

12. Appendices

Appendix 1

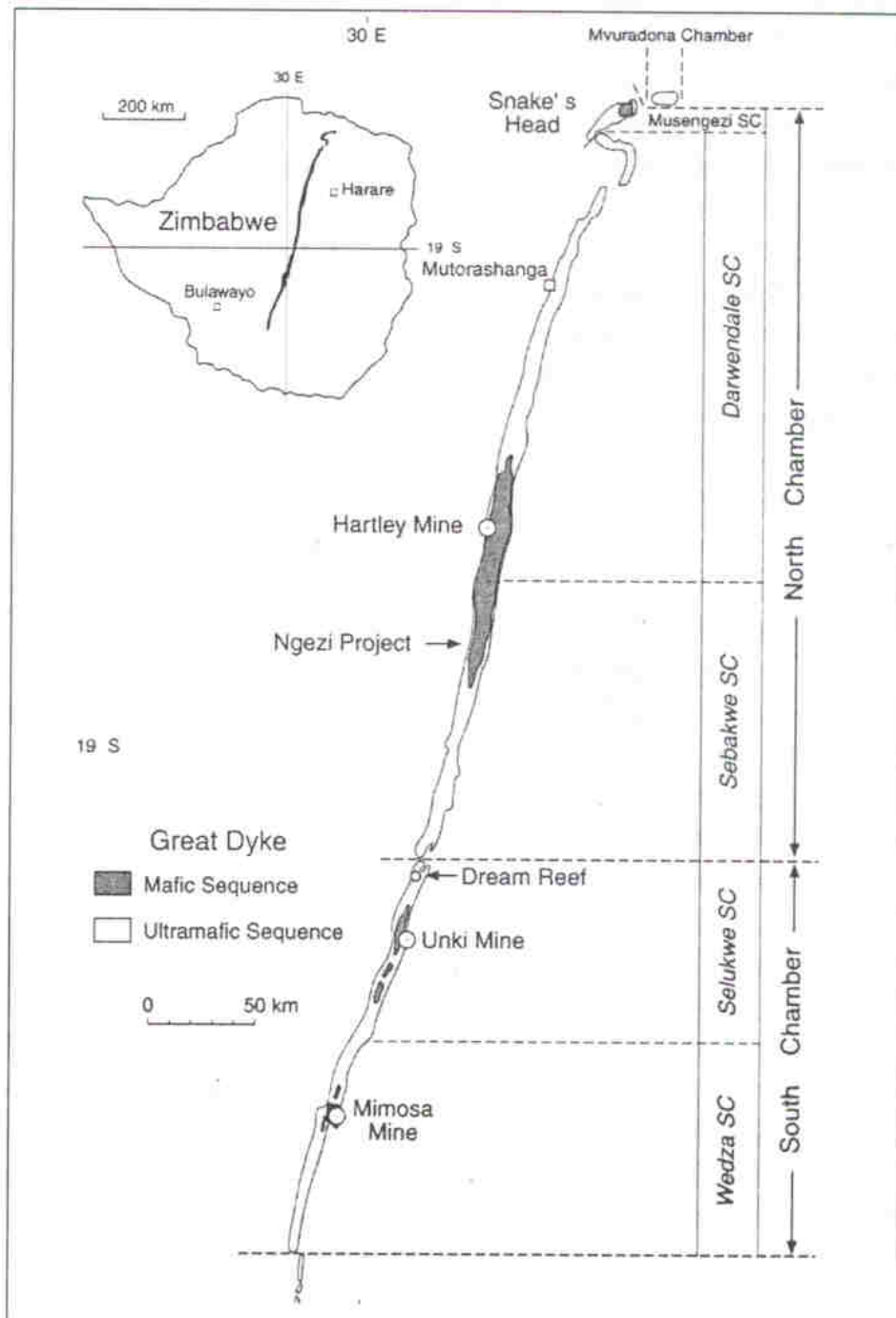


Figure: Great Dyke of Zimbabwe (Oberthür, 2002b)

Appendix 2

Microprobe analysis of natural PGMs from Mimosa Mine, Zimbabwe

PtAs ₂ (proportions are by weight)																			
Sample	Ru	Rh	Pd	Os	Ir	Pt	Fe	Cu	Ni	Co	S	Se	Te	As	Sb	Bi	Ag	Hg	Total
As5219a	0.03	0.10	0.09	0.06	0.00	54.78	0.75	0.02	0.04	0.02	0.46	0.00	0.05	43.76	0.00	0.02	0.03	0.03	100.24
As5220a	0.15	0.32	0.05	0.07	3.64	50.80	2.01	0.14	0.02	0.00	1.32	0.02	0.06	42.45	0.00	0.01	0.00	0.05	101.11
As5291	0.09	0.05	0.05	0.01	0.00	56.13	0.59	0.03	0.02	0.00	0.35	0.06	0.03	44.07	0.03	0.00	0.00	0.00	101.51
As5296	0.01	0.03	0.03	0.00	0.00	53.43	2.07	0.61	0.09	0.00	0.38	0.01	0.00	44.92	0.00	0.07	0.00	0.00	101.65
As5299	0.81	3.62	0.00	0.03	1.17	48.95	1.56	0.03	0.21	0.01	3.17	0.16	0.00	40.13	0.02	0.12	0.15	0.09	100.23
As5301	0.03	0.55	0.00	0.00	0.00	52.69	1.80	0.18	1.36	0.08	0.92	0.17	0.00	43.33	0.03	0.00	0.12	0.00	101.26
	0.02	1.10	0.05	0.00	0.00	53.12	1.14	0.65	0.23	0.00	0.86	0.17	0.00	43.49	0.00	0.25	0.00	0.01	101.09
As5305	0.00	0.00	0.00	0.00	0.26	53.16	1.35	0.22	0.06	0.00	0.51	0.02	0.01	44.92	0.00	0.11	0.00	0.00	100.64
As5309	0.05	0.04	0.00	0.05	1.24	54.45	0.73	0.04	0.07	0.00	0.70	0.07	0.03	43.35	0.00	0.00	0.00	0.00	100.82
	0.04	0.14	0.00	0.00	0.46	53.72	1.36	0.04	0.03	0.01	0.51	0.04	0.00	44.12	0.03	0.02	0.06	0.00	100.58
As5310	0.03	0.08	0.00	0.05	0.39	53.48	2.97	0.10	0.09	0.06	0.92	0.03	0.03	43.00	0.10	0.04	0.00	0.00	101.37
As5311	0.03	0.21	0.00	0.21	0.00	53.84	1.21	0.00	0.30	0.01	0.74	0.01	0.05	43.83	0.04	0.14	0.00	0.00	100.76
As5314	0.15	0.00	0.00	0.00	0.00	54.21	1.23	0.00	0.00	0.00	0.48	0.03	0.00	44.30	0.01	0.00	0.00	0.00	100.68
	0.06	0.00	0.00	0.00	0.00	53.95	1.12	0.00	0.00	0.00	0.49	0.00	0.12	43.64	0.07	0.12	0.00	0.00	99.89
As5434	0.03	0.14	0.27	0.00	0.14	52.77	1.48	1.49	0.14	0.14	0.57	0.04	0.18	43.39	0.07	0.10	0.00	0.00	100.63
As5435	0.01	0.13	0.04	0.00	0.00	54.56	1.09	0.05	0.01	0.01	0.55	0.06	0.00	43.88	0.01	0.17	0.00	0.00	100.56
	0.00	0.06	0.00	0.00	0.02	54.88	0.55	0.02	0.03	0.00	0.29	0.00	0.04	43.87	0.00	0.07	0.00	0.00	99.97
As5436	0.04	0.03	0.00	0.01	0.22	53.67	1.10	0.00	0.09	0.01	0.49	0.05	0.03	43.54	0.06	0.00	0.14	0.06	99.54
	0.09	0.07	0.00	0.00	0.64	53.59	0.96	0.78	0.19	0.01	0.42	0.07	0.00	44.07	0.00	0.00	0.00	0.17	101.06
	0.09	0.08	0.01	0.03	0.06	54.46	0.61	0.45	0.01	0.01	0.26	0.00	0.00	44.25	0.00	0.00	0.00	0.00	100.32
As5441	0.00	0.16	0.00	0.02	0.00	54.25	0.98	0.17	0.45	0.02	0.26	0.07	0.00	44.60	0.11	0.12	0.05	0.00	101.26
As5444	0.05	0.00	0.03	0.10	0.37	55.81	0.50	0.01	0.08	0.01	0.33	0.11	0.05	42.76	0.00	0.05	0.00	0.00	100.26
As5446	0.45	1.05	0.00	0.12	0.14	52.68	0.97	0.29	0.27	0.04	1.47	0.00	0.02	42.60	0.09	0.09	0.00	0.00	100.28
As5538	0.11	0.09	0.07	0.06	0.91	55.87	0.76	0.00	0.02	0.00	0.65	0.13	0.02	41.94	0.03	0.00	0.10	0.00	100.76
As5937	0.06	0.07	0.00	0.09	0.01	55.74	1.35	0.08	0.02	0.00	0.37	0.09	0.01	43.54	0.04	0.00	0.00	0.00	101.51
As5939	0.08	0.03	0.03	0.08	0.02	54.93	0.55	0.74	0.02	0.00	0.17	0.02	0.01	43.78	0.06	0.00	0.06	0.00	100.58
	0.06	0.14	0.00	0.09	1.46	54.93	0.33	0.00	0.04	0.00	0.55	0.04	0.06	42.71	0.10	0.00	0.00	0.00	100.59
	0.07	0.05	0.00	0.09	2.17	53.62	0.48	0.07	0.12	0.00	0.65	0.00	0.07	42.86	0.21	0.08	0.17	0.02	100.73
Average	0.09	0.30	0.03	0.04	0.48	53.87	1.13	0.22	0.14	0.02	0.67	0.05	0.03	43.47	0.04	0.06	0.03	0.02	100.71
Stdev	0.16	0.71	0.05	0.05	0.83	1.51	0.58	0.35	0.26	0.03	0.57	0.05	0.04	0.97	0.05	0.07	0.05	0.04	0.52
High	0.81	3.62	0.27	0.21	3.64	56.13	2.97	1.49	1.36	0.14	3.17	0.17	0.18	44.92	0.21	0.25	0.17	0.17	101.65
Low	0.00	0.00	0.00	0.00	0.00	48.95	0.33	0.00	0.00	0.00	0.17	0.00	0.00	40.13	0.00	0.00	0.00	0.00	99.54
95% Confidence	0.06	0.26	0.02	0.02	0.31	0.56	0.22	0.13	0.10	0.01	0.21	0.02	0.02	0.36	0.02	0.02	0.02	0.01	0.19

Table: Composition of natural PtAs₂ (proportions by mass) (Oberthür, 2002c).

Pt-Pd-Bi-Te (proportions are by mass)																	
Sample	Pd	Os	Ir	Pt	Fe	Cu	Ni	Co	S	Se	Te	Sb	Bi	Pb	Ag	Hg	Total
As5287	6.74	0.00	0.00	24.76	1.21	0.00	2.13	0.03	0.05	0.00	43.40	0.00	21.50	0.00	0.19	0.06	100.09
As5292	0.70	0.00	0.00	37.94	1.01	0.00	0.02	0.00	0.05	0.00	39.65	0.01	21.26	0.18	0.15	0.00	100.97
	0.00	0.00	0.15	36.50	1.73	0.84	0.34	0.02	0.22	0.02	32.37	0.00	26.56	0.00	0.06	0.00	98.81
As5537	0.00	0.00	0.00	35.71	0.40	0.09	0.00	0.00	0.05	0.04	21.74	0.00	41.60	0.00	0.32	0.00	99.95
	0.00	0.00	0.00	37.35	0.55	0.06	0.03	0.00	0.04	0.03	33.89	0.02	27.56	0.00	0.00	0.00	99.53
	2.18	0.00	0.00	33.96	1.21	0.49	0.06	0.00	0.07	0.00	34.43	0.00	27.30	0.00	0.00	0.00	99.70
As5941	0.02	0.02	0.00	36.48	1.90	0.58	1.49	0.00	0.22	0.00	32.74	0.07	26.43	0.43	0.00	0.00	100.38
	1.26	0.00	0.00	35.34	0.72	0.24	0.06	0.00	0.05	0.00	35.94	0.00	26.48	0.00	0.19	0.00	100.28
As5492	0.00	0.00	0.00	35.69	2.24	1.76	0.79	0.00	0.18	0.00	31.01	0.08	28.57	0.31	0.12	0.00	100.75
Average	1.21	0.00	0.02	34.86	1.22	0.45	0.55	0.01	0.10	0.01	33.91	0.02	27.47	0.10	0.11	0.01	100.05
Stdev	2.21	0.01	0.05	3.96	0.63	0.57	0.78	0.01	0.08	0.02	6.00	0.03	5.89	0.17	0.11	0.02	0.66
High	6.74	0.02	0.15	37.94	2.24	1.76	2.13	0.03	0.22	0.04	43.40	0.08	41.60	0.43	0.32	0.06	100.97
Low	0.00	0.00	0.00	24.76	0.40	0.00	0.00	0.00	0.04	0.00	21.74	0.00	21.26	0.00	0.00	0.00	98.81
95% Confidence	1.37	0.00	0.03	2.45	0.39	0.35	0.48	0.01	0.05	0.01	3.72	0.02	3.65	0.10	0.07	0.01	0.41

Table: Composition of natural Pt-Pd-Bi-Te (proportions by mass) (Oberthür, 2002c)

Sample no.	Pd-Pt-Bi-Te (Proportions in mass%)																			
	Rh	Pd	Os	Ir	Pt	Fe	Cu	Ni	Co	S	Se	Te	As	Sb	Bi	Pb	Ag	Au	Hg	Total
	0.00	24.17	0.00	0.00	0.00	2.02	0.00	0.03	0.00	0.06	0.04	31.38	0.00	0.23	42.46	0.05	0.10	0.03	0.00	100.57
As5313	0.00	24.15	0.00	0.00	0.00	1.05	0.25	0.04	0.00	0.01	0.00	29.30	0.00	1.17	43.72	0.15	0.06	0.01	0.06	99.97
	0.00	38.50	0.00	0.00	0.00	0.95	0.20	0.07	0.03	0.04	0.00	21.17	0.00	1.56	38.70	0.02	0.24	0.00	0.00	101.48
As5449	0.00	34.50	0.00	0.02	0.00	3.80	0.08	0.02	0.00	0.53	0.00	10.14	0.00	2.95	48.65	0.00	0.29	0.00	0.00	100.98
As5451	0.00	23.66	0.05	0.21	0.00	1.04	0.00	0.56	0.02	0.05	0.00	26.72	0.00	0.03	47.02	0.06	0.00	0.06	0.00	99.48
As5443	0.00	38.51	0.04	0.00	0.00	0.39	0.20	0.40	0.00	0.03	0.00	22.43	0.00	0.20	38.11	0.05	0.31	0.00	0.00	100.67
As5940	0.00	23.54	0.00	0.00	0.00	3.25	1.06	0.07	0.13	0.44	0.02	31.79	0.10	0.40	41.70	0.00	0.00	0.00	0.00	102.50
	0.00	24.02	0.00	0.00	0.00	1.18	0.11	1.02	0.29	0.01	0.00	28.42	0.00	0.10	46.61	0.05	0.00	0.06	0.00	101.87
	0.00	23.48	0.00	0.29	0.10	0.78	0.00	0.12	0.17	0.19	0.00	28.84	0.26	0.09	45.48	0.02	0.20	0.00	0.00	100.20
	0.00	23.68	0.00	0.00	0.00	0.83	0.35	0.02	0.03	0.04	0.00	28.96	0.00	0.00	46.97	0.02	0.01	0.06	0.00	100.97
	0.00	23.84	0.00	0.12	0.00	0.56	0.23	0.03	0.02	0.02	0.00	29.34	0.00	0.00	46.63	0.00	0.00	0.00	0.00	100.79
As5943	0.00	23.69	0.00	0.01	0.00	2.38	0.34	0.03	0.01	0.08	0.00	29.99	0.00	0.02	44.25	0.14	0.00	0.02	0.00	100.97
Average	0.00	27.15	0.01	0.05	0.01	1.52	0.24	0.20	0.06	0.13	0.01	26.54	0.03	0.56	44.19	0.05	0.10	0.02	0.01	100.87
Stdev	0.00	6.13	0.02	0.10	0.03	1.10	0.29	0.31	0.09	0.18	0.01	6.09	0.08	0.90	3.38	0.05	0.12	0.03	0.02	0.82
High	0.00	38.51	0.05	0.29	0.10	3.80	1.06	1.02	0.29	0.53	0.04	31.79	0.26	2.95	48.65	0.15	0.31	0.06	0.06	102.50
Low	0.00	23.48	0.00	0.00	0.00	0.39	0.00	0.02	0.00	0.01	0.00	10.14	0.00	0.00	38.11	0.00	0.00	0.00	0.00	99.48
95% Confidence		3.21	0.01	0.05	0.02	0.58	0.15	0.16	0.05	0.09	0.01	3.19	0.04	0.47	1.77	0.03	0.07	0.01	0.01	0.43

Table: Composition of natural Pd-Bi-Te (proportions by mass) (Oberthür, 2002c)

Appendix 3

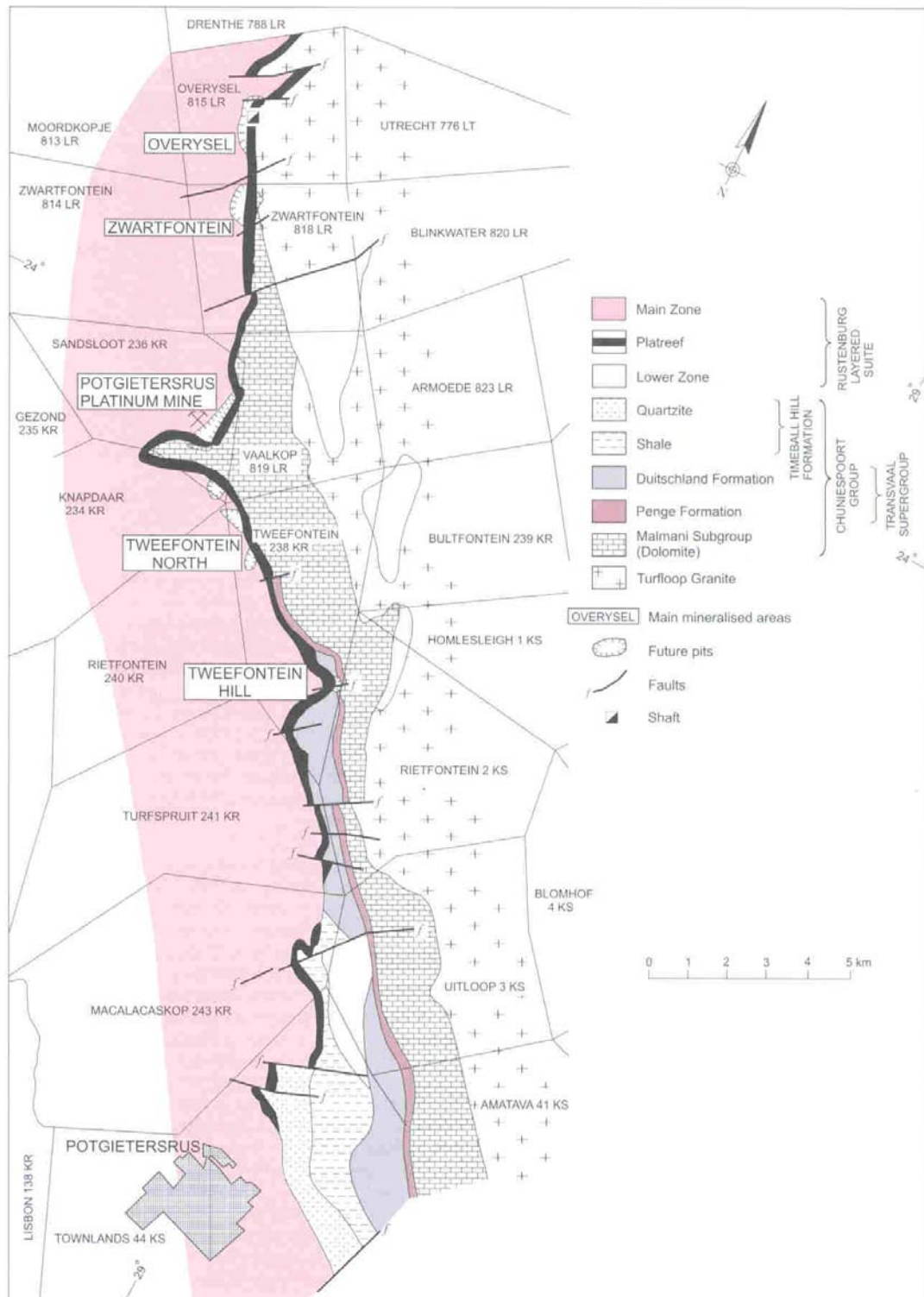


Figure: Platreef showing the location of possible open pits (Wilson,1998).

Appendix 4

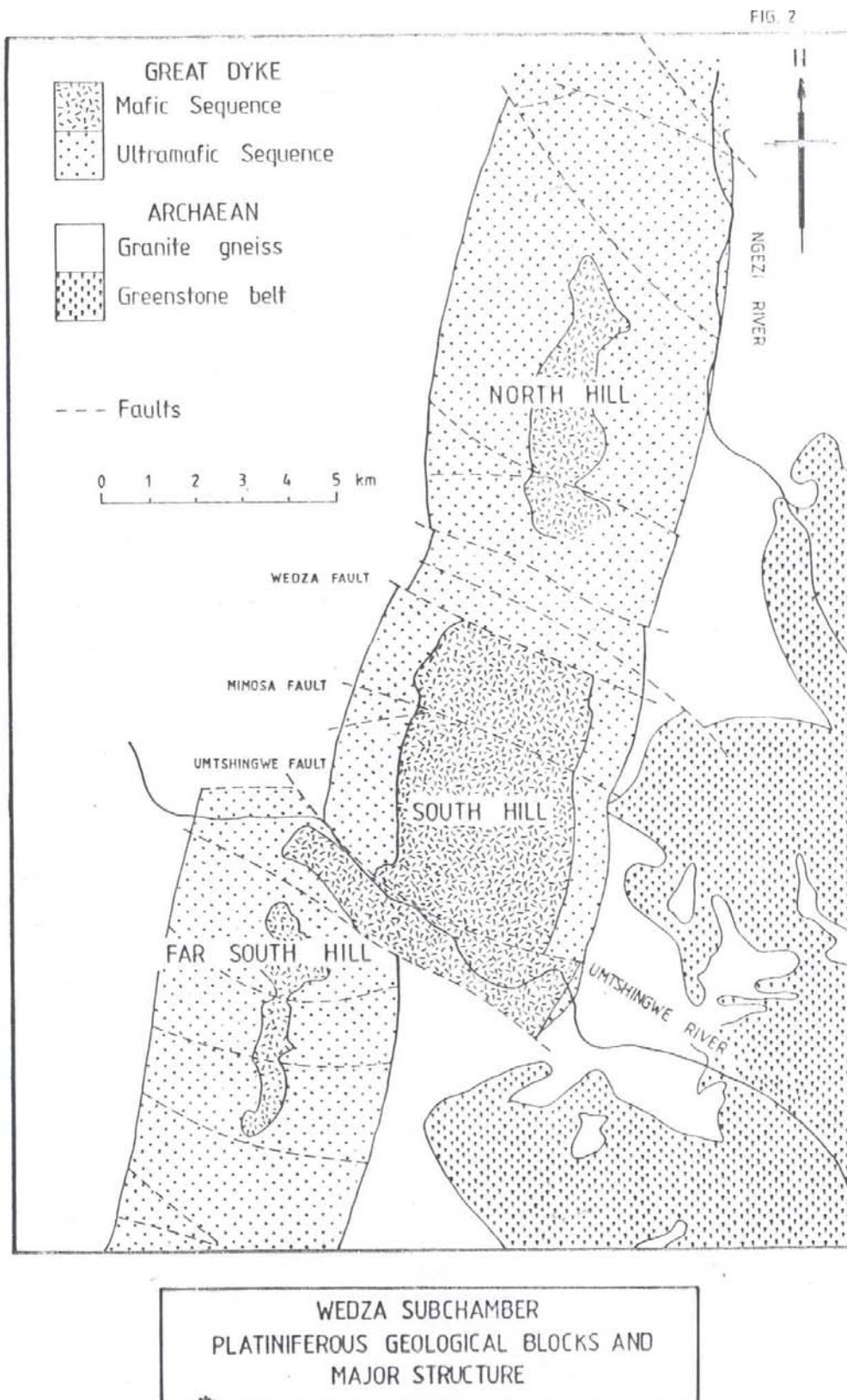


Figure: The geological complex of Mimosa Mine, Zimbabwe (Van Wouw, 2004).

Appendix 5

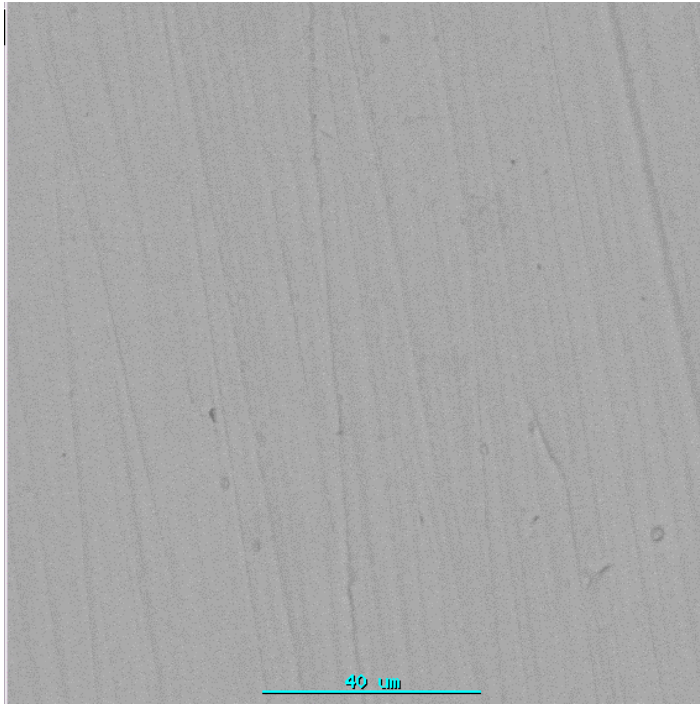


Figure: Back-scattered electron micrograph of the synthetically prepared michenerite (PdBiTe) heat-treated at 480°C for 60 days. Accelerating voltage 25kV.

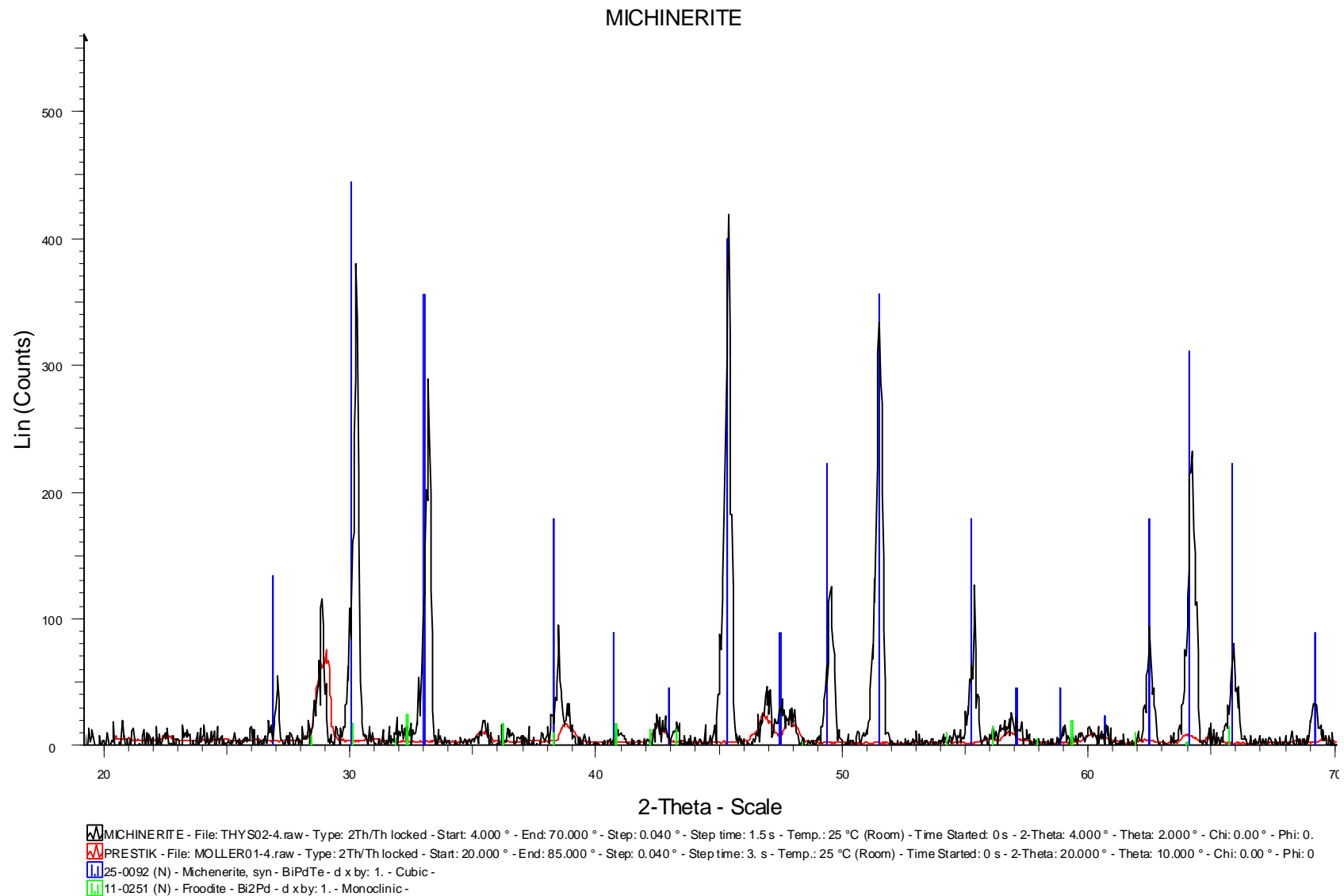
Appendix 6

Figure: XRD Spectrum of synthetic Pd-Bi-Te (Michenerite)

Appendix 7

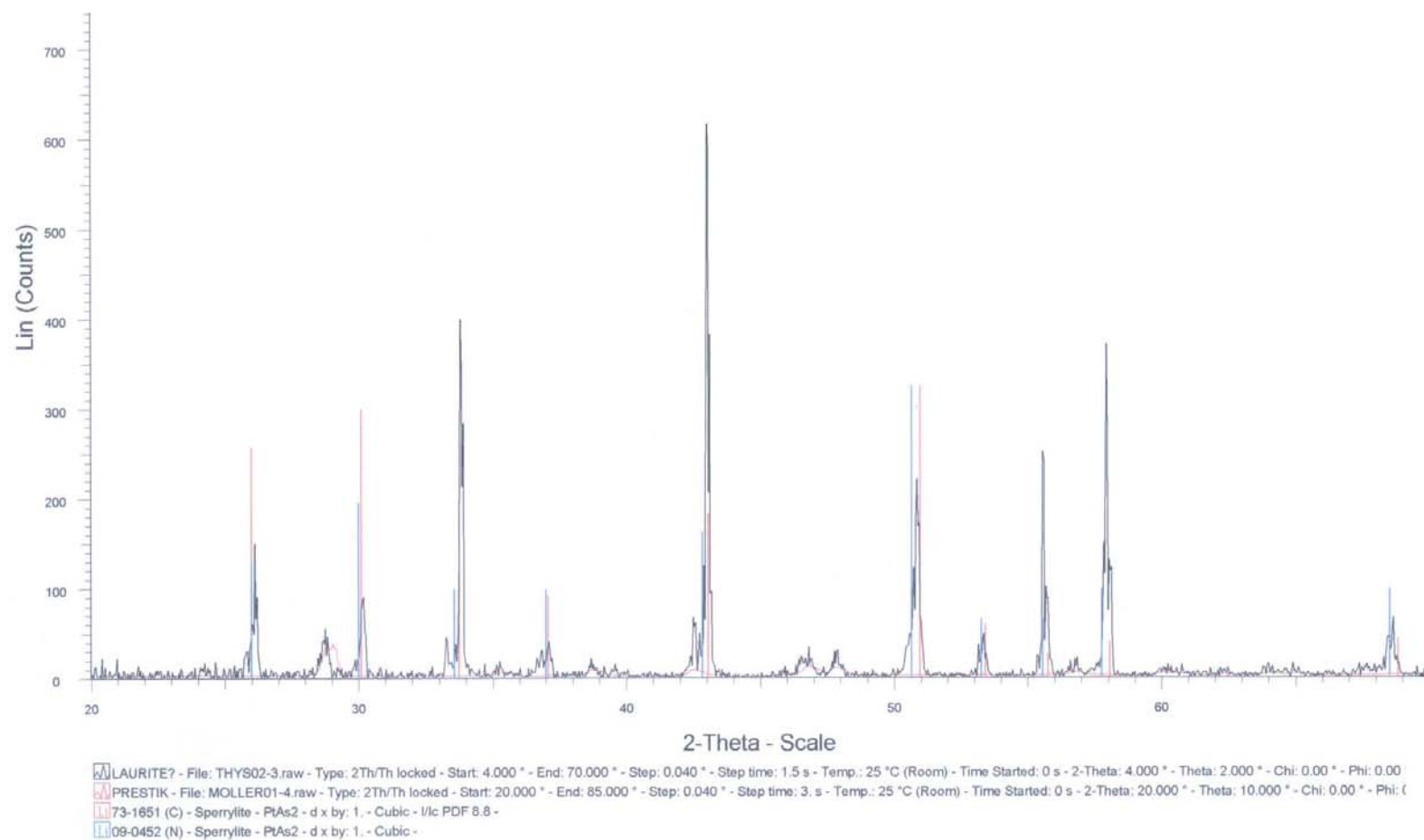
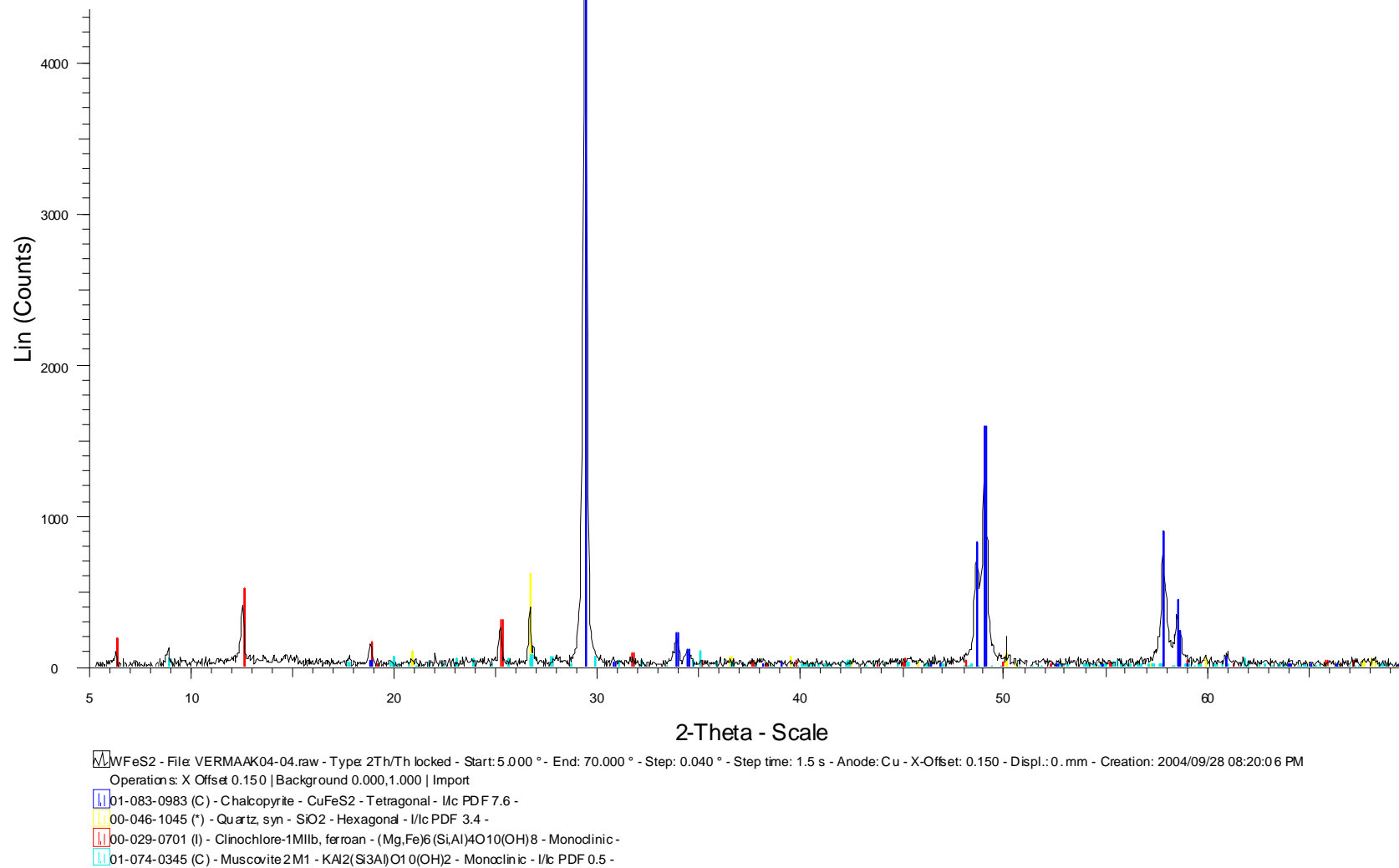


Figure: XRD Spectrum of PtAs₂ (Sperrylite)

CuFeS₂**Appendix 8****Figure:** XRD Spectrum of natural CuFeS₂ (Chalcopyrite)

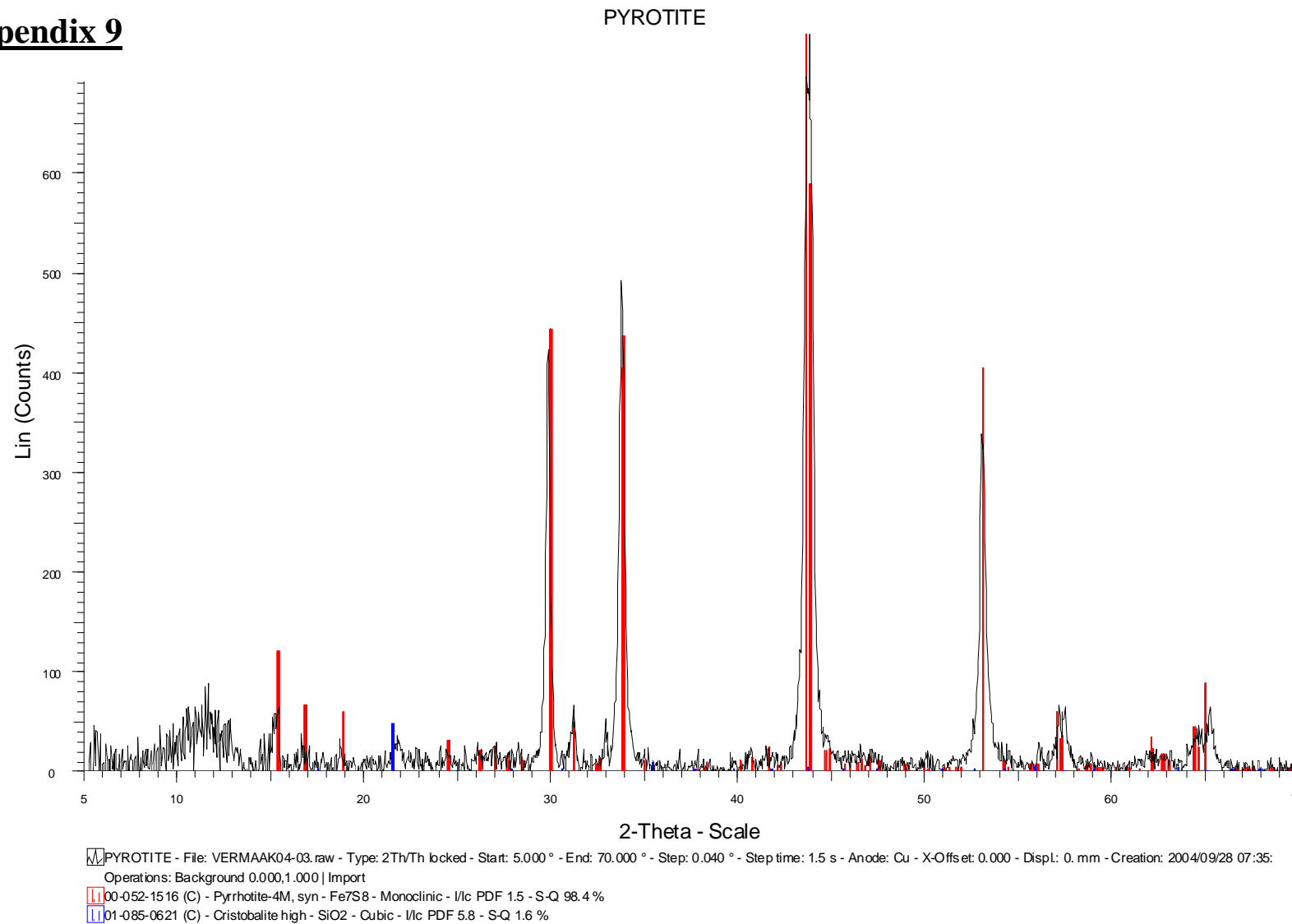
Appendix 9

Figure: XRD Spectrum of natural pyrrhotite

Appendix 10

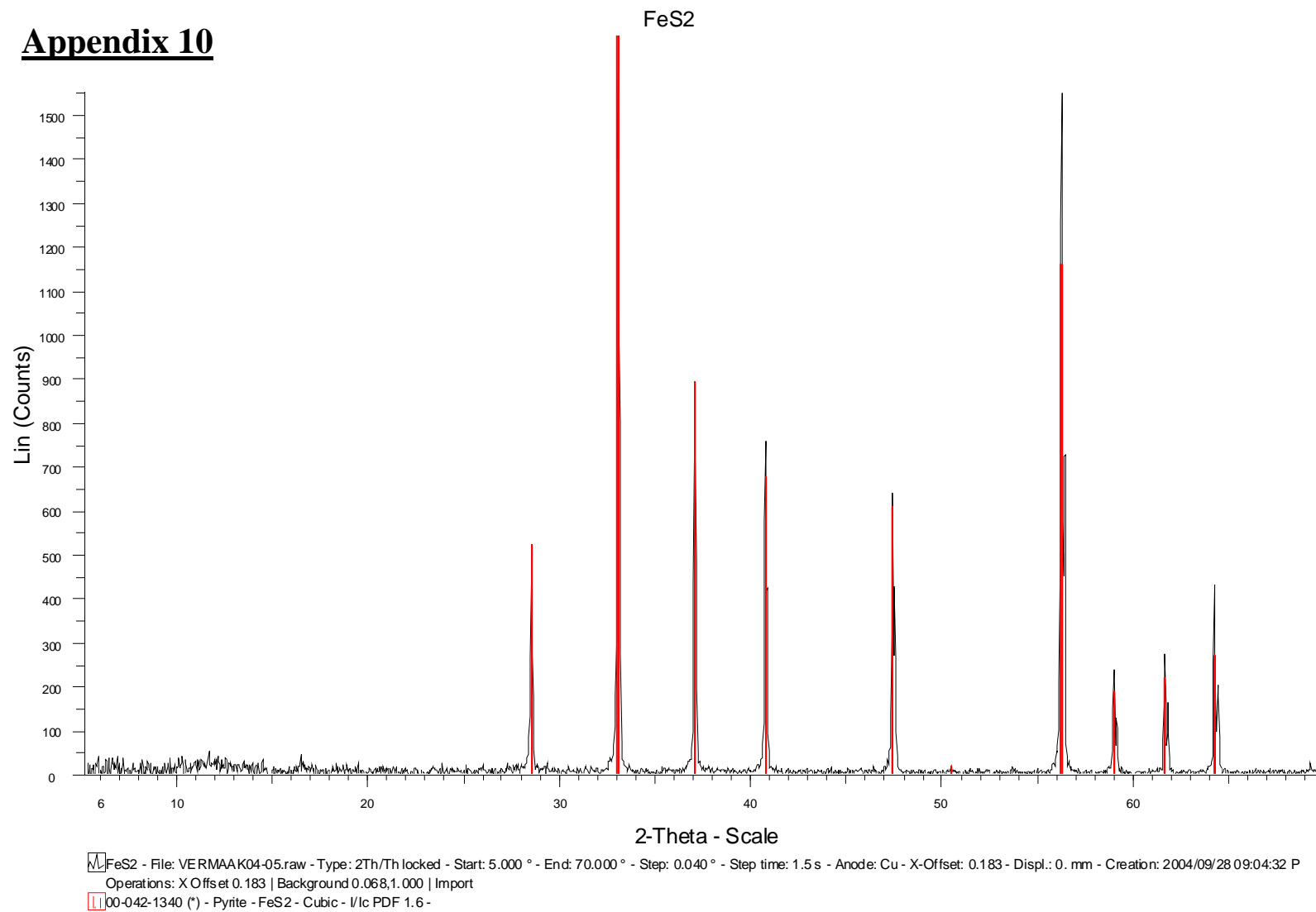


Figure: XRD Spectrum of natural pyrite

Appendix 11

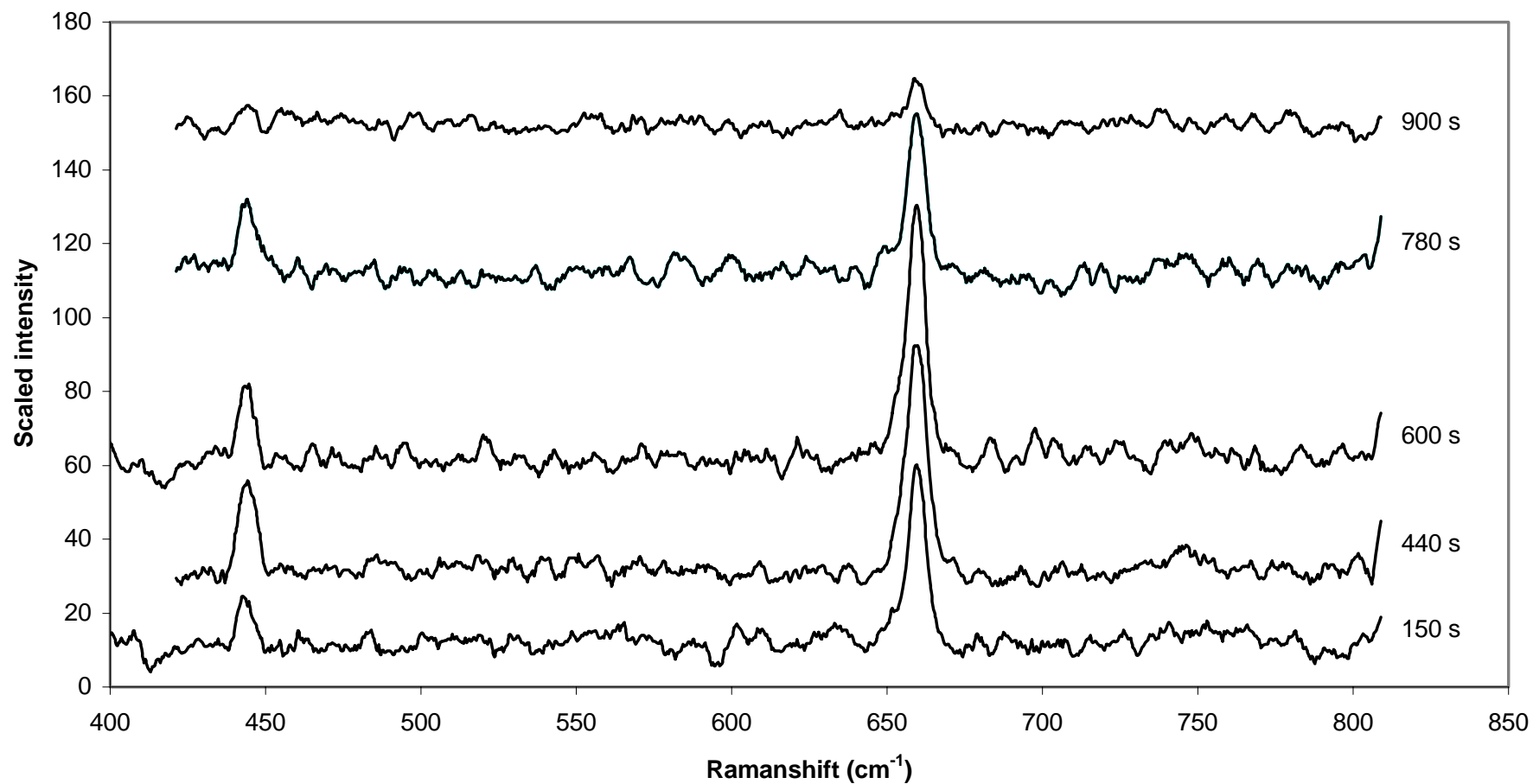


Figure: Raman spectra of Pd-Bi-Te electrode polarized for different lengths of time at 0.3V (SHE) in 0.05M $\text{Na}_2\text{B}_4\text{O}_7$ solution containing 1×10^{-3} M potassium ethyl xanthate

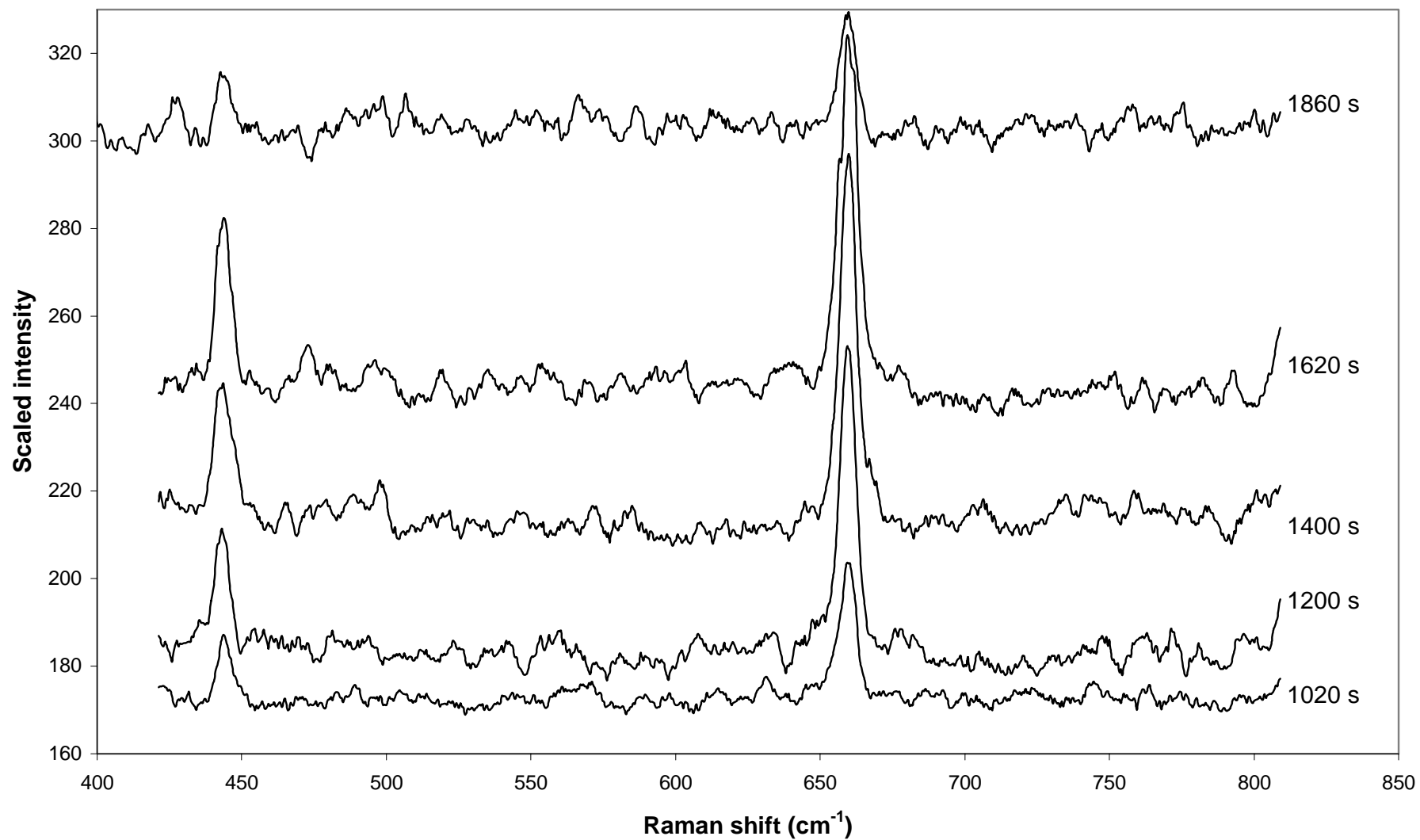


Figure: Raman spectra of Pd-Bi-Te electrode polarized for different lengths of time at 0.3V (SHE) in 0.05M $\text{Na}_2\text{B}_4\text{O}_7$ solution containing 1×10^{-3} M potassium ethyl xanthate

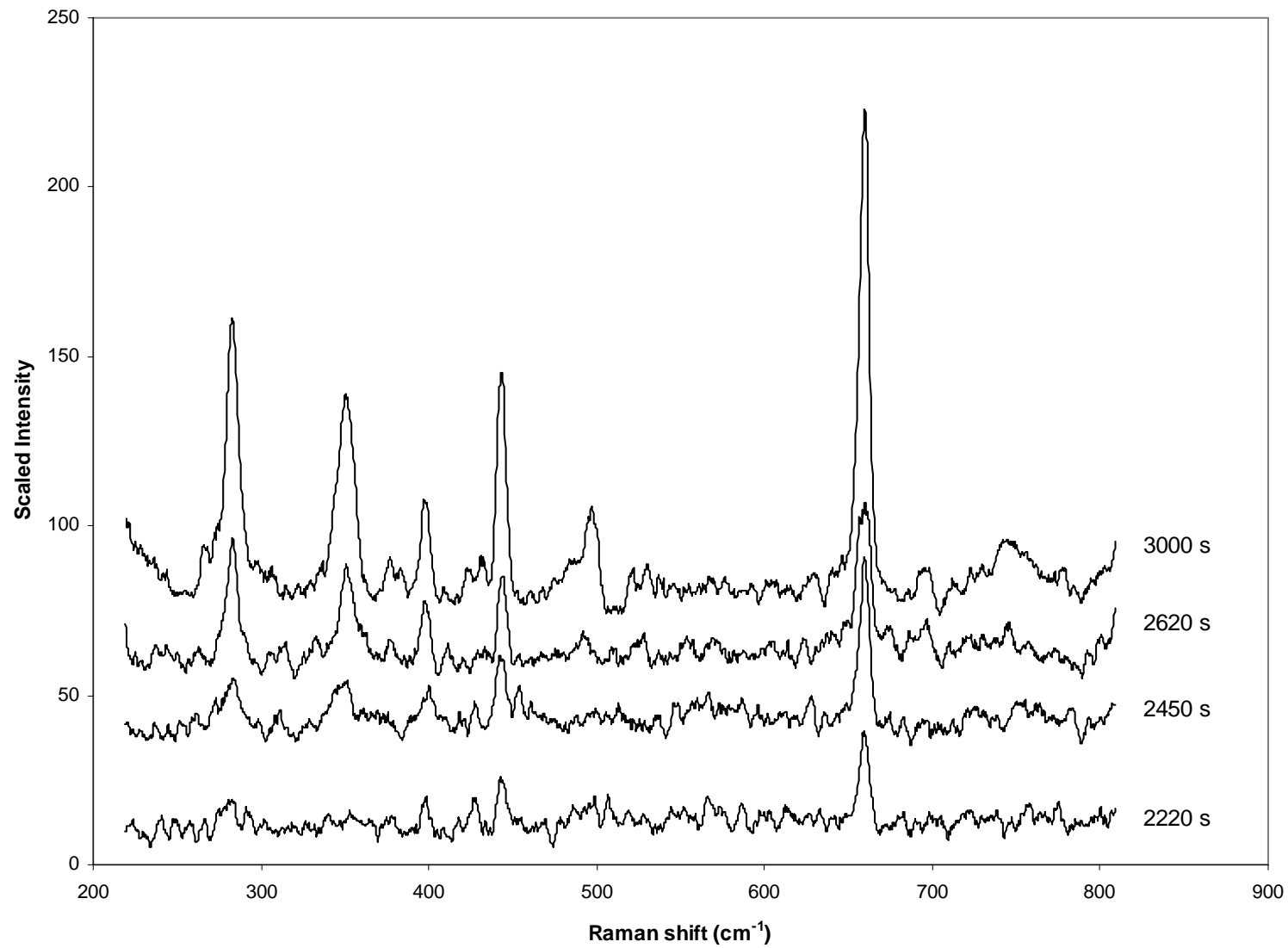


Figure: Raman spectra of Pd-Bi-Te electrode polarized for different lengths of time at 0.3V (SHE) in 0.05M $\text{Na}_2\text{B}_4\text{O}_7$ solution containing 1×10^{-3} M potassium ethyl xanthate

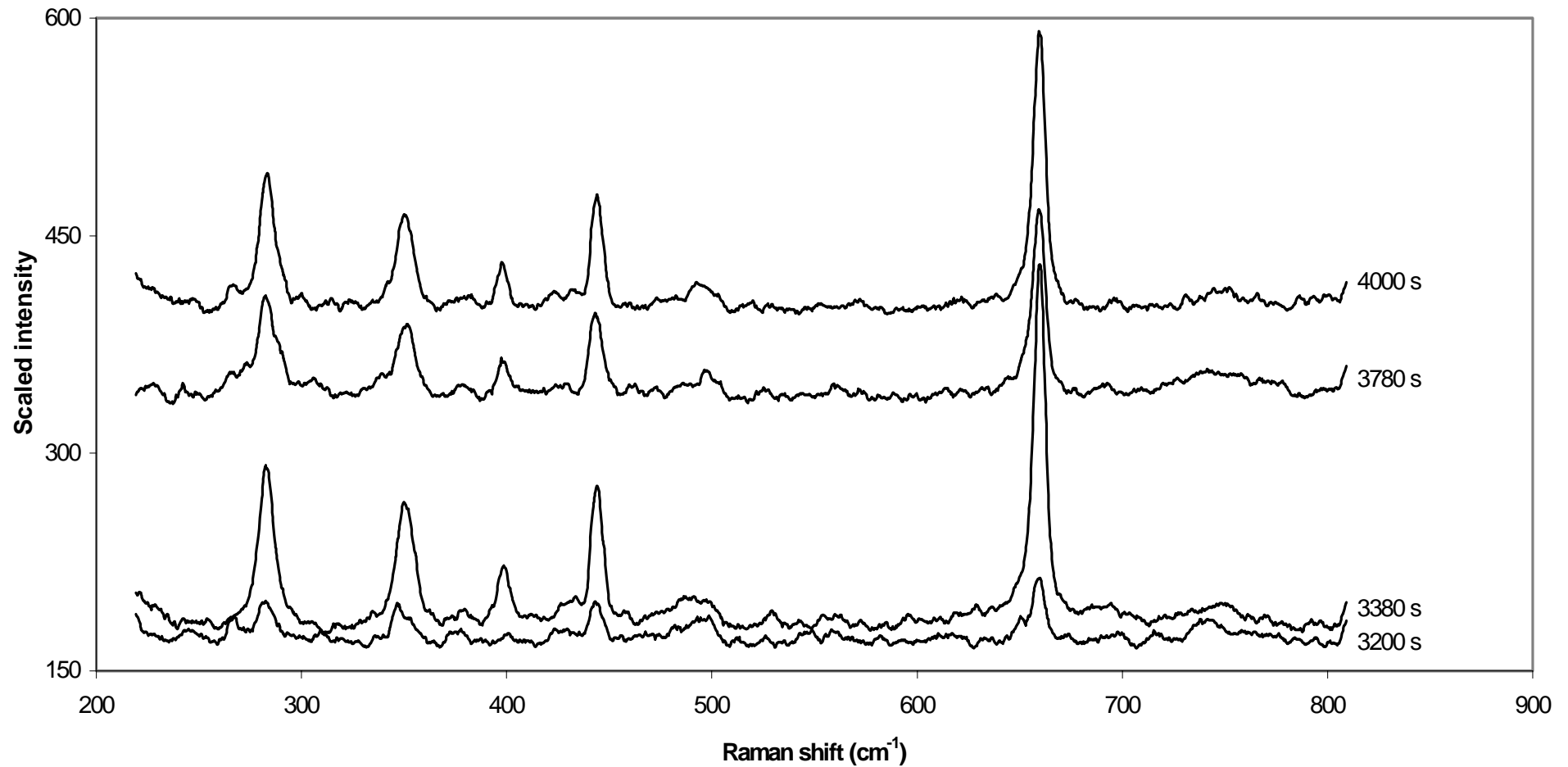


Figure: Raman spectra of Pd-Bi-Te electrode polarized for different lengths of time at 0.3V (SHE) in 0.05M $\text{Na}_2\text{B}_4\text{O}_7$ solution containing 1×10^{-3} M potassium ethyl xanthate

Table : Summary of intensity ratios as functions of anodic polarization time

Time (s)	743 cm ⁻¹ peak intensity	660 cm ⁻¹ peak intensity	498 cm ⁻¹ peak intensity	660 cm ⁻¹ : 743 cm ⁻¹ ratio	498 cm ⁻¹ : 743 cm ⁻¹ ratio	498 cm ⁻¹ : 743 cm ⁻¹ ratio		660 cm ⁻¹ : 743 cm ⁻¹ ratio	
						Average	Stedev	Average	Stdev
150	7.90	62.34	3.64	7.89	0.46				
440	8.37	69.28	6.00	8.28	0.72				
600	6.80	44.79	2.85	6.59	0.42				
780	6.01	14.10	5.12	2.35	0.85	0.61	0.21	6.27	2.72
1000	6.02	33.57	4.24	5.57	0.70				
1200	6.45	72.51	6.48	11.25	1.01				
1400	8.64	85.78	11.69	9.93	1.35				
1620	6.68	82.77	9.64	12.39	1.44				
1860	7.85	55.79	8.08	7.11	1.03	1.11	0.30	8.37	4.48
2220	133.11	155.41	136.59	1.17	1.03				
2450	7.49	50.00	5.54	6.68	0.74				
2620	11.06	45.99	7.89	4.16	0.71				
3000	15.93	140.73	24.59	8.84	1.54	1.01	0.39	5.63	3.30
3200	15.05	43.08	17.11	2.86	1.14				
3380	17.16	125.59	16.73	7.32	0.97				
3780	16.55	247.37	18.62	14.94	1.12				
4000	13.42	188.45	17.28	14.04	1.29	1.21	0.22	9.79	4.99