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EXPERIMENTAL TREATMENT OF NEVADA AND CALIFORNIA FLUORSPAR ORES

By A. L. Engel and H. J. Heinen

Complete Report District 192
Item 12

BROKEN HILLS DISTRICT
(0730 0013)

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GEOLOGY OF THE GREEN SPRINGS MINE

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INTRODUCTION

The Green Springs Mine is located in the southwest corner of the historic White Pine mining district, 37 miles west of Ely, Nevada. USMX, Inc. staked the claims in 1979, drilled the discovery hole in 1986, and achieved full open pit, heap leach production in mid 1988.

As many as five deposits have been identified within a mile long north-trending band of jasperoids that border the western edge of the White Pine Range (Fig. 1). The "C" pit is in production. The "D" and "North C" will be phased in through the end of production in 1990.

GENERAL GEOLOGY

Strata exposed in the district are the alternating limestones, shales and siltstones of Devonian to Mississippian age. Upward, they include the massive Guilimette Limestone, the calcoreous shales and siltstones of the Pilot Formation, the massive cherty crinoidal coarse grained Joana Limestone, the Chainman Formation, and the Diamond Peak Formation (Fig. 2). The important Chainman is subdivided into a lower thin to medium bedded silty limestone - the main ore host, a middle black shale, and an upper silty unit. Humphrey (1960) originally placed the lower limestone unit in the Chainman Formation, a precedent we follow. Kleinhampl and Ziony (1985), however, correlate it with the upper Joana Limestone.

The gold deposits occur in the westward-dipping limb of a broad south-plunging anticline, one of a series of north-trending folds in the White Pine district. Bedding thrusts, common throughout the section, probably originated with the folding and remained active into the Tertiary. The major Green Springs Thrust which occupies the Joana-Chainman contact has removed the favorable lower Chainman Limestone in the western part of the district. Bedding faults exposed in the pit do not appear to offset ore.

High angle faults served as conduits for hydrothermal fluids and offset ore. Pre-ore control is exemplified by the northerly trend of the "D" deposit, northeastern elongation of the "B" deposit, and the large northwest jasperoid zone in the "C" pit. Post-ore displacement is most obvious on the northeasterly faults in the "C" pit.

ALTERATION AND MINERALIZATION

Alteration is characterized by widespread oxidation, silicification, and argillization. Hydrothermal facies are a function of lithology and can be correlated with stratigraphic position (Figs. 2 and 3). Formations below the Chainman are relatively unaltered except for local pyritization in the Pilot Formation.

The top of the Joana Formation is commonly jasperized on a regional scale where it served as a major hydrothermal channelway. At Green Springs it is characterized by chalcedony filled fractures in intensely silicified jasper breccia. (Subsequent movement and rebrecciation along the Green Springs Thrust fault developed a commonly 25-foot thick zone of cavernous, completely uncemented breccia at its base.)

Brecciation and silicification continue, though with decreasing intensity, upward into the lower Chainman to form the 20 to 70 foot thick "lower jasperoid" unit.

A 5 to 10 foot transitional zone of decalcified "siltstone" separates the jasperoid from overlying limestone. Argillization dominates in these silty limestones, usually as fracture fillings but often as massive replacement, especially near the top.

The limestones are capped by a 10 to 50 foot thick upper jasperoid zone, similar in appearance to the less intensely brecciated portions of the lower jasperoid. Massive clays, similar to those in the underlying limestones replace portions of these jaspers, especially along structures. The overlying middle shales usually alter to clays.

Ore occurs in highly deformed, contorted, fractured limestone and jasperoid in zones as much as 200 feet wide by 100 feet thick (Fig. 3). Gold values as high as 0.2 ounces per ton in the cores of these "feeder zones" decrease rather uniformly outward into less fractured waste rock. Alteration facies do not, themselves, bound ore. Contours of blast hole assays generally show strong linear trends that reflect structural controls. Classical "veins" have not been identified. Assays of screened size fractions in which the minus 1" feed is generally double the grade of the coarse feed indicates the gold is in fracture fillings and not dissemented in the host rock. Gold deposition was evidently late.

GEOCHEMISTRY

USMX's discovery was based on a well defined gold anomaly in soils over the main orebody. Values as high as 0.1 ounces per ton occur over non-outcropping argillized limestone adjacent to bold outcrops of sub-ore upper and lower jasperoid. Trace elements with values as high as 1081 ppm As, 33 ppm Sb, 29 ppm Hg, and 34 ppm Tl, as well as Ag and base metals are also anomalous. Geochemical assays of drill cuttings show the highest concentrations in the favorable argillized limestones, followed closely by the bordering jasperoids. However, the correlation to gold is poor.

MINING AND BENEFICATION

Initial engineered reserves were 1.25 million tons at a grade of .06 ounces per ton gold. The overall stripping ratio is 2.75 tons waste to 1.0 ton ore. The ore is mined by open pit methods at a rate of 640,000 tons of ore per year. Lost Dutchman Construction, Inc., has been awarded the mining contract and does all mining, crushing, agglomerating, and pad loading. The process design consists of the leach pad, solution collection and distribution, recovery plant, offices, and laboratory. The recovery process includes a skid-mounted modular 500 gallons-per-minute carbon adsorption plant, carbon stripping by the Anglo_American Research Laboratory (AARL) process, electrowinning and dore production. Total mining and processing costs are approximately $10.00 per ton of ore.

REFERENCES

Humphrey, F. L., 1960, Geology of the White Pine mining district, White Pine County, Nevada: Nevada Bur. Mines Bull. 57

Kleinhampl, F. J., and Ziony, J. I., 1985, Geology of northern Nye County, Nevada: Nevada Bur. Mines Bull. 99A

TABLE 1

Pearson Correlation Coefficients and Summary Statistics (ppm) for Lower Chainman Soil Samples

	Au	As	Sb	Tl	Te	Hg	Ag	Cu	Mo	Zn	Pb
Au	1										
As	0.42	1									
Sb	0.56	0.78	1								
Tl	0.58	0.78	0.77	1							
Te	0.32	0.62	0.51	0.42	1						
Hg	0.56	0.37	0.44	0.46	0.23	1					
Ag	0.45	0.47	0.51	0.39	0.44	0.32	1				
Cu	0.04	0.12	0.16	0.10	0.17	0.11	0.22	1			
Mo	0.05	0.30	0.27	0.13	0.43	0.10	0.27	0.32	1		
Zn	0.00	0.31	0.24	0.13	0.57	-0.01	0.07	0.18	0.36	1	
Pb	0.10	0.17	0.22	0.10	0.55	-0.02	0.41	0.29	0.35	0.19	1
Mean	0.10	52	2.7	1.2	0.1	0.0	0.2	24	1	158	13
Max	4.29	1081	24.0	34.0	5.8	4.3	2.2	150	20	1764	106
sd	0.33	86	2.6	2.8	0.5	0.2	0.2	13	1	156	6

n = 664

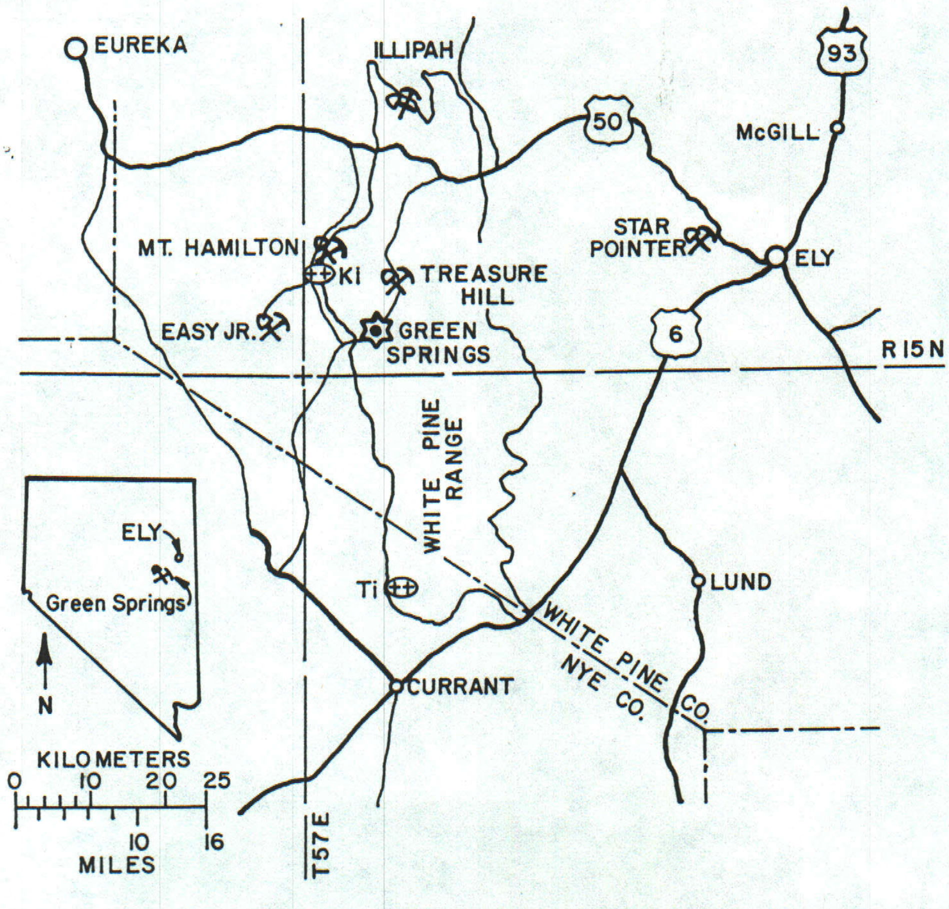

EUREKA
ILLIPAH
93
50
McGILL
MT. HAMILTON
KI
TREASURE
HILL
STAR
POINTER
ELY
EASY JR.
GREEN
SPRINGS
6
R15N
WHITE
PINE
RANGE
ELY
Green Springs
N
Ti
LUND
WHITE PINE CO.
NYE CO.
CURRANT
KILOMETERS
0 10 20 25
10 16
MILES
T57E

Fig. 1

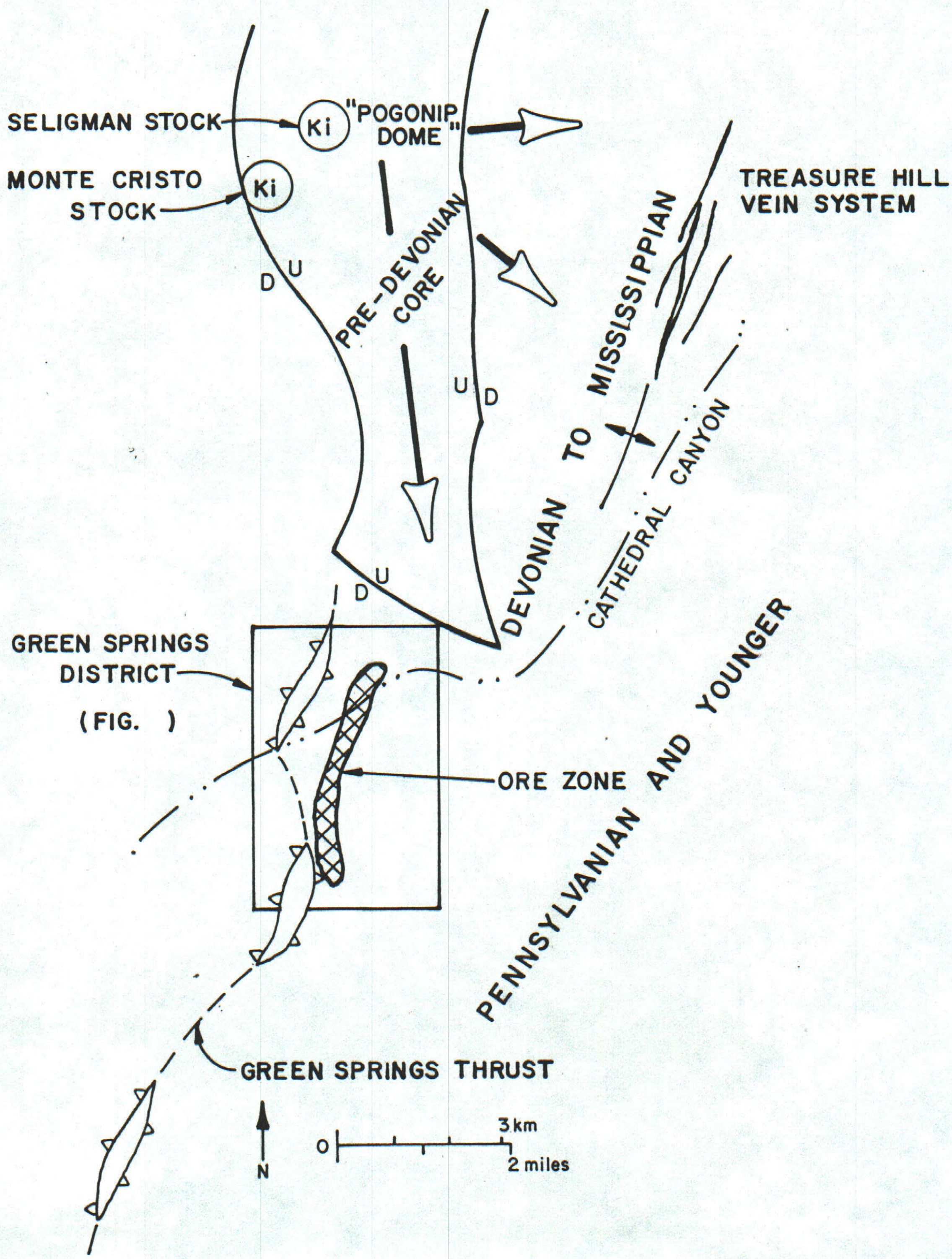

SELIGMAN STOCK
Ki
"POGONIP DOME"
MONTE CRISTO STOCK
Ki
TREASURE HILL VEIN SYSTEM
PRE-DEVONIAN CORE
D U
U D
DEVONIAN TO MISSISSIPPIAN
CATHEDRAL CANYON
D U
GREEN SPRINGS DISTRICT
(FIG.)
ORE ZONE
PENNSYLVANIAN AND YOUNGER
GREEN SPRINGS THRUST
N
0
3 km
2 miles

Fig. 2

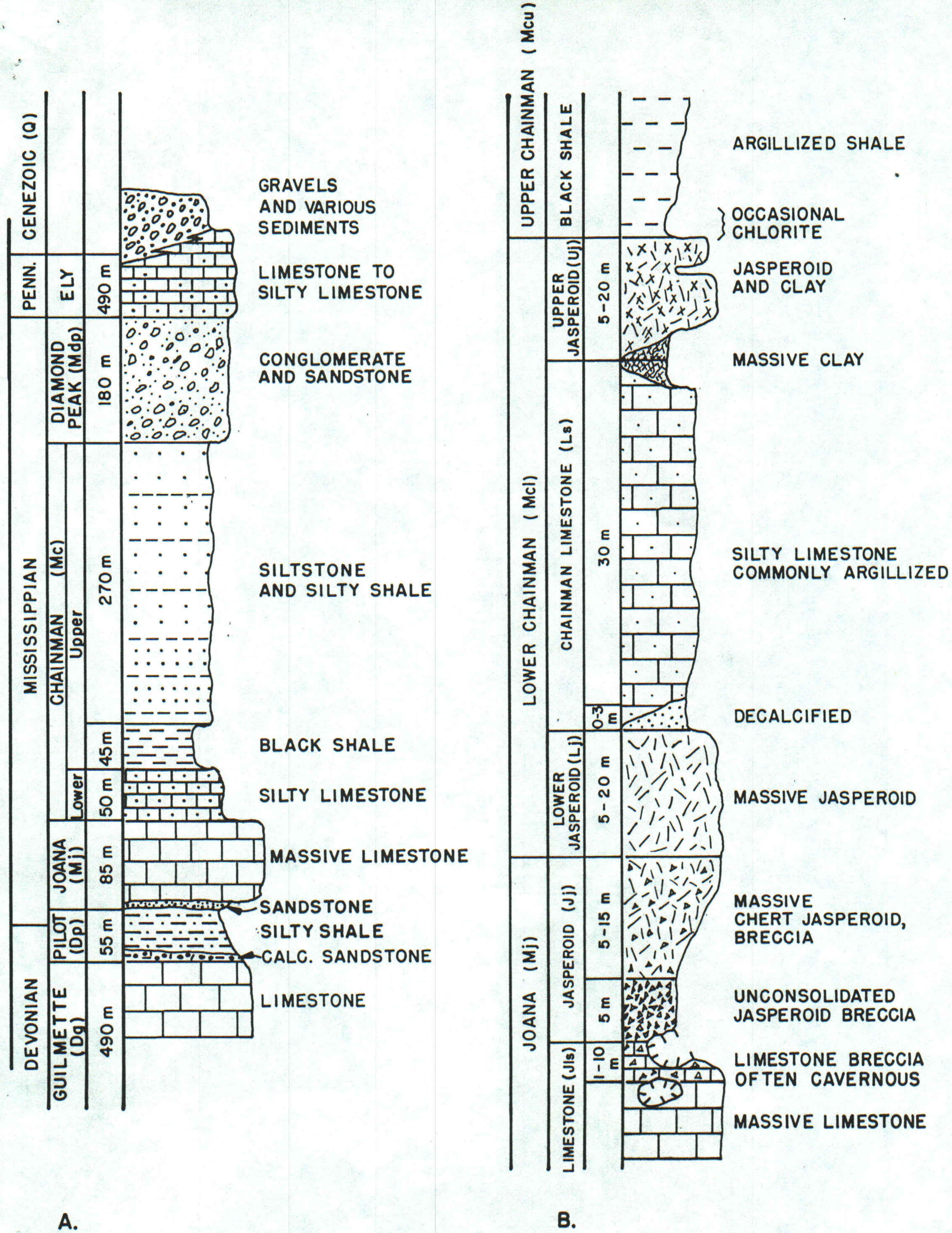
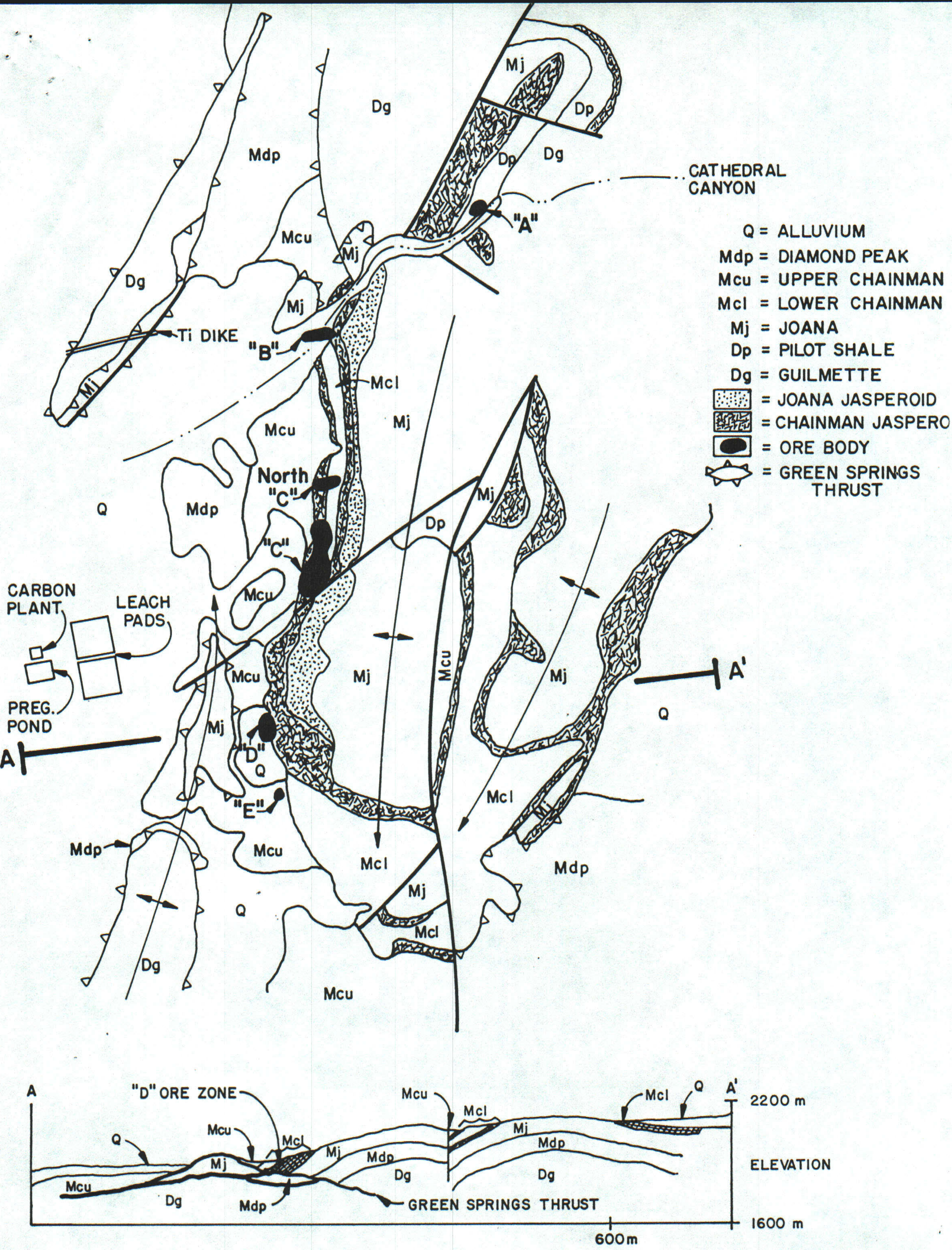
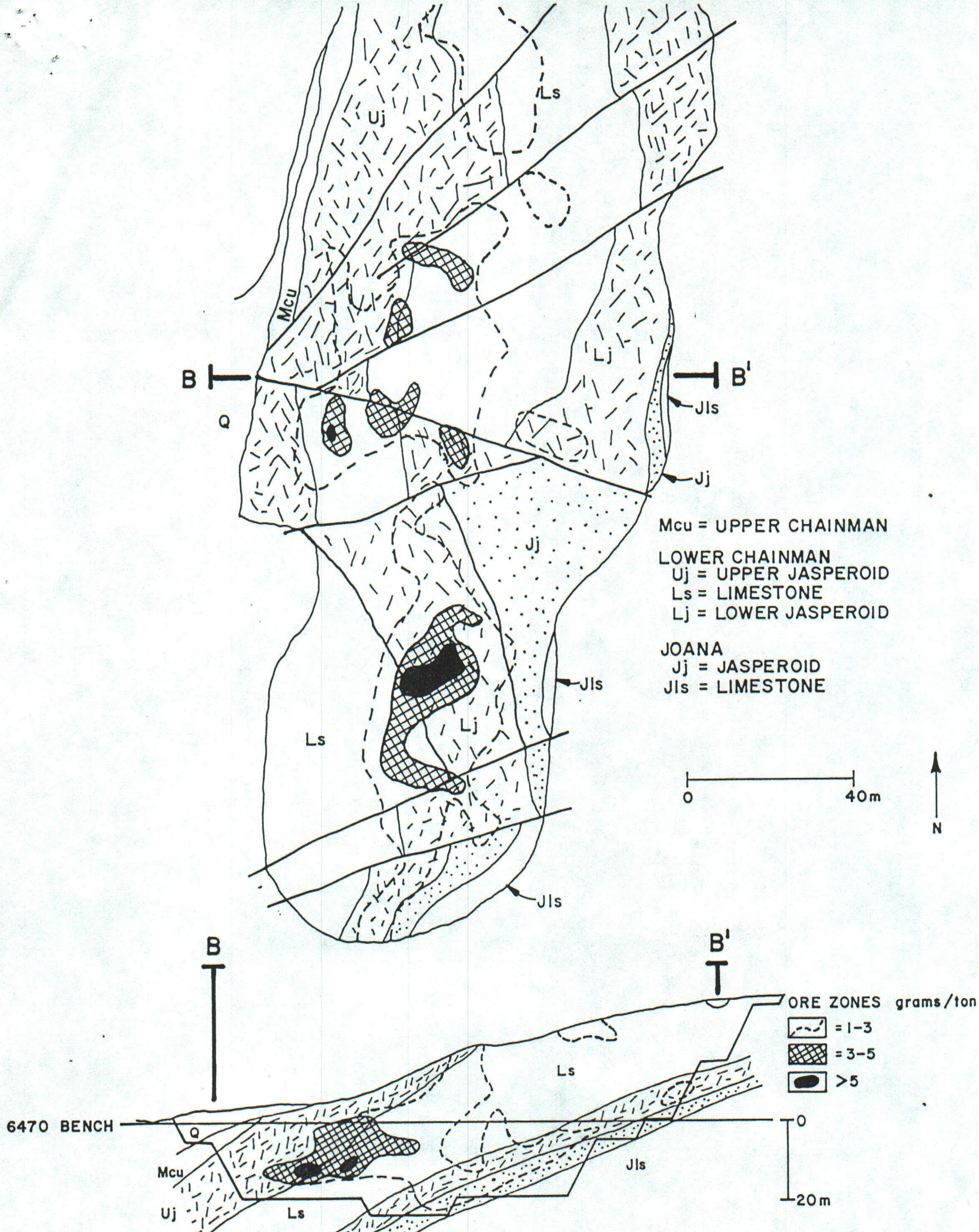

CENEZOIC (Q)
PENN.
ELY
490 m
MISSISSIPPIAN
DIAMOND PEAK (Mdp)
180 m
CHAINMAN (Mc)
Upper
270 m
45 m
Lower
50 m
JOANA (Mj)
85 m
DEVONIAN
PILOT (Dp)
55 m
GUILMETTE (Dg)
490 m
GRAVELS AND VARIOUS SEDIMENTS
LIMESTONE TO SILTY LIMESTONE
CONGLOMERATE AND SANDSTONE
SILTSTONE AND SILTY SHALE
BLACK SHALE
SILTY LIMESTONE
MASSIVE LIMESTONE
SANDSTONE
SILTY SHALE
CALC. SANDSTONE
LIMESTONE
A.
UPPER CHAINMAN (Mcu)
BLACK SHALE
LOWER CHAINMAN (Mcl)
UPPER JASPEROID (Uj)
5-20 m
CHAINMAN LIMESTONE (Ls)
30 m
0-3 m
LOWER JASPEROID (Lj)
5-20 m
JOANA (Mj)
JASPEROID (Jj)
5-15 m
5 m
LIMESTONE (Jls)
1-10 m
ARGILLIZED SHALE
OCCASIONAL CHLORITE
JASPEROID AND CLAY
MASSIVE CLAY
SILTY LIMESTONE COMMONLY ARGILLIZED
DECALCIFIED
MASSIVE JASPEROID
MASSIVE CHERT JASPEROID, BRECCIA
UNCONSOLIDATED JASPEROID BRECCIA
LIMESTONE BRECCIA OFTEN CAVERNOUS
MASSIVE LIMESTONE
B.

Fig. 3



CATHEDRAL CANYON
Q = ALLUVIUM
Mdp = DIAMOND PEAK
Mcu = UPPER CHAINMAN
Mcl = LOWER CHAINMAN
Mj = JOANA
Dp = PILOT SHALE
Dg = GUILMETTE
= JOANA JASPEROID
= CHAINMAN JASPERO
= ORE BODY
= GREEN SPRINGS THRUST
"A"
"B"
Ti DIKE
North "C"
"C"
"D"
"E"
CARBON PLANT
LEACH PADS
PREG. POND
A
A'
Mj
Dp
Dg
Mdp
Mcu
Mcl
Q
"D" ORE ZONE
GREEN SPRINGS THRUST
2200 m
ELEVATION
1600 m
600m

Fig 4



Uj
Ls
Mcu
B
B'
Q
Lj
Jls
Jj
Mcu = UPPER CHAINMAN
LOWER CHAINMAN
Uj = UPPER JASPEROID
Ls = LIMESTONE
Lj = LOWER JASPEROID
JOANA
Jj = JASPEROID
Jls = LIMESTONE
0
40m
N
ORE ZONES grams/ton
= 1-3
= 3-5
>5
6470 BENCH
0
20m

Fig. 5

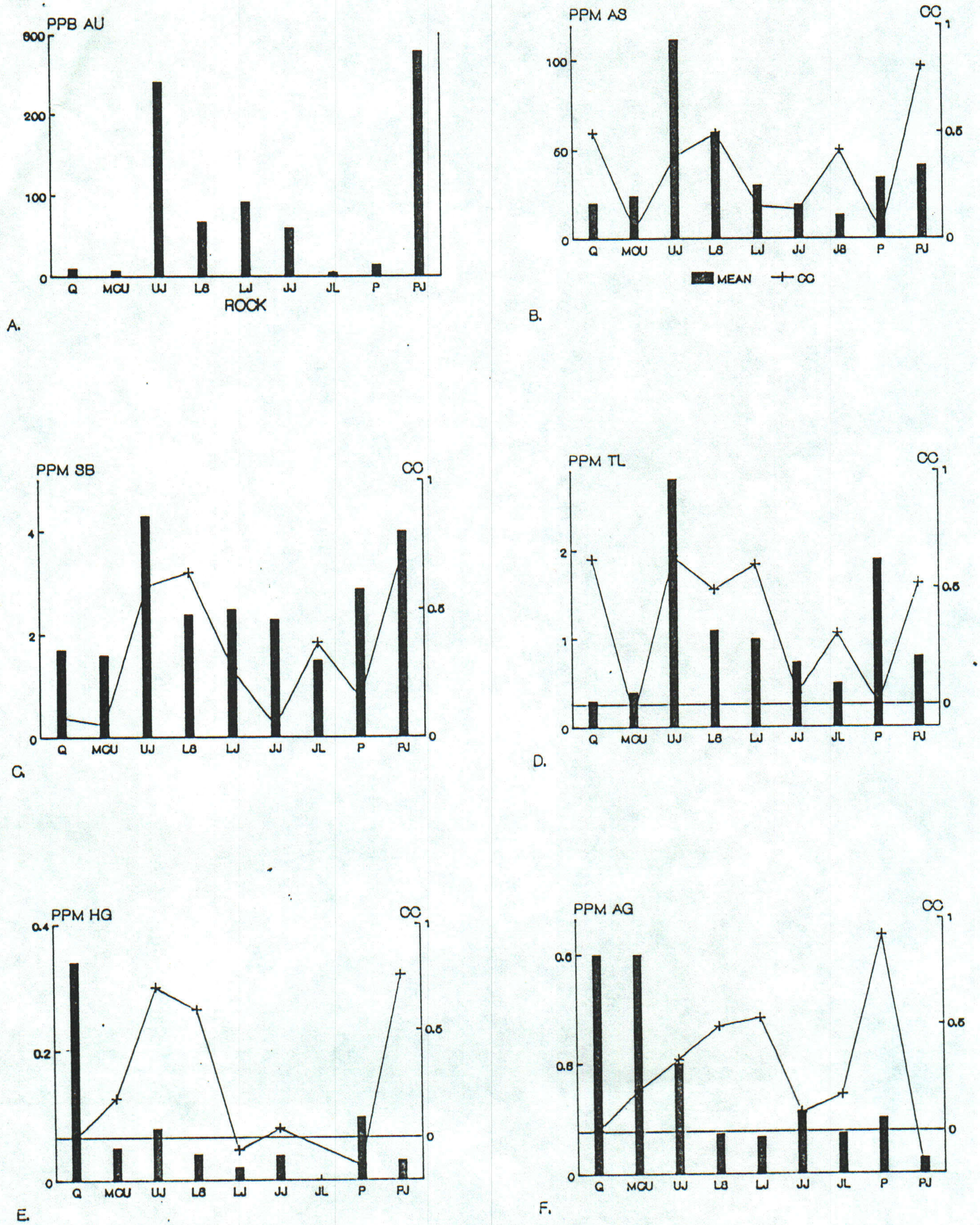
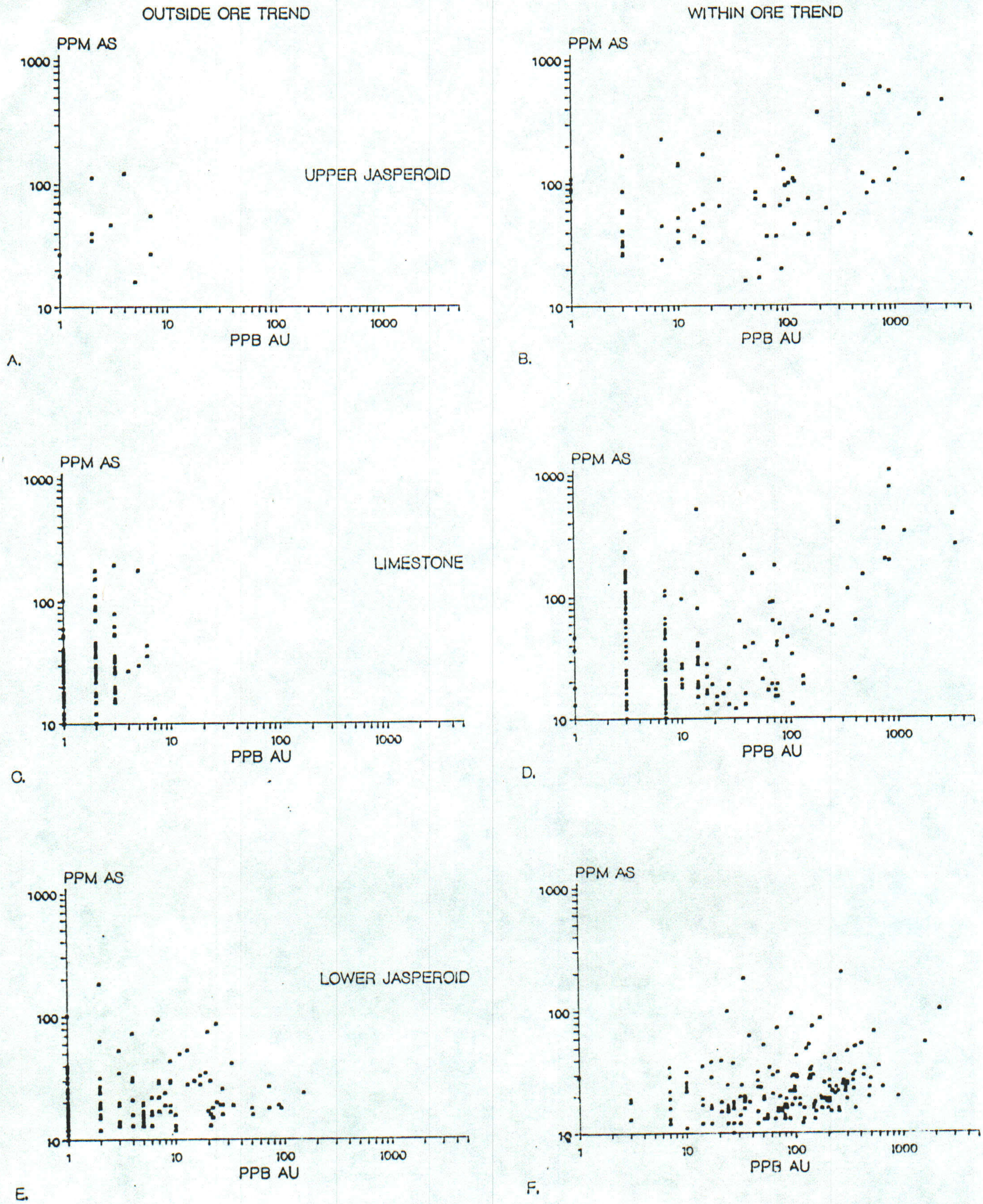

PPB AU
300
200
100
0
Q MCU UJ LS LJ JJ JL P PJ
ROCK
A.
PPM AS
CC
100
50
0
1
0.5
0
Q MCU UJ LS LJ JJ JS P PJ
MEAN
CC
B.
PPM SB
CC
4
2
0
1
0.5
0
Q MCU UJ LS LJ JJ JL P PJ
C.
PPM TL
CC
2
1
0
1
0.5
0
Q MCU UJ LS LJ JJ JL P PJ
D.
PPM HG
CC
0.4
0.2
0
1
0.5
0
Q MCU UJ LS LJ JJ JL P PJ
E.
PPM AG
CC
1
0.5
0
Q MCU UJ LS LJ JJ JL P PJ
F.

Fig 6



OUTSIDE ORE TREND
WITHIN ORE TREND
PPM AS
PPB AU
1
10
100
1000
UPPER JASPEROID
A.
B.
LIMESTONE
C.
D.
LOWER JASPEROID
E.
F.

1. LIMESTONE RUBBLE GRADES UPWARD INTO MASSIVE CLAY AT LIMESTONE-UPPER JASPEROID CONTACT ALONG BARREN FEEDER.

2. GOOD SECTION ACROSS LOWER CHAINMAN.

3. VARIOUS HYDROFRACTURE, TECTONIC AND KARST BRECCIAS ALONG CHAINMAN-JOANA CONTACT.

   DANGER STAY OUT OF CAVES!

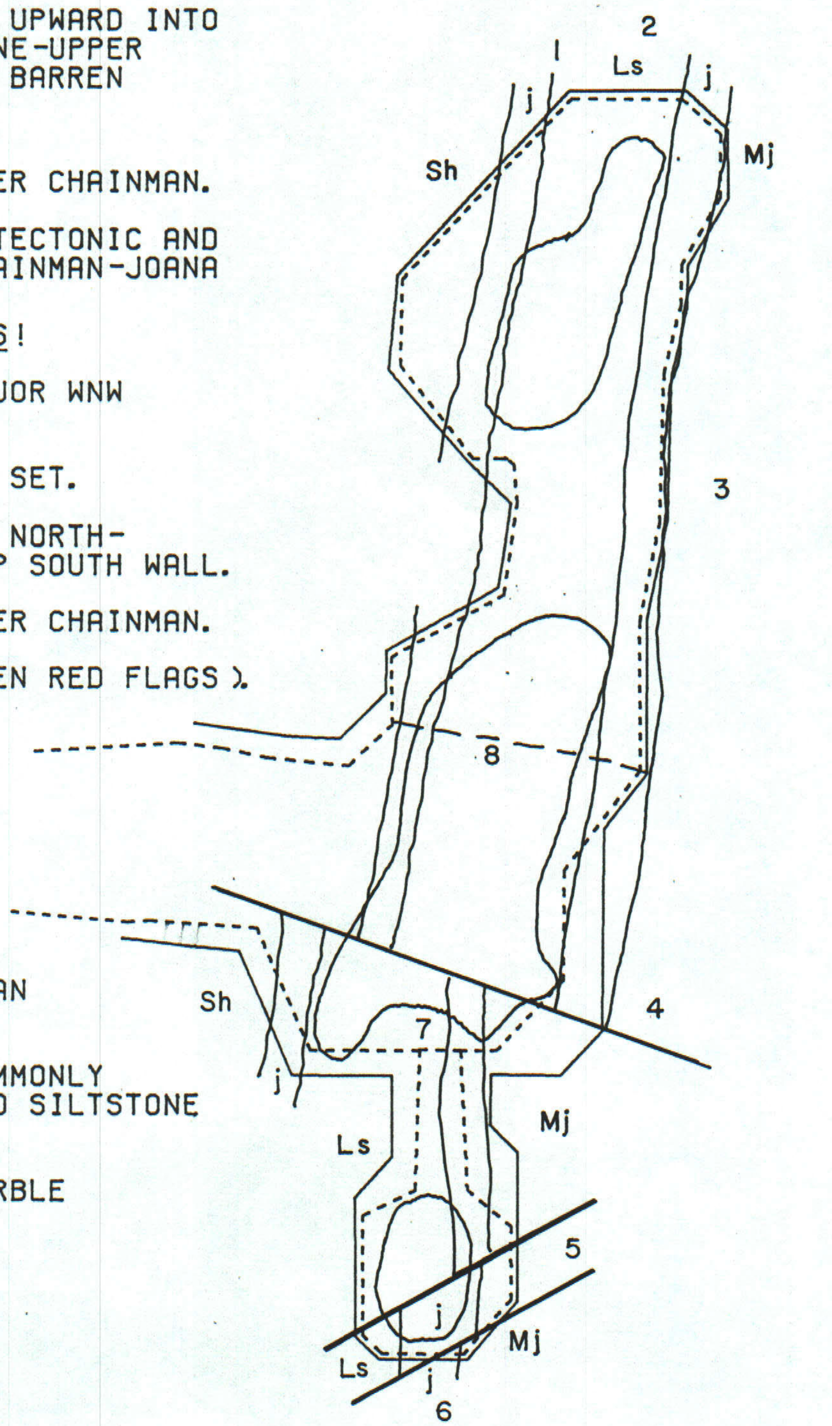
4. CU-MN OXIDE CLAYS IN MAJOR WNW PRE-ORE CROSS FAULT.

5. MAJOR NE POST-ORE FAULT SET.

6. 15 FT. WIDE ORE ZONE IN NORTH-TRENDING FEEDER, RUNS UP SOUTH WALL.

7. GOOD SECTION ACROSS LOWER CHAINMAN.

8. ORE IN LIMESTONE (BETWEEN RED FLAGS).



Sh CHAINMAN SHALE

j UPPER AND LOWER CHAINMAN JASPEROIDS

Ls CHAINMAN LIMESTONE, COMMONLY ARGILLIZED, DECALCIFIED SILTSTONE AT JASPEROID CONTACTS.

Mj JOANA JASPEROID AND MARBLE

N

OUTLINE OF +.Ø2 OZ/TON ORE

USMX GREEN SPRINGS

C-PIT

SCALE: 1 IN. = 2ØØ FT.

6455 BENCH - SOLID LINE

644Ø BENCH - DOTTED LINE

USMX - Green Springs Process Plant

The USMX Process Plant is a classic heap leach, carbon adsorption-desorption, electrowinning process.

Ore is crushed to minus 1" size, agglomerated with cement and stacked on 600' x 300' plastic lined pads in 20' lifts. Cyanide solution is applied to the top of the heaps via drip-emitter irrigation tubing. Total barren solution flow to the heaps is 450 gpm with a typical leach cycle of 50 days at an 80% gold recovery.

Gold bearing pregnant solution is diverted from the leach heaps into a three million gallon plastic lined pregnant liquor pond. Pregnant liquor is pumped to the process plant where it is cascaded through a five-stage series of 5' diameter carbon columns, each holding one ton of activated carbon. Gold adsorbs onto the carbon from the pregnant solution, which then exits the plant as gold poor barren solution. After having cyanide made-up, barren solution is pumped back upon the heaps to begin the leach cycle anew.

As the carbon becomes loaded with gold it is advanced counter-current to the solution flow from column to column and loaded into the carbon stripping vessel. The carbon stripping method utilized at Green Springs is an Anglo American Research Laboratories (AARL) system, in which the carbon is acid washed, and the gold desorbed off the carbon via a high cyanide solution soak followed by a high temperature water rinse.

Gold is subsequentially removed from the solution exiting the AARL column via an electrowinning and replating circuit, the final product of which is smelted in a tilting furnace and poured into bullion buttons assaying 98% precious metals by weight.

At the end of the strip cycle, stripped carbon now carrying 0.5 ounces gold per ton carbon is reactivated in a rotary kiln at 1200°F, quenched in water, and then advanced to the last carbon column in the train to begin the adsorption cycle over again.

Property production averages 2,000 ounces gold per month.

GREEN SPRINGS PROJECT

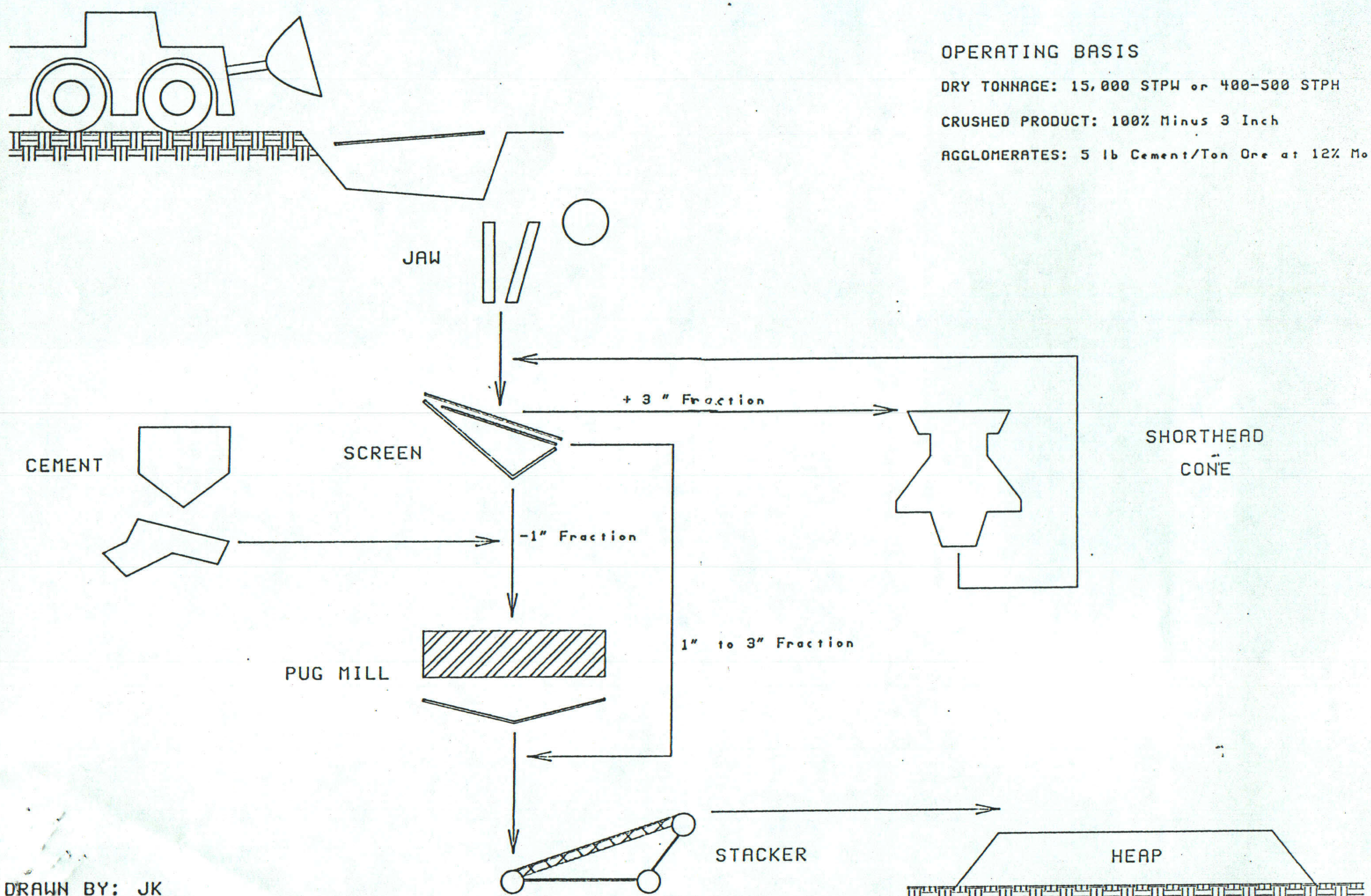
CRUSHING AND AGGLOMERATION FLOWSHEET

OPERATING BASIS

DRY TONNAGE: 15,000 STPW or 400-500 STPH

CRUSHED PRODUCT: 100% Minus 3 Inch

AGGLOMERATES: 5 lb Cement/Ton Ore at 12% Moisture



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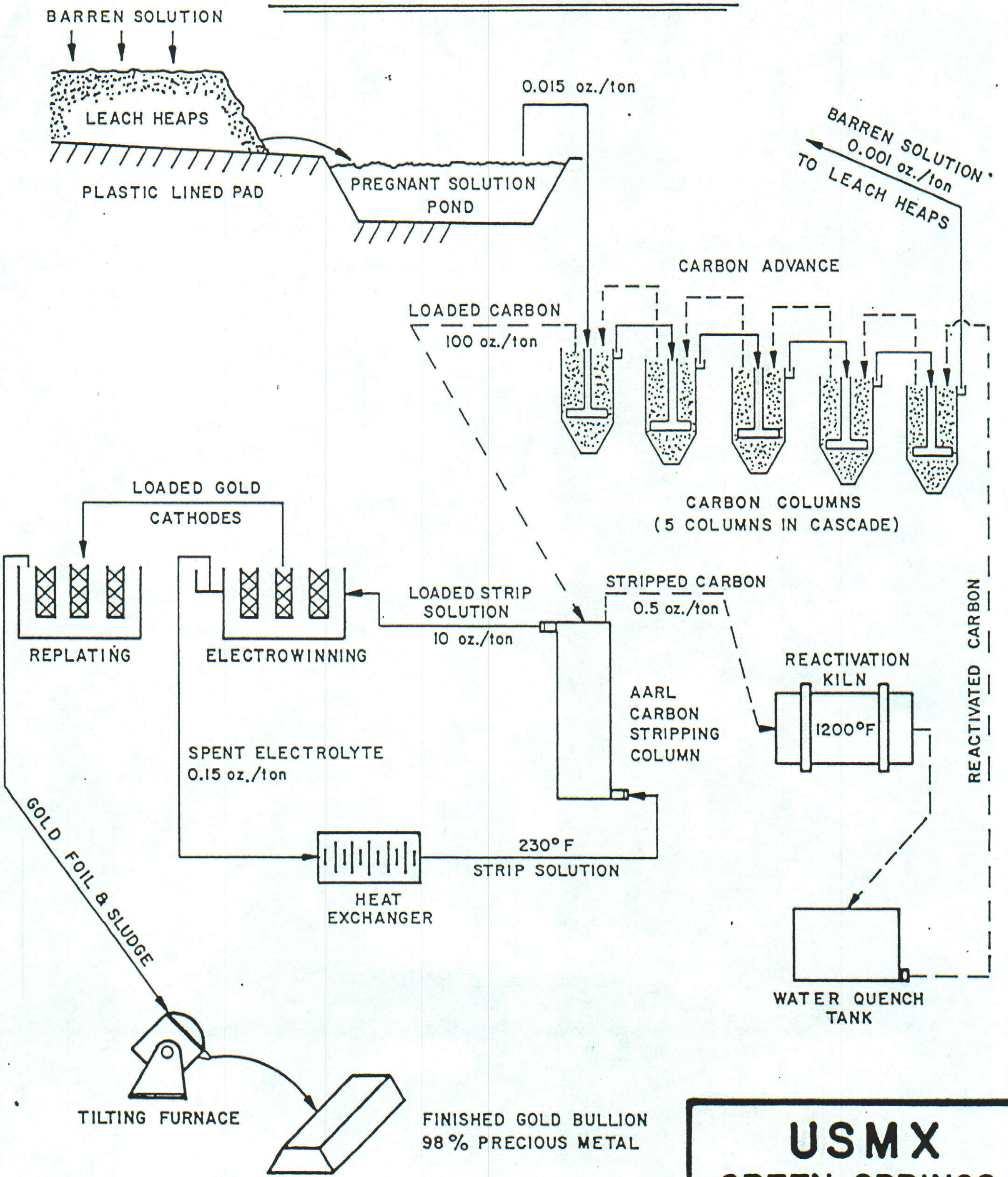
DATE: JAN 1988

PROCESS PLANT FLOW SHEET



USMX
GREEN SPRINGS MINE