

PROGRESS REPORT ON

DY DEPOSIT, FARO, YUKON T

No. 2 "4L units in 3G"

Jan. 23, 1981

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4 L in 3G --- Hydrothermally Altered Rock Units within Mt. Mye Formation

There has been recognized one or two hydrothermally altered rock units (4 L units in mine terminology) within footwall Mt. Mye Formation below the DY deposit and are designated as Horizon 1. It is not yet confirmed whether the altered units are strata-bound or not, however, relatively continuous and conformable Horizon 1 is observed along a survey line L18+00E. To investigate the lateral variation within this horizon, eight representative samples are taken from eight drill holes along L18+00E and nearby holes (Fig. LG-1). Ore intersections within the Vangorda Formation have been reported.

from 6" drill holes, namely, high grade ones
 from 77X11, 80X09, 78X02, and 77X06 and low grade ones
 from 80X07 and 79X07, respectively. No essential
 ore has been intersected within the Horizon 1

The ratio $Cu/Pb+Zn$ in the ore and lateral distribution
 of altered rock suggests that the center of mineralization
 had existed near the south end of the examined section,
 that is, near the hole DDH 80X07 (DY262) (B. Hall et al., 1979).

Therefore, the sequence of samples from DY262 to
 DY 264 may represent the lateral zoning from core
 to margin of the hydrothermally altered horizon.

Mineral assemblages of the examined samples are more or less similar each other (Table LG-1). In general, all the samples are ^(-chalcopyrite-sphalerite) pyrrhotite-bearing rutile-albite-chlorite-muscovite-quartz schist in common nomenclature and biotite after chlorite, carbonates, and manganese-rich ilmenite associate in minor amounts.

It is noteworthy that ilmenite, rutile, and albite occur exclusively in muscovite-rich sublayers and all sulfides tend to occur in quartz-rich sublayers. Very high concentration of titanium-bearing minerals, that is, ilmenite and rutile in muscovite(-chlorite) layers suggests that the layers are of volcanic tuff origin. On the other hand, typical ^(fine-grained) secondary quartz texture of the

quartz-rich layers suggests that they had precipitated together with sulfides from hydrothermal (?) solution

In the cases of volcanogenic massive sulfide deposits like Kuroko-type and Archean ones, albite is not a stable mineral in the core of the alteration halo and is altered to chlorite and/or sericite. Besides, ilmenite in fresh footwall rocks has been altered to rutile + sphene near the massive sulfide orebody at South Bay and Corbet mines. In an analogy to these deposits, the degree of hydrothermal alteration is considered to be relatively low in this case.

One of the most interesting results obtained is the lateral variation in chlorite chemistry. Even though the bulk mineralogy shows no appreciable variation as mentioned above, Mg/Mg+Fe ratio in chlorite changes substantially along the section (Table LG-2 and Fig. LG-2). Apparently, there are two segments which are separated between DY 267 and DY 263. Within each segment, the Mg/Mg+Fe ratio in chlorite decreases towards the margin except a case between DY 265 and DY 264. The cause of the large discontinuity between the two segments is not certain by now, however, it is possible to deduce a fault or difference in horizons at that place.

← Neither manganese nor aluminium content in chlorite show systematic variation, however, they may be in anti-proportional relation, that is, aluminous chlorite contains less manganese and vice versa. The reason of this phenomena is not known.

As was discussed in my extended abstract titled "Comparison among Kuroko, Besshi-type, and Archean volcanogenic massive sulfide deposits", Mg/Mg+Fe ratio in chlorite from footwall rocks to the volcanogenic massive sulfide deposits decreases towards the margin of the alteration haloes.

Maximum distance (from actual orebody) of noticeable change in chlorite chemistry is about 1.5 Km in

many cases and ^{it} comprises a good local exploration tool. Probably the present results indicate that the chlorite chemistry can be ^{also} used for the exploration of the Anvil type shale-hosted massive sulfide deposits. We need oxygen isotope data on these samples to check the possibility of oxygen isotope zoning along the section

Table LG-1 Mineral assemblages of the Horizon 1" rock along L18+00E, DY deposit, Faro.

sample No.	DDH	depth m	Qtz	Muscov	Chl	Biot.	Ab.	Ilm.	Rutile	Po	Py	Carbonate	Others
Y262	80X07	884.5	##	##	##		+	+	+	+			cp, sp
Y266	77X11	835.2	##	##	##	+	+	+	+	+		Mn-calc.	cp, sp
Y268	80X09	952.0	##	##	##		+	+		+			cp, sp
Y267	78X02	762.8	##	##	##	+	+	+	+	+		Mn-calc.	sp, cp
Y263	77X06	783.0	##	##	##		+		+	+		Do+Ca	cp, sp
Y261	79X07	666.8	##	##	##		+		+	+	+	Ca	cp
Y265	78X03	865.0	##	##	##	+	+	+	+	+			cp
Y264	77X08	847.0	##	##	+		+		+	+		Sd+Do	{K-feld, cp}

##, abundant, #, common; +, minor to rare.

carbonate appears to change also

Mn-calc → Sd + Do

(Table LG-2 continued)

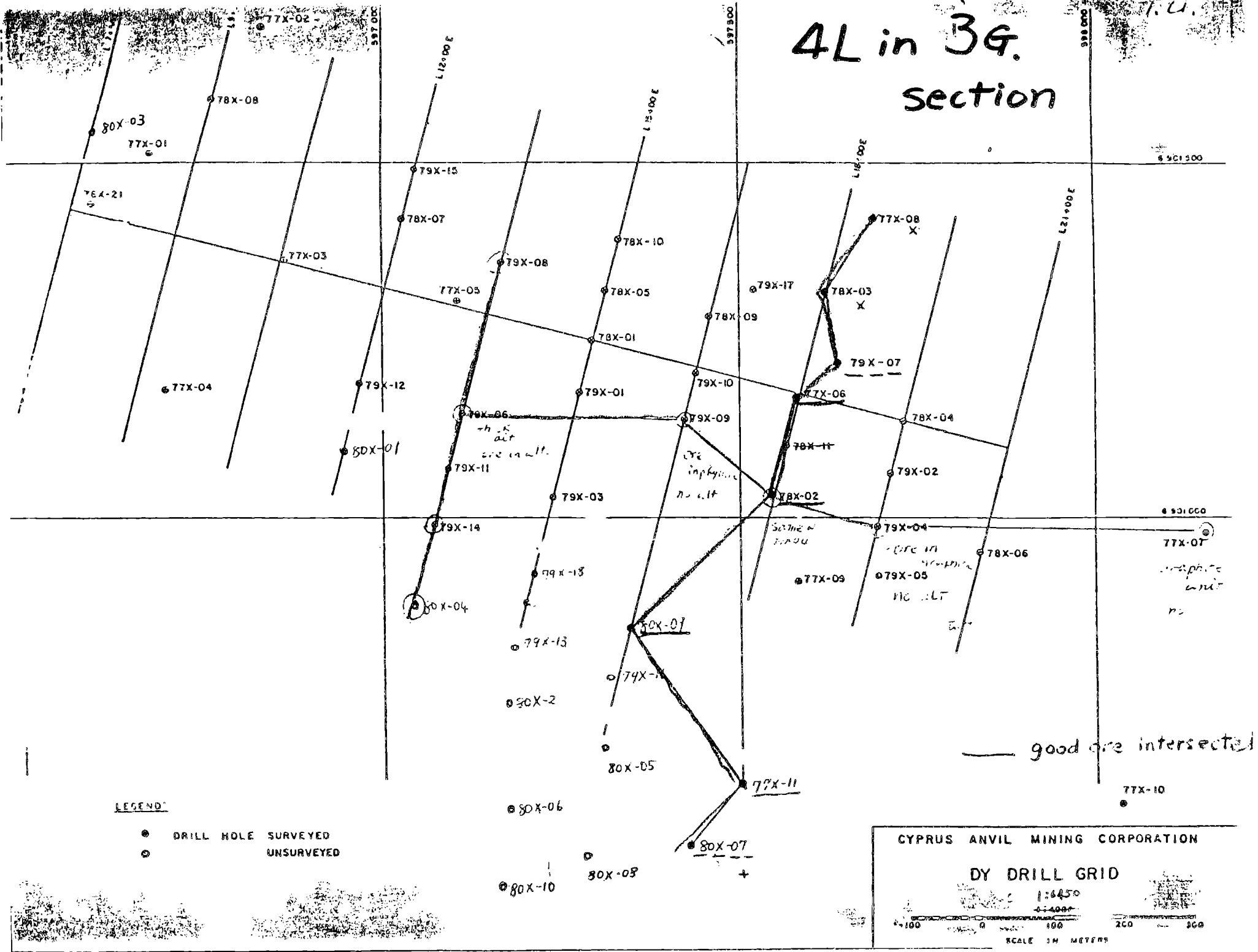
Sample No.	DY263	DY261	DY265	DY 264
DDH	77X06	79X07	78X03	77X08
Depth (m)	783.0	666.8	865.0	847.0
No. of analyses	5	9	7	9
Oxide wt%				
MgO	13.68(1.01)	11.12(0.81)	8.43(0.94)	8.79(0.71)
FeO	24.45(1.19)	27.64(1.49)	31.90(1.06)	28.55(1.25)
MnO	0.36(0.21)	0.29(0.21)	0.74(0.18)	0.17(0.14)
Al ₂ O ₃	21.44(0.72)	22.30(0.33)	21.01(0.66)	23.44(1.35)
SiO ₂	24.47(0.48)	23.67(0.36)	23.63(0.57)	24.19(1.68)
H ₂ O	10.97	10.86	10.65	10.88
Total	95.37	95.88	96.36	96.02
Atomic proportions				
Mg	2.23	1.83	1.42	1.44
Fe	2.24	2.55	3.01	2.63
Mn	0.03	0.03	0.07	0.02
Al ^{IV}	1.44	1.52	1.45	1.71
Al ^{VI}	1.32	1.38	1.34	1.33
Si	2.68	2.62	2.66	2.67

Table LG-2 Lateral variation in chemical composition
of chlorite from "Horizon 1" along
L18+00E, DY deposit, Faro.

Sample No.	DY262	DY266	DY268	DY267
DDH	80X07	77X11	80X09	78X02
Depth (m)	884.5	835.2	952.0	762.8
No. of analyses	5	7	3	4
Oxide wt%				
MgO	11.37(0.92)*	9.01(0.91)	8.95(1.53)	6.52(1.81)
FeO	27.88(0.81)	30.74(0.63)	32.50(1.46)	33.86(2.30)
MnO	0.05(0.10)	1.62(0.18)	0.27(0.25)	1.21(0.07)
Al ₂ O ₃	21.84(0.48)	21.19(0.23)	22.13(0.32)	21.18(0.46)
SiO ₂	23.70(0.22)	23.78(0.51)	22.82(0.23)	22.93(0.83)
H ₂ O**	10.83	10.76	10.76	10.49
Total	95.67	97.10	97.43	96.19
Atomic proportions				
Mg	1.88	1.50	1.49	1.11
Fe	2.58	2.87	3.03	3.24
Mn	0.00	0.15	0.03	0.12
Al ^{VI}	1.48	1.44	1.45	1.48
Al ^{IV}	1.37	1.35	1.45	1.38
Si	2.63	2.65	2.55	2.62

* 1 or ** Calculated on the formula (Mg, Fe, Mn, Al)₆ [Si₄, Al]₂ O₁₀ (OH)₂

4L in 3G. section



LEGEND:
 ● DRILL HOLE SURVEYED
 ○ DRILL HOLE UNSURVEYED

CYPRUS ANVIL MINING CORPORATION
 BY DRILL GRID
 1:6450
 4:4000
 0 100 200 300
 SCALE IN METERS

PROGRESS REPORT

ON DY DEPOSIT, FARD, YUKON T

No.1. Mineralogy of the baritic units

Jan. 20, 1981

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MINERALOGY OF THE BARITIC UNITS

Ten barite-bearing ore samples are taken from drilled cores and are divided into two groups, namely, (A) DY 155-DY 178 and (B) DY 257-DY 260 (Table BA-1). Group (A) samples are taken from six different baritic horizons which are intersected at a drill hole 79X14. It is more or less probable that part of the strata is repeated by folding; however, we may be able to investigate vertical variation in mineralogy and geochemistry of the baritic units of the DY deposit.

Samples are compositionally banded and rich in pyrite and barite. Barite aggregates have embayed mutual boundaries and have no preferred orientation. Carbonate minerals, that is, dolomite and siderite tend to occur

as discrete grains interlocked with barite and show no replacement textures. Sphalerite, galena, and magnetite are common but small in their amounts. Magnetite, which occurs in every sample except DY174, usually has embayed corroded outlines. Iron content of sphalerite falls in a range between 1.4 wt.% Fe and 3.9 wt.% Fe and shows no apparent systematic variations with depth. Arsenopyrite and bismuthinite are identified (with microprobe analyzer) in sample DY174. It is noteworthy that reworked texture is observed in only one sample DY159.

Most remarkable change in mineral assemblage is observed in carbonates, that is, siderite and dolomite samples

Siderite is observed exclusively in Δ DY155, DY156, and DY158

which stand for "upper" half of barite-bearing

horizons. On the other hand, dolomite is found in

deeper horizons including DY158. Furthermore, mole

fraction of magnesium in dolomite and siderite decreases

and that of iron increases upwards respectively with

an exception between DY174 and DY178 (Fig. BA-2)

moderately

$\text{FeO} \rightarrow$

TFe

The ratio $\text{Fe}/\text{Fe}+\text{Mg}$ also increases towards the margin

within a single grain of dolomite and siderite.

Therefore, it is quite probable that the Δ activity ^{relative} in the ore-forming solution

of Fe(II) ion Δ had increased more than that of

Mg ion consistently during the ore deposition.

Variations in manganese and strontium contents in dolomite and siderite are not systematic, however, ~~strontium tend to be enriched in deep horizons.~~ Up to 0.5 wt% of SrO is detected in barite grains which coexist with Sr-rich dolomite, however, the strontium contents in dolomite and barite are highly variable even in a grain further and no detailed analyses have been planned.

~~(B) DY 259, DY 260 samples from lateral extension of
same unit~~

Group (B) samples are taken from a ^{relatively} convincingly correlated section which includes 4 drill holes listed in Table BA-1. Lateral distribution of many adjacent units suggests that the sample DY 259 represents the "central" facies and the other three samples are in order of increasing distances from center of lateral distribution of the particular baritic unit.

Barite, pyrite, sphalerite, and galena are the ^{minerals} major constituent, and small amounts of chalcopyrite and carbonate minerals associate with the former.

Sample DY259 contains both secondary aggregates of one grain of quartz and argentic tetrahedrite (checked with microprobe).

Carbonate mineralogy of the sample DY258 is very unusual, since two barium-bearing double carbonate minerals, that is, barytocalcite $\text{CaBa}(\text{CO}_3)_2$ and norsethite $\text{MgBa}(\text{CO}_3)_2$ are identified in this well-banded sample. Dolomite occurs closely associated with these carbonates, however, witherite BaCO_3 is not found in spite of the detailed investigation.

The mineral norsethite was first reported in the dolomitic black oil shale at the Westvaco trona mine, Wyoming by Mrose et al. (1961). Other occurrences of this rare mineral include; (i) as

irregularly-shaped veins in dolomite gangue at Rosh Pinal

Zn-Pb-Cu hydrothermal deposit, South Africa (Steyn and Watson, 1967). Norsethite is associated with calcite, celserite,

barite, barytocalcite, benstonite ($\text{Ca}_7\text{Ba}_6(\text{CO}_3)_{13}$), pyrite,

sphalerite, galena, chalcopryite, and tennantite, and

(ii) as a mass in braunite ore at high-temperature

skarn deposit at Långban, Sweden (Sandius, 1965;

Sandius and Blix, 1965; Moore, 1971). It associates with dolomite

barytocalcite and benstonite and is considered to be

formed during skarnization from reactants like

psilomelane $\text{BaMn}_7\text{O}_{14}(\text{H}_2\text{O})$ and dolomite.

Norsethite can

be formed by the reaction of solid barium carbonate

with dilute solutions of magnesium chloride and
at room temperature)
sodium bicarbonate (Lippmann, 1973) Lippmann

discussed that norsethite is possible only in the
presence of additional dissolved CO_3^{2-} . It is widely
accepted that witherite BaCO_3 is commonly formed
from barite at low temperatures and at high fugacity
of CO_2 (Holland, 1967; Baldasari and Speer, 1979) and
as an analogy, "norsethite" is likely to be
a possible mechanism of its genesis.

Although norsethite also can be easily precipitated
from aqueous solution containing barium, magnesium,
and carbonate ions at room temperature (Hood et al.,
1974), the present authors prefer the idea of

metasomatic origin of norsethite and barytocalcite in
DY258. Sub-microscopic mixture between these two
carbonates and close association with dolomite and
barite support this idea. However, it is hard to
explain the reason why barium-bearing carbonates have been
formed only in this particular place, because grain
by grain association of barite and dolomite is very common
(7 samples out of 10) without any evidence of reaction between
them. (See footnote on next page).

Chemical compositions, particularly iron and
magnesium contents in dolomite show lateral zoning
namely, magnesium-rich at center and iron rich
at the margin. Iron-rich dolomite coexists with

Footnote to page BA-9

"Calcareous witherite" was reported by Carne (1976) from TEA barite deposit, Middery Lake map area, Yukon and consists the base of baritic ore in the area. However, Lydon et al. (1979) failed to confirm the presence of witherite and pointed out that Carne's original identification did not include an X-ray confirmation. Therefore, this may be the first report on the occurrence of barium-bearing carbonates in shale-hosted barite-sulfide ore in Yukon.

siderite in samples DY 257 and DY260, which represent marginal facies of the bartic unit.

Neither manganese nor strontium content in dolomite shows no systematic variation, however, there is proportional relation between these two contents. This is more obvious in group (A) samples than this case. It suggests that concentration ratio between manganese (II) and strontium ions did not change remarkably in the ore-forming solutions.

Consistent increase in the ratio $Fe/Fe+Mg$ towards upper horizon and towards the margin which is represented by the chemical composition of dolomite and siderite can be explained in several ways. First of all, even though the

ratio total iron vs. magnesium ions stayed constant; reduction from ferric to ferrous ion causes the relative increase in ferrous ion concentration over magnesium ion. However, the sulfide orebodies in the DY deposit have repeated "Anvil Cycles" * and the trend is well-explained by increasing oxidation state throughout the sequence. Therefore, the upward reduction is not consistent with the general trend of ore deposition. Secondary, relative increase in pH with time and space can produce the

* Vertical zoning in mineral assemblages in ore which was first described by Dr. D. Jennings at Faro deposit, that is, from bottom to top, graphite-bearing, quartz-bearing, massive, and barite-bearing sulfide ores.

observed trend Third alternative explanation is
to assume)

that the composition of ore forming solution had
evolved during ore deposition. Oxygen, carbon and

sulfur isotope study will give more reliable clues
to solve the problem.

W. C. Shanks III in progress.

TABLE BA-1 Sample locations and mineral assemblages (in order of decreasing amounts) of the barite-bearing ores from DY deposits
(See Fig. BA-1 for the drill sites)

Sample No.	DDH	Depth (cm)	mineral assemblage
(A) DY 155	79X14	706.9	Ba, Py, Sd, Sp, Gn, mt
DY 156	ditto	712.0	Py, Ba, Sd, Sp, Gn, Mt, Cp
DY 158	ditto	717.7	Py, Do, Sd, Ba, Gn, Mt, Sp, Cp
DY 159	ditto	720.7	Ba, Py, Sp, Gn, Do, mt, Cp
DY 174	ditto	811.7	Ba, Py, Sp, Do, Gn, As, Bi
DY 178	ditto	856.9	Py, Ba, Cp, Do, mt, Sp, Gn
(B) DY 259	80X08	847.8	Ba, Py, Sp, Gn, Qz, Do, Cp, Ag-Te, Mt
DY 258	80X05	860.5	Ba, Py, Sp, Ba-carbonates (see text), Do, Gn, Cp
DY 257	79X16	818.5	Ba, Py, Sp, Gn, Cp, Do, Sd
DY 260	80X09	769.9	Ba, Py, Sp, Gn, Cp, Sd, Do, Mt

Abbreviations are as follows; Ba, barite; Py, pyrite; As, arsenopyrite; Sp, sphalerite; Gn, galena; Cp, chalcopyrite; Ag-Te, argentian tetrahedrite; Qz, quartz; Mt, magnetite; Do, dolomite; Sd, siderite; Bi, bismuthinite;

Table BA-2. Selected chemical compositions of carbonates in barite-bearing samples (see Table BA-1).

	DY 155	DY 156	DY 158	
Weight %	siderite	siderite	siderite	dolomite
CaO	0.77 (.20)*	0.40 (.13)	0.47 (.12)	26.21 (.86)
MgO	2.07 (.33)	3.37 (.83)	3.75 (.83)	5.17 (.41)
FeO	51.35 (.52)	52.20 (1.29)	51.78 (.94)	21.81 (.33)
MnO	5.46 (1.21)	3.79 (.66)	3.56 (.17)	2.36 (.03)
SrO	0.00 (—)	0.00	0.13 (.18)	0.29 (.04)
CO ₂ **	37.70	38.32	38.44	41.16
Total	97.34	98.08	98.12	97.00
Mole fractions				
CaCO ₃	0.016	0.008	0.010	0.500
MgCO ₃	0.060	0.096	0.106	0.137
FeCO ₃	0.834	0.834	0.825	0.325
MnCO ₃	0.090	0.061	0.057	0.036
SrCO ₃	—	—	0.001	0.003
n***	(6)	(11)	(5)	(3)

* 1.0

** Calculated assuming stoichiometry

*** Number of analyses.

ankerite $\text{Ca}(\text{Mg}, \text{Fe}^{+2}, \text{Mn})(\text{CO}_3)_2$
 should really be ankerite as
 opposed to dolomite.

(Table BA-2 continued ^{1/3})

	DY159	DY174	DY178
Weight %	dolomite	dolomite	dolomite
CaO	25.28 (.41)*	27.61 (.61)	24.91 (.55)
MgO	4.45 (1.13)	13.62 (2.15)	9.54 (2.08)
FeO	20.23 (.98)	8.69 (3.13)	8.55 (.26)
MnO	4.76 (.09)	3.68 (.05)	9.60 (2.69)
SrO	1.27 (.06)	0.09 (.15)	1.27 (.57)
CO ₂ **	40.58	44.18	41.67
Total	96.57	97.87	95.48

Mole fractions

CaCO ₃	0.489	0.490	0.469
MgCO ₃	0.120	0.337	0.250
FeCO ₃	0.305	0.120	0.126
MnCO ₃	0.073	0.052	0.143
SrCO ₃	0.013	0.001	0.012
n***	(3)	(7)	(3)

(Table BA-2 continued 3/2)

Weight%	-DY259	DY258		
	dolomite	norse thite	barytocalcite	dolomite
BaO	0.00	50.86(1.19)	47.60(2.25)	0.00
CaO	28.14(.47)*	0.33(.19)	17.94(1.34)	25.40(.70)
MgO	12.85(.76)	8.66(1.44)	1.00(.83)	6.12(1.80)
FeO	9.25(.55)	4.19(1.61)	0.55(.50)	11.41(1.08)
MnO	3.59(1.16)	5.00(.23)	0.66(.53)	8.14(1.99)
SrO	0.00	0.41(.21)	2.03(2.06)	0.54(.29)
CO ₂ **	44.01	30.15	32.03	38.88
Total	97.84	99.59	101.82	90.49

Mole fractions

BaCO ₃	0.0	0.484	0.476	0.0
CaCO ₃	0.502	0.009	0.439	0.513
MgCO ₃	0.319	0.313	0.034	0.172
FeCO ₃	0.129	0.085	0.011	0.180
MnCO ₃	0.051	0.103	0.013	0.130
SrCO ₃	0.0	0.006	0.027	0.006
-n***	(4)	(7)	(6)	(8)

(Table BA-2 continued 1/3)

Weight %	DY257		DY 260	
	siderite	dolomite	siderite	dolomite
CaO	0.86 (.71)	26.45 (.68)	1.50 (.61)	25.82 (.20)
MgO	3.12 (.06)	6.08 (1.24)	0.96 (.42)	6.22 (.44)
FeO	38.36 (.11)	16.77 (1.21)	55.79 (2.18)	18.16 (.84)
MnO	12.73 (.37)	6.92 (1.43)	0.84 (.87)	4.79 (.46)
SrO	n.d.	0.27 (.18)	0.09 (.16)	0.39 (.12)
CO ₂ **	35.47	42.08	36.96	41.31
Total	90.53	98.57	96.14	96.69

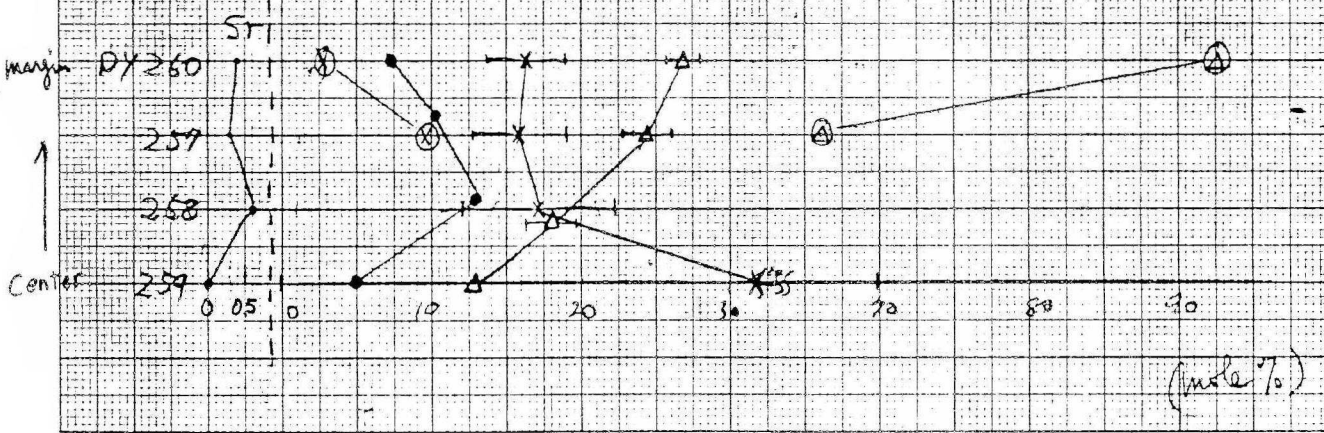
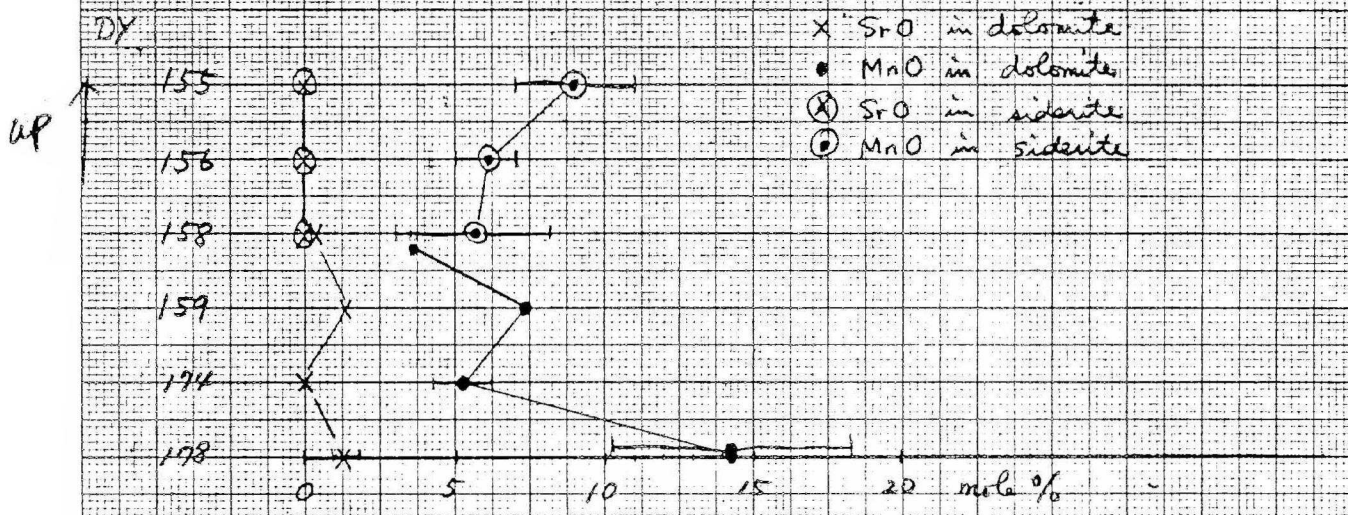
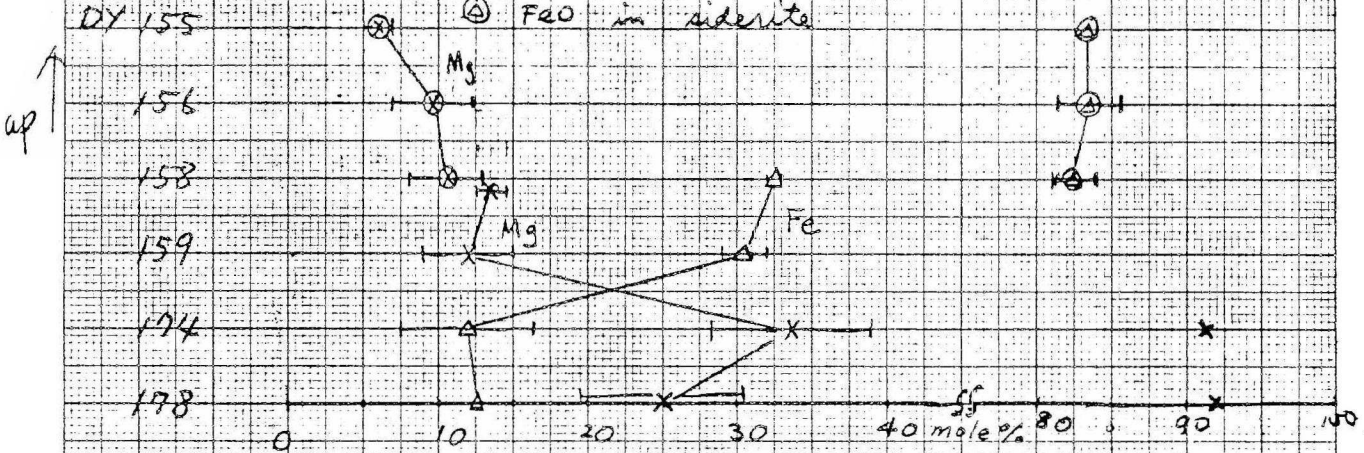
Mole fractions

CaCO ₃	0.019	0.493	0.032	0.490
MgCO ₃	0.096	0.158	0.028	0.164
FeCO ₃	0.663	0.244	0.925	0.269
MnCO ₃	0.223	0.102	0.014	0.072
SrCO ₃	---	0.003	0.001	0.004
n***	(2)	(5)	(3)	(4)

79X14

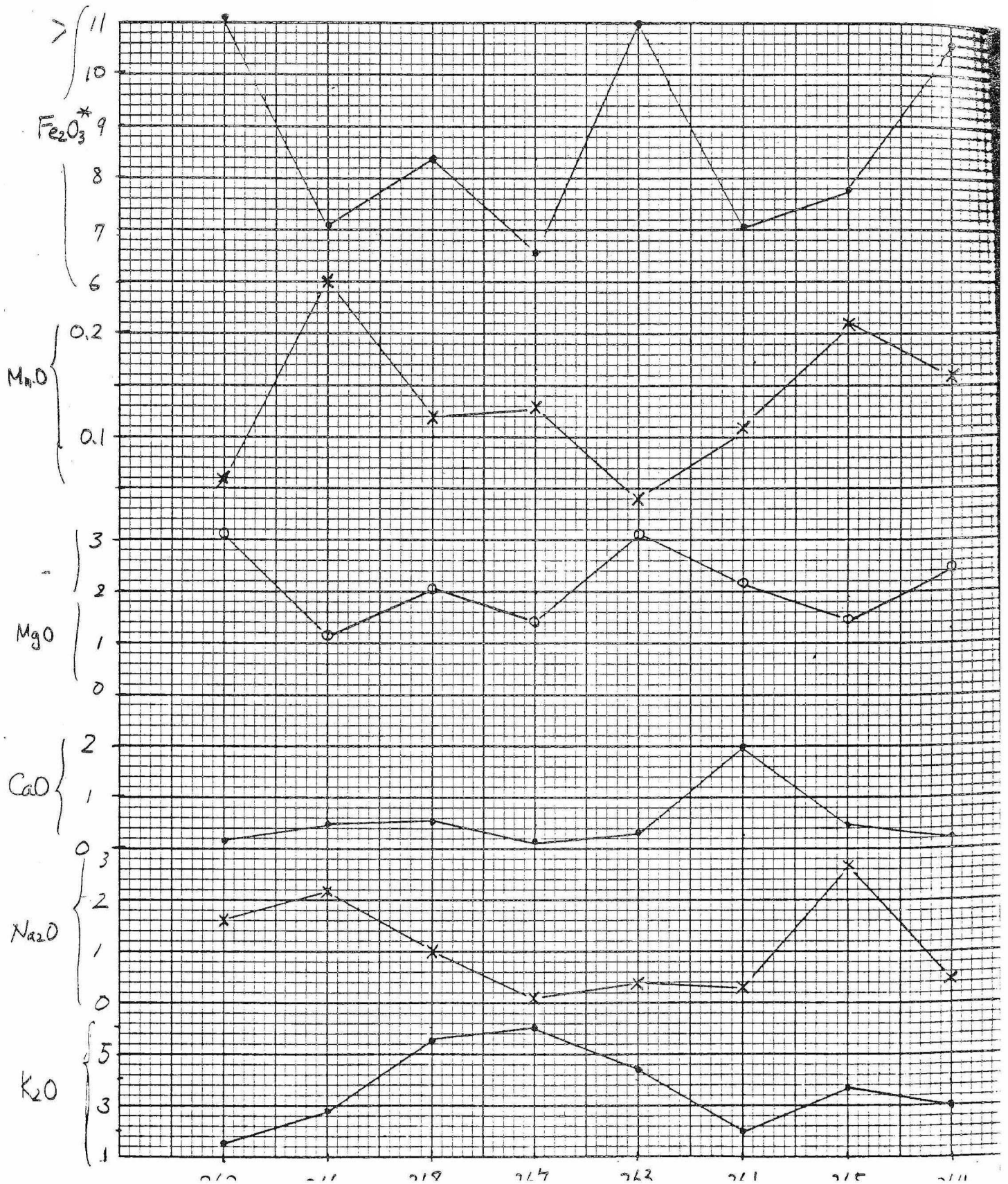
② $3a_2 \rightarrow 2a_0 \frac{Fe/Mg}{2}$

- x MgO in dolomite
- ⊗ MgO in siderite
- △ FeO in dolomite
- ⊕ FeO in siderite



(mole%)

4L in 5G BULK (4/2)



4L in 3G BULK (1/2)

Feb. 17/81

