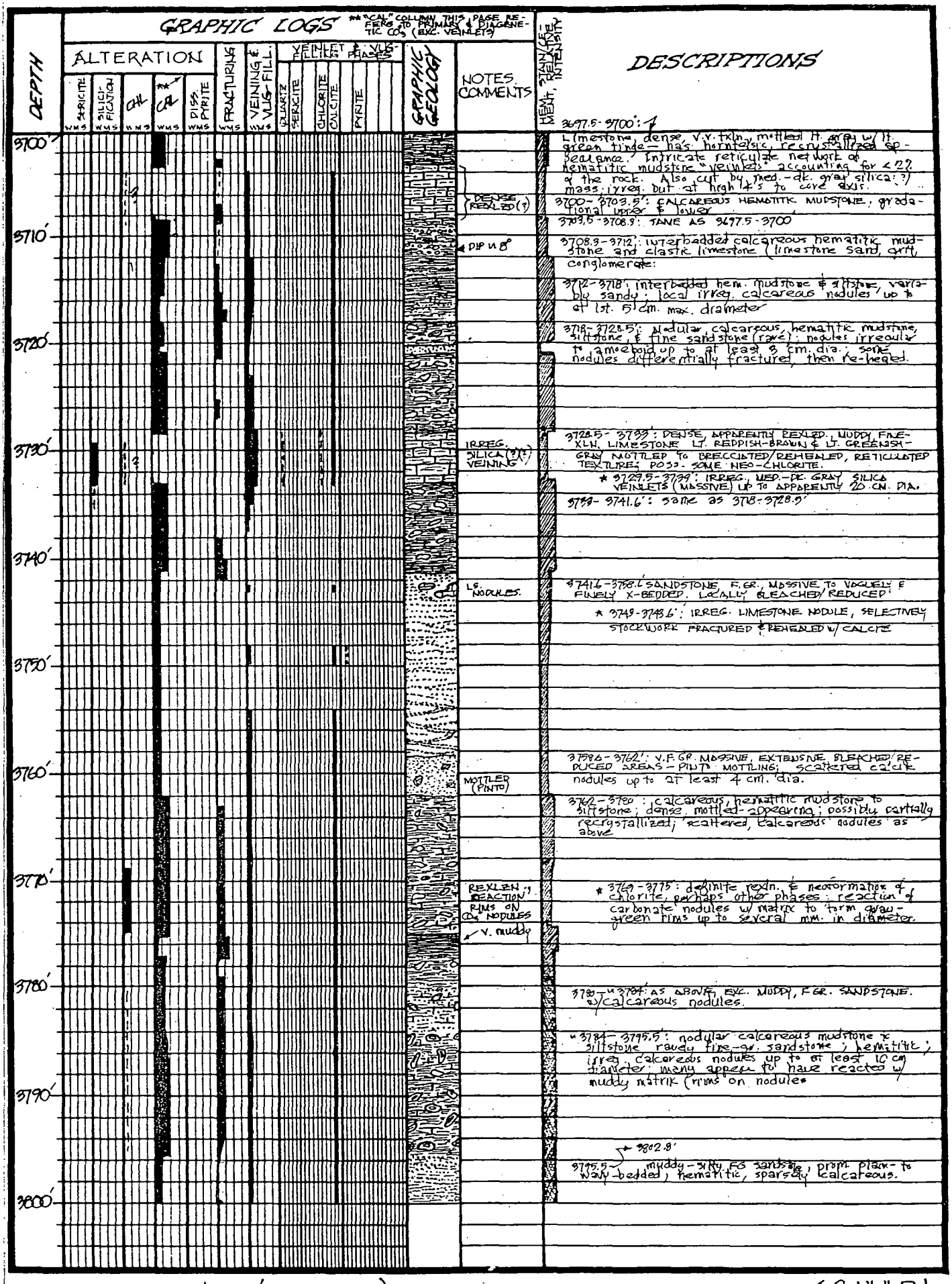


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEXICO

LOGGED BY J. B. HULEN

SEPT. 15, 1988



DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEXICO

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

SEPT. 16, 1988

GRAPHIC LOGS

** "CHL" COLUMN THIS PAGE REFERS TO PRIMARY & DIAGENETIC CARBONATE

NOTE: FRACTURING SHOWS GOOD CORRELATION WITH FISSILE SHALES/MUDSTONES — PROBABLY NOT THROUGHGOING PERMEABILITY

DESCRIPTIONS

DEPTH

ALTERATION: SERICITE (WMS); SILICIFICATION (WMS); CHL (S, WMS); CAL ** (WMS); DISS. PYRITE (WMS)

FRACTURING (WMS)

VEINING & VUG-FILL (SEC'S)

VEINLET & VUG-FILLING PHASES (EXC. VEINS): QUARTZ; SERICITE; CHLORITE; CALCITE; PYRITE

GRAPHIC GEOLOGY

NOTES, COMMENTS

HEM, STAIN/LEMELIT, RELATIVE INTENSITY

3800'

→ HEM. "SPOTS" & STRINGERS

3802.8–3813': calcareous hematitic mudstone to siltstone; mottled & locally dense & recrystallized-appearing; see previous page; below 3807' numerous bleached/reduced "spots" mmu w/ dark centers (organic debris?); nodular below ~ 3810', as in overlying units.

REXLZD.?

3813–3822.8': V.F.GR., hem., sparsely calcareous, argill. to silty sandstone, mottled, locally bleached/reduced.

3820'

3822.8–3830.1': calcareous, hematitic mudstone, mottled, recrystallized-appearing; microbrecciated/relicted texture locally; cut by random-oriented stockwork veinlets apparently of hematite, silica (?) & calcite; lower 2½ FT. nodular.

partly rexlzd.?

nodular

3830'

3830.1–3835': Limestone, v. f-xln., argillaceous, sparsely hematitic, v. lt. pinkish to greenish-gray; poss. partly recrystallized.

3838.5–3842.8': same as 3842.8–3830.1'

3840'

3842.8–3847': shale, hem., highly fissile, extremely fractured but this may be drilling-induced in part.

3847–3851': as above, except silty & locally sandy; cut by green chl veinlets w/ calcite selvages; med.–dk. gray-green nodules up to 3 cm. in diameter; should check these for ACTINOLITE

for chl-cal veinlets & green nodules

3850'

3851–3855.2': interbedded sandy mudstone to siltstone & med.-gr. ss; ss's are sericitized, chloritized, selectively.

ss, white, ser. chl. alt'n.

3855.2–3861.8': argillaceous-silty, hem. ss, f.gr. size; ss beds are selectively bleached, sericitized; some diagenetic reduction/"spotting" locally

3860'

3861.8–3865.9': clean, bleached, med.-grained sandstone, vaguely plane- to X-bedded, sericitized.; scattered hem. argillaceous interlaminations

(CHLORITE-SERICITE)

3870'

★ 3871.5–3872.0': CHL-CAL veinlet offsets beds ~ ½ cm.

3880'

★ 3887–3888.5': slumped bedding? dips as high as 60°.

★ 3888–3890.6 FT → abundant shale rip-ups bleached (ser-chl?); lt. gray-green.

★ 3891–3892': 5–10 mm. clastic dike, 70° dip, slightly more stained than matrix, otherwise texturally identical.

3890'

3898.3–3912': hem., silty, sparsely calcareous mudstone as above

3900'

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEXICO

LOGGED BY J. B. HULEN

SEPT. 16, 17 1968

GRAPHIC LOGS

** "CAL" COLUMN THIS PAGE REFERS TO PRIMARY & DIAGENETIC CARBONATE (EXC. VEINS)

NOTE GOOD CORRELATION OF FRACTURING & FISSILE MUDSTONES — THESE PROBABLY DO NOT PROVIDE THROUGHGOING PERMEABILITY.

DESCRIPTIONS

DEPTH	ALTERATION: SERICITE (WMS)	ALTERATION: SILICIFICATION (WMS)	ALTERATION: CHL (WMS)	ALTERATION: CAL** (WMS)	ALTERATION: DISS. PYRITE (WMS)	FRACTURING (WMS)	VEINING & VUG-FILL. (SWS)	VEIN/VUG FILLING PHASES: QUARTZ	SERICITE	CHLORITE	CALCITE	PYRITE	GRAPHIC GEOLOGY	NOTES, COMMENTS	HEM. STAIN/CEMENT, RELATIVE INTENSITY	DESCRIPTIONS
3900'																HEMATITIC MUDSTONE TO SILTSTONE, AS MOLE FISSILE. Highly fractured, but fractures may be drilling-induced.
																* 3903.7-3905.7': irreg. hematite "blooms", maroon & much darker than red-orange matrix → these up to 20 mm. dia.
3910'																3912-3919': hem. arg.-silty sandstone, massive, locally bleached/reduced to lt gray/green
3920'														3919'		3919-3937: med.-gr., X-bedded, partially sericitized weakly hematitic sandstone
														← shale horizon		NOTE HIGHEST INTENSITY SERICITIZATION AT BASE OF UNIT — PROB. REFLECTS COARSER GRAIN SIZE & HIGHER PRIMARY POROSITY.
3930'														(CAL + CHL) & (HEM) VNLTS.		← * mod. abund hem & cal. vnlts — cal post-dates (X-cuts) hem. vnlts. chloritic selvages assoc. w/ calcite veinlets) → hem. veining could be diagenetic.
														3937'		3937-3946.5': calcareous mudstone, dense, mottled, hematitic, mottled, locally microbrecciated/rehealed, cut by med. gray, irreg.-veinlets & patches which could be silica; local calcareous nodules up to at least 5 cm. dia.
3940'														3946.5'		3946.5-3952': same as 3930.1-3936.3 bxtd/rehealed texture (reticulated)
3950'														3952'		3952-3959.5 Nodular, sl. calc, hem. mudstone to shale
3960'														3959.5'		3959.5-3963': hem, arg. f-gr. ss. to coarse siltstone
														3963'		3963-3974': ss, f-m-grained, locally bleached/sericitized but predom. hematitic. massive to prom. X-bedded
3970'														MUDSTONE		
														MUDSTONE		
														3974'		3974-3976.7': FISSILE SHALE, hem, highly fractured.
														— SANDSTONE		3976.7-3980.2'; interbedded arg. hem. sltst. & med.-gr. ss — some bleached, some still hematitic.
3980'														QTZ. CEM. BRECCIA		* 3978.7-3976.9': QTZ-CEMENTED BRECCIA w/ grey fractures — rare prismatic qtz. x/s. in open fracs.
														UPWARD-FINING SANDSTONE		3980.2-3989': med-crs. gr., upward-fining arkosic sandstone, vaguely X-bedded to massive sericitized (particularly toward base); beds dip up to 30°
														dip S 30° cWc		
3990'														3989'		3989-3993.8': hem. arg. siltstone.
														3993.8'		3993.8-3997.6': same as 3980.2-3989'
														MICROFLT. CONTACT 80°		
4000'														FAULT ZONE (SEE NEXT P.)		3997.6-3999.7'; interbedded arg. siltstone & sandstone — hematitic

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NEW MEXICO.

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

SEPT. 17, 1988

GRAPHIC LOGS

** "CAL" COLUMN. THIS PAGE REFERS TO PRIMARY & PIA-GENETIC CO_3 (EXC. VEINS)

DEPTH | ALTERATION (SER WMS; SILICIFICATION WMS; CHL W WS; CAL** WMS; DISS. PYRITE WMS) | FRACTURING WMS | VEINING & VUG-FILL WMS | VEIN FILLING & VUG PHASES (QUARTZ, SERICITE, CHLORITE, CALCITE, PYRITE) | GRAPHIC GEOLOGY | NOTES, COMMENTS | HEM STAIN/CEMENT RELATIVE INTENSITY | DESCRIPTIONS

4000'
4010'
4020'
4030'
4040'
4050'
4060'
4070'
4080'
4090'
4100'

← faulted

n 3993.7 - 4000.7': argillaceous, poorly-sorted, well-bedded, hematitic arkosic sandstone; gs higher in hole, lower portion most intensely altered (ser.+ chlorite), local "heavy mineral segregations."

* 3999.7 - n 4000.7': high-ϕ fault (< 2 mm. gouge/bx) w/ at least 1 ft of displacement.

4005.7 - 4009.5': hem., arg. fissile shale, reddish-brown

4009.5 - 4011.2': hem., arg. fine-gr. massive ss., bleached toward lower contact in "spots" up to 6 cm - 7.5 cm. diameter

4011.2 - 4016.4': Fine-med. gr. plane-bedded to X-bedded ss; sparsely sericitic; local soft-sediment deformation

SOFT-SED. DEFORMATION

4016.4 - 4024: hem. silty mudstone w/ calcareous nodules as above

4024 - 4033': SANDSTONE AS ABOVE, w/ curious soft-sed. deformation (see below)

• 4026 - 4028.3: large soft sediment defm. prob load cast

← like this for 2.3 FT! (ORIGIN??)

← 3-MINRL. VNLT (SEE DRAWING AT LEFT)

4033 - 4037: calcareous pebbly mudstone; clasts < 1cm ave. dom. carbonate

4037 - 4042.6: massive to bedded ss; marbly bleached, chloritized

• 4043 - 4045: sandy to silty mudstone; hematitic rich, poorly sorted; sparse hematite veining

• 4045 - 4051: poorly sorted, med. gr. ss. w/ silt & mudstone lenses up to 10 cm.; bedded & X-bedded

• 4048 - 4049 - bleaching ~ 1cm along cc. veinlets

• 4044 - 4049: hem. veining; incipient hydrothermal brecciation(?)

• 4049 - 4057: poss. incipient hydrotherm. breeciation w/ cc, hem., & qtz veinlets along jig-saw puzzle of "microfaults"; some veinlets appear to follow gash fractures

4051 - 4057: poorly sorted, sandy siltstone & mudstone; thinly bedded; sparse carb. nods.

4057 - 4060.2': massive v. fine-gr.; ameboid bleached spots

4060.2 - 4067.2': hem., arg., siltstone to fine-gr. ss; w/ small to lg. up to at least 40 cm. dia calcite nodules

4067.2'

Fault w/ hydrothermal bx

4067.8 - 4071': high-ϕ fracture w/ hydrothermal bx up to 1 cm. wide separating silty mudstone from muddy siltstone; fracture/bx dips n 75-80° — ϕ clasts of both cemented by quartz and calcite. ← @ margins of calcareous nodules, appears rexld. to unknown greenish mnrl.

4071 FT.

4071 - 4088.3': hem. silty mudstone to shale interbedded with arg. to silty, hematitic fine-gr. sandstone

HYDROTH. BRECCIA

* 4080 - 4081': HYDROTH. BX. PIPELET — up to 13 mm. wide; ss clasts, ϕ embedded in calcite - qtz. matrix — some open space lined w/ euhedral, prismatic, qtz. microcrystals

4089.3 - 4095': Fine-gr., ϕ hem. silty sandstone, massive to v. vaguely bedded.

4095 - 4099': hem., argillaceous, silty to sandy shale to mudstone

4099 - 4101.4': sandstone, arg. to silty, as above, hem., but w/ calcite nodules up to several cm. in diameter (irreg. to ameboid).

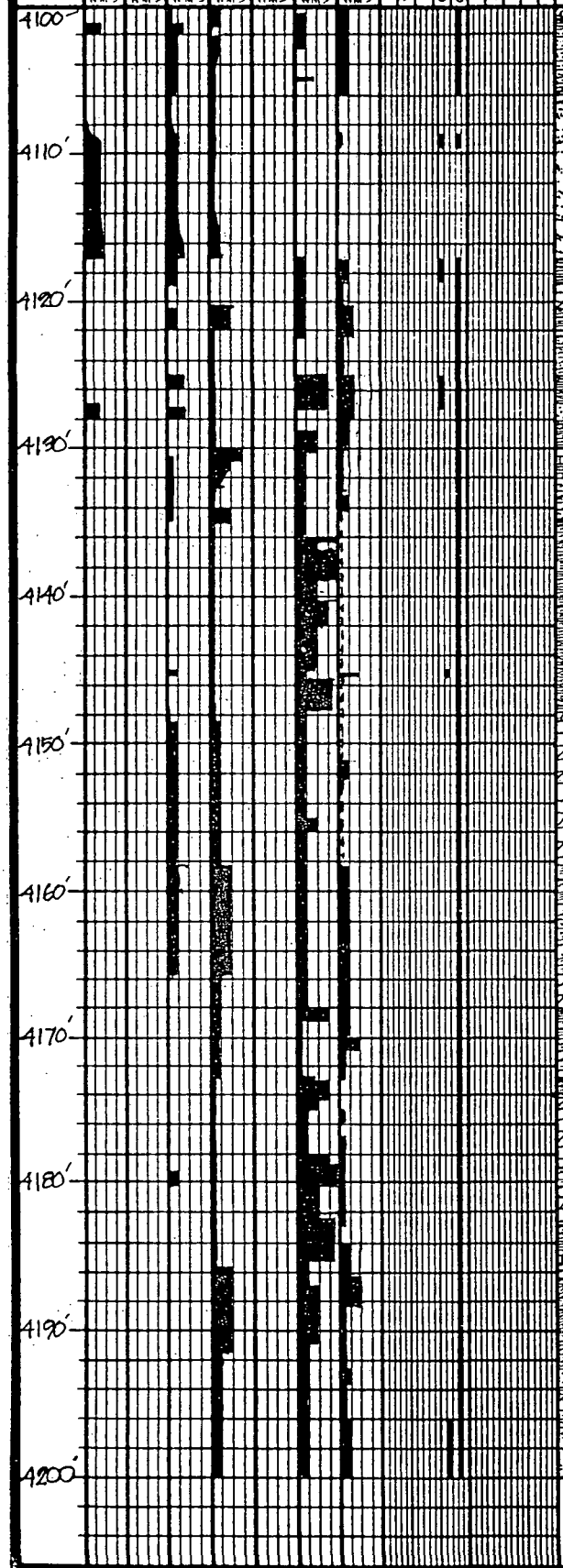
DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

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

SEPT. 17, 18, '88

GRAPHIC LOGS



NOTES, COMMENTS

- STRONG ALTN.
- REXLZN.
- DOLOMITE
- REXLZN.
- bed. dip 5-10°

HEMATITE STAINING/CEMENT/RELATIVE FRIABILITY/TENSILITY

NOTE: FRACTURING SHOWS GOOD CORRELATION WITH FISSILITY OF MUDSTONES/SHALES — THIS TYPE OF FRACTURING PROBABLY DOES NOT PROVIDE THROUGHGOING PERMEABILITY.

DESCRIPTIONS

4101.4-4106': arg. siltstone to f. gr. sandstone, highly bleached/altered upper 0.7 FT to light gray-green prob. chlorite-ser

4106-4117': F-m gr. ss, locally silty to arg., fining upward; chlorite, ser. below 4108.3' bedding ranges from massive to prom. X-bedded. some bleaching/reduction in amiehoid spots.

* basal 2' strongly bleached, sericitized, so altered w/ calcite + leven shale rip-ups toward base are so attacked.

4117-4118.7': nodular dolomitic mudstone, partly rexlzd.; dol. nodules up to 3-4 cm. dia w/ gray-green rims up to 5 mm. wide

4118.7-4120.9' DOLOMITE, lt. greenish-gray, v. f. xln., poss. silty; has "porphyritic" appearance w/ lt. gray to orange-gray irreg., more coarsely-xln. clots. up to 3-4 mm. in diameter.

4120.9-4122': CALC. MUDSTONE, prob. rexlzd., mottled w/ brecciated/reheeled texture; neoformation of med. gray-green mineral

4122-4125': hem., argillaceous siltstone to sandstone

4125-4127': mudstone/shale

4127-4128': SANDSTONE, f. gr., massive, altered

4128-4130': arg., hem. siltstone

4130-4131': ls., v. f. xln., lt. gray

4131-4139': arg. to silty ls to calcareous sltst.

4139-4147.8': mudstone, locally extremely fissile, local irreg. calcitic blebs up to 5-6 cm dia.

4147.8-4148.6': DOLOMITIC MUDSTONE TO ARGILL. DOL. MOTTLED, W/IRREG. DOL+CHL. "NODULES" UP TO 1.5 CM. DIA. SOME OF THESE APPEAR TO HAVE CHLORITIC RIMS.

4148.6-4158.2': DOLOMITE, massive, lt.-med greenish-gray, looks "speckled" under hand lens — local calcite nodules or concretions up to 1cm. dia.

4158.2-4168.5': CALC. MUDSTONE AS ABOVE

4168.5-4168': DOLOMITE, AS ABOVE.
4168-4168.8': Med. gray fissile shale

4168.8-70.8': calcar. sltst., lower one ft. heavily veined w/ prob. diagenetic calcite-reticulate texture

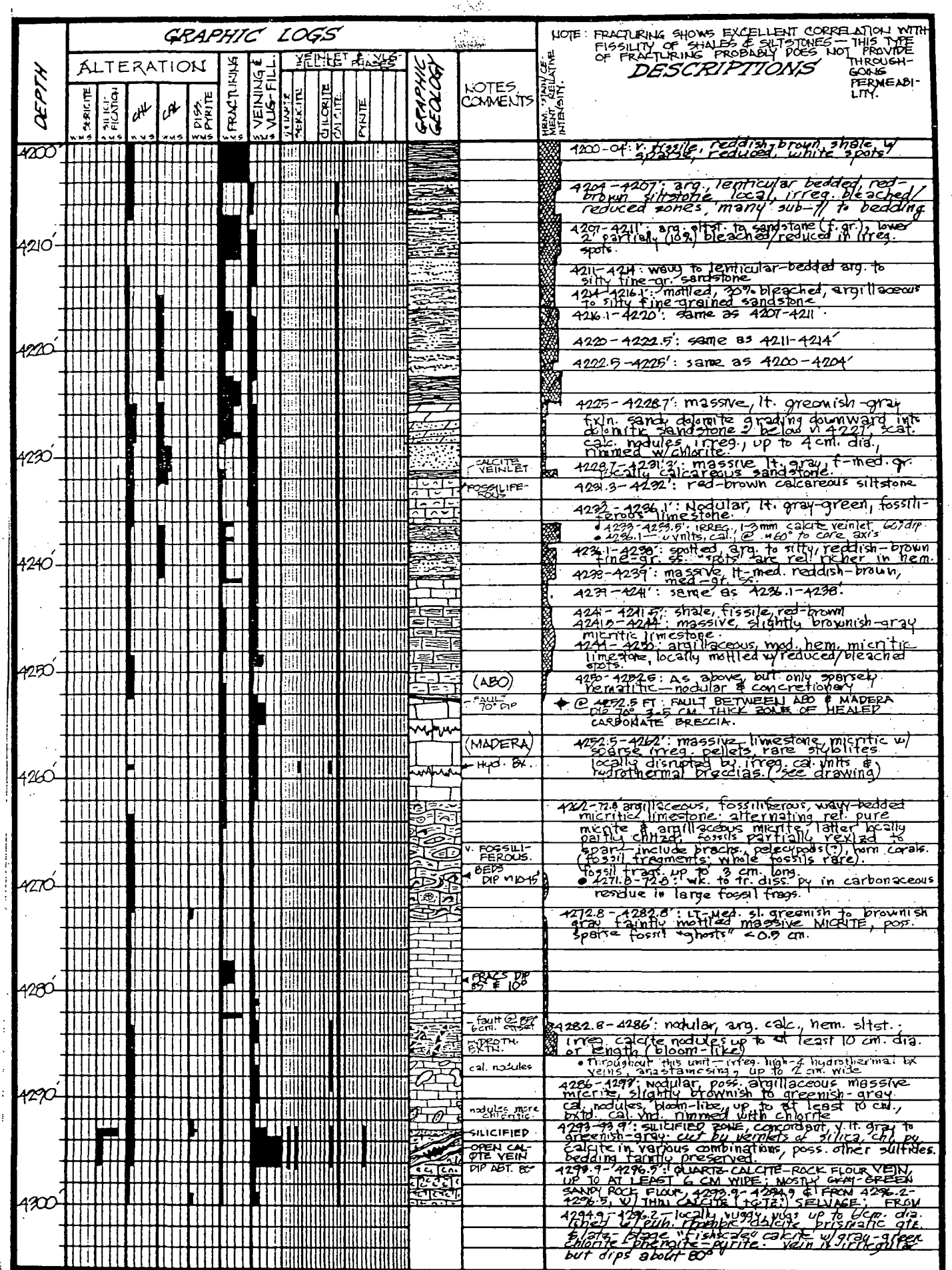
4170.8-4173': argill., locally calcareous siltstone, rare calcareous nodules.

4173-4174.5': fissile mudstone
4174.5-4175': dolomitic mudstone
4175-4179': massive gray dolomite, as above
4179-4180.5': GRAY, fissile dol. mudstone
4180.5-4181': mottled, calc. mudstone w/ 10% chlor/cal. nodules.
4181-4183': DOL., AS ABOVE
4183-4185.5' GRAY, CALCAR., HIGHLY FISSILE SHALE
4185.5-4186.2': CALC. MUDSTONE
4186.2-4196': Calc. mudstone, red again, with local, irreg. concretions up to 1/2 cm. dia.
• 4186.2-4188.5': reticulate network of stockwork calcite veinlets

4196-4200': lenticular bedded, interbedded f. gr. sandstone & argillaceous siltstone, mottled gray & red coloration

DRILL HOLE VC-2B (FIELD LOG)
LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. HULEN & J. GARDNER
27 SEPT., 9 DEC. '80

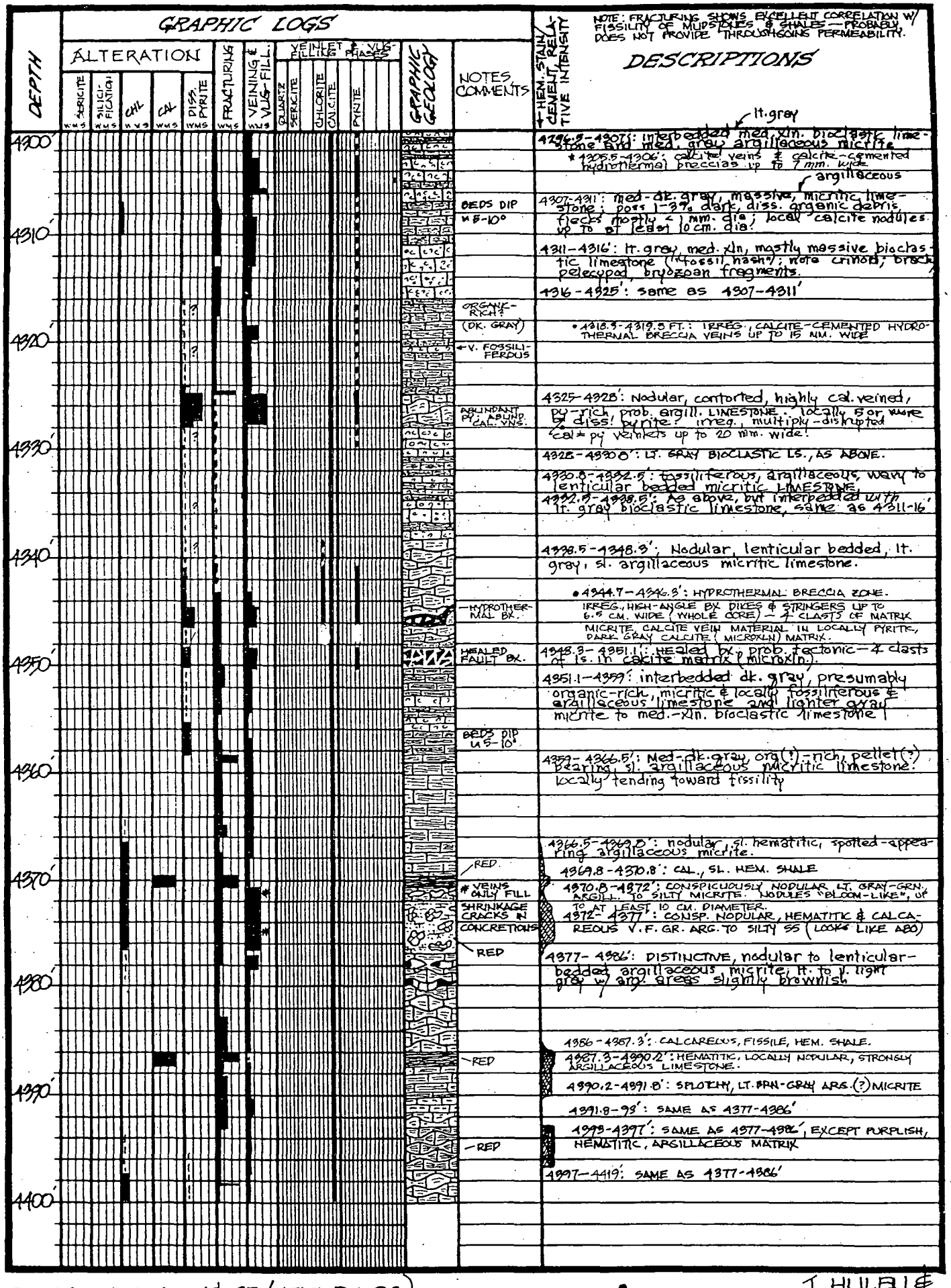


DRILL HOLE VC-2B (FIELD LOG)

LOCATION VALLES CALDERA, NM

LOGGED BY J. HULEN & T. GARDNER

9 & 10 DEC. 1988

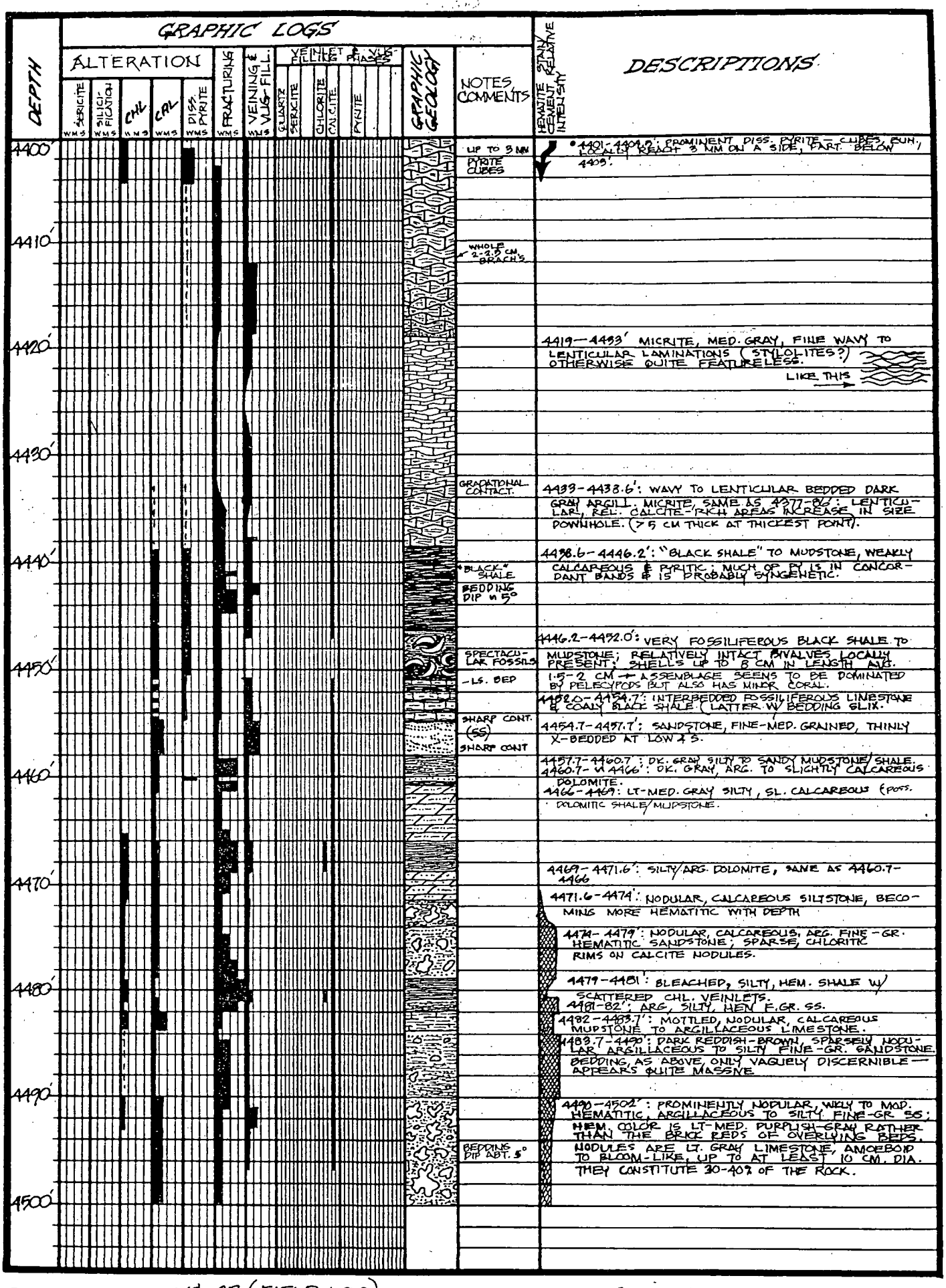


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. HULEN & J. GARDNER

10 DEC. 1988

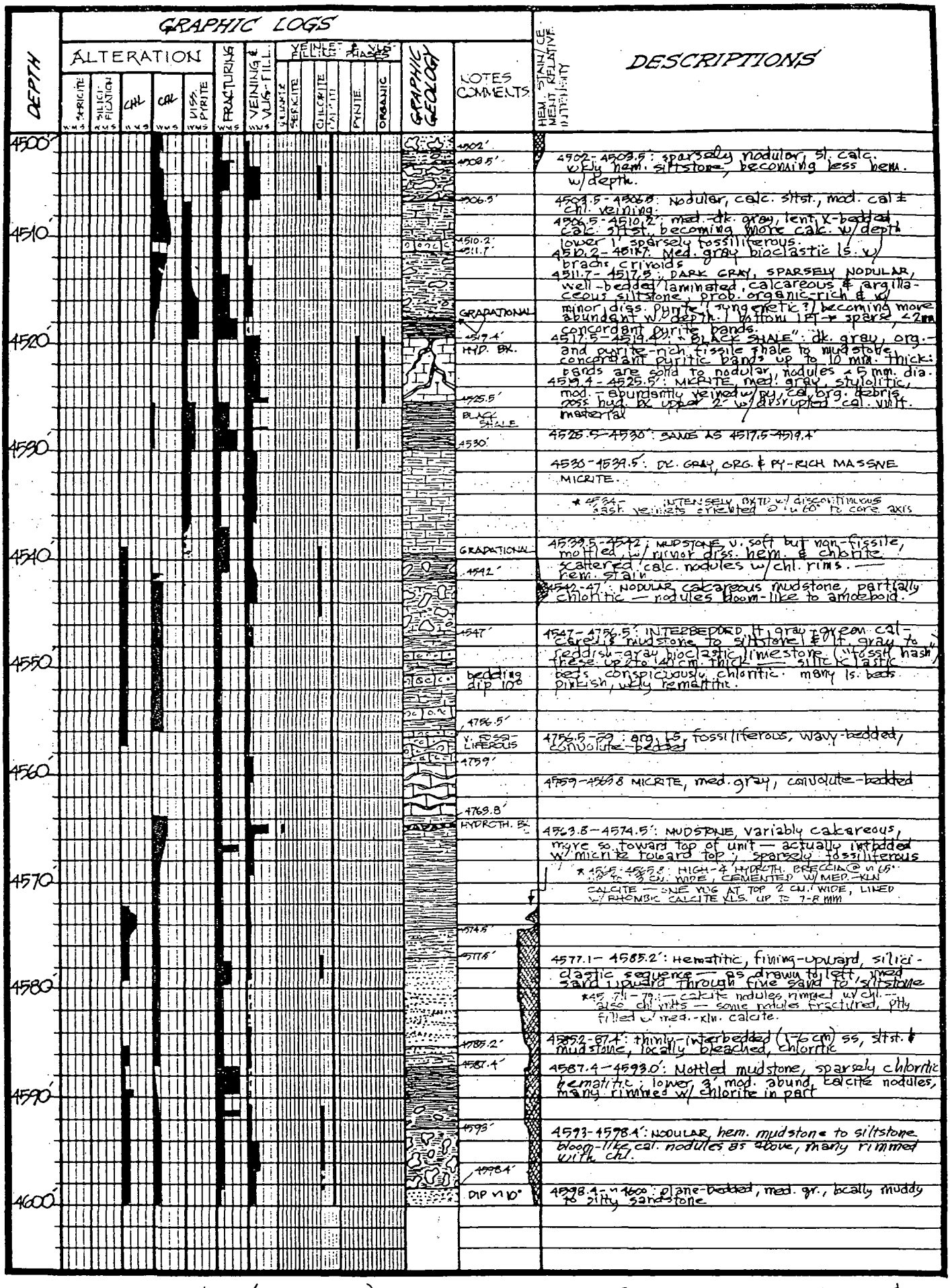


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM.

LOGGED BY J. HULEN

10 DECEMBER 1988

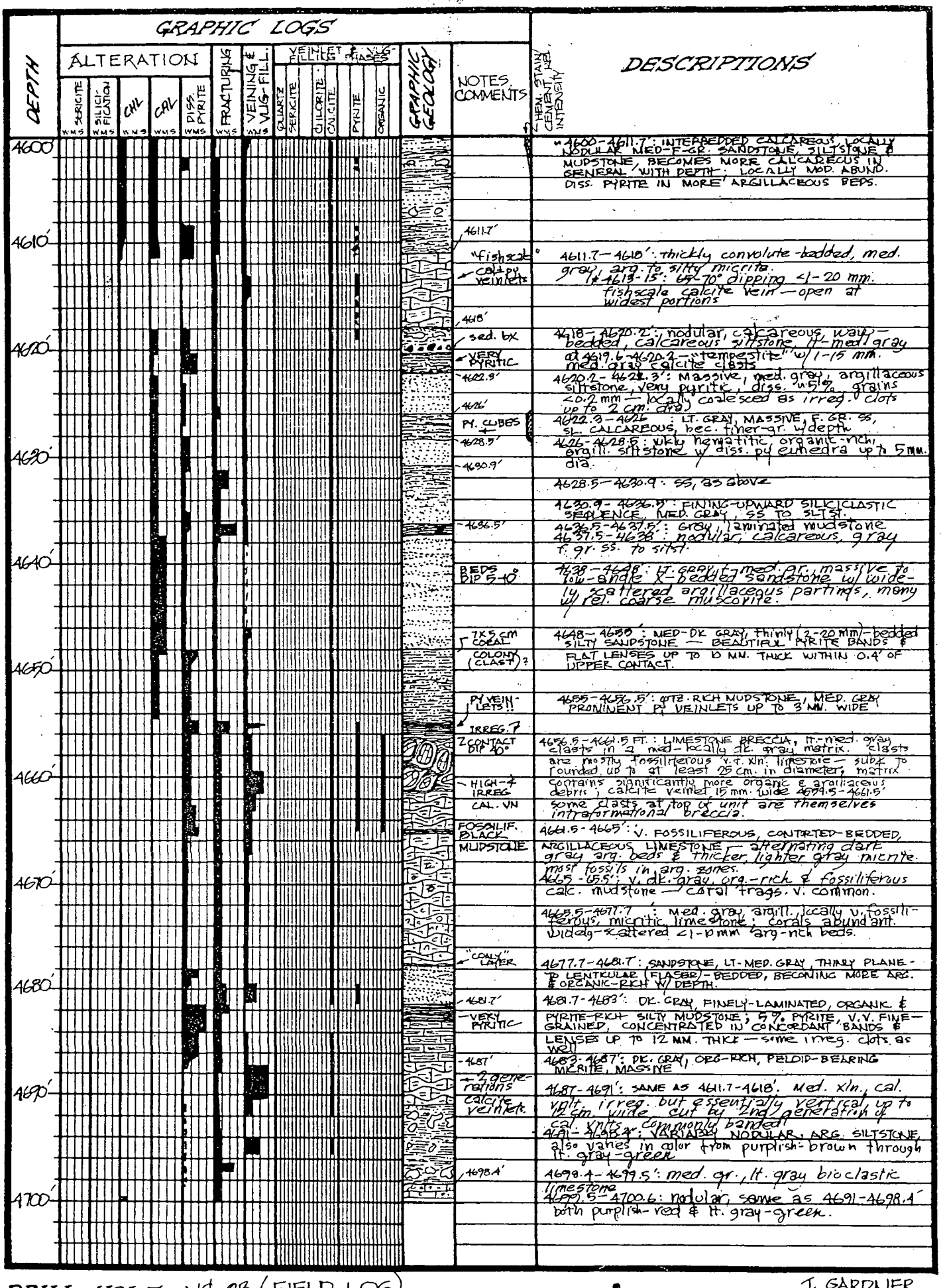


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY HULEN & GARDNER

12 DEC., 1988

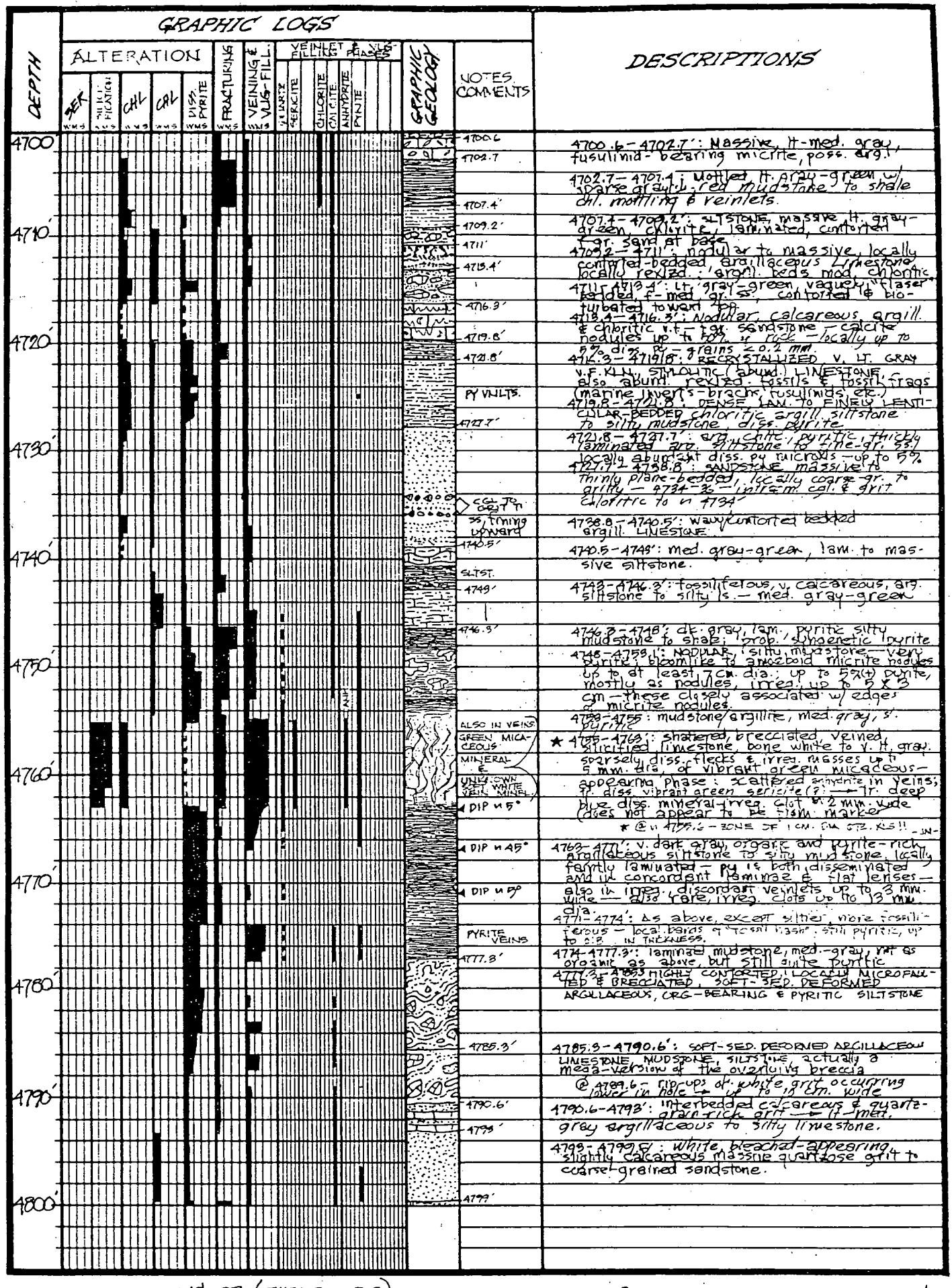


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. GARDNER, J. HULEN

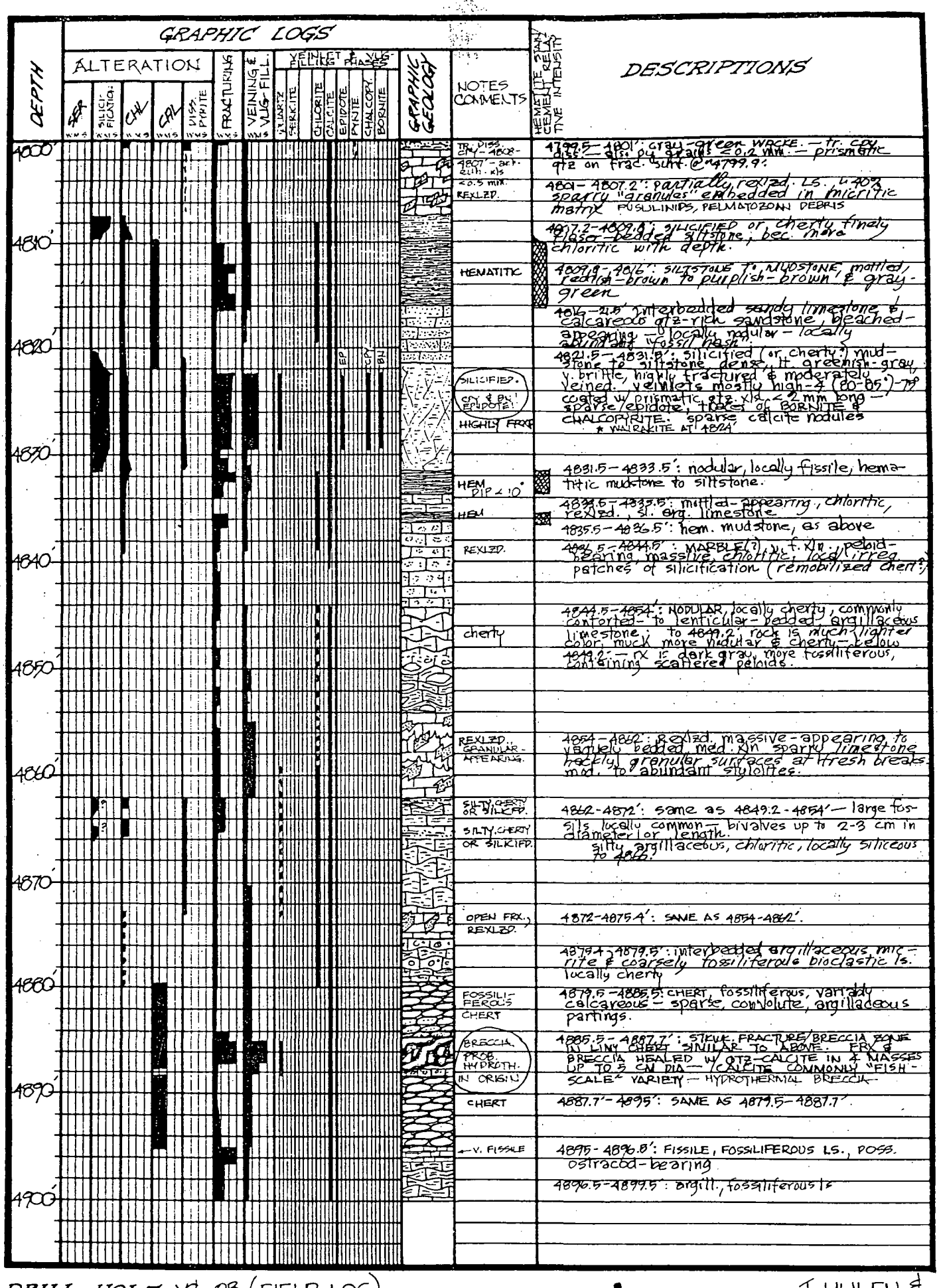
SEPT. 27, 1988
DEC. 12,



DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS VALLES CALDERA NM

LOGGED BY J. HULEN & J. GARDNER 12 DEC. '88

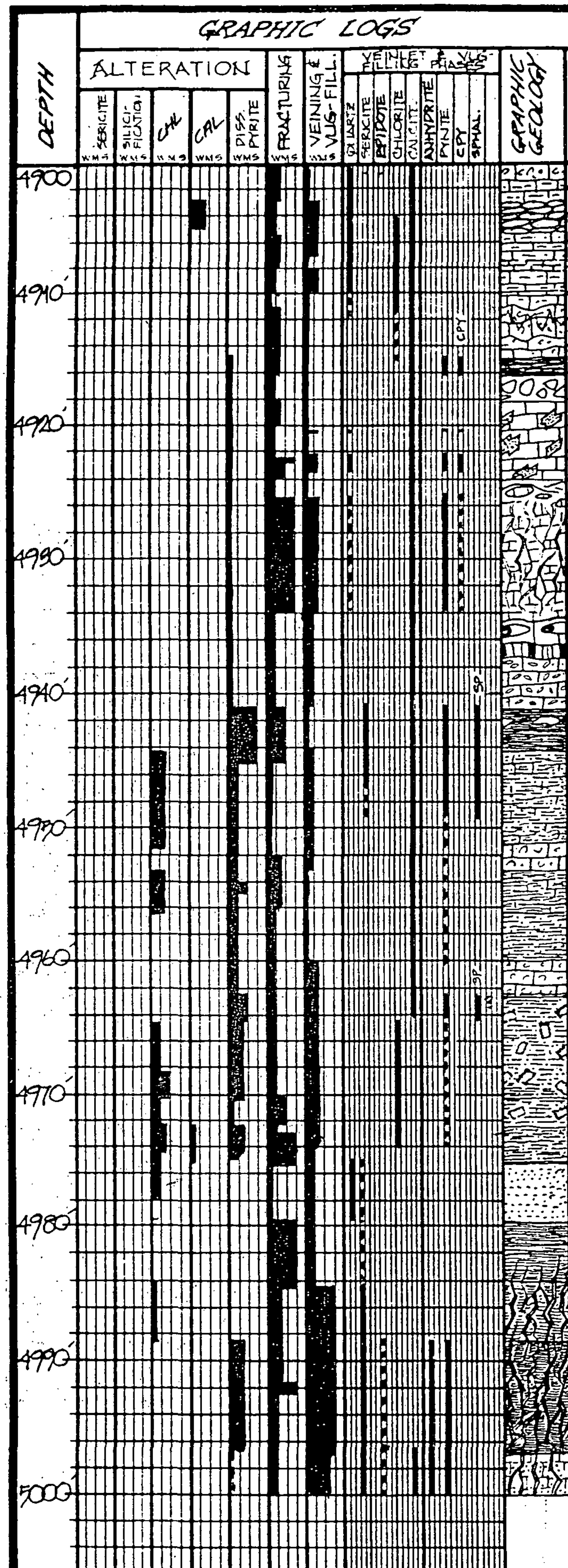


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. HULEN & J. GARDNER

12 DEC. '88



NOTES, COMMENTS	DESCRIPTIONS
	4899.5–4901.5': massive, fossiliferous LS, dk. gray, stylolitic.
CHERT	4901.5–4910.1': INTERBEDDED ARGILLACEOUS LIMESTONE & CALCAREOUS CHERT, BOTH FOSSILIFEROUS — locally argillaceous.
4910.1'	4910.1–4915.1': MICRITE, med. gray, thinly bedded, stylolitic (sparse); variably fossiliferous, fusulinids locally abundant; scattered, undulose, argillaceous partings
BED DIP 5°	4915.1–4916.1 "BLACK", ORG-RCH, THINLY LAMINATED Argill. SILTSTONE.
INTRAFORM. CGL.	4916.1–4918.1 — LIMY, intraformational CGL.
	4918.1–4924': Partially rexlzd., locally fossiliferous limestone; rare qtz. sand grains; speckled appearance due to rexlzn.; variably fossiliferous as above
SEV. 2–5 CM. PY CLOTS	4924–4937.5': NODULAR, ARILLACEOUS, ORGANIC-RICH. MED.–DK. GRAY LIMESTONE, LOCALLY REXLZD.
CPY IN VNLTS. STRONG FRACTURE ZONE.	★ Strongly fractured 4925–4934', frx both along bedding & at high ∠'s. calcite ± qtz + pyrite & cpy vnlts. 60°–vertical dips & widths up to 1 cm. some delicately banded.
4937.5' ← FUSULINIDS	4937.5–4941': argillaceous, fusulinid-rich, dk. gray limestone
PY & SP IN NODULES & VEINLETS	4941–4944.2': "BLACK" organic & pyrite-rich mudstone
← SP-PY NODS	★ 4942.3': irreg. to amoeboid, 6x4 cm. pyrite + sphalerite nodule — sulfides are microcrystalline aggregates
BEDS DIP ~10°	★ 4943.8–44': highly irregular "ptygmatic-appearing" calcite–pyrite–sphalerite veinlet <1–4 mm. wide.
	4944.2–4951': Med. grey muddy siltstone, thinly-bedded to laminated
	★ 4944.9': 2 irreg. to elongate pyrite-sphalerite nodules.
MADERA	4951–4953.5': Lt. gray–med. grey, arg. to silty limestone, fossiliferous
	4953.5–4960': siltstone, arg., faintly plane-bedded, pyritic
	4960–4962.8': v. fossiliferous, sl. argill., somewhat disrupted limestone — microfaults present — some filled w/ calcite. lower 0.15' is org(?)-rich, cut by irreg. py-sp(?) vein up to 13 mm. wide.
4962.8' SANDIA FM. UNIT CONTAINS SCATTERED, RECTANGULAR PORPHYROBL.	4962.8–4970.2': METASILTSTONE, lt. greenish gray, mottled-appearing, vaguely bedded; scattered, translucent to nearly opaque white to lt. gray porphyroblasts (≤2 vol. %), commonly rectangular, rimmed w/ chlorite. avg. 2–3 mm. length; abund. chl. in veinlets; sieve-textured euh. pyrite up to 5 mm. dia. toward base of unit; below 4967.2 → brownish, resinous-appearing unknown metamorphic mineral.
4970.2' 4972.8'	4970.2–4972.8': argillaceous, hematitic METASILTSTONE — blotchy, oxidized/reduced texture — hem. patches rimmed w/ lt. gray-grn. RECTANGULAR PORPHYROBLASTS AS ABOVE.
4975.5'	4972.8–4975.5' SAME AS 4962.8–4970.2'. diss. ep. below 4974.
← HORIZ. BEDDING	4975.5–4979.8': METASANDSTONE, lt. greenish-gray med.-crs. grnd. qtz-rich — minor diss. epidote
	★ UNIT cut by high-∠, partly open qtz. veinlets
INTENSE HYDRAULIC FRACTURING (HEALED)	4979.8–4984': silty mudstone, upper 1.2' dark & organic-rich
	4984–4988.6': As above, exc. sl. more siliceous(?) & INTENSE HYDRAULIC FRACTURING/VEINING; local "jigsaw puzzle" brecciation.
◄ 6 cm PY nodule	
← INTENSE HYDRAULIC FRX & VEINLETS	4988.6–4996.8': Black, organic-rich, locally coaly mudstone — v. pyritic w/ nodules & remobilized py. in veinlets — intense hydraulic fracturing & veining — most very high ∠ (>60°); veins consist of ser., anh., pyrite & tr. epidote
4996.8'	4996.8–5012.2': Interbedded silty to sandy limestone & calcareous siltstone to sandstone; strong calcite-anhydrite-sulfide veining in hydraulic fractures to ...

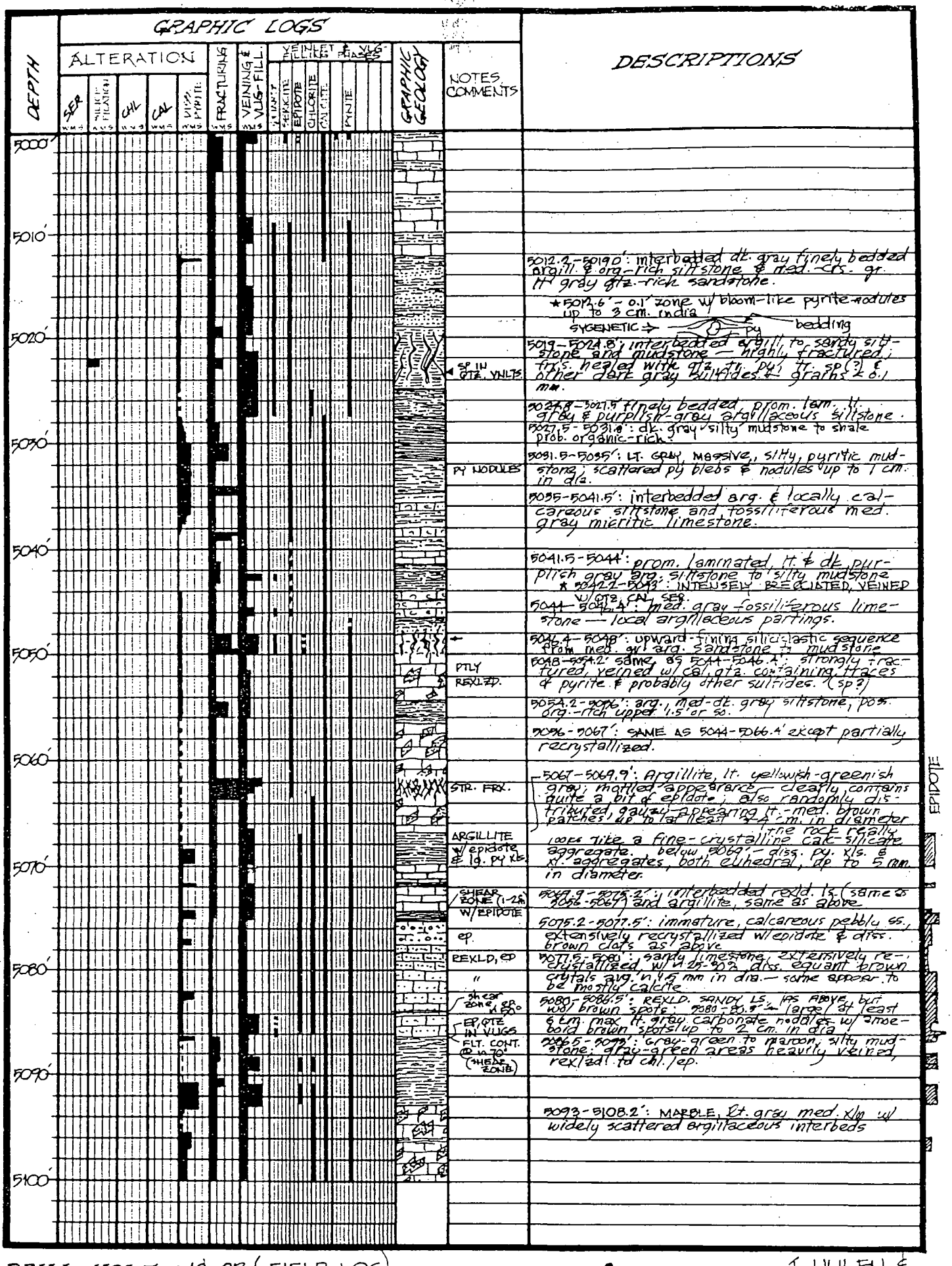
EP

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N. MEXICO

LOGGED BY J. HULEN & J. GARDNER

12 DEC. 1988



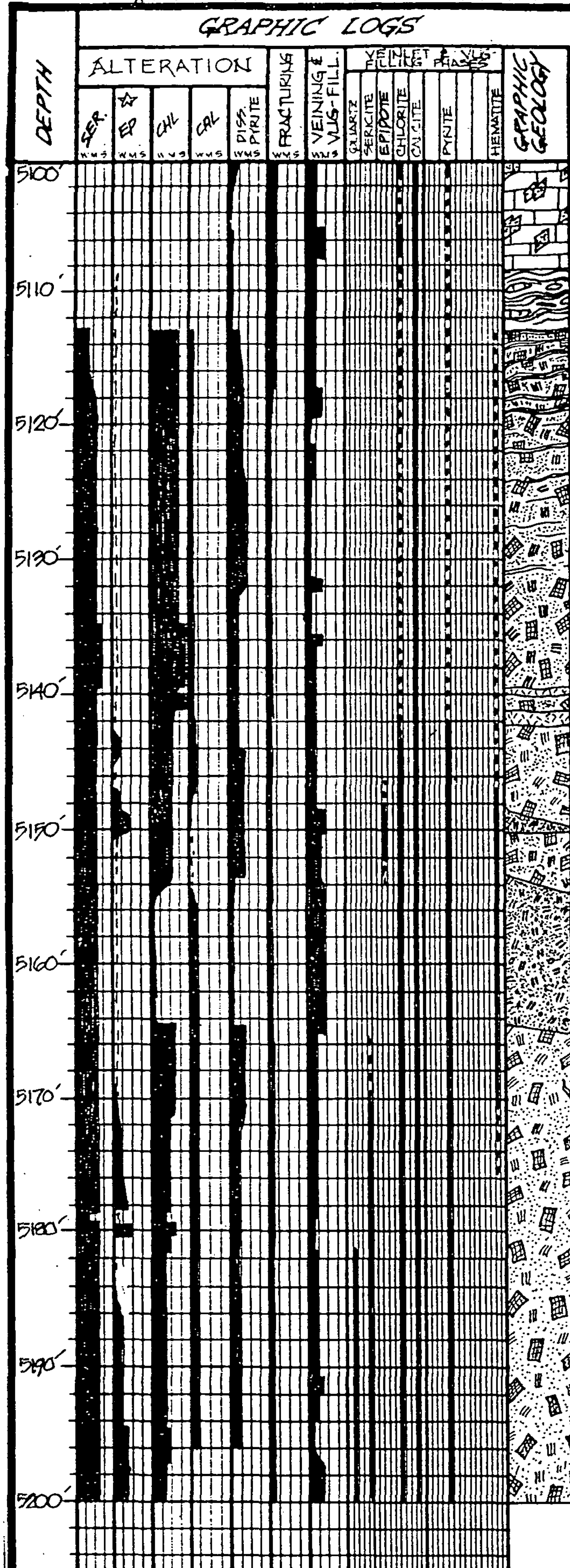
DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N. MEX.

LOGGED BY J. HULEN & J. GARDNER

JAN. 10, 1989

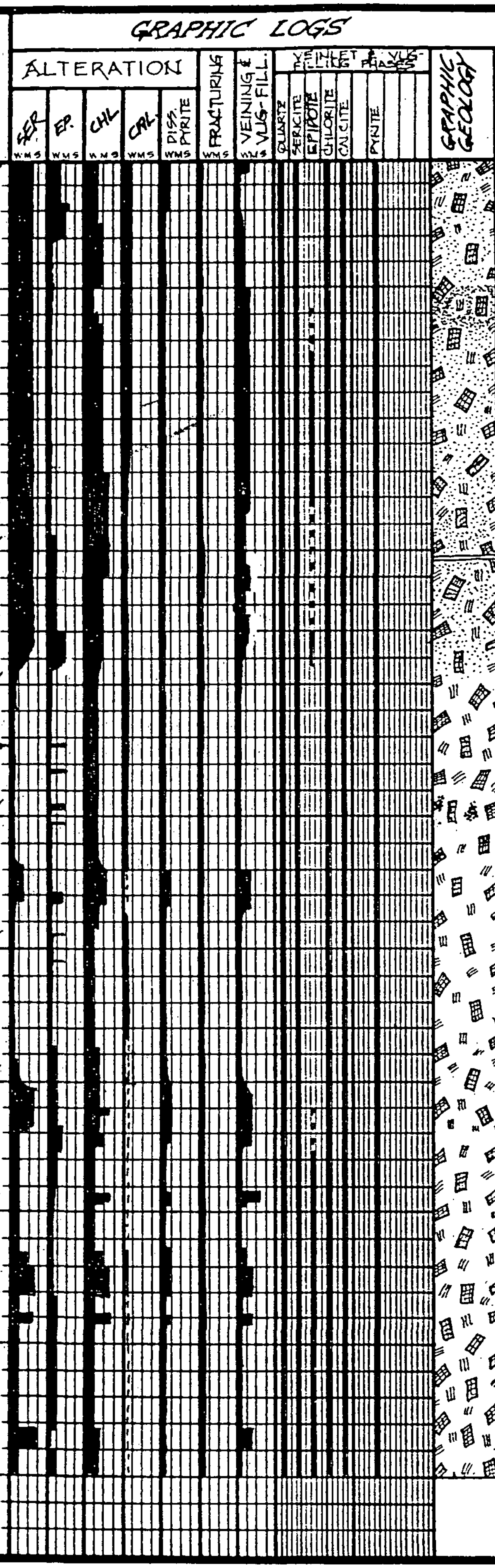
☆ NOTE CHANGE IN COLUMN HEADING FROM SILICIF. TO EPIDOTE



NOTES, COMMENTS	DESCRIPTIONS
	TO 5108.2': MARBLE, AS ABOVE.
(SANDIA) "MELANGE" (SHEAR CONTACT ~30°)	5108.2–5113': "Melange": highly sheared mixture of limestone, mudstone, siltstone in a foliate, altered matrix of calcite, chl. w/ minor epidote; some post-shearing high-∠ microfaulting.
QTZ. MONZ. (SHEARED) (HIGHLY ALTERED) (PC)	5113–5119' sheared, highly altered porphyritic qtz. monzonite; shears avg 30–40° dip — consist of comminuted rock altered to chl ± ep ± cal(?): lg. K-spar phenocrysts up to 3x2 cm (avg. ~ 2x1.5 cm) now almost totally chloritized; leucoxene after sphene & ilmenite.
K-SPAR PHENOS HIGHLY CHLTZD	5119–5153'': As above, but not as intensely sheared; strong chltzn. not only of matrix but also of potassium feldspar phenocrysts. increase in intensity of sericitization of plagioclase
SHEARING DIMINISHES	
F. XLN GRD DIKES	
DIP ~ 40°	★ 5148.2–5150.1': highly sheared & veined f-med xln. qtz. monzonite dike — especially strong shearing at base — appearance of epidote in veinlets
CONTACT DIP 80°	5153–5165': APLITIC DIKE, V. H., slightly greenish to pinkish-gray – avg. grain size ~1 mm. laced w/ high-∠, calcite-dominated veinlets
APLITIC DIKE	
CONT. DIP 70°	5165–5431.8': altered, porphyritic qtz. monzonite as above
hyd. bx veinlet 0.5 cm. 85° dip	(epidote increases + replaces mafics & K-feldspar as well as plagioclase)
	★ 5178.2–5179.5': K-spar phenos. pink, only slightly altered.
	★ Below ~5185': K-spars extensively altered to chlorite plus epidote — have mottled to reticulate appearance
K-SPAR PHENOS HIGHLY CHLTZD.	★ BELOW 5189' → : sparse 1–2 cm felsic fine-xln dikelets dip up to 45°
	★ 5191.8': 2 cm. qtz-cal cemented breccia dipping @ ~30°

DRILL HOLE VC-2B (FIELD LOG)
LOCATION SULPHUR SPRINGS, VALLES CALDERA

LOGGED BY HULEN & GARDNER
9/10/89

DEPTH	GRAPHIC LOGS	NOTES COMMENTS	DESCRIPTIONS
5200'			PORPHYRITIC QTZ. MONZONITE CONTINUES
			★ NOTE: widespread diss. ilmenite(?) partly replaced with leucoxene.
5210'		← SILICIFIED	★ 5210-5213': Rock has been intensely fractured but then healed → micro-crystalline lt. gray translucent qtz. possibly with minor albite. → 5211-5212: ~5-10 cm silicified rock flour 80-90° dip
		K-FELDSPAR PHENOS. CHLORITIZED.	★ epidote prominent in veins below 5215'.
5220'			
5230'			★ 5231-5237': mod. veined w/ qtz-cal-chl-ser-py; vnlts up to 1 cm. wide; commonly banded — mostly high-angle (? 70°).
5240'		NOTE REDUCTION IN SERICITE INTENSITY	
	VEIN DIP 45°	KFSP PHENOS BECOME PINK, VERY FRESH	
5250'		◄ VEIN DIP 60°	★ 5249.5-5250': → scattered mafic-rich amoeboid clots up to 5 cm. dia., selectively pyritized — perhaps other sulfides.
5260'			
5270'		CPY DISS.	★ 5271-5274: zone of more intense chl-ser-ep-py alteration & hydrothermal veining. scattered tr. cpy (diss)
5280'			★ 5278.5-5279.8': zone of intense brecciation @ ~dip 65°: strong alteration — mostly silicification of matrix rock flour.
			★ 5277.8-5278.3': 55° dip on microxln. silica + sericite vein up to 2 cm. wide.
5290'		◄ VEIN DIP 55°	★ 5295.5: calcite-quartz-pyrite-ser. vein w/ tr. cpy. → actual vein is ~10-15 mm. wide, but has selvage of epidotized plagioclase.
		& QTZ ◄ SER-CAL-PY VN W/CPY DIP ~40°	
5300'			

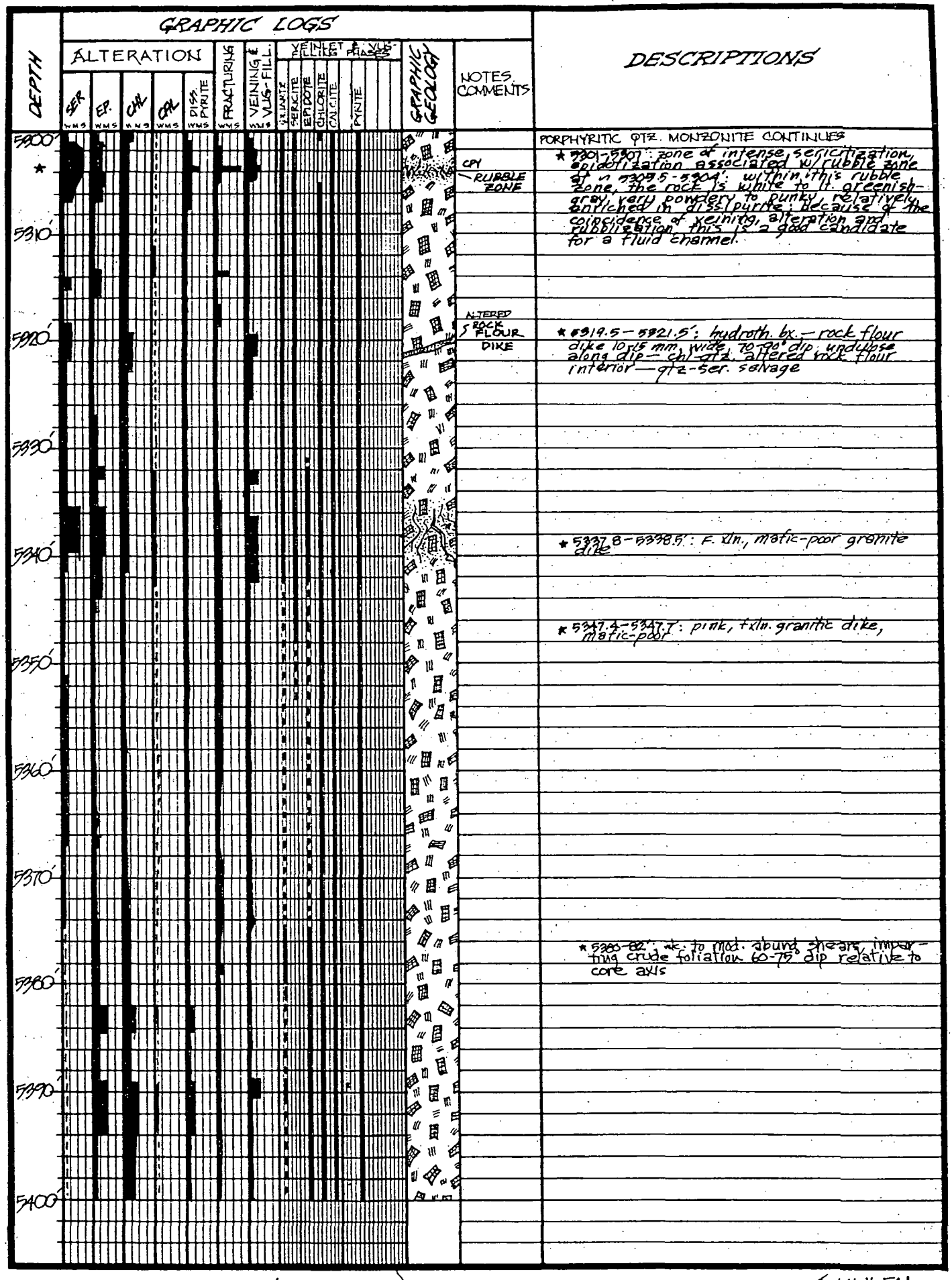
SILIC.

DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA,

LOGGED BY J. HULEN & J. GARDNER

01/11/89

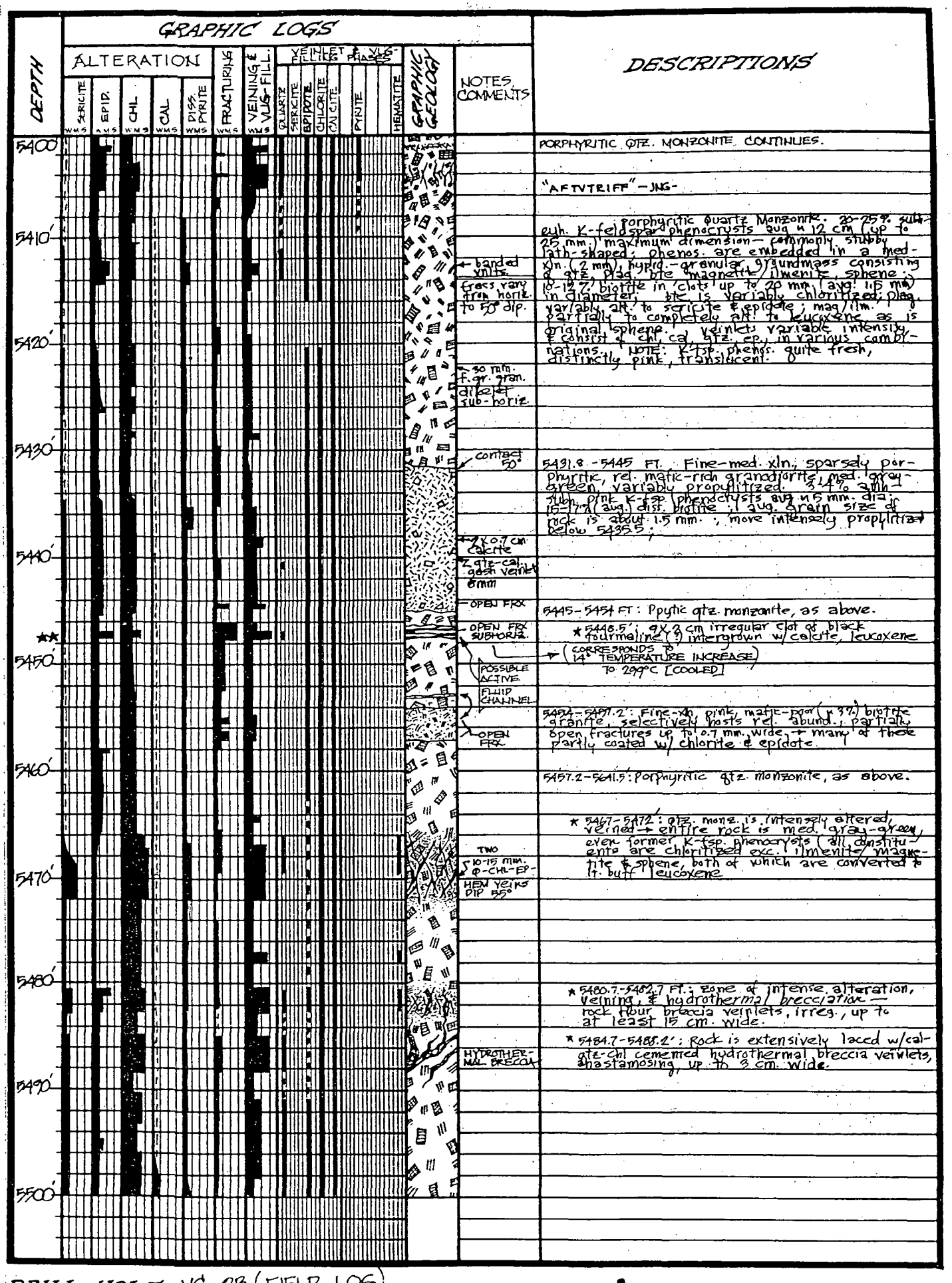


DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, NM

LOGGED BY J. HULEN, J. GARDNER

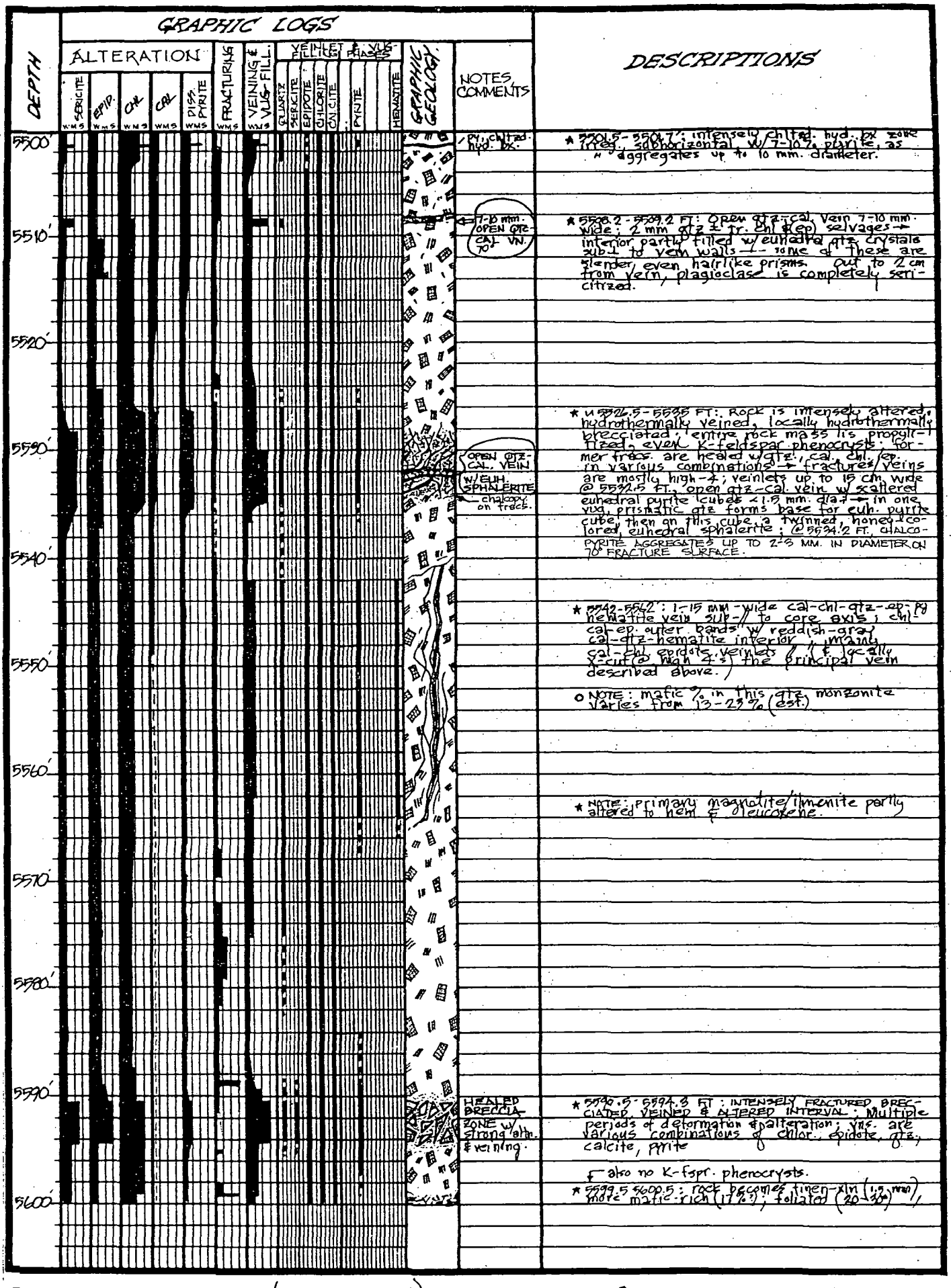
DEC. 1988



DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N. MEXICO

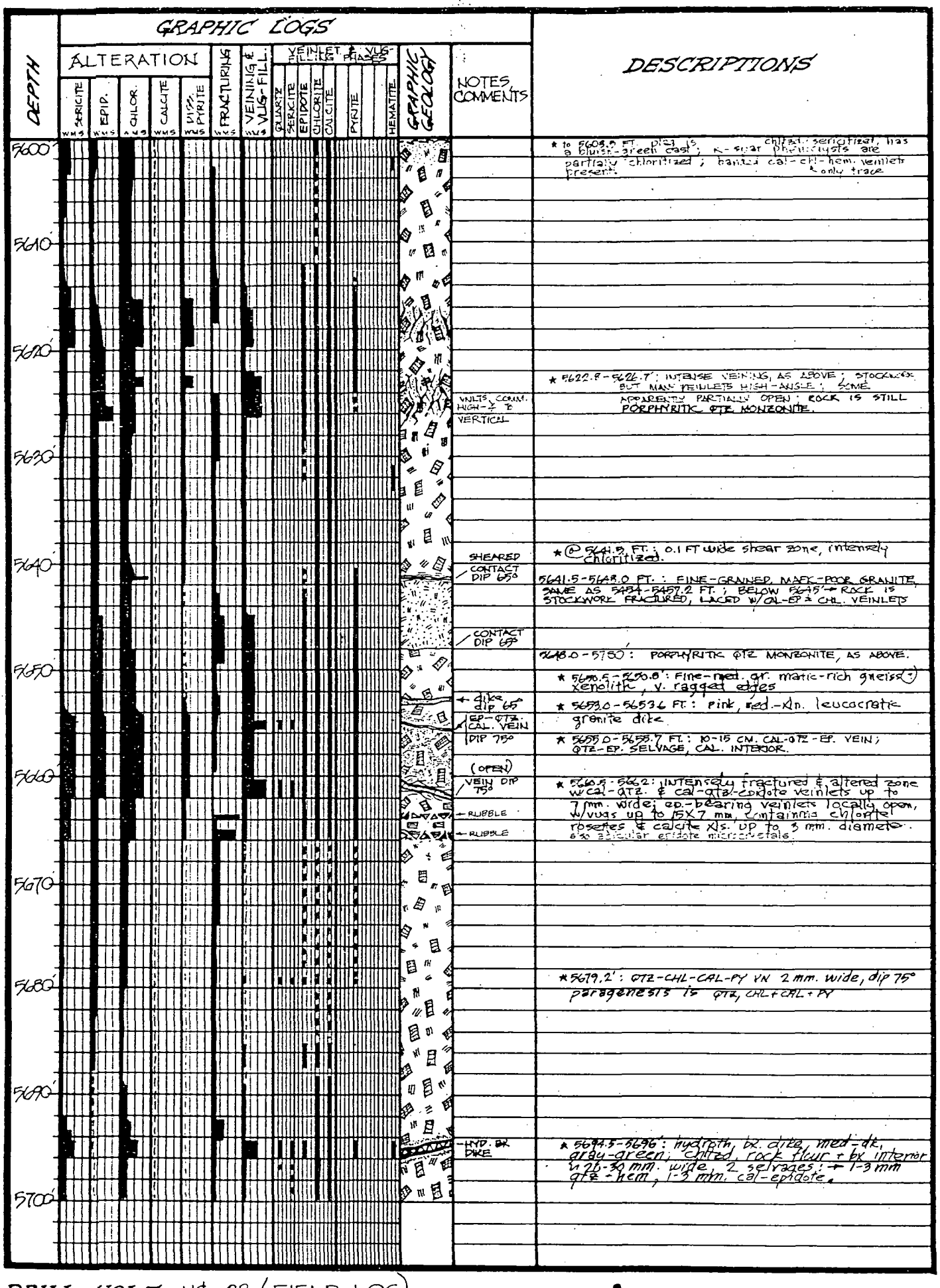
LOGGED BY J.B. HULEN



DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA, N.M.

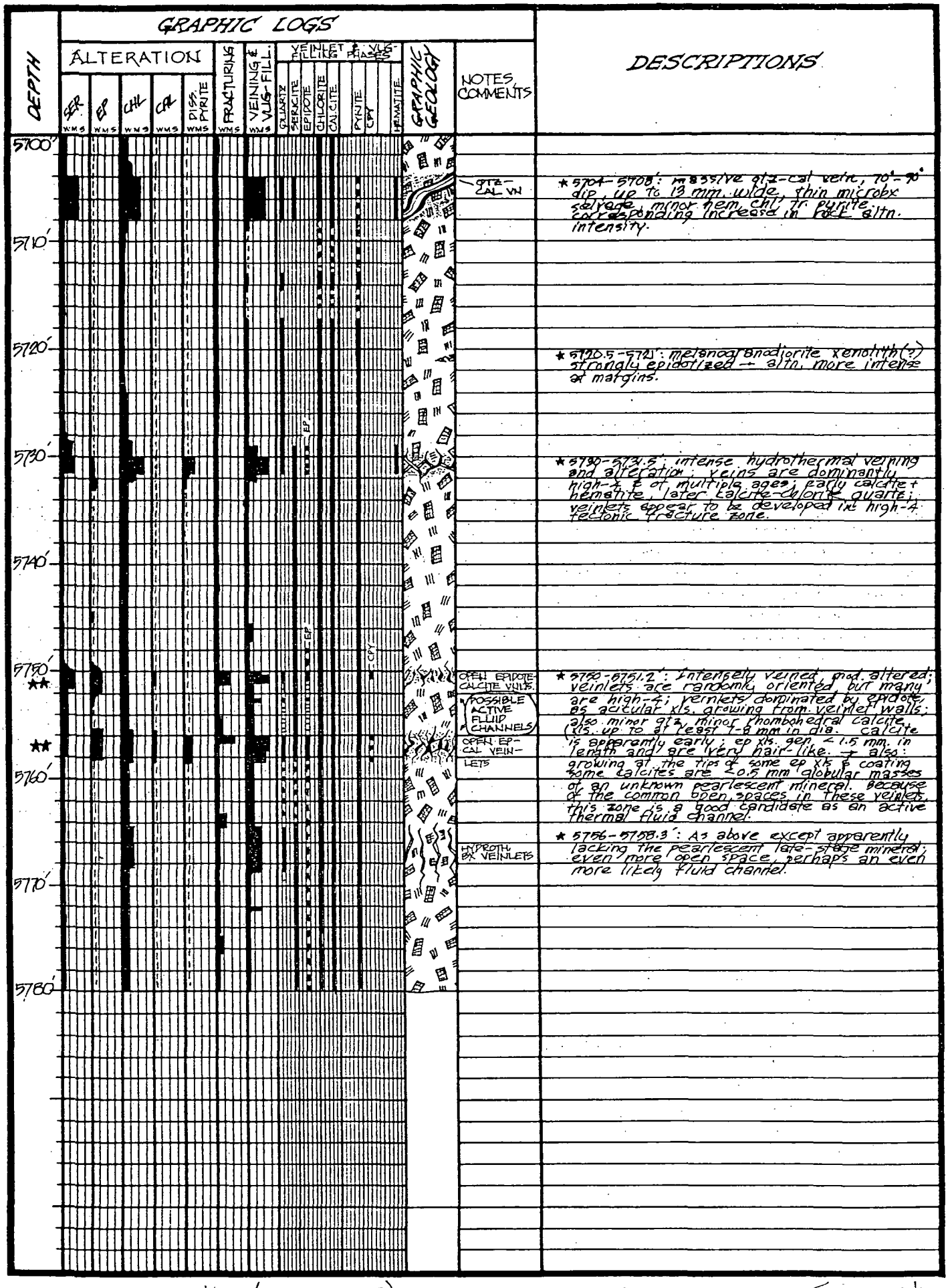
LOGGED BY J. B. HULEN



DRILL HOLE VC-28 (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA NM

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



DRILL HOLE VC-2B (FIELD LOG)

LOCATION SULPHUR SPRINGS, VALLES CALDERA NM

LOGGED BY J. HULEN & J. GARDNER 01/12/88

SAMPLE ACQUISITION

Core from VC-2B (as well as VC-1 and VC-2A, previously drilled Valles CSDP coreholes) is ready for sampling at the Dept. of Energy's Core and Sample Repository in Grand Junction, Colorado. Those wishing to obtain core samples can either do so in person or submit requests to the Repository's curator. A companion volume to this log, written by Virginia Starquist of LANL and containing detailed curatorial information, will shortly be available and should facilitate sample requests. These should be directed to:

Richard Dayvault, Curator
DOE Core and Sample Repository
UNC Geotech
P.O. Box 1400
Grand Junction, CO 81502
(303)-242-8621

A copy of each request should be sent to Jamie Gardner at LANL (address in Appendix 2).

ACKNOWLEDGEMENTS

The VC-2B project was sponsored by the U.S. Department of Energy's Office of Basic Energy Sciences. Meticulous observations by drill-site scientists Bill Crisswell, Rob Gribble, Kim Meeker, John Musgrave, Tim Smith, and Dan Wilson were essential in preparing this log. Thom Little and Peggy Snow identified many of the metallic and other vein minerals using the scanning electron microscope. Kim Meeker and Fraser Goff employed the petrographic microscope and electron microprobe to investigate deep

recrystallization and hydrothermal alteration in the Sandia Formation. VC-2B site operations were supervised by Pete Lysne, Ron Jacobson, and Allan Sattler of the GRDO. The actual drilling was smoothly completed by Tonto Drilling Services under the direction of Larry Pisto, Ron Fireback, Mike LaOrange, Bill Cunningham and Jerry Gillespie.

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APPENDIX 1
ABBREVIATIONS

AB--albite
ABUND--abundant
ACC--accessory
ACCR--accretionary
ACCRET--accretionary
AF--ash-flow
AFT--ash-flow tuff
AGG--aggregate
ALT--altered
ALTN--alteration
AND--andesite
ANH--anhydrite (rarely "anhedral")
ANHYD--anhydrite
APP-apparently
ARG-argillaceous
ARGILL--argillaceous

BEC--becoming
BIPYR--bipyramidal
BN--bornite
BRACH--brachiopod
BX--breccia
BXTN--brecciation

CAL--calcite
CALC--calcite, calcareous
CALCAR--calcareous
CARB--carbonate
CH--chlorite
CHALCED--chalcedony
CHALCOPY--chalcopyrite
CHL--chlorite
CHLTZD--chloritized
CHLTZN--chloritization
CM--centimetres(s)
COMP--compaction (rarely "composition")
COMPAC--compaction
COMP FOL--compaction foliation
CONT--contact
CPY--chalcopyrite
CRS--coarse
CRSR--coarser

DEF--definitely
DEFM--deformation
DEP--deposited
DIA--diameter
DISS--disseminated
DK-dark
DOL--dolomite, dolomitic
DOM--dominated, dominantly
DW--densely welded

E G.--for example
EP--epidote
ESP--especially
EUH--euhedral
EXC--except

F--fine
FL--fluorite
FLD--fluid
FLUOR--fluorite
FLT--fault
FM--formation
FOL--foliation
FOL'N--foliation
FRAC--fracture(s)
FRACT--fracture(s)
FRAG--fragment
FRX--fractures, fracturing
FSP--feldspar
FT--feet
FXLN--fine-crystalline

G--grained
GR--grained
GRN--green

HEM--hematite
HORIZ--horizontal
HYD--hydrothermal
HYDROTH--hydrothermal
HYDROVOLC--hydrovolcanic

IG--ignimbrite
IL--illite
ILM--ilmenite
INC--inclusion(s)
INCR--increase, increasing
INTBDDED--interbedded
INTM--intermediate
INTRAFM--intraformational
IRREG--irregular

K--potassium
KF--potassium feldspar
KFSP--potassium feldspar
K-SPAR--potassium feldspar

LAM--laminated
LAP--lapilli
LEUC--leucoxene
LG--large
LIMEST--limestone
LS--limestone
LST--least
LT--light

M--metre(s) (rarely "medium")
MAG--magnetite
MAX--maximum
MED--medium
MICROXLN--microcrystalline
MINRL--mineral
MM-millimetre(s)
MO--molybdenite
MOD--moderate, moderately
MOLYBD--molybdenite
MOS_2--molybdenite
MONZ--monzonite

NOD--nodule
NW--non-welded

PH--phengite
PHENG--phengite
PHENO--phenocryst
PL--plagioclase
PLAG--plagioclase
PORPYROB--porphyroblast
POSS--possibly
PPY--porphyry
PPYTIC--porphyritic
PR--primary
PREDOM--predominantly
PROB--probable, probably
PROM--prominent,
prominently
PTLY--partly
PY--pyrite

Q--quartz
QTZ--quartz

REL--relatively
RH--rhodochrosite
RHODOCHR--rhodochrosite
RHY--rhyolite
RND--round(ed)
RX--rock(s)

S--strong
SCATT--scattered
SEC--section
SED--sediment
SEP--separated
SEQ--sequence
SER--sericite
SEV--several
SILIC--silicification
SILTST--siltstone
SL--slightly
SLIX--slickensides
SLTST--siltstone
SOLN, SOL'N--solution
SP--sphalerite
SPH--sphalerite
SPHAL--sphalerite
SPHALER--sphalerite
SS--sandstone
STKWK--stockwork
SUBH--subhedral
SURF--surface

TEMP--temperature
TL--total
TR--trace
TRANSL--translucent

V-very
VAP--vapor
VN--vein
VNLT--veinlet
VOLC--volcanic

W/--with
WO/--without
WK--weak
WKLY--weakly
WT--weight

X--cross
XL--crystal
XLINE--crystalline
XLN--crystalline
XTAL--crystal

SYMBOLS

& --and
∪ --about
∢ --angular
= --equal to
> --greater than
< --less than
≤ --less than or equal to
μ --micro-
// --parallel
⊥ --perpendicular
2nd --secondary
± --with or without

APPENDIX 2

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