2005 GEOLOGICAL REPORT

FOR THE

VULCAN PROPERTY

Fort Steele Mining Division, Southeastern B.C.
Mapsheets 82F079, 82F089
Latitude 49°47' N, Longitude 116°20'W

VOLUME II
APPENDICES

APPENDIX III DIAMOND DRILL LOGS
APPENDIX IV CONDOR CONSULTING GEOPHYSICAL REPORT

Prepared for

EAGLE PLAINS RESOURCES LTD.
200-16 11th Ave. S.
Cranbrook, B.C., V1C 2P1
Tel: 1 250 426-0749 Fax: 1 250 426-6899
Email: info@eagleplains.ca

by

C.C. Downie, P.Geo
Exploration Manager, Eagle Plains Resources Ltd.
Cranbrook B.C., Canada

and

Glen Hendrickson, B.Sc.
GIS Tech, Eagle Plains Resources Ltd.
301 8th St. S.
Cranbrook B.C., Canada

February 16, 2006

APPENDIX III

DIAMOND DRILL LOGS

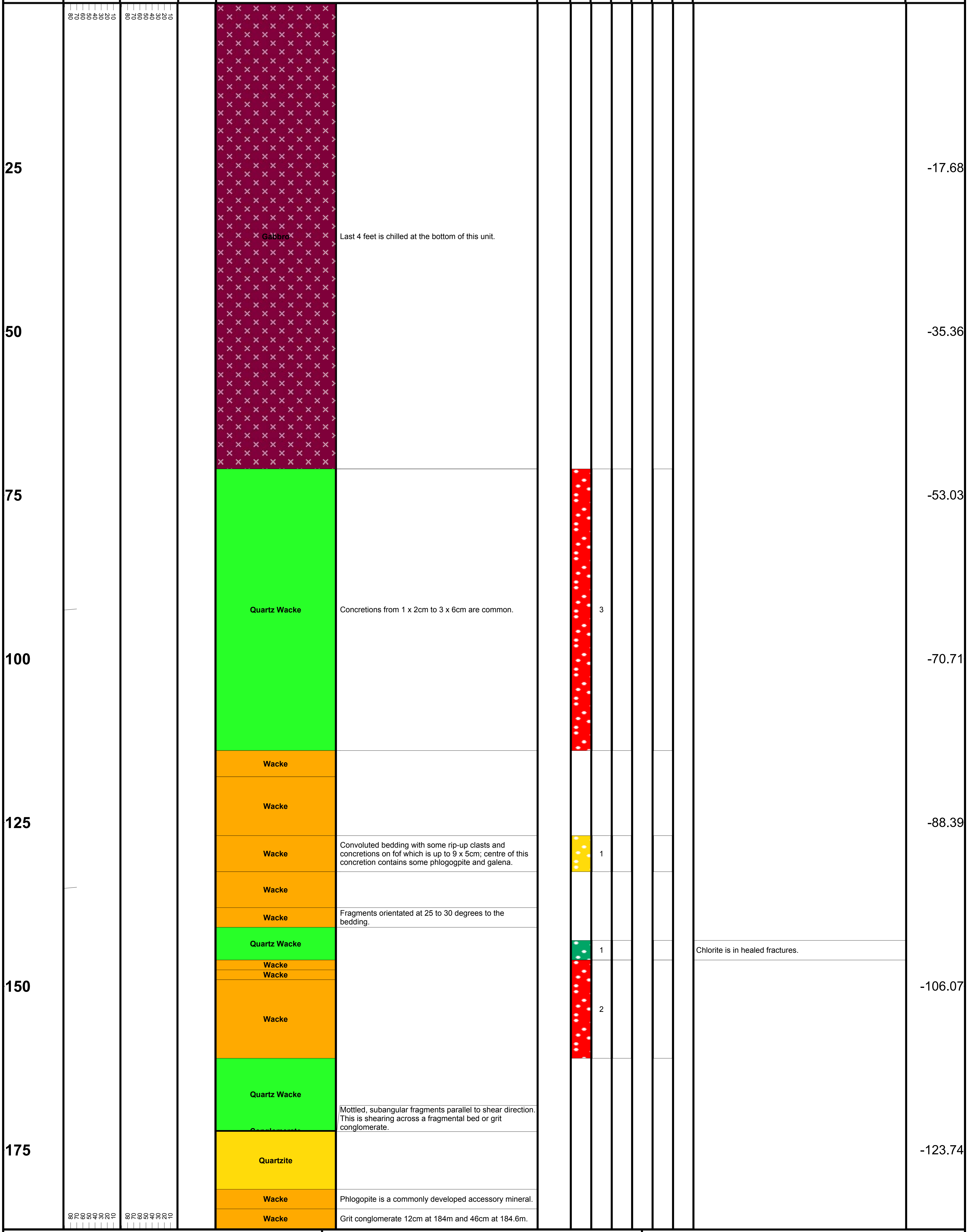
APPENDIX III

DIAMOND DRILL LOGS

3.1 Strip Logs

Hole Name :V-79-1

Hole Name :V-79-1	Hole Azimuth :	Hole Inclination :

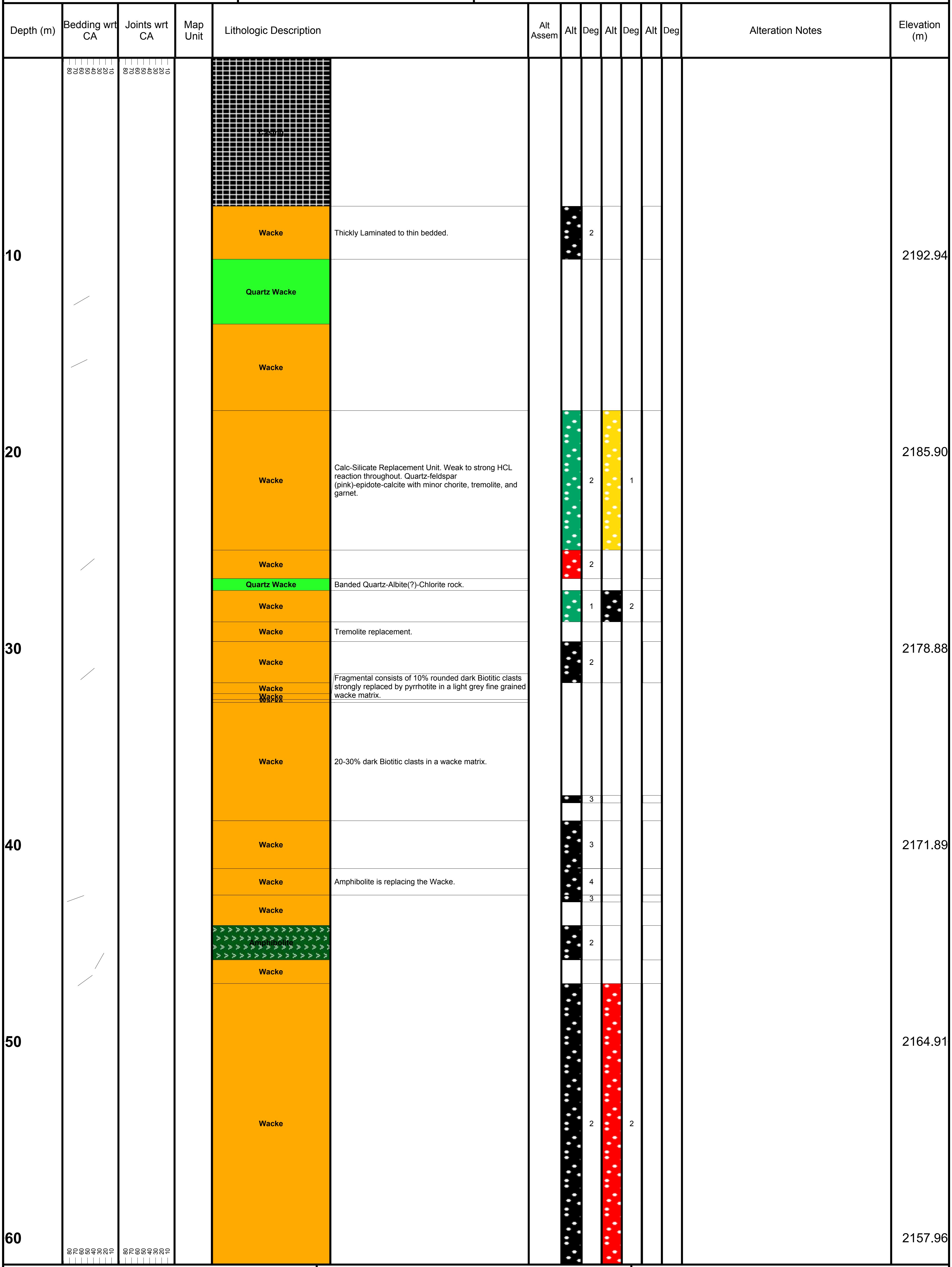


Depth (m)	Lithologic Description		Alt	Deg	Alteration Notes	Elevation (m)
25						-17.68
	Gabbro	Last 4 feet is chilled at the bottom of this unit.				
50						-35.36
75						-53.03
	Quartz Wacke	Concretions from 1 x 2cm to 3 x 6cm are common.	🟥	3		
100						-70.71
	Wacke					
	Wacke					
125						-88.39
	Wacke	Convoluted bedding with some rip-up clasts and concretions on fof which is up to 9 x 5cm; centre of this concretion contains some phlogogpite and galena.	🟨	1		
	Wacke					
	Wacke	Fragments orientated at 25 to 30 degrees to the bedding.				
	Quartz Wacke		🟩	1	Chlorite is in healed fractures.	
	Wacke					
	Wacke					
150						-106.07
	Wacke		🟥	2		
	Quartz Wacke					
	Conglomerate	Mottled, subangular fragments parallel to shear direction. This is shearing across a fragmental bed or grit conglomerate.				
175						-123.74
	Quartzite					
	Wacke	Phlogopite is a commonly developed accessory mineral.				
	Wacke	Grit conglomerate 12cm at 184m and 46cm at 184.6m.				

Scale 1:559	02/09/06	15:43:43

Hole Name :Vu-91-1

Hole Name :Vu-91-1	Hole Azimuth :	Hole Inclination :



Thickly Laminated to thin bedded.

Calc-Silicate Replacement Unit. Weak to strong HCL reaction throughout. Quartz-feldspar (pink)-epidote-calcite with minor chorite, tremolite, and garnet.

Banded Quartz-Albite(?)-Chlorite rock.

Tremolite replacement.

Fragmental consists of 10% rounded dark Biotitic clasts strongly replaced by pyrrhotite in a light grey fine grained wacke matrix.

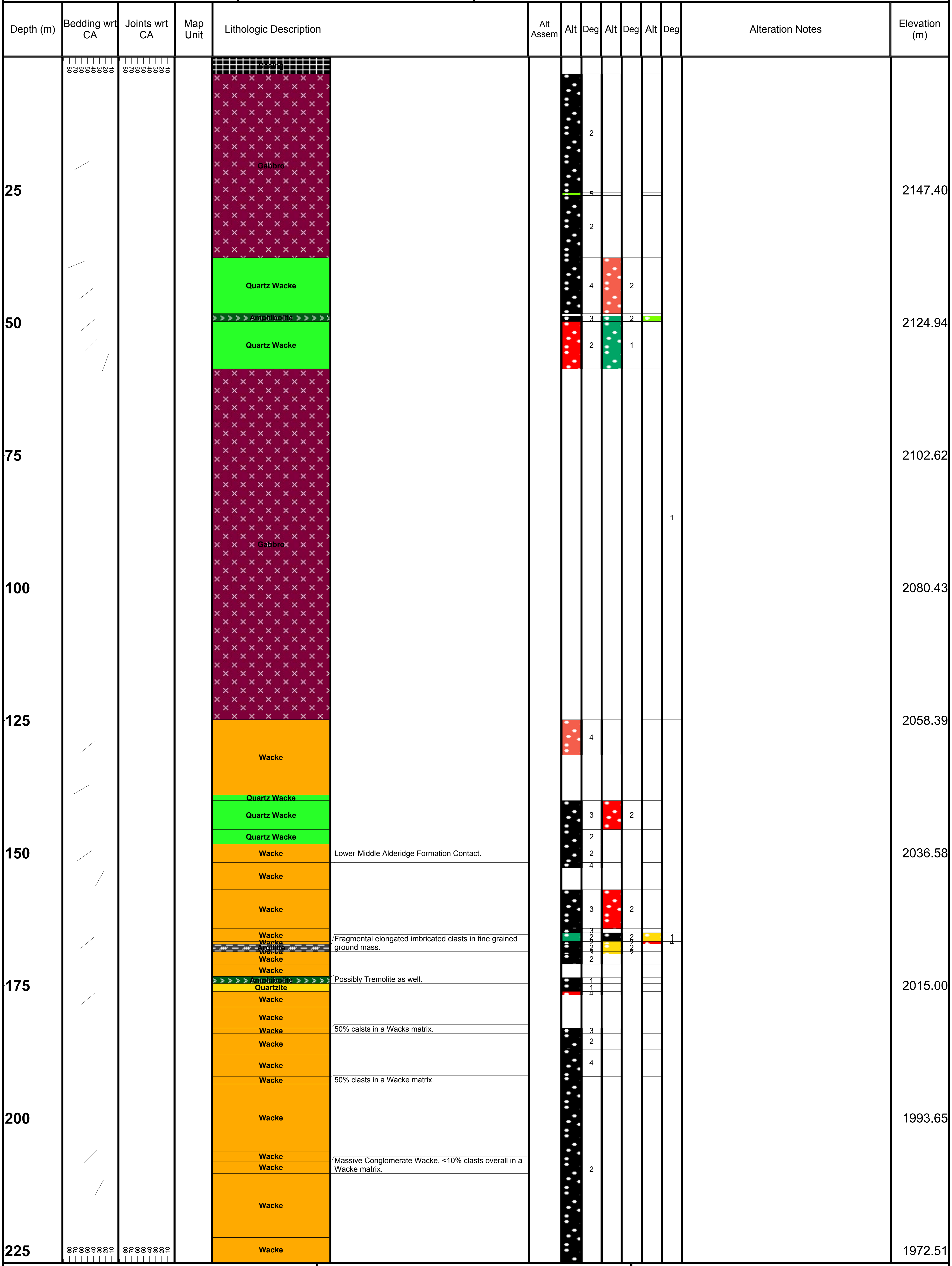
20-30% dark Biotitic clasts in a wacke matrix.

Amphibolite is replacing the Wacke.

Scale 1:183	02/09/06	15:43:47

Hole Name :Vu-91-2

Hole Name :Vu-91-2	Hole Azimuth :	Hole Inclination :



Lower-Middle Alderidge Formation Contact.

Fragmental elongated imbricated clasts in fine grained ground mass.

Possibly Tremolite as well.

50% calsts in a Wacks matrix.

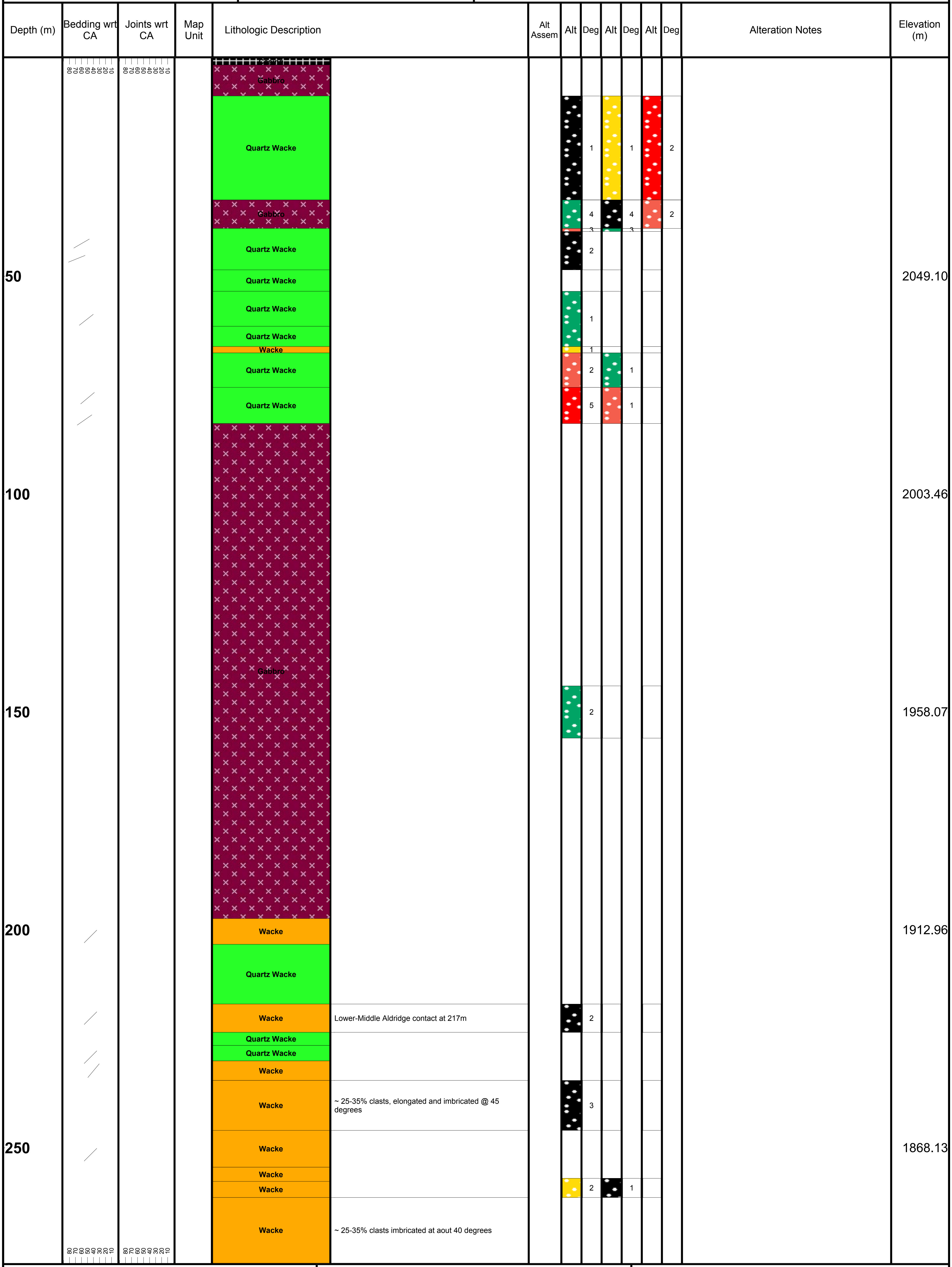
50% clasts in a Wacke matrix.

Massive Conglomerate Wacke, <10% clasts overall in a Wacke matrix.

Scale 1:679	02/09/06	15:43:49

Hole Name :Vu-91-3

Hole Name :Vu-91-3	Hole Azimuth :	Hole Inclination :



Lower-Middle Aldridge contact at 217m

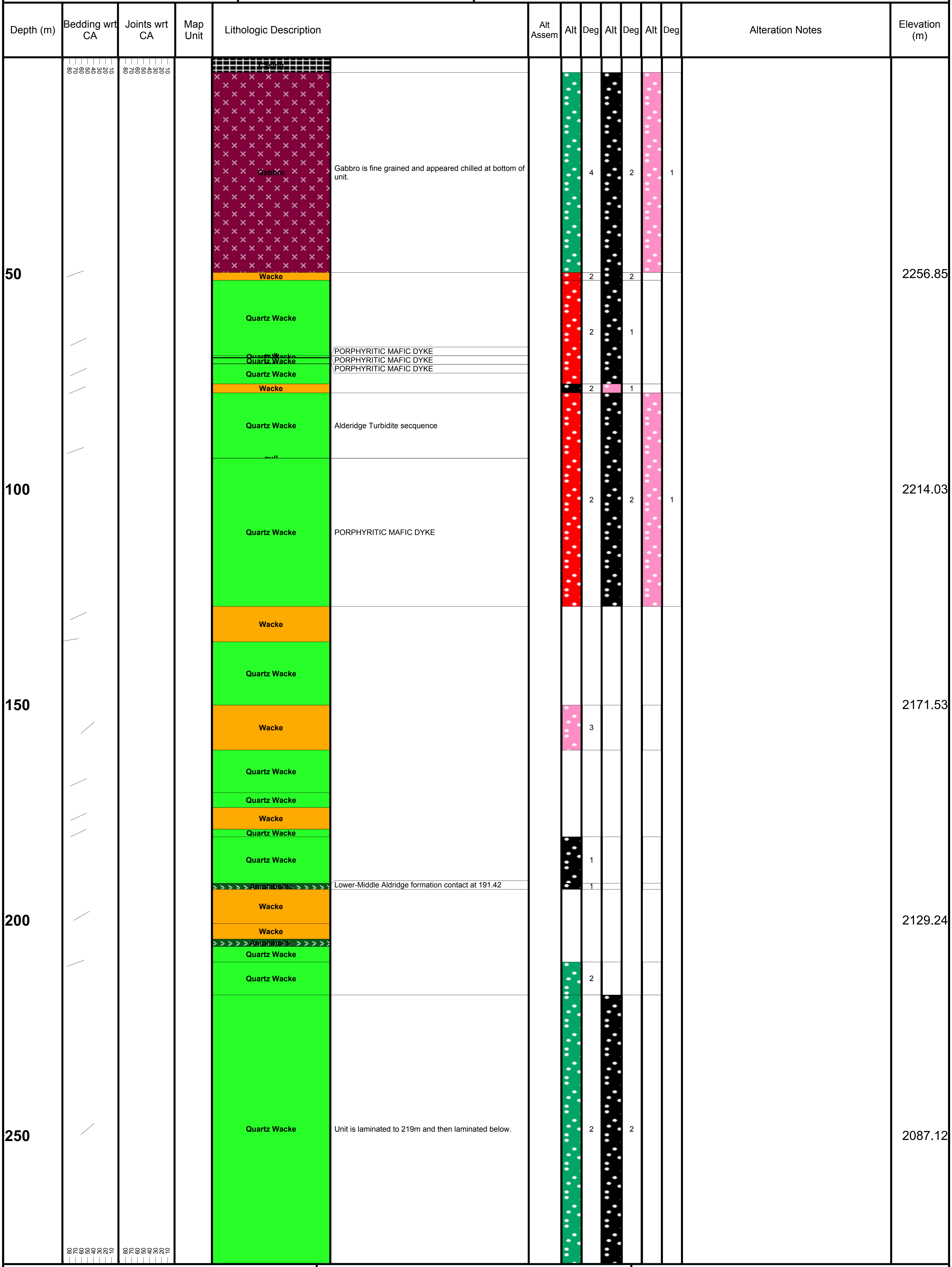
~ 25-35% clasts, elongated and imbricated @ 45 degrees

~ 25-35% clasts imbricated at aout 40 degrees

Scale 1:827	02/09/06	15:43:55

Hole Name :Vu-91-4

Hole Name :Vu-91-4	Hole Azimuth :	Hole Inclination :



Gabbro is fine grained and appeared chilled at bottom of unit.

PORPHYRITIC MAFIC DYKE

PORPHYRITIC MAFIC DYKE

PORPHYRITIC MAFIC DYKE

Alderidge Turbidite secquence

PORPHYRITIC MAFIC DYKE

Lower-Middle Aldridge formation contact at 191.42

Unit is laminated to 219m and then laminated below.

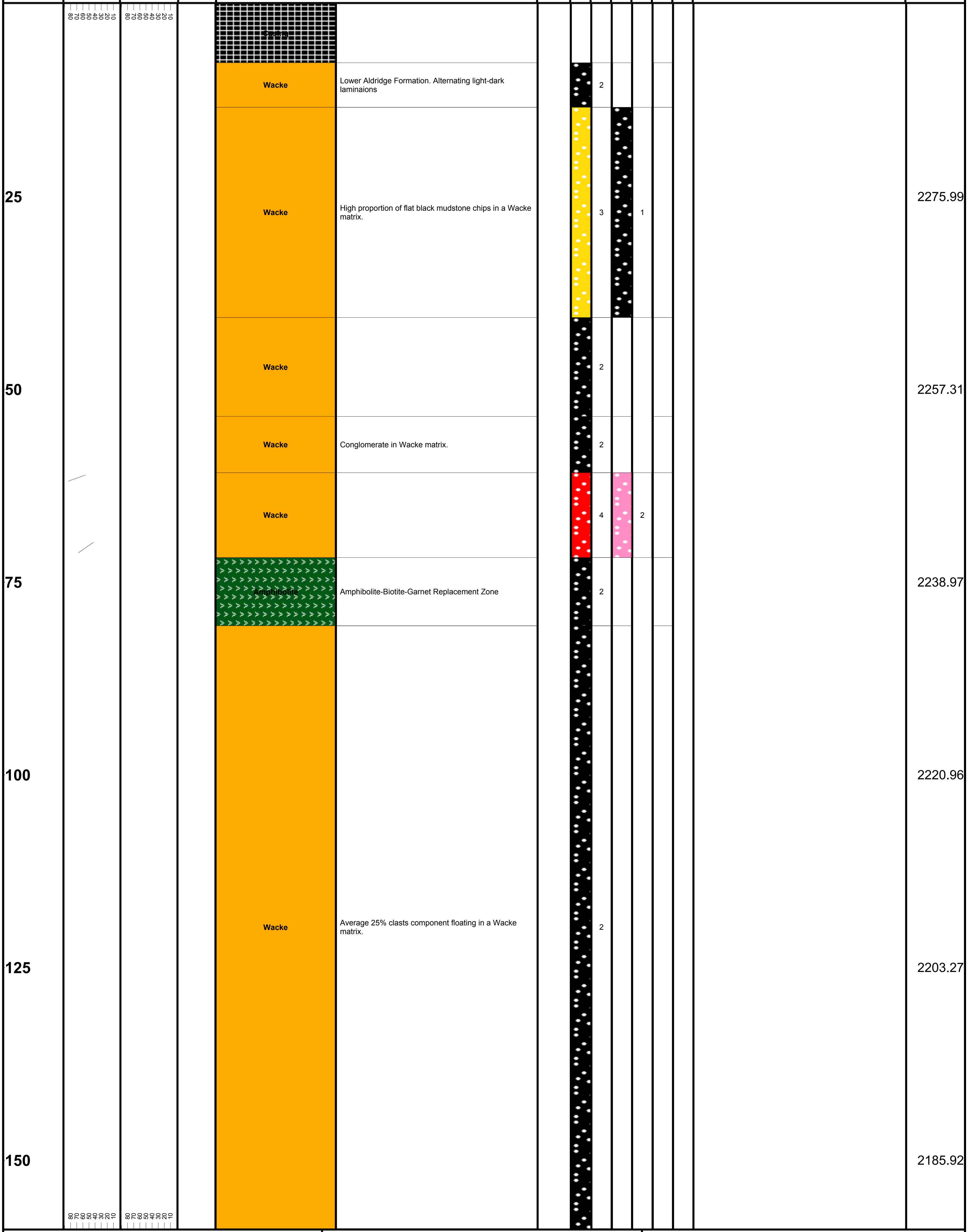
Scale 1:836	02/09/06	15:44:00

Hole Name :Vu-91-5

Hole Name :Vu-91-5

Hole Azimuth :

Hole Inclination :



Depth (m)	Elevation (m)
25	2275.99
50	2257.31
75	2238.97
100	2220.96
125	2203.27
150	2185.92

Lithologic Description		Deg	Deg
Casing			
Wacke	Lower Aldridge Formation. Alternating light-dark laminaions	2	
Wacke	High proportion of flat black mudstone chips in a Wacke matrix.	3	1
Wacke		2	
Wacke	Conglomerate in Wacke matrix.	2	
Wacke		4	2
Amphibolite	Amphibolite-Biotite-Garnet Replacement Zone	2	
Wacke	Average 25% clasts component floating in a Wacke matrix.	2	

Scale 1:475

02/09/06

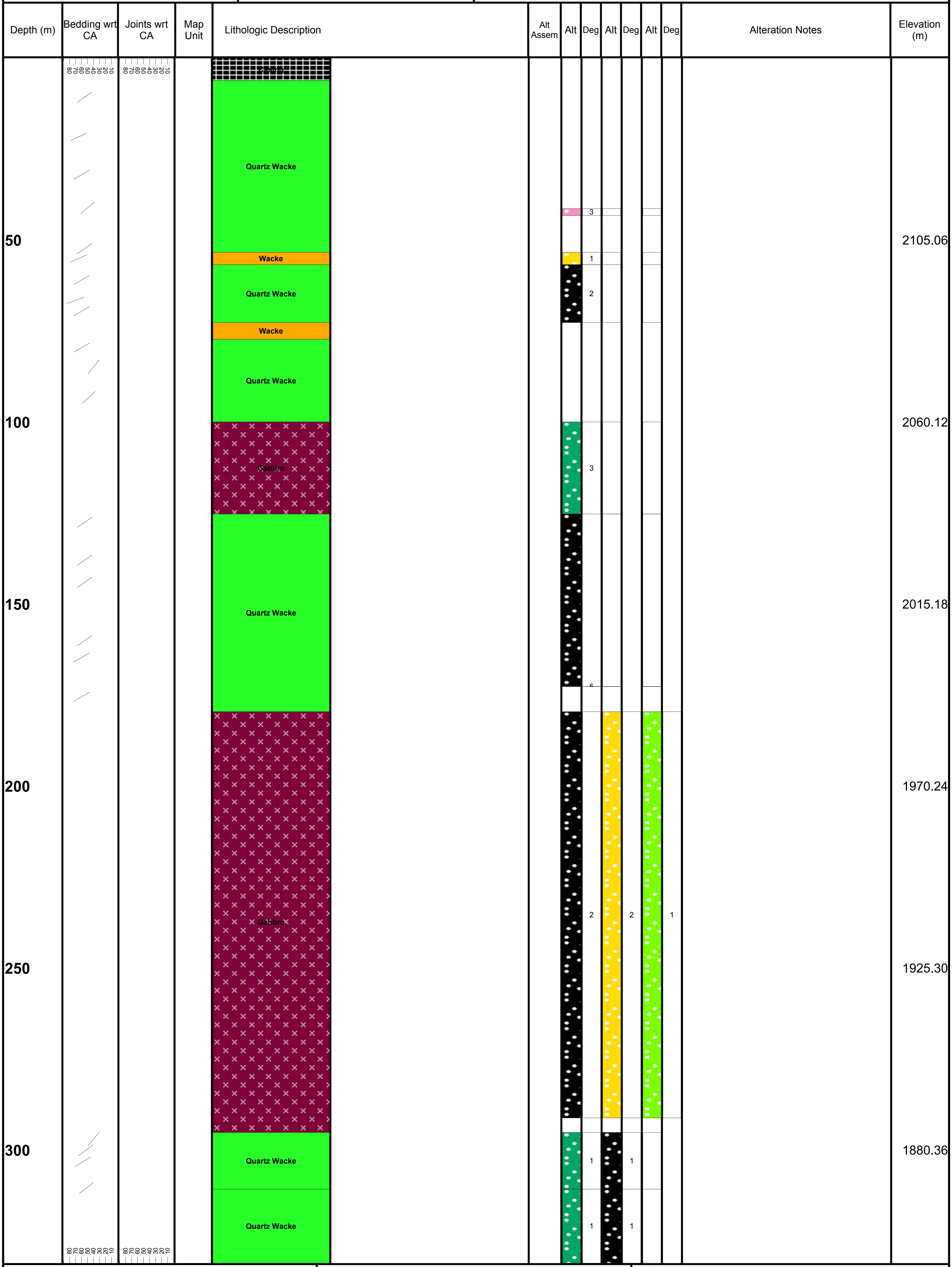
15:44:03

Hole Name :Vu-92-1

Hole Name :Vu-92-1

Hole Azimuth :

Hole Inclination :



Scale 1:990

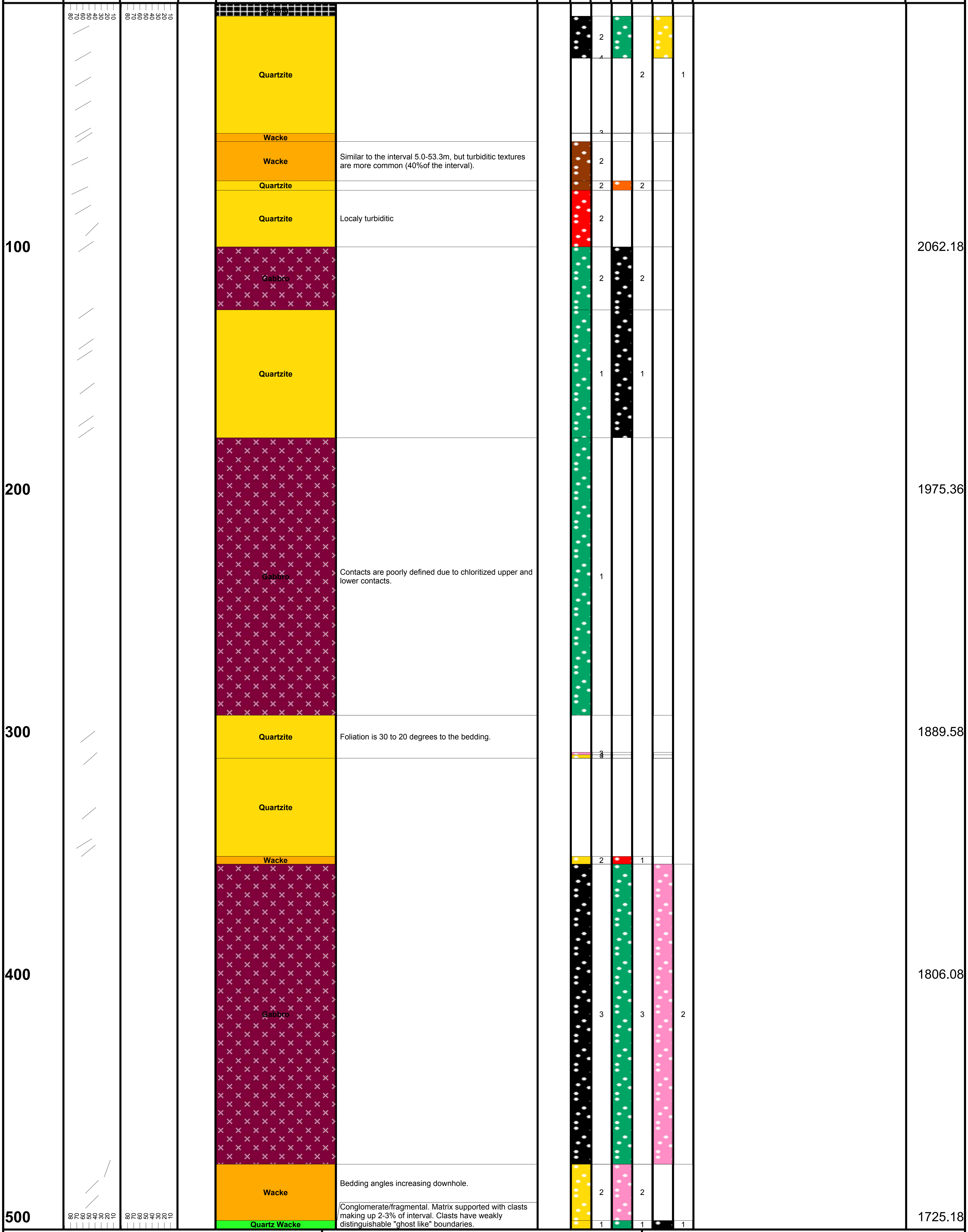
02/09/06

15:44:05

Hole Name :Vu-92-2

Hole Name :Vu-92-2	Hole Azimuth :	Hole Inclination :

Depth (m)	Bedding wrt CA	Joints wrt CA	Map Unit	Lithologic Description	Alt Assem	Alt	Deg	Alt	Deg	Alt	Deg	Alteration Notes	Elevation (m)



Similar to the interval 5.0-53.3m, but turbiditic textures are more common (40%of the interval).

Localy turbiditic

Contacts are poorly defined due to chloritized upper and lower contacts.

Foliation is 30 to 20 degrees to the bedding.

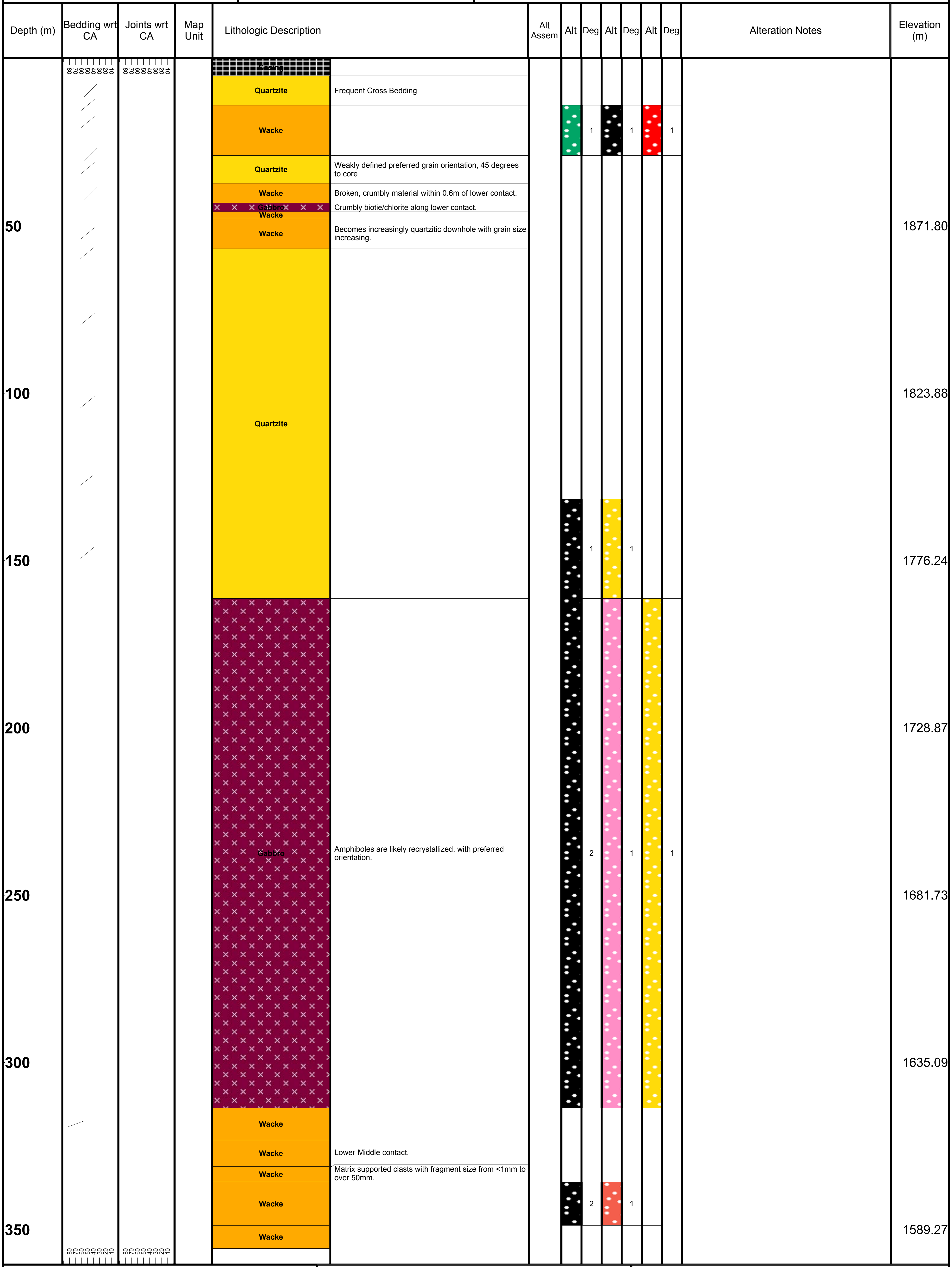
Bedding angles increasing downhole.

Conglomerate/fragmental. Matrix supported with clasts making up 2-3% of interval. Clasts have weakly distinguishable "ghost like" boundaries.

Scale 1:1510	02/09/06	15:44:11

Hole Name :Vu-92-3

Hole Name :Vu-92-3	Hole Azimuth :	Hole Inclination :

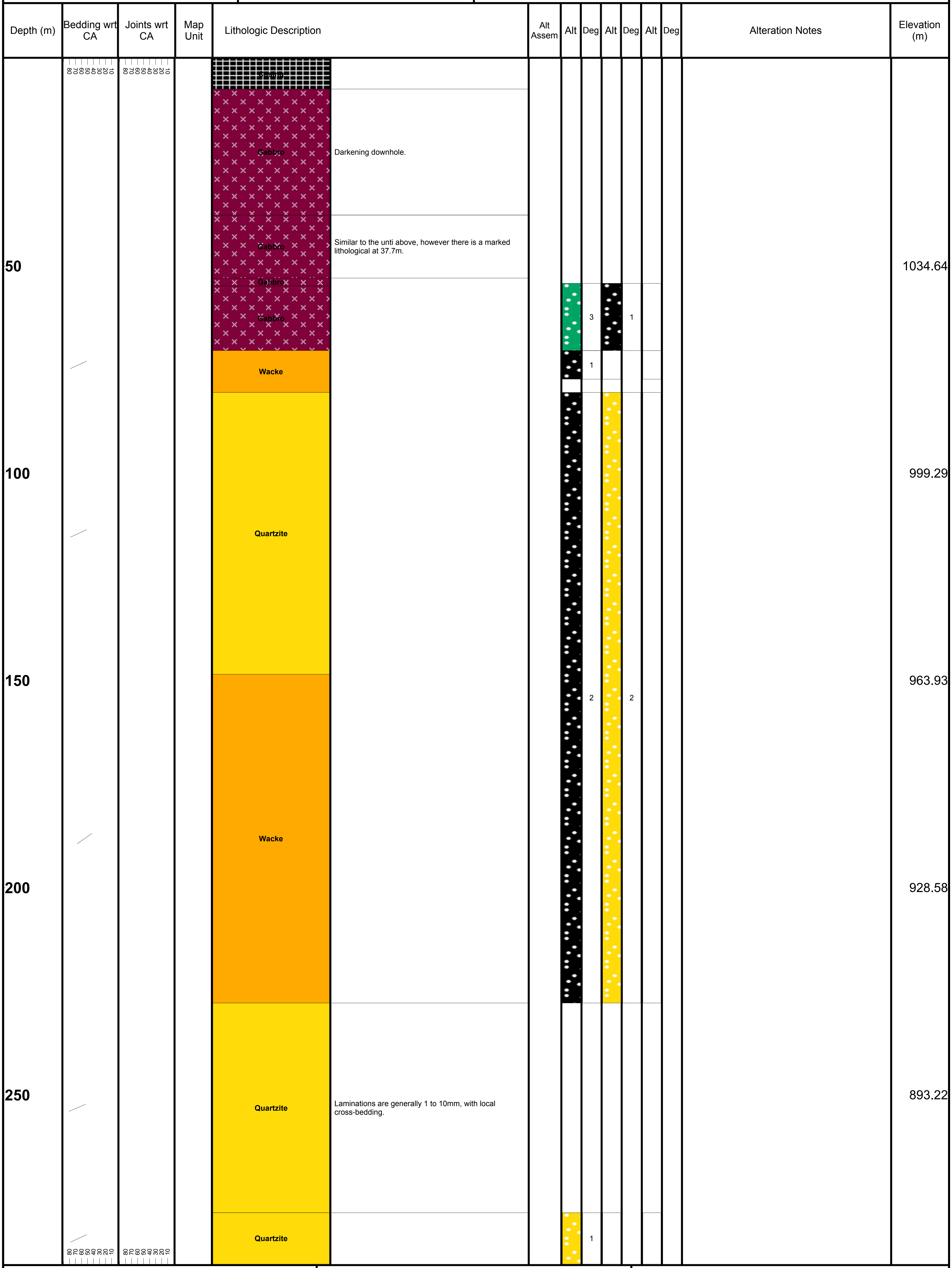


Lithologic Description	
Casing	
Quartzite	Frequent Cross Bedding
Wacke	
Quartzite	Weakly defined preferred grain orientation, 45 degrees to core.
Wacke	Broken, crumbly material within 0.6m of lower contact.
Gabbro	Crumbly biotie/chlorite along lower contact.
Wacke	
Wacke	Becomes increasingly quartzitic downhole with grain size increasing.
Quartzite	
Gabbro	Amphiboles are likely recrystallized, with preferred orientation.
Wacke	
Wacke	Lower-Middle contact.
Wacke	Matrix supported clasts with fragment size from <1mm to over 50mm.
Wacke	
Wacke	

Scale 1:1077	02/09/06	15:44:17

Hole Name :Vu-92-4

Hole Name :Vu-92-4	Hole Azimuth :	Hole Inclination :



Gabbro: Darkening downhole.

Gabbro: Similar to the unti above, however there is a marked lithological at 37.7m.

Quartzite: Laminations are generally 1 to 10mm, with local cross-bedding.

Scale 1:870	02/09/06	15:44:23

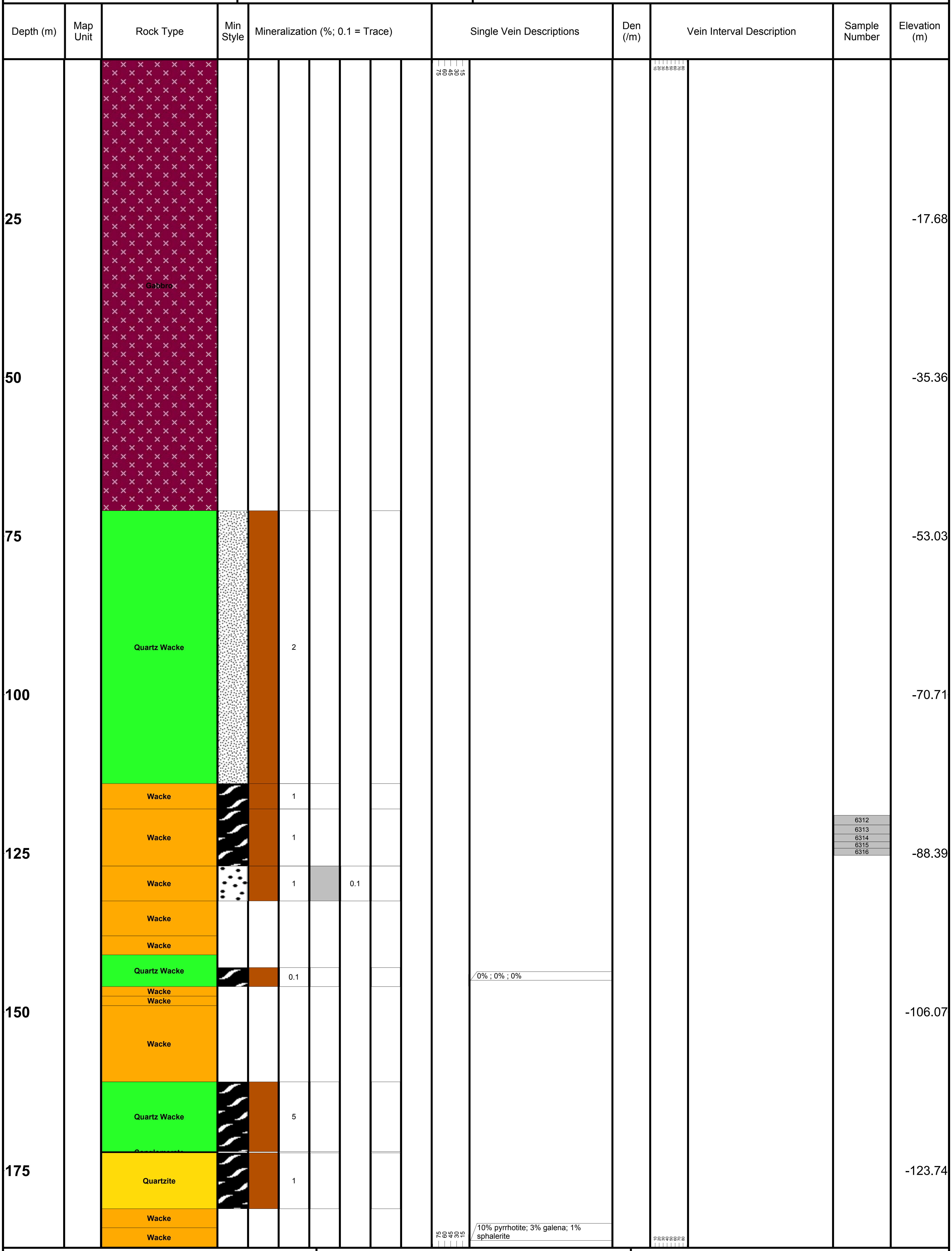
APPENDIX III

DIAMOND DRILL LOGS

3.1.2 Mineralization and Veining

Hole Name :V-79-1

Hole Length :187.00	Hole Azimuth :	Hole Inclination :

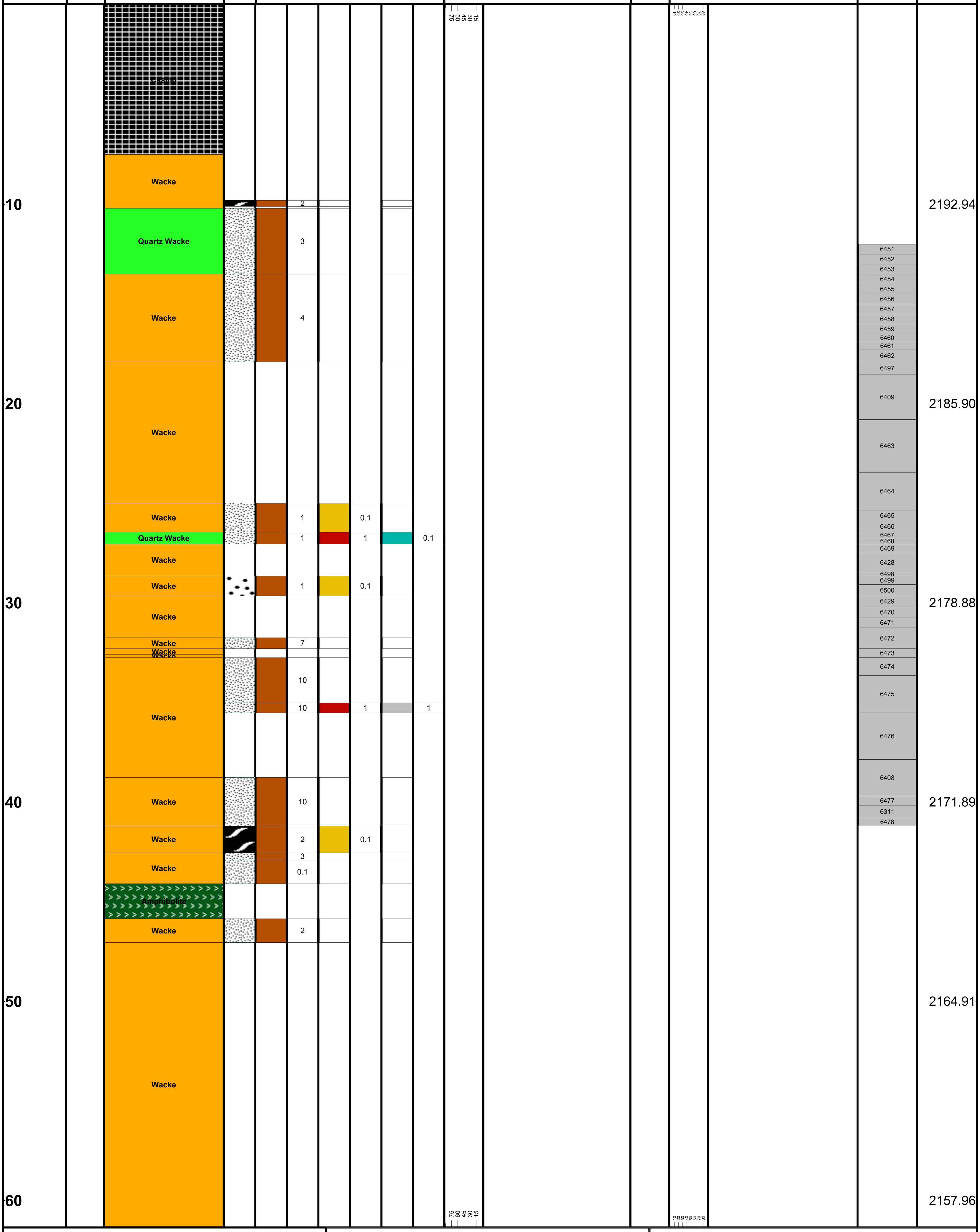


Scale 1:564	02/09/06	16:03:44

Hole Name :Vu-91-1

Hole Length :61.30	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Rock Type	Min Style	Mineralization (%; 0.1 = Trace)	Single Vein Descriptions	Den (/m)	Vein Interval Description	Sample Number	Elevation (m)



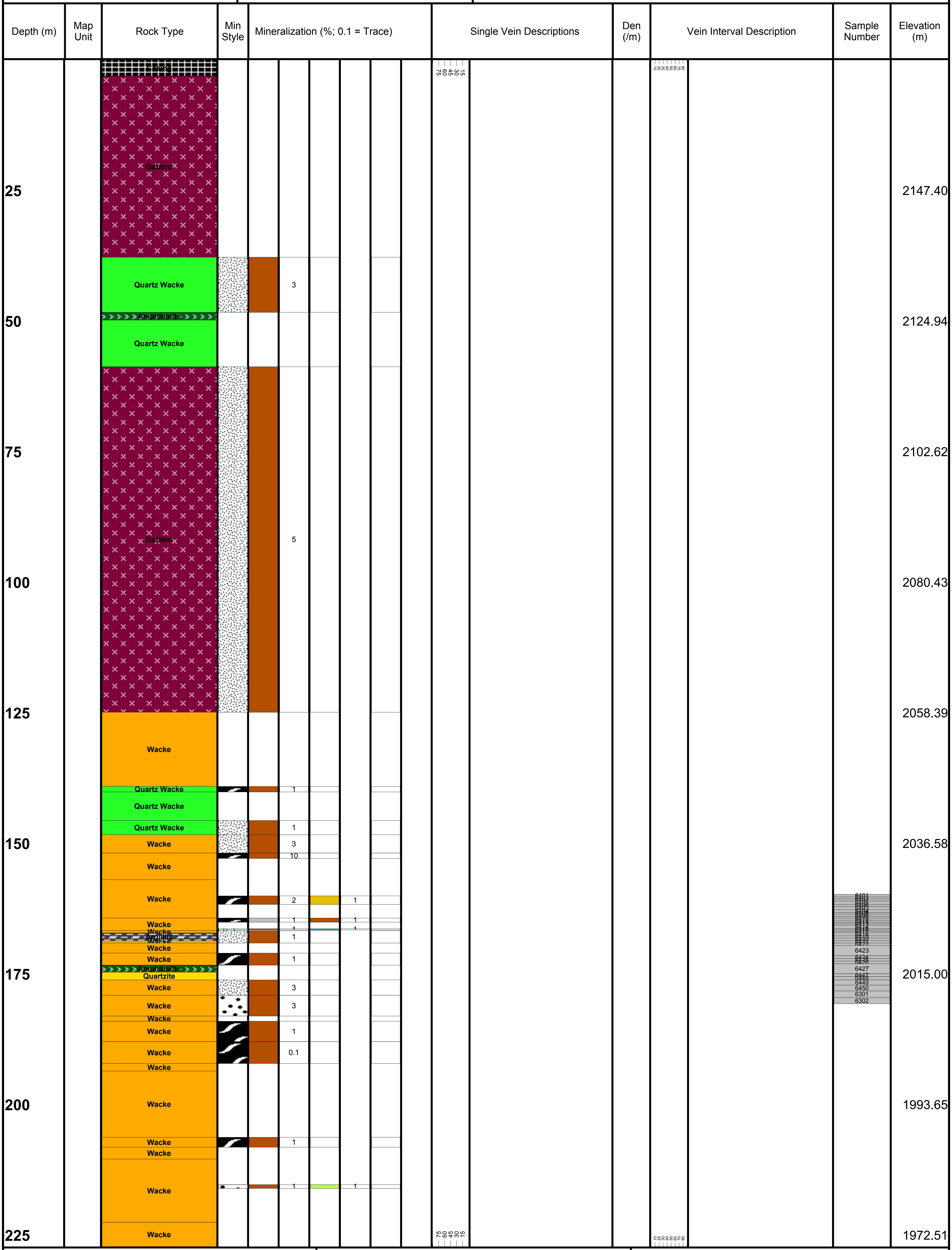
Scale 1:185	02/09/06	16:03:48

Hole Name :Vu-91-2

Hole Length :227.13

Hole Azimuth :

Hole Inclination :



Scale 1:685

02/09/06

16:03:49

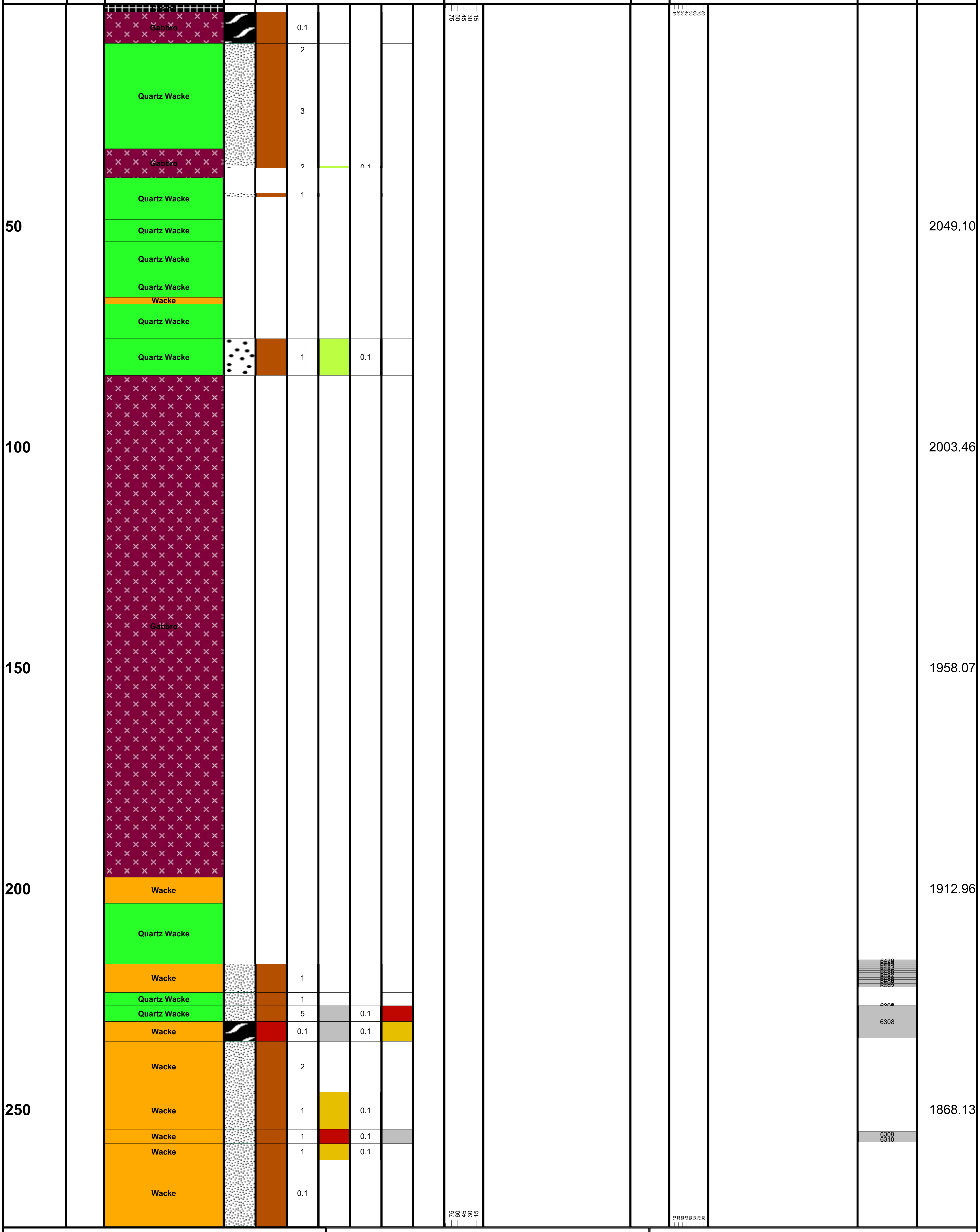
Hole Name :Vu-91-3

Hole Length :276.52

Hole Azimuth :

Hole Inclination :

Depth (m)	Map Unit	Rock Type	Min Style	Mineralization (%; 0.1 = Trace)	Single Vein Descriptions	Den (/m)	Vein Interval Description	Sample Number	Elevation (m)



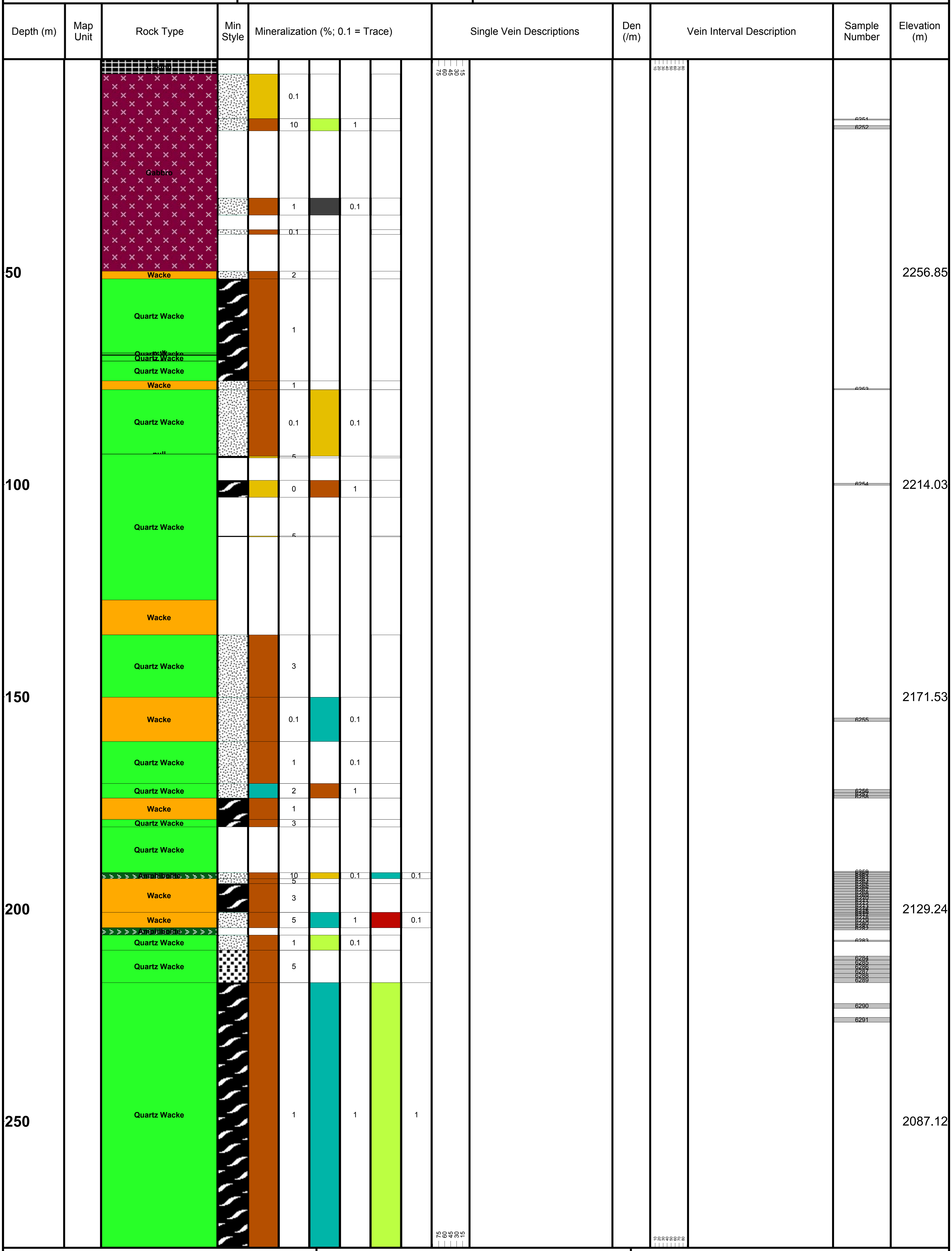
Scale 1:833

02/09/06

16:03:54

Hole Name :Vu-91-4

Hole Length :279.57	Hole Azimuth :	Hole Inclination :



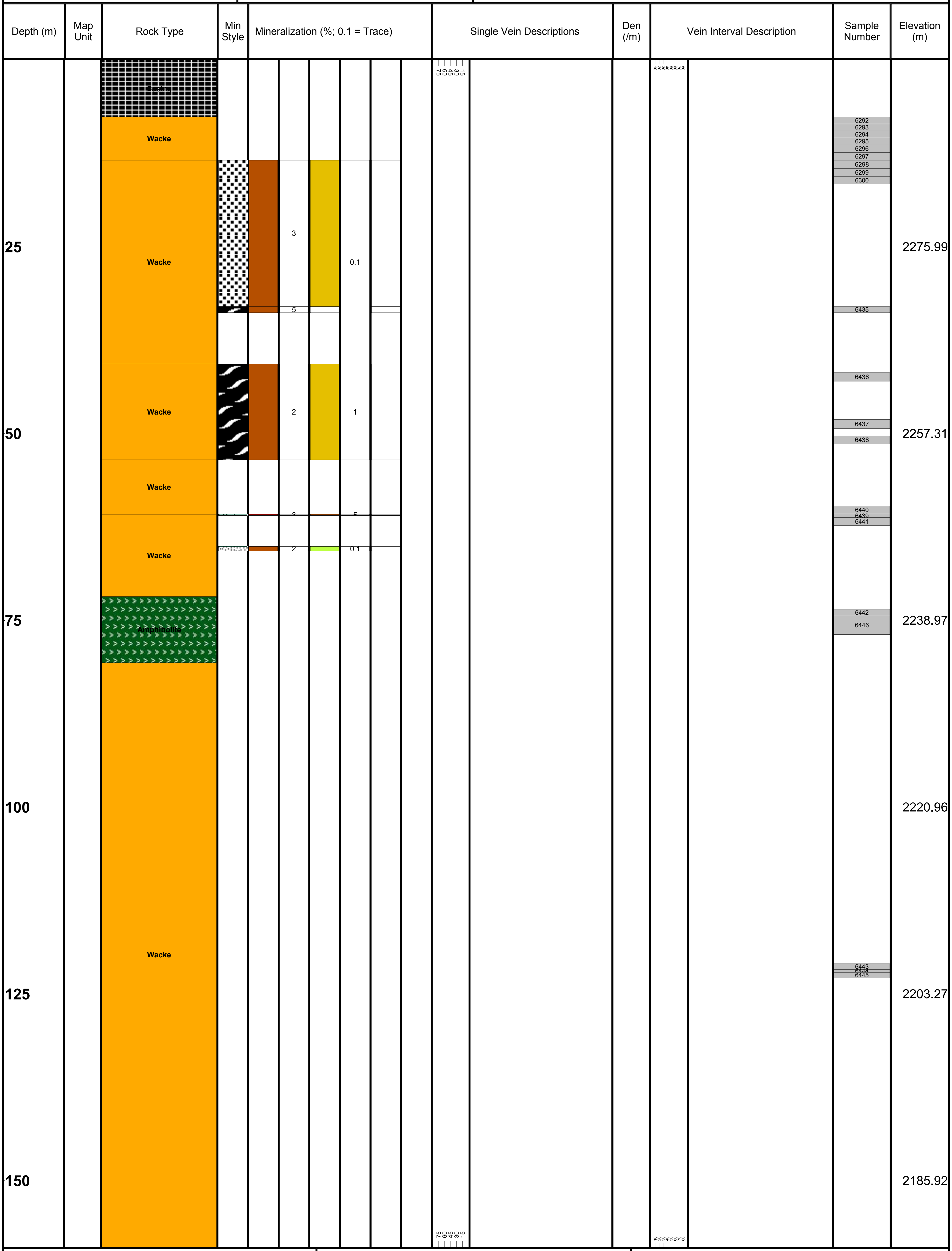
Scale 1:843	02/09/06	16:03:59

Hole Name :Vu-91-5

Hole Length :158.84

Hole Azimuth :

Hole Inclination :



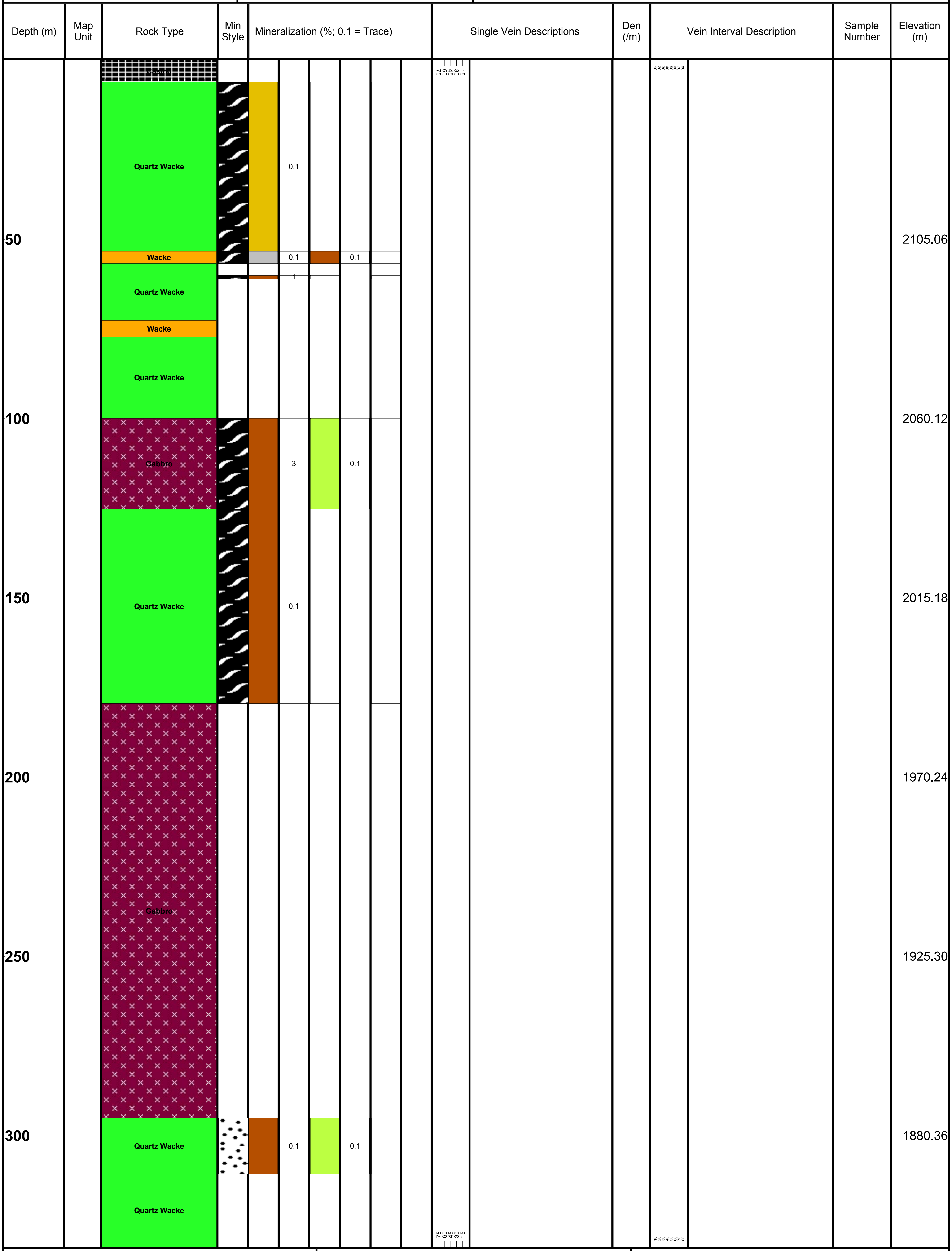
Scale 1:479

02/09/06

16:04:01

Hole Name :Vu-92-1

Hole Length :331.00	Hole Azimuth :	Hole Inclination :

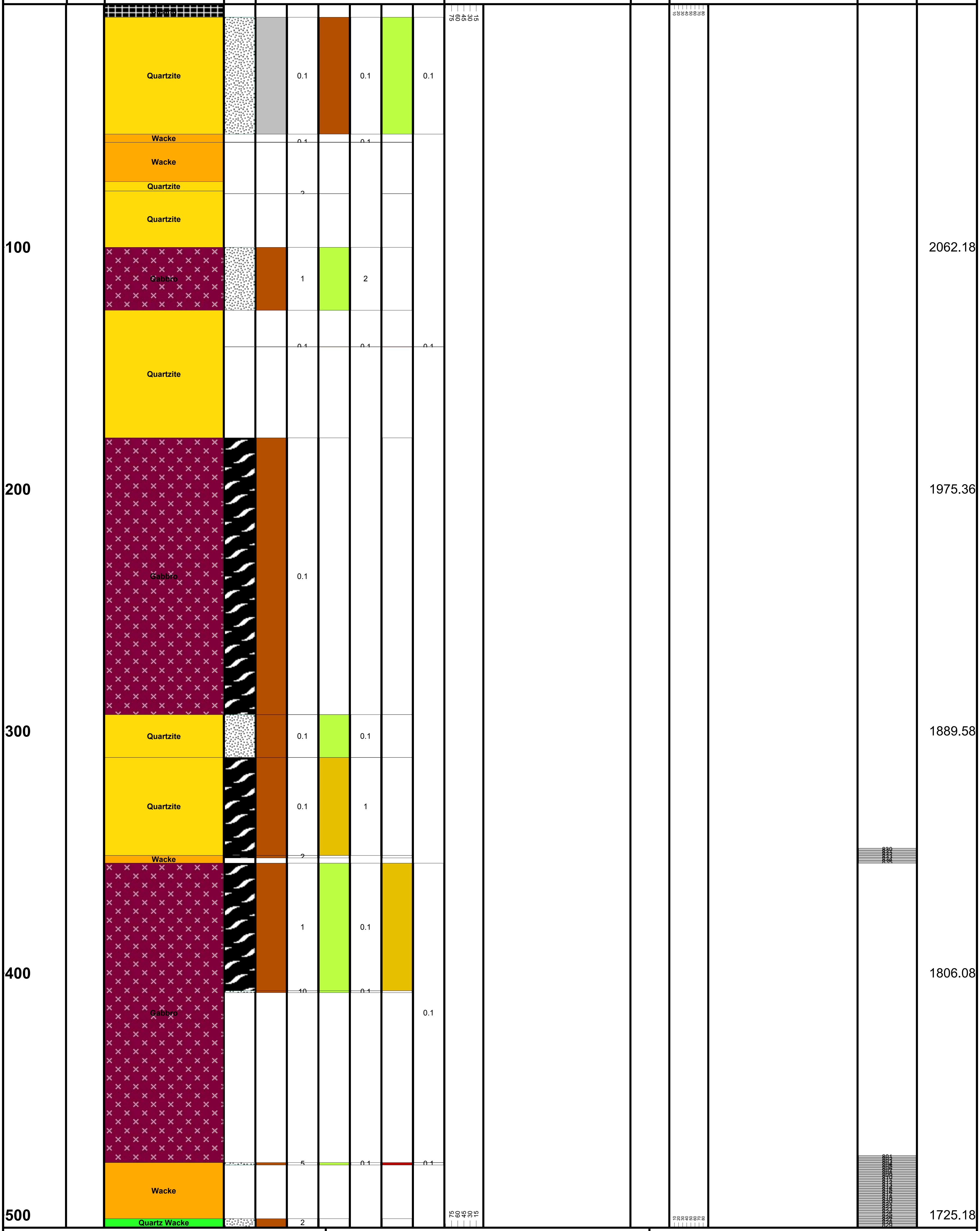


Scale 1:998	02/09/06	16:04:02

Hole Name :Vu-92-2

Hole Length :684.60	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Rock Type	Min Style	Mineralization (%; 0.1 = Trace)	Single Vein Descriptions	Den (/m)	Vein Interval Description	Sample Number	Elevation (m)



Scale 1:1522	02/09/06	16:04:06

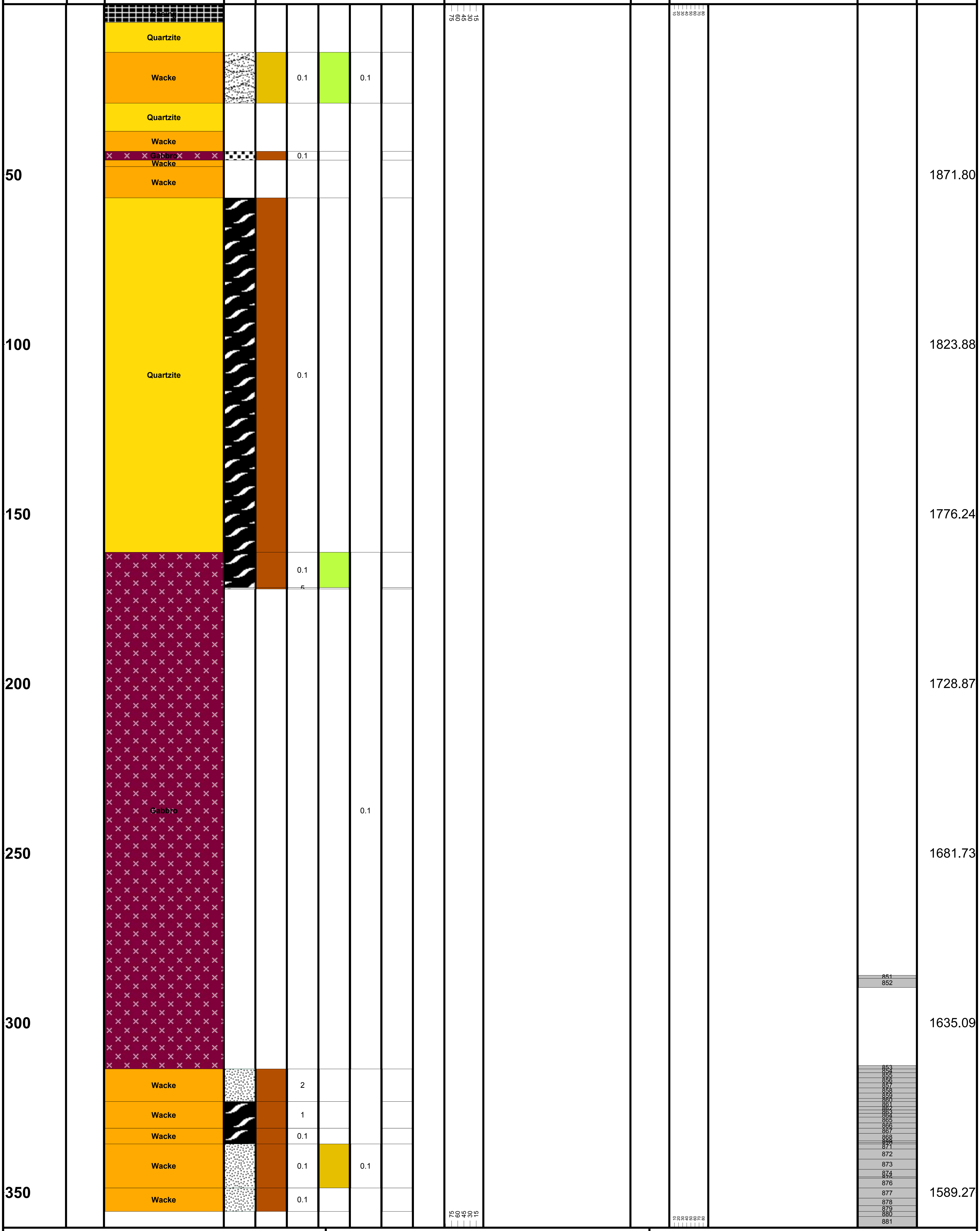
Hole Name :Vu-92-3

Hole Length :519.40

Hole Azimuth :

Hole Inclination :

Depth (m) | Map Unit | Rock Type | Min Style | Mineralization (%; 0.1 = Trace) | Single Vein Descriptions | Den (/m) | Vein Interval Description | Sample Number | Elevation (m)



Scale 1:1086

02/09/06

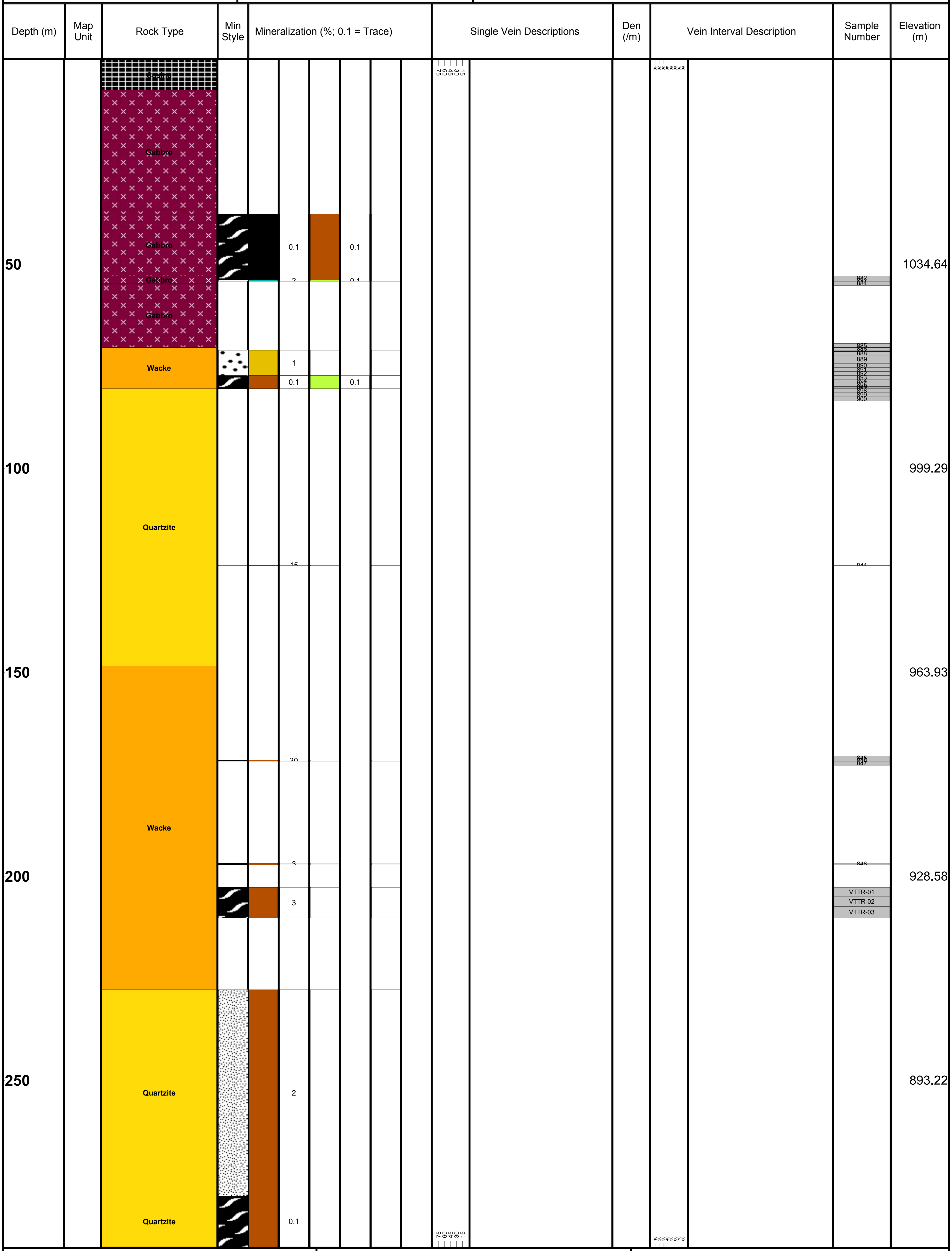
16:04:12

Hole Name :Vu-92-4

Hole Length :290.80

Hole Azimuth :

Hole Inclination :



Scale 1:877

02/09/06

16:04:16

APPENDIX III

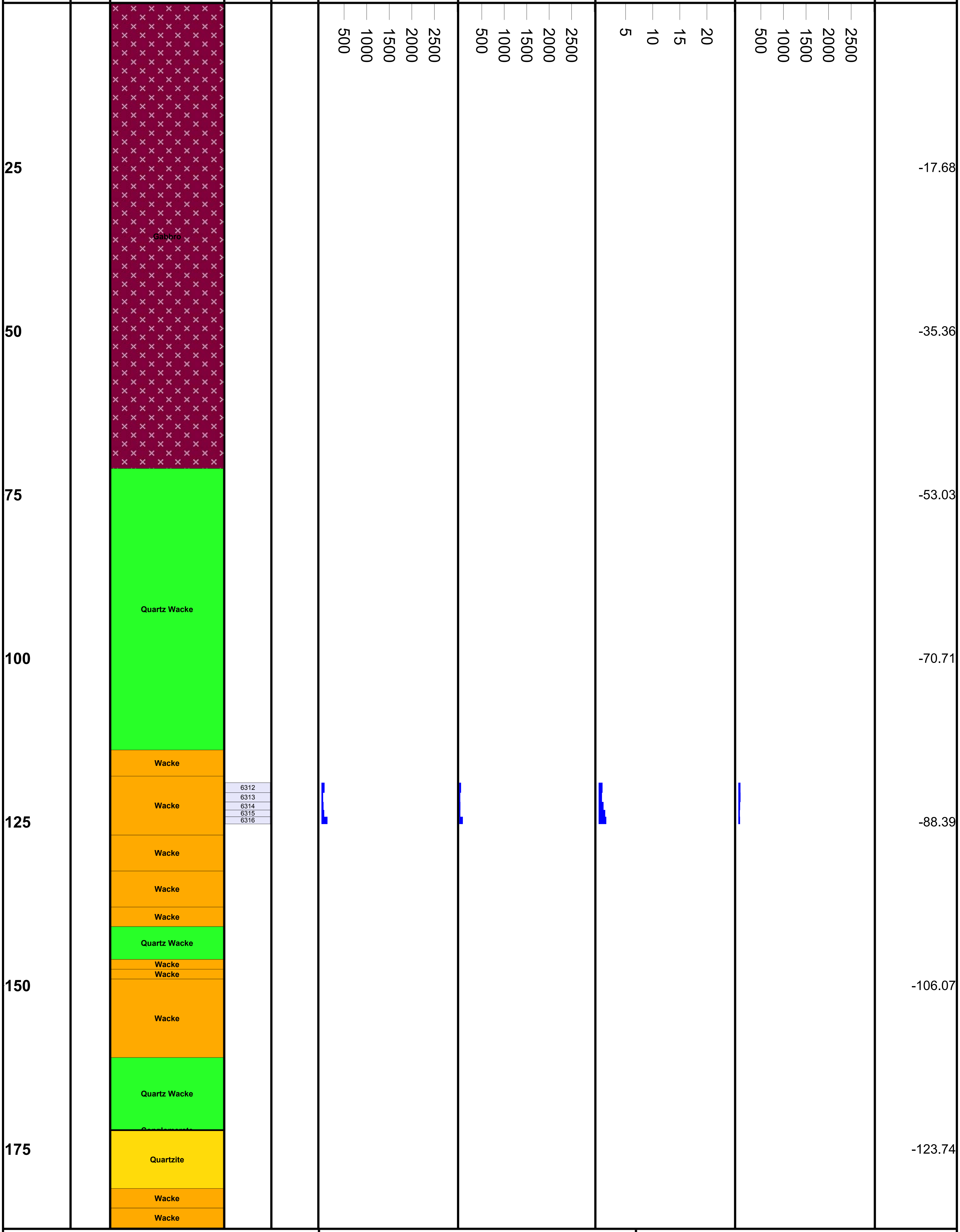
DIAMOND DRILL LOGS

3.1.3 Analytical Results

Hole Name :V-79-1

Hole Length :187.00	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results				Elevation (m)
Depth At	DDH_LITH_UNIT	DDH_LITH_RTYPE_MAJ	DDH_SAMP_SAMP	SAMP_ANAL	Zn_ppm	Pb_ppm	Ag_ppm	Cu_ppm	Elevation

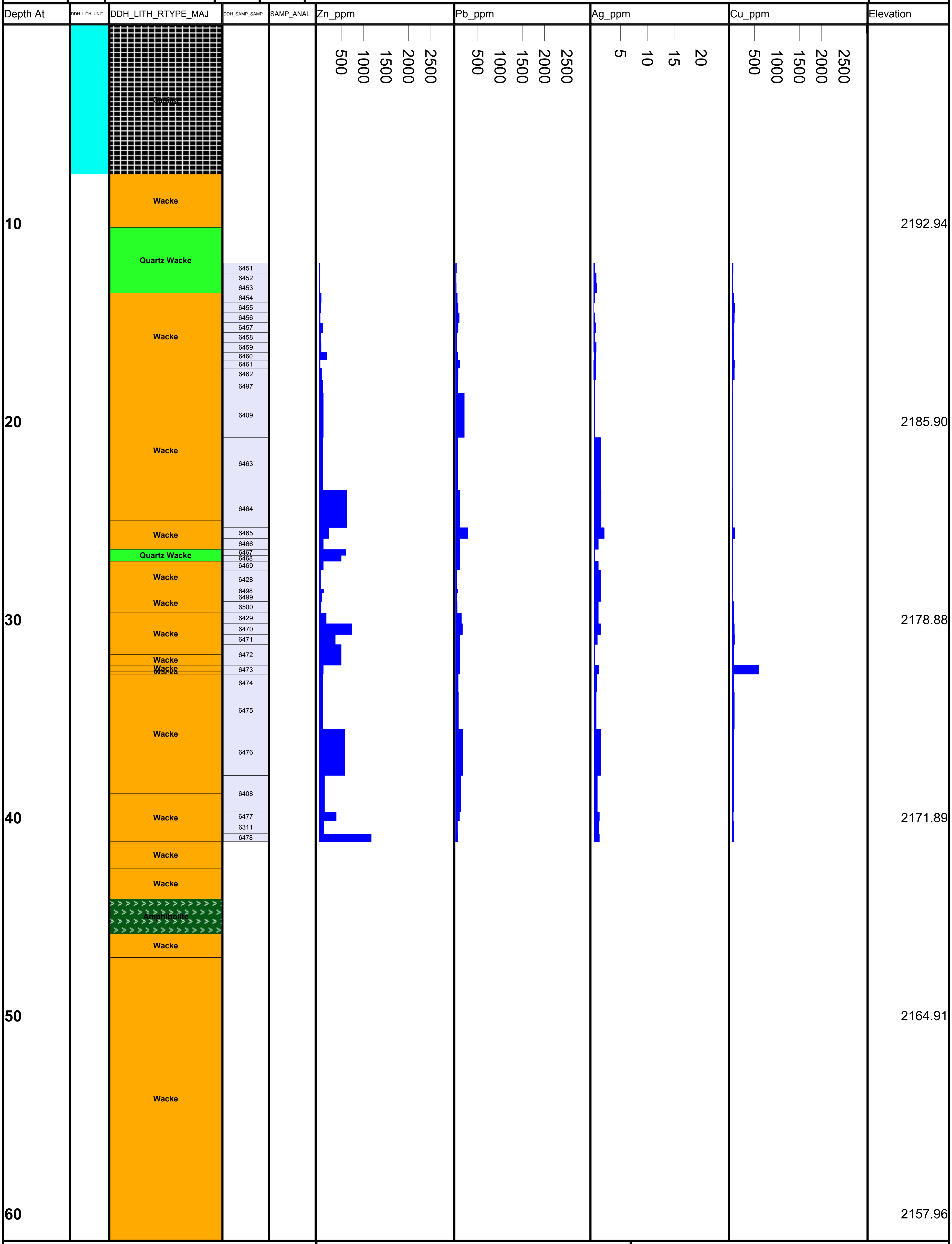


Scale 1:570	02/09/06	15:47:16

Hole Name :Vu-91-1

Hole Length :61.30	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results	Elevation (m)



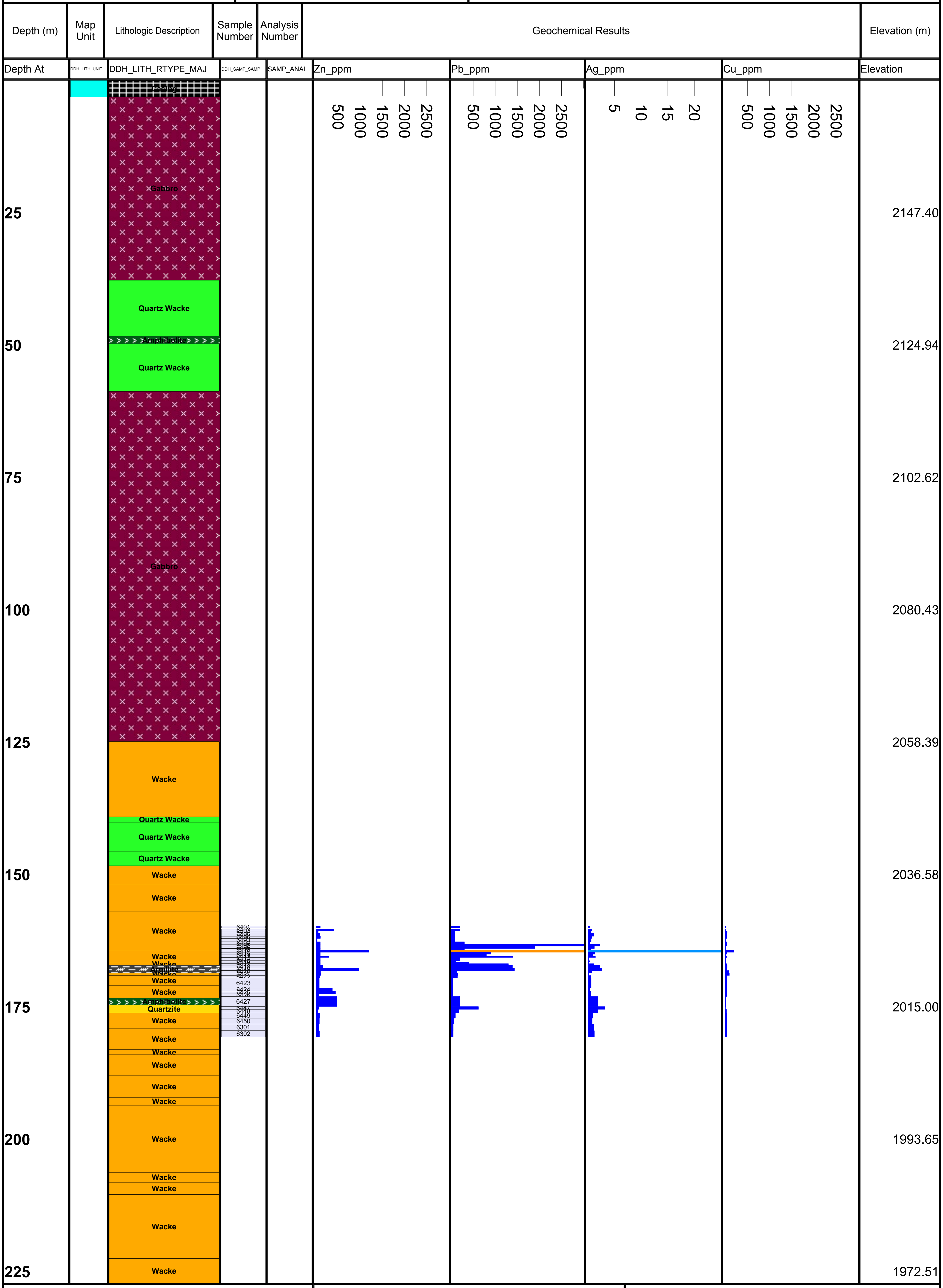
Scale 1:187	02/09/06	15:47:19

Hole Name :Vu-91-2

Hole Length :227.13

Hole Azimuth :

Hole Inclination :



Scale 1:693

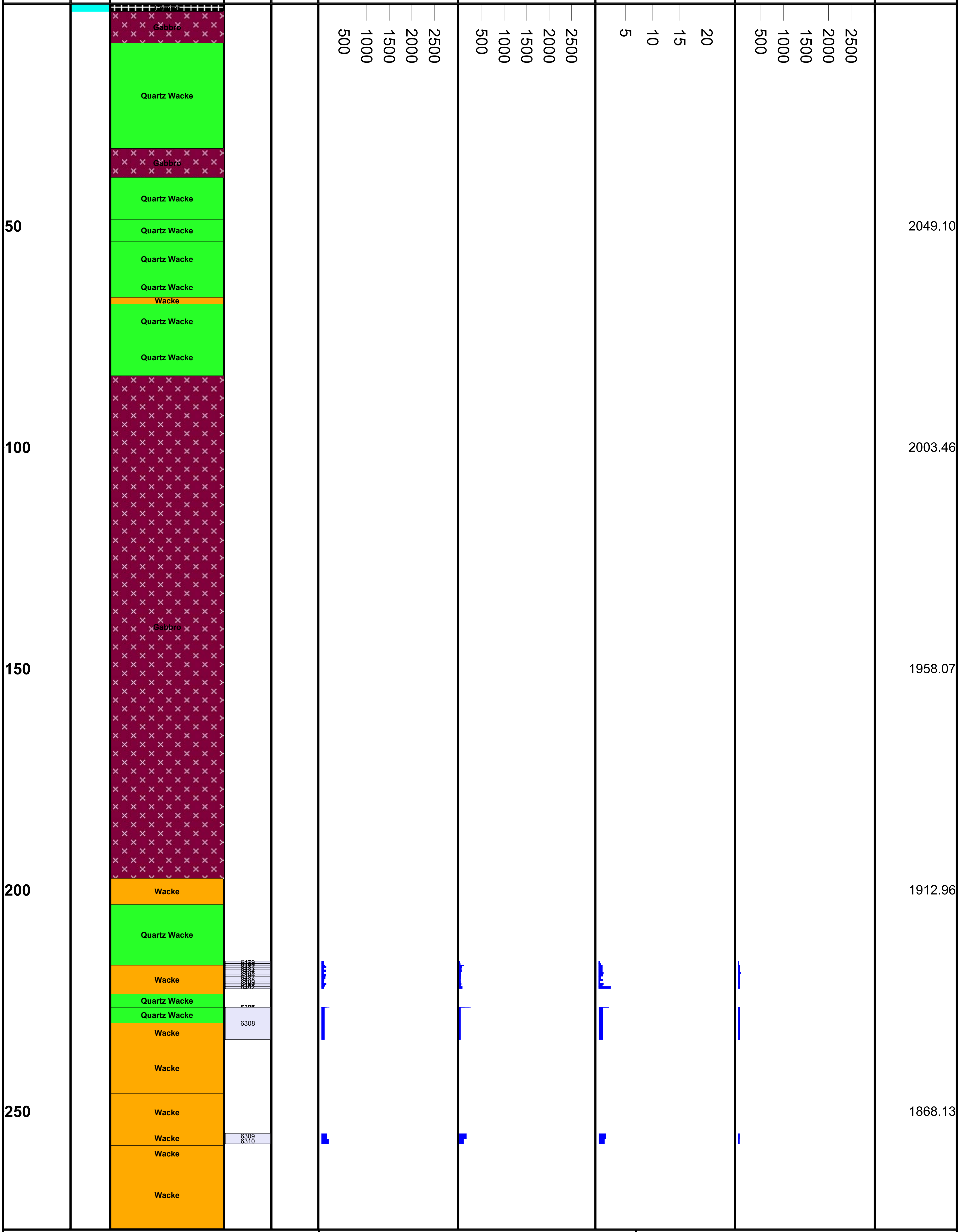
02/09/06

15:47:19

Hole Name :Vu-91-3

Hole Length :276.52	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results				Elevation (m)
Depth At	DDH_LITH_UNIT	DDH_LITH_RTYPE_MAJ	DDH_SAMP_SAMP	SAMP_ANAL	Zn_ppm	Pb_ppm	Ag_ppm	Cu_ppm	Elevation



Scale 1:843

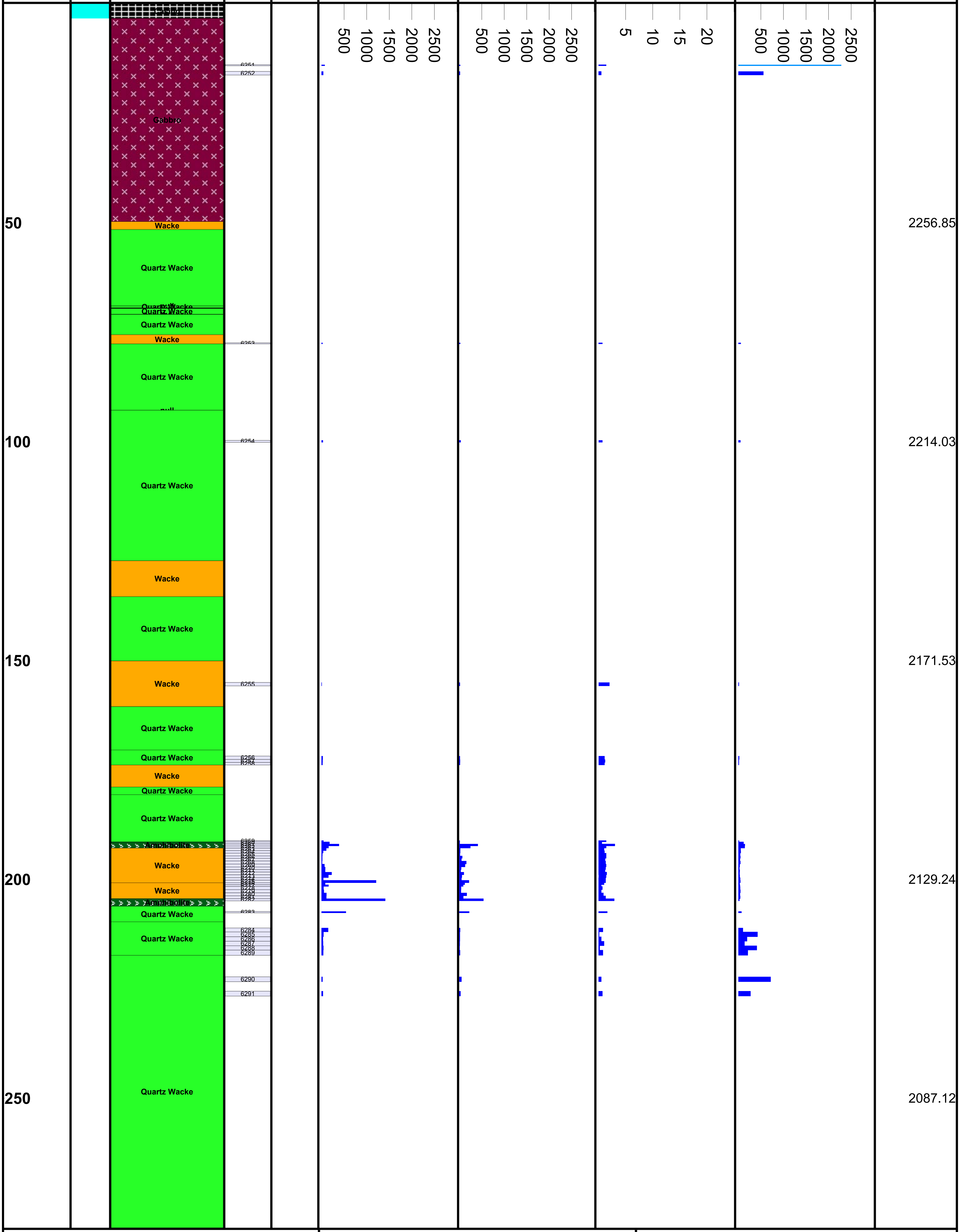
02/09/06

15:47:23

Hole Name :Vu-91-4

Hole Length :279.57	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results				Elevation (m)
Depth At	DDH_LITH_UNIT	DDH_LITH_RTYPE_MAJ	DDH_SAMP_SAMP	SAMP_ANAL	Zn_ppm	Pb_ppm	Ag_ppm	Cu_ppm	Elevation

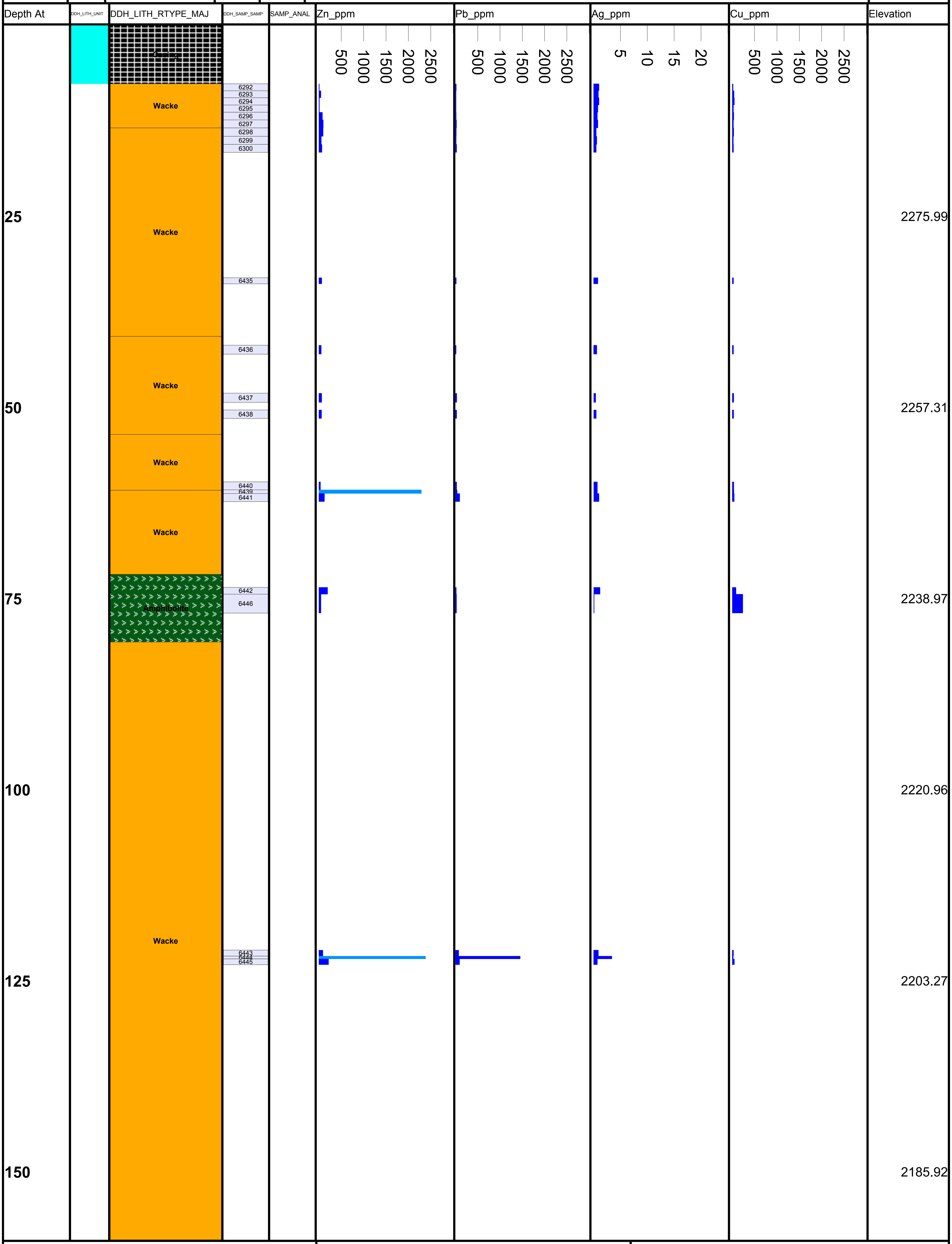


Scale 1:853	02/09/06	15:47:27

Hole Name :Vu-91-5

Hole Length :158.84	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results	Elevation (m)

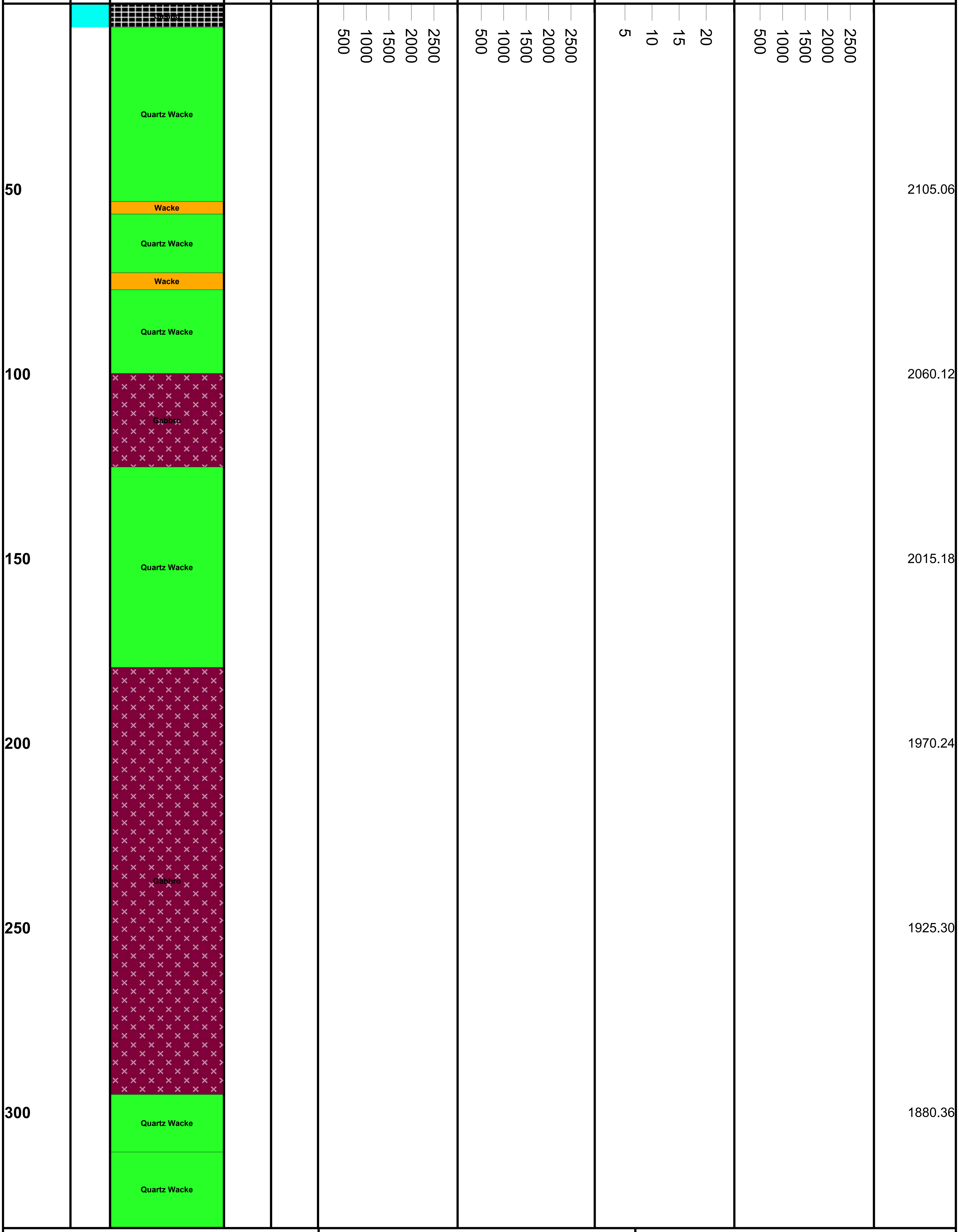


Scale 1:485	02/09/06	15:47:28

Hole Name :Vu-92-1

Hole Length :331.00	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results				Elevation (m)
Depth At	DDH_LITH_UNIT	DDH_LITH_RTYPE_MAJ	DDH_SAMP_SAMP	SAMP_ANAL	Zn_ppm	Pb_ppm	Ag_ppm	Cu_ppm	Elevation



Scale 1:1010	02/09/06	15:47:29

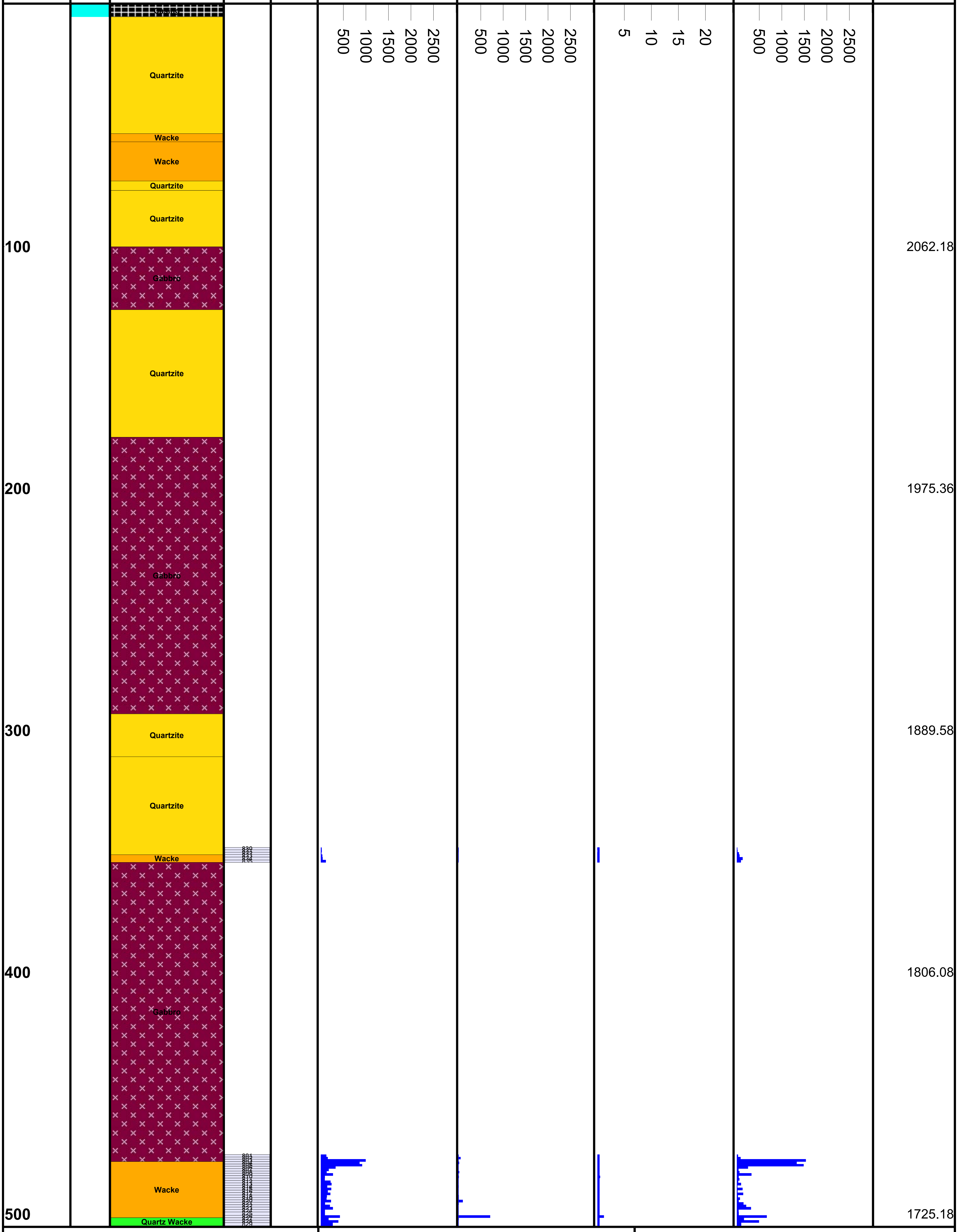
Hole Name :Vu-92-2

Hole Length :684.60

Hole Azimuth :

Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results				Elevation (m)
Depth At	DDH_LITH_UNIT	DDH_LITH_RTYPE_MAJ	DDH_SAMP_SAMP	SAMP_ANAL	Zn_ppm	Pb_ppm	Ag_ppm	Cu_ppm	Elevation



Scale 1:1540

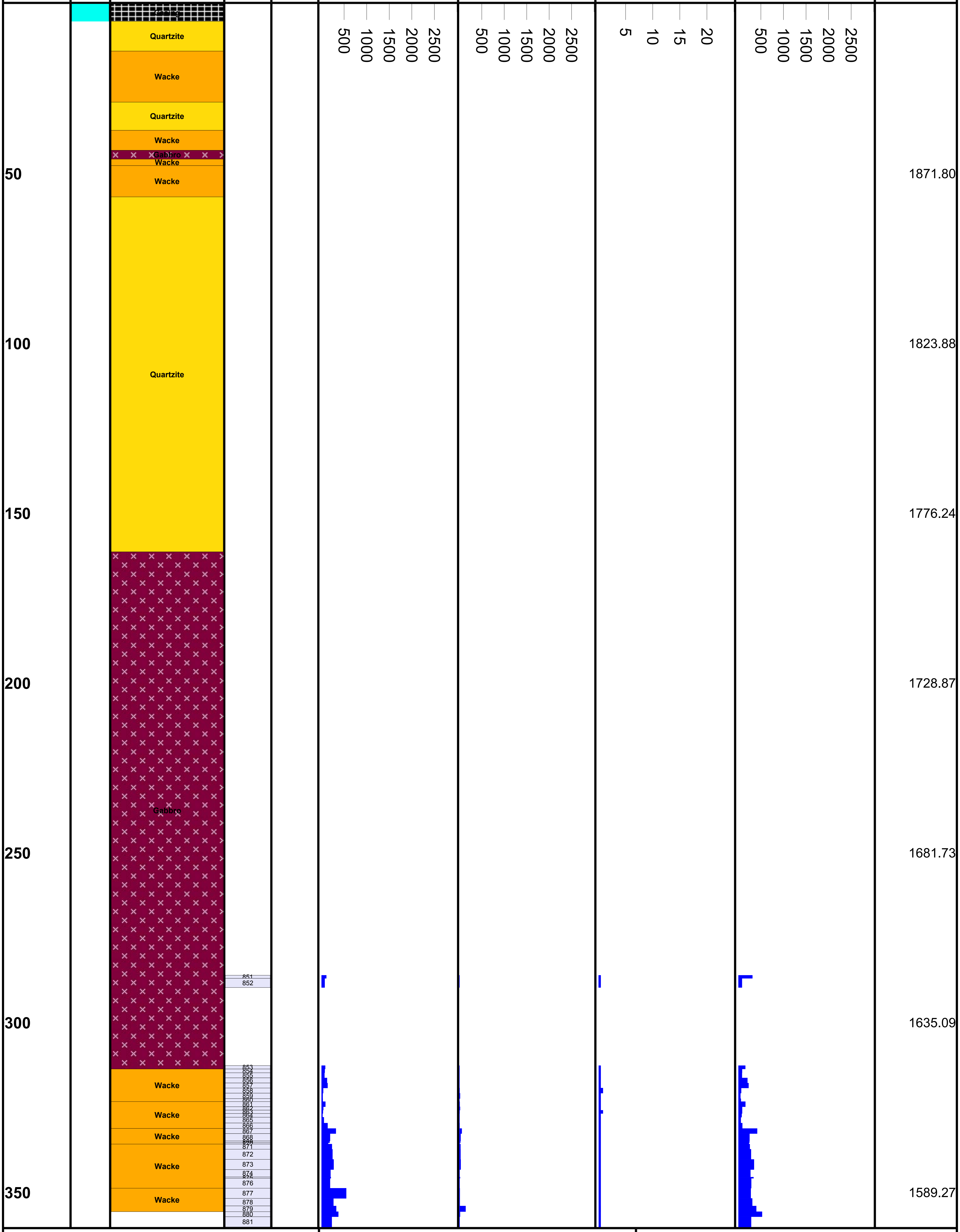
02/09/06

15:47:32

Hole Name :Vu-92-3

Hole Length :519.40	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results				Elevation (m)
Depth At	DDH_LITH_UNIT	DDH_LITH_RTYPE_MAJ	DDH_SAMP_SAMP	SAMP_ANAL	Zn_ppm	Pb_ppm	Ag_ppm	Cu_ppm	Elevation

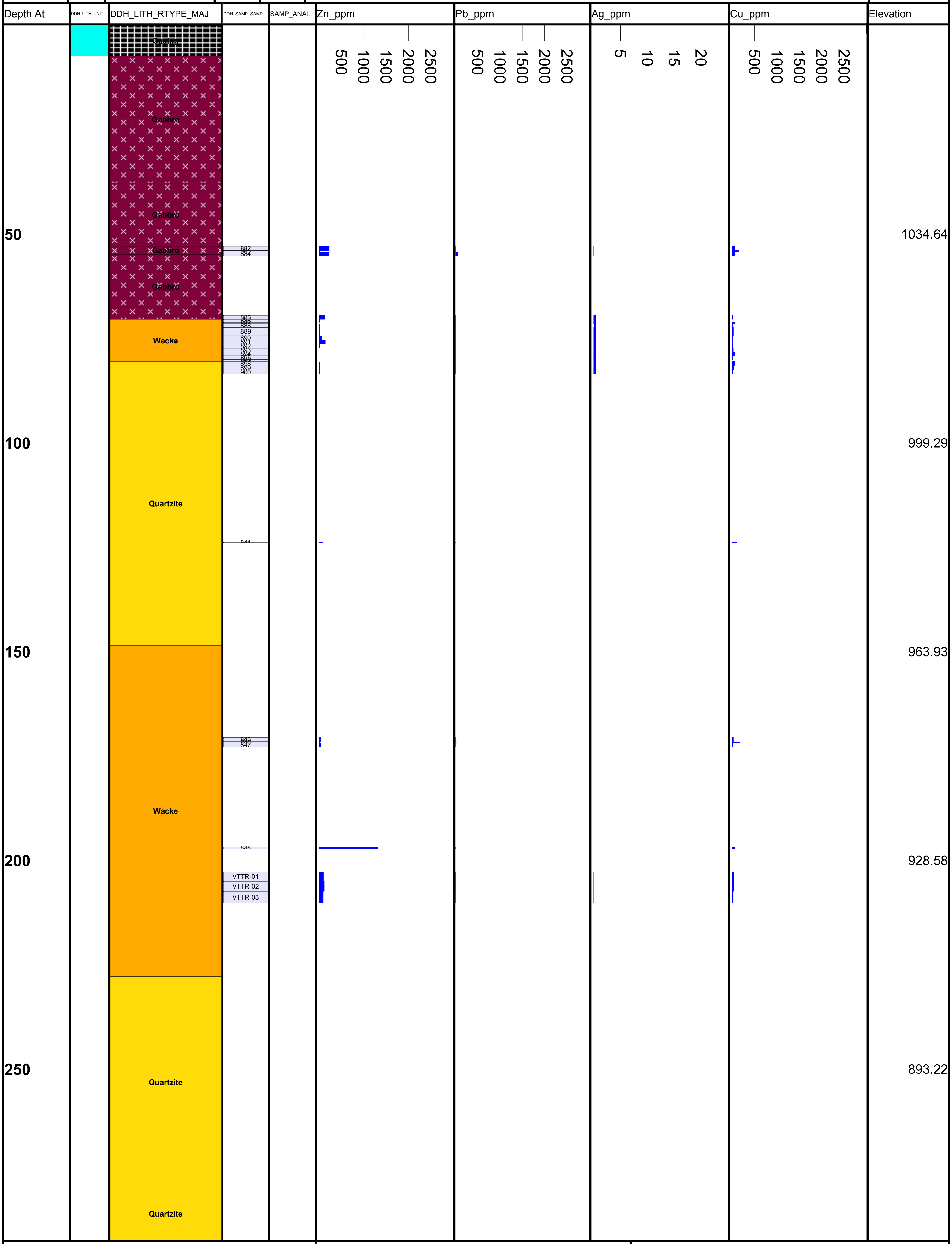


Scale 1:1098	02/09/06	15:47:36

Hole Name :Vu-92-4

Hole Length :290.80	Hole Azimuth :	Hole Inclination :

Depth (m)	Map Unit	Lithologic Description	Sample Number	Analysis Number	Geochemical Results	Elevation (m)



Scale 1:887	02/09/06	15:47:40

APPENDIX III

DIAMOND DRILL LOGS

3.1.4 Strip Log Legend

Legend - Global - Alteration	
	?
🟥	ALBITE
🟧	ANKERITE
⬛	BIOTITE
🟦	BLEACHED
🟦	CALCITE
🟦	CARBONATE
🟩	CHLORITE
🟧	CLAY
🟩	EPIDOTE
🟫	FE STAINING
🟪	FLOURITE
🟧	KSPAR
	NONE
🟨	PYRITE
🟨	SERICITE
🟥	SILICA
🟪	TOURMALINE

Legend - Global - Min Style	
🟦	?
●	BLEBBY
⁘	DISSEMINATED
▨	FRACTURES
⬛	MASSIVE
▤	NODULAR
	NONE
	SELECT

Legend - Global - Lithology			
🟩	Amphibolite	🟥	Andesite
🟥	Anhydrite	🟧	Aplite
🟦	Argilliceous Dolomite	🟦	Argilliceous Limestone
⬛	Argillite	🟫	Arkosic Grit
🟪	Breccia	🟩	Calc-silicate
▦	Casing	▦	Collar
🟦	Dacite	🟩	Diorite
▤	Dolomite	🟦	Dolomitic Mudstone
⁘	Dolomitic Sandstone	🟧	Felsic Intrusive
🟥	Gabbro	▤	Gneiss
🟪	Granite	🟧	Granodiorite
🟩	Greenstone	⬜	Greywacke
🟪	Gypsum	🟥	Hornblende GranoD
🟥	Hornfels	🟨	Intermediate Intrusive
🟧	Intermediate volcanic	🟪	Lamprophyre
🟦	Limestone	🟩	Mafic Dyke
▤	Meta-siltstone	🟪	Monzonite
▤	Mudstone	●	Overburden
🟧	Pegmatite	🟨	Phy Quartzite
▤	Phy Siltstone	▤	Phyllite
🟫	Plag-phyric Andesite	🟧	Porphyry
🟪	Q Monzonite	🟦	Quartz Diorite
🟧	Quartz Prophyry	🟩	Quartz Wacke
🟧	Quartz-Feldspar Porphyry	🟨	Quartzite
●	Rubble	⁘	Sandstone
▤	Siliceous Limestone	⬛	Siltstone
🟥	Skarn	🟦	Tonalite

Legend - Global - Mineralization	
	?
🟫	anhydrite
🟦	arsenopyrite
🟦	azurite
🟩	chalcopyrite
⬜	Ga
🟨	Au
🟪	gypsum
🟥	hematite
🟥	Ilmt
⬛	Mgt
🟦	malachite
🟦	Mo
🟨	native sulphur
	none
🟨	Py
🟫	Po
🟦	quartz

APPENDIX III

DIAMOND DRILL LOGS

3.2 DDH Logs
3.2.1 Alteration

Appendix 3.2.1 - Alteration

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
V-79-1	187	100	-45	546996	5516763.53		COMPLETE	7/29/1979	GL WEBBER

From (m)	To (m)	Alteration 1	Degree	Alteration 2	Degree	Alteration 3	Degree	Note:
71	114	SILICA	3					
127	132.5	SERICITE	1					
143	146	CHLORITE	1					Chlorite is in healed fractures.
146	161	SILICA	2					

Appendix 3.2.1 - Alteration

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-1	61.3	167	-45	547952.4	5517396.1	2200	COMPLETE	9/13/1991	I. D. McCartney

From (m)	To (m)	Alteration 1	Degree	Alteration 2	Degree	Alteration 3	Degree	Note:
7.5	10.2	BIOTITE	2					
17.9	25	CHLORITE	2	SERICITE	1			
25	26.45	SILICA	2					
27.05	28.65	CHLORITE	1	BIOTITE	2			
29.65	31.75	BIOTITE	2					
37.48	37.86	BIOTITE	3					
38.77	41.2	BIOTITE	3					
41.2	42.55	BIOTITE	4					
42.55	42.9	BIOTITE	3					
44.1	45.85	BIOTITE	2					
47.05	61.3	BIOTITE	2	SILICA	2			

Appendix 3.2.1 - Alteration

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-2	227.13	167	-65	547911.9	5517508.6	2170	COMPLETE	9/15/1991	I. D. McCartney

From (m)	To (m)	Alteration 1	Degree	Alteration 2	Degree	Alteration 3	Degree	Note:
3.05	25.5	BIOTITE	2					
25.5	26	EPIDOTE	5					
26	37.73	BIOTITE	2					
37.73	48.28	BIOTITE	4	ALBITE	2			
48.7	124.85	BIOTITE	3	CHLORITE	2	EPIDOTE	1	
49.77	58.7	SILICA	2	CHLORITE	1			
124.85	131.5	ALBITE	4					
140.11	145.57	BIOTITE	3	SILICA	2			
145.57	148.3	BIOTITE	2					
148.3	151.8	BIOTITE	2					
151.8	152.83	BIOTITE	4					
156.9	164.26	BIOTITE	3	SILICA	2			
164.26	165.04	BIOTITE	3					
165.04	166.68	CHLORITE	2	BIOTITE	2	SERICITE	1	
166.68	167.1	BIOTITE	2	SERICITE	2	SILICA	4	
167.1	168.58	BIOTITE	2	SERICITE	2			
168.58	169.04	BIOTITE	3	SERICITE	2			
169.04	170.96	BIOTITE	2					
173.51	174.62	BIOTITE	1					
174.62	176.1	BIOTITE	1					

Appendix 3.2.1 - Alteration

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-91-2	227.13	167	-65	547911.9	5517508.6	2170	COMPLETE	9/15/1991	I. D. McCartney

From (m)	*To (m)*	*Alteration 1*	*Degree*	*Alteration 2*	*Degree*	*Alteration 3*	*Degree*	*Note:*
176.1	176.8	SILICA	4					
183	184	BIOTITE	3					
184	187.9	BIOTITE	2					
187	192.1	BIOTITE	4					
192.1	227.13	BIOTITE	2					

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-3	276.52	213	-67	548526.6	5517489.1	2095	COMPLETE	9/17/1991	I. D. McCartney

From (m)	To (m)	Alteration 1	Degree	Alteration 2	Degree	Alteration 3	Degree	Note:
8.65	32.5	BIOTITE	1	SERICITE	1	SILICA	2	
32.5	39.05	CHLORITE	4	BIOTITE	4	ALBITE	2	
39.05	39.75	ALBITE	3	CHLORITE	3			
39.75	48.55	BIOTITE	2					
53.46	66.14	CHLORITE	1					
66.14	67.6	SERICITE	1					
67.6	75.5	ALBITE	2	CHLORITE	1			
75.5	83.8	SILICA	5	ALBITE	1			
144	156	CHLORITE	2					
217	223.5	BIOTITE	2					
234.54	246	BIOTITE	3					
257	261.4	SERICITE	2	BIOTITE	1			

Appendix 3.2.1 - Alteration

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-91-4	279.57	106	-60	547247.8	5516177.4	2300	COMPLETE	9/20/1991	I. D. McCartney

From (m)	*To (m)*	*Alteration 1*	*Degree*	*Alteration 2*	*Degree*	*Alteration 3*	*Degree*	*Note:*
3.28	49.72	CHLORITE	4	BIOTITE	2	TOURMALINE	1	
49.72	51.52	SILICA	2	BIOTITE	2			
51.52	75.56	SILICA	2	BIOTITE	1			
75.56	77.65	BIOTITE	2	TOURMALINE	1			
77.65	127.2	SILICA	2	BIOTITE	2	TOURMALINE	1	
150.1	160.53	TOURMALINE	3					
180.65	191.42	BIOTITE	1					
191.42	192.85	BIOTITE	1					
209.7	217.34	CHLORITE	2					
217.34	279.57	CHLORITE	2	BIOTITE	2			

Appendix 3.2.1 - Alteration

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-5	158.84	124	-50	547412.8	5517259.7	2295	COMPLETE	9/22/1991	I. D. McCartney

From (m)	To (m)	Alteration 1	Degree	Alteration 2	Degree	Alteration 3	Degree	Note:
7.62	13.4	BIOTITE	2					
13.4	40.67	SERICITE	3	BIOTITE	1			
40.67	53.5	BIOTITE	2					
53.5	60.8	BIOTITE	2					
60.8	71.8	SILICA	4	TOURMALINE	2			
71.8	80.65	BIOTITE	2					
80.65	158.84	BIOTITE	2					

Appendix 3.2.1 - Alteration

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-1	331	118	-64	546750.2	5517463.6	2150	ABANDONED	8/30/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Alteration 1	Degree	Alteration 2	Degree	Alteration 3	Degree	Note:
41.3	43.2	TOURMALINE	3					
53.3	56.7	SERICITE	1					
56.7	72.6	BIOTITE	2					
99.9	125.2	CHLORITE	3					
125.2	172.6	BIOTITE						
172.6	172.64	TOURMALINE	5					
179.5	291.1	BIOTITE	2	SERICITE	2	EPIDOTE	1	
295.1	310.7	CHLORITE	1	BIOTITE	1			
310.7	331	CHLORITE	1	BIOTITE	1			

Appendix 3.2.1 - Alteration

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-92-2	684.6	120	-62	546750.2	5517463.6	2150	COMPLETE	9/15/1992	Tim Termuende, P. Geo.

From (m)	*To (m)*	*Alteration 1*	*Degree*	*Alteration 2*	*Degree*	*Alteration 3*	*Degree*	*Note:*
5	53.2	BIOTITE	2	CHLORITE	2	SERICITE	1	
22.3	22.3	FE STAINING	4					
53.2	53.3	GRAPHITE	3					
56.7	72.9	FE STAINING	2					
72.9	76.8	FE STAINING	2	ANKERITE	2			
76.8	100.1	SILICA	2					
100.1	126.1	CHLORITE	2	BIOTITE	2			
126.1	178.8	CHLORITE	1	BIOTITE	1			
178.8	293.2	CHLORITE	1	TREMOLITE	1			
308.5	309.5	TOURMALINE	3					
309.5	351.4	SERICITE	2					
310.9	308.5	SERICITE	2					
351.4	354.6	SERICITE	2	SILICA	1			
354.6	478.3	BIOTITE	3	CHLORITE	3	TOURMALINE	2	
478.3	501.5	SERICITE	2	TOURMALINE	2			
501.5	504.8	SERICITE	1	CHLORITE	1	BIOTITE	1	

Appendix 3.2.1 - Alteration

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-3	519.4	106	-75	546547.8	5516297.3	1920	COMPLETE	9/18/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Alteration 1	Degree	Alteration 2	Degree	Alteration 3	Degree	Note:
13.9	28.9	CHLORITE	1	BIOTITE	1	SILICA	1	
131.6	323.2	BIOTITE	1	SERICITE	1			
161.3	313.6	BIOTITE	2	TOURMALINE	1	SERICITE	1	
335.7	348.7	BIOTITE	2	ALBITE	1			

Appendix 3.2.1 - Alteration

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-4	290.8	100	-45	545889.19	5509981.1	1070	COMPLETE	11/17/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Alteration 1	Degree	Alteration 2	Degree	Alteration 3	Degree	Note:
54.2	70.4	CHLORITE	3	BIOTITE	1			
70.4	77.3	BIOTITE	1					
80.5	227.8	BIOTITE	2	SERICITE	2			
278.4	290.8	SERICITE	1					

APPENDIX III

DIAMOND DRILL LOGS

3.2.2 Lithology

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
V-79-1	187	100	-45	546996	5516763.53		COMPLETE	7/29/1979	GL WEBBER

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
0	71		Gabbro							Last 4 feet is chilled at the bottom of this unit.
71	114		Quartz Wacke		grey			turbidite		Concretions from 1 x 2cm to 3 x 6cm are common.
114	118		Wacke		grey			laminated		
118	127		Wacke		greenish	grey	fine	laminated		
127	132.5		Wacke							Convoluted bedding with some rip-up clasts and concretions on fof which is up to 9 x 5cm; centre of this concretion contains some phlogogpite and galena.
132.5	138		Wacke				fine	laminated		
138	141		Wacke					fragmental		Fragments orientated at 25 to 30 degrees to the bedding.
141	146		Quartz Wacke	Wacke	grey	dark	fine	laminated		
146	147.5		Wacke							
147.5	149		Wacke		dark	grey	fine	laminated		
149	161		Wacke		light	grey				
161	172		Quartz Wacke							
172	172.2		Conglomerate	Grit						Mottled, subangular fragments parallel to shear direction. This is shearing across a fragmental bed or grit conglomerate.
172.2	181		Quartzite	Wacke						
181	184		Wacke		grey	dark	fine-medium	laminated		Phlogopite is a commonly developed accessory mineral.
184	187		Wacke	Grit	grey	buff				Grit conglomerate 12cm at 184m and 46cm at 184.6m.

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-1	61.3	167	-45	547952.4	5517396.1	2200	COMPLETE	9/13/1991	I. D. McCartney

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
7.5	10.2		Wacke		dark	grey		laminated		Thickly Laminated to thin bedded.
10.2	13.5		Quartz Wacke		light	grey	fine-medium	laminated		
13.5	17.9		Wacke		grey			laminated		
17.9	25		Wacke		light	green	medium-coarse	banded		Calc-Silicate Replacement Unit. Weak to strong HCL reaction throughout. Quartz-feldspar (pink)-epidote-calcite with minor chorite, tremolite, and garnet.
25	26.45		Wacke		dark	grey	fine	laminated		
26.45	27.05		quartz	Wacke	white	green	fine	banded		Banded Quartz-Albite(?)-Chlorite rock.
27.05	28.65		Wacke		dark	grey				
28.65	29.65		Wacke							Tremolite replacement.
29.65	31.75		Wacke		dark	grey		laminated		
31.75	32.3		Wacke		grey			banded		
32.3	32.6		Wacke		light	grey		fragmental		Fragmental consists of 10% rounded dark Biotitic clasts strongly replaced by pyrrhotite in a light grey fine grained wacke matrix.
32.6	32.75		Wacke		grey			laminated		
32.75	38.77		Wacke		light	grey	fine-medium	fragmental	massive	20-30% dark Biotitic clasts in a wacke matrix.
38.77	41.2		Wacke		light	grey		laminated		
41.2	42.55		Wacke	Amphibolite						Amphibolite is replacing the Wacke.
42.55	44.1		Wacke	Quartz Wacke	grey		fine-medium	laminated	massive	
44.1	45.85		Amphibolite				medium			
45.85	47.05		Wacke					laminated		
47.05	61.3		Wacke		light	grey		massive	fragmental	

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-2	227.13	167	-65	547911.9	5517508.6	2170	COMPLETE	9/15/1991	I. D. McCartney

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
3.05	37.73		Gabbro	Amphibolite	dark	green	medium			
37.73	48.28		Quartz Wacke	Wacke	grey					
48.28	49.77		Amphibolite	Quartzite	grey		fine-medium			
49.77	58.7		Quartz Wacke	Wacke	white					
58.7	124.85		Gabbro				fine-medium			
124.85	139.05		Wacke		light	grey		turbidite		
139.05	140.11		Quartz Wacke					turbidite		
140.11	145.57		Quartz Wacke		grey			turbidite		
145.57	148.3		Quartz Wacke		grey			turbidite		
148.3	151.8		Wacke		grey			laminated		Lower-Middle Alderidge Formation Contact.
151.8	156.9		Wacke		grey			laminated	massive	
156.9	164.26		Wacke		grey			laminated		
164.26	166.68		Wacke		dark	grey		fragmental		
166.68	167.1		Wacke		dark			laminated		
167.1	168.58		Argillite	Quartzite	dark	grey		fragmental		Fragmental elongated imbricated clasts in fine grained ground mass.
168.58	169.04		Wacke		dark			laminated		
169.04	170.96		Wacke					fragmental		
170.96	173.27		Wacke		light	grey	Fine	laminated		
173.27	174.62		Amphibolite	Gabbro	green		medium	massive		Possibly Tremolite as well.
174.62	176.1		quartz	Amphibolite	white			banded		
176.1	179.03		Wacke		grey			laminated		
179.03	183		Wacke		grey			laminated		
183	184		Wacke		grey	brown		fragmental		50% calsts in a Wacks matrix.
184	187.9		Wacke					banded		
187.9	192.1		Wacke					massive		
192.1	193.55		Wacke		grey	brown		fragmental		50% clasts in a Wacke matrix.
193.55	206.22		Wacke					massive		
206.22	208.12		Wacke		dark			laminated		
208.12	210.4		Wacke	Conglomerate				massive		Massive Conglomerate Wacke, <10% clasts overall in a Wacke matrix.

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-2	227.13	167	-65	547911.9	5517508.6	2170	COMPLETE	9/15/1991	I. D. McCartney

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
210.4	222.5		Wacke	Arenite	light	grey		laminated		
222.5	227.13		Wacke		dark	grey		laminated		

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-3	276.52	213	-67	548526.6	5517489.1	2095	COMPLETE	9/17/1991	I. D. McCartney

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
1.52	8.65		Gabbro	Amphibolite			coarse			
8.65	32.5		Quartz Wacke		brownish	grey				
32.5	39.05		Gabbro		green					
39.05	48.55		Quartz Wacke	Turbidite				laminated		
48.55	53.46		Quartz Wacke	Turbidite						
53.46	61.5		Quartz Wacke	Turbidite						
61.5	66.14		Quartz Wacke							
66.14	67.6		Wacke					laminated		
67.6	75.5		Quartz Wacke	Turbidite				banded		
75.5	83.8		Quartz Wacke	Turbidite				laminated		
83.8	197.4		Gabbro							
197.4	203.3		Wacke	Turbidite	light	grey				
203.3	217		Quartz Wacke	Turbidite						
217	223.5		Wacke					laminated		Lower-Middle Aldridge contact at 217m
223.5	226.5		Quartz Wacke				fine-medium	massive		
226.5	230.05		Quartz Wacke							
230.05	234.54		Wacke		light	grey	fine	laminated		
234.54	246		Wacke		grey		medium	fragmental		~ 25-35% clasts, elongated and imbricated @ 45 degrees
246	254.45		Wacke					laminated		
254.45	257.7		Wacke					laminated		
257.7	261.4		Wacke	Conglomerate	dark	grey	fine	massive		
261.4	276.45		Wacke		grey		medium	fragmental		~ 25-35% clasts imbricated at aout 40 degrees

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-4	279.57	106	-60	547247.8	5516177.4	2300	COMPLETE	9/20/1991	I. D. McCartney

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
3.28	49.72		Gabbro	Amphibolite	greenish	grey	medium	massive		Gabbro is fine grained and appeared chilled at bottom of unit.
49.72	51.52		Wacke					laminated		
51.52	69		Quartz Wacke	Turbidite				laminated		
69	69.02		null	Amphibolite						PORPHYRITIC MAFIC DYKE
69.02	69.41		Quartz Wacke	Turbidite				laminated		
69.41	69.58		Null	Amphibolite						PORPHYRITIC MAFIC DYKE
69.58	70.88		Quartz Wacke	Turbidite				laminated		
70.88	70.92		Null	Amphibolite						PORPHYRITIC MAFIC DYKE
70.92	75.56		Quartz Wacke	Turbidite				laminated		
75.56	77.65		Wacke		grey			laminated		
77.65	92.8		Quartz Wacke	Turbidite				banded		Alderidge Turbidite secquence
92.8	92.82		null	Amphibolite						
92.82	127.2		Quartz Wacke	Turbidite				laminated		PORPHYRITIC MAFIC DYKE
127.2	135.4		Wacke					laminated		
135.4	150.1		Quartz Wacke	Turbidite				laminated		
150.1	160.53		Wacke		greenish	grey		massive		
160.53	170.43		Quartz Wacke	Turbidite				glassy		
170.43	173.87		Quartz Wacke	Turbidite				banded		
173.87	178.9		Wacke	Turbidite				laminated		
178.9	180.65		Quartz Wacke	Turbidite				banded		
180.65	191.42		Quartz Wacke	Turbidite				laminated		
191.42	192.85		Calcarenite					massive		Lower-Middle Aldridge formation contact at 191.42
192.85	200.78		Wacke		dark			laminated		
200.78	204.4		Wacke	Conglomerate			very fine	laminated		
204.4	206.13		Calcarenite	Amphibolite			coarse			
206.13	209.7		Quartz Wacke					banded		
209.7	217.34		Quartz Wacke	Wacke	dark	grey		massive		
217.34	279.57		Quartz Wacke	Conglomerate						Unit is laminated to 219m and then laminated below.

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-5	158.84	124	-50	547412.8	5517259.7	2295	COMPLETE	9/22/1991	I. D. McCartney

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
7.62	13.4		Wacke		light	dark		laminated		Lower Aldridge Formation. Alternating light-dark laminaions
13.4	40.67		Wacke	Mudstone			fine	fragmental		High proportion of flat black mudstone chips in a Wacke matrix.
40.67	53.5		Wacke					massive	laminated	
53.5	60.8		Wacke	Conglomerate	light	grey	fine			Conglomerate in Wacke matrix.
60.8	71.8		Wacke					laminated		
71.8	80.65		Amphibolite				medium	massive	banded	Amphibolite-Biotite-Garnet Replacement Zone
80.65	158.84		Wacke		grey			fragmental	massive	Average 25% clasts component floating in a Wacke matrix.

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-1	331	118	-64	546750.2	5517463.6	2150	ABANDONED	8/30/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
0	6.1	C	Casing							
6.1	53.3		Quartz Wacke		grey		fine-medium	laminated	turbidite	
53.3	56.7		Wacke	Argillite	dark	grey	fine	laminated		
56.7	72.6		Quartz Wacke		grey		fine-medium	laminated		
72.6	77.2		Wacke	Quartz Wacke			fine	laminated		
77.2	99.9		Quartz Wacke				fine-medium	laminated	turbidite	
99.9	125.2		Gabbro		light	green	fine	massive		
125.2	179.5		Quartz Wacke		light	grey	fine-medium	turbidite	laminated	
179.5	295.1		Gabbro		light	green	fine	massive		
295.1	310.7		Quartz Wacke		light	grey	fine	laminated		
310.7	331		Quartz Wacke		white			laminated		

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-2	684.6	120	-62	546750.2	5517463.6	2150	COMPLETE	9/15/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
0	5	Casing	Casing							
5	53.3		Quartzite	Wacke	grey		fine-medium	laminated	turbidite	
53.3	56.7		Wacke	Argillite	dark	grey		laminated		
56.7	72.9		Wacke		grey		fine-medium	turbidite		Similar to the interval 5.0-53.3m, but turbiditic textures are more common (40%of the interval).
72.9	76.8		Quartzite	Wacke	greyish		fine	laminated		
76.8	100.1		Quartzite	Wacke	grey		fine-medium	laminated	turbidite	Localy turbiditic
100.1	126.1		Gabbro		dark	green		massive	foliated	
126.1	178.8		Quartzite	Wacke	grey		fine-medium	laminated		
178.8	293.2		Gabbro		dark	grey		massive		Contacts are poorly defined due to chloritized upper and lower contacts.
293.2	310.9		Quartzite	Wacke	grey		fine	laminated	turbidite	Foliation is 30 to 20 degrees to the bedding.
310.9	351.4		Quartzite	Wacke	light	grey				
351.4	354.6		Wacke							
354.6	478.3		Gabbro		green					
478.3	501.5		Wacke		light	brown	fine-medium	laminated	foliated	Bedding angles increasing downhole.
501.5	504.8		Conglomerate		light	grey				Conglomerate/fragmental. Matrix supported with clasts making up 2-3% of interval. Clasts have weakly distinguishable "ghost like" boundaries.

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-3	519.4	106	-75	546547.8	5516297.3	1920	COMPLETE	9/18/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
0	5.1	Casing	Casing							
5.1	13.9		Quartzite	Wacke	light		medium	turbidite	foliated	Frequent Cross Bedding
13.9	28.9		Wacke		dark	grey	fine-medium	laminated		
28.9	37.2		Quartzite	Wacke	light	grey	medium	massive		Weakly defined preferred grain orientation, 45 degrees to core.
37.2	43.1		Wacke		light	grey	fine-medium	laminated		Broken, crumbly material within 0.6m of lower contact.
43.1	45.7		Gabbro		light	green	medium	massive		Crumbly biotie/chlorite along lower contact.
45.7	47.6		Wacke				fine-medium	laminated		
47.6	56.8		Wacke		light	grey	medium	laminated		Becomes increasingly quartzitic downhole with grain size increasing.
56.8	161.3		Quartzite	Wacke	light	grey	fine-medium	laminated	turbidite	
161.3	313.6		Gabbro		grey	white	fine	massive	equigranular	Amphiboles are likely recrystallized, with preferred orientation.
313.6	323.2		Wacke		light	grey		massive		
323.2	331.1		Wacke		light	creamy				Lower-Middle contact.
331.1	335.7		Conglomerate	Wacke						Matrix supported clasts with fragment size from <1mm to over 50mm.
335.7	348.7		Wacke		white	creamy	fine	laminated	turbidite	
348.7	355.6		Wacke		light	grey		massive		

Appendix 3.2.2 - Lithology

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-4	290.8	100	-45	545889.19	5509981.1	1070	COMPLETE	11/17/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Map Unit	Major Rock Type	Minor Rock Type	Primary Colour	Secondary Colour	Grainsize	Primary Texture	Secondary Texture	Notes:
0	7.3	Casing	Casing							
7.3	37.7		Gabbro		light	grey		massive	equigranular	Darkening downhole.
37.7	52.9		Gabbro		dark	green		massive	equigranular	Similar to the unti above, however there is a marked lithological at 37.7m.
52.9	54.8		Gabbro		light	red	fine	porphyritic		
54.8	70.4		Gabbro		dark	green		massive	equigranular	
70.4	80.5		Wacke		light	buff		turbidite		
80.5	148.5		Quartzite	Wacke	light	grey		turbidite		
148.5	227.8		Wacke		light	grey	fine-medium	laminated	turbidite	
227.8	278.4		Quartzite	Wacke	greyish			laminated		Laminations are generally 1 to 10mm, with local cross-bedding.
278.4	290.8		Quartz	Arenite	buff	brown				

APPENDIX III

DIAMOND DRILL LOGS

3.2.3 Mineralogy

Appendix 3.2.3 - Mineralogy

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
V-79-1	187	100	-45	546996	5516763.53		COMPLETE	7/29/1979	GL WEBBER

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
71	114	DISSEMINATED	pyrrhotite	2		0		0	Some concretions contain pyrrhotite
114	118	VEINLETS	pyrrhotite	1		0		0	Alternating laminated beds may contain up to 8% Fe. Some rip-up clasts contain Pyrrhotite.
118	127	VEINLETS	pyrrhotite	1		0		0	
127	132.5	BLEBBY	pyrrhotite	1	galena			0	Rip-up clasts contain pyrrhotite and galena.
143	146	VEINLETS	pyrrhotite	0		0		0	Pyrrhotite is in healed fractures
161	172	VEINLETS	pyrrhotite	5		0		0	
172.2	181	VEINLETS	pyrrhotite	1		0		0	

Appendix 3.2.3 - Mineralogy

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-1	61.3	167	-45	547952.4	5517396.1	2200	COMPLETE	9/13/1991	I. D. McCartney

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
9.8	10.1	VEINLETS	pyrrhotite	2		0		0	
10.2	13.5	DISSEMINATED	pyrrhotite	3		0		0	Locally up to 10%.
13.5	17.9	DISSEMINATED	pyrrhotite	4		0		0	
25	26.45	DISSEMINATED	pyrrhotite	1	pyrite	0		0	
26.45	27.05	DISSEMINATED	pyrrhotite	1	sphalerite	1	arsenopyrite	0	
28.65	29.65	BLEBBY	pyrrhotite	1	pyrite	0		0	
31.75	32.3	DISSEMINATED	pyrrhotite	7		0		0	
32.75	35.02	DISSEMINATED	pyrrhotite	10		0		0	
35.02	35.52	DISSEMINATED	pyrrhotite	10	sphalerite	1	galena	1	
38.77	41.2	DISSEMINATED	pyrrhotite	10		0		0	
41.2	42.55	VEINLETS	pyrrhotite	2	pyrite	0		0	
42.55	42.9	DISSEMINATED	pyrrhotite	3		0		0	
42.9	44.1	DISSEMINATED	pyrrhotite	0		0		0	
45.85	47.05	DISSEMINATED	pyrrhotite	2		0		0	

Appendix 3.2.3 - Mineralogy

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-2	227.13	167	-65	547911.9	5517508.6	2170	COMPLETE	9/15/1991	I. D. McCartney

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
37.73	48.28	DISSEMINATED	pyrrhotite	3		0		0	
58.7	124.85	DISSEMINATED	pyrrhotite	5		0		0	
139.05	140.11	VEINLETS	pyrrhotite	1		0		0	
145.57	148.3	DISSEMINATED	pyrrhotite	1		0		0	
148.3	151.8	DISSEMINATED	pyrrhotite	3		0		0	
151.8	152.83	VEINLETS	pyrrhotite	10		0		0	
160	161.63	VEINLETS	pyrrhotite	2	pyrite	1		0	
164.26	165.04	VEINLETS	galena	1	pyrrhotite	1		0	
166.3	166.51	DISSEMINATED	pyrrhotite	1	arsenopyrite	1		0	
166.68	169.04	DISSEMINATED	pyrrhotite	1		0		0	
170.96	173.27	VEINLETS	pyrrhotite	1		0		0	
176.1	179.03	DISSEMINATED	pyrrhotite	3		0		0	
179.03	183	BLEBBY	pyrrhotite	3		0		0	
184	187.9	VEINLETS	pyrrhotite	1		0		0	
187.9	192.1	VEINLETS	pyrrhotite	0		0		0	
206.22	208.12	VEINLETS	pyrrhotite	1		0		0	
215.3	216	BLEBBY	pyrrhotite	1	chalcopyrite	1		0	

Appendix 3.2.3 - Mineralogy

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-3	276.52	213	-67	548526.6	5517489.1	2095	COMPLETE	9/17/1991	I. D. McCartney

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
1.52	8.65	VEINLETS	pyrrhotite	0		0		0	
8.65	32.5	DISSEMINATED	pyrrhotite	2		0		0	
11.5	144	DISSEMINATED	pyrrhotite	3		0		0	Locally 5-8% pyrrhotite.
36.45	36.9	BLEBBY	pyrrhotite	2	chalcopyrite	0		0	
42.54	43.43	DISSEMINATED	pyrrhotite	1		0		0	
75.5	83.8	BLEBBY	pyrrhotite	1	chalcopyrite	0		0	
217	223.5	DISSEMINATED	pyrrhotite	1		0		0	
223.5	226.5	DISSEMINATED	pyrrhotite	1		0		0	
226.5	230.05	DISSEMINATED	pyrrhotite	5	galena	0	sphalerite	0	
230.05	234.54	VEINLETS	sphalerite	0	galena		pyrite	0	
234.54	246	DISSEMINATED	pyrrhotite	2		0		0	
246	254.45	DISSEMINATED	pyrrhotite	1	pyrite	0		0	
254.45	257.7	DISSEMINATED	pyrrhotite	1	sphalerite	0	galena	0	
257.7	261.4	DISSEMINATED	pyrrhotite	1	pyrite	0		0	
261.4	276.45	DISSEMINATED	pyrrhotite	0		0		0	

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-4	279.57	106	-60	547247.8	5516177.4	2300	COMPLETE	9/20/1991	I. D. McCartney

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
3.28	13.78	DISSEMINATED	pyrite	0		0		0	
13.78	16.66	DISSEMINATED	pyrrhotite	10	chalcopyrite	1		0	
32.5	36.5	DISSEMINATED	pyrrhotite	1	magnetite	0		0	
39.93	41.06	DISSEMINATED	pyrrhotite	0		0		0	
49.72	51.52	DISSEMINATED	pyrrhotite	2		0		0	
51.52	75.56	VEINLETS	pyrrhotite	1		0		0	
75.56	77.65	DISSEMINATED	pyrrhotite	1		0		0	
77.65	93.3	DISSEMINATED	pyrrhotite	0	pyrite	0		0	
93.3	93.7	VEINLETS	pyrite	5		0		0	
99	103	VEINLETS	pyrite	0	pyrrhotite	1		0	
112.1	112.3	VEINLETS	pyrite	5		0		0	
135.4	150.1	DISSEMINATED	pyrrhotite	3		0		0	
150.1	160.53	DISSEMINATED	pyrrhotite	0	arsenopyrite	0		0	
160.53	170.43	DISSEMINATED	pyrrhotite	3		0		0	
170.43	173.87	DISSEMINATED	arsenopyrite	2	pyrrhotite	1		0	
173.87	178.9	VEINLETS	pyrrhotite	1		0		0	
178.9	180.65	VEINLETS	pyrrhotite	3		0		0	
191.42	192.85	DISSEMINATED	pyrrhotite	10	pyrite	0	arsenopyrite	0	
192.85	194	DISSEMINATED	pyrrhotite	5		0		0	
194	200.78	VEINLETS	pyrrhotite	3		0		0	

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-4	279.57	106	-60	547247.8	5516177.4	2300	COMPLETE	9/20/1991	I. D. McCartney

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
200.78	204.4	DISSEMINATED	pyrrhotite	5	arsenopyrite	1	sphalerite	0	
206.13	209.7	DISSEMINATED	pyrrhotite	1	chalcopyrite	0		0	
209.7	217.34	SEMIMASSIVE	pyrrhotite	5		0		0	Pyrrhotite is in bands up to 5cm thick.
217.34	279.57	VEINLETS	pyrrhotite	1	arsenopyrite	1	chalcopyrite	1	

Appendix 3.2.3 - Mineralogy

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-5	158.84	124	-50	547412.8	5517259.7	2295	COMPLETE	9/22/1991	I. D. McCartney

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
13.4	40.67	SEMIMASSIVE	pyrrhotite	3	pyrite	0		0	
33	33.8	VEINLETS	pyrrhotite	5		0		0	
40.67	53.5	VEINLETS	pyrrhotite	2	pyrite	1		0	
60.8	60.95	DISSEMINATED	sphalerite	3	pyrrhotite	5		0	
65.1	65.7	DISSEMINATED	pyrrhotite	2	chalcopyrite	0		0	

Appendix 3.2.3 - Mineralogy

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-1	331	118	-64	546750.2	5517463.6	2150	ABANDONED	8/30/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
6.1	53.3	VEINLETS	pyrite			0		0	
53.3	56.7	VEINLETS	galena		pyrrhotite			0	
60.1	61	VEINLETS	pyrrhotite	1		0		0	
99.9	125.2	VEINLETS	pyrrhotite	3	chalcopyrite			0	
125.2	179.5	VEINLETS	pyrrhotite			0		0	
295.1	310.7	BLEBBY	pyrrhotite		chalcopyrite			0	

Appendix 3.2.3 - Mineralogy

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-92-2	684.6	120	-62	546750.2	5517463.6	2150	COMPLETE	9/15/1992	Tim Termuende, P. Geo.

From (m)	*To (m)*	*Mineralization Style*	*Mineralization 1*	*%*	*Mineralization 2*	*%*	*Mineralization 3*	*%*	*Notes:*
5	53.3	DISSEMINATED	galena		pyrrhotite		chalcopyrite		
56.6	56.7	VEINLETS	pyrrhotite		chalcopyrite			0	
77.9	77.93	BLEBBY	galena	2		0		0	
100.1	126.1	DISSEMINATED	pyrrhotite	1	chalcopyrite	2		0	
141.15	141.2	DISSEMINATED	Pyrite		pyrrhotite		sphalerite		
178.8	293.2	VEINLETS	pyrrhotite			0		0	
293.2	310.9	DISSEMINATED	pyrrhotite		chalcopyrite			0	
310.9	351.4	VEINLETS	pyrrhotite		pyrite	1		0	
351.4	352.4	VEINLETS	pyrrhotite	2		0		0	
354.6	478.3	VEINLETS	pyrrhotite	1	chalcopyrite		pyrite		
407.3	408.1	DISSEMINATED	pyrrhotite	10	chalcopyrite			0	
478.3	479.3	DISSEMINATED	pyrrhotite	5	chalcopyrite		sphalerite		
501.5	504.8	DISSEMINATED	pyrrhotite	2		0		0	

Appendix 3.2.3 - Mineralogy

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-92-3	519.4	106	-75	546547.8	5516297.3	1920	COMPLETE	9/18/1992	Tim Termuende, P. Geo.

From (m)	*To (m)*	*Mineralization Style*	*Mineralization 1*	*%*	*Mineralization 2*	*%*	*Mineralization 3*	*%*	*Notes:*
13.9	28.9	FRACTURES	pyrite		chalcopyrite			0	
43.1	45.7	SEMIMASSIVE	pyrrhotite			0		0	Pyrrhotite as localized breccia over 2cm.
56.8	161.3	VEINLETS	pyrrhotite			0		0	
161.3	313.6	VEINLETS	pyrrhotite	0	chalcopyrite	0		0	
171.7	172.1	BLEBBY	pyrrhotite	5		0		0	
313.6	323.2	DISSEMINATED	pyrrhotite	2		0		0	
323.2	331.1	VEINLETS	pyrrhotite	1		0		0	
331.1	335.7	VEINLETS	pyrrhotite	0		0		0	
335.7	348.7	DISSEMINATED	pyrrhotite	0	pyrite	0		0	
348.7	355.6	DISSEMINATED	pyrrhotite	0		0		0	

Appendix 3.2.3 - Mineralogy

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-4	290.8	100	-45	545889.19	5509981.1	1070	COMPLETE	11/17/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Mineralization Style	Mineralization 1	%	Mineralization 2	%	Mineralization 3	%	Notes:
37.7	70.4	VEINLETS	Pyrite		pyrrhotite			0	
53.9	54.2	BLEBBY	arsenopyrite	2	chalcopyrite	1		0	
71.1	77.3	BLEBBY	pyrite	1		0		0	
77.3	80.5	VEINLETS	pyrrhotite		chalcopyrite			0	
123.7	123.85	DISSEMINATED	pyrrhotite	15		0		0	
171.5	171.8	VEINLETS	pyrrhotite	30		0		0	
196.8	197.2	VEINLETS	pyrrhotite	3		0		0	
202.7	210.2	VEINLETS	pyrrhotite	3		0		0	
227.8	278.4	DISSEMINATED	pyrrhotite	2		0		0	
278.4	290.8	VEINLETS	pyrrhotite			0		0	

APPENDIX III

DIAMOND DRILL LOGS

3.2.4 Shear Zone

Appendix 3.2.4 - Shear Zones

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
V-79-1	187	100	-45	546996	5516763.53		COMPLETE	7/29/1979	GL WEBBER

From (m)	To (m)	Deformation	Angle (to CA)	Mineralogy 1	%	Mineralogy 2	%	Mineralogy 3	%	Alteration 1	Deg	Alteration 2	Deg	Alteration 3	Deg	Gauge	Clay	Oxidized	Clean	Note:
138	138	Brittle	25		0		0		0		0		0		0	0	0	0	0	
141	141	Brittle	0		0		0		0		0		0		0	1	0	0	0	
146	147.5	Brittle	0		0		0		0		0		0		0	4	0	0	0	
161	172	Ductile	32		0		0		0		0		0		0	0	0	0	0	

Appendix 3.2.4 - Shear Zones

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-91-1	61.3	167	-45	547952.4	5517396.1	2200	COMPLETE	9/13/1991	I. D. McCartney

From (m)	*To (m)*	*Deformation*	*Angle (to CA)*	*Mineralogy 1*	*%*	*Mineralogy 2*	*%*	*Mineralogy 3*	*%*	*Alteration 1*	*Deg*	*Alteration 2*	*Deg*	*Alteration 3*	*Deg*	*Gauge*	*Clay*	*Oxidized*	*Clean*	*Note:*

Appendix 3.2.4 - Shear Zones

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-2	227.13	167	-65	547911.9	5517508.6	2170	COMPLETE	9/15/1991	I. D. McCartney

From (m)	To (m)	Deformation	Angle (to CA)	Mineralogy 1	%	Mineralogy 2	%	Mineralogy 3	%	Alteration 1	Deg	Alteration 2	Deg	Alteration 3	Deg	Gauge	Clay	Oxidized	Clean	Note:

Appendix 3.2.4 - Shear Zones

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-91-3	276.52	213	-67	548526.6	5517489.1	2095	COMPLETE	9/17/1991	I. D. McCartney

From (m)	*To (m)*	*Deformation*	*Angle (to CA)*	*Mineralogy 1*	*%*	*Mineralogy 2*	*%*	*Mineralogy 3*	*%*	*Alteration 1*	*Deg*	*Alteration 2*	*Deg*	*Alteration 3*	*Deg*	*Gauge*	*Clay*	*Oxidized*	*Clean*	*Note:*

Appendix 3.2.4 - Shear Zones

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-4	279.57	106	-60	547247.8	5516177.4	2300	COMPLETE	9/20/1991	I. D. McCartney

From (m)	To (m)	Deformation	Angle (to CA)	Mineralogy 1	%	Mineralogy 2	%	Mineralogy 3	%	Alteration 1	Deg	Alteration 2	Deg	Alteration 3	Deg	Gauge	Clay	Oxidized	Clean	Note:

Appendix 3.2.4 - Shear Zones

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-5	158.84	124	-50	547412.8	5517259.7	2295	COMPLETE	9/22/1991	I. D. McCartney

From (m)	To (m)	Deformation	Angle (to CA)	Mineralogy 1	%	Mineralogy 2	%	Mineralogy 3	%	Alteration 1	Deg	Alteration 2	Deg	Alteration 3	Deg	Gauge	Clay	Oxidized	Clean	Note:

Appendix 3.2.4 - Shear Zones

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-1	331	118	-64	546750.2	5517463.6	2150	ABANDONED	8/30/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Deformation	Angle (to CA)	Mineralogy 1	%	Mineralogy 2	%	Mineralogy 3	%	Alteration 1	Deg	Alteration 2	Deg	Alteration 3	Deg	Gauge	Clay	Oxidized	Clean	Note:

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-92-2	684.6	120	-62	546750.2	5517463.6	2150	COMPLETE	9/15/1992	Tim Termuende, P. Geo.

From (m)	*To (m)*	*Deformation*	*Angle (to CA)*	*Mineralogy 1*	*%*	*Mineralogy 2*	*%*	*Mineralogy 3*	*%*	*Alteration 1*	*Deg*	*Alteration 2*	*Deg*	*Alteration 3*	*Deg*	*Gauge*	*Clay*	*Oxidized*	*Clean*	*Note:*

Appendix 3.2.4 - Shear Zones

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-3	519.4	106	-75	546547.8	5516297.3	1920	COMPLETE	9/18/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Deformation	Angle (to CA)	Mineralogy 1	%	Mineralogy 2	%	Mineralogy 3	%	Alteration 1	Deg	Alteration 2	Deg	Alteration 3	Deg	Gauge	Clay	Oxidized	Clean	Note:

Appendix 3.2.4 - Shear Zones

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-92-4	290.8	100	-45	545889.19	5509981.1	1070	COMPLETE	11/17/1992	Tim Termuende, P. Geo.

From (m)	*To (m)*	*Deformation*	*Angle (to CA)*	*Mineralogy 1*	*%*	*Mineralogy 2*	*%*	*Mineralogy 3*	*%*	*Alteration 1*	*Deg*	*Alteration 2*	*Deg*	*Alteration 3*	*Deg*	*Gauge*	*Clay*	*Oxidized*	*Clean*	*Note:*

APPENDIX III

DIAMOND DRILL LOGS

3.2.5 Structure

Appendix 3.2.5 - Structure

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
V-79-1	187	100	-45	546996	5516763.53		COMPLETE	7/29/1979	GL WEBBER

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
71	114	Bedding	85	
132.5	138	Bedding	85	
147.5	161	Crenulated Bedding		

Appendix 3.2.5 - Structure

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Complete*	*Project Geologist*
Vu-91-1	61.3	167	-45	547952.4	5517396.1	2200	COMPLETE	9/13/1991	I. D. McCartney

From (m)	*To (m)*	*Structural Measurement*	*Angle (to CA)*	*Note:*
12.3	12.3	Bedding	60	
15.5	15.5	Bedding	64	
25	26.45	Bedding	50	
31.3	31.3	Bedding	50	
42.55	42.9	Bedding	70	
45.9	45.9	Bedding	30	
46.9	46.9	Bedding	54	

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-2	227.13	167	-65	547911.9	5517508.6	2170	COMPLETE	9/15/1991	I. D. McCartney

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
3.05	37.73	Bedding	60	
39	39	Bedding	68	
44.5	44.5	Bedding	52	
49.77	58.7	Bedding	45	
50.5	50.5	Bedding	50	
57.5	57.5	Bedding	20	
130	130	Bedding	50	
138	138	Bedding	60	
150.5	150.5	Bedding	55	
152.83	156.9	Bedding	30	
166.68	167.1	Bedding	50	
176.1	179.03	Bedding	50	
206.22	208.12	Bedding	45	
213	213	Bedding	30	

Appendix 3.2.5 - Structure

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-3	276.52	213	-67	548526.6	5517489.1	2095	COMPLETE	9/17/1991	I. D. McCartney

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
42.5	42.5	Bedding	60	
46	46	Bedding	68	
60	60	Bedding	52	
78	78	Bedding	50	
83	83	Bedding	55	
201.5	201.5	Bedding	45	
217	223.5	Bedding	45	
229.2	229.2	Bedding	45	
230.05	234.54	Bedding	40	
245.45	257.7	Bedding	45	

Appendix 3.2.5 - Structure

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-4	279.57	106	-60	547247.8	5516177.4	2300	COMPLETE	9/20/1991	I. D. McCartney

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
50	50	Bedding	70	
65.8	65.8	Bedding	65	
72.8	72.8	Bedding	65	
77	77	Bedding	67	
91	91	Bedding	70	
129.4	129.4	Bedding	65	
135	135	Bedding	80	
150.1	160.53	Bedding	50	
168	168	Bedding	65	
176	176	Bedding	65	
178.9	180.65	Bedding	65	
199	199	Bedding	60	
210	210	Bedding	70	
217.34	279.57	Bedding	50	

Appendix 3.2.5 - Structure

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-91-5	158.84	124	-50	547412.8	5517259.7	2295	COMPLETE	9/22/1991	I. D. McCartney

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
61.5	61.5	Bedding	70	
70.5	70.5	Bedding	55	

Appendix 3.2.5 - Structure

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-1	331	118	-64	546750.2	5517463.6	2150	ABANDONED	8/30/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
10.7	10.7	Bedding	55	
21.6	21.6	Bedding	65	
32	32	Bedding	60	
41.1	41.1	Bedding	50	
52.3	52.3	Bedding	55	
53.3	56.7	Bedding	65	
60.9	60.9	Bedding	60	
66.5	66.5	Bedding	70	
69.5	69.5	Bedding	60	
79.5	79.5	Bedding	60	
84.8	84.8	Bedding	40	
93.2	93.2	Bedding	48	
127.5	127.5	Bedding	55	
137.9	137.9	Bedding	55	
144	144	Bedding	55	
160	160	Bedding	55	
164.6	164.6	Bedding	60	
175.4	175.4	Bedding	60	
296.9	296.9	Bedding	40	
300	300	Bedding	53	
303.2	303.2	Bedding	58	
310.4	310.4	Bedding	52	

Appendix 3.2.5 - Structure

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-2	684.6	120	-62	546750.2	5517463.6	2150	COMPLETE	9/15/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
10.7	10.7	Bedding	63	
21.6	21.6	Bedding	60	
32	32	Bedding	60	
41.9	41.9	Bedding	60	
53	53	Bedding	60	
53.3	56.7	Bedding	57	
56.7	72.9	Bedding	65	
76.9	76.9	Bedding	65	
84.8	84.8	Bedding	60	
92.9	92.9	Bedding	45	
100	100	Bedding	55	
127.5	127.5	Bedding	55	
140.2	140.2	Bedding	55	
144.8	144.8	Bedding	57	
158.5	158.5	Bedding	53	
171.9	171.9	Bedding	55	
176.7	176.7	Bedding	55	
293.2	310.9	Bedding	52	
311.1	311.1	Bedding	48	
333.6	333.6	Bedding	50	
346.1	346.1	Bedding	58	
349.1	349.1	Bedding	51	
480.1	480.1	Bedding	20	
487.6	487.6	Bedding	45	
493.8	493.8	Bedding	45	

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-2	684.6	120	-62	546750.2	5517463.6	2150	COMPLETE	9/15/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
506.2	506.2	Bedding	40	

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-3	519.4	106	-75	546547.8	5516297.3	1920	COMPLETE	9/18/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
5.1	13.9	Bedding	45	
13.9	13.9	Bedding	50	
19	19	Bedding	50	
28.7	28.7	Bedding	45	
32.6	32.9	Bedding	50	
37.2	43.1	Bedding	45	
47.6	56.8	Bedding	50	
58	58	Bedding	50	
77.8	77.8	Bedding	50	
102.6	102.6	Bedding	50	
126.1	126.1	Bedding	52	
147.6	147.6	Bedding	50	
313.6	323.2	Bedding	70	

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Complete	Project Geologist
Vu-92-4	290.8	100	-45	545889.19	5509981.1	1070	COMPLETE	11/17/1992	Tim Termuende, P. Geo.

From (m)	To (m)	Structural Measurement	Angle (to CA)	Note:
70.4	77.3	Bedding	65	
80.5	148.5	Bedding	65	
148.5	227.8	Bedding	55	
227.8	278.4	Bedding	67	
278.4	290.8	Bedding	65	

APPENDIX III

DIAMOND DRILL LOGS

3.2.6 Veining

Appendix 3.2.6 - Veining - Points

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Completed*	*Logged By*
V-79-1	187	100	-45	546996	5516763.53		COMPLETE	7/29/1979	GL WEBBER

Depth (m)	*Width (cm)*	*Angle (to CA)*	*Colour*	*Grainsize*	*Primary Texture*	*Mineralogy 1*	*Mineralogy 2*	*Mineralogy 3*	*Sulphides 1*	*%*	*Sulphides 2*	*%*	*Sulphides 3*	*%*	*Alteration Setting*	*Alteration 1*	*Alteration 2*	*Alteration 3*	*Note:*
145	3	0	white		MASSIVE					0		0		0					
186	4	0	white						pyrrhotite	10	galena	3	sphalerite	1					

Appendix 3.2.6 - Veining - Points

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Completed	Logged By
Vu-91-1	61.3	167	-45	547952.4	5517396.1	2200	COMPLETE	9/13/1991	I. D. McCartney

Depth (m)	Width (cm)	Angle (to CA)	Colour	Grainsize	Primary Texture	Mineralogy 1	Mineralogy 2	Mineralogy 3	Sulphides 1	%	Sulphides 2	%	Sulphides 3	%	Alteration Setting	Alteration 1	Alteration 2	Alteration 3	Note:

Appendix 3.2.6 - Veining - Points

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Completed	Logged By
Vu-91-2	227.13	167	-65	547911.9	5517508.6	2170	COMPLETE	9/15/1991	I. D. McCartney

Depth (m)	Width (cm)	Angle (to CA)	Colour	Grainsize	Primary Texture	Mineralogy 1	Mineralogy 2	Mineralogy 3	Sulphides 1	%	Sulphides 2	%	Sulphides 3	%	Alteration Setting	Alteration 1	Alteration 2	Alteration 3	Note:

Appendix 3.2.6 - Veining - Points

DDH Hole Number	*DDH Length (m)*	*DDH Azimuth (Deg)*	*DDH Dip (+ Down)*	*DDH Easting (NAD83)*	*DDH Northing (NAD83)*	*DDH Elevation (m)*	*DDH Status*	*Date Completed*	*Logged By*
Vu-91-3	276.52	213	-67	548526.6	5517489.1	2095	COMPLETE	9/17/1991	I. D. McCartney

Depth (m)	*Width (cm)*	*Angle (to CA)*	*Colour*	*Grainsize*	*Primary Texture*	*Mineralogy 1*	*Mineralogy 2*	*Mineralogy 3*	*Sulphides 1*	*%*	*Sulphides 2*	*%*	*Sulphides 3*	*%*	*Alteration Setting*	*Alteration 1*	*Alteration 2*	*Alteration 3*	*Note:*

Appendix 3.2.6 - Veining - Points

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Completed	Logged By
Vu-91-4	279.57	106	-60	547247.8	5516177.4	2300	COMPLETE	9/20/1991	I. D. McCartney

Depth (m)	Width (cm)	Angle (to CA)	Colour	Grainsize	Primary Texture	Mineralogy 1	Mineralogy 2	Mineralogy 3	Sulphides 1	%	Sulphides 2	%	Sulphides 3	%	Alteration Setting	Alteration 1	Alteration 2	Alteration 3	Note:

Appendix 3.2.6 - Veining - Points

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Completed	Logged By
Vu-91-5	158.84	124	-50	547412.8	5517259.7	2295	COMPLETE	9/22/1991	I. D. McCartney

Depth (m)	Width (cm)	Angle (to CA)	Colour	Grainsize	Primary Texture	Mineralogy 1	Mineralogy 2	Mineralogy 3	Sulphides 1	%	Sulphides 2	%	Sulphides 3	%	Alteration Setting	Alteration 1	Alteration 2	Alteration 3	Note:

Appendix 3.2.6 - Veining - Points

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Completed	Logged By
Vu-92-1	331	118	-64	546750.2	5517463.6	2150	ABANDONED	8/30/1992	Tim Termuende, P. Geo.

Depth (m)	Width (cm)	Angle (to CA)	Colour	Grainsize	Primary Texture	Mineralogy 1	Mineralogy 2	Mineralogy 3	Sulphides 1	%	Sulphides 2	%	Sulphides 3	%	Alteration Setting	Alteration 1	Alteration 2	Alteration 3	Note:

Appendix 3.2.6 - Veining - Points

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Completed	Logged By
Vu-92-2	684.6	120	-62	546750.2	5517463.6	2150	COMPLETE	9/15/1992	Tim Termuende, P. Geo.

Depth (m)	Width (cm)	Angle (to CA)	Colour	Grainsize	Primary Texture	Mineralogy 1	Mineralogy 2	Mineralogy 3	Sulphides 1	%	Sulphides 2	%	Sulphides 3	%	Alteration Setting	Alteration 1	Alteration 2	Alteration 3	Note:

Appendix 3.2.6 - Veining - Points

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Completed	Logged By
Vu-92-3	519.4	106	-75	546547.8	5516297.3	1920	COMPLETE	9/18/1992	Tim Termuende, P. Geo.

Depth (m)	Width (cm)	Angle (to CA)	Colour	Grainsize	Primary Texture	Mineralogy 1	Mineralogy 2	Mineralogy 3	Sulphides 1	%	Sulphides 2	%	Sulphides 3	%	Alteration Setting	Alteration 1	Alteration 2	Alteration 3	Note:

Appendix 3.2.6 - Veining - Points

DDH Hole Number	DDH Length (m)	DDH Azimuth (Deg)	DDH Dip (+ Down)	DDH Easting (NAD83)	DDH Northing (NAD83)	DDH Elevation (m)	DDH Status	Date Completed	Logged By
Vu-92-4	290.8	100	-45	545889.19	5509981.1	1070	COMPLETE	11/17/1992	Tim Termuende, P. Geo.

Depth (m)	Width (cm)	Angle (to CA)	Colour	Grainsize	Primary Texture	Mineralogy 1	Mineralogy 2	Mineralogy 3	Sulphides 1	%	Sulphides 2	%	Sulphides 3	%	Alteration Setting	Alteration 1	Alteration 2	Alteration 3	Note:

APPENDIX IV

CONDOR CONSULTING REPORT

REVIEW OF ST. MARY RIVER MAGNETICS AND RADIOMETRICS.

A DIGHEM helicopter-borne EM / Magnetic / Radiometric survey was carried out by Dighem I-Power (now Fugro Airborne Surveys) over the St Mary River area in southeast British Columbia in August-November, 1995.

Magnetic and radiometric data from this survey have been imaged and enhanced to assist interpretation. The following images were produced:-

Magnetics.
Total magnetic intensity (TMI)
Reduced to pole (RTP)
Reduced to pole – detrended (a linear trend has been removed from the TMI image)
Reduced to pole – 1st vertical derivative (1VD)
Analytic Signal
ZS_Tilt
ZS_Plateau

Reduced to the Pole transforms the data to appear as though it has been acquired in a vertical magnetic field, to avoid the asymmetric anomalies due to the dipping earth's field and declination. In RTP images the peak magnetic response for a vertical magnetic body is symmetric and directly over the center of the body. Thus asymmetry is normally due to dip. However, the RTP process does not consider magnetic remanence - so any negative anomalies due to reversed magnetization are not corrected and apparent dips may also be affected by remanence.

Analytic Signal (AS) is the square root of the sum of the squared X, Y and Z component gradients of the TMI. Its advantage is that it peaks directly over magnetic sources, regardless of earth's field inclination and declination and remanent magnetization. So an AS peak is produced over a negative TMI anomaly from (say) a kimberlite. Analytic Signal is most useful in low magnetic latitudes, where magnetic anomalies are severely distorted by this low inclination. It has problems in properly resolving anomalies on the flanks of broad, high-amplitude responses and deeper, broad features are also not well resolved.

The last two images were produced using Encom Profile Analyst software, using algorithms developed by Shi and Butt (2004) – see Appendix B.

The Tilt filter is also called the tilt derivative and was developed by Miller and Sigh (1994). It is defined as arctan (VDR/THDR) where VDR and THDR are the first vertical and total horizontal derivatives, respectively, of the TMI (Verduzco et al, 2004). This filter has maximum response over the top of the magnetic source (similar to 1st vertical gradient) and has the advantage that the arctan function makes the filter act like an AGC (automatic gain control) filter, and thus tends to equalize the amplitudes of strong and weak (and deep and shallow) TMI responses.

Plateau is a new linear, derivative-based filter which uses a combination of derivative and amplitude compression techniques to render the magnetic data into regions, whose edges are sharply defined and whose amplitudes have a reduced range in comparison to the original TMI (Shi and Butt, 2004). The filter "groups" adjacent similar magnetic anomalies into "units" with similar colour and thus may assist in geological mapping.

Sun-shaded (shaded-relief) images often are extremely useful in recognizing faults and other structures.

Radiometrics

TCRAW (raw total count - there was no final TC in the database)
K (potassium)
eU (equivalent uranium)
eTh (equivalent thorium)
TH_K (eTh/K)
U_K (eU/K)
U_TH (eU/eTh)

K, eU and eTh have been processed to correct for the effects of variable altitude and converted into "true" ground units (%K and ppm eU and eTh). eU and eTh are "equivalent units" because the measured gamma rays come from daughter products (^{214}Bi and ^{208}Tl) rather than of U and Th themselves.

The ratios are useful because they remove any residual errors due to altitude corrections and calibration and also partial absorption of gamma rays due to snow cover or thick vegetation.

COMMENTARY

A brief (one day) review was made of the magnetic and radiometric images, to assess their usefulness for geological mapping and target generation for Sullivan-type Pb-Zn-Ag deposits. Some observations follow – the geology and sample magnetic and radiometric images in the Appendix A may be useful in placing the features mentioned in context:-

Magnetics

- The Lower Aldridge (Pa1l, Pa1q and Pa1u) sediments are somewhat magnetic, but show little contrast with the somewhat magnetic Middle Aldridge sediments (Pa2) and Upper Aldridge (Pa3).
- The Creston Formation sediments (Pc1 and Pc2) in the eastern part of the area have similar properties. However, in the west the Pc sediments exhibit strong N-S magnetic banding (best seen on the Tilt image).
- The Kitchener (Coppery Creek) Formation sediments in the southeast (Pk) exhibit very little magnetization. However in the west the Pk1 sediments appear to have some layered magnetization.
- The Purcell Supergroup rocks (Pk1, Pk3 and Pdc) in the west have quite consistent magnetic layering in a N-S direction (best seen on the Tilt image), indicating the absence of major cross faults.
- The mapped Moyie sills (Pm) do not exhibit a consistent magnetic signature – sometimes they are highs, sometimes lows and often show little contrast with the enclosing rocks. This apparent lack of consistent response may be partly due to the relatively wide line spacing of 400 m, so that the gridding has limitations in correlating narrow anomalies from line to line when the magnetic trend is oblique to the flight lines, but even mapped sills trending perpendicular to the flight lines do not show good correlation with magnetic anomalies. Either the mapping is not reliable or the sills do not have consistent magnetization.

- The Upper Cretaceous intrusives (Kg) in the west exhibit magnetic lows that appear due to remanent magnetization. In the southeast a mapped intrusive just south of the St. Mary fault exhibits a strong magnetic high and other highs along this fault are likely due to other unmapped or buried intrusives.
- The Qal in St. Mary River correlates with a broad magnetic high (on the 1VD and Tilt images) from above the junction with Redding Creek eastwards almost to the survey boundary. This is interpreted to arise from magnetic material in the alluvium washed down from upstream.
- The Sullivan mine correlates with a moderate magnetic high, which appears due to the magnetite and pyrrhotite associated with the ore zone.
- Within the area of Eagle Plains Vulcan property, the mapped Lower Aldridge Formation correlates with a moderate magnetic high while the Middle Aldridge appears relatively non-magnetic, except for a number of discrete magnetic anomalies. These may arise from within this formation, but alternatively could be deeper and lie at the Sullivan Stratigraphic Horizon (see Possible Sullivan Targets below). The mapped Moyie Intrusions do not appear to have any particular magnetic signature).

Radiometrics

- The K, eTh and U_Th images appear to best discriminate the different sedimentary units.
- As expected, very low counts for all parameters were observed over St. Mary Lake.
- The main drainage of St. Mary River (Qal) has “average” K and eTh response and does not stand out on the radiometric images.
- Lower Aldridge (Pa1l and Pa1q) has generally low K, eU and eTh, but Pa1u generally exhibits high values.
- Middle Aldridge (Pa2) has generally high K, eTh and eU.
- In the north the Upper Aldridge (Pa3) and the Creston Formation (Pc1 and Pc2) exhibit high K, eU and eTh.
- Eager Formation (Ce) in the south exhibits high eTh.
- The Upper Cretaceous intrusives (Kg) do not exhibit any particular radiometric signature.
- Moyie sills (Pm) do not exhibit any systematic radiometric signature.
- Within the Eagle Plains Vulcan property, the Lower Aldridge correlates with relatively high K and eTh, which is contrary to the generally low counts observed in the east part of the St. Mary survey area. Most of the mapped Middle Aldridge has relatively low response. The Moyie Intrusives do not appear to have any particular radiometric signature.

Possible Sullivan Targets

The Sullivan ore body correlates with a discrete, moderate-amplitude magnetic anomaly (Fig.1)

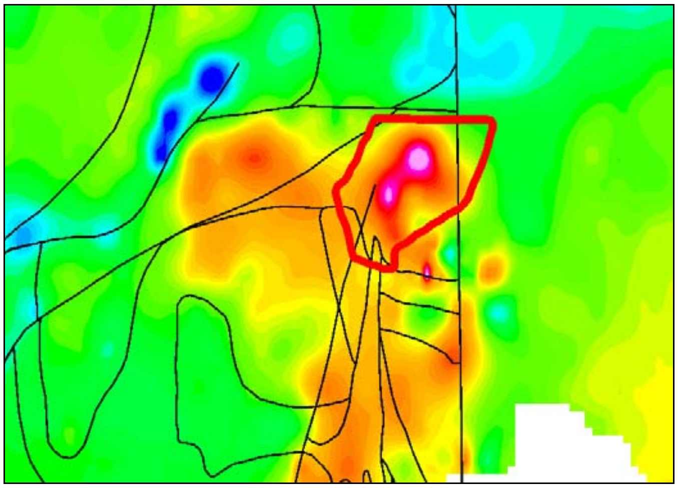


Fig. 1 TMI detrended image showing outline of Sullivan ore body.

The Sullivan ore body occurs near the contact between the Lower and Middle Aldridge at what is termed the Sullivan Stratigraphic Horizon. An examination of the geology and magnetics for the area indicates a number of similar features that may be of economic interest as Sullivan analogs. These are outlined in black on Fig.2.

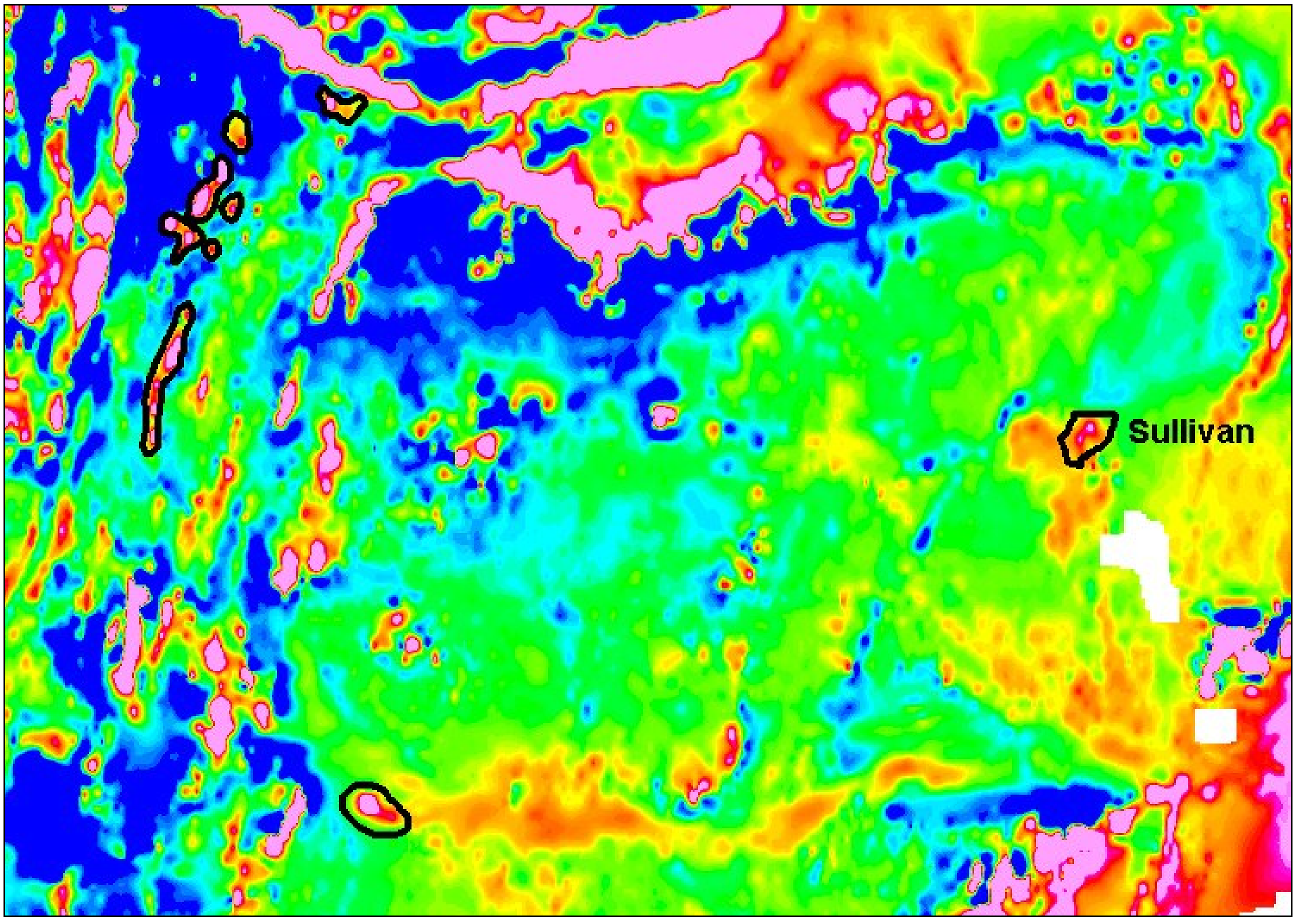


Fig. 2 Possible Sullivan analogs (outlines in black) superimposed on TMI (detrended) image

The same zones are shown superimposed on geology in Fig. 3.

The northernmost target lies within Eagle Plains ground and is recommended for follow-up. If geological mapping confirms the potential of this magnetic target (which may be several hundred meters deep) then a follow-up ground EM survey is recommended. The DIGHEM EM data does not indicate any good conductor at this location, but the limited depth penetration of this system (less than 100 m) does not rule out a deeper conductor.

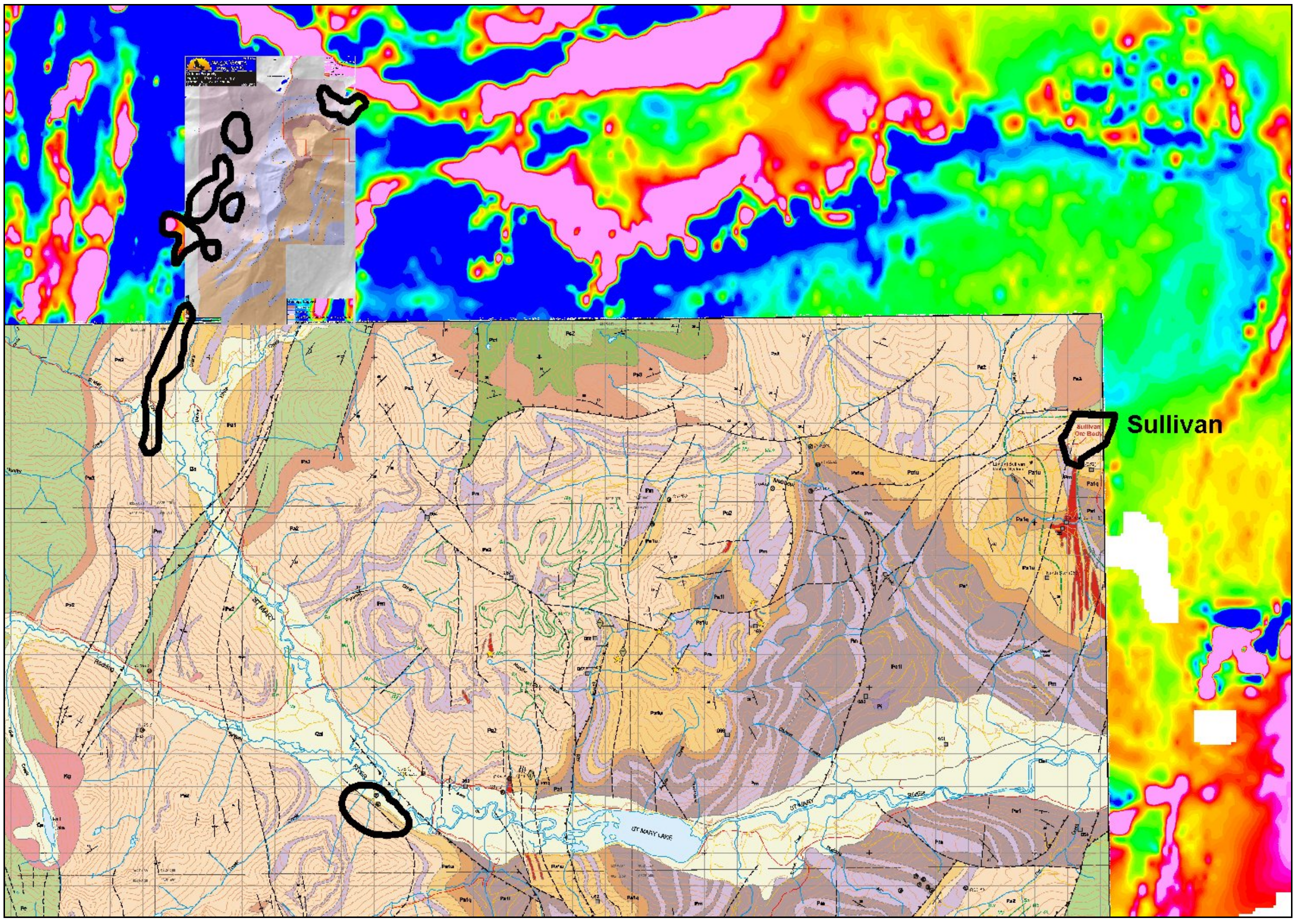


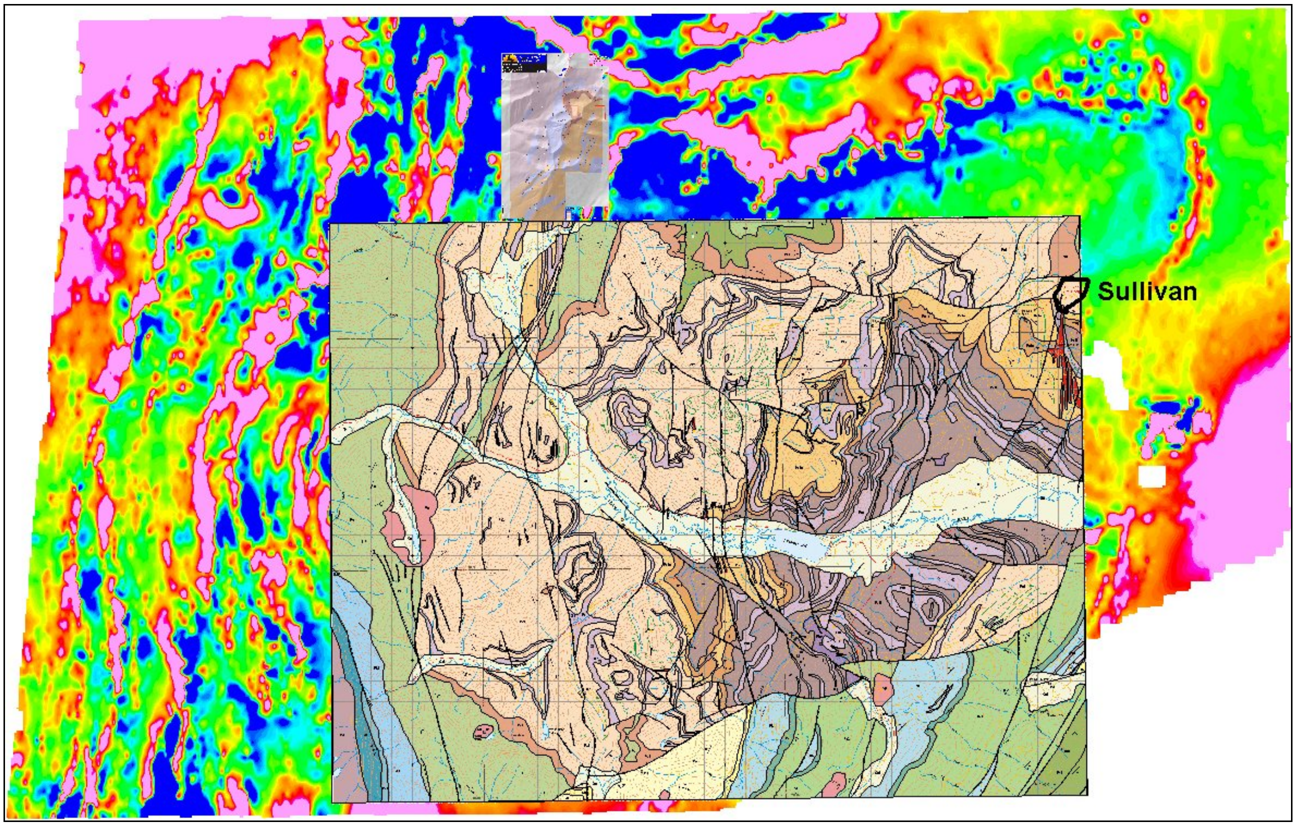
Fig. 3 Possible Sullivan analogs (outlines in black) superimposed on geology

Richard Irvine

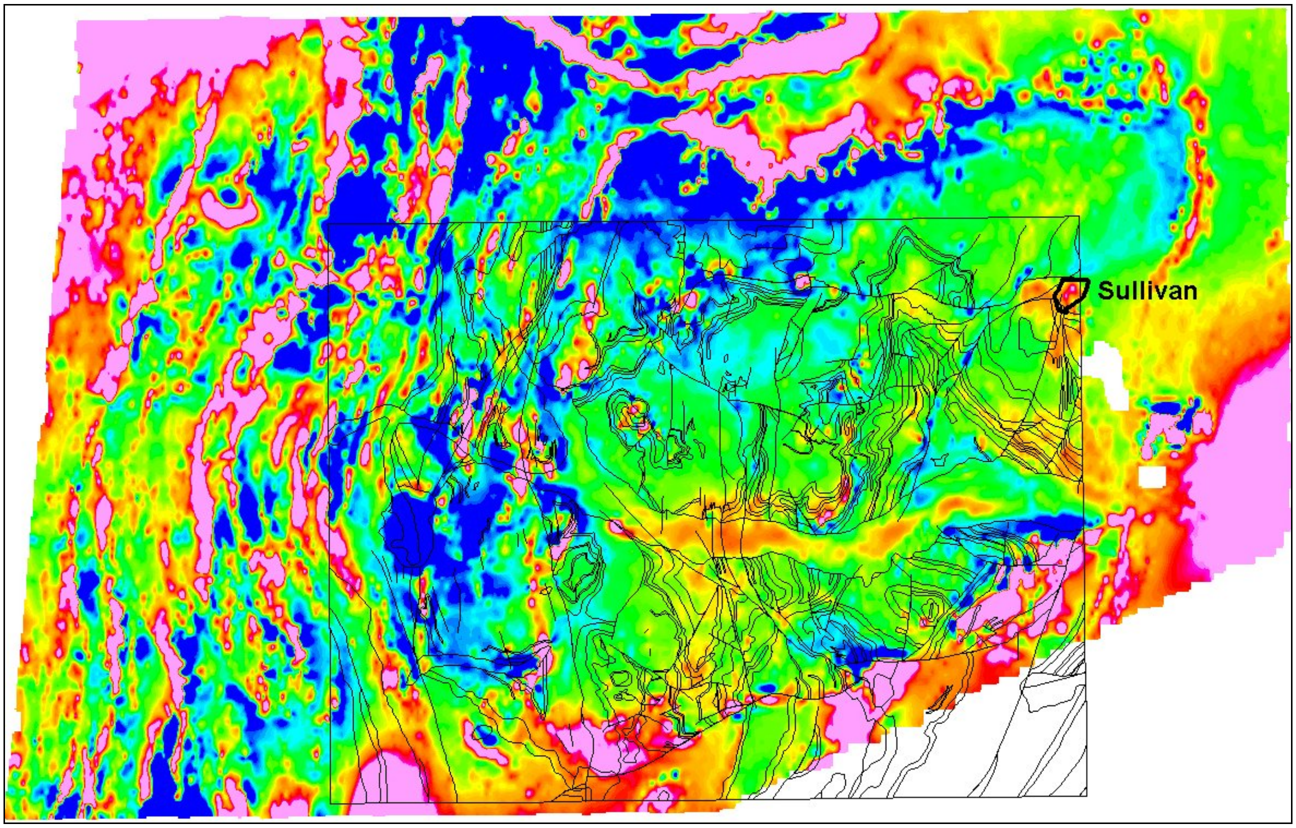
Richard Irvine
Condor Consulting, Inc.
February 8, 2006

APPENDIX A

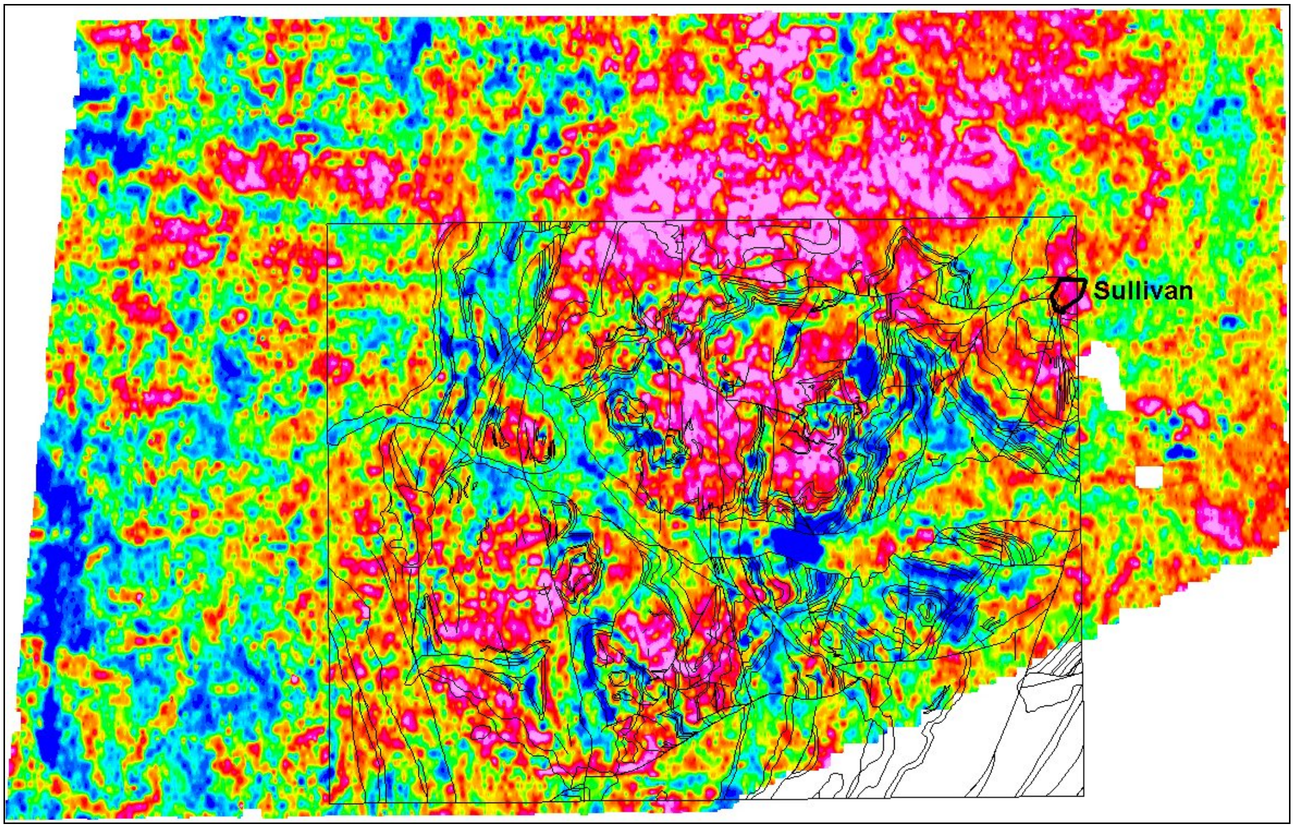
Geology and sample magnetic and radiometric images



Geology maps superimposed on TMI (detrended) image



TMI (detrended) image showing geology outlines and faults



K (Potassium) image showing geology outlines and faults

APPENDIX B

Shi and Butt paper

New enhancement filters for geological mapping

Zhiqun Shi*
Encom Technology Australia
zhiqun.shi@encom.com.au

Graham Butt
Encom Technology Australia
graham.butt@encom.com.au

SUMMARY

Two types of filters have been developed for the purpose of enhancing weak magnetic anomalies from near-surface sources while simultaneously enhancing low-amplitude, long-wavelength magnetic anomalies from deep-seated or regional sources. The Edge filter group highlights edges surrounding both shallow and deeper magnetic sources. The results are used to infer the location of the boundaries of magnetised lithologies. The Block filter group has the effect of transforming the data into “zones” which, similar to image classification systems, segregate anomalous zones into apparent lithological categories. Both filter groups change the textural character of a dataset and thereby facilitate interpretation of geological structures.

The effect of each filter is demonstrated using theoretical model studies. The models include both shallow and deep sources with a range of magnetisations. Comparative studies are made with traditional filters using the same theoretical models. In order to simulate real conditions, Gaussian noise has been added to the model response. Techniques for noise reduction and geological signature enhancement are discussed in the paper.

The new approaches are applied to actual magnetic survey data covering part of the Goulburn 1:100 000 scale map sheet area, New South Wales. Some new geological inferences revealed by this process are discussed

Key words: Enhancement filters, magnetic sources, geological mapping.

INTRODUCTION

High-resolution aeromagnetic survey data represent a rich source of detailed information for mapping surface geology as well as for mapping deep tectonic structure. Traditional enhancement techniques, such as first vertical and horizontal derivatives (1VD, 1HD), analytic signal (AS), and high-pass in-line or grid filters are used in enhancing magnetic anomalies from near-surface geology.

In recent years the potential field tilt filter has been introduced (Miller and Singh, 1994) and it has achieved recognition for its value in the analysis of potential field data for structural mapping and enhancement of both weak and strong magnetic anomalies (Verduzco *et al*, 2004). The total horizontal derivative of the TMI reduced to the pole is also widely used for detecting edges or boundaries of magnetic sources (Cordell and Grauch, 1985; Blakely and Simpson, 1986; Phillips, 1998).

Several disadvantages pertain to the use of these traditional filters. They often only diffusely identify source location and boundaries, particularly in colour image presentations. They usually emphasise short wavelength anomalies at the expense of signal from deeper magnetic sources and the range of amplitudes remaining in the filtered output may dominate the source boundary information being sought. In addition, some traditional filters emphasise noise with resultant impact on the interpretation of source boundaries.

This paper identifies new processes which have been developed to address these disadvantages and provide output which can improve map-based interpretations.

Unless otherwise stated, all filters have been operated on TMI data reduced to the pole (RTP).

METHOD AND RESULTS

Theoretical Model Testing

A theoretical 2D grid of total magnetic intensity (TMI) computed at the surface was created by forward 3D modelling of the TMI response from a set of theoretical magnetic sources having variable width, strike extent, depth, depth extent (DE), dip, magnetic susceptibility and strike azimuth. A list of these parameters is presented in Table 1. In two of the sources, remanence was simulated using negative magnetic susceptibility. The TMI of the theoretical models was computed at a geomagnetic inclination of -60 degrees using a notional east–west line spacing of 200 m and a grid cell size of 40 m. The TMI grid was then reduced to the pole (RTP) (Figure 1).

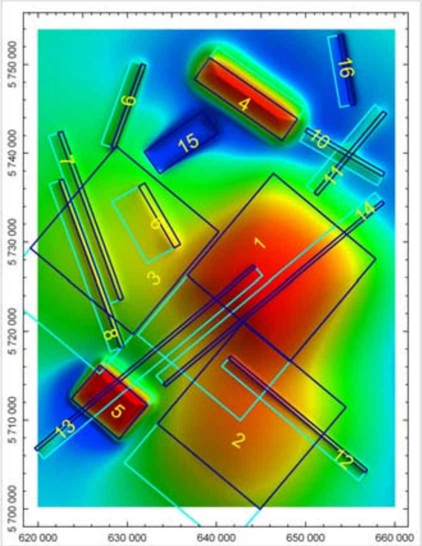


Figure 1. RTP image derived from multiple theoretical 3D magnetic sources, shown as wire frame outlines

A set of traditional filters was operated on the theoretical RTP grid. They include AS, 1VD, modulus of horizontal derivatives (MS) and Tilt and the results are presented in

Figure 2. The output grids variously show discontinuous trending (crossed sources in upper right of AS image), diffuse, weak edges (deep source in centre right of the MS image) and lack of precise source edge definition (1VD and Tilt).

Model Label	Depth (m)	Width (m)	DE (m)	Dip (deg)	Magnetic Susceptibility (SI)	Strike Length (m)	Azimuth (deg)
1	4000	15000	15000	120	0.010	15000	-050
2	6000	15000	10000	120	0.010	15000	-050
3	10000	15000	10000	120	0.010	15000	-050
4	1000	3000	4000	70	0.010	12000	-055
5	500	5000	2000	60	0.010	7000	-050
6	1000	800	2000	150	0.005	8000	-030
7	600	500	2000	120	0.001	20000	-020
8	200	500	2000	120	0.001	20000	-020
9	500	500	2000	120	0.003	10000	020
10	1000	500	2000	120	0.003	10000	-060
11	1000	500	2000	120	0.003	12000	040
12	200	400	2000	120	0.001	20000	-050
13	500	400	1000	40	0.002	32000	050
14	500	400	1000	140	0.001	32000	050
15	600	3000	4000	90	-0.002	8000	055
16	400	600	2000	120	-0.010	8000	-010

Table 1. List of parameters of theoretical magnetic sources

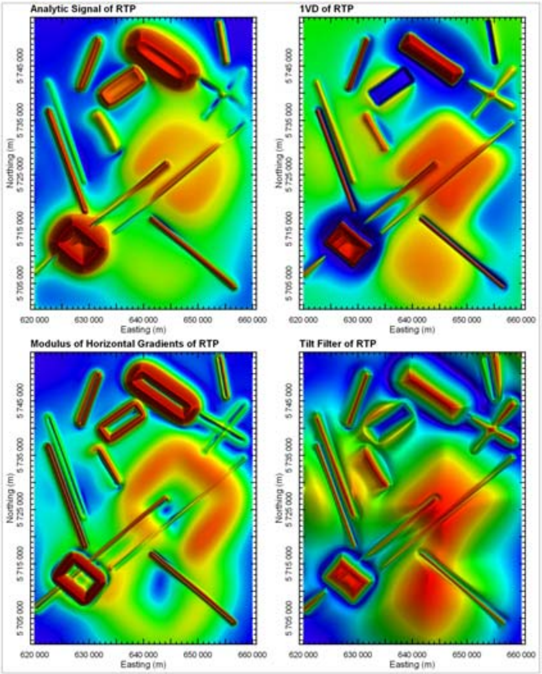


Figure 2. Comparison of enhancement filters of RTP: AS, 1VD, MS and Tilt filter. The models used are those depicted in Figure 1.

Edge Filters

The first avenue of development was to increase the sharpness of the anomalies used to map the edge of the magnetic sources. The MS grid yields anomaly peaks over the source edge locations, whereas these edges coincide with gradients in the 1VD, Tilt and AS filtered outputs. None of these filters produces easily interpreted edges in image form when the sources are weakly magnetised or are deep.

A new linear, derivative-based filter termed the ZS-Edgezone filter has been developed to improve edge detection in these situations. Its effect is shown in Figure 3 using the same theoretical models discussed earlier. The advantages of the filter are greatly increased anomaly sharpness over source edges and compression of the amplitude range so that differences in the original TMI amplitudes do not persist to dominate the edge interpretation. This has the ancillary effect that the method can be modified to provide automated edge conversion to vectors for use in GIS systems.

Although this filter significantly improves the precision of edge determination, it is subject to normal potential field limitations which determine that source edges cannot be resolved where the source is narrow relative to its depth. The filter also can produce a "halo" type artefact due to superposition of the response of a limited depth extent shallow source (Figure 1, Model 6) on that of deeper sources. A similar "halo" effect can be seen around the edges of remanently magnetised Model 15, also in Figure 1.

The ZS-Edge filter (Figure 4) has also been developed to map source edges. This filter differs from the ZS-Edgezone filter in that a greater contribution of the TMI anomaly amplitude over the source is retained, thereby improving anomaly characterisation at the expense of edge sharpness.

Both these filters produce edges which migrate down-dip towards the deepest edge of the source. This effect produces anomaly asymmetry that can assist interpretation of dip, although this effect is more pronounced for the ZS-Edge filter than for the ZS-Edgezone filter. Down-dip source extensions are depicted in cyan in Figure 1.

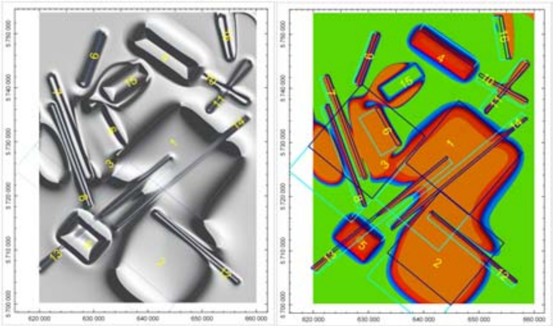


Figure 3. Anomaly edge and block enhancements using the ZS-Edgezone (left) and ZS-Block filters (right). Model positions are shown using wire frames.

Block Filters

In attempting to improve edge detection filters, an obvious progression is to highlight the magnetic regions whose edges have been mapped. To do this, a set of filters called "block" filters has been developed.

The Block filter group has the effect of transforming the potential field data into "zones" which, similar to image classification systems, segregate anomalous zones into apparent lithological categories. These filters can be imported for use in image classification systems or displayed in RGB space with other grids for empirical classification purposes.

The block filters, like the edge filters, are linear, derivative-based filters which use a combination of derivative and amplitude compression techniques to render the magnetic data into regions whose edges are sharply defined and whose amplitudes have a reduced range in comparison to the original TMI.

The ZS-Block filter (Figure 3) and the ZS-Plateau filter (Figure 4) depict the magnetic data as a 2D plan of apparent magnetic source distribution. Artefacts may occur as discussed for the edge filters.

The choice of ZS-Block, ZS-Plateau or ZS-Area filters will depend on the data characteristics of each magnetic survey and on the end-use requirement. The ZS-Plateau filter, for example, yields less variation in amplitude "texture" over a magnetic unit that either the ZS-Block or ZS-Area filters.

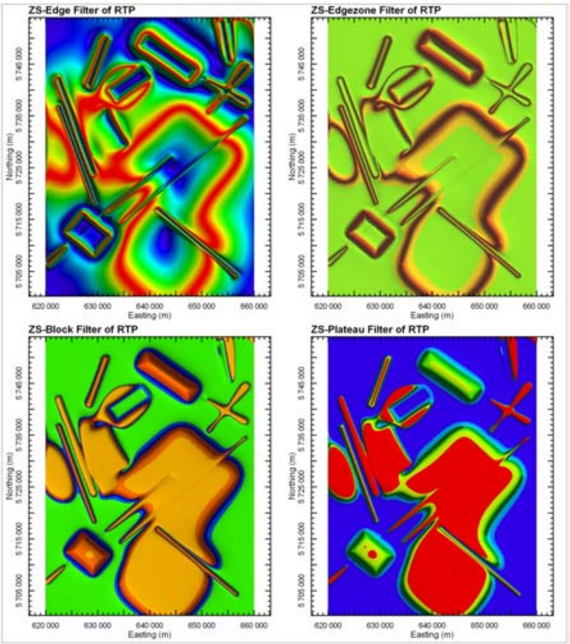


Figure 4. Comparison of ZS-Edge, ZS-Edgezone, ZS-Block and ZS-Plateau filtered outputs of RTP data

Effects of Noise

The influence of noise on the operation of these enhanced grids was tested by adding a large component of noise to the theoretical TMI profile data. This noise had a Gaussian distribution with a standard deviation equal to ten percent of the TMI standard deviation. The noise-modified TMI profile data were then de-spiked using a non-linear technique. Both the noise-affected and the de-spiked TMI data were then gridded and converted to RTP. The RTP data were then processed both with the traditional and newly developed filters.

Figure 5 shows the effect of the noise on the computations. The image of the noise-affected 1VD RTP data (top right) shows that weak and deep sources have been severely masked by the noise. Significant improvement can be achieved by using de-spiked data (lower left) or by low-pass grid filtering — for example, using an upward continuation filter (lower right).

Figure 6 shows that if real data with significant noise is encountered, a standard de-spiking or low-pass smoothing procedure may be used to achieve successful application of both the traditional and newly developed filters.

Figure 6 also depicts the use of enhanced outputs in RGB space to provide examples of how the combination of amplitude information (red colour) with edge information (green and blue colours) can be used to highlight source boundaries and remanence in a single image.

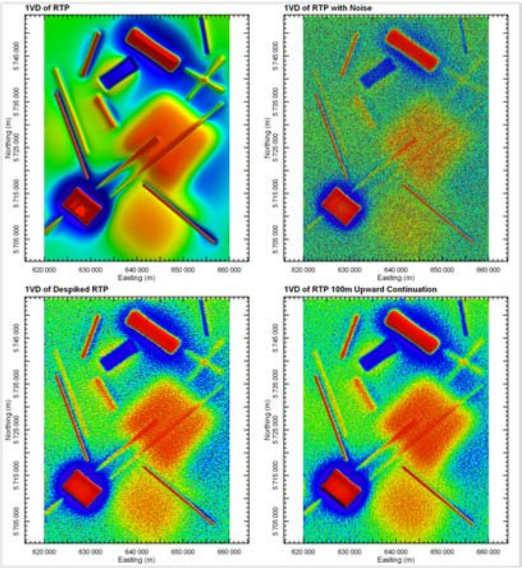


Figure 5. Comparison of 1VD of original model RTP data (top left) with noise-affected RTP data (top right) and noise-reduced RTP data (lower images)

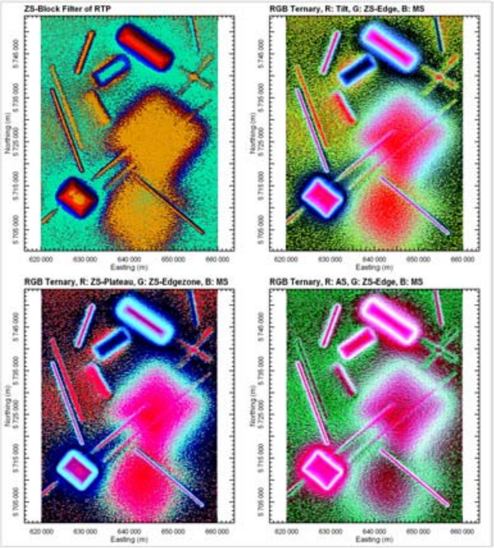


Figure 6. ZS-Block filter using noise-reduced RTP data (top left) and examples of filter combinations in RGB space using noise-reduced RTP data

Application to Field Data, Goulburn 1:100 000 Scale Map Sheet Area, New South Wales

Both the traditional and new enhancement filters were applied to test their suitability for geological definition to airborne magnetic survey data over the Goulburn 1:100 000 scale map sheet area (Johnson *et al,* 2003). These data were acquired as part of a joint program between the NSW Department of Mineral Resources and Geoscience Australia, with 250 m–spaced east–west flightlines. The magnetometer sensor occupied a nominal terrain clearance of 80 m. This dataset was selected since new detailed geological mapping had been recently completed. All the enhancements have been computed using TMI data reduced to the pole.

Figure 7 shows a comparison of part of the Goulburn 1:100 000 map sheet area surface geology with the ZS-Area filter output. In the area surrounding location C, the ZS-Area filter transforms the magnetic data into separate magnetic units, which comprise the Devonian Bindook Volcanic Complex. The magnetic regions correlate closely with mapped andesites (Dkqa–cream coloured unit in Figure 7) whilst the intervening less-magnetic units correlate with rhyolitic ignimbrites (Dkqy–red unit in Figure 7)

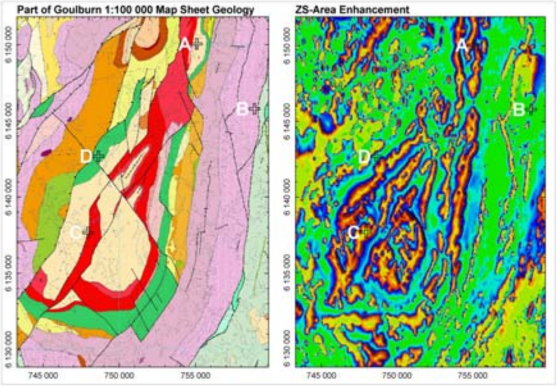


Figure 7. Comparison of geology and ZS-Area enhancement over the Bindook Volcanic Complex

Figure 8 displays some of the advantages of the edge detection filters. At location A, ambiguity concerning the continuity of Quialigo Formation units (cream and red units in Figure 7) is resolved by the ZS-Edgezone filter. At location B, a subtle lineament is confirmed, whilst at location D, the extent of the Bullamalita Conglomerate (green unit in Figure 7) is clearly mapped by the ZS-Edge filter. Structural breaks are often more easily interpreted using these transforms, for example, immediately southwest of location D.

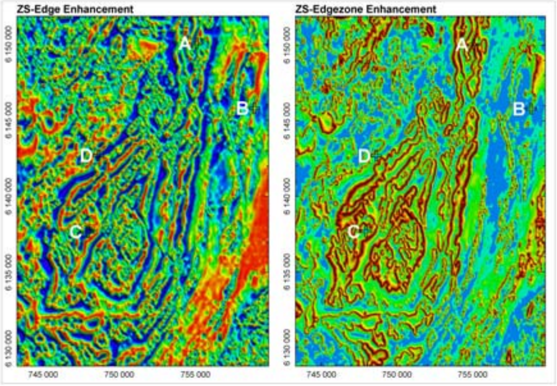


Figure 8. Comparison of ZS-Edge and ZS-Edgezone enhancements over the Bindook Volcanic Complex

Figure 9 shows standard RTP and Tilt transforms over the same area for reference.

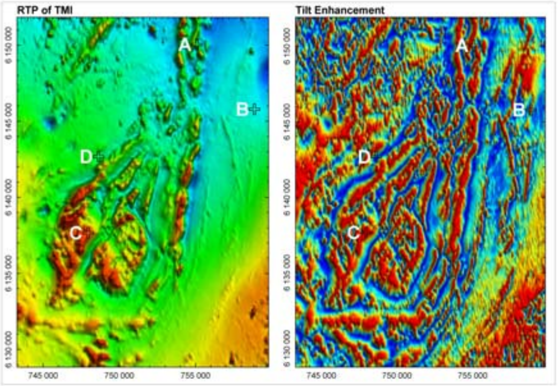


Figure 9. Comparison of RTP and Tilt filters over the Bindook Volcanic Complex

CONCLUSIONS

Traditional filters used to enhance magnetic data, including the more recently developed potential field tilt filter, are currently used to assist in determination of the location and extent of magnetic units.

Newly developed derivative-based filters may be used to improve the precision of source edge detection and, by extension, the determination of the spatial extent of magnetic units. These filters are demonstrated to perform successfully on both strongly magnetised features as well as on weakly magnetised or deep magnetic features. Artefacts may result particularly where anomaly superposition occurs.

The impact of noise in real data may be accommodated by these new methods provided noise-reduction techniques are employed.

The new filter outputs may be used as part of regional or detailed geological mapping projects, including in classification systems or in RGB space, to improve lithological discrimination and mapping.

The speed of magnetic unit mapping can be considerably increased through reliance on edge detection filters. Further improvements in mapping speed can be envisaged through automated conversion of edge anomalies to vector files.

ACKNOWLEDGMENTS

The authors would like to acknowledge the New South Wales Department of Mineral Resources for permission to use aeromagnetic and geological data from the Goulburn 1:100 000 map sheet area and helpful comments by David Robson during the project.

The authors wish to acknowledge Encom Technology for permission to publish the results of research into the proprietary filters used in this paper. The 3D modelling was carried out using Encom ModelVision Pro software, whilst processing and data visualisation were accomplished using Geosoft OASIS montaj and Encom Geoscape.

REFERENCES

Blakely, R. J. and Simpson, R. W., 1986, Locating edges of source bodies from magnetic or gravity anomalies, Geophysics, 51, 1494-1498.

Buckingham, A.J, Dentith, M.C., and List, R.D, 2003, Towards a system for content-based magnetic image retrieval: Exploration Geophysics, 34, 195-206.

Cordell, Lindrith, and Grauch, V.J.S., 1985, Mapping basement magnetization zones from aeromagnetic data in the San Juan Basin, New Mexico pp.181-197. In Hinze, W.J., ed,. The utility of regional gravity and magnetic maps: Society of Exploration Geophysicists,

Johnson A.J. *et al.*, 2003, Goulburn 1:100 000 Sheet 8828 Geology Map, New South Wales Department of Mineral Resources.

Miller, H.G., and Singh V., 1994, Potential field tilt — a new concept for location of potential field sources: Journal of Applied Geophysics, 32, 213-217.

Phillips, J.D., 1998, Processing and interpretation of aeromagnetic data for the Santa Cruz Basin–Patagonia Mountains Area, South-Central Arizona: United States Geological Survey Open-File Report 02-98.

Verduzco, B., Fairhead, J. D., Green, C. M., and MacKenzie, C., 2004, New insights into magnetic derivatives for structural mapping: The Leading Edge, 23 (2), 116-119.