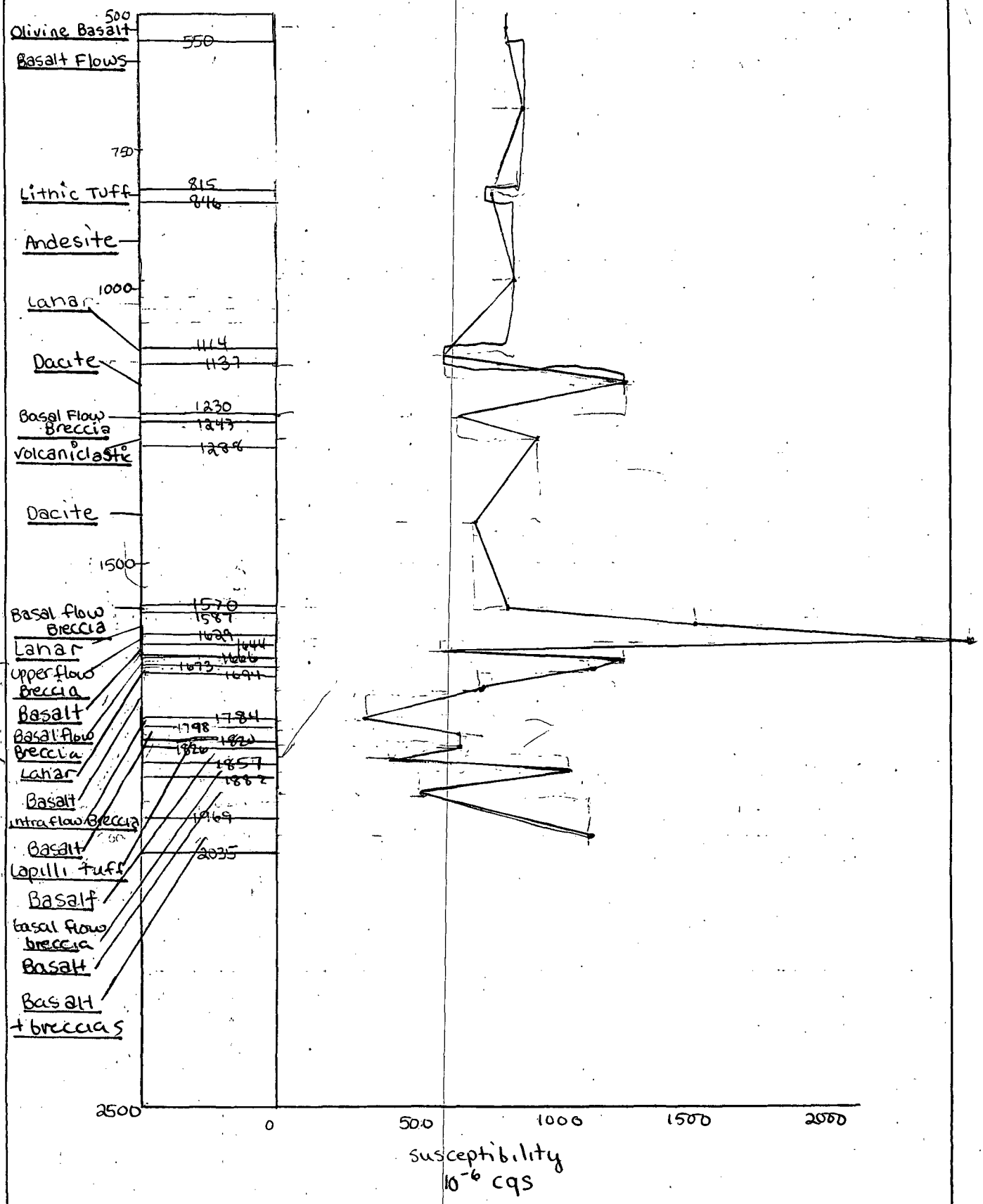
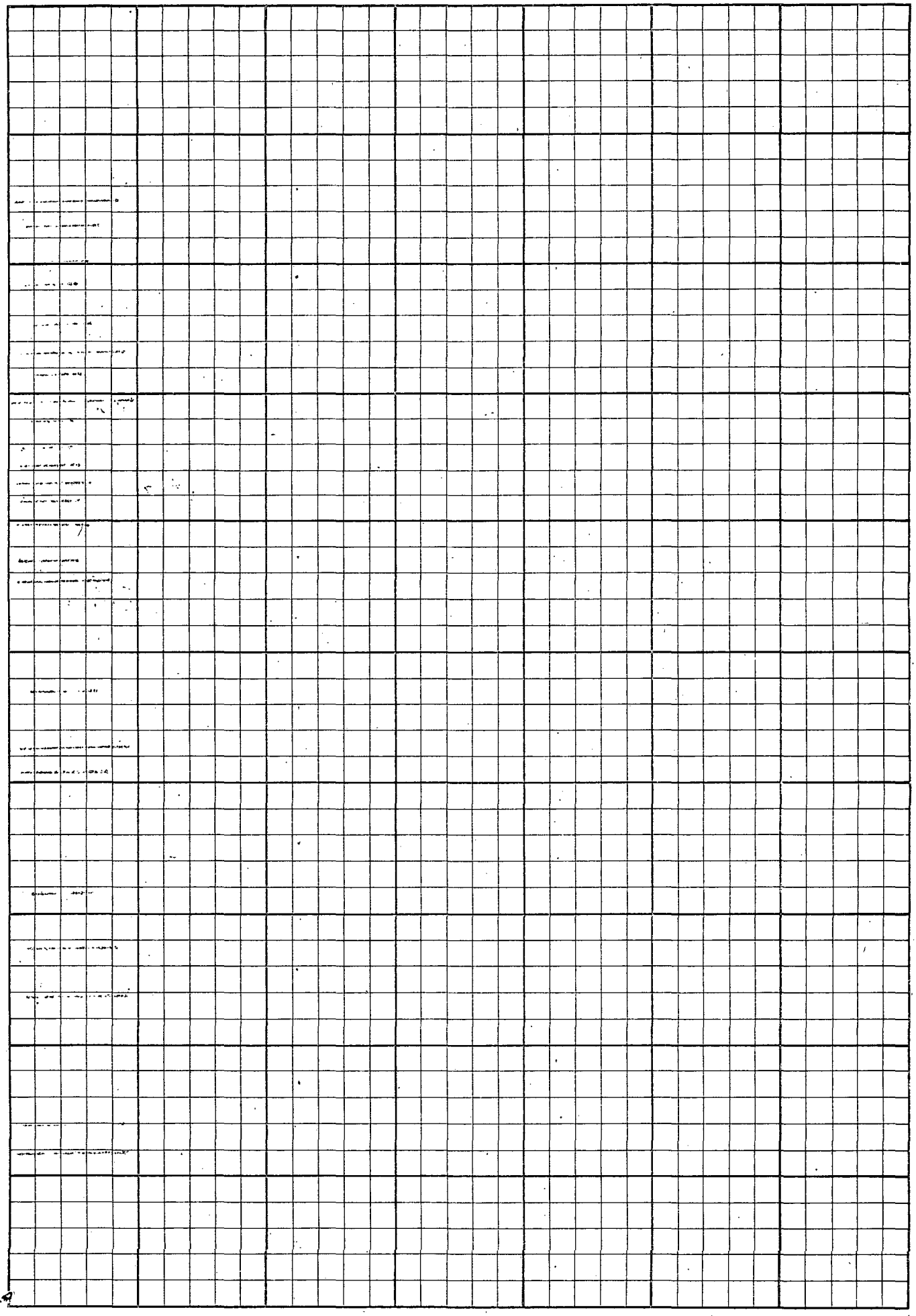
GL019016

CLACKAMAS CTGH -1

Average Magnetic susceptibility





Depth (ft)	susceptib. 10^{-6} cgs
525	863
682	918
830	804
980	885
1125	625
1183	1294
1236.	685
1265	962
1429.	739
1578	866.
1608	1527.
1636	2550
1655	608
1669	1295
1683	1168
1728.	769
1791	309
1809	670
1823	673
1869 ~ 1841	409 ~ 1091
1913	527
2002	1267

misc. notes on minerals:

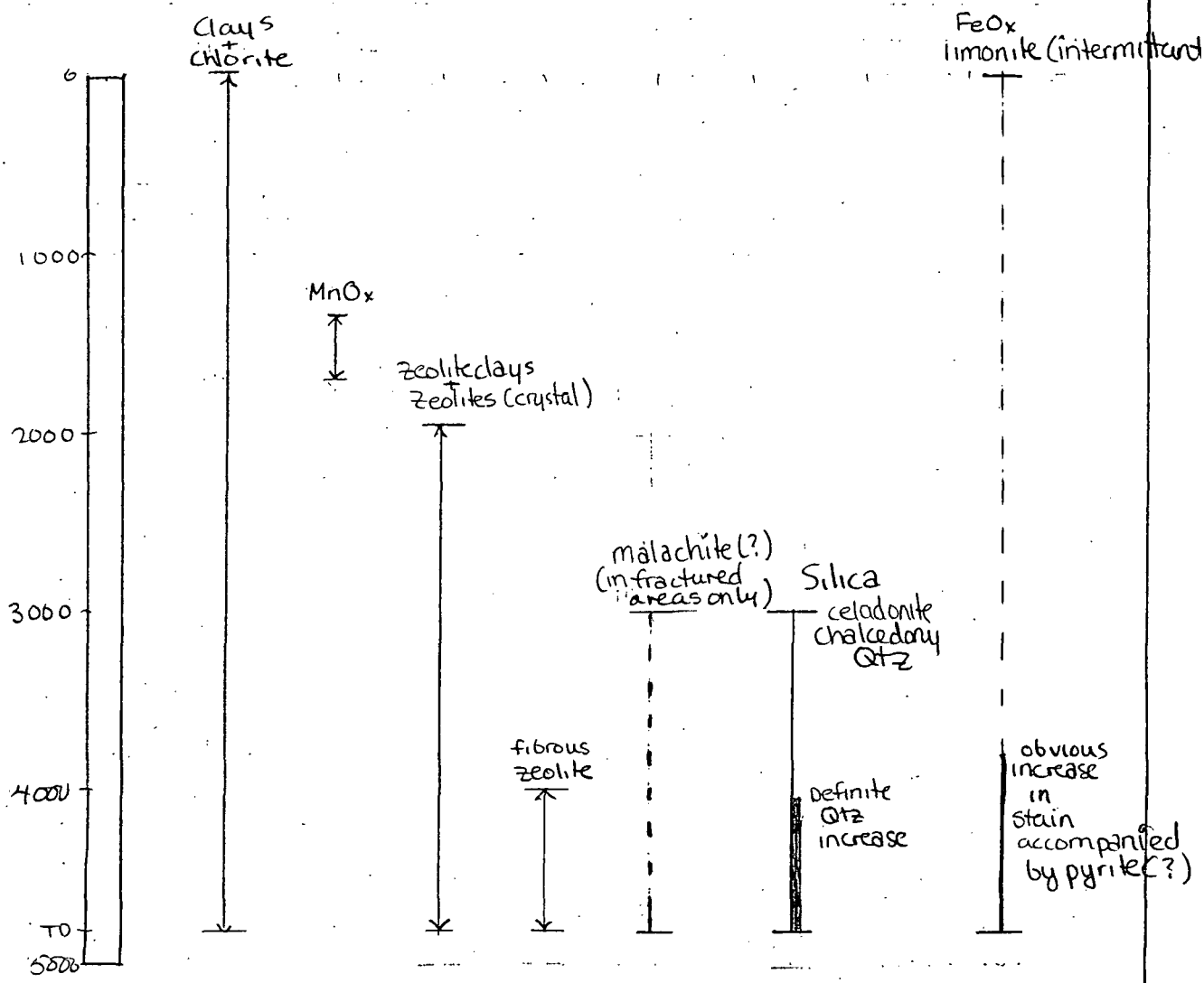
The secondary mineralization for the first 2000' was mainly clay & chlorite. MnOx minerals appeared for a short duration (1350'-1700') on fractures in the Dacite/Andesite flows. The first well developed zeolite appeared at ± 1990' and appeared thereafter on a regular basis. There was a white clay that appeared about the same time as the zeolites did indicating that it could be an alteration product of zeolite (zeolite clay?) This "clay" was often in the same vesicles or fractures that the zeolites were, and throughout the hole filled amygdules. In certain cases the zeolites would be accompanied by brown "mud" with desication cracks; usually in vesicles. The last several hundred feet (± 4000' to 4800 TD) contained a soft white fibrous "clay" that the thermal Power Geologists called zeolite. (this was different than previous white clay.) It formed in vesicles and was very abundant in the breccia flows that separated the basaltic Andesites. It was very soft (< 1-2) and fibrous, and increased as total depth neared.

A blue-green mineral that had the appearance of malachite occured about 3000'-TD. It had the appropriate hardness and effervesed slightly in HCl as malachite is supposed to. In addition, it only appeared in very highly fractured areas. However, there were many blue green clays, so this was somewhat confusing.

At ± 3000' Silica appeared, at first in the form of celadonite/chalcedony amygdules as well as in silicified clays. However, as TD was approached, there appeared abundant Quartz, either white or opalescent light blue. The Quartz occured in veins and amygdules both. The last 200' or so had a significant amount.

There was FeOx staining throughout most of the hole, however it began to noticably increase about 3800'. It typically followed fractures and was associated with flecks of a metallic mineral (pyrite?) in most cases. I didn't see this "pyrite" until about 4000', however, the Thermal Power Geologists identified microscopic pyrite & copper under the binocular microscope at much shallower depths. I included a list of the descriptions they made regarding these disseminated metallic minerals and where they were found.

Appearance of Secondary minerals



samples where minerals were very apparent; not only samples where they occured.

Lithology	Box #'s	Depths	mineral	Description
Dacite/ Andesite	84	1354'	Pyrolusite(?) or other MnO_x	blue "dendritic" mineral on fresh fractures
"	103	1526'	"	"
"	105	1542.5'	"	"
"	106	1552.0'	"	"
Basalt	152	1983.0'	zeolites	drusy void coatings and individual crystals mostly in cavities (1ST appearance of zeolite I noted)
Basalt	159	2040'	zeolites	vesicles with zeolites + white clays
"	161	2062.5	zeolites	many zeolite XIs on fracture
"	168	2124'-2133'	zeolites	in vesicles throughout box
"	173	2175	white clay + zeolites	vesicle appears to have both, perhaps white clay is alteration of zeolite. (wht clay does no effervesce in HCl)
"	186	2296.5	zeolite	on fractures
Andesite Breccia	200	2429	zeolite	"
Flow breccia	226	2663.5	zeolite	zeo in amygdules; white clay on fractures
Olivine Basalt	227	2674	zeolite white clay	much zeolite in vesicle much white clay (zeolite cement)
Flow Breccia	229	2690.5	zeolite	extensive zeolites in vesicles especially one large vesicle
Basaltic Andesite	238	2781.5	zeolite MnO_x(?)	minor zeolites on fracturer pyrolusite also
"	244	2835.5	zeolites white clay mud	This sample has extensive zeolites on fractures - also chlorite and mud with apparent desication cracks white clay in fractures

Lithology	Box #'s	Depths	Mineral	Description
volcanic Breccia	247	2864'	zeolite mud/clay	much zeol. on fractures desicated clay also
basalt	268	3062'	malachite(?) Calcite(?) zeolites	blue-green Cu mineral on fracture (appears to be malachite) also yellowish clay which effervesses in dilute HCl (calcite(?) cement there is clay with desication crack and zeolites in vesicles. Also note- most of this box badly broken
Basaltic Andesite	274	3113'- 3123'	malachite whiteclay	This entire box contain a blue-green mineral that I think could be malachite - it had appropriate hardness + appearar and effervesed in dilute HCl. However, my judgement should be taken with grain of salt - 2 other Geologists logging hole (Thermal Power Geos + B. Sibbett) considered this to be merely a clay. It was accompanied by a white clay that did not react in HCl. This zone is highly fractured
flow breccia	281	3183'-3187'	malachite(?)	same mineral on fracture zone - does efferves in HCl
"	283	3201	zeolite	drusy zeolite coating over blush grey clay on fracture surfaces
"	287	3235.5 3238	malachite or clay zeolites	zeolites on fracture + in one large vesicle - turquois mn. effervesces in HCl
Basalt	288	3244	Qtz.	at top of this sample is vein with opalescent pale blue Qtz.
"	297	3336	SiO_2	drusy silica on fractures at sample base

Lithology	Box #	Depths	mineral	Description
Basaltic Andesite	277	3141.5	Calcite cement	white "clay" at beginning of box effereses slightly Calcite cement? (it is on fract.)
"	"	3148'	zeolites	vesicles filled w/ zeolites/ zeolite cements - malachite(?) on fract. amygdules - brown clay white clay reacts slightly in HCl
"	278	3157	calcite/ carbonate cement	
"	313	3483	Chelcedony +/or celadonite	on fracture also in veins 3481-3485'
"	314	3487.5	SiO_2	silica on vesicle light blue (celadonite?)
flow Breccia	323	3578'	zeolite	much drusy zeol. on fract. and vesicles - green clay coating on zeol.
"	324	3589.5	zeolites	drusy zeolites in lg vesicle
basaltic Andesite	326	3602	zeolites	zeolites as drusy coatings on turquois clays.
"	"	3606	SiO_2 (celadonite?)	blue/green min. that looks like qtz (conchoidal fracture) however is too soft, possibly celadonite or silicified clays
basalt	336	3703	zeol, chacedony celadonite	3 cm. vesicle w/ zeolite coat amygdules of chalcedony + celadonite
basaltic Andesite	307	3426	zeolites	on fractures throughout this box
flow breccia	348	3806.5	zeolites	zeolite coating of blue clays in vesicles
"	350	3828	celadonite chalcedony	extensive - on fractures; white clay +/or laminated clay in vesicles

Lithology	Box #	Depth	mineral	Description
Basaltic Andes.	351	3836	silica clay	amygdules filled w/ various colored clay or silica
"	353	3673	limonite	stain
"	358	3906	zeolites	amydules filled with banded clays + zeolites; one large cavity with very well developed zeolite crystals
flow breccia	363	3946	zeolite	lg vesicle filled with clay coated zeolites
basaltic Andesite	371	4023'	Quartz	large veins with extensive Qtz.
basaltic andesite	380	4103.5	Qtz	light blue opalescent Qtz in vesicles
flow breccia	380	4105	zeolites	grey clay coating zeolites in vesicles
Flow breccia	382	4122	celadonite or chalcedony	amygdules
Basaltic Andesite	382	4124	malachite (?)	on fracture → (efferveses slightly in HCl)
flow breccia	384	4154	limonite(?)	stain; also drusy zeolites in vesicles
		4156	zeolite	extensive zeolites coating green clay in vesicles
basaltic andesite	394	4241	pyrite malachite Qtz celadonite	disseminated pyrite on top fracture; also malachite (?- it effeveses slightly) Qtz + celadonite amygdules
"	396	4308	hematite/ limonite(?)	stain
"	398	4 276.5	Pyrite Qtz	disseminated pyrite on bottom of fracture this sample – QTZ veins also.

lithology	Box #	Depth	mineral	Description
Breccia flow	403	4323.5	FeOx Pyrite	FeOx on bottom fracture; very small amts of disseminated pyrite.
"	404	4334'-4338'	malachite	highly fracture area ⇒ blue green clay and/or malachite on fracture ⇒ slight effervesence
"	407	4364	Pyrite; FeOx stain; zeolites	v. minor pyrite flakes (hard to see) appears to be associated with FeOx brown/yellow stain. Also zeolites in vesicle exposed on bottom fracture of this sample highly fractured; much Qtz and clay; possible malachite (effervesces)
basaltic Andesite	412	4407.5 - 4410	Qtz clay malachite	
basaltic Andesite	426	4545	Qtz and/or zeolites	top fracture had awesome fully developed crystals — looks like Quartz although could be zeolites (from the way crystals grew in cavity)
"	425	4532	zeolites(?)	very white, fibrous, fragile, soft "clay" (is what it looks like) however thermal Geo's called it a zeolite based on binocular microscope identification. 1-2
breccia flow	431	4587	zeolites (?)	very large vesicle with same white fibrous "Whatever"
"	4	4591	"	many vesicles with this fibrous zeolite.
"	440	4679	"	much fibrous zeolite
basaltic Andesite	451	4778 - 4782	FeOx stain	increase on fractures
"	452	4794'	Qtz	about ½ cm thick, extensive Qtz on fracture, white, opalescent

☆ minerals noted by THERMAL POWER GEOLOGISTS (that I missed or couldn't see) under Binocular Microscope.

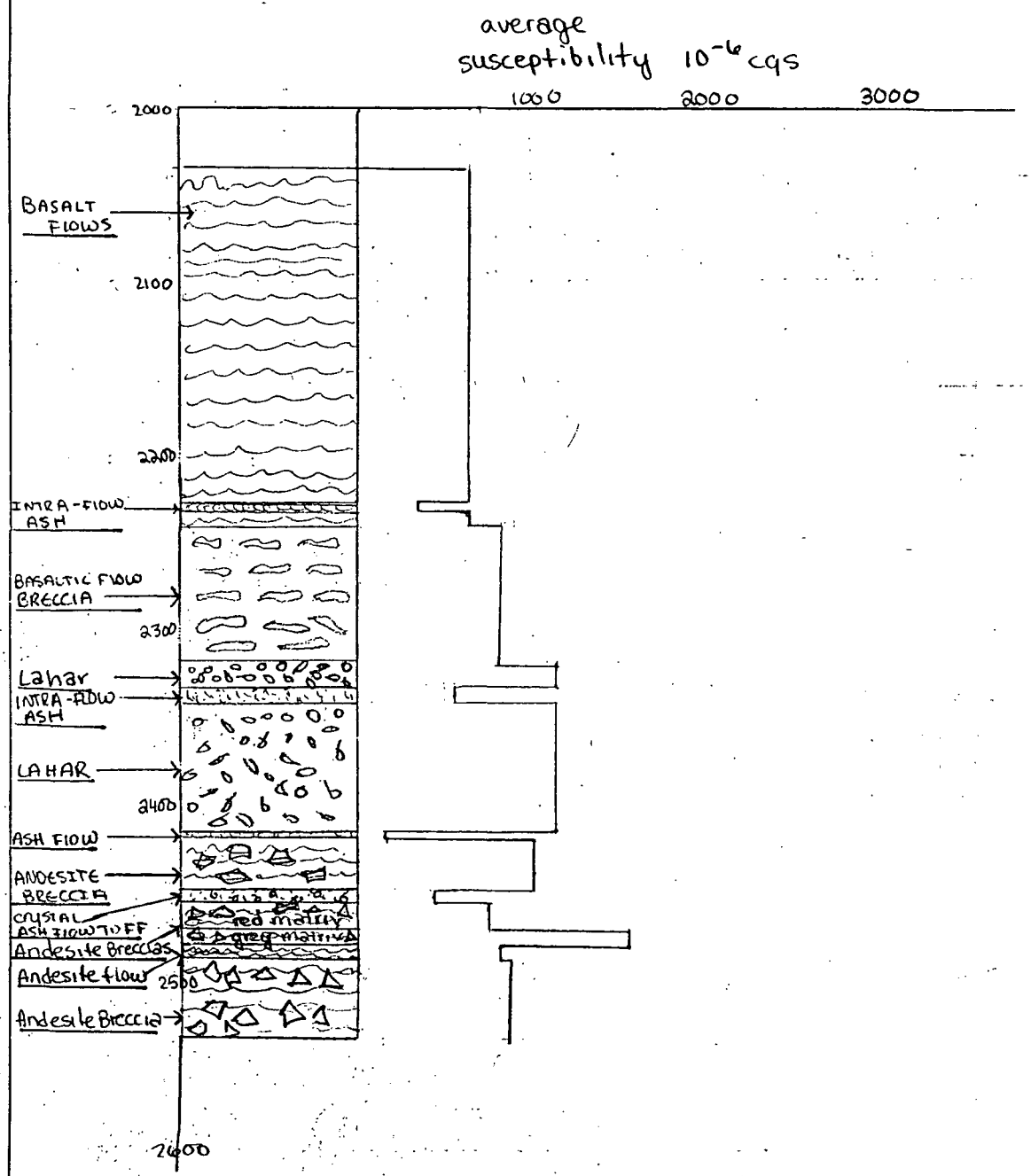
	Lithology	Depth
1) trace black iron mineral (hematite) v. fine - through grnd mass	Dacite	1047'
2) trace pyrite → Fe Ox	Andesite	1570
3) heavy limonite	Basaltic Andesite	2103'
4) minor metallic pyrite → hematite in matrix; hematite alteration	"	2192' - 2195.5'
5) Rare, finely disseminated pyrite → limonite / hematite	"	≈ 2264'
6) microscopic thin irregular golden flecks (tarnished w/ lt. grn) - unidentified metallic min - occuring as v. finely disseminate grains on frac surface w/ clays (native copper)	Basaltic Andesite	3350'
7) disseminate copper-colored metallic flakes on botryoidal frac. coating of zeol. + pale blue clay	Basaltic Andesite	3383 - 3395
8) same copper colored mineral occurs as thin malleable flakes + as flat wire-like form	"	3421 - 3434.6
9) " on clays in fractures	"	3455 - 3459
10) "	"	3443 - 3451
11) microscopic copper in vugs	" "	~ 3757

The metallic minerals from ≈ 4000' ~ on were visible with hand lens; the above were not.

misc. notes on susceptibility.

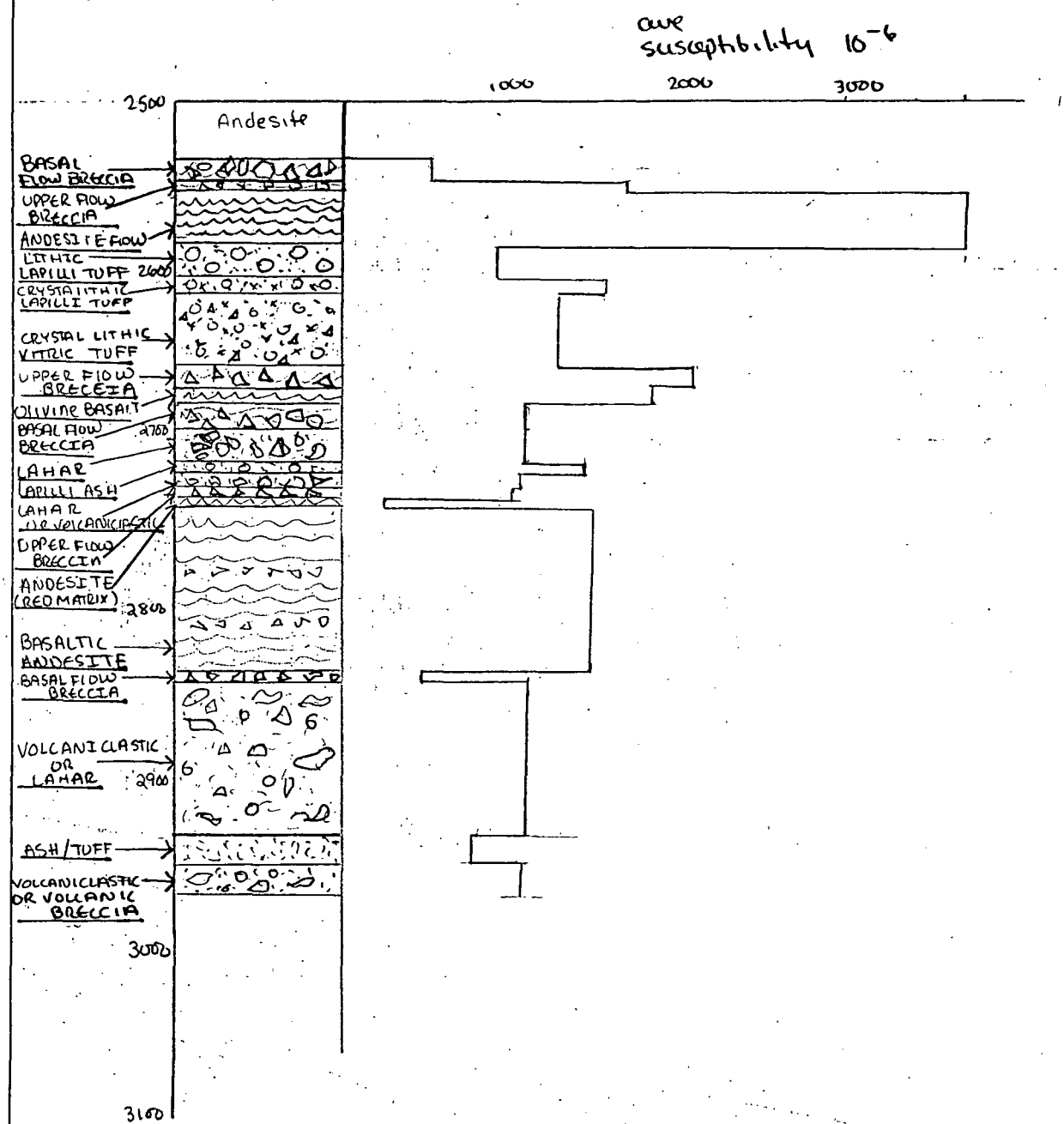
The variations in susceptibility measurements within a lithologic unit appeared to be dependent on the following: clast amount and composition (for flow breccias.), vesicularity (for lava flows + breccias with basaltic clasts), and matrix composition. A clast supported unit had a significantly higher susc. measurement than a matrix supported unit. In addition, if the clast were of a mafic composition, the susc. was higher as compared to clasts with a more intermediate makeup. The vesicularity played a dramatic role in causing variations within a lithologic unit, especially the 2000 feet of Olivine basalt and basaltic andesite at bottom of hole. This particular sequence would have very dense and very vesicular flows interbedded within one foot of each other. Another variation is the matrix "color", which seems to be directly proportional to susceptibility magnitude. It appeared that the lighter the matrix, (the more red/orange ash clay) the lower the susceptibility, for example, the sequence of Andesite Breccias at depths 2454' - 2478' has 2 distinct matrixes: a unit with a red orange matrix having a susceptibility ave. of $781 \cdot 10^{-6}$ cgs followed by a unit with a grey matrix that has an ave. susc. of $1585.2 \cdot 10^{-6}$ cgs. Nevertheless, it was obvious that these breccias belonged to the same lithologic unit.

There didn't appear to be any correlation between alteration minerals (and extent of alteration) and susceptibility.



Lithology	Depth interval	ave susceptibility 10^{-6} cgs
Basalt flows	2037' - 2240'	652.7
intra-flow ash	2225' - 2229'	351.4
Basaltic flow breccia	2240' - 2318'	838.6
Lahar	2318' - 2341.7	1155.9
INTRA FLOW ASH	2331 - 2341	562.6
ASH FLOW	2417 - 2419	181.8
Andesite Breccia	2419 - 2448	1012
crystal-ash flow tuff	2448 - 2454	251.8
Andesite Breccia with red ash matrix	2454 - 2469	781.5
Andesite Breccia with grey matrix	2469' - 2478'	1585.2
Andesite flow	2478' - 2486'	815.7
Andesite Breccia flow	2486' - 2535'	884.4

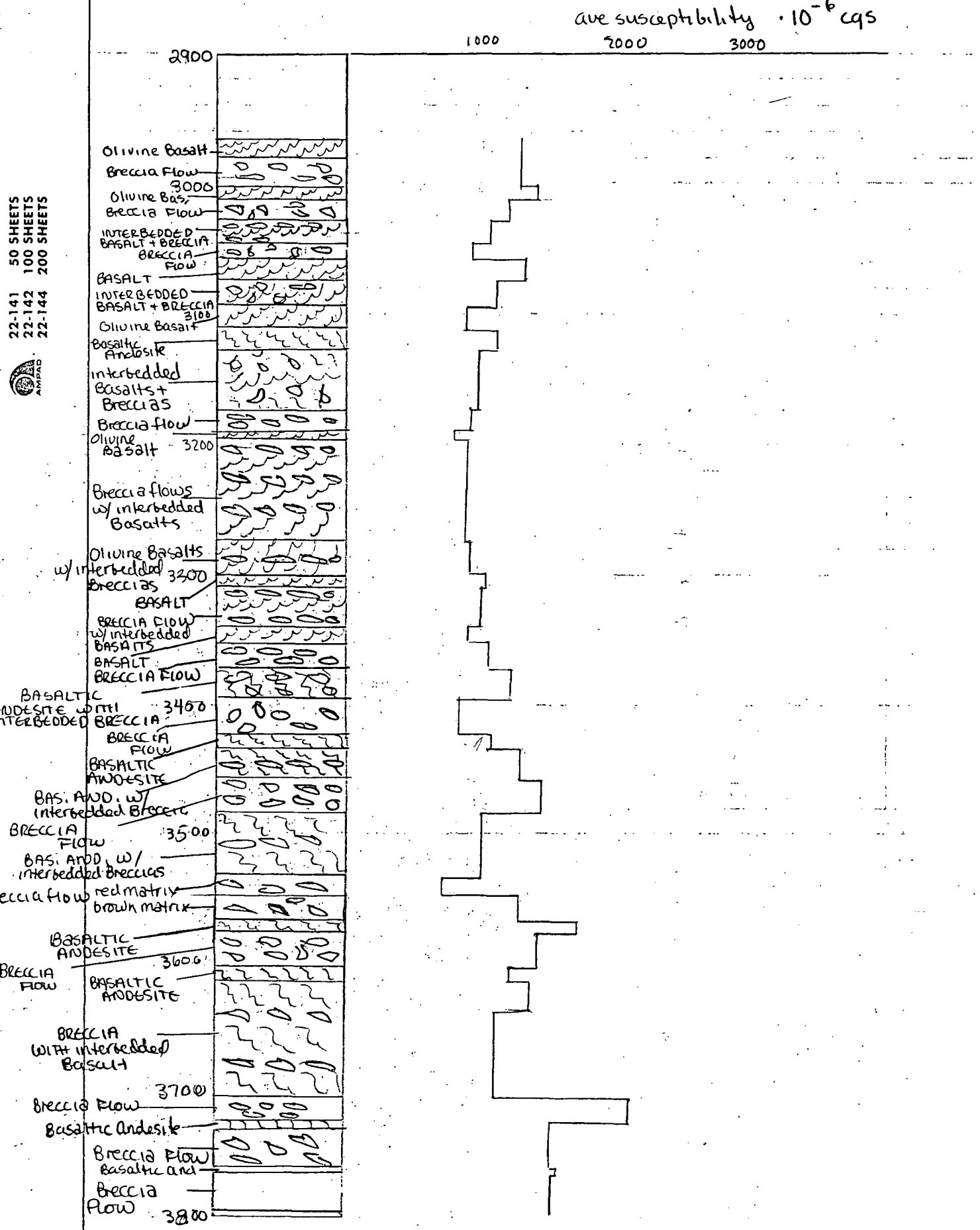
2535' - 2966'



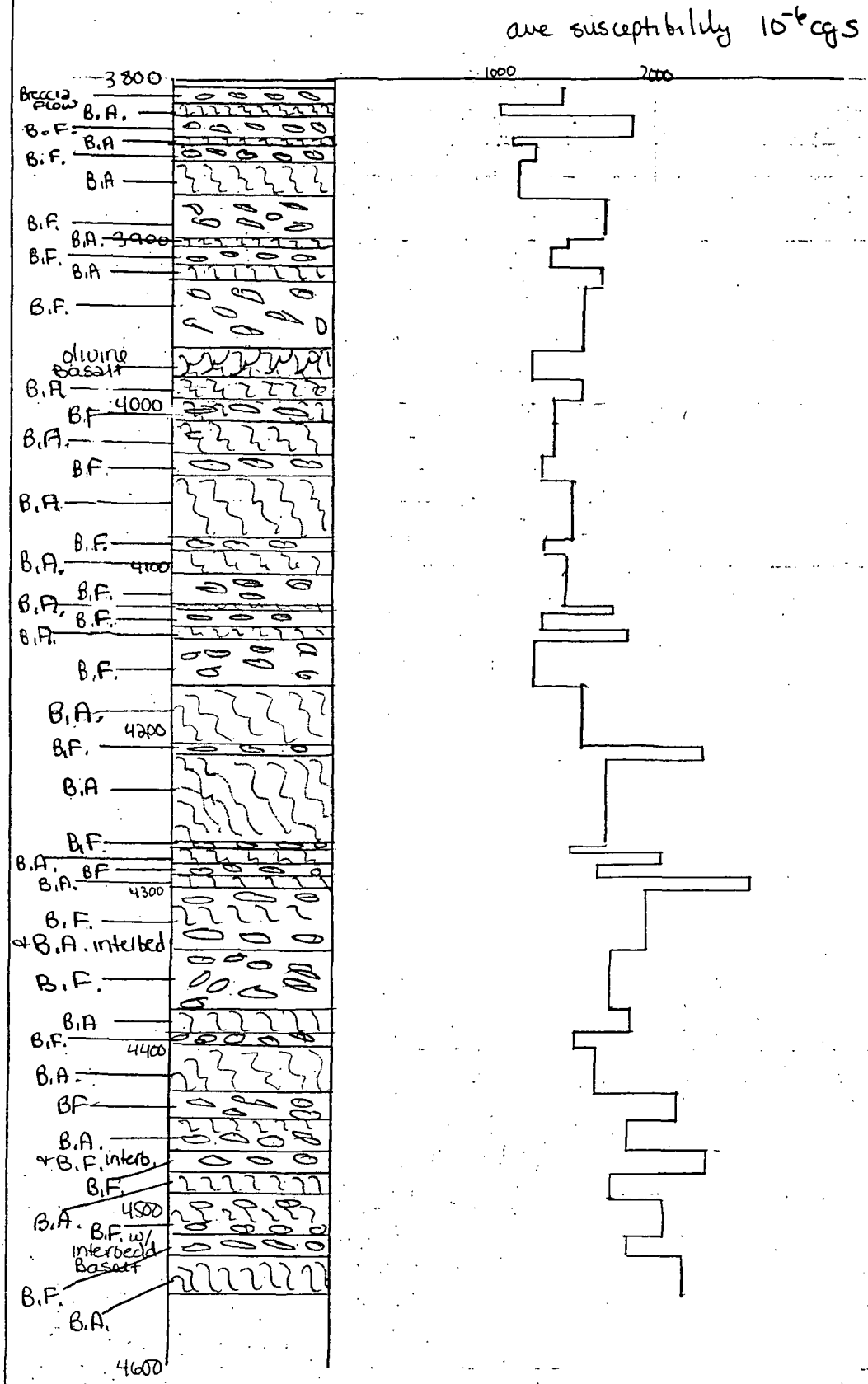
lithology	Depth interval	ave suscept. 10^{-6} cgs
basal flow Breccia	2535 - 2546'	514.4
upper flow Breccia	2546' - 2553'	1698
Andesite flow	2553' - 2586'	3685.9
Lithic Lapilli Tuff	2586' - 2603'	901
Crystal lithic lapilli tuff	2603 - 2616	1566.4
crystal lithic vitric tuff	2616 - 2657	1276
UPPER FLOW BRECCIA	2657' - 2668'	2083.4
Andesite(?) Olivine Basalt	2668' - 2678'	1888.9
Basal Flow Breccia	2678' - 2694'	1061.6
Lahar	2694' - 2713'	1061
Lapilli ash	2713' - 2719'	1439.4
Lahar / volcaniclast.	2719' - 2726'	1061
upper flow breccia	2726' - 2733'	991.2
andesite (red matrix)	2733 - 2740	259.6
Basaltic Andesite	2740' - 2837'	1471.8
Basal Flow breccia	2837' - 2842'	511.3
volcaniclastic	2842' - 2935'	1086.3
ash/tuff volcaniclastic - volcanic Breccia	2935' - 2952'	784.3
	2952' - 2966'	1075.9

CTGH-1

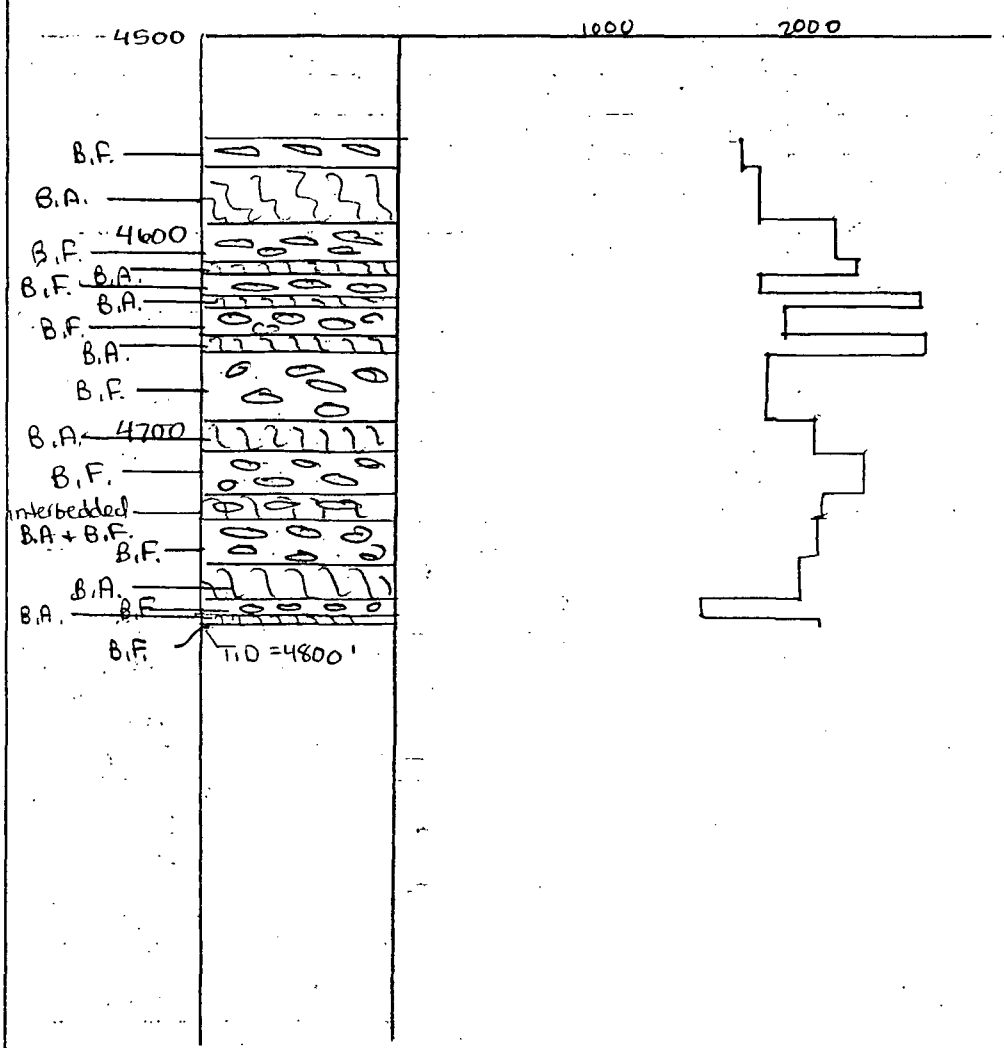
2966' - 4800' TD



B.F. = Breccia Flow
B.A. = Basaltic Andesite



ave susceptibility 10^{-6} cgs



Data

ave susceptibility 2966' - 4800' TD

Lithology	Depth Interval	ave suscept.
- Olivine Basalt	2966 - 2979	1370
- Breccia flow	2979' - 3001'	1399
- Olivine Basalt	3001' - 3013'	1460.8
- Breccia flow	3013' - 3028'	1246.3
- Interbedded Olivine basalts & breccia flows	3028' - 3044'	1110.2
- Breccia flow	3044' - 3058'	989.4
- Basalt	3058' - 3065	1374.8
- Interbedded Breccia & Olivine basalts	3067 - 3093	1159.8
- Olivine Basalt	3093 - 3109	962.5
- Basaltic Andesite	3109 - 3127	1166.4
- Interbedded Basalts & Breccias	3127 - 3175	1005.3
- Breccia flow	3175 - 3191	945.5
- Olivine basalt	3191 - 3197	848.8
- Breccia flow w/ interbedded Basalts	3197' - 3274'	938.3
- Olivine Basalts w/ interbedded Breccias	3274' - 3300'	968.6
- Basalt	3300 - 3308'	1084.5
- Breccia flow with interbedded basalt	3308' - 3340'	1014
- Basalt	3340' - 3352'	962.1
- Breccia flow	3352' - 3372	1084.6
- Basaltic Andesite w/ interbedded Breccias	3372' - 3396'	1242
- Breccia Flow	3396' - 3421	873.8
- Basaltic Andesite	3421' - 3434'	1036.1
- Bas. Andes. w/ interb. Breccias	3434' - 3459'	1318.3
- Breccia Flow	3459' - 3481'	1502.7
- Basaltic And. w/ intebedded breccias	3481' - 3531'	1079.5
- Breccia flows red brown	3531' - 3546'	765.9
	3546' - 3571'	1344.8
- Basaltic And.	3571' - 3575'	1803.5
- Breccia Flow	3575 - 3601'	1460.4
- Basaltic And.	3601' - 3616	1286
- Breccia flows w/ interbedded basalt	3616 - 3706	1401.2
Breccia flow	3706' - 3723'	1166
Basaltic Andes	3723' - 3727	2200.1
Breccia flow	3727 - 3760	1611.9

Olivine Basalts & Olivine Breccia Flows

ave = 1066.6

2966' - 3292'

Basaltic Andesite + Breccia flows

3292 - 4800 TD

ave = 1572.5

Sdev = 518.8

Basaltic Andes	3760 - 3764	1661.3
Breccia flow	3764 - 3797	1611.9
Basaltic Andes	3797 - 3804	1380.4
Breccia Flow	3804 - 3815	1425.5
Basaltic Andes	3815 - 3821	1141.6
flow breccia	3821 - 3835	1851.0
basaltic Andesite	3835 - 3840	1159.7
flow. breccia	3840 - 3852	1239.1
Basaltic Andesite	3852 - 3874	1188.5
Breccia flow	3874 - 3897	1692.1
Basaltic Andes.	3897 - 3902	1450.1
Breccia flow	3902 - 3915	1345.9
Basaltic Andesite	3915 - 3922	1623.7
Breccia flow	3922 3965	1523.6
Olivine Basalt	3965 - 3982	1250.2
Basaltic Andes	3982 - 3999	1556.8
Breccia Flow	3999 - 4010	1380.7
Basaltic Andes.	4010 - 4029	1394.8
Breccia flow	4029 - 4044	1296.8
Basaltic Andes.	4044 - 4081	1494.0
Breccia Flow	4081 - 4089	1328.9
Basaltic Andes,	4089 - 4105	1469.5
Breccia flow	4105 - 4122	1465.2
Bas. And	4122 - 4125	1742.1
Breccia flow	4125 - 4139	1289.2
B. A.	4139 - 4144	1821
Breccia flow	4144 - 4175	1256.1
Bas. And	4175 - 4210	1572.9
Breccia flow	4210 - 4217	2313.4
Bas. And.	4217 - 4267	1703.6
Breccia flow	4267 - 4271	1491
Bas: And	4271 - 4282	2043.4
Breccia flow	4282 - 4287	1626.1
Bas. And.	4287 - 4298	2606.6
interbedded	4298 - 4338	1929.6
Breccias + Basaltic Andes.		
Breccia flow	4338 - 4376	1771.6
Bas. Andes.	4376 4390	1837.8
Brecia flow	4390 - 4399	1505.9
Bas. And.	4399 - 4426	1646.4
Breccia flow	4426 - 4442	2146.7
basalt + breccia flows (interbedded)	4442 - 4463	1849.8
breccia flow	4463 - 4477	2335.8
Basalt. Andes	4477 - 4490	1770.6
Breccia flow with interbedded basalt	4490 - 4519	2014.0
Breccia flow	4519 - 4529	1809.2
Basaltic Andesite	4529 - 4553	2184.4

Lithology	Depth Interval	Ave Susc.
Breccia flow	4553 - 4565	1718.8
basaltic And. & breccia flows interbedded	4565 - 4596	18.59.6
Breccia flow	4596 - 4616	2229.7
Basaltic And	4616 - 4620	2353.1
Breccia flow	4620 - 4630	1865.7
Basalt And	4630 - 4636	2660.3
breccia flow	4636 - 4649	1989.8
basaltic And.	4649 - 4658	2672.6
breccia flow	4658 - 4694	1861.7
Basaltic Andes.	4694 - 4707	2161.1
Breccia flow	4707 - 4730	2363.5
interbedded Breccia and basalt flow	4730 - 4742	2190.0
Breccia flow	4742 - 4767	2155.7
Basaltic And	4767 - 4784	2043.5
Breccia flow	4784 - 4790	1559.9
Basaltic And.	4790 - 4796	2146.0
Flow Breccia	4796 - TD	?