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INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: 9-24-63

Send #1	0-10S											
Receive	20-30	30-40	40-50	50-60	60-70	70-80						
Time	2.	2.	2	2	2							
Range												
Current												
Send #2	10-20S											
Receive	CAL	30-40	40-50	50-60	60-70	70-80S						
Time	300	2.	2	2	2							
Range												
Current												

INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: 9-24-67

Send #1	20-30											
Receive	4050	5060	6070	7080								
Time	2.	2.	2.	2.								
Range												
Current												
Send #2	3040											
Receive	CAL	5060	6070	7080	8090							
Time	300	2	2.	2								
Range												
Current												

INDUCED POLARIZATION SENDER NOTES

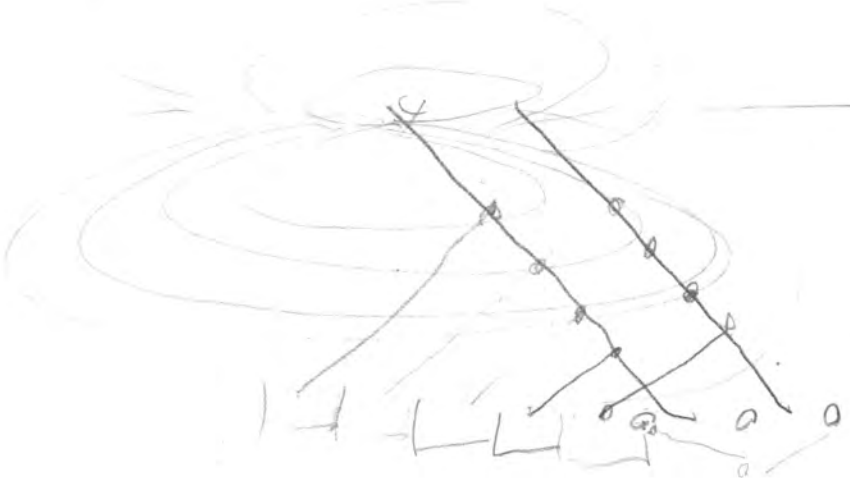
Project: _____ Line: _____ Date: 9-24-64

Send #1	4050											
Receive	2	2.	2.	2.								
Time												
Range												
Current												
Send #2	5060											
Receive	CA	2.	2.	2.	2							
Time	300											
Range												
Current												

INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: 9-25-64

Send #1	60-70											
Receive	80-90	90-100	100-110	110-120								
Time	2	2	2	2								
Range												
Current												
Send #2	70-80											
Receive	0-1	90-100	100-110	110-120	120-130							
Time	300	2	2	2								
Range												
Current												



INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: _____

Send	80-90											
Receive	100-110	110-120	120/130	130-140								
Time	2.0	2.0	2.0	2.0								
Range												
Current												
Send	90-100				CHL							
Receive	110-120	120-130	130-140		.3 AMP							
Time	2.0	2.0	2.0									
Range												
Current												

80
90
100

Line 2

Tx 60-75S	Rx	Tx 75-90S	Rx
2A	(1) 90-105S	2A	(2) 105-120S
2A	(2) 105-120S	2A	(3) 120-135S
2A	(3) 120-135S	2A	(4) 135-150S
2A	(4) 135-150S	2A	(5) 150-165S
2A	(5) 150-165S	2A	(6) 165-180S
2A	(6) 165-180S	2A	(7) 180-195S

Cal #1 360 mH

NORTH STAR, Minn.

INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: _____

Send												
Receive												
Time												
Range												
Current												
Send												
Receive												
Time												
Range												
Current												

line 2

Tx 90-105S

2A (6) 120-135S
2A (5) 135-150S
2A (4) 150-165S
2A (3) 165-180S
2A (2) 180-195S
2A (1) 195-210S

Tx 105-120S

2A (6) 135-150S
2A (5) 150-165S
2A (4) 165-180S
2A (3) 180-195S
2A (2) 195-210S

INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: _____

Send												
Receive												
Time												
Range												
Current												
Send												
Receive												
Time												
Range												
Current												

Line 3

Tx 60 - 75

ZA - 1 - 90 - 105
ZA - 2 - 105 - 120
ZA - 3 - 120 - 135
ZA - 4 - 135 - 150
ZA - 5 - 150 - 165
- 6 - 165 - 180

Tx 75-90 Rx

ZA - 2 - 105 - 120
ZA - 3 - 120 - 135
ZA - 4 - 135 - 150
ZA - 5 - 150 - 165
- 6 - 165 - 180
- 7 - 180 - 195

cal # 1 300 mA

INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: _____

Send												
Receive												
Time												
Range												
Current												
Send												
Receive												
Time												
Range												
Current												

INDUCED POLARIZATION SENDER NOTES

Project: N. Star Mine Line: 1A 5 1/2 Date: 9-15-64

Send	3/4	4/5	2/3	3/4	4/5	1/2	2/3	3/4	4/5	1/2	2/3	3/4
Receive												
Time												
Range	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Current	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Send	4/5	1/2	2/3	3/4	4/5		dAL 2/3	1/2				
Receive												
Time												
Range	2.0	2.0	2.0	2.0	2.6		.30	.30				
Current	2000	2000	2000	2000	2000		300	300				

Tx		Rx
0-15S	2A	30S-45S(1)
	2A	45S-60S(2)
	2A	60S-75S(3)
	2A	75-90S(4)
	2A	90S-105S(5)
	2A	105S-120S(6)

Tx		Rx.
15-30S	2A	45-60S(2)
	2A	60S-75S(3)
	2A	75-90S(4)
	2A	90-105S(5)
	2A	105-120S(6)
	2A	120-135S(7)

Cal #1 300 MA
range 3.0

INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: _____

Send												
Receive												
Time												
Range												
Current												
Send												
Receive												
Time												
Range												
Current												

Tx		Rx
30 - 45S		
2A	6	60 - 75S
2A	5	75 - 90S
2A	4	90 - 105S
2A	3	105 - 120S
2A	2	120 - 135S
2A	1	135 - 150S

Tx		Rx
45 - 60S		
2A	5	75 - 90S
2A	4	90 - 105S
2A	3	105 - 120S
2A	2	120 - 135S
2A	1	135 - 150S

INDUCED POLARIZATION SENDER NOTES

Project: _____ Line: _____ Date: _____

Send												
Receive												
Time												
Range												
Current												
Send												
Receive												
Time												
Range												
Current												

INDUCED POLARIZATION SENDER NOTES

Project: North Star Line: #1 North Date: 9-9-64

Send	23	12	34	23	12	45	34	23	12	45	34	
Receive	→	→	→	→	→	→	→	→	→	→	⏚	
Time												
Range			2.0	2.0	2.0						2.0	
Current	2.0	2.0	~~2.0~~	~~2.0~~	~~2.0~~	2.0	2.0	2.0	2.0	2.0	9-10-64	
Send	23	12	45	34					CAL	3-4	CAL	4-5
Receive	→	→	→	→								
Time												
Range												
Current	2.6	X	2.0	2.0						1.0		1.0

INDUCED POLARIZATION SENDER NOTES

Project: North Star Line: #1 South Date: 9-11-69

Send	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	1-2	2-3	3-4
Receive	→	→	→	→	→	→	→	→	→	|	→	→
Time												
Range												
Current	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Send	4-5	1-2	2-3	3-4	4-5				N/A	2.3		
Receive	→											
Time												
Range												
Current	2.0	2.0	2.0	2.0	2.0				30			

45	34	23	12
1400	1000	~~1000~~ 1400	2000

INDUCED POLARIZATION SENDER NOTES

Project: North Star Line: # 1 A North Date: 9-11-64

Send	2-3	1-2	3-4	2-3	1 2	4 5	3 4	2 3	1 2	4-5	3 4	2-3
Receive	→	→	→	→	→	→	→	→	→	→	→	→
Time												
Range												
Current	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Send	1-2	4-5	3-4						CAL	4-5		
Receive	→	→	→									
Time	2.0											
Range												
Current										.30		

Standard I.P. Survey Data

OPERATOR VB SWEEN DATE

PROPERTY NORTH STAR LINE 2 N/2

TX. LOC. 1 - 2 TIME 100/684 CAL. 1.0

RX. LOC.	ATT.	A.C.VOL.	I	F.E.	Corr. F.E.	$\frac{P_a}{2\pi}$	M.F.
2-	100	176	#1	4.8	3.8	110 300 P	11.5
	30	255	#2	5.3	4.5	40 350	12.0
	10	685		5.3	4.5	21.4 320	14.0

TX LOC. 2 - 3 # ~~TIME~~ 100/635 CAL. .8

RX. LOC.	ATT.	A.C.VOL.	I	F.E.	Corr. F.E.	$\frac{P_a}{2\pi}$	M.F.
	300	215	#1	4.7	3.7	378 284	13.0
	100	046	#2	5.7	4.9	86 258	19.0
	30	278		5.1	4.3	41 310	14.0
	10	580				19.4 290	

TX. LOC. 3 - 4 TIME CAL.

RX. LOC.	ATT.	A.C.VOL.	I	F.E.	Corr. F.E.	$\frac{P_a}{2\pi}$	M.F.
	300	040	#2	5.6	4.8	280 210	23
	100	021		5.5	4.7	53.2 160	29
	30	113		(4.0)	3.2	32.0 240	13
	10	405				16.0 240	

REMARKS OVER

Standard I.P. Survey Data

OPERATOR _____ DATE _____

PROPERTY _____ LINE 1 N/2

TX. LOC. 4-5 TIME CAL.

RX. LOC.	ATT.	A.C.VOL.	I	F.E.	Corr. F.E.	$\rho_a / 2\pi$	M.F.
	100	950		4.0	3.2	240/195	16
	30	555		4.0	3.2	56.8/150	19
	10	815		(4.0)	3.2	23.7/180	18

TX LOC. TIME CAL.

RX. LOC.	ATT.	A.C.VOL.	I	F.E.	Corr. F.E.	$\rho_a / 2\pi$	M.F.

TX. LOC. TIME CAL.

RX. LOC.	ATT.	A.C.VOL.	I	F.E.	Corr. F.E.	$\rho_a / 2\pi$	M.F.

REMARKS OVER

INDUCED POLARIZATION - RECEIVER NOTES PAGE_____

Project: North Star Line: 3 Int.Cal_____ Date:_____

Send	0-15S	→	→	→	→							
Rec.	30-45S	45-60S	60-75S	75-90S	90-105S	105-120S						
Time	30	10	3	3				30				
DC-1	12.6	4.6	1.88 2.15	0.78 1.06				15				
DC-2	13.2	4.38	1.52 2.09	0.78 1.00				15				
Σ	25.8	8.98	3.93 3.60	1.84 1.78								
DC-3	13.2	4.6	1.8 1.93	0.70 0.94				15				
Dc-4	12.8	4.5	1.90 1.74	0.65 1.08				15				
Σ	26.0	9.1	3.73 3.67	1.65 1.93								
DC-AV	25.9	9.04	3.75	1.25								
AC-1	12.2	4.15	1.68	.73				14.4				
AC-2	12.2	4.15	1.68	.72				14.5				
Σ	24.4	8.30	3.36	1.45								
S. P.	+35.2	+14.7	+2.4	−0.5	+8.7							
AC-N	.100	.05	.06	.06	.06							

.70
.68
1.38

.56
.72
1.28

.58
.65
1.23

.73
.60
1.33

.72
.69
1.41

.68
.72
1.37

1.38
1.23
1.41
1.28
1.33
21.37
8.00

1.333
6 | 8.0
6
20
18

INDUCED POLARIZATION - RECEIVER NOTES PAGE_____

Project:_____ Line:_____ Int.Cal_____ Date:_____

Send	15-305	→										
Rec.	45-605	60-755	75-905	90-1055	105-1205	120-135						
Time	30	10	3	1								
DC-1	19	4.6 4.3	1.50 1.70	0.62								
DC-2	19.2	4.5 4.2	1.78 1.65									
Σ	38.2	8.8 8.5	3.28 3.42									
DC-3	19.1	4.6 4.8	1.67 1.30									
Dc-4	19.5	4.95 4.25	1.60 1.80									
Σ	38.6	9.80 9.20	2.97 3.40	1.333								
DC-AV	38.4	9.06	3.24	1.332								
AC-1	17.8	4.18	1.42	.61								
AC-2	17.9	4.18	1.44	.615								
Σ	35.7	8.36	2.86	1.225								
S. P.												
AC-N												
				55								

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Project North Star Line 3 Field date _____ Data page _____ Comp. date _____. Comp by _____

(A) Send	0-15S											
(B) Receive	30-45S	45-60S	60-75S	75-90S			Cal.					
(C) n separation	30	10	3	3			30					
(D) I	2A	→	→	→								
(E) Vdc (avg)	25.9	9.04	3.75	1.75			30	1.000				
(F) DCcal	1.000	→	→	→								
(G) Kn x 10^{-3}	4.5	18	45	90								
(H) ρ dc=ExFxGx10^3/D	58.3	81.3	84.5	79								
(I) Vac Σ	24.4	8.3	3.36	1.45			28.9	.964				
(J) AC noise x 2	—	—	—	—								
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.964	.964	.967	.967								
(M) ρ dc/ρac=ExL/K	1.023	1.052	1.078	1.167								
(N) PFE=(M-1)(10^2)	2.3	5.2	7.8	16.7								
(O) MCF=(M-1)(10^5)/H	40	64	92	210								

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	15-30											
(B) Receive	45-60S	60-75S	75-90S	90-105S								
(C) n separation	30	10	3	1								
(D) I	2A	→	→	→								
(E) Vdc (avg)	38.4	9.06	3.24	1.33								
(F) DCcal	1.000	→	→	→								
(G) Kn x 10^{-3}	45	18	45	90								
(H) ρ dc=ExFxGx10^3/D	86.4	81.7	73	60								
(I) Vac Σ	35.7	8.36	2.86	1.22								
(J) AC noise x 2	—	—	—	—								
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.964	.964	.967	1.028								
(M) ρdc/ρac =ExL/K	1.036	1.043	1.097	1.120								
(N) PFE=(M-1)(10^2)	3.6	4.3	9.7	12.0								
(O) MCF=(M-1)(10^5)/H	42	53	133	200								

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: North Arc Line: 3 Int.Cal Date:

Send	90-105											
Rec.	120-135	135-150	160-165	165-180		Cal						
Time	10	3	1	1		30						
DC-1	7.35 7.20	2.16 2.08	.830 .820			15						
DC-2	7.30 7.28	2.14 2.11	.840 830	.390		14.8						
Σ	14.58 14.28	4.26 4.19	1.670 1.650			29.8						
DC-3	7.30 7.20	2.10 2.14	.840 810	?		14.8						
Dc-4	7.30 7.20	2.12 2.13	.840 810			15						
Σ	14.50 14.20	4.24 4.25	1.680 1.620			29.8						
DC-AV	14.52	4.24	1.666	.780								
AC-1	6.7	1.97	.80	.370		14.2						
AC-2	6.7	1.98	805	.368		14.3						
Σ	13.4	3.95	1.605	.738		28.5						
S. P.	+2.2	+.8	-10.2	-10.8								
AC-N	.04	.03	.03	.060								

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: Line: 3 Int.Cal Date:

Send	105-120											
Rec.	135-150	150-165	165-180	180-195								
Time	10	3	1									
DC-1	7.3 7.12	1.99 1.87	.740 .832									
DC-2	7.3 7.12	2.10 1.28	.640 .960									
Σ	14.45 14.42	3.86 3.88	?									
DC-3	7.3 7.12	1.92 2.03	?									
Dc-4	7.3 7.12	1.82 2.08										
Σ	14.45 14.42	3.74 3.90	1.570 1.602									
DC-AV	14.45	3.91	1.59									
AC-1	6.7	1.83	.730									
AC-2	6.7	1.82	.740									
Σ	13.4	3.65	1.470									
S. P.												
AC-N												

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Page 11

Project North STAR Line 3 Field date _____ Data page _____ Comp. date M.L. Comp by J.P.M.

(A) Send	90-105S												
(B) Receive	120-135	135-150	150-165	165-180			Cal						
(C) n separation	10	3	1	1			30						
(D) I	2A	→	→	→									
(E) Vdc (avg)	14.58	4.24	1.66	.780									
(F) DCcal	1.007	→	→	→			29.8	.993					
(G) Kn x 10^{-3}	4.5	18	45	90									
(H) ρdc=ExFxGx10^3/D	33.0	38.4	37.6	35.3									
(I) Vac Σ	13.40	3.95	1.60	.738			28.5	.957					
(J) AC noise x 2	—	—	—	—									
(K) Vac(corr) = $\sqrt{I^2 - J^2}$													
(L) AC-DC cal.	.957	.960	1.021	1.021									
(M) ρ dc/ρac=ExL/K	1.040	1.031	1.060	1.079									
(N) PFE=(M-1)(10^2)	4.0	3.1	6.0	7.9									
(O) MCF=(M-1)(10^5)/H	120	81	159	229									

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	105-120S												
(B) Receive	135-150S	150-165S	165-180S	180-195S									
(C) n separation	10	3	1										
(D) I	2A	→	→										
(E) Vdc (avg)	14.45	3.91	1.59										
(F) DCcal	1.007	→	→										
(G) Kn x 10^{-3}	4.5	18	45										
(H) ρ dc=ExFxGx10^3/D	32.8	35.4	36.0										
(I) Vac Σ	13.4	3.65	1.47										
(J) AC noise x 2	—	—	—										
(K) Vac (corr) = $\sqrt{I^2 - J^2}$													
(L) AC-DC cal.	.957	.960	1.021										
(M) ρdc/ρac =ExL/K	1.032	1.029	1.104										
(N) PFE=(M-1)(10^2)	3.2	2.9	10.4										
(O) MCF=(M-1)(10^5)/H	98	82	289										

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: North Shore Line: 3 Int.Cal Date:

Send	60-75	5					Cal.					
Rec.	90-105	105-120	120-135	135-150	150-165							
Time	30	3	3	1	1		30					
DC-1	11 - 10.8	2.62 2.64	1.21 1.13	.56 .61	.330 .220		15					
DC-2	10.9 10.4	2.59 2.62	1.20 1.16	.56 .60			15					
Σ	21.5 21.3	5.26 5.24	2.34 2.36	1.17 1.16								
DC-3	11.0 10.3	2.52 2.70	1.21 1.17	.60 .57			15					
Dc-4	11.0 10.3	2.50 2.68	1.18 1.20	.66 .51			15					
Σ	21.3 21.3	5.22 5.13	2.38 2.38	1.17 1.17	.600							
DC-AV	21.3	5.23	2.37	1.17								
AC-1	10	2.39	1.16	.570	.310							
AC-2	10	2.40	1.14	.570	.310		14.7					
Σ	20	4.79	2.30	1.145	.620		14.7					
S. P.	+13.6	+2.4	+1.5	0.2			29.4					
AC-N	.05	.07	.06	.08	.08							

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: Line: 3 Int.Cal Date:

Send	75-90											
Rec.	105-120	120-135	135-150	150-165								
Time	10	3	3	1								
DC-1	8.3 7.8	2.48 2.45	1.04 .92									
DC-2	8.25 7.90	2.47 2.47	1.07 .91	Q								
Σ	16.1- 16.15	4.93 4.94	1.96 1.87									
DC-3	8.15 7.90	2.45 2.45	1.07 .92	.940								
Dc-4	8.15 7.95	2.47 2.47	1.05 .96									
Σ	16.06 16.10	4.90 4.94	1.99 2.01	.940								
DC-AV	16.12	4.93	1.98	.470								
AC-1	6.7	2.29	.92	.428								
AC-2	6.7	2.29	.92	.428								
Σ	13.4	4.58	1.84	.956								
S. P.												
AC-N												

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

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Project North Star Line 3 Field date _____ Data page _____ Comp. date _____. Comp by _____

(A) Send	60-75S												
(B) Receive	90-105S	105-120	120-135	135-150	150-165		Cal						
(C) n separation	30	3	3	1	1		30						
(D) I	2A →												
(E) Vdc (avg)	21.3	5.23	2.37	1.17	.600		30						
(F) DCcal	1.000 →												
(G) Kn x 10^{-3}	45	18	45	90	157.5								
(H) ρ dc=ExFxGx10^3/D	48	47	53.2	52.5	47.3								
(I) Vac Σ	20	4.79	2.30	1.14	.620		29.4	.979					
(J) AC noise x 2	—	—	—	.16	.16								
(K) Vac(corr) = $\sqrt{I^2 - J^2}$				1.13	.591								
(L) AC-DC cal.	.979	.982	.982	1.043	1.043								
(M) ρ dc/ρac=ExL/K	1.042	1.074	1.012	1.080	1.060								
(N) PFE=(M-1)(10^2)	4.2	7.4	1.2	8.0	6.0								
(O) MCF=(M-1)(10^5)/H	87.5	152	22.6	151	127								

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	75-90S												
(B) Receive	105-120S	120-135S	135-150S	150-165									
(C) n separation	10	3	3	1									
(D) I	2A →												
(E) Vdc (avg)	16.12	4.93	1.98	.940									
(F) DCcal	1.000 →												
(G) Kn x 10^{-3}	45	18	45	90									
(H) ρ dc=ExFxGx10^3/D	36	44.3	44.7	42.3									
(I) Vac Σ	13.4	4.58	1.84	.956									
(J) AC noise x 2	—	—	—	.16									
(K) Vac (corr) = $\sqrt{I^2 - J^2}$				.943									
(L) AC-DC cal.	.979	.982	.982	1.043									
(M) ρdc/ρac =ExL/K	1.125	1.057	1.058	1.039									
(N) PFE=(M-1)(10^2)	12.5	5.7	5.8	3.9									
(O) MCF=(M-1)(10^5)/H	490	129	130	92									

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: 30-45S Line: 3 Int.Cal Date:

NORTHSIDE

Send	60-75S	75-90S	90-105	105-120	120-135	135-150		Cal				
Rec.												
Time	30	10	3	1				30				
DC-1	24.0 24.2	5.2 5.3	1.58 1.57	.80 .82				15				
DC-2	24.0 24.3	5.4 5.1	1.56 1.48	.79 .82				14.9				
Σ	48.3 48.5	10.9 10.4	3.13 3.04	1.62 1.61								
DC-3	24.4 24.3	5.35 5.0	1.55 1.53	.78 .82				15				
Dc-4	24.1 24.3	5.35 5.3	1.60 1.50	.79 .80				14.9				
Σ	48.4 48.4	10.35 10.65	3.08 3.10	1.60 1.61								
DC-AV	48.4	10.6	3.1	1.61								
AC-1	22.5	4.8	1.4	.74				14.2				
AC-2	22.5	4.8	1.4	.75				14.3				
Σ	45.0	9.6	2.8	1.49								
S. P.	.04	.06	.04	.08	.03							
AC-N	-6.2	+0.5	+7.4	+5.8	+2.2							

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: 45-60S Line: Int.Cal Date:

Send	75-90S	90-105	105-120	120-135	135-150							
Rec.												
Time	30	10	3	1	1							
DC-1	17.3 18.4	3.3 3.4	1.28 1.30	.76 .82	.47 .54							
DC-2	17.8 18.2	3.2 3.4	1.28 1.40	.73 .85	.41 .59							
Σ	35.7 36.0	6.4 6.6	2.58 2.68	1.58 1.58	.90 1.00							
DC-3	17.2 18.1	3.2 3.3	1.32 1.40	.82 .78	.41 .58							
Dc-4	17.7 17.8	3.2 3.4	1.31 1.40	.86 .74	.31 .56							
Σ	35.3 35.5	6.4 6.6	2.73 2.71	1.60 1.60	.89 .89							
DC-AV	35.7	6.66	2.68	1.59	.89							
AC-1	16.4	3.05	1.23	.73	.45							
AC-2	16.4	3.05	1.24	.73	.45							
Σ	32.8	6.10	2.47	1.46	.90							
S. P.												
AC-N												

HEINRICHS GEOEXPLORATION COMPANY
INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Project North Star Line 3 Field date _____ Data page _____ Comp. date _____. Comp by _____

(A) Send	30-45S											
(B) Receive	60-75S	75-90S	90-105S	105-120S	120-135S	135-150S		Cal				
(C) n separation	30	10	3	1				30				
(D) I	2A	→	→	→								
(E) Vdc (avg)	48.4	10.16	3.1	1.61				29.9	.997			
(F) DCcal	1.003	→	→	→								
(G) Kn x 10^{-3}	4.5	18	45	90								
(H) ρdc=ExFxGx10^3/D	109	95.7	70.0	72.8								
(I) Vac Σ	45.0	9.6	2.8	1.49				28.7	.960			
(J) AC noise x 2	—	—	—	—								
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.960	.960	.963	1.024								
(M) ρ dc/ρac=ExL/K	1.022	1.060	1.067	1.106								
(N) PFE=(M-1)(10^2)	3.2	6.0	6.7	10.6								
(O) MCF=(M-1)(10^5)/H	29	63	96	146								

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	45-60S											
(B) Receive	75-90S	90-105S	105-120S	120-135S	135-150S							
(C) n separation	30	10	3	1	1							
(D) I	2A	→	→	→	→							
(E) Vdc (avg)	35.7	10.016	2.68	1.59	.989							
(F) DCcal	1.003	→	→	→	→							
(G) Kn x 10^{-3}	4.5	18	45	90	157.5							
(H) ρ dc=ExFxGx10^3/D	80.5	60.2	60.5	71.8	78.2							
(I) Vac Σ	32.8	6.1	2.47	1.46	.90							
(J) AC noise x 2	—	—	—	—	—							
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.960	.960	.963	1.024	1.024							
(M) ρdc/ρac =ExL/K	1.046	1.098	1.095	1.116	1126							
(N) PFE=(M-1)(10^2)	4.6	4.8	4.5	11.6	12.6							
(O) MCF=(M-1)(10^5)/H	57	80	74	161	161							

INDUCED POLARIZATION - RECEIVER NOTES PAGE 5

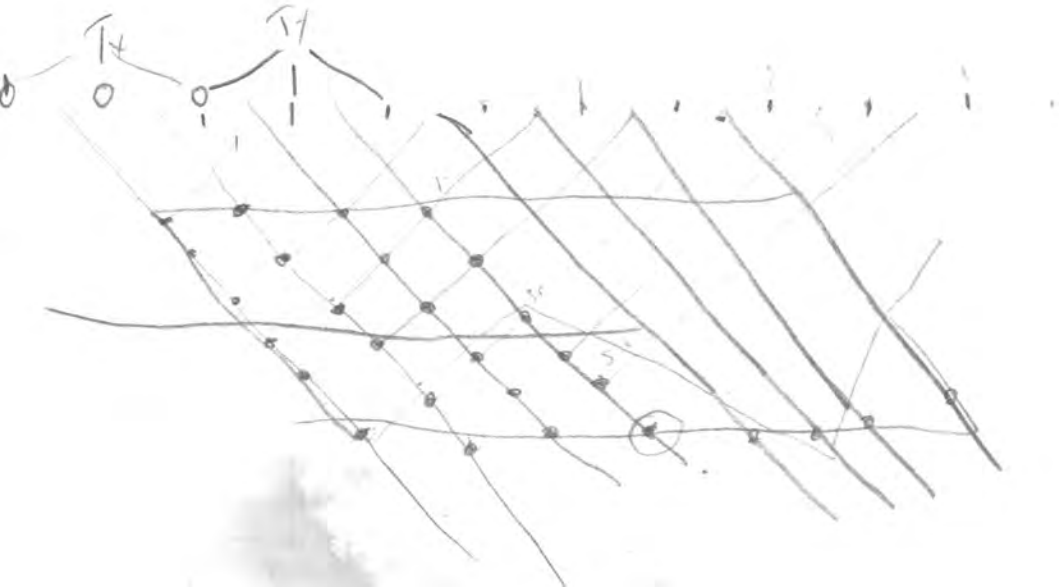
Project: NORTH SPAR Line: 2 Int.Cal Date:

Send	60-75							CAL					
Rec.	90-105	105-120	120-135	135-150	150-165	165-180							
Time	100	30	10	3.0	3.0	1.0		30					
DC-1	42.0	12.1	4.75 4.85	2.65 2.52	1.08 1.21	.70 .67		15 1					
DC-2	41.9	11.4	4.75 4.70	2.64 2.55	1.03 1.26	.68 .63		15 1					
Σ	83.9	23.5	9.60 9.55	5.12 5.19	2.29 2.29	1.37 1.31							
DC-3	42.0	10.1	4.45 5.20	2.78 2.25	1.14 1.14	.69 .65		15 1					
Dc-4	41.9	11.4	4.05 5.0	2.92 2.32	1.11 1.17	.71 .63		15 1					
Σ	83.9	23.5	9.65 9.42	5.03 5.24	2.28 2.35	1.34 1.38							
DC-AV	83.9	23.5	9.55	5.15	2.285	1.34							
AC-1	40.0	11.0	4.4	2.43	1.06	.65		14 1.5					
AC-2	40.0	11.0	4.4	2.44	1.06	.65		14.5					
Σ	80.0	22.0	8.8	4.87	2.12	1.30		29.0					
S. P.	-.6	-3.6	-11.7	-3.4	-12.7	+3.6							
AC-N	.05	.05	.04	.04	.06	.03							
	55.0												

INDUCED POLARIZATION - RECEIVER NOTES PAGE 16

Project: _____ Line: _____ Int.Cal _____ Date: _____

Send	75-90												
Rec.	105-120	120-135	135-150	150-165	165-180	180-195							
Time	100	30	10	3.0	3.0	1.0							
DC-1	41.9	12.4	5.85 5.30	2.23 2.37	1.08 1.28	.25 .60							
DC-2	41.5	12.4	5.98 5.25	2.20 2.36	1.09 1.24	.46 .22							
Σ	83.3	24.8	10.95 11.23	4.60 4.56	2.96 2.33								
DC-3	41.9	12.5	5.55 5.60	2.25 2.34	1.17 1.20	.40 .68							
Dc-4	41.5	12.3	5.60 5.50	2.21 2.34	1.18 1.20	.55 .38							
Σ	83.3	24.8	11.15 11.10	4.52 4.55	2.37 2.38								
DC-AV	83.3	24.8	11.1	4.57	2.31								
AC-1	39.5	11.3	5.15	2.12	1.08	.62							
AC-2	39.5	11.4	5.15	2.12	1.08	.62							
Σ	79.0	22.7	10.30	4.24	2.16	1.24							
S. P.						-12.4							
AC-N						.04							



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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Project North STAR Line 2 Field date _____ Data page _____ Comp. date _____. Comp by _____

(A) Send	60-75S	→	→	→	→				Cal			
(B) Receive	90-105S	105-120S	120-135S	135-150S	150-165S	165-180S						
(C) n separation	1.00	90	10	3.0	3.0	1.0			30			
(D) I	2A	→	→	→	→	→						
(E) Vdc (avg)	83.9	23.5	9.55	5.15	2.28	1.34			30.2	.994		
(F) DCcal	.994	→	→	→	→	→						
(G) Kn x 10^{-3}	4.5	18	45	90	157.5	252						
(H) ρdc=ExFxGx10^3/D	187	210	214	230	179	171						
(I) Vac Σ	20.0	22.0	8.8	4.87	2.12	1.30			29.0	.960		
(J) AC noise x 2	—	—	—	—	—	—						
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.981	.960	.960	.963	.963	1.024						
(M) ρ dc/ρac=ExL/K	1.028	1.024	1.040	1.019	1.035	1.054						
(N) PFE=(M-1)(10^2)	2.8	2.4	4.0	1.9	3.5	5.4						
(O) MCF=(M-1)(10^5)/H	15	11	19	8.3	20	33						

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	75-90S	→	→	→	→	→						
(B) Receive	105-120S	120-135S	135-150S	150-165S	165-180S	180-195S						
(C) n separation	100	30	10	3.0	3.0	1.0						
(D) I	2A	→	→	→	→	→						
(E) Vdc (avg)	83.3	24.8	11.1	4.57	2.31							
(F) DCcal	.994	→	→	→	→	→						
(G) Kn x 10^{-3}	4.5	18	45	90	157.5	252						
(H) ρ dc=ExFxGx10^3/D	186	221	249	205	181	159						
(I) Vac Σ	79.0	22.7	10.30	4.24	2.16	1.24						
(J) AC noise x 2	—	—	—	—	—	—						
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.981	.960	.960	.963	.963	1.024						
(M) ρdc/ρac =ExL/K	1.037	1.050	1.035	1.038	1.030							
(N) PFE=(M-1)(10^2)	3.7	5.0	3.5	3.8	3.0							
(O) MCF=(M-1)(10^5)/H	19.9	22.6	14	19	17							

INDUCED POLARIZATION - RECEIVER NOTES PAGE 3

Project: 30-45 S Line: 2 Int.Cal Date:

Send						C		CAL.				
Rec.	60-75	75-90	90-105	105-120	120-135	135-150						
Time	100	30	10	3.0	3.0	3.0		30				
DC-1	50.2	12.8	4.95	2.17 2.16	1.03 1.16	.68 .73		15.0				
DC-2	50.2	12.8	4.8	2.18 2.14	1.16 1.0	.68 .71		15.0				
Σ	100.4			4.33 4.32	2.19 2.16	1.41 1.39		30.0				
DC-3	50.2	12.8	4.95	2.22 2.11	1.18 1.0	.69 .76		15.0				
Dc-4	50.2	12.8	4.80	2.23 2.07	1.22 .96	.68 .71		15.0				
Σ	100.4	25.6	9.75	4.33 4.30	2.18 2.18	1.39 1.38		30.0				
DC-AV						1.39?						
AC-1	48.2	11.9	4.50	2.03	1.02	.67						
AC-2	48.2	11.9	4.55	2.04	1.02	.67		14.4				
Σ	96.4					1.34?		14.4				
S. P.	+4.9	+5.9	-.8	+5.0	+5.5	+5.5		28.8				
AC-N	.06 SAT.	.04 SAT.	.03 SAT.	.02	.03	.03						
				54.5								

INDUCED POLARIZATION - RECEIVER NOTES PAGE 4

Project: 45 - 605 Line: 2 Int.Cal Date:

Send					4							
Rec.	75-90	90-105	105-120	120-135	135-150	—						
Time	100	30	10	3.0	3.0							
DC-1	47.8	12.6	4.82	2.39	1.40 1.43							
DC-2	48.0	12.6	5.02	2.36	1.33 1.47							
Σ		25.2	9.84	4.75	2.80							
DC-3	47.9	12.7	4.80	2.38	1.30 1.50							
Dc-4	48.0	12.6	5.01	2.36	1.25 1.55							
Σ		25.3	9.81	4.74	2.80							
DC-AV	95.9											
AC-1	45.5	11.8	4.6	2.18	1.31							
AC-2	45.8	11.8	4.6	2.18	1.30							
Σ	91.3	23.6		4.36								
S. P.					+3.8							
AC-N					.04							

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 1

Project North Star Line E Field date _____ Data page _____ Comp. date _____. Comp by M.L.

(A) Send	30-45S								OAL			
(B) Receive	60-75	75-90	90-105	105-120	120-135	135-150						
(C) n separation	100	30	10	3	3	3			30			
(D) I	2000											
(E) Vdc (avg)	100.9	25.6	9.75	4.32	2.18	1.39			30.0			
(F) DCcal	1.00											
(G) Kn x 10^{-3}	4.5	18	45	90	157.5	252						
(H) ρdc=ExFxGx10^3/D	226	230	219	194	172	175						
(I) Vac Σ	96.4	23.8	9.05	4.07	2.09	1.39			28.8			
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.981	960	960	963	963	963						
(M) ρ dc/ρac=ExL/K	1.021	1.032	1.034	1.023	1.029	1.00						
(N) PFE=(M-1)(10^2)	2.1	3.2	3.4	2.3	2.9	0						
(O) MCF=(M-1)(10^5)/H	9	14	16	12	17	0						

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	45-60S											
(B) Receive	75-90	90-105	105-120	120-135	135-150							
(C) n separation	100	30	10	3	3							
(D) I	2000											
(E) Vdc (avg)	95.9	25.25	9.82	4.74	2.80							
(F) DCcal	1.00											
(G) Kn x 10^{-3}	4.5	18	45	90	157.5							
(H) ρ dc=ExFxGx10^3/D	216	227	221	213	221							
(I) Vac Σ	91.3	23.6	9.2	4.36	2.61							
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.981	960	960	963	963							
(M) ρdc/ρac =ExL/K	1.030	1.027	1.024	1.048	1.039							
(N) PFE=(M-1)(10^2)	3.0	2.7	2.4	4.8	3.9							
(O) MCF=(M-1)(10^5)/H	14	12	11	23	15							

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: North Star Line: 1 A S/2 Int.Cal Date:

Send	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	1-2	2-3	3-4
Rec.												
Time	100	100	100	30	30	100	100	30	10	100	30	10
DC-1	85.0	33.8	71.0	21.3	12.3	90.5	28.0	13.0	9.35	32.1	17.1	9.15
DC-2	85.0	33.5	71.0	20.5	12.4	89.0	29.5	13.5	9.70	31.5	17.5	9.25
Σ	170.0	67.3	142.0	41.8	24.7	179.5	57.5	26.5	19.05	63.6	34.6	18.40
DC-3	85.0	33.8	71.0	21.3	12.3	90.5	28.0	13.0	9.35	32.1	17.0	9.1
Dc-4	85.0	33.5	71.0	20.5	12.5	89.0	29.5	13.5	9.70	31.5	17.4	9.2
Σ	170.0	67.3	142.0	41.8	24.8	179.0	57.5	26.5	19.05	63.6	34.4	18.3
DC-AV	170.0	67.3	142.0	41.8	24.8	179.2	57.5	26.5	19.05	63.6	34.5	18.35
AC-1	81.0	31.8	69.0	20.2	11.8	81.5	26.0	11.6	8.35	29.0	15.3	8.22
AC-2	81.0	31.8	69.0	20.3	11.8	81.5	26.0	11.6	8.35	29.0	15.3	8.20
Σ	162.0	63.6	138.0	40.5	23.6	163.0	52.0	23.2	16.70	58.0	30.4	16.42
S. P.		-37.2	+4.7		+5.5				+4.0	+9.1		
AC-N		.05 SMS	.10		.02				.02	.03		
					55.0				55.0			

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: North Star Line: 1A S/2 Int.Cal Date:

Send	4-5	1-2	2-3	3-4	4-5		CAL	#2				
Rec.	10	30	10	10	10		#1					
Time							30					
DC-1	6.6	12.5	8.1	4.35	3.35 3.42		15.0	15.1				
DC-2	6.9	12.7	8.0	4.42	3.35 3.42		15.0	15.2				
Σ	13.5	25.2	16.1	8.77	6.77 6.77		30.0	30.3				
DC-3	6.55	12.5	8.05	4.35	3.30 3.45		15.0	15.2				
Dc-4	6.9	12.8	8.0	4.42	3.30 3.45		15.0	15.2				
Σ	13.45	25.3	16.05	8.77	6.75 6.75		30.0	30.4				
DC-AV	13.50	25.25	16.1	8.77	6.76			30.35				
AC-1	6.1	11.4	7.25	4.0	3.05		14.3	14.7				
AC-2	6.1	11.5	7.25	4.0	3.05		14.4	14.7				
Σ	12.2	22.9	14.50	8.0	6.10		28.7	29.4				
S. P.	-7.2	-7.1										
AC-N	.03											

HEINRICHS GEOEXPLORATION COMPANY
INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 2

Project NORTH STAR Line 1A 3/2 Field date _____ Data page _____ Comp. date _____. Comp by ML

(A) Send	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	1-2	2-3	3-4
(B) Receive												
(C) n separation	100	100	100	30	30	100	100	30	10	100	30	10
(D) I	2.000											
(E) Vdc (avg) 2	170.0	67.3	142.0	41.8	24.8	179.2	57.5	26.5	19.05	63.6	34.5	18.55
(F) DCcal	1000	1.000	.990									
(G) Kn x 10^{-3}	3.0	12	3.0	12	30	3.0	12	30	60	12	30	60
(H) ρ dc=ExFxGx10^3/D B	255	403	211	247	268	266	341	294	564	377	513	544
(I) Vac Σ 3	162.0	63.6	138.0	40.5	23.6	163.0	52.0	23.2	16.70	58.0	30.6	16.42
(J) AC noise x 2	—											
(K) Vac(corr) = $\sqrt{I^2 - J^2}$	—											
(L) AC-DC cal. 1	.977	.977	.977	.956	.956	.977	.977	.956	.956	.977	.956	.956
(M) ρ dc/ρac=ExL/K	1.023	1.032	1.005	.989	1.005	1.021	1.029	1.091	1.118	1.071	1.078	1.070
(N) PFE=(M-1)(10^2) A	2.3	3.2	.5	-1.1	.5	2.1	2.9	9.1	11.8	7.1	7.8	7.0
(O) MCF=(M-1)(10^5)/H	9.0	8.0	2.5	-4.5	1.9	2.10	29.0	31.0	24.0	14.0	15.0	13

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	4-5	1-2	2-3	3-4	4-5		CH CH#1	CH CH#2				
(B) Receive												
(C) n separation	10	30	10	10	10		30	30				
(D) I												
(E) Vdc (avg) 2	13.50	25.25	16.1	8.77	6.76		30.0	30.3				
(F) DCcal												
(G) Kn x 10^{-3}	105	30	60	105	168							
(H) ρ dc=ExFxGx10^3/D B	704	374	477	456	562							
(I) Vac Σ 3	12.2	22.9	14.50	8.0	6.1		28.2	29.4				
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal. 1	.956	.956	.956	.956	.956		.956	.971				
(M) ρdc/ρac =ExL/K	1.060	1.055	1.063	1.048	1.060							
(N) PFE=(M-1)(10^2) A	6.0	5.5	6.3	4.8	6.0							
(O) MCF=(M-1)(10^5)/H	8.5	14.5	13.0	10.5	10.5							

10 .956
30 .956
100 .977

INDUCED POLARIZATION - RECEIVER NOTES PAGE 1

Project: Newton Stake Line: 1 S/2 Int.Cal 0 Date:

Send	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	1-2	2-3	3-4
Rec.	→	→	←	←	→	←	←	←	→	←	←	←
Time	300	100	300	100	30	300	100	20	10	100	30	10
DC-1	103	28·0	116.0	33·0	12·6	111.1	33	14.5	6.9	30·5	13·5	7·3
DC-2	103	27·8	116.0	33·0	12·9	111.2	32.5	14.5	6.9	30·5	13·5	7·35
Σ	206	55·8	232·0	66·0	25·5	222.3	65.5	29.0	13.8	61·0	27·0	14·65
DC-3	103	28·0	117.0	33·0	12·6	111.2	32.5	14.4	6.9	30.5	13·5	7·25
Dc-4	103	27·8	116.0	32.4	13·0	111.2	32.5	14.5	6.9	30·5	13·5	7·35
Σ	206	55·8	233.0	65.9	25·6	222.4	65.0	28.9	13.8	61·0	27·0	14·60
DC-AV	206	55·8	232·5	66·0	25·5	222.3	65.25	28.9	13.8	61·0	27·0	14·60
AC-1	95·0	26·2	107	31·2	12·0	103.0	31	13.5	6.5	29·0	12·5	6·75
AC-2	95·0	26·2	107	31·2	12·0	103.0	31	13.5	6.5	29·0	12·5	6·75
Σ	190·0	52·4	214	62·4	24·0	206	62	27.0	13.0	58·0	25·0	13·50
S. P.	+15·0	+7·2			+7·3	+1.2				+2·5		
AC-N	0	0			0	·04			0	·08		
	55·5				50	55.5			55.5	55·5		

INDUCED POLARIZATION - RECEIVER NOTES PAGE 2

Project: _____ Line: 1 5/2 Int.Cal _____ Date: _____

Send	4-5	1-2	2-3	3-4	4-5		CAL					
Rec.	7	→	→	→	3							
Time	10	30	10	10	10		300					
DC-1	3.55	16.7	9.1	5.55	3.15		15.0					
DC-2	3.85	16.3	9.2	5.10	2.65		15 0					
Σ	7.40	33.0	18.3	10.65	5.80		30.0					
DC-3	3.55	16.7	9.0	5.55	3.15		15.0					
Dc-4	3.90	16.3	9.2	5.05	2.62		15.0					
Σ	7.45	33.0	18.2	10.60	5.77		30.0					
DC-AV	7.4	33.0	18.25	10.63	5.78		30.0					
AC-1	3.40	15.2	8.4	4.9	2.70		14.5					
AC-2	3.4	15.2	8.4	4.9	2.70		14.5					
Σ	6.80	30.4	16.8	9.8	5.40		29.0	.967				
S. P.	42.1	-5.1										
AC-N	.09	.04										
	55.5	55.5										

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 1

Project North Strand Line 1 S/2 Field date _____ Data page _____ Comp. date _____. Comp by _____

(A) Send	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	1-2	2-3	3-4
(B) Receive												
(C) n separation	300	100	300	100	30	300	100	30	10	100	30	10
(D) I	2.0	→	→	→	→	→	→	→	→	→	→	→
(E) Vdc (avg)	206	55.8	232.5	66.0	25.5	223.3	65.25	28.9	13.8	61.0	27.0	14.6
(F) DCcal 1000	→											
(G) Kn x 10^{-3}	3.0	12.	3.0	12.0	30.	3.0	12.0	30.0	60.0	12	30	60
(H) ρdc=ExFxGx10^3/D	310	336	348	397	382	335	392	434	414	367	405	438
(I) Vac Σ	190.0	52.4	214.	62.4	24.0	206	62.0	27.0	13.0	58.0	25.0	13.5
(J) AC noise x 2												
(K) Vac(corr) $=\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	957	982	957	982	967	957	982	967	967	982	967	967
(M) ρ dc/ρac=ExL/K	1.038	1.048	1.038	1.040	1.028	1.036	1.033	1.032	1.025	1.032	1.043	1.042
(N) PFE=(M-1)(10^2)	3.8	4.8	3.8	4.0	2.8	3.6	3.3	3.2	2.5	3.2	4.3	4.2
(O) MCF=(M-1)(10^5)/H	12.0	14.0	11.0	10.0	7.5	10.5	8.5	7.5	6.0	9.0	10.5	9.5

Project _____ Line * Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	4-5	1-2	2-3	3-4	4-5		CHL					
(B) Receive	→	→					→					
(C) n separation	10	30	10	10	10		30					
(D) I	2.0	→	→	→	→		→					
(E) Vdc (avg)	7.4	33.0	18.25	10.63	5.78		30					
(F) DCcal												
(G) Kn x 10^{-3}	105	30	60	105	168							
(H) ρ dc=ExFxGx10^3/D	388	495	546	556	486							
(I) Vac Σ	4.8	30.4	16.8	9.8	5.4		29.0					
(J) AC noise x 2												
(K) Vac (corr) $=\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	967	→	→	→	→		967					
(M) ρdc/ρac =ExL/K	1.050	1.050	1.050	1.051	1.035							
(N) PFE=(M-1)(10^2)	5.0	5.0	5.0	5.1	3.5							
(O) MCF=(M-1)(10^5)/H	13.0	10.0	9.0	9.0	7.0							

10 .967
30 967
100 982
300 957

INDUCED POLARIZATION - RECEIVER NOTES PAGE_____

Project: NORTH STAR Line: 1A. N/2 Int.Cal_____ Date:_____

Send	3-2	2-1	4-3	3-2	2-1	5-4	4-3	3-2	2-1	5-4	4-3	5-2
Rec.	→	→	→	→	→	→	→	→	→	→	→	→
Time	300	100	100	30	30	300	30	30	10	100	80	10
DC-1	106	33	92	28	12	134	28.3	13.3	7	39	138	8.4
DC-2	106	32.5	91.5	27	10.7	133	27	13	7.3	39	13.5	8.6
Σ	212	65.5	183.5	56	22.7	267	55.3	26.3	14.3	78	27.3	17.4
DC-3	106	33	92	28	10.7	134	28.7	13.3	7	39	13.9	8.4
Dc-4	106	33	91	27	12	133	26.7	13	7.3	39	13.6	8.6
Σ	212	66	183	56	22.7	267	55.4	26.3	14.3	78	27.5	17.0
DC-AV	212	66	183	56	22.7	267	55.3	26.3	14.3	78	27.4	17.2
AC-1	98.0	31.5	86	25.5	10.7	122	26	12.5	10.8	37	12.6	8
AC-2	98.0	31.5	86	25.5	10.7	122	26	12.5	6.8	37	12.6	8
Σ	196.0	63.0	172	51.0	21.4	244	52	25.0	13.6	74	25.2	16
S. P.	-14.4	-17.5				-17.3				+2.4		
AC-N	.04	.05										

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: Line: 1A" N/2 Int.Cal Date:

Send	2-1	5-4	4-3	3-2	2-1		CAL.					
Rec.	→	→	→	→	→							
Time	10	30	10	10	10		30					
DC-1	4.8	16.0	7.4	4.8	3.0		15					
DC-2	4.9	15.8	7.0	5.0	3.2		15					
Σ	9.7	31.8	14.4	9.8	6.2		30.0					
DC-3	5.2	16.2	7.5	5.1	3.0		15					
Dc-4	4.95	15.8	7.0	5.2	3.2		15					
Σ	10.15	32.0	14.5	10.3	6.2		30.0					
DC-AV	9.9	31.9	14.5	10.0	6.2							
AC-1	4.7	15	6.8	4.7	3		14.5					
AC-2	4.7	15	6.8	4.7	3		14.5					
Σ	9.4	30	13.6	9.4	6		29.0					
S. P.												
AC-N												

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Project North Star Mine Line 1"A" N/2 Field date _____ Data page _____ Comp. date _____. Comp by ML

(A) Send	3-2	2-1	4-3	3-2	2-1	5-4	4-3	3-2	2-1	5-4	4-3	3-2
(B) Receive	→	→	→	→	→	→	→	→	→	→	→	→
(C) n separation	300	100	100	30	30	300	30	30	10	100	30	10
(D) I	20.00	→	→	→	→	→	→	→	→	→	→	→
(E) Vdc (avg) ②	212.0	66	183.0	56.0	22.7	267	55.3	26.3	14.3	78	27.4	17.2
(F) DCcal	1.000	→	→	→	→	→	→	→	→	→	→	→
(G) Kn x 10^{-3}	3.0	12.0	3.0	12.0	30.	3.0	12.0	30.0	60.0	12	30	60
(H) ρdc=ExFxGx10^3/D	318	396	274	340	340	400	333	394	428	468	412	512
(I) Vac Σ ③	196	63.0	172	51	21.4	244.0	52	25.0	13.6	74.0	25.2	16.0
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.957	.982	.982	.967	.967	.957	.967	.967	.967	.982	.967	.967
(M) ρdc/ρac=ExL/K	1.045	1.032	1.042	1.062	1.025	1.047	1.028	1.018	1.018	1.032	1.043	1.039
(N) PFE=(M-1)(10^2)	4.5	3.2	4.2	6.2	2.5	4.7	2.8	1.8	1.8	3.2	4.3	3.9
(O) MCF=(M-1)(10^5)/H	14.0	8.0	15.5	18.0	7.5	11.5	8.5	4.5	4.0	7.0	10.5	7.5

Project _____ Line * Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	2-1	5-4	4-3	3-2	2-1		CAL.					
(B) Receive	→	→	→	→	→							
(C) n separation	10	30	10	10	10		30					
(D) I	→	→	→	→	→							
(E) Vdc (avg)	9.9	31.9	14.5	10.0	6.2		30.0					
(F) DCcal	→	→	→	→	→							
(G) Kn x 10^{-3}	105	30	60	105	168							
(H) ρdc=ExFxGx10^3/D	520	480	435	525	520							
(I) Vac Σ	9.4	30.0	13.6	9.4	6.0		29.0					
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.967	→	→	→	→		.967					
(M) ρdc/ρac =ExL/K	1.018	1.029	1.031	1.030	1.000							
(N) PFE=(M-1)(10^2)	1.8	2.9	3.1	3.0	0							
(O) MCF=(M-1)(10^5)/H	3.5	6.0	7.0	6.0	0							

10 .917
30 .967
100 .982
300 .957

INDUCED POLARIZATION - RECEIVER NOTES PAGE 7

Project: NORTH STAR Line: 2 Int.Cal Date:

Send	90-105							CAL					
Rec.	120-135	135-150	150-165	165-180	180-195	195-210		30					
Time	1.00	30	10	3.0	3.0	1.0							
DC-1	40.0	13.2	4.62	2.34 2.23	.95 1.2	.70 .64		15.0					
DC-2	40.05	13.2	4.60	2.36 2-19	.97 1.22	.80 .67		15.0					
Σ	80.05	26.4	9.22	4.52 4.50	2.15 2.18	1.94 1.33		30.0					
DC-3	40.0	13.0	4.65	2.34 2.25	.88 1.28	.76 .67		15.0					
Dc-4	40.5	13.3	4.59	2.30 2.26	.88 1.29	.82 1.63		15.0					
Σ	80.5	26.3	9.24	4.59 4.56	2.14 2.17	1.42 1.46		30.0					
DC-AV	80.27	26.35	9.23	4.57	2.17	1.42							
AC-1	37.8	12.1	4.30	2.08	1.02	.73		14.4					
AC-2	37.8	12.2	4.30	2.08	1.02	.725		14.3					
Σ	75.6	24.3	8.60	4.16	2.04	1.455		28.7					
S. P.		-3.4	-12.4	44.5	-13.6	7.2							
AC-N	.04	.04	.03	.02	.06	03							
						55.0							

INDUCED POLARIZATION - RECEIVER NOTES PAGE 8

Project: _____ Line: 2 Int.Cal _____ Date: _____

Send	105-120	→	→	→	→							
Rec.	135-150	150-165	165-180	180-195	195-210							
Time	100	30	10	3.0	3.0							
DC-1	44.0	10.08	4.62	2.12 2.07	1.25 1.24							
DC-2	43.9	10.09	4.55	2.20 2.10	1.26 1.20							
Σ	87.9	20.17	9.21	4.19 4.30	2.49 3.46							
DC-3	46.0	10.08	4.65	2.07 2.16	1.30 1.15							
Dc-4	43.9	10.09	4.35	1.98 2.20	1.28 1.19							
Σ	87.9	20.17	9.00	4.23 4.18	2.45 3.47							
DC-AV	82.9	20.17	9.10	4.22	2.46							
AC-1	41.5	10.0	4.15	1.93	1.19							
AC-2	41.5	10.0	4.15	1.93	1.19							
Σ	83.0	20.0	8.30	3.86	2.38							
S. P.												
AC-N					.03							
					55.0							

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

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Project North Star Line 2 Field date _____ Data page _____ Comp. date _____. Comp by M.L.

(A) Send	90-105S												
(B) Receive	120-135	135-150	150-165	165-180	180-195	195-210		Cal.					
(C) n separation	100	30	10	3.0	3.0	1.0		30					
(D) I	2 A	—	—	—	—	→							
(E) Vdc (avg)	80.27	26.35	9.23	4.57	2.17	1.42			1.000				
(F) DCcal	1.000	—	—	—	—	→		30					
(G) Kn x 10^{-3}	45	18	45	90	157.5	252							
(H) ρ dc=ExFxGx10^3/D	181	236	208	206	170	179							
(I) Vac Σ	75.6	24.3	8.60	4.14	2.04	1.455		28.7	.946	.956			
(J) AC noise x 2	—	—	—	—	—	—							
(K) Vac(corr) = $\sqrt{I^2 - J^2}$													
(L) AC-DC cal.	.977	.956	.956	.959	.959	1.020							
(M) ρ dc/ρac=ExL/K	1.035	1.037	1.026	1.053	1.020	.995							
(N) PFE=(M-1)(10^2)	3.5	3.7	2.6	5.3	2.0	-0.5							
(O) MCF=(M-1)(10^5)/H	19	16	13	26	12	-3							

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	105-120												
(B) Receive	135-150	150-165	165-180	180-195	195-210								
(C) n separation	100	30	10	3.0	3.0								
(D) I	2 A	—	—	—	→								
(E) Vdc (avg)	82.9	20.17	9.10	4.22	2.46								
(F) DCcal	1.000	—	—	—	→								
(G) Kn x 10^{-3}	45	18	45	90	157.5	252							
(H) ρ dc=ExFxGx10^3/D	198	181	204	190	194								
(I) Vac Σ	83.0	20.0	8.30	3.86	2.38								
(J) AC noise x 2	—	—	—	—	—								
(K) Vac (corr) = $\sqrt{I^2 - J^2}$													
(L) AC-DC cal.	.977	.956	.956	.959	1.020								
(M) ρdc/ρac =ExL/K	1.034	.963	1.049	1.047	1.054								
(N) PFE=(M-1)(10^2)	3.4	-3.8	4.9	4.7	5.4								
(O) MCF=(M-1)(10^5)/H	17	-21	24	25	28								

INDUCED POLARIZATION - RECEIVER NOTES PAGE 1

Project: O-15-5 Line: 2 Int.Cal Date:

NORTH STAR

Send	1	2	3	4	5	6		CAL.				
Rec.	30-45	45-60	60-75	75-90	90-105	105-120						
Time	100	30	10	10	3.0	1.0		30				
DC-1	34.5	14.0	6.7	2.95	1.65 1.37	.76 .79		15.1				
DC-2	34.5	13.8	6.8	2.85	1.40 1.60	.77 .82		15.1				
Σ	69.0	27.8	13.5	5.80	3.02 3.00	1.53 1.59		30.2				
DC-3	34.5	13.9	6.75	2.95	1.42 1.65	.80 .80		15.1				
Dc-4	34.5	13.8	6.80	2.85	1.40 1.55	.79 .80		15.1				
Σ	69.0	27.7	13.55	5.80	3.07 2.95	1.60 1.59		30.2				
DC-AV	69.0	27.75	13.525	5.80	3.01	1.58		30.2				
AC-1	33.0	12.8	6.2	2.7	1.37	.76		14.4				
AC-2	33.0	12.8	6.2	2.7	1.38	.77		14.4				
Σ	66.0	25.6	12.4	5.4	2.75	1.53		28.8				
S. P.	-1.0	-6.1	-.2	-7.4	-3.1							
AC-N	.05	.05	.04	.04	.10 ±	.05 ±						
	55.0		55.0									

INDUCED POLARIZATION - RECEIVER NOTES PAGE 2

Project: 15-305 Line: Int.Cal Date:

Send					C	7						
Rec.	45-60	60-75	75-90	90-105	105-120	120-135						
Time	100	30	10	3.0	3.0	1.0						
DC-1	44.2	14.2	5.20 5.25	2.33 2.35	1.10 1.10	.65 .60						
DC-2	46.2	13.7	5.20 5.20	2.45 2.40	1.13 1.07	.66 .59						
Σ	88.4	27.9	10.45 10.40	4.68 4.85	2.20 2.20	1.25 1.25						
DC-3	44.2	14.3	5.20 5.20	2.30 2.35	1.10 1.1	.67 .57						
Dc-4	44.2	13.7	5.20	2.30 2.46	1.07 1.13	.67? .57						
Σ	88.4	28.0	5.20	4.65 4.76	2.30 2.20	1.24 1.24						
DC-AV	88.4	28.6	10.40	4.73	2.20	1.25?						
AC-1	42.0	13.0	4.8	2.2	1.1	.61?						
AC-2	42.0	13.0	4.8	2.2	1.1	.61						
Σ	84.0	26.0	9.8	4.4	2.2	1.22?						
S. P.												
AC-N						.08						

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Project North Star Line 2 Field date _____ Data page 1 Comp. date _____. Comp by _____

(A) Send	0-15S							Cal				
(B) Receive	30S-45S	45-60S	60-75S	75-90S	90-105S	105-120S						
(C) n separation	100	30	10	10	3	1		30				
(D) I	2A	→	→	→	→	→		.3				
(E) Vdc (avg) —	69	27.7	13.52	5.8	3.01	1.58		30.2				
(F) DCcal	.994	→	→	→	→	→						
(G) Kn x 10^{-3}	4.3	18.	45	90	157.5	252						
(H) ρdc=ExFxGx10^3/D	154	248	302	260	236	198?						
(I) Vac Σ —	66.0	25.6	12.4	5.4	2.75	1.53		28.8				
(J) AC noise x 2	0	→	→	→	→	→						
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal. —	.975	.954	.954	.954	.957	1.018		.954				
(M) ρdc/ρac=ExL/K	1.018	1.030	1.040	1.025	1.050	1.064						
(N) PFE=(M-1)(10^2)	1.8	3.0	4.0	2.5	5.0	5.1						
(O) MCF=(M-1)(10^5)/H	7.0	12	13	10	21	25						

Project _____ Line 2 Field date _____ Data page 2 Comp. date _____ Comp by _____

(A) Send	15-30S											
(B) Receive	45-60S	60-75S	75-90S	90-105S	105-120S	120-135S						
(C) n separation	100	30	10	3.0	3.0	1.0						
(D) I	2A	→	→	→	→	→						
(E) Vdc (avg)	88.4	28.6	10.4	4.73	2.20	1.25						
(F) DCcal	.994	→	→	→	→	→						
(G) Kn x 10^{-3}	45	18	45	90	157.5	252						
(H) ρdc=ExFxGx10^3/D	197	256	233	211	173	157						
(I) Vac Σ —	84.6	26.0	9.8	4.4	2.2	1.22						
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	.975	.954	.954	.957	.957	1.018						
(M) ρdc/ρac =ExL/K	1.008	1.05	1.010	1.030	.960	1.040						
(N) PFE=(M-1)(10^2)	0.8	5.0	1.0	3.0	-4.0	4.0						
(O) MCF=(M-1)(10^5)/H	4.0	20	4.3	14	-23	25						

UCED POLARIZATION - RECEIVER NOTES PAGE_____

Project:_____ Line:_____ Int.Cal_____ Date:_____

Send	80-90												
Rec.	100-110	110-120	120-130	130-140			Cal #1						
Time	10	3	3	1									
DC-1	8.3 8.4	2.70 2.74	1.13 1.08	.605 .605	.665 .570		15.0						
DC-2	8.42 8.25	2.70 2.76	1.16 1.05	1.210	.730 .535		15.3						
Σ	16.7 16.67	5.44 5.46	2.21 2.20		12.30 1.265		30.3						
DC-3	8.42 8.28	2.72 2.74	1.20 1.02		.715 .615		15.0						
Dc-4	8.40 8.30	2.68 2.78	1.22 1.02		.740 .518		15.3						
Σ	16.87 16.70	5.40 5.46	2.22 2.04	1.25	1.230 1.278		30.3						
DC-AV	16.71	5.45	2.22	1.21			30.3						
AC-1	7.8	2.53	1.03	.580			14.4						
AC-2	7.8	2.53	1.03	.594			14.4						
Σ	15.6	5.06	2.06	1.20			28.8	9					
S. P.	8.0												
AC-N	.02												

INDUCED POLARIZATION - RECEIVER NOTES PAGE _____

Project: _____ Line: _____ Int.Cal _____ Date: _____

Send	90-150											
Rec.	110-130	120-140	130-150	140-160								
Time	30	10	3									
DC-1	10.1 10.14	3.0 3.03	1.38 1.23									
DC-2	10.1 10.15	2.95 3.08	1.33 1.30									
Σ	20.24 20.25	6.03 6.02	2.61 2.59									
DC-3	10.1 10.15	3.12 2.90	1.37 1.24									
Dc-4	10.1 10.15	3.10 2.87	1.33 1.24									
Σ	20.25 20.25	6.02 5.97	2.31 2.59									
DC-AV	20.25	6.0	2.59									
AC-1	10.05	2.78	1.23									
AC-2	10.05	2.78	1.23									
Σ	20.10	5.56	2.46									
S. P.	-5	13.0	1.0									
AC-N	1.0	.05	.05									

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Project Hecla Line 1 Field date _____ Data page _____ Comp. date _____ Comp by _____ Page _____

(A) Send	80-90S												
(B) Receive	100-110	110-120	120-130	130-140									
(C) n separation	10	3	3	1									
(D) I	2.0												
(E) Vdc (avg)	16.71	5.45	2.22	1.21		30.3							
(F) DCcal	.990	→	→	→		.995							
(G) Kn x 10^{-3}													
(H) ρdc=ExFxGx10^3/D	24.8	32.4	32.9	35.9									
(I) Vac Σ	47.60	5.02	2.06	1.20		28.8							
(J) AC noise x 2													
(K) Vac(corr) = $\sqrt{I^2 - J^2}$													
(L) AC-DC cal.	952	955	955	.999		.951							
(M) ρ dc/ρac=ExL/K	1.020	1.030	1.029	1007									
(N) PFE=(M-1)(10^2)	2.0	3.0	2.9	0.7									
(O) MCF=(M-1)(10^5)/H	81	93	91	20									
	1.1%	1.7%	3%	4.5%									

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	90-100S												
(B) Receive	110-120	120-130	130-140										
(C) n separation	30	1	3										
(D) I	2.0												
(E) Vdc (avg)	20.25	6.0	2.57										
(F) DCcal	.990	→	→										
(G) Kn x 10^{-3}													
(H) ρ dc=ExFxGx10^3/D	30.1	35.6	38.4										
(I) Vac Σ	20.10	5.56	2.46										
(J) AC noise x 2													
(K) Vac (corr) = $\sqrt{I^2 - J^2}$													
(L) AC-DC cal.	951	952	955										
(M) ρdc/ρac =ExL/K	958	1.028	1.005										
(N) PFE=(M-1)(10^2)	−4.2	2.8	0.5										
(O) MCF=(M-1)(10^5)/H	−140	79	13										
	1%	1.5%	2.6%										

INDUCED POLARIZATION - RECEIVER NOTES PAGE _____

Project: _____ Line: 1 Int.Cal _____ Date: _____

Send	60-70	South										
Rec.	80-90	90-100	100-110	110-120		CAL						
Time	10	3.0	1.0	1.0								
DC-1	5.8	1.65 1.65	.82 .79			14.8						
DC-2	5.7	1.60 1.75	.82 .84			15.0						
Σ	11.5	3.20 3.35	1.61 1.66			29.8		994				
DC-3	5.8	1.60 1.65	.76 .82			16.8						
Dc-4	5.7	1.55 1.80	.78 .82			15.0						
Σ	11.5	3.25 3.35	1.58 1.68			29.8						
DC-AV	11.5	3.31	1.61			29.8						
AC-1	5.2	1.54	.75	.45		14.4						
AC-2	5.2	1.53	.75			14.4						
Σ	10.4	3.07	1.50			28.8						
S. P.	+1220	+1220	7.0									
AC-N	1.5	1.0	.05	.03								

INDUCED POLARIZATION - RECEIVER NOTES PAGE_____

Project:_____ Line:_____ Int.Cal_____ Date:_____

Send	70-80	50um										
Rec.	90-100	100/10	110/120	120/130								
Time	10	3.0	3.0									
DC-1	5.5	2.50 2.50	1.32 1.25									
DC-2	5.2	2.50 2.43	1.23 1.27									
Σ	10.7	5.00 4.93	2.57 2.50									
DC-3	5.3	2.57 2.46	1.37 1.32									
Dc-4	5.3	2.50 2.48	1.17 1.25									
Σ	10.6	5.03 4.98	2.44 2.42									
DC-AV	10.65	4.99	2.48									
AC-1	4.95	2.32	1.14									
AC-2	4.95	2.32	1.13									
Σ	9.90	4.64	2.27									
S. P.												
AC-N												

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Project HECLA Line 1 Field date _____ Data page _____ Comp. date _____ Comp by _____ Page _____

(A) Send	60-70					CAC						
(B) Receive	80-90	90-100	100-110	110-120								
(C) n separation	10	3	1	1								
(D) I	2.0											
(E) Vdc (avg)	11.5	3.31	1.61			29.8						
(F) DCcal	1.005	———	———	———								
(G) Kn x 10^{-3}	3	12	30	60								
(H) ρdc=ExFxGx10^3/D	17.4	20.0	24.3									
(I) Vac Σ	10.4	3.07	1.50			28.8						
(J) AC noise x 2	———	———	———									
(K) Vac(corr) = $\sqrt{I^2 - J^2}$	———	———	———									
(L) AC-DC cal.	967	970	1.017			.966						
(M) ρ dc/ρac=ExL/K	1.068	1056	1.089									
(N) PFE=(M-1)(10^2)	6.8	5.6	8.9									
(O) MCF=(M-1)(10^5)/H	390	280	366									
	1.6%	3%	4%									

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	70-80											
(B) Receive	90-100											
(C) n separation	10	3	3									
(D) I	2.0											
(E) Vdc (avg)	10.65	4.99	2.48									
(F) DCcal	1.005	———	———									
(G) Kn x 10^{-3}	3	12	30									
(H) ρ dc=ExFxGx10^3/D	16.1	30.1	37.4									
(I) Vac Σ	9.9	4.64	2.27									
(J) AC noise x 2	———	———	———									
(K) Vac (corr) = $\sqrt{I^2 - J^2}$	———	———	———									
(L) AC-DC cal.	967	970	1.017									
(M) ρdc/ρac =ExL/K	1.040	1.044	1.111									
(N) PFE=(M-1)(10^2)	4.0	4.4	11.1									
(O) MCF=(M-1)(10^5)/H	249	146	297									
	1.7%	18%	2.7%									

2.3 2.6 8.4

INDUCED POLARIZATION - RECEIVER NOTES PAGE _____

Project: _____ Line: _____ Int.Cal _____ Date: _____

Send	40-50						Cal					
Rec.	60-70	70-80	80-90	90-100			30					
Time	10	3	3	1								
DC-1	8.0	2.84 2.60	1.06 1.04	0.6			17.7					
DC-2	7.8	2.82 2.58	1.08 1.02	0.6			17.7					
Σ	15.8	5:44 5:40	3:10 3:40	?			35.4					
DC-3	8	2.84 2.61	?	?			17.7					
Dc-4	7.8	2.84 2.60	.	.			17.7					
Σ	15.8	5:45 5:44					35.4					
DC-AV	15.8	5.43	2.10	1.20			35.4					
AC-1	7.38	2.32	0.95	0.53			16.7					
AC-2	7.38	2.32	0.95	0.53			16.7					
Σ	14.76	4.64	1.90	1.06			33.4					
S. P.	4.0											
AC-N	0.16											

INDUCED POLARIZATION - RECEIVER NOTES PAGE_____

Project:_____ Line:_____ Int.Cal_____ Date:_____

Send	50-60											
Rec.	20-80	40-50	90-100	100-110								
Time	10	3	3	1								
DC-1	7.5	2.21 2.15	1.0 .96	.62								
DC-2	7.46	2.23 2.13	1.06 1.0	?								
Σ	14.96	4.36 4.28	1.98 2.03									
DC-3	7.5	2.28 2.10	1.03 1.0									
Dc-4	7.46	2.26 2.11	1.06 .97									
Σ	14.96	4.38 4.33	2.03 2.03									
DC-AV	14.96	4.32	2.03	1.24								
AC-1	16.9	2.0	0.88	0.53								
AC-2	16.9	2.0	0.88	0.53								
Σ	13.8	4.0	1.76	1.08								
S. P.	9	0	5	8								
AC-N	.08	.04	.03	04								

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

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Project Heela Line 1 Field date_____ Data page_____ Comp. date_____. Comp by_____

(A) Send	40-50											
(B) Receive	60-70	70-80	80-90	90-00								
(C) n separation	10	3	3	1								
(D) I	2.0											
(E) Vdc (avg)	15.8	5.43	2.10	1.20		35.4						
(F) DCcal	.848					.848						
(G) Kn x 10^{-3}	3	12	30	60								
(H) ρdc=ExFxGx10^3/D	20.1	27.7	26.8	34.2								
(I) Vac Σ	14.76	4.64	1.9	1.06		33.4						
(J) AC noise x 2				.12								
(K) Vac(corr) =$\sqrt{I^2 - J^2}$				1.05								
(L) AC-DC cal.	946	949	949	.993		.945						
(M) ρ dc/ρac=ExL/K	1.014	1.110	1.049	1.136								
(N) PFE=(M-1)(10^2)	1.4	11.0	4.9	13.6								
(O) MCF=(M-1)(10^5)/H	70	400	183	398								
	1.4 %	2 %	3.5%	4.8%								

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send	50-60											
(B) Receive	70-80	80-90	90-00	00-10								
(C) n separation	10	3	3	1								
(D) I	2.0											
(E) Vdc (avg)	14.96	4.37	2.03	1.27								
(F) DCcal	898											
(G) Kn x 10^{-3}	3	12	30	60								
(H) ρ dc=ExFxGx10^3/D	19.0	22.2	25.8	31.6								
(I) Vac Σ	13.8	4.0	1.76	1.08								
(J) AC noise x 2				.12								
(K) Vac (corr) =$\sqrt{I^2 - J^2}$				1.073								
(L) AC-DC cal.	946	949	949	.993								
(M) ρdc/ρac =ExL/K	1.025	1.037	1.095	1.147								
(N) PFE=(M-1)(10^2)	2.5	3.7	9.5	14.7								
(O) MCF=(M-1)(10^5)/H	131	167	368	465								
	1.5%	2.7%	3.7%	5 %								

INDUCED POLARIZATION - RECEIVER NOTES PAGE _____

Project: _____ Line: _____ Int.Cal _____ Date: _____

Send	20-30					Cal.						
Rec.	40-50	50-60	60-70	70-80								
Time	30	10	3	1								
DC-1	10.7	3.10 3.03	1.10 1.13	.750 .764		18						
DC-2	10.6	3.13 3.03	1.08 1.12	.738 .770		18						
Σ	21.3	6.15 6.16	2.23 2.20	1.514 1.510		36						
DC-3	10.8	3.10 3.0				18						
Dc-4	10.6	3.12 3.02				18						
Σ	21.4	6.10 6.14				36						
DC-AV	21.35	6.14	2.22	1.51		36						
AC-1	10.0	2.83	1.02	.710		16.8						
AC-2	10.0	2.83	1.02	.718		16.8						
Σ	20.0	5.66	2.04	1.428		33.6						
S. P.	24											
AC-N	.03											

INDUCED POLARIZATION - RECEIVER NOTES PAGE _____

Project: _____ Line: _____ Int.Cal _____ Date: _____

Send	30-40											
Rec.	50-60	60-70	70-80	80-90								
Time	30	3	3									
DC-1	10.8 10.8	2.62 2.43	1.84 1.26									
DC-2	10.9 10.8	2.56 2.42	1.29 1.26									
Σ	21.6 21.7	4.95 5.01	2.60 2.55									
DC-3	10.9 10.8	20										
Dc-4	10.8 10.9											
Σ	21.65	60 1 Power 12										
DC-AV	21.65	4.98	2.57									
AC-1	10.2	2.23	1.23									
AC-2	10.1	2.23	1.25									
Σ	20.3	4.46	2.48									
S. P.	-15	0	0									
AC-N	.3 to .35	.04 .2 to .35	.46.5									

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page_____

Project HELIA Line 1 Field date_____ Data page_____ Comp. date_____. Comp by_____

(A) Send	20-30					CAL						
(B) Receive	40-50	50-60	60-70	70-80								
(C) n separation	30	10	3.0	1								
(D) I	2.0											
(E) Vdc (avg)	2.135	6.14	2.22	1.50		36.0						
(F) DCcal	.835					.835						
(G) Kn x 10^{-3}	3	12	30	60								
(H) ρdc=ExFxGx10^3/D	26.7	30.7	27.8	37.6								
(I) Vac Σ	20.0	5.66	2.04	1.43		33.6						
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	934	935	938	.982		.934						
(M) ρ dc/ρac=ExL/K	.998	1.040	1.020	1.030								
(N) PFE=(M-1)(10^2)	-0.2	4.0	2.0	3.0								
(O) MCF=(M-1)(10^5)/H	-8	131	72	80								
	1%	1.8%	3.5%	4.3%								

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send	30-40											
(B) Receive	50-60	60-70	70-80	80-90								
(C) n separation	30	3.0	3.0									
(D) I	2.0											
(E) Vdc (avg)	2.65	4.98	2.52									
(F) DCcal	.835											
(G) Kn x 10^{-3}	3	12	30	60								
(H) ρ dc=ExFxGx10^3/D	27.1	25.0	32.2									
(I) Vac Σ	20.3	4.46	2.48									
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	939	938	938									
(M) ρdc/ρac =ExL/K	.995	1.050	.974									
(N) PFE=(M-1)(10^2)	-0.5	5.0	-2.6									
(O) MCF=(M-1)(10^5)/H	-18	200	81									
	1%	2.3%	3%									

INDUCED POLARIZATION - RECEIVER NOTES PAGE 1

Project: Line: Int.Cal Date:

Send	0-10							Cal				
Rec.	20-30	30-40	40-50	50-60	60-70	70-80						
Time	30	10	3	1				30				
DC-1	11.2	2.95	1.28 1.22	0.70 0.55				14.9				
DC-2	11.3	2.95	1.18 1.28	0.63 0.55				14.8				
Σ	22.5	5.90	2.50 2.40	1.23 1.18				29.7	1.10			
DC-3	11.2	2.98	1.12 1.33	0.69 0.59				14.9				
Dc-4	11.3	2.92	1.04 1.36	0.79 0.68				14.8				
Σ	22.5	5.90	2.40 2.40	1.28 1.27				29.7				
DC-AV	22.6	5.90	2.44	1.3				29.7				
AC-1	10.6	2.75	1.10	0.60				14.2				
AC-2	10.6	2.75	1.10	0.60				14.3				
Σ	21.2	5.50	2.20	1.20				28.5				
S. P.	.90											
AC-N	.02											

INDUCED POLARIZATION - RECEIVER NOTES PAGE 2

Project: _____ Line: 1 Int.Cal _____ Date: _____

Send	10-20											
Rec.	30-40	40-50	50-60	60-70	70-80	80-90						
Time	30	10	3	1								
DC-1	10.0	2.82 2.79	1.24 1.24	0.52 0.61								
DC-2	10.0	2.74 2.75	1.22 1.80	0.45 0.62								
Σ	20.0	5.56 5.54	2.46 3.52	1.13 1.07								
DC-3	10.0	2.66 2.80	1.16 1.33	0.50 0.48								
Dc-4	10.1	2.65 2.87	1.07 1.86	0.56 0.51								
Σ	20.1	5.46 5.52	2.49 2.42	0.98 1.07								
DC-AV	20.05	5.53	2.47	1.05								
AC-1	9.4	2.54	1.09	0.478								
AC-2	9.4	2.54	1.09	0.478								
Σ	18.8	5.08	2.18	0.956								
S. P.	+7.0	+34	-11.4	+6.3								
AC-N	.02	.02	.03	.04								

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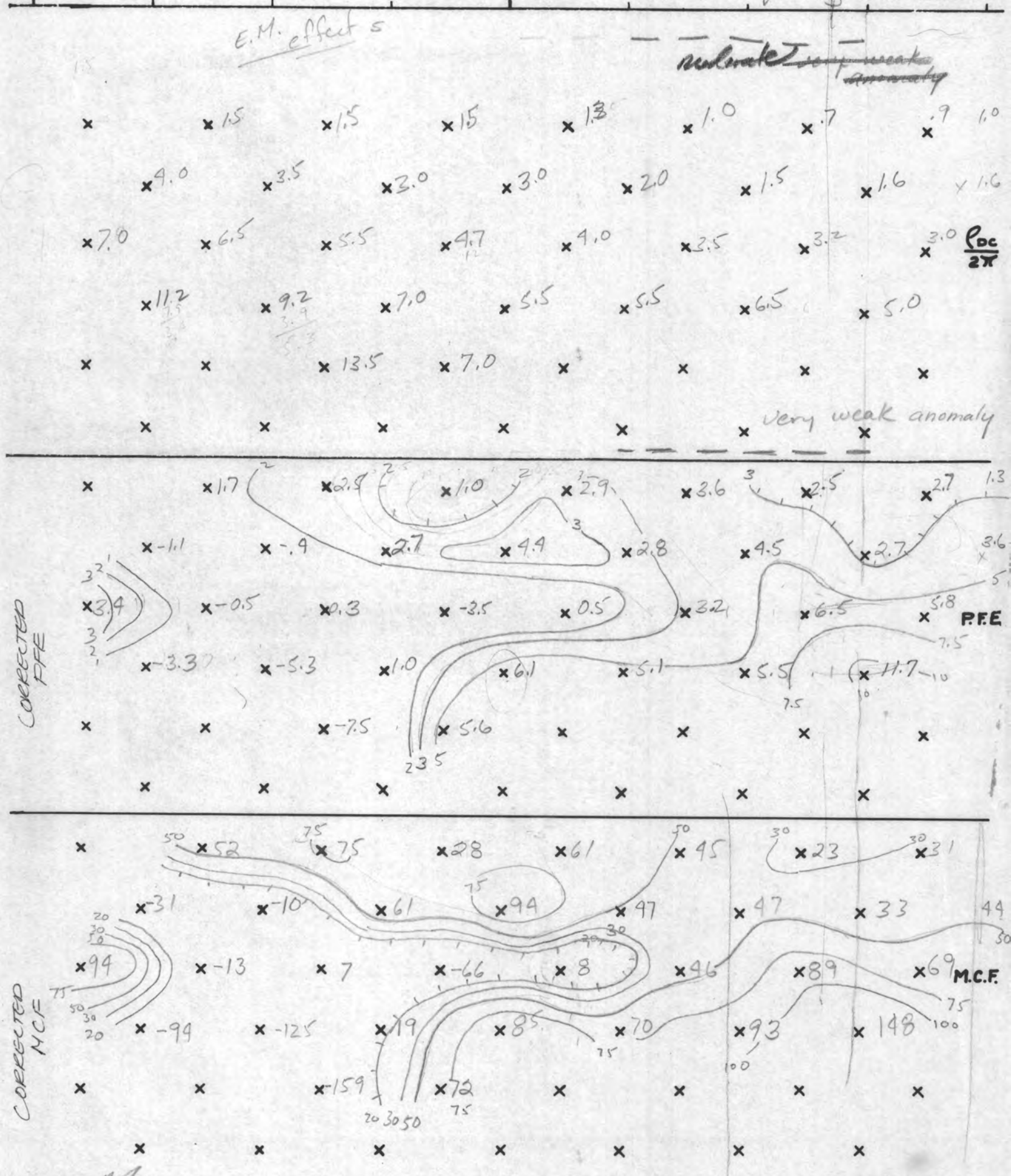
Project HECLA Line 1 Field date _____ Data page _____ Comp. date _____ Comp by _____ Page _____

(A) Send	0-10s											
(B) Receive	20-30	30-40	40-50	50-60								
(C) n separation	3.0	10	3.0	1.0								
(D) I	2.0											
(E) Vdc (avg)	22.5	5.9	2.44	1.3		29.7						
(F) DCcal	1.01	→	→	→		1.01						
(G) Kn x 10^{-3}	3	12	30	60								
(H) ρ dc=ExFxGx10^3/D	34.1	35.8	37.0	39.3								
(I) Vac Σ	21.2	5.5	2.2	1.2		28.5						
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	960	961	969	1.008		.960						
(M) ρ dc/ρac=ExL/K	1.018	1.030	1.070	1.092								
(N) PFE=(M-1)(10^2)	1.8	3.0	7.0	9.2								
(O) MCF=(M-1)(10^5)/H	53	84	189	234								
	1%	1.5%	2.6%	4.25%								

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	10-20s											
(B) Receive	30-40	40-50	50-60	60-70								
(C) n separation	3.0	10	3.0	1.0								
(D) I	2.0											
(E) Vdc (avg)	20.05	5.53	2.47	1.05								
(F) DCcal	1.01	→	→	→								
(G) Kn x 10^{-3}	3	12	30	60								
(H) ρ dc=ExFxGx10^3/D	31.1	33.5	36.4	31.9								
(I) Vac Σ	18.8	5.08	2.18	.950								
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.	960	961	969	1.008								
(M) ρdc/ρac =ExL/K	1.027	1.045	1.092	1.115								
(N) PFE=(M-1)(10^2)	2.7	4.5	9.2	11.5								
(O) MCF=(M-1)(10^5)/H	87	134	253	360								
	1%	1.6%	2.7%	5%								

HEINRICHS GEOEX. - INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING Line 3 E.M. coupling corrected



AREA North Star LINE 3 a = ' SCALE: 1" = 1500 DATE: 9/64

COPY

October 15, 1964

Mr. Hugh Steele
General Superintendent
Magma Copper Co.
Superior, Arizona

Re: North Star I. P. Survey

Dear Hugh:

In discussing the North Star I. P. report with Don Hammer last Tuesday, a few ideas were brought out which I thought I would outline in a letter to you.

As shown in our I. P. report, a moderate I. P. response between stations 30 and 60 on Line 3 has been indicated. It was decided here that a test hole might be justified to see if the anomalism was related to anything of economic interest. In talking to Don, however, he said that because of the land situation, it would not be desirable to move a drill rig in prior to knowing more about the extent of the I. P. anomalism. With this in mind, I would recommend a minimum of two lines, one parallel to Line 3 and 1,500 ft. east and one normal to Line 3 across the anomalous zone.

It is estimated the lines would approximate 1½ miles in length and on a 1,500 ft. dipole spacing, cost is estimated to be about $2,500.00. Of course if the anomalous trend extends further, than expected then more coverage may be desired.

A similar spread may be desired in the vicinity of Line 1-A, stations 1 and 2 although for the moment, I would recommend tying down the extent of the major show first.

Very truly yours,

EGH:jh
cc: Extra Encl.

E. Grover Heinrichs

COPY

October 9, 1964

Mr. Hugh Steele
General Superintendent
Magma Copper Co.
Superior, Arizona

Re: North Star Area
Geophysics

Dear Mr. Steele:

Enclosed is an original and two copies of our report on the resistivity and induced polarization survey run over the North Star Area. In addition, we are sending one reproducible map of each sectional data sheet and the base map of the area.

If you have any questions concerning this report or if we can be of assistance in any way, please let us know.

It has been a pleasure to be of service to you and we shall look forward to the opportunity of serving you again in the near future.

As requested, I am enclosing copies of our work com--putation sheets in the original copy, for your files.

Sincerely yours,

HEINRICHS GEOEXPLORATION CO.

E. Grover Heinrichs
Vice President

EGH:jh

Enclosures

September 12, 1964

COPY

Mr. H. J. Steele
General Superintendent
Magma Copper Co.
Superior, Arizona

Re: North Star Area
Geophysics

Dear Hugh:

Line No. 1 results suggest desirability of expanding dipole spacing from 1,000 ft. to 1,500 ft. and go to our big sender in order to better insure depth of penetration on Lines 2 and 3. Conditions to the east may be a little more adverse than we had hoped; however, data so far is believed quite reliable.

Consequence of this is slightly less speed and therefore equivalent increased cost or less coverage or detail. We will use four men and two vehicles. Unless you advise to the contrary, we will adjust matters to conform to the $4,500.00 expenditure and we believe will still provide about 75% certainty of not missing anything of major potential interest within the original objective volume to be explored.

Unless results warrant extending the work, field work should be completed next week and report the following week.

Best personal regards,

Sincerely,

HEINRICHS GEOEXPLORATION CO.

P.S. In case I should be away, Gover or Phil Matthews will be on deck.

WEH:jh
cc: Extra Encl.

Walter E. Heinrichs, Jr.

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

July 22, 1964

Mr. H. J. Steele,
General Superintendent
Magma Copper Co.
Superior, Arizona

Re: Proposed geophysical work,
North Star Area, T 6 - 7 S,
R 9 - 10 E Pinal County, Arizona

Dear Hugh:

This will serve to confirm our recent discussions.

It is your desire to explore a general area southwest and southeast from the old North Star workings more or less between the southeastward projection of its indicated trend and the covered area immediately east of the stock and other exposures at the foot of the eastern flank of the Picacho Mts.

Since depth will be important, we propose running I. P. spreads utilizing dipoles 1,000 ft in length to provide penetration in excess of 1,500 ft. deep if possible. One such spread will obtain sectional data somewhat in excess of 7,000 ft. in length and representing material approx. 1,500 ft. on either side of line. Therefore an initial broad reconnaissance of an area can be undertaken with such lines one half mile apart with over 90% certainty of not missing anything of major potential interest.

If, as discussed with you today by phone, six such spreads were laid out in three parallel lines one half mile apart, consisting of two end-on spreads each, we would effectively reconoiter a rectangle about three and one half by one and one half miles or an area about five miles square, to a maximum depth of 2,000 ft. The latter of course, depending

on the resistivity, size, shape, depth and distribution factors encountered.

For such work we would agree to quote a turn-key price of $4,500.00 including final report in triplicate or $750.00 per 1,000 ft. dipole spread or setup.

On a daily basis our charges are based on a minimum required three man field operating crew rate of $250.00 per day. Five men, $350.00 per day and two vehicles. Vehicle charges are $10.00 per day plus $0.10 per mile. Living expenses at $10.00 per day per man or at our cost if in excess of this.

Whenever feasible, data is rough-computed and interpreted daily in order that our results may be continually appraised and desired or indicated changes made as we go, if indicated. However, final report is usually compiled by our Tucson staff at the rate of $100.00 per day plus direct incidental expenses. Anticipated production rate is about two-thirds spread per day and one field crew day usually requires one staff day compilation or about three weeks total job time.

Billings are bi-weekly. We request your protection and assumption of all liability for any damage or trespass done by us at your request. Otherwise, we carry our own property damage and public liability insurance in six figure amounts and Arizona State Workmen's Comp. on all of our operations and employees.

On a 'first come' basis, your work could be now scheduled to start on or about the third week in August. However, owing to being extremely busy because of current contract extensions and work related to the September 1 Federal annual labor deadline, etc., any concession you are able to grant in allowing us to stretch out the work into September would be most appreciated.

Faithfully,

HEINRICHS GEOEXPLORATION CO.

Walter E. Heinrichs, Jr.
President & General Manager

WEH:jh
cc: Extra Encl.

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COPY

20 Contact Prints

+2 Enlarged prints taken for scanning

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INDUCED POLARIZATION
and
RESISTIVITY SURVEYS

NORTH STAR AREA
Pinal County, Arizona

for
MAGMA COPPER COMPANY

September 1964

by
HEINRICHS GEOEXPLORATION COMPANY
P. O. Box 5671 Tucson, Arizona

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Procedure	2
Conclusions & Recommendations	2
Interpretation	2
Basis of I. P. Method	1a

In Pocket:

Location Map

Sectional Data Sheets, Line 1, Line 2 and Line 3.

COPY

INTRODUCTION

During the period 8 September through 18 September 1964, Heinrichs Geoexploration Co., at the request of Magma Copper Company conducted an induced polarization and resistivity survey over the North Star Area, township 7 south, range 9 and 10 east, Pinal County, Arizona.

A total of 58,000 line feet of induced polarization and resistivity traverses were run, giving 39,500 ft. of subsurface information. These data were obtained using the dual frequency induced polarization method, employing a dipole-dipole electrode configuration. Three lines were run, one at a dipole spacing of 1,000 ft. (Line 1) and two at a dipole spacing of 1,500 ft., (Lines 2 and 3).

The data are plotted on sectional data sheets, showing the apparent resistivity, percent frequency effect and metallic conduction factor, all contoured in vertical section. In all cases the data obtained were checked to determine the extent of electro-magnetic coupling. (See "Basis of I. P. Method" Figure 3). When these coupling effects were of a magnitude to be a significant part of the total I. P. effect, they were calculated and applied to the raw data to obtain corrected frequency effects free from the adverse effects of electro-magnetic coupling. When coupling effects were applied, the corrected data were plotted in above the uncorrected data. In all cases where the corrections were made, the data were contoured according to these corrected results. The metallic conduction factor was based on the corrected frequency effects when used.

The I. P. lines also have been located on a base map furnished by Magma Copper Co.

Heinrichs GEOEX personnel on this project were Mr. Peter Beuden, party chief; Marcel Leduc, Ron Palmer and John Beeler, technicians and Gene Juarez, field assistant. Interpretation and report by J. P. Matthews, Jr.

COPY

PROCEDURE

The initial work (Line 1) was run at a dipole spacing of 1,000 ft. After consideration of the depth to target and resistivities involved, it was decided to increase the dipole spacing to 1,500 ft. This allowed a continuous penetration to a depth in excess of 2,000 ft. The remaining two lines (2 and 3) were run using this larger dipole spacing.

CONCLUSIONS AND RECOMMENDATIONS

1. Line 1 and 1a shows weak anomalism indicating sulfides of approximately 1% by volume at a depth of from 300 ft. to 1,000 ft. below the surface, from 1,000 ft to 3,000 ft. southwest of the center point on Line 1a.

2. The above zone could be checked out by a 1,000 ft. drill hole in the vicinity 2,000 ft. southwest of the center point on Line 1a.

3. Line 2 shows no anomalism and no further work is recommended.

4. Line 3 shows moderate anomalism indicative of a sulfide content of 1 to 2% by volume at a depth of approximately 1,000 ft. and from 3,000 to 6,000 ft. southwest.

5. The anomaly on Line 3 should be checked out by a 1,500 ft. drill hole in the vicinity of 4,500 ft. southwest.

6. If drill results are encouraging, it would be useful to extend I. P. coverage in the vicinity to outline the two zones of anomalism. In addition to I. P. and resistivity, reconnaissance magnetics might be very useful in the area.

INTERPRETATION

Line 1 and 1a. There appears to be two slight resistivity contrasts located approximately 1,000 ft. southwest of the center point on Line 1 and 2,000 ft. northeast of the center point on Line 1a. The resistivities are quite high

COPY

undoubtedly reflecting the close proximity to bedrock.

The induced polarization data shows a small anomaly from 1,000 to 3,000 ft. southwest of the center point on Line 1a, indicating a sulfide content of approximately 1% by volume. Although this anomaly is only weak, it extends from about 300 ft. to 1,500 ft. in depth. The effect of the high resistivity is reflected in the low M.C.F., despite the moderate I. P. effects.

Line 2. The resistivities here indicate the possibility of a three layer case, with the middle layer higher in resistivity than either the upper or lower layer. The resistivity on this line is generally lower than that encountered on Line 1, indicating a somewhat greater depth to bedrock.

The frequency effects on this line are low and reflect only the background polarization in the area. No anomalies were observed on this line.

Line 3. There is a possible contact located at 7,500 ft. southwest as shown by the slight resistivity contrast. The resistivity northeast of this contact is about twice as high as that to the southwest, possibly caused by a decrease in depth to bedrock, which, on the end of this line is probably at least 1,000 ft. and perhaps deeper.

The I. P. data shows gradually increasing frequency effects and M.C.F.'s to the northeast. There is a moderate I. P. and M.C.F. anomaly indicating a sulfide content of 1 to 2% by volume at the northeast, extending from about 3,000 to 6,000 ft. southwest. This anomaly is only moderate in strength, but because of the large dipole spacings involved and the probable depth to the target, a small sulfide zone would only give a moderate I. P. effect. Because of this, the anomaly may be of significance.

Respectfully submitted,

HEINRICHS GEOEXPLORATION CO.

J. P. Matthews, Jr.
Geophysicist

October 8, 1964
P. O. Box 5671
Tucson, Arizona

COPY

INDUCED POLARIZATION
and
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NORTH STAR AREA
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J. P. Matthews, Jr.
Geophysicist

October 8, 1964
P. O. Box 5671
Tucson, Arizona

BASIS OF THE INDUCED POLARIZATION METHOD

The induced polarization method is based on the electrical properties exhibited by electronic or metallic conductors imbedded in an ionic or electrolytic conducting matrix. These properties are noticed in that the potential across a block of this dual conduction mode material will increase with time, approaching a constant value, when a constant current is made to flow through the block. This phenomenon occurs because at the boundaries between the two conductor types, electrolytic ions have to give up or take on electrons thereby requiring an additional force (overvoltage) over that which would be needed with only one mode of conduction; showing up as a building of potential across the block with time as more ions are backed up. This potential approaches a constant value when an equilibrium is established between the ions backed up at the boundaries and the flow across the boundaries. Therefore from the preceeding discussion, it is seen that the gross effect is quite similar to the charging of a leaky capacitor and for most applications, it is proper to use this mode as a guide. These capacitive-like properties are normally measured by three different techniques.

In the time domain (pulse) method, a steady direct current is imposed across the block for a few seconds and abruptly terminated so that the capacitive-like decay (discharge) curve can be measured or recorded. Usually, the voltage decay curve is integrated with respect to time to give the area under the decay curve in units of volt-seconds. The more area determined, the more capacitance or polarization the block exhibits.

In the frequency domain method, the percentage difference between the impedance (AC resistance) offered to a lower and a higher frequency is measured. A capacitor offers a lower impedance to a higher frequency than it does to a lower frequency, therefore the percentage difference between the impedances will increase with increased polarization.

A third technique is to measure the phase angle or delay between an introduced current wave-form and the received voltage wave across the block. This phase delay also increases as polarization increases.

Almost all metallic lustered sulfides such as for example; pyrite, chalcopyrite, chalcocite, bornite and molybdenite are electronic conductors and the rocks and ground water, with which they permeate or are permeated, are ionic conductors, therefore if an electric current is made to flow through a sulfide deposit, it will polarize and can be detected by the three methods described above.

This induced polarization property is not entirely unique with sulfides since magnetite, graphite and some clays will exhibit it; however, with sufficient geological and geophysical data, effects due to sulfides can generally be interpreted apart from non-sulfide anomalism. The type of sulfide however, say pyrite, as distinct from chalcopyrite, cannot yet be distinguished with present induced polarization techniques since all types give quite similar types of problems.

The I. P. technique was developed primarily for porphyry type deposits and is perhaps the only reliable means of detecting hidden disseminated sulfides. However, the I. P. method works just as well or perhaps better on semi-massive to massive sulfides, contrary to some of the earlier thinking, for it gives increased response with increased volume percentage of sulfide.

FIELD TECHNIQUES AND INTERPRETATION

For routine exploration, we prefer and use the dual frequency system because of its greater simplicity of instrumentation, operation and greater accuracy as well as simplicity of interpretation. However, all three methods give basically the same results and the choice is either a matter of opinion or highly technical reasons and therefore should be left to the individual application and the geophysicist's discretion.

The two frequencies we most commonly use are 0.05 and 3.0 cycles per second, respectively or so called "D.C." and "A.C." modes. Other frequencies are available with our equipment and are occasionally used when desired. The usual frequency range used is from about 0.01 cps. to 10 cps. The lower frequency limit is due to naturally existing time varying Telluric (earth) currents and

electrode polarization. The upper limit is determined by electro-magnetic coupling effects which increase rapidly with increasing frequency.

In our standard reconnaissance field practice, five equally spaced co-linear current electrodes are placed in the ground by burying aluminum foil in pits wetted with brine. Observations are made in accordance with a symmetrical dipole-dipole configuration where the distance between the receiver or potential electrodes is kept equal to the distance between adjacent electrode pairs. Generally the receiving dipole is separated by one to six dipole units ("n" separation) from the sending dipole. Figures 1 and 2 indicate this configuration and resulting data plotting positions. A precisely controlled square wave current is sent through a sending dipole at 0.05 and 3.0 cycles per second from which, at the receiving dipole, a "D.C." and an "A.C." voltage are measured, respectively. By knowing the geometry involved (the dipole length or spacing and the separation distance between the two receiving-sending dipole pairs), along with the two voltages, an apparent "D.C." and an "A.C." resistivity can be calculated. From these apparent resistivities, their percentage difference is determined, thus giving the Percent Frequency Effect (PFE). A third quantity proportional to PFE and inversely proportional to "D.C." resistivity, called Metallic Conduction Factor (MCF) is computed in order to somewhat normalize PFE for variations in ground conductivity purely as a technical interpretational aid. Formulas for these various quantities are given on Figure 3.

Selection of electrode spacings is determined by the objectives to be reached in a given survey. This spacing will range from very small (50 feet or less) for very detailed and shallow surveys, up to 1,000 feet, or occasionally more, for broad and deep reconnaissance work. Other factors involved in the selection of spacing are concerned with the anticipated physical geometry of any possibly existing mineral occurrence. This includes consideration of such size, shape and position factors as expected depth of burial to the top of the deposit, the dimensions of the deposit itself, its orientation, strike and dip, etc., as well as its expected electrical properties.

In general, the greater the dipole spacing and "n" separation, the greater the depth penetration and the less

the resolution. A rule of thumb used in practice is that, with a good contrast of electrical properties, using the symmetrical - co-linear dipole-dipole system, and having data from 1 through 6 in "n" separations, two times the dipole length is the maximum depth of detectable penetration, and 0.2 times the dipole length is about the minimum depth of detectable penetration for a body having two or three of its dimensions large in relation to the dipole spacing. However, a body having two or three of its dimensions less than the dipole spacing, and buried more than one spacing probably will not be detectable. A zone, regardless of orientation, having a dimension less than 0.1 the dipole spacing will not likely be detectable. Also, zones differing by less than about 30% in electrical conductivity will not be very easily resolved by resistivity measurements, but may still be detected if a polarization contrast exists.

To illustrate the above in more concrete terms, consider a dipole spacing of 1,000 feet for the following: An overburden of more than 2,000 feet would likely not allow enough current penetration into bedrock to detect even a large and highly mineralized zone in the bedrock. Also, a sulfide zone lying completely within 200 feet of the surface generally would not be detected. A spherical or elongated cylindrical body whose top is more than about 1,000 feet below surface and whose diameter is much less than 1,000 feet would be just out of the range of detectability. A Dike-like or sill-like zone whose width is less than 100 feet probably would not be detected regardless of how it lies relative to the spread.

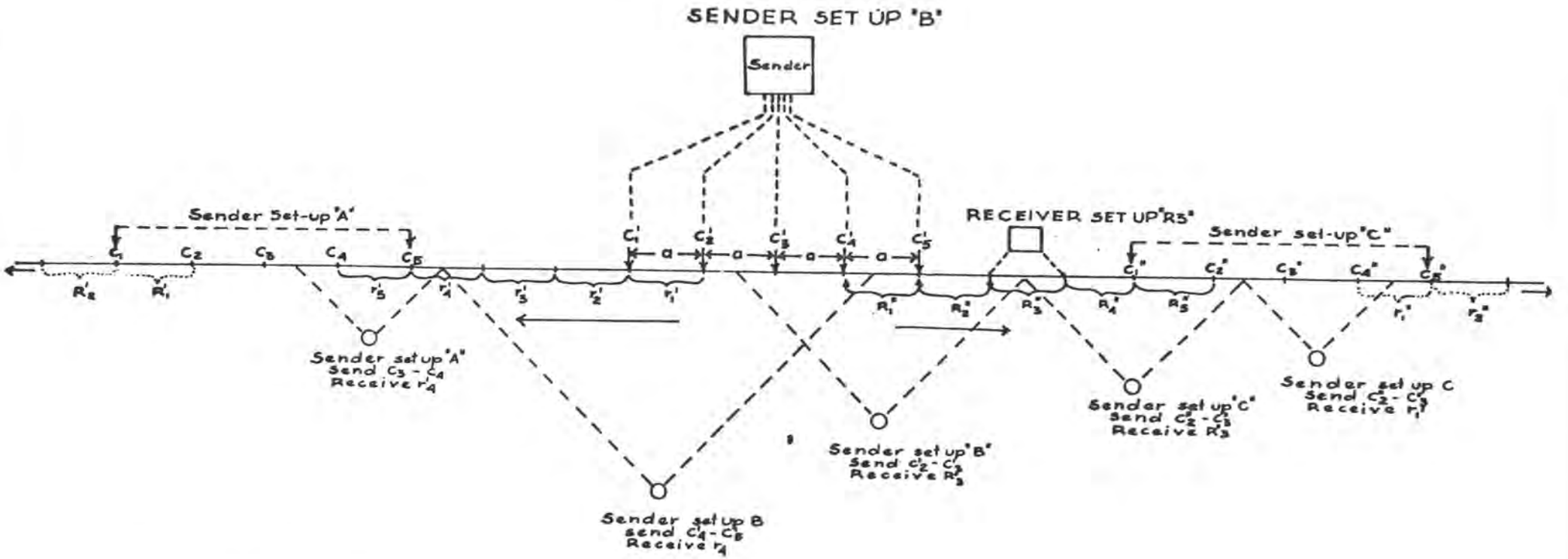
So far, only the maximum and minimum limits of detection and resolution relative to the various geological and geometrical configurations have been discussed, thus omitting optimum conditions. Generally, we attempt to make the dipole spacing one to two times the expected depth to the target in order to obtain a good electrical response. Of course, where it is suspected that the zone has a good depth extent, say two or more dipole spacings, as is typical of most porphyry type copper deposits, a spacing considerably more than two times the expected depth to sub-outcrop can be used to obtain broader and more rapid coverage, as long as we do not exceed the zone's width. Because of these factors, we usually use 500 to 1,000 foot dipole spacings in prospecting for porphyry-type deposits.

The field data are interpreted after plotting the PFE, MCF and resistivity as in Figures 1 and 2. These values are then contoured, the resistivity and metallic conduction factor logarithmically (because of the usual large variations in magnitude) and the percent frequency effect on a constant interval. This two dimensional method of plotting gives an additional leverage over the standard profile methods in that easily recognizable patterns are associated with various subsurface geometrical configurations and that lateral variations can be separated from vertical effects.

It should be realized that there is no definite relation between the vertical scale on these plots and actual subsurface depth. The data point values are a complexly weighted average of the electrical contrast distribution in the vicinity of the sending-receiving dipole pair and contain depth as well as lateral information. About all that can be said is that by increasing the dipole length and the dipole separation ("n" separation) more volume of ground is being affected and therefore more depth penetration.

There are cases where the depth to a subsurface feature can be determined fairly precisely as in the two horizontal layer situation. The field data is compared with theoretical type curves for various resistivity contrasts between the top and bottom layer and various thickness of the top layer until a close match is found. This enables the depth to the bottom layer in the field to be determined as well as the true resistivity of both layers. A major limitation to this interpretational technique is that only a few simple geometric cases related to a relatively few number of layers have been theoretically developed. However, extremely valuable information can still be derived in alluvial and lake bed applications for depth to bedrock and ground water purposes, etc.

In interpreting PFE's, values of 0 to 4 percent are usually considered background, 4 to 8% marginally anomalous and 8 to 40 plus definitely anomalous, but they must be considered in light of the associated resistivity. Very high resistivities give an increased background frequency effect due to an electromagnetic inductive coupling interference phenomenon that must be corrected for. The MCF tends to correct the high resistivity increased background frequency effects but tends to amplify the electro-magnetic frequency effects making a correction imperative.



Schematic diagram illustrating the method of obtaining and plotting Dipole-Dipole I. P. data. Diagram shows three separate current electrode spreads along a traverse line. In normal procedure, there are three dipole separations between current electrode spreads. The receiver setups are moved outwards from the ends of each current electrode spread usually until three dipole spacings separate the potential electrode setup from the near end of the spread. Current is "sent" to each possible pair of electrodes for each receiver setup. For instance, in Sender setup "B" when the receiver is receiving at R_1 only $C_3' - C_2'$ and $C_2' - C_1'$ can be "sent" so that data at 1 and 2 dipole separations is obtained respectively. When the receiver is at R_5'; $C_5' - C_4'$, $C_4' - C_3'$, $C_3' - C_2'$, and $C_1' - C_2'$ are sent and data is obtained for 3, 4, 5 and 6 dipole separations respectively. Each sender setup provides 33 data points.

Figure 2

(Data obtained from the three setups of Figure 1)

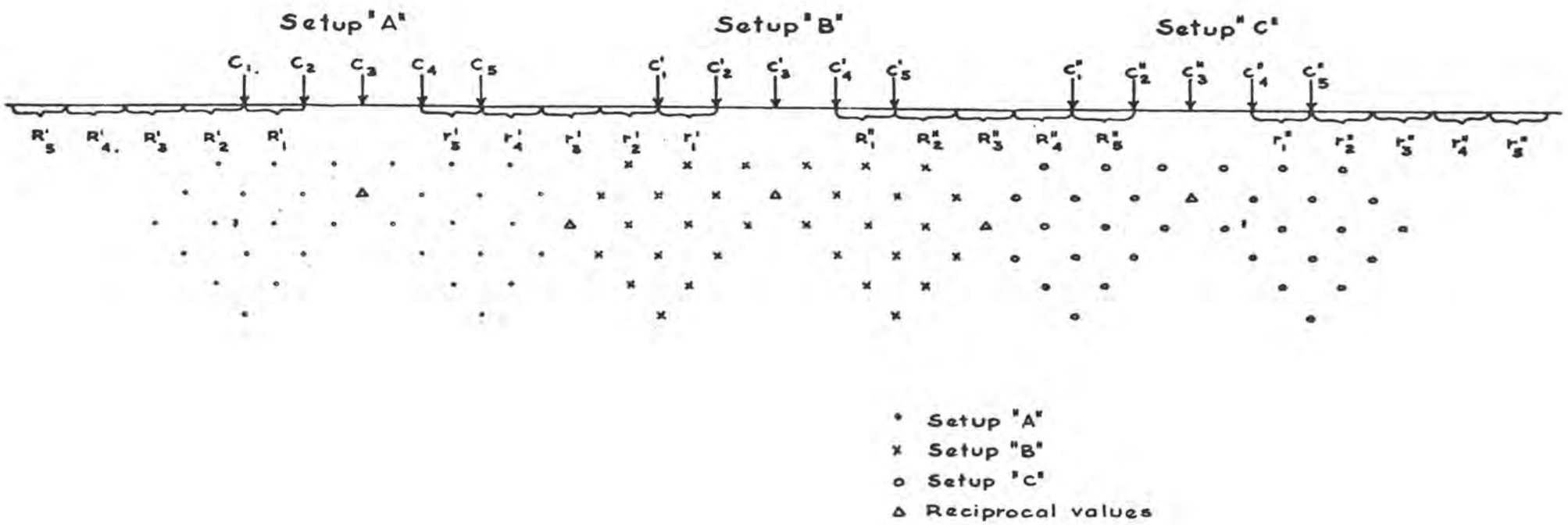


FIGURE 3

$$PFE = \left(\frac{\rho_{dc}}{\rho_{ac}} - 1\right) 100$$

Where PFE is Percent Frequency Effect, ρ_{dc} is the apparent resistivity at the lower frequency and ρ_{ac} is the higher frequency apparent resistivity.

$$\rho = \frac{2\pi V}{I} K_n$$

Where ρ is either ρ_{dc} or ρ_{ac} depending on frequency of the current I which is measured in amperes. The potential V, arising from I, is measured in volts. K_n is the geometric factor given by:

$$K_n = \frac{an(n+1)(n+2)}{2}$$

(Only for dipole-dipole arrays)

Where a is the dipole spacing in feet and n is the number of dipoles separating the sending and receiving dipoles, this gives, for apparent resistivity:

$$\rho = \frac{2\pi V}{I} \left(\frac{an(n+1)(n+2)}{2}\right)$$

from which we see that ρ is in units of ohm-feet. However, the apparent resistivity usually plotted is $\rho/2\pi$ or:

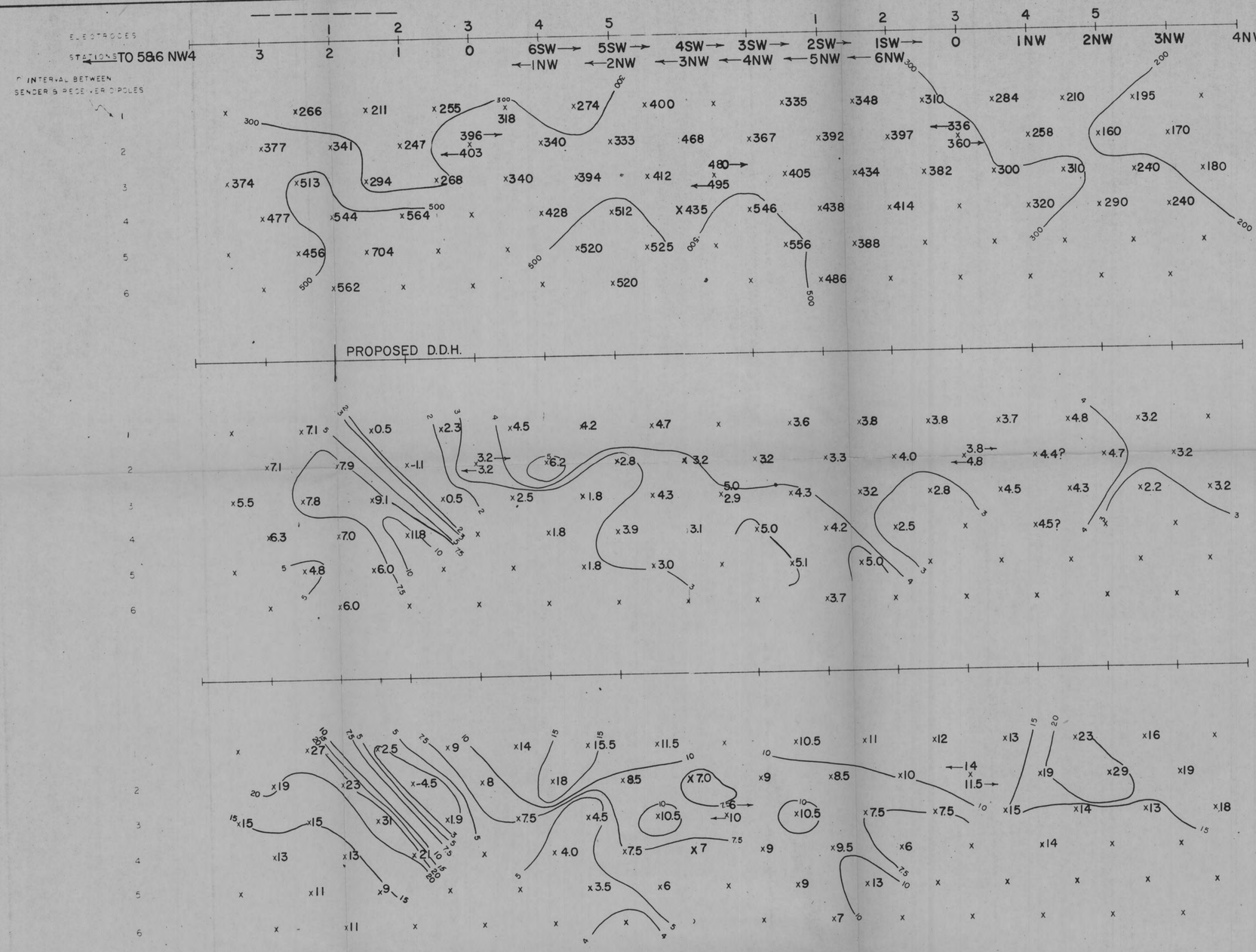
$$\frac{\rho}{2\pi} = \frac{V}{I} K_n = \frac{V}{I} \left(\frac{an(n+1)(n+2)}{2}\right)$$

$$MCF = \frac{PFE}{\rho_{dc}/2\pi} \times 1000$$

Where MCF is the Metallic Conduction Factor and $\rho_{dc}/2\pi$ is apparent "D.C." resistivity.

INDUCTIVE COUPLING INTERFERENCE

If $a(n+1)\sqrt{\frac{f}{\rho/2\pi}}$ is less than 1000 then the inductive coupling false frequency effect will be less than 2.5%. Likewise if less than 1500 the false effect will be less than 5%, and if less than 2000, the false effect will be less than 10%. Frequency f is in cycles per second.



APPARENT RESISTIVITY (ρ_{DC}) IN UNITS OF OHM FEET

CONTOUR INTERVAL LOGARITHMIC
SENDER FREQUENCY: 0.05 c.p.s.

PERCENT FREQUENCY EFFECT (PFE)
CONTOUR INTERVAL CONSTANT:
SENDER FREQUENCIES: 0.05 & 3.0 c.p.s

APPARENT "METALLIC CONDUCTION" FACTOR (MCF)

$$(MCF = \frac{PFE \times 1000}{\rho_{DC}})$$

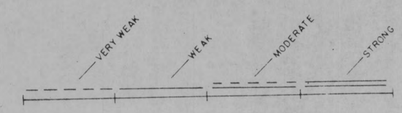
CONTOUR INTERVAL LOGARITHMIC

SELF POTENTIAL
SURFACE PROFILE
GEOLOGY, ETC.

EXPLANATION

ELECTRODE ARRAY: 1000 — n x 1000 — 1000
SENDER DIPOLE — RECEIVER DIPOLE

RELATIVE ANOMALY STRENGTH



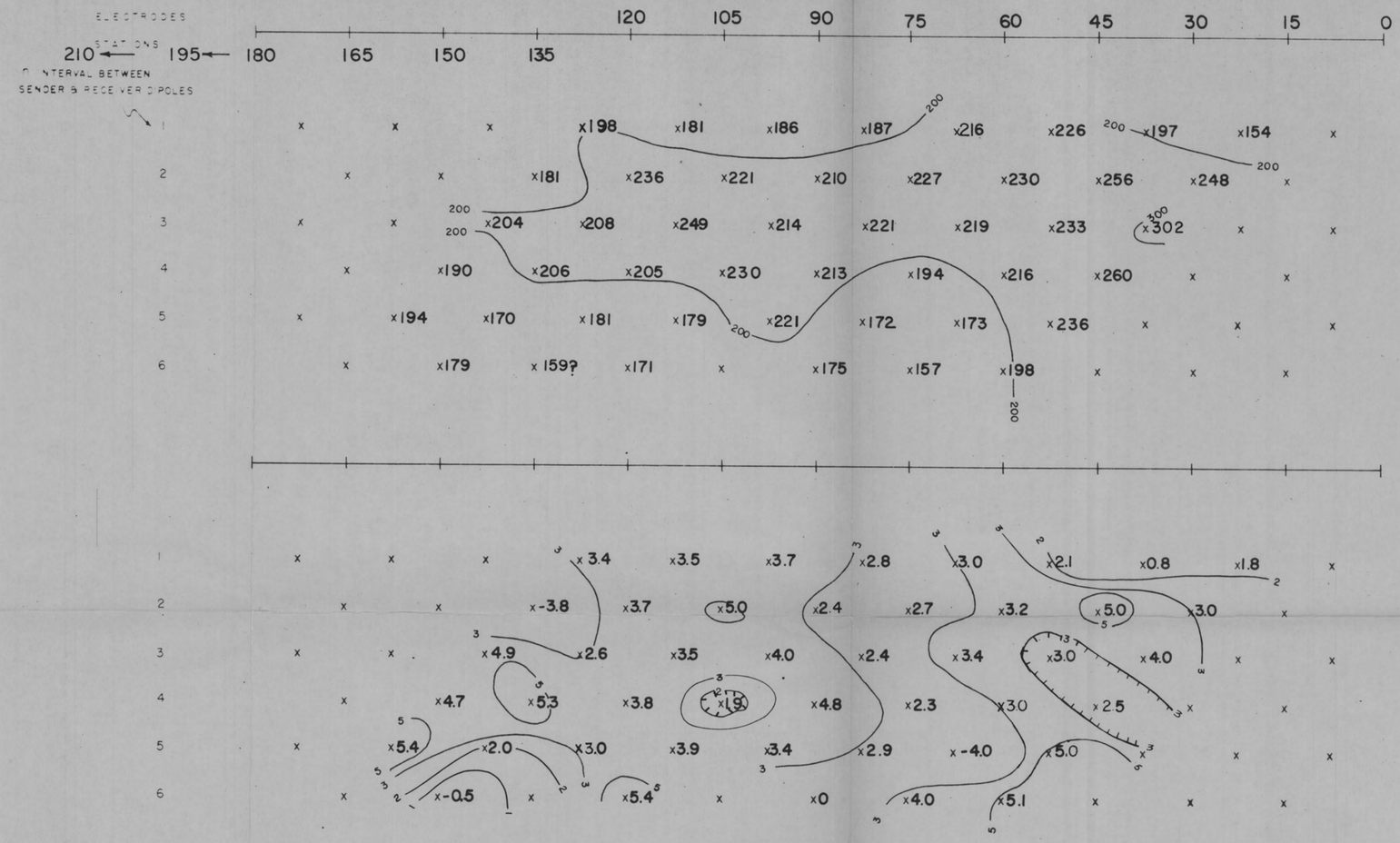
LOOKING NORTH-WESTERLY

NORTH STAR MINE AREA
PINAL COUNTY, ARIZ.

SECTIONAL DATA SHEET
LINE NO. 1
INDUCED POLARIZATION TRAVERSE

HEINRICHS GEOEXPLORATION COMPANY
SCALE: 1" = 1000' DATE: 9-64

FOR
THE MAGMA COPPER CO.



APPARENT RESISTIVITY (ρ_{DC}) IN UNITS OF OHM FEET

CONTOUR INTERVAL LOGARITHMIC
SENDER FREQUENCY: 0.05 c.p.s.

PERCENT FREQUENCY EFFECT (PFE)
CONTOUR INTERVAL CONSTANT
SENDER FREQUENCIES: 0.05 & 3.0 c.p.s.

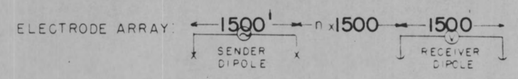
APPARENT "METALLIC CONDUCTION" FACTOR (MCF)

$$(MCF = \frac{PFE \times 1000}{\rho_{DC}/2\pi})$$

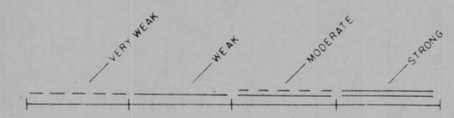
CONTOUR INTERVAL LOGARITHMIC.

SELF POTENTIAL
SURFACE PROFILE
GEOLOGY, ETC.

EXPLANATION



RELATIVE ANOMALY STRENGTH



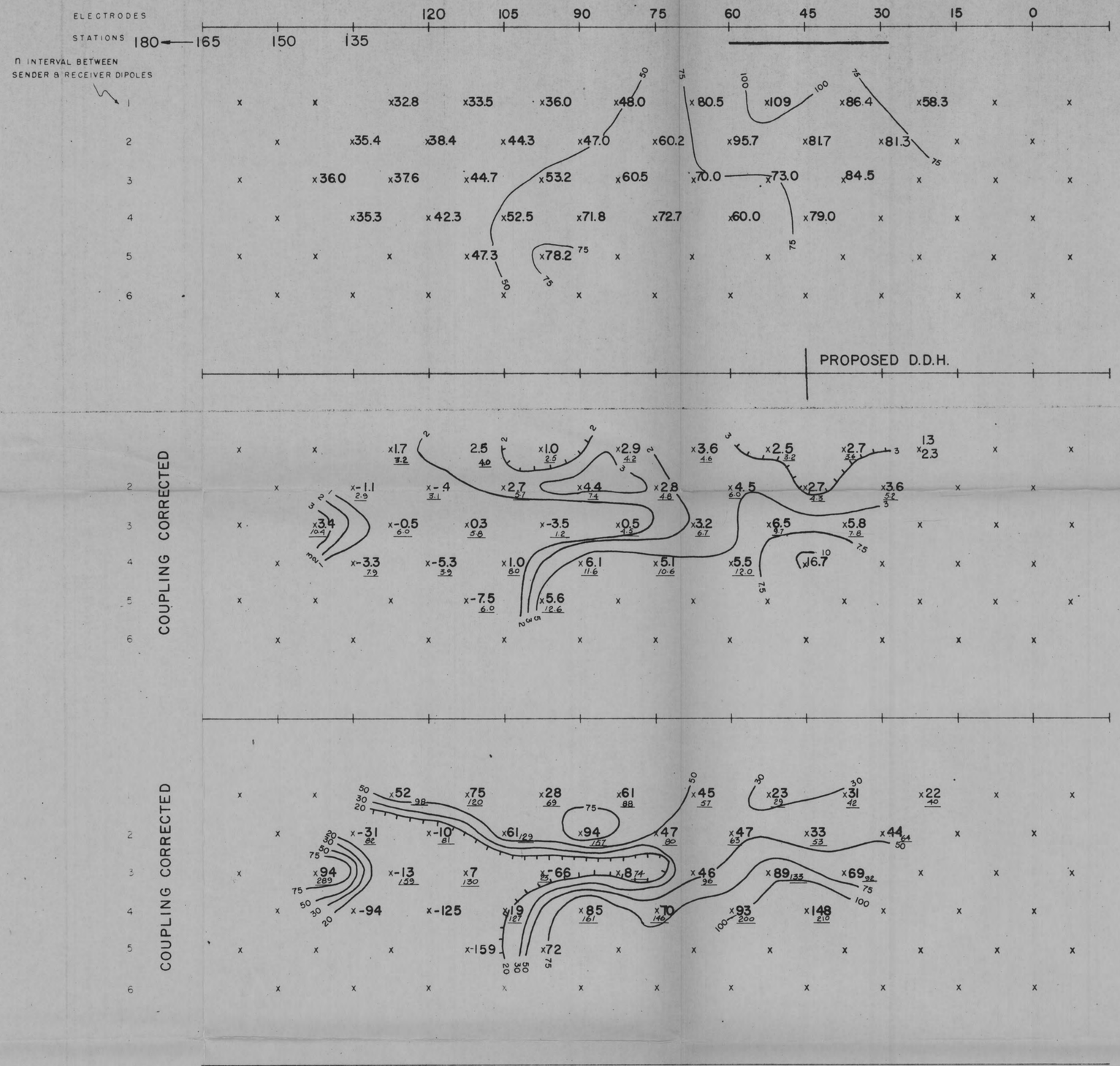
LOOKING NORTH WESTERLY

NORTH STAR MINE AREA
PINAL COUNTY, ARIZ.

SECTIONAL DATA SHEET
LINE NO. 2
INDUCED POLARIZATION TRAVERSE

HEINRICHS GEOEXPLORATION COMPANY
SCALE: 1"=1500' DATE: 9-64

FOR
THE MAGMA COPPER CO.



130 INDICATES VALUES NOT CORRECTED FOR COUPLING EFFECT.

APPARENT RESISTIVITY (ρ_{DC}) IN UNITS OF OHM FEET

CONTOUR INTERVAL LOGARITHMIC

SENDER FREQUENCY: 0.05 c.p.s.

PERCENT FREQUENCY EFFECT (PFE)

CONTOUR INTERVAL CONSTANT

SENDER FREQUENCIES: 0.05 & 3.0 c.p.s

APPARENT "METALLIC CONDUCTION" FACTOR (MCF)

$MCF = \frac{PFE \times 1000}{\rho_{DC}}$

CONTOUR INTERVAL LOGARITHMIC

SELF POTENTIAL
SURFACE PROFILE
GEOLOGY, ETC.

EXPLANATION

ELECTRODE ARRAY: 1500' SENDER DIPOLE x n x 1500' RECEIVER DIPOLE

RELATIVE ANOMALY STRENGTH

VERY WEAK — WEAK — MODERATE — STRONG

LOOKING NORTHWESTERLY

NORTH STAR MINE AREA
PINAL COUNTY, ARIZ.

SECTIONAL DATA SHEET
LINE NO. 3
INDUCED POLARIZATION TRAVERSE

HEINRICHS GEOEXPLORATION COMPANY

SCALE: 1" = 1500' DATE: 9-64

FOR

THE MAGMA COPPER CO.

R 9 E

R 10 E

T 7 S

7 8 9

18 17 16

19 20 21

30 29 28

31 32 33

28 29 30 31 32 39 33 38 40 34 37 41 35 36 42

12 11 9 10 8 7 5 6 4 3 1 2

21 20 19 18 17 16 15 14 13

LINE 1

LINE 14

LINE 2

LINE 3

NO.2

N

INDICATES INDUCED POLARIZATION SURVEY LOCATION

INDICATES WEAK ANOMALISM

" MODERATE "

PROPOSED D.D.H.

HEINRICHS GEOEXPLORATION COMPANY
P.O. Box 56?1 Tucson, Arizona

INDUCED POLARIZATION SURVEY LOCATION
NORTH STAR MINE AREA
FOR
THE MAGMA COPPER CO.
PINAL COUNTY ARIZ.

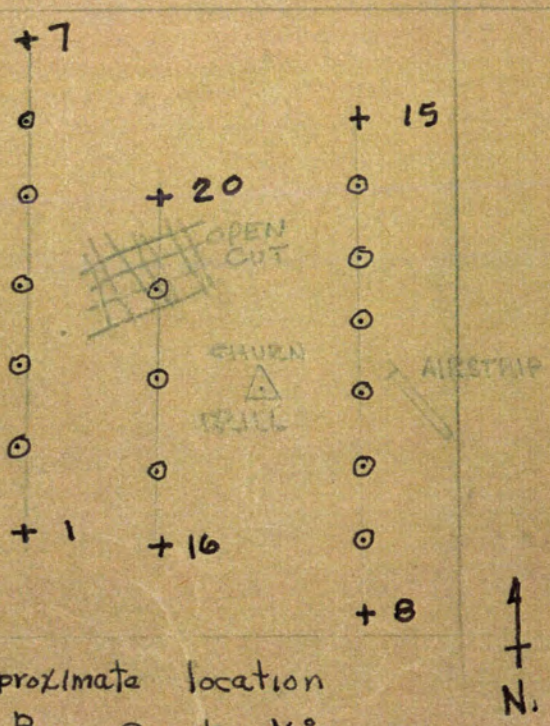
SCALE 1" = 1000'	CONTOUR INTERVAL:	REVISIONS
	DATA BY: P.B & J.P.M.	
DATE 9-64	SHEET OF	
DRAWN BY	DRAWING NO.:	FILE:

E. D. CASSITY
PHOTOGRAMMETRIST
for CLYDE DAVIS

MAGMA

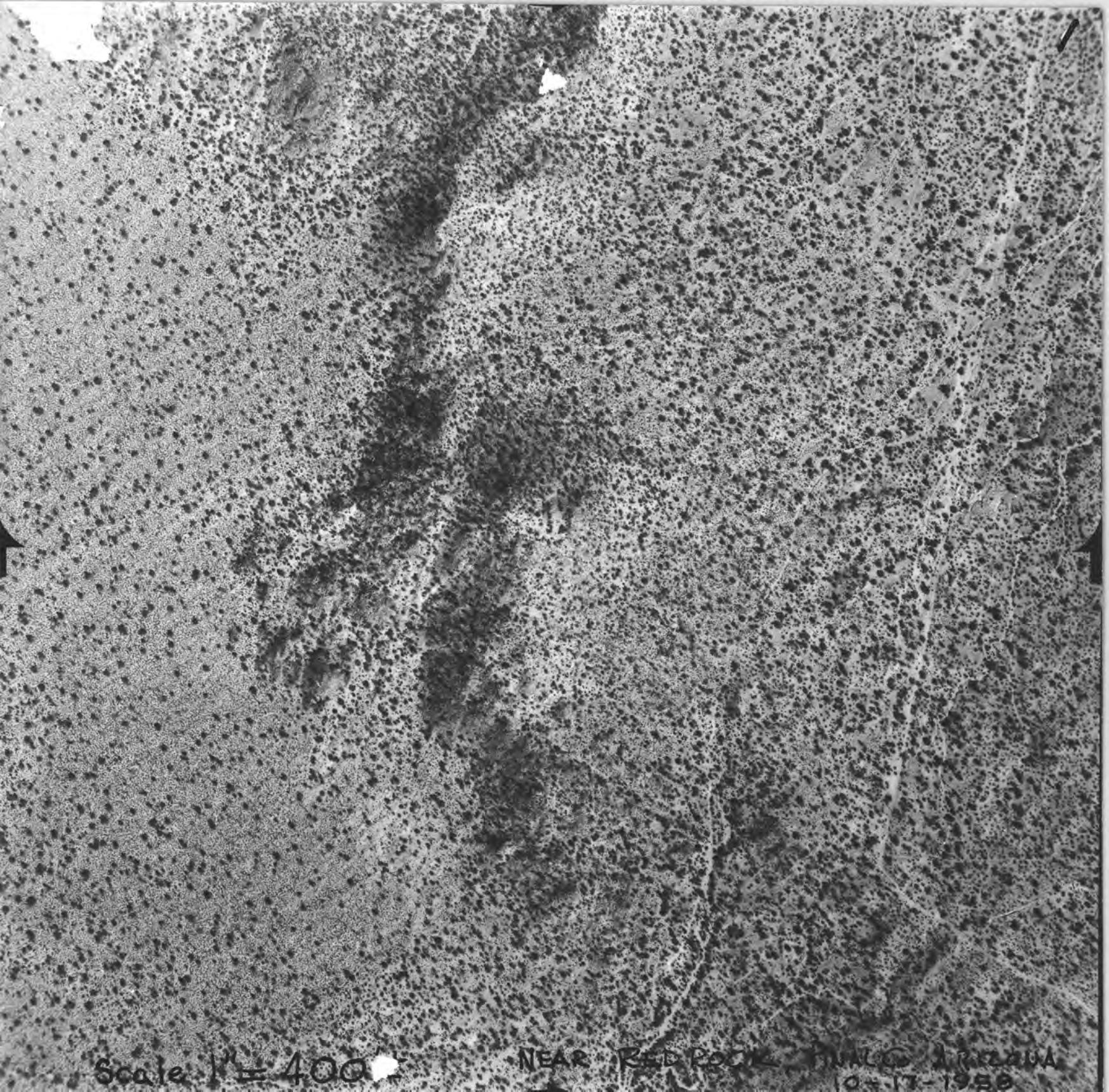
20 CONTACT PRINTS OF AERIAL PHOTOS.
SCALE : 1" = 400' ±
10-17-1958
NEAR RED ROCK, PINAL CO. ARIZONA
(PAISANO TANKS)

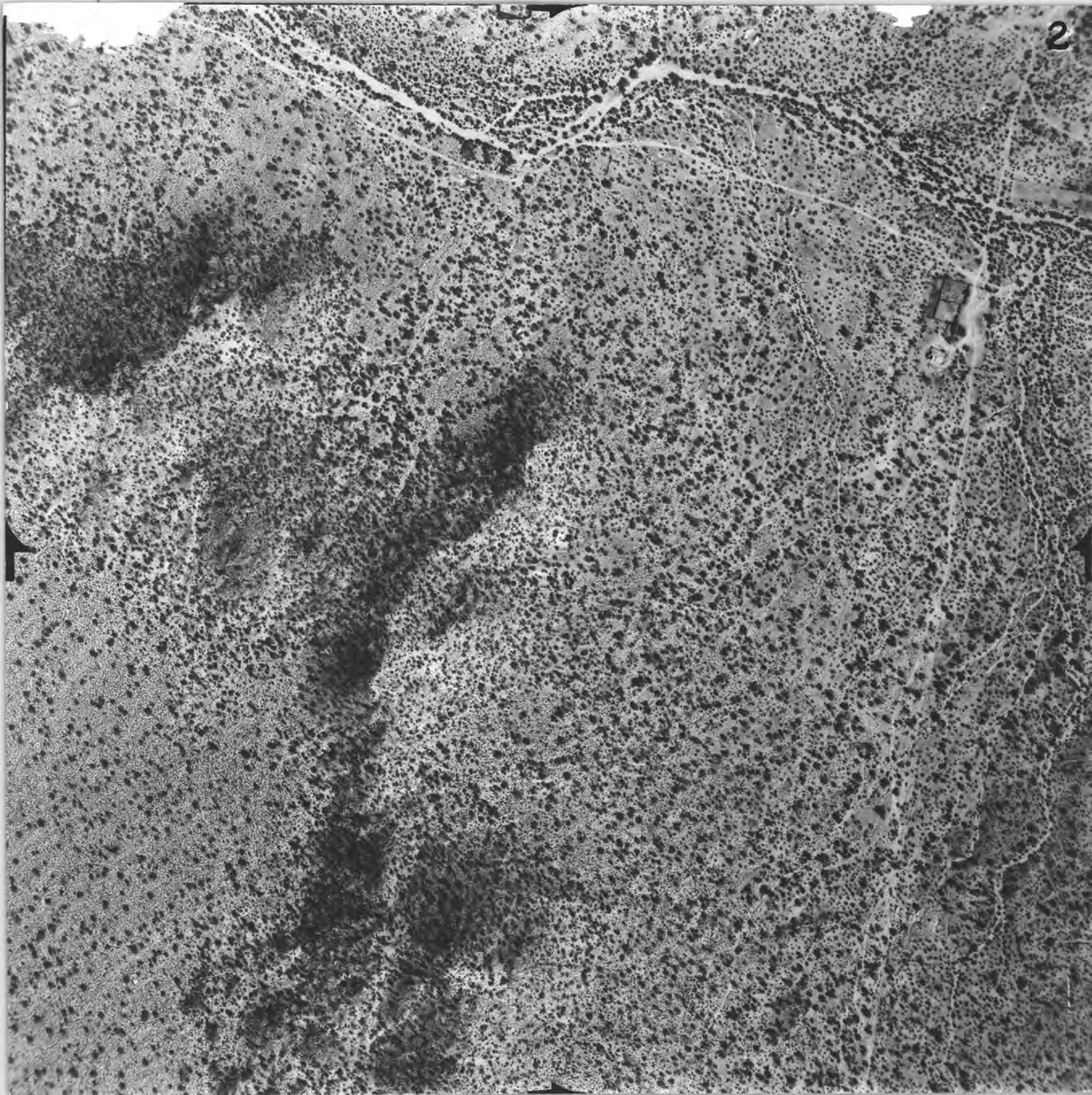
STEREOSCOPIC COVERAGE: W/ 305 mm lens ABOUT 4,800' ABOVE AVERAGE GROUND ELEVATION



Approximate location
By Print N°

+2 Enlarged prints


Scale 1"=400'
NEAR RED ROCK
10-17-1950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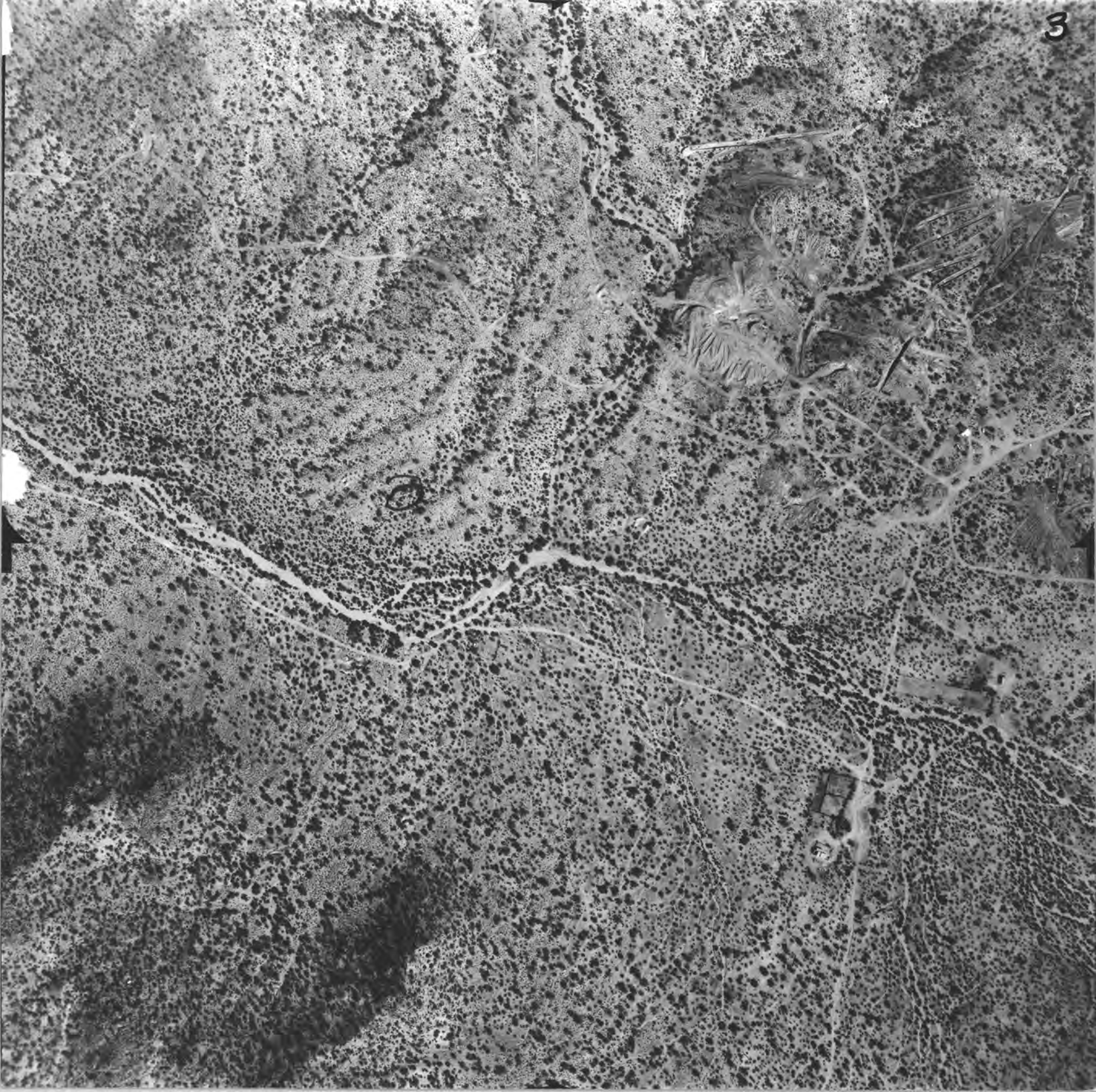
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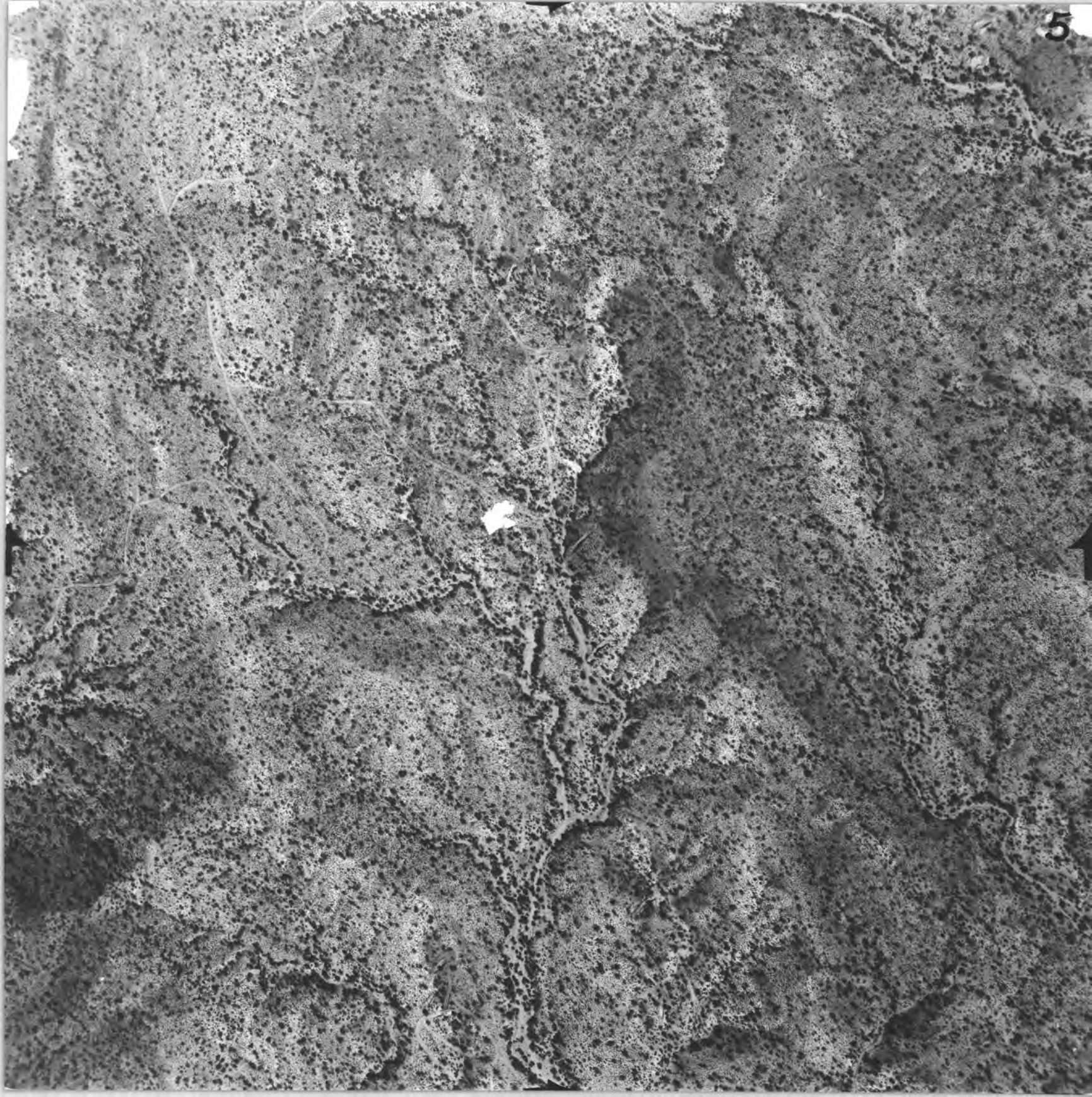
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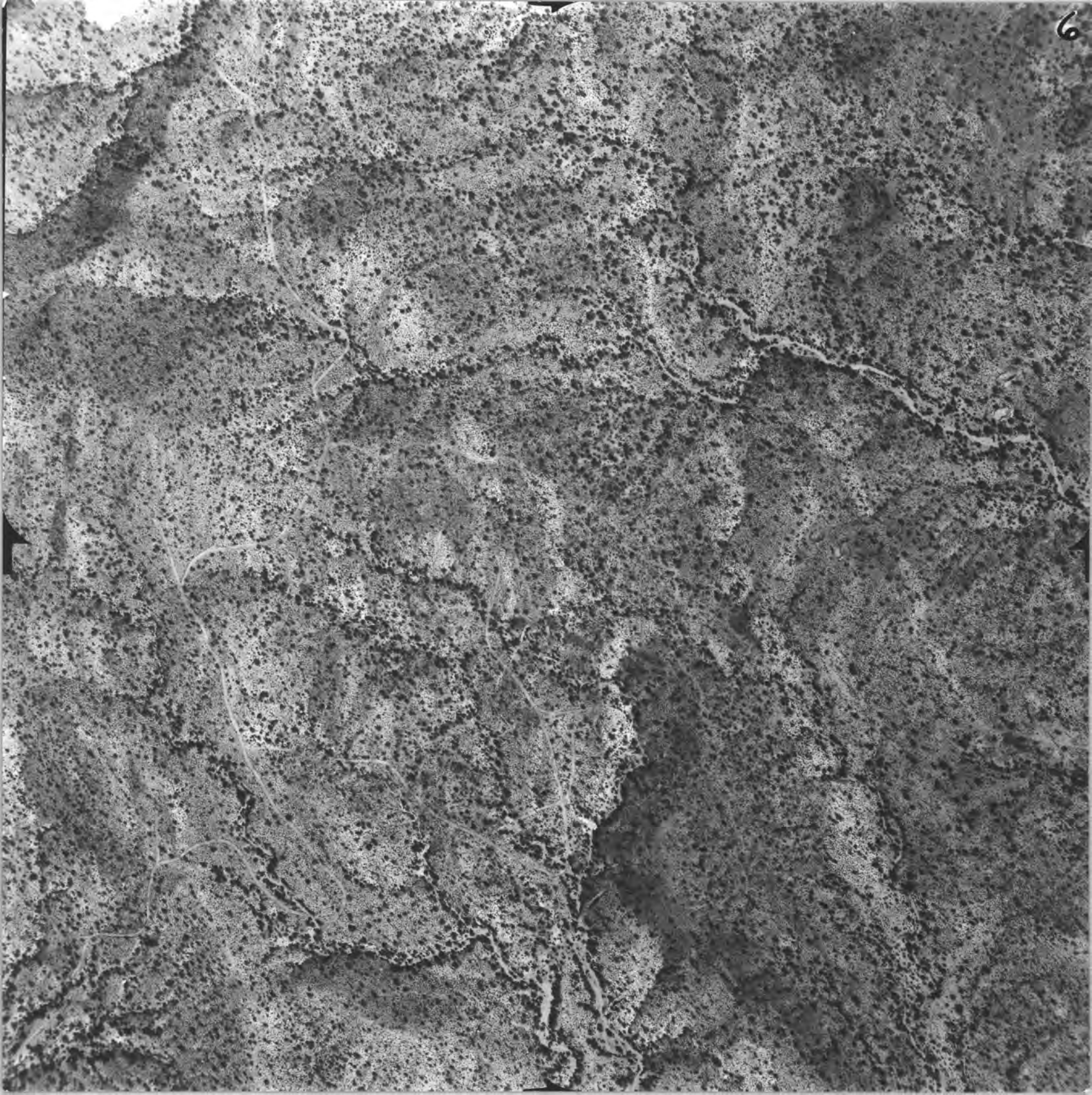

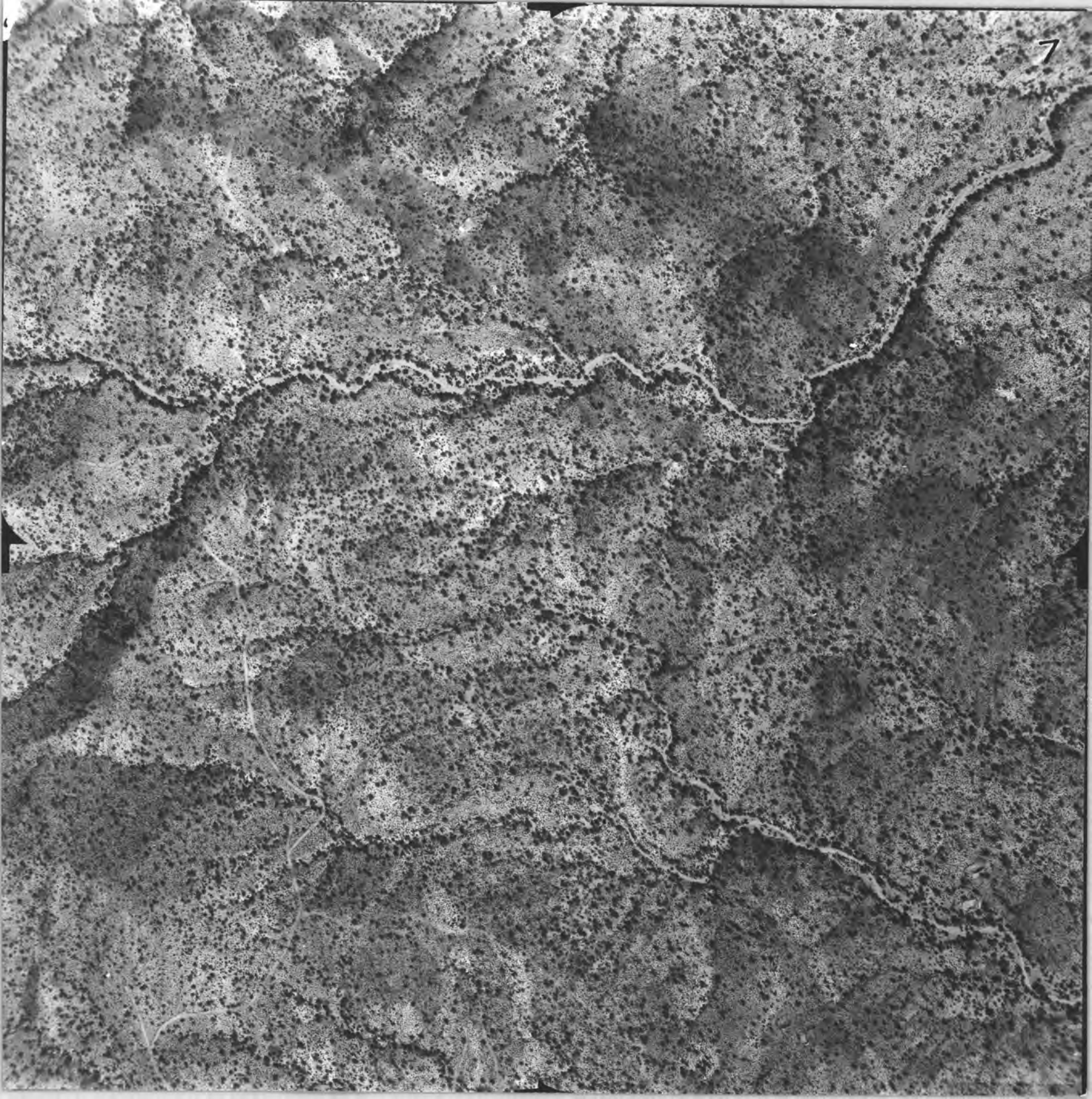
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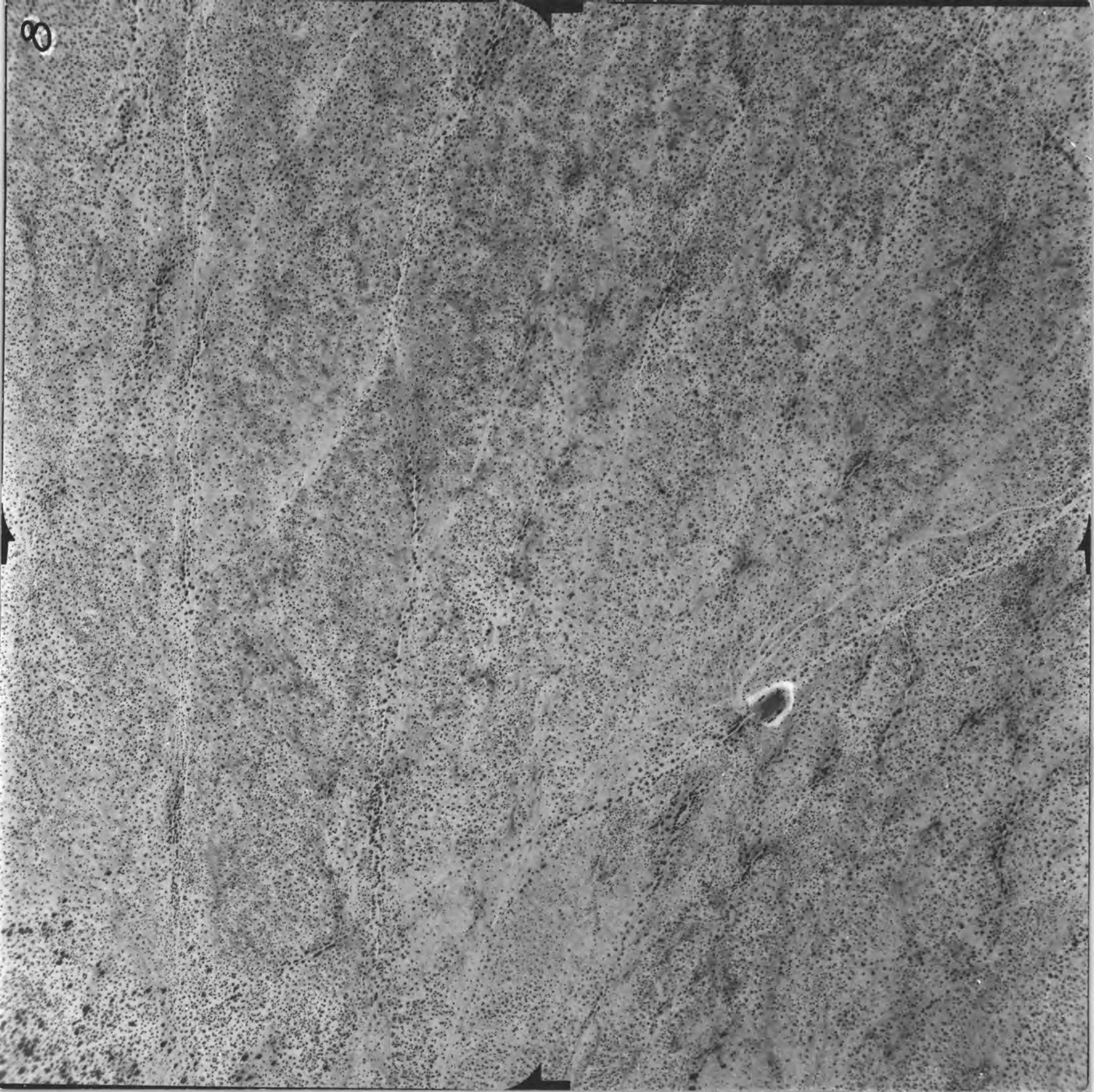
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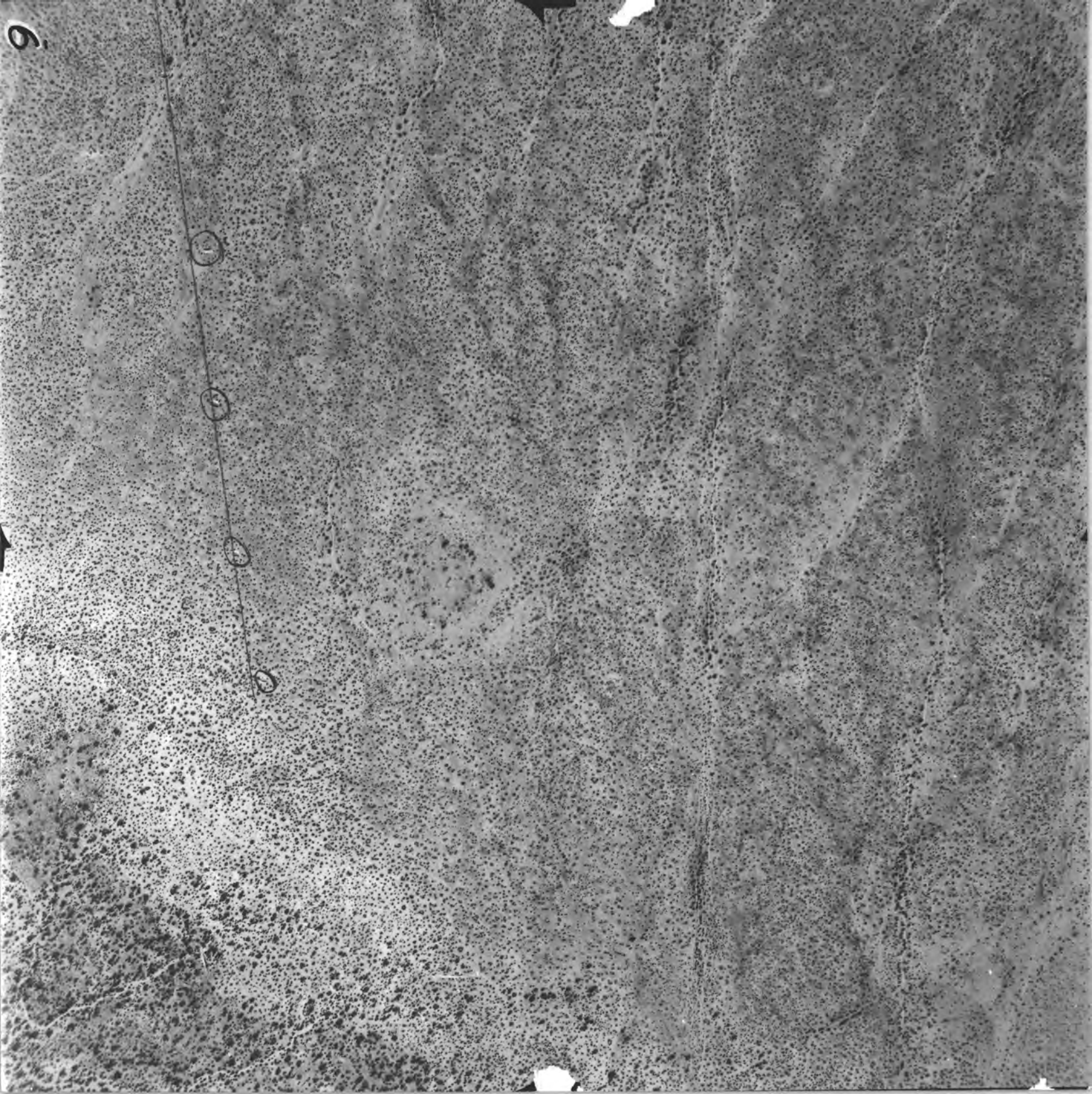

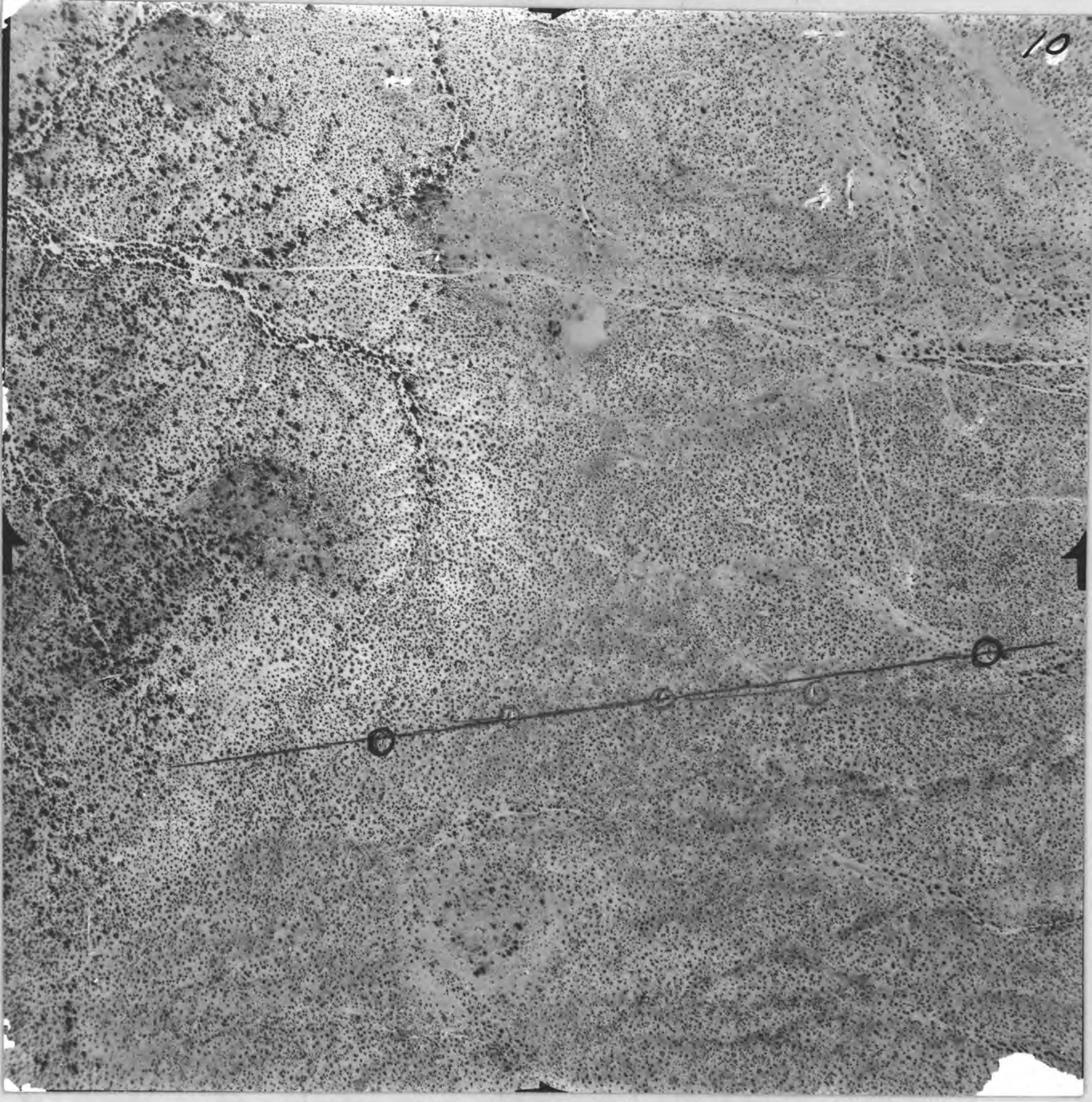

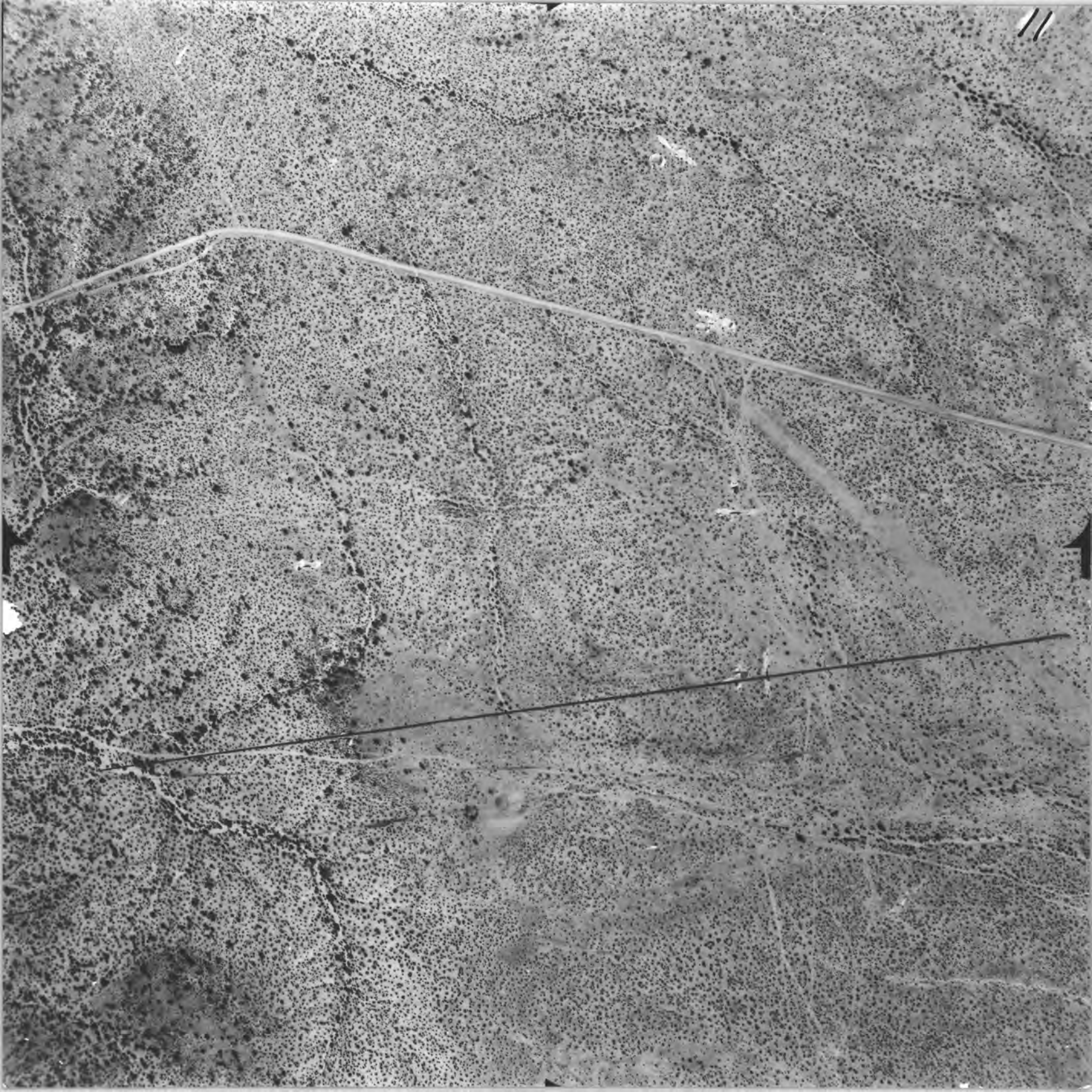

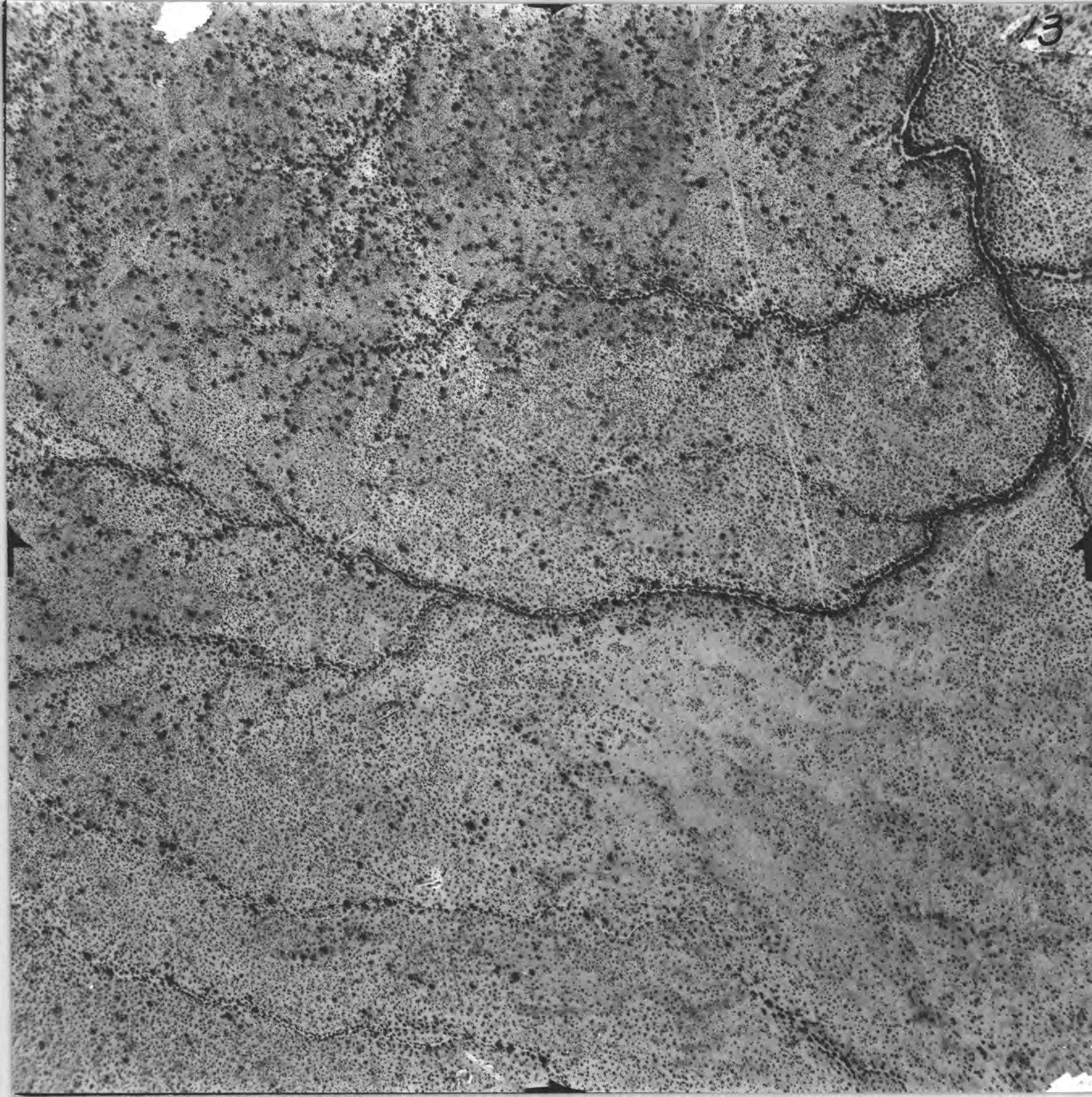
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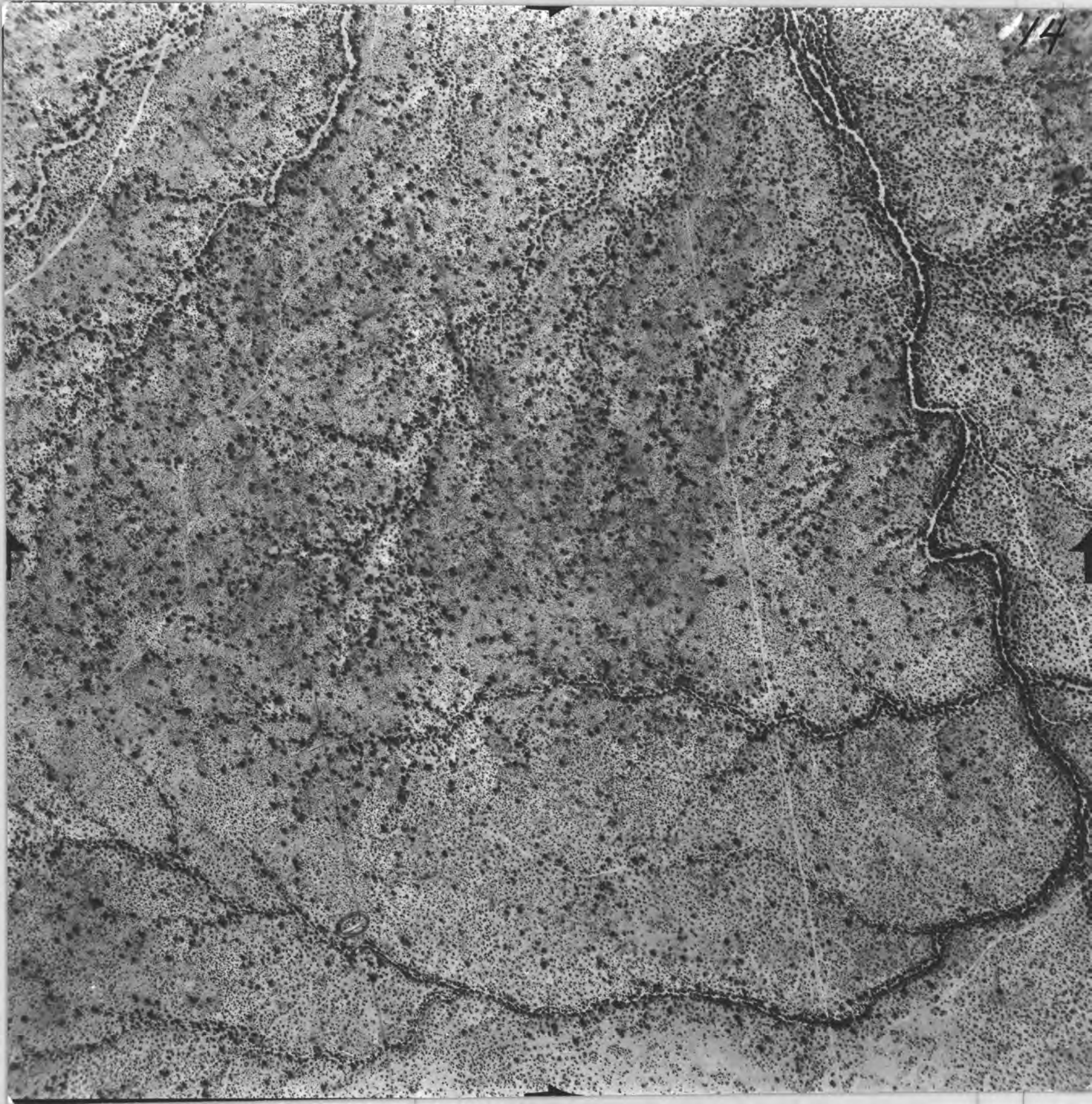

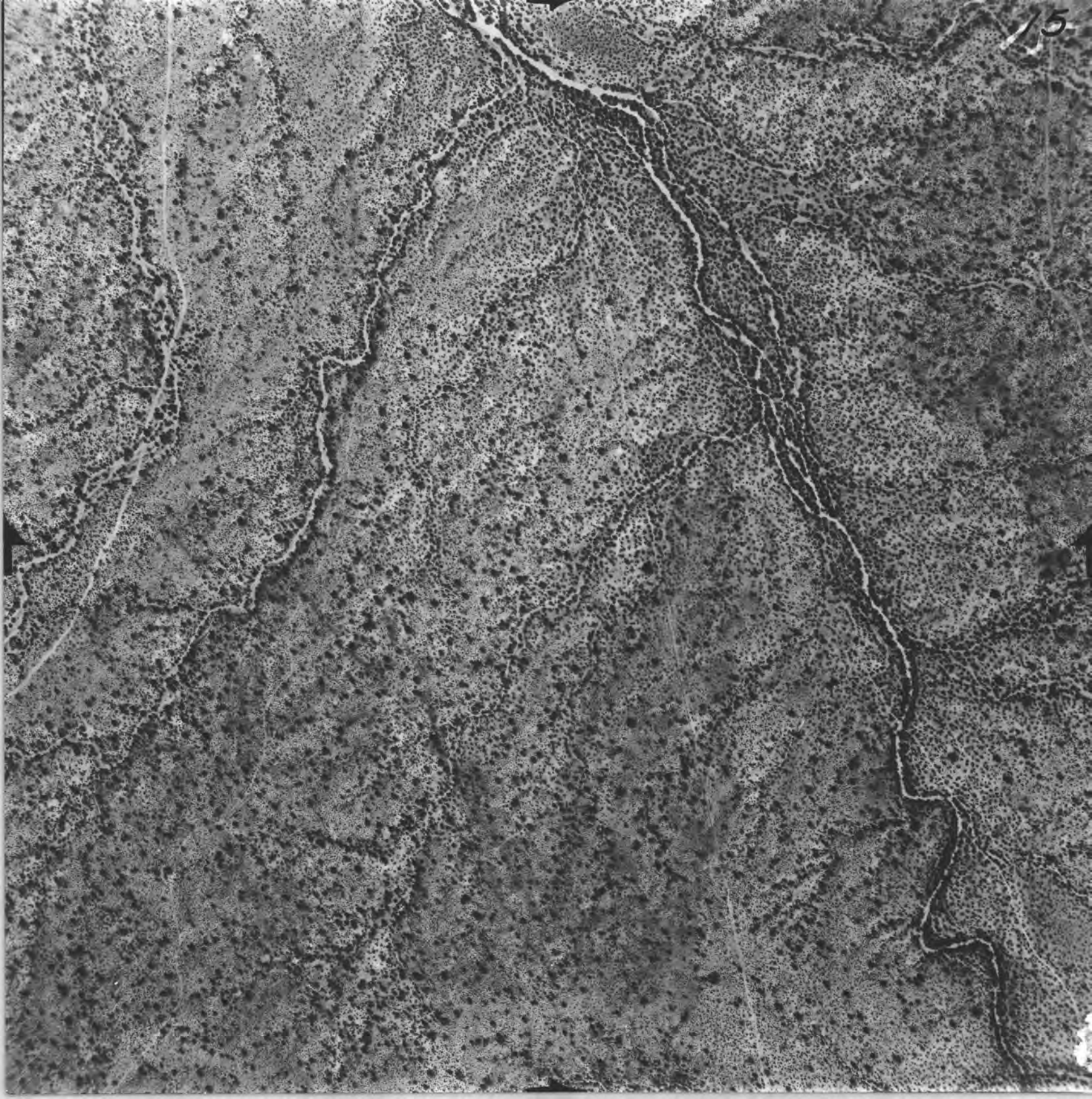

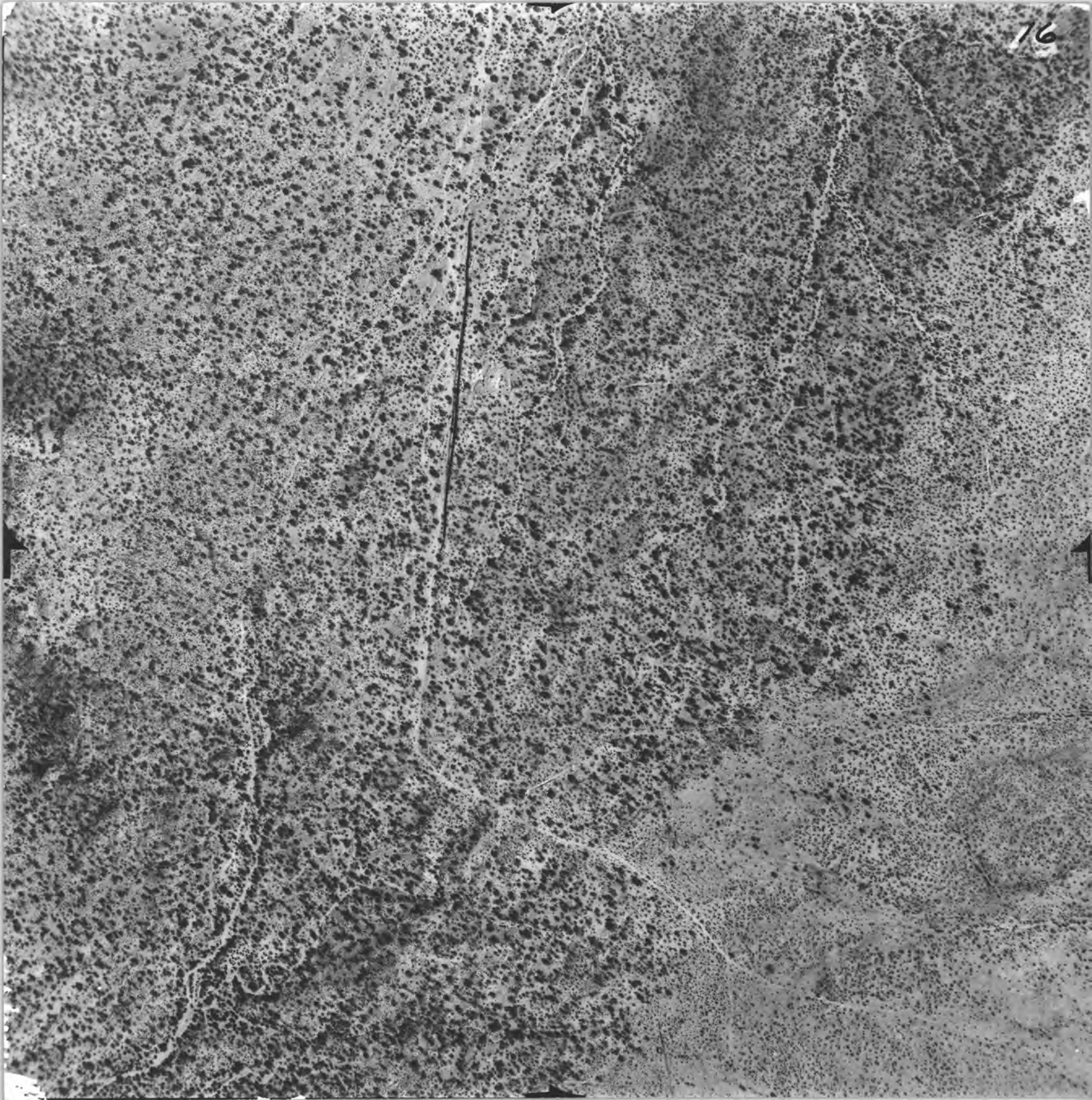

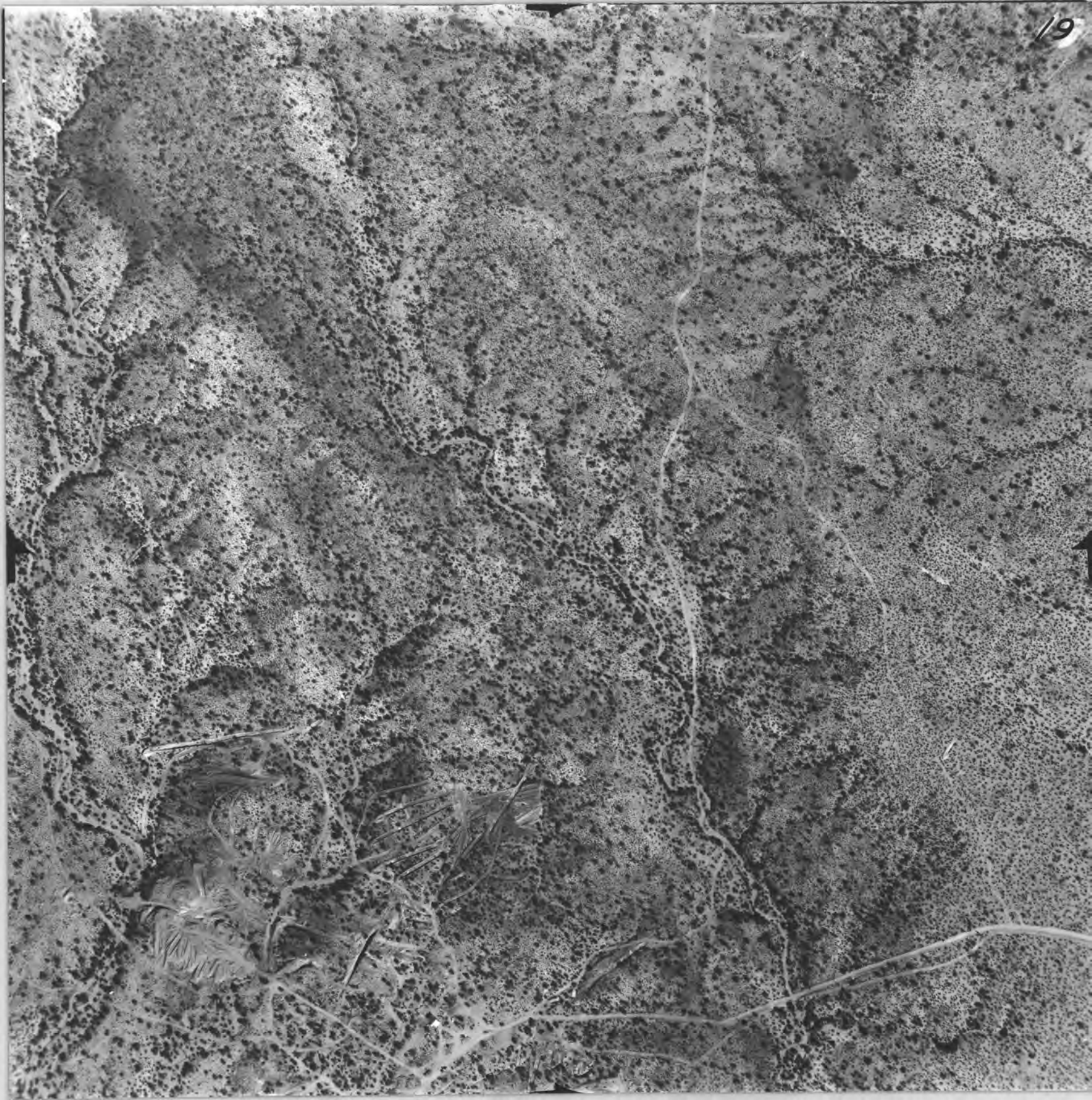
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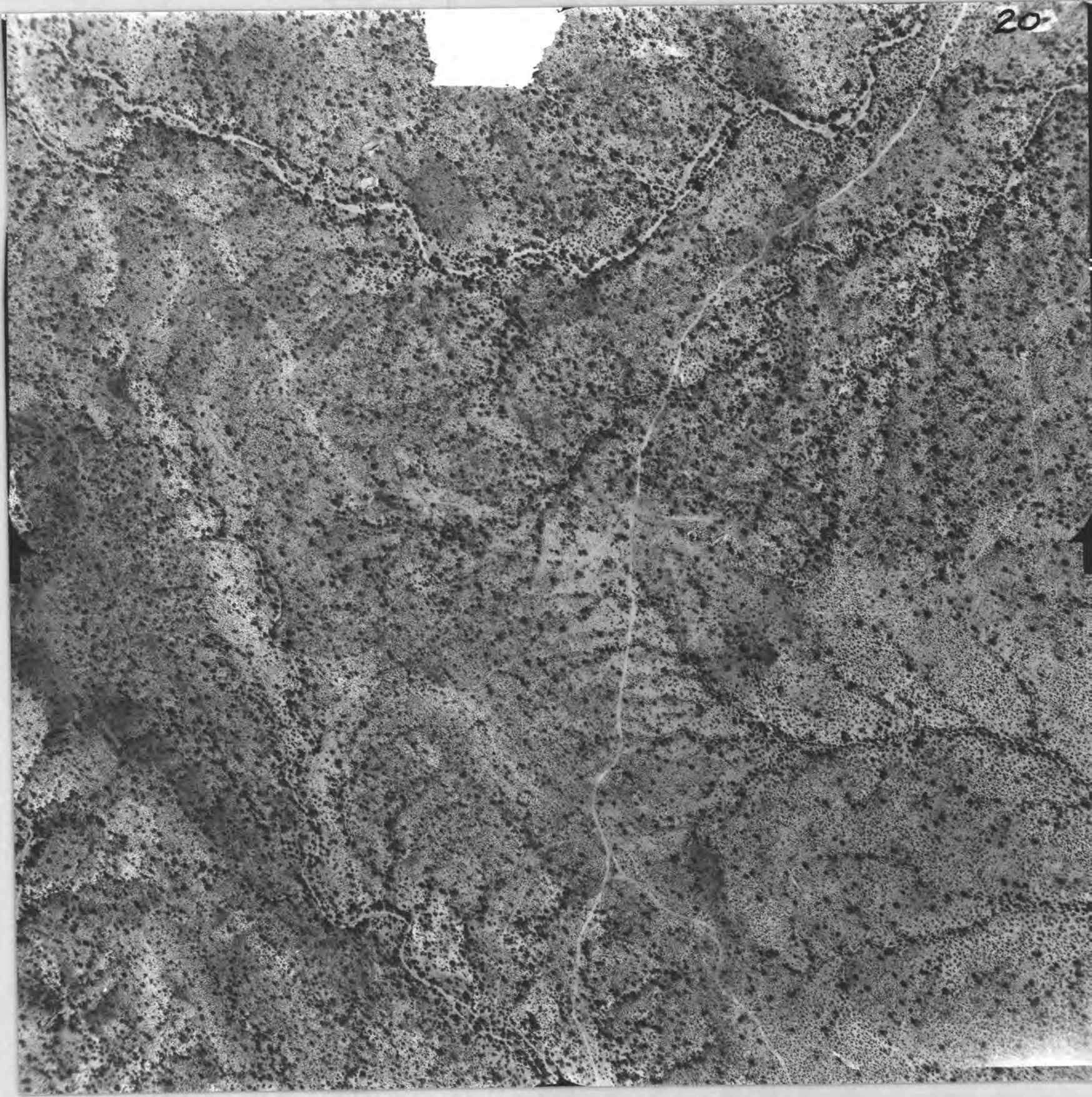
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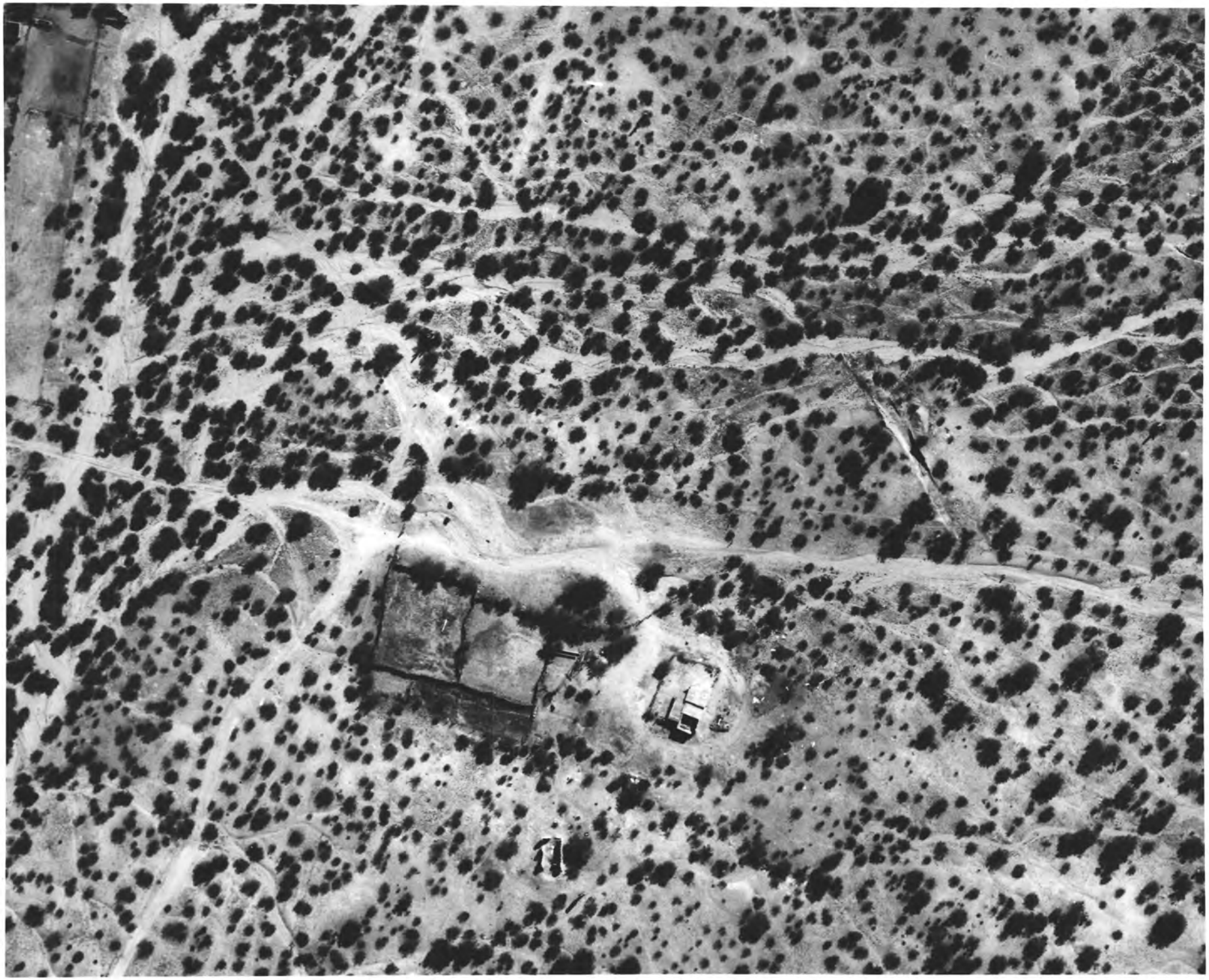
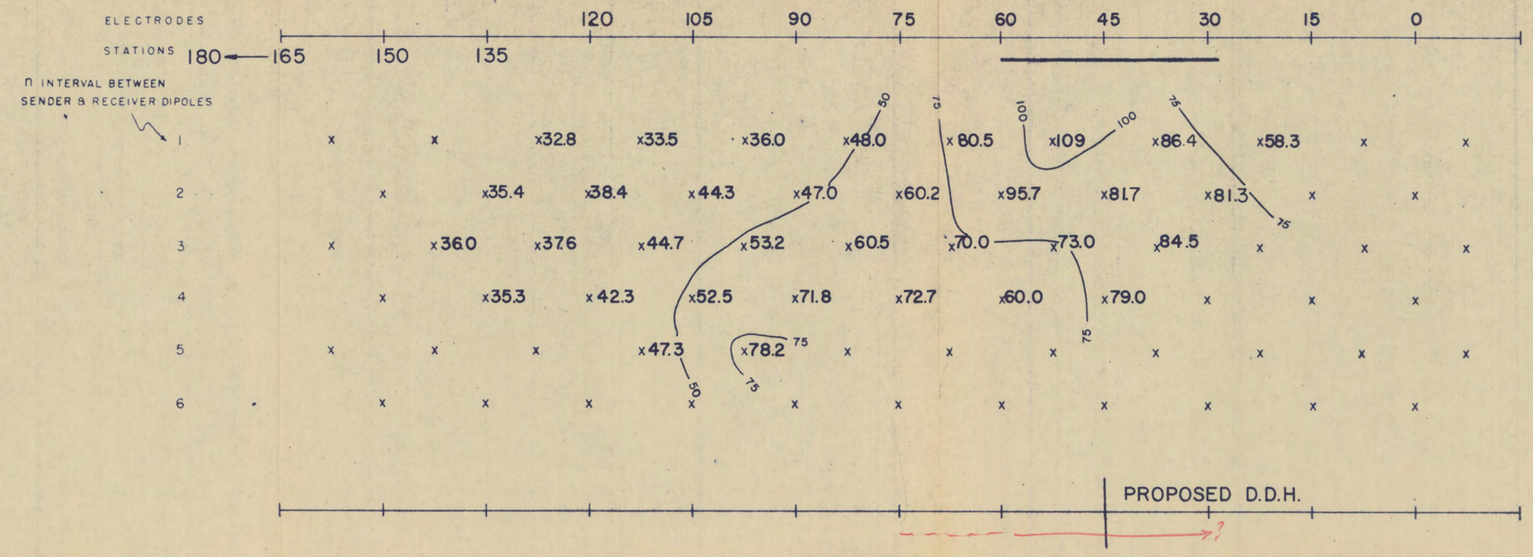
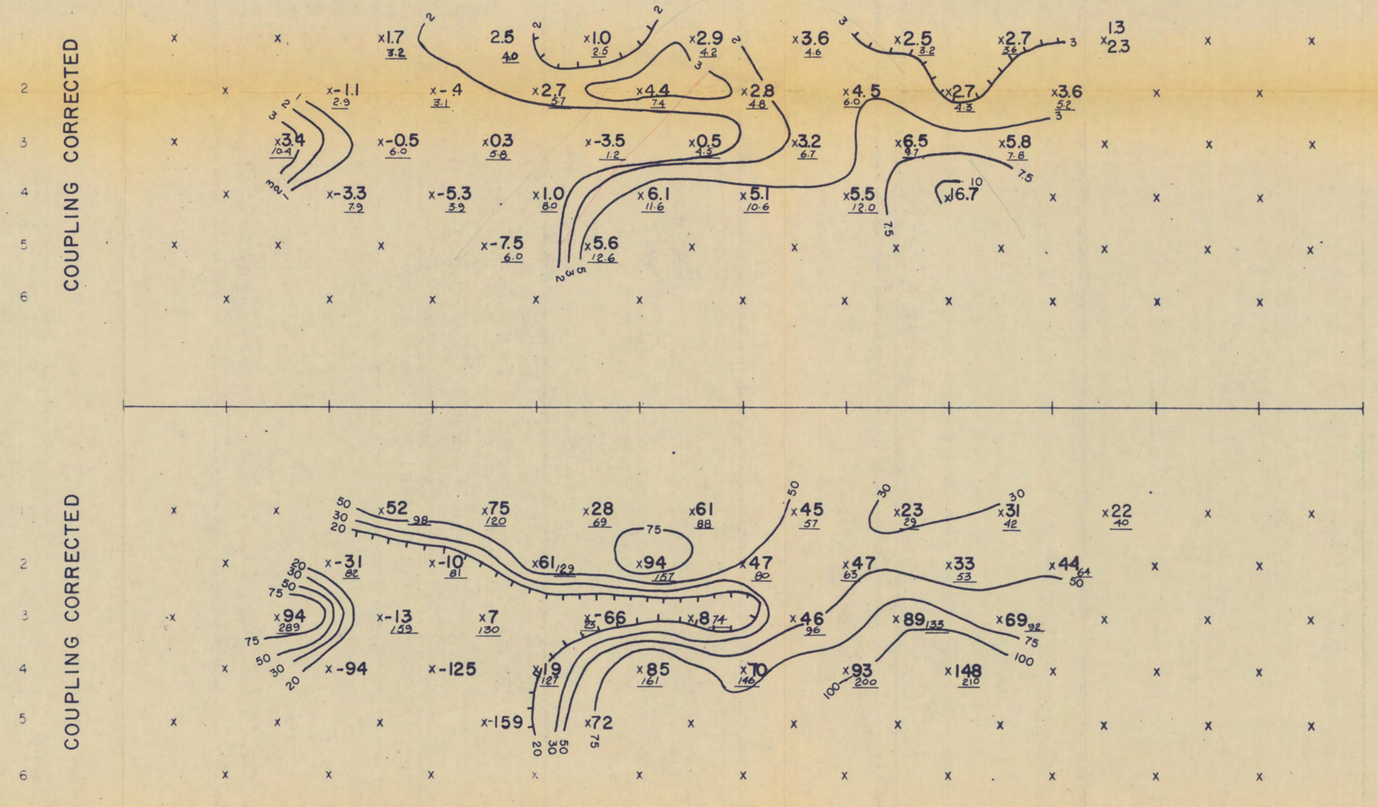






/130 INDICATES VALUES NOT CORRECTED FOR COUPLING EFFECT.

APPARENT RESISTIVITY (ρ_{DC}) IN UNITS OF OHM FEET

CONTOUR INTERVAL LOGARITHMIC

SENDER FREQUENCY: 0.05 c.p.s.

PERCENT FREQUENCY EFFECT (PFE)
CONTOUR INTERVAL CONSTANT
SENDER FREQUENCIES: 0.05 & 3.0 c.p.s

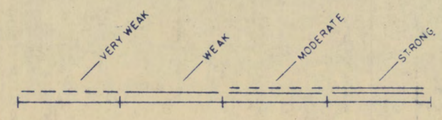
APPARENT "METALLIC CONDUCTION" FACTOR (MCF)
$MCF = \frac{PFE \times 1000}{\rho_{DC}}$
CONTOUR INTERVAL LOGARITHMIC

SELF POTENTIAL
SURFACE PROFILE
GEOLOGY, ETC.

EXPLANATION

ELECTRODE ARRAY: 1500' — n x 1500 — 1500'
SENDER DIPOLE — RECEIVER DIPOLE

RELATIVE ANOMALY STRENGTH



LOOKING NORTHWESTERLY

NORTH STAR MINE AREA
PINAL COUNTY, ARIZ.

SECTIONAL DATA SHEET

LINE NO. 3

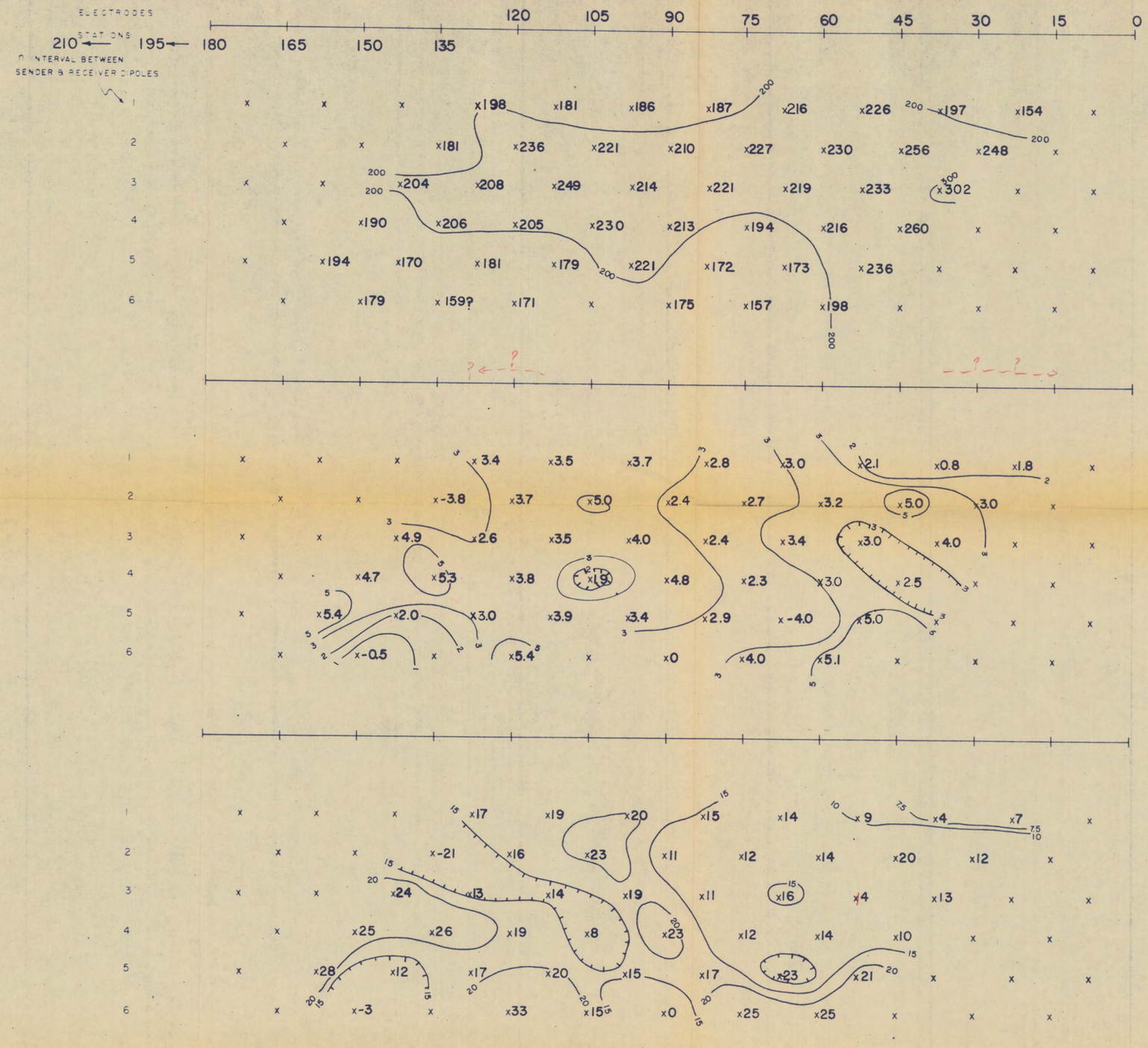
INDUCED POLARIZATION TRAVERSE

HEINRICHS GEOEXPLORATION COMPANY

SCALE: 1" = 1500' DATE: 9-64

FOR

THE MAGMA COPPER CO.



APPARENT RESISTIVITY (ρ_{DC}) IN UNITS OF OHM FEET 2π

CONTOUR INTERVAL LOGARITHMIC

SENDER FREQUENCY: 0.05 c.p.s.

PERCENT FREQUENCY EFFECT (PFE)

CONTOUR INTERVAL CONSTANT

SENDER FREQUENCIES: 0.05 & 3.0 c.p.s.

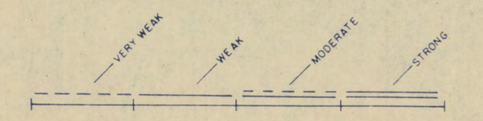
APPARENT "METALLIC CONDUCTION" FACTOR (MCF)

$\left(MCF = \frac{PFE \times 1000}{\rho_{DC}/2\pi}\right)$

CONTOUR INTERVAL LOGARITHMIC

EXPLANATION

RELATIVE ANOMALY STRENGTH



LOOKING NORTH WESTERLY

NORTH STAR MINE AREA
PINAL COUNTY, ARIZ.

SECTIONAL DATA SHEET

LINE NO. 2

INDUCED POLARIZATION TRAVERSE

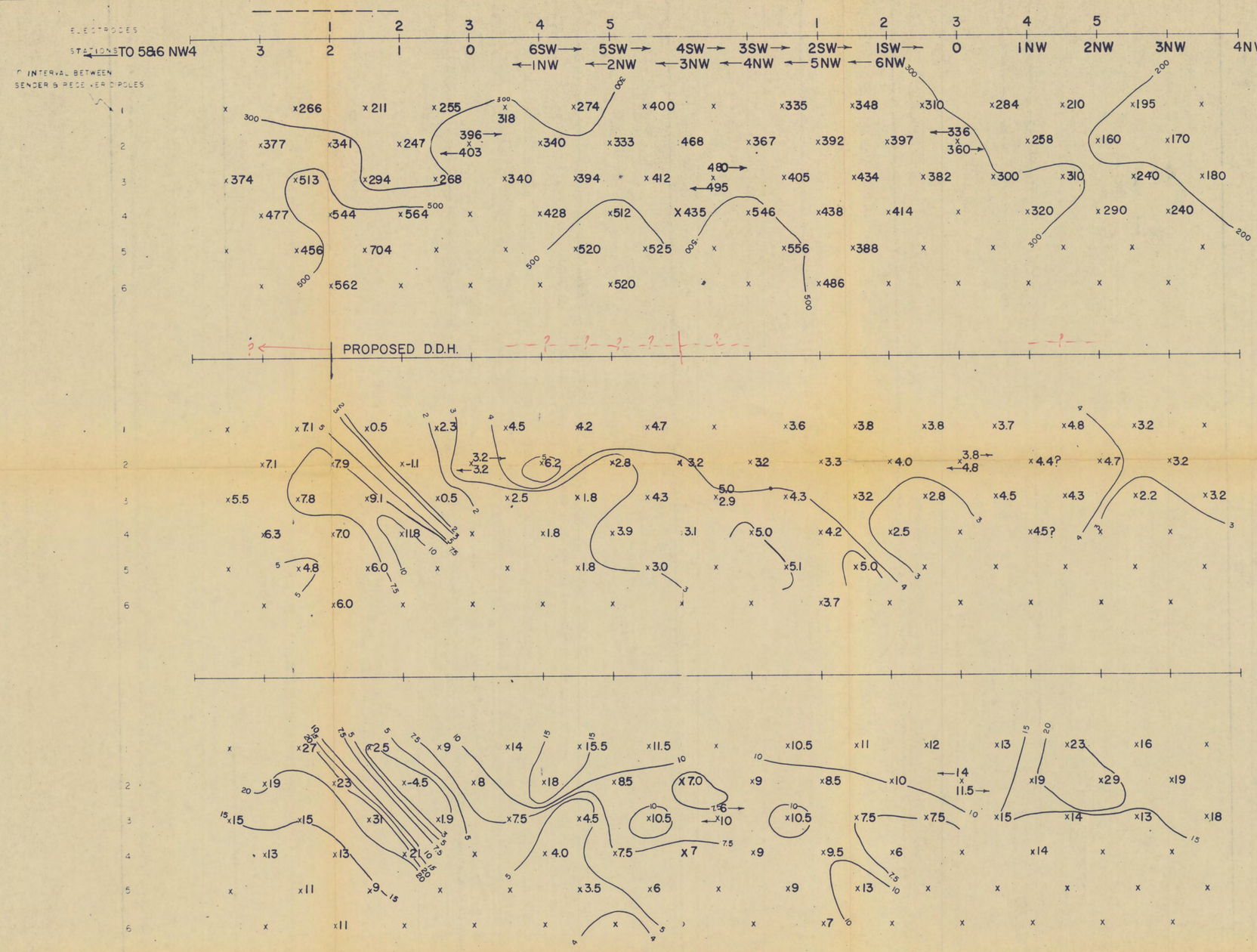
HEINRICHS GEOEXPLORATION COMPANY

SCALE: 1"=1500' DATE: 9-64

FOR

THE MAGMA COPPER CO.

SELF POTENTIAL
SURFACE PROFILE
GEOLOGY, ETC.



APPARENT RESISTIVITY (ρ DC) IN UNITS OF OHM FEET

CONTOUR INTERVAL: LOGARITHMIC
SENDER FREQUENCY: 0.05 C.P.S.

EXPLANATION

ELECTRODE ARRAY: 1000 — 1000 — 1000
SENDER DIPOLE — RECEIVER DIPOLE

RELATIVE ANOMALY STRENGTH

VERY WEAK — WEAK — MODERATE — STRONG

LOOKING NORTH-WESTERLY

PERCENT FREQUENCY EFFECT (PFE)
CONTOUR INTERVAL CONSTANT
SENDER FREQUENCIES: 0.05 & 3.0 C.P.S.

APPARENT "METALLIC CONDUCTION" FACTOR (MCF)
(MCF = PFE x 1000 / ρ DC)
CONTOUR INTERVAL: LOGARITHMIC

NORTH STAR MINE AREA
PINAL COUNTY, ARIZ.

SECTIONAL DATA SHEET
LINE NO. 1
INDUCED POLARIZATION TRAVERSE

HEINRICHS GEOEXPLORATION COMPANY
SCALE: 1" = 1000' DATE: 9-64

FOR
THE MAGMA COPPER CO.

SELF POTENTIAL
SURFACE PROFILE
GEOLOGY, ETC.

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R 9 E

R 10 E

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LINE 1

LINE 1A

LINE 2

LINE 3

N

INDICATES INDUCED POLARIZATION SURVEY LOCATION

INDICATES WEAK ANOMALISM

HEINRICHS GEOEXPLORATION COMPANY
P. O. Box 5671 Tucson, Arizona

INDUCED POLARIZATION SURVEY LOCATION
NORTH STAR MINE AREA
FOR
THE MAGMA COPPER CO.
PINAL COUNTY ARIZ.

SCALE 1" = 1000'	CONTOUR INTERVAL:	REVISIONS
	DATA BY: P.B & J.P.M.	
DATE 9 - 64	SHEET OF	
DRAWN BY	DRAWING NO.:	FILE:

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LINE 1
LINE 14
LINE 2
LINE 3
NO.2
NO.1

N

INDICATES INDUCED POLARIZATION SURVEY LOCATION

INDICATES WEAK ANOMALISM

" MODERATE "

PROPOSED D.D.H.

HEINRICHS GEOEXPLORATION COMPANY
P.O. Box 5671 Tucson, Arizona

INDUCED POLARIZATION SURVEY LOCATION
NORTH STAR MINE AREA
FOR
THE MAGMA COPPER CO.
PINAL COUNTY ARIZ.

SCALE: 1" = 1000'	CONTOUR INTERVAL:	REVISIONS
	DATA BY: P.B & J.P.M.	
DATE 9-64	SHEET OF	
DRAWN BY	DRAWING NO.:	FILE:

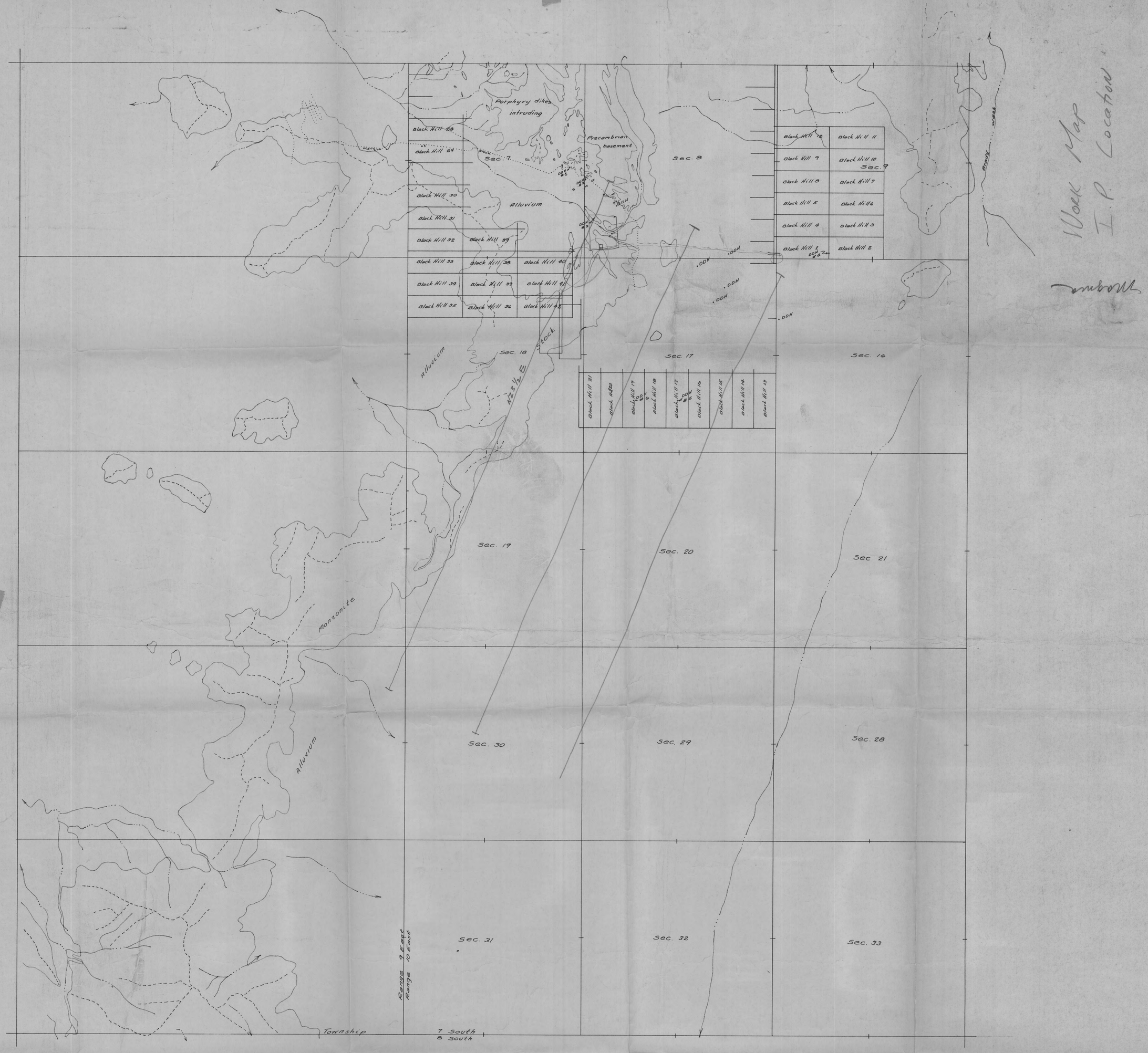
INDUCED POLARIZATION SURVEY LOCATION
NORTH STAR MINE AREA
THE MAGMA COPPER CO.
PINAL COUNTY. ARIZ

MAP OF PART OF THE
NORTHERN PICACHO MOUNTAINS
SHOWING BEDROCK OUTCROPS

Scale 1" = 1000'

INDUCED POLARIZATION SURVEY LOCATION
NORTH STAR MINE AREA
THE MAGMA COPPER CO.
PINAL COUNTY, ARIZONA
Shows 1967 Hanna Coverage also

SCALE 1" = 1000'
DATE 9-64
DATA BY P.B. & JPM

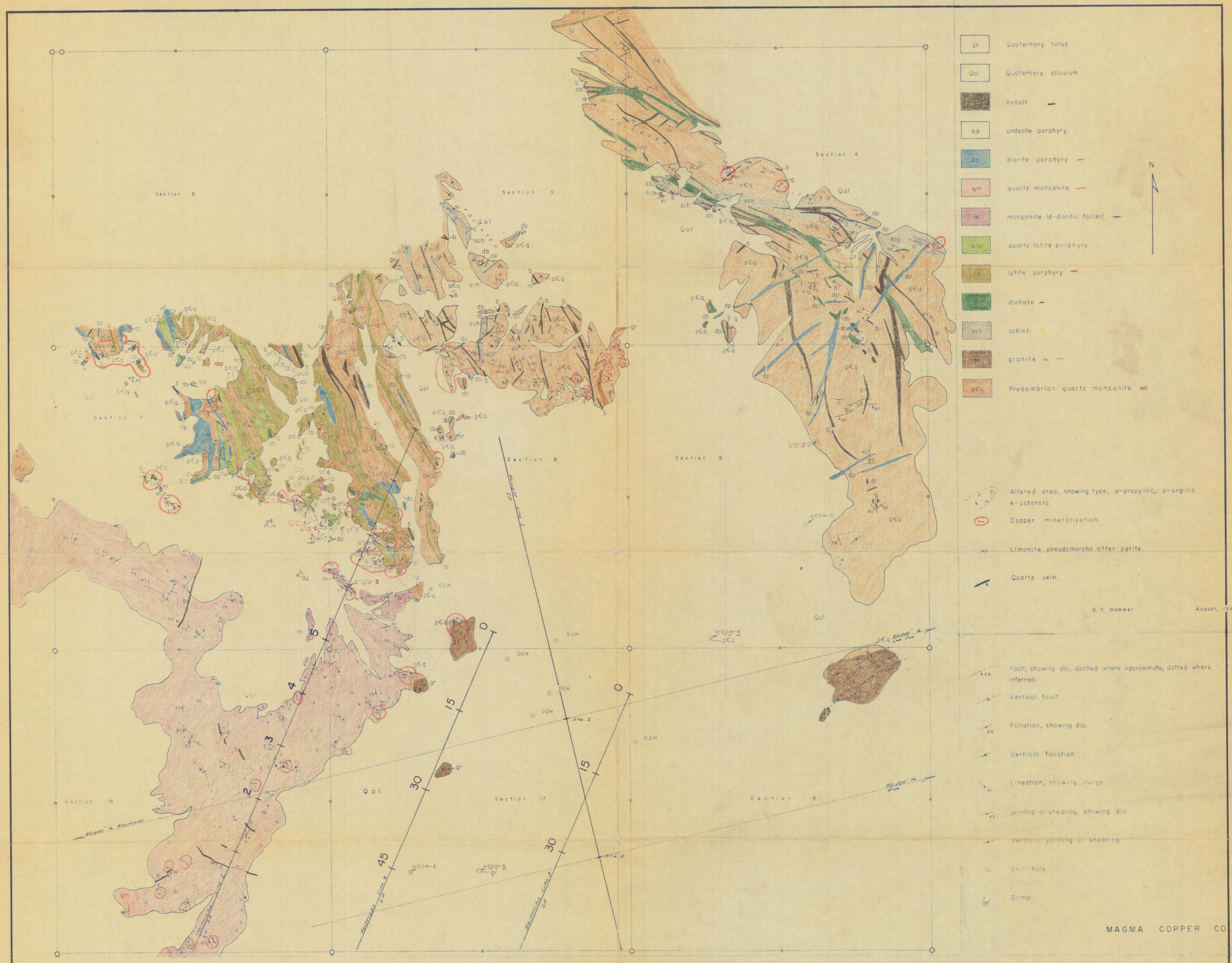


Work Map
I.P. Location

Magma

MAP OF PART OF THE
NORTHERN PICACHO MOUNTAINS
SHOWING BEDROCK OUTCROPS

Scale 1" = 1000'



T. 7 S.
R. 10 E.

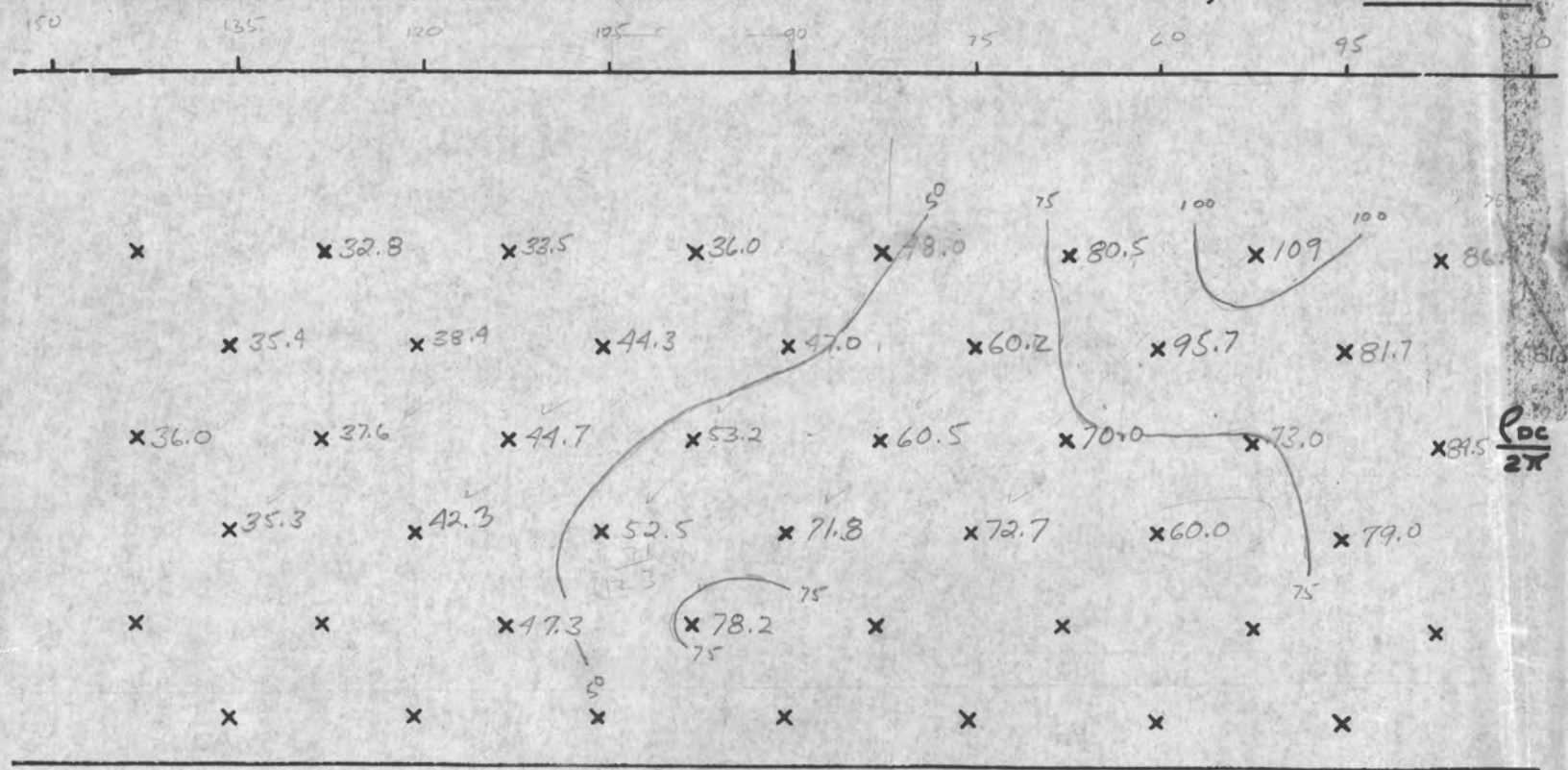
GEOLOGIC MAP OF PART OF THE NORTHERN PICACHO MOUNTAINS, PINAL COUNTY, ARIZONA

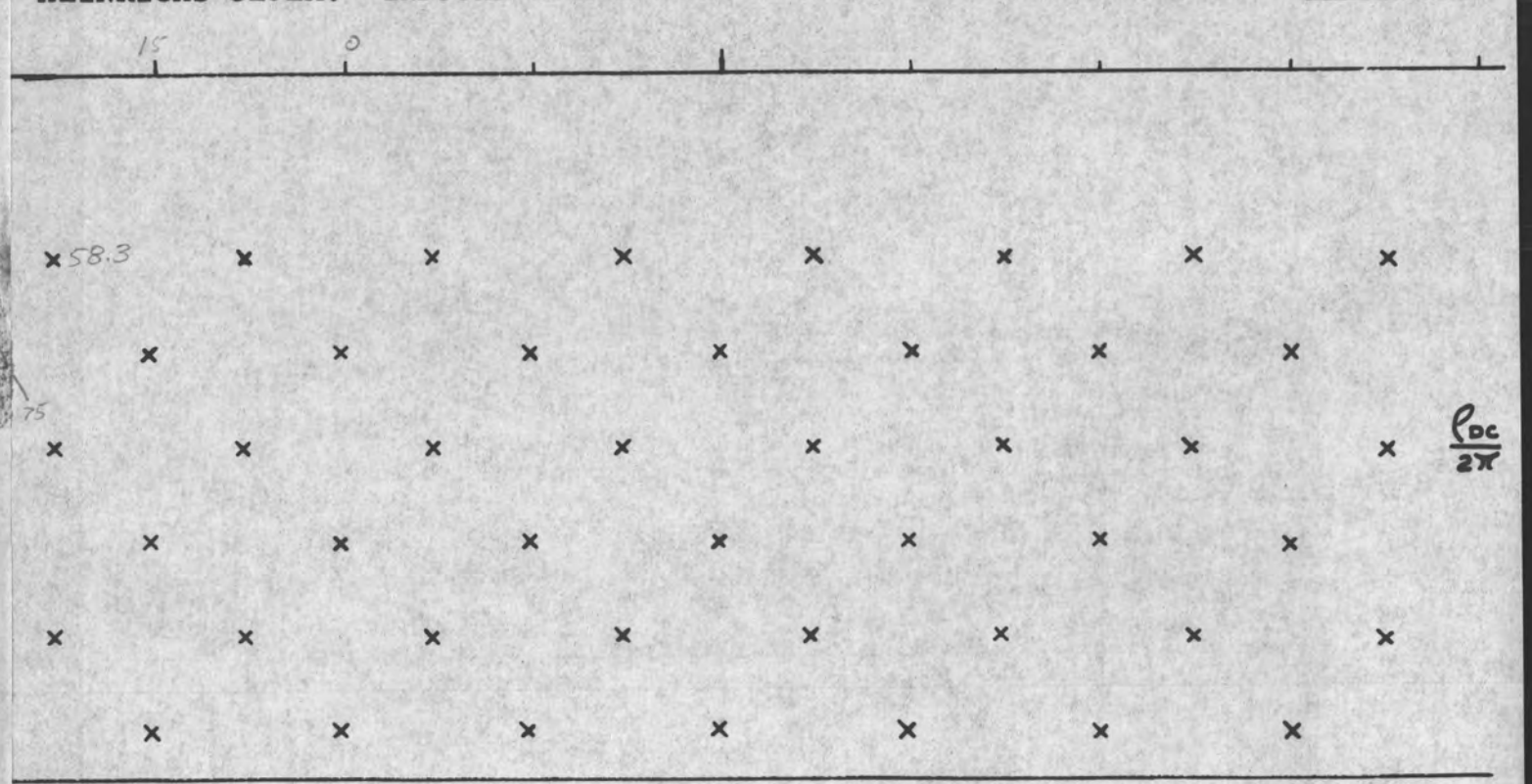
1" = 1000'

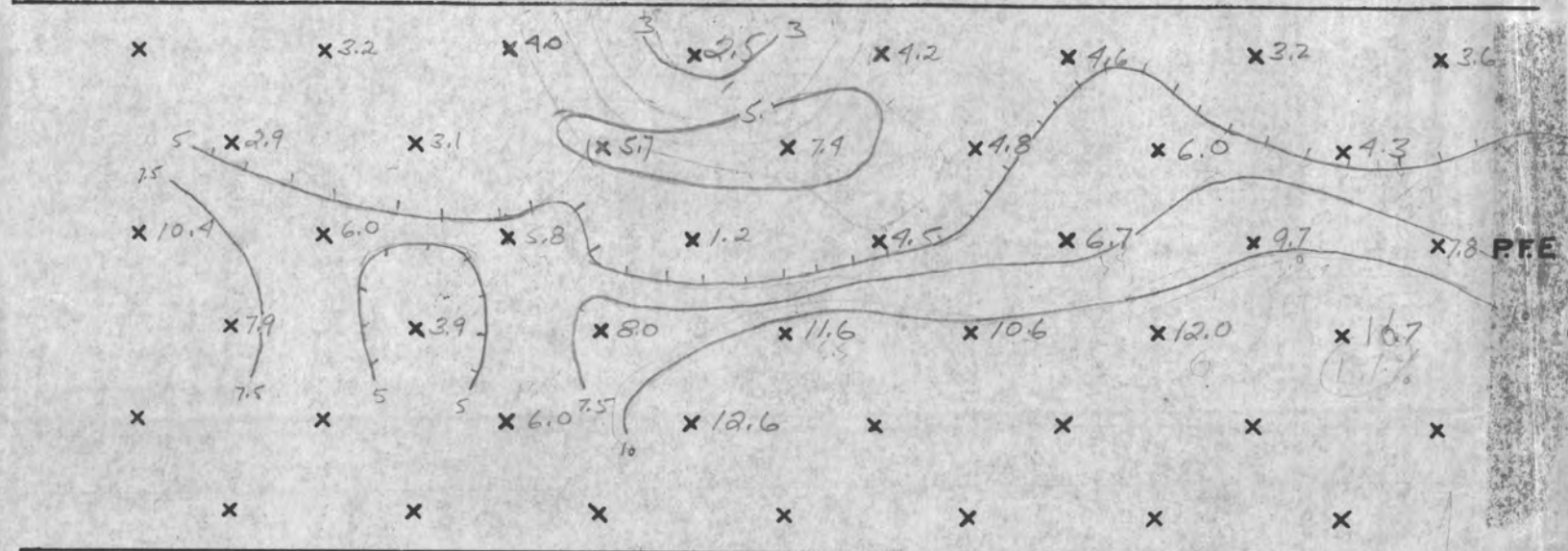
Return to J. Kalo of Streich
Cardon
Weeks
French etc.

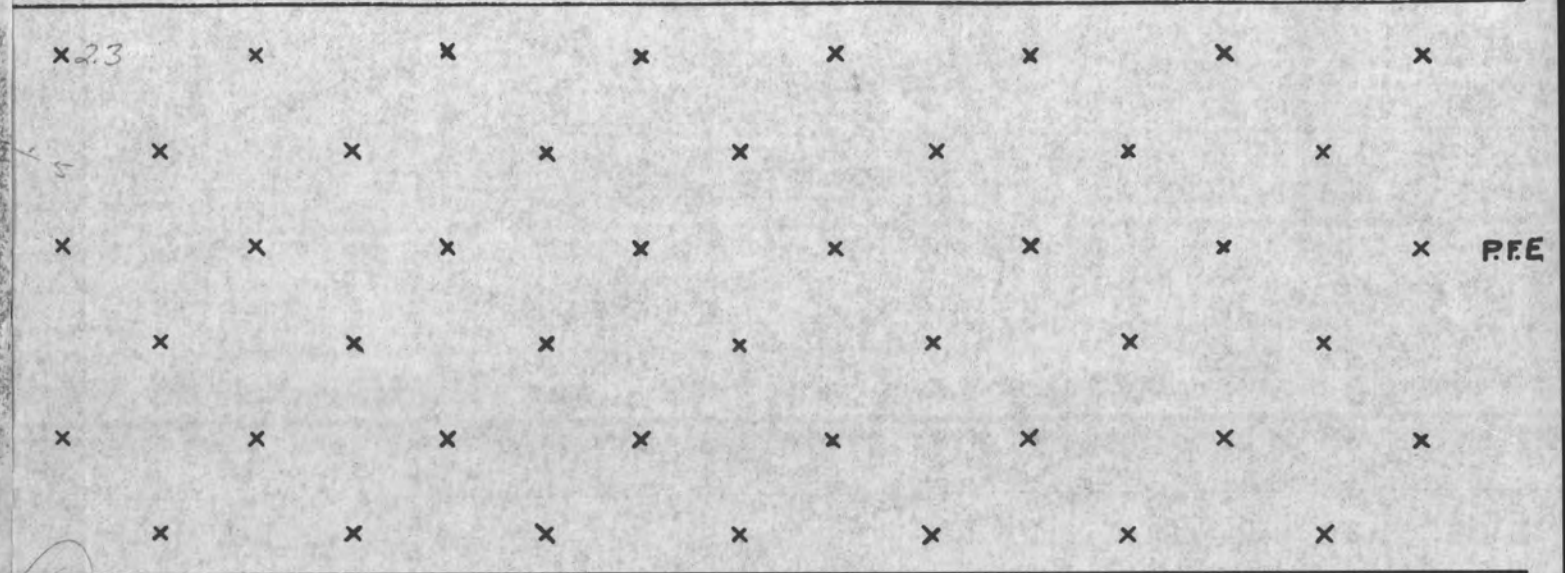
HEINRICHS GEOEX. INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING W

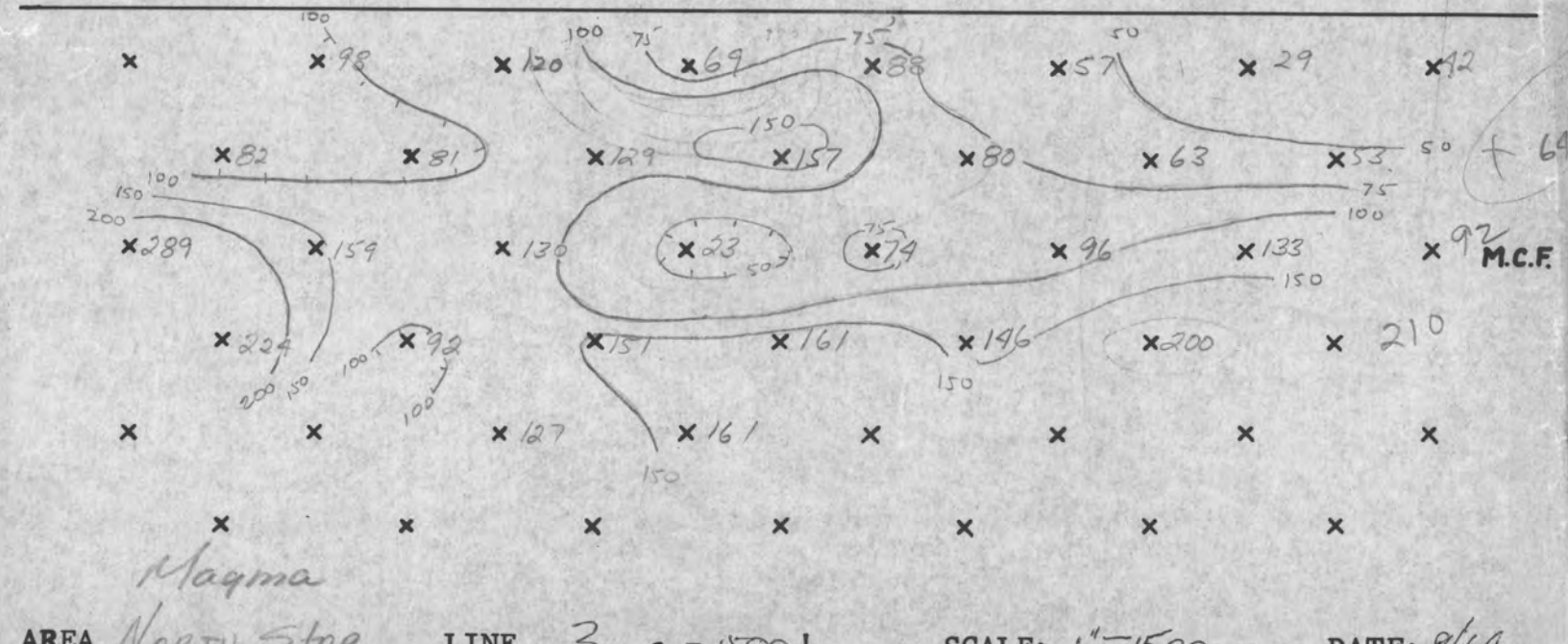
HEINRICHS GEOEX. INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING

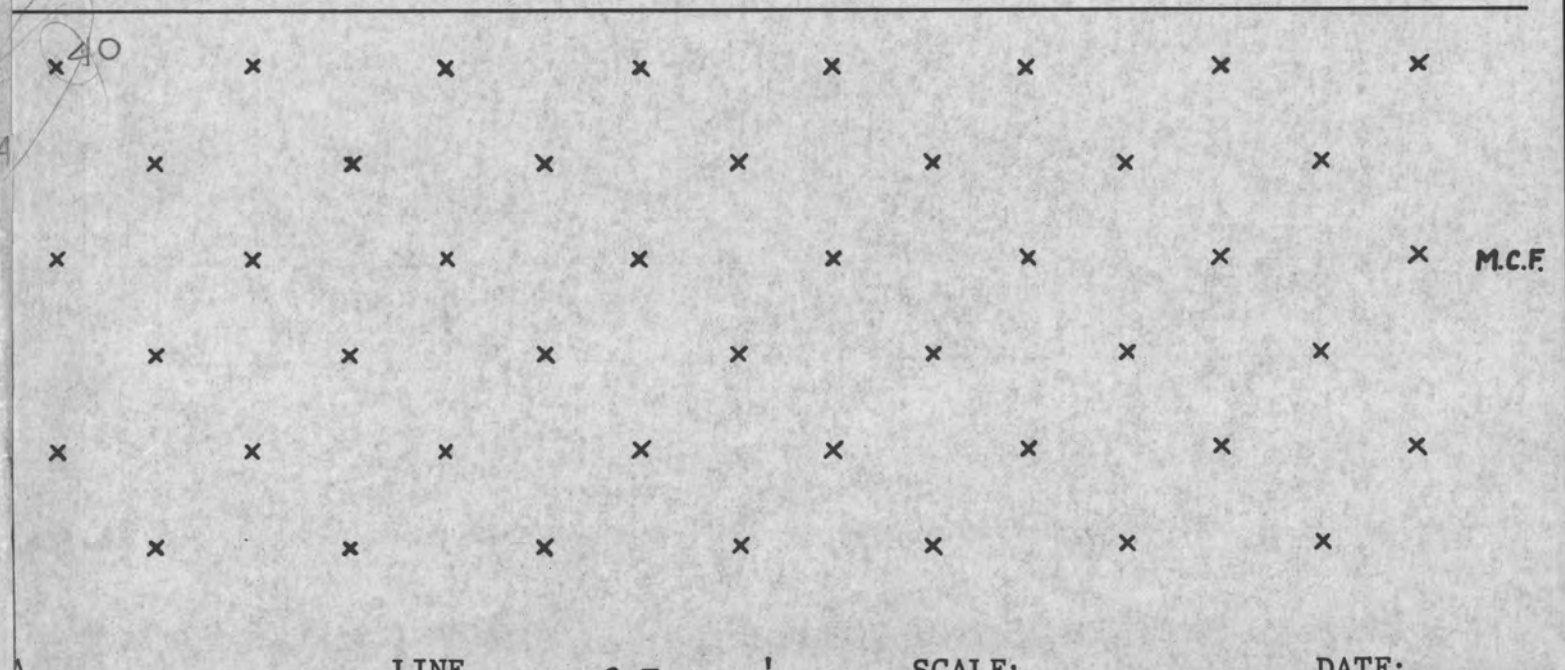












Magma

AREA North Star LINE 3 a = 1500' SCALE: 1"=1500 DATE: 9/64

A LINE a = ' SCALE: DATE:

HEINRICHS GEOEX. INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING _____

HEINRICHS GEOEX. INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING _____

$\frac{\rho_{DC}}{2\pi}$

P.F.E

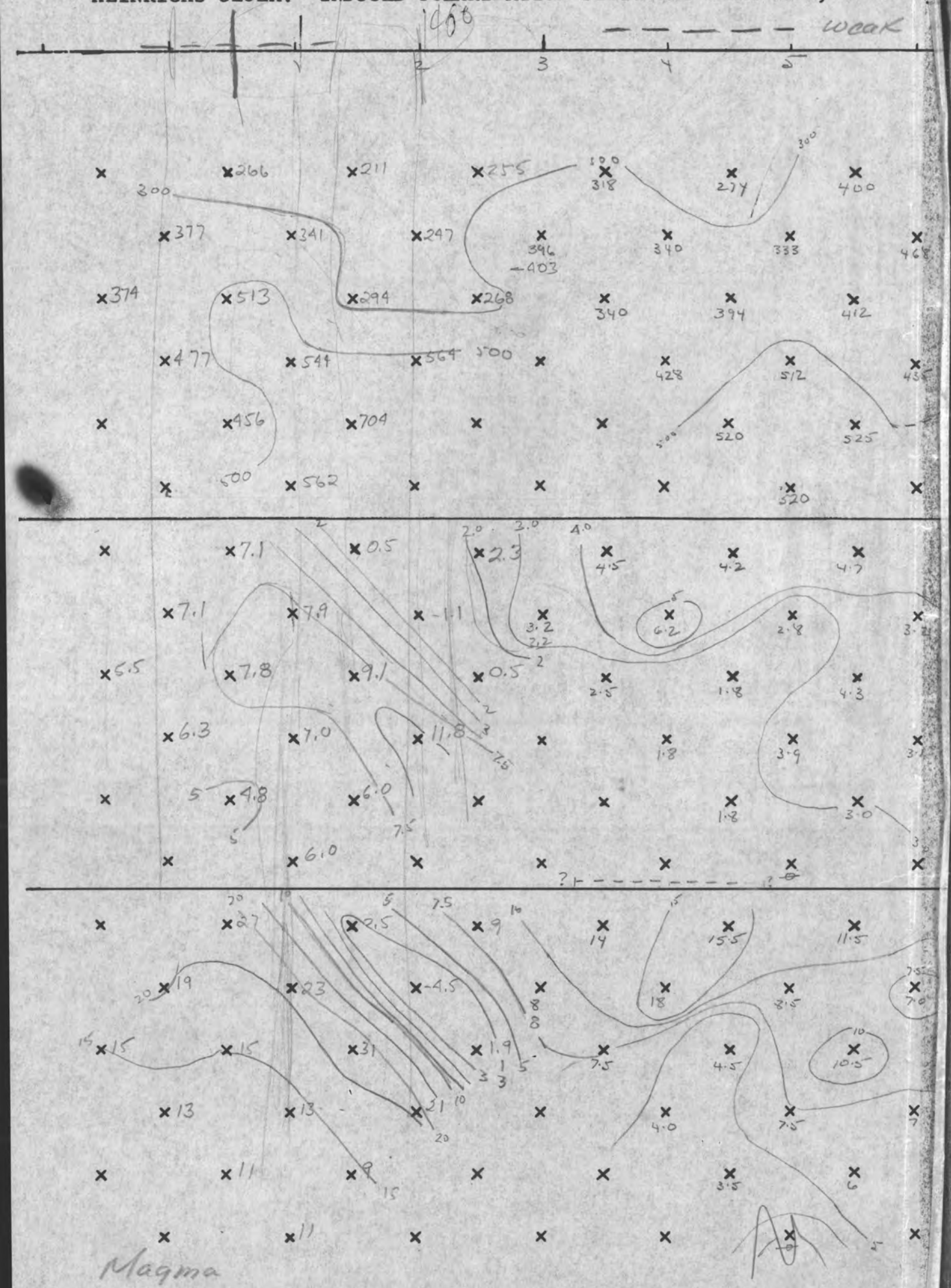
M.C.F.

Magma

AREA North Star LINE 2 a = 1500 ' SCALE: 1"=500 DATE: 9-

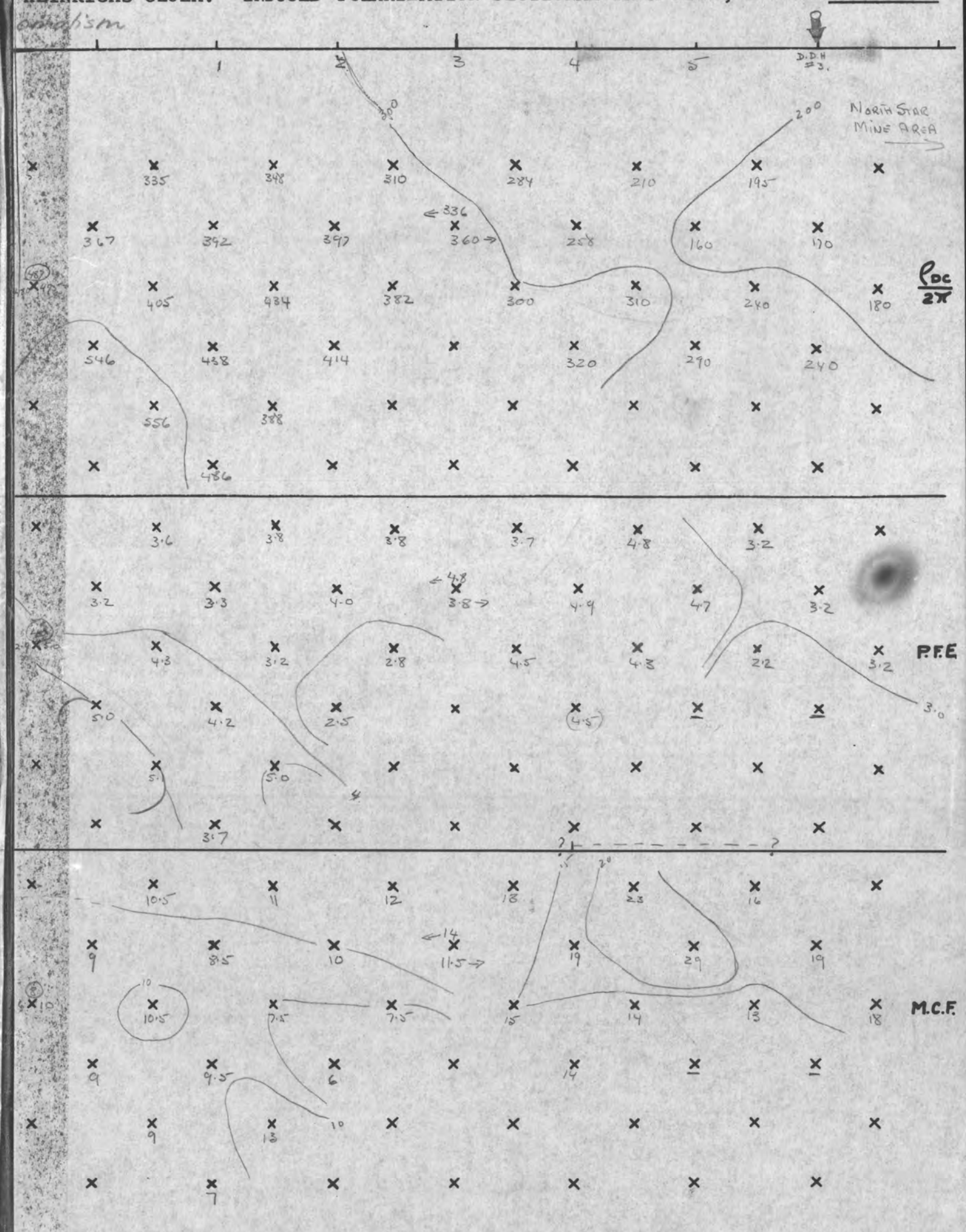
AREA _____ LINE _____ a = ' SCALE: 1"=500' DATE: 9/64

HEINRICHS GEOEX. INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING



AREA North Star LINE 1"A" a = 1000 ' SCALE: D

HEINRICHS GEOEX. INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING West



LINE 1 & 1a a = 1000 ' SCALE: 1000' = 1" DATE: 9/64

Sec 6

Sec 4

Sec 8

Sec 9

Sec 17

Sec 16

Sec 19

Sec 20

Sec 21

DDH #4

DDH #6

DDH #5

Well grounded fence

Qal — Alluvium

ap — Andesite porphyry (dikes)

dp — Diorite porphyry (dikes)

lp — Latite porphyry (dikes)

gp — Granite porphyry (dikes)

b — Basalt (dikes)

db — Diabase (dikes)

m — Monzonite (stock)

gr — Granite (foliated)

Sch. — Schist

pEqm — Quartz Monzonite (Owelo Conglomerate)

Sequence of Intrusions not definite

Magma

NORTH STAR Proj.

Scale 1" = 1000'

Don Hammer?

1964

FX