नेपाल विद्युत प्राधिकरण
Nepal Electricity Authority

UPDATED FEASIBILITY STUDY & DETAILED ENGINEERING DESIGN OF

UPPER ARUN HYDROELECTRIC PROJECT

Power Sector Reform and Sustainable Hydropower Development Project
(Credit No. 5728-NP)



Phase I: Project Optimization and Updated Feasibility Study Report

Volume IV – Annex C-5: Notes on the Geology of Test Adits of UAHEP

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Annex C-5-1 Tunnel logging of AD1_AD5

Annex C-5-2 Joints characteristics of AD1_AD5

1. Introduction

In order to ascertain the engineering geological condition of UAHEP, two test adits at both abutments and one test adit at powerhouse site were arranged with total length of 1275m. Till May 20, 2020, 812m of them have been completed. The parameters and completed works of test adits are listed in Table 1.

Table 1 The parameters and completed works of test adits

S.N.	Location	Portal Elevation (m)	Slope (%)	Planned length (m)	Completed Length (m)	Remark
AD1	Left abutment	1595	1	70	30	
AD3		1635	1	80	0	
AD2	Right abutment	1575	1	89	89	Extended as suggested by DSPOE
AD4		1635	1	103	103	
AD5	PH	1105.6		945	627	
Total				1275	849	

2. Geology of the Dam Abutment

As of May 20, 2020, adits of AD2 and AD4 on the right abutment have been excavated to the adjusted lengths of 89m and 103m respectively, lower adit AD1 of the left abutment have been excavated to 30m.The locations of the adits at the dam site are shown in Figure 1. Considering that adit AD1 is under excavation, the following geological note is only for adit AD2 and AD4 on the right abutment.

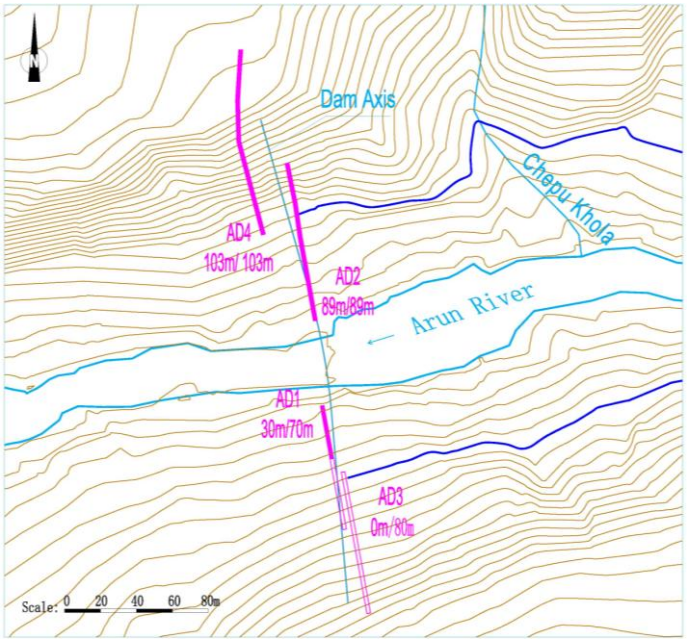


Figure 1 The locaitons of test adits at dam site

2.1 Lithology

The excavation of adits on both abutments reveals that the lithology is Precambrian gneiss with lenticular quartz vein (see Figure 2), in gray to dark gray color, and the main mineral composition include feldspar, quartz and mica. The strike of gneissosity is between 5° and 30° with dip angle between 12° and 25°.

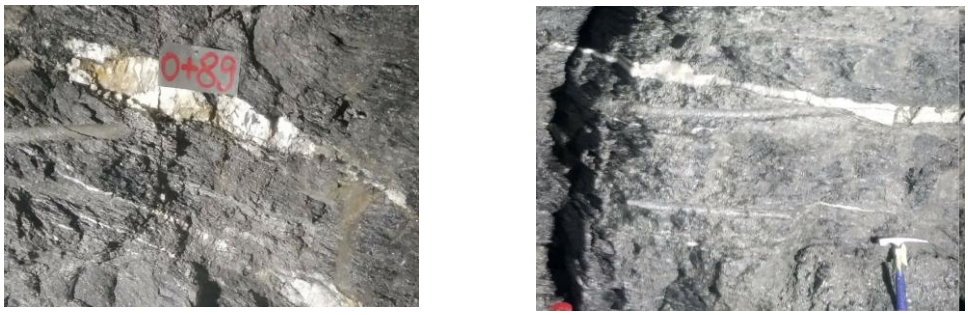


Figure 2 The gneiss rock and lenticular quartz vein in the adits of abutments

2.2 Geological structure

No fault can be found in the completed adits, the main geological structure revealed is joint. Generally, there are three sets of joints developed in the dam abutment. J1 set of joints is nearly parallel to the abutment slope, inclining outwards the slope, with dip direction between 160° and 210°, and dip angle between 45°and 80°.The joints surfaces are mainly unloading and rough.The J2 set of joints is nearly perpendicular to the abutment slope, trending to the upstream (70 ° ~ 90 °) or the downstream (270 ° ~ 300 °), with dip angle between 55° and 85°.Since the strike of this set is consistent with that of adit,

the excavation reveals relatively few J2 joints. The J3 is developed along the gneissosity. Figure 3 shows the stereo net of joints at dam abutment. The main characteristics of each set of joints are listed in Table 2.

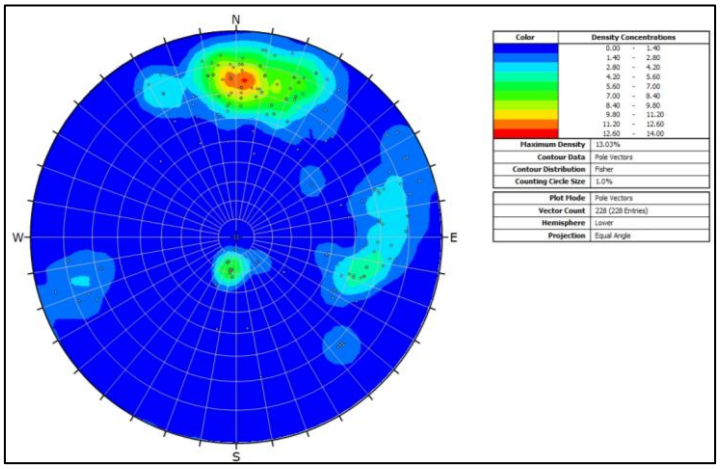


Figure 3 Stereo net of joints at right abutment

Table 2 Main characteristics of each set of joints

S.N.	Strike	Dip direction (°)	Dip angle (°)	Spacing (m)	Description
J1	NWW	180~210	45~80	2~20	The joint sets are parallel to the river bank. Mainly relief joints, mostly short, less than 20m. The aperture is up to 5cm.
	NEE	160~180	45~80		
J2	NNE	270~300	55~85	5~20	The joint sets are perpendicular to the river bank. The persistence is less than 15m, the aperture is up to 8mm. Mainly filling with rock debris.
	NNW	70~90	60~80		
J3	NWW	5~25	10~25	10~20	Joints formed along gneissosity, inclines into the slope on the right bank while outside the slope on the left bank.

According to the joint's occurrence, persistence, opening and undulation condition, the main joints revealed by the right dam abutment are listed in Table 3.

Table 3 The main joints revealed by the Adits of AD2 and AD4 at right dam abutment

Adit	Joint set	Joint Number	Chainage(m)	Lithology	DA	DD	Spacing(m)	Aperture (mm)	Persistence (m)	Infilling	Weathering	Roughness	Remarks
AD2	J1 Parallel to the slope	1	0+010	Gneiss	55	135	-	2-20mm	>3	Silty material	W1	Rough and wavy	Single entry
		2	0+013.8	Gneiss	77	190	0.1-0.2	2-10mm	>3	Silty material	W1	Rough and wavy	Five entries
		4	0+018.7	Gneiss	83	206	1	5-10mm	>2	Silty material	W1	Rough and wavy	Four entries
		7	0+026	Gneiss	68	182	0.1-0.5	Tight	>3	-	W1	Rough and wavy	3 entries
		10	0+030	Gneiss	45	192	-	2-10mm	>3	Silty clay	W2-W3	Rough and wavy	Single entry
		15	0+055	Gneiss	63	204	0.1-0.5	Tight	>2	-	W1-W2	Rough and wavy	3 entries
AD4	J1 Parallel to the slope	1	0+009	Gneiss	73	171	0.5-1	2-100mm	>3	Silty material	W1	Rough and wavy	6 Entries
		2	0+018.2	Gneiss	66	169	0.5	2-20mm	>3	Silty material	W1	Rough and wavy	2 entries
		3	0+020.1	Gneiss	58	150	0.3-1.5	2-15mm	>3	Silty material	W1	Rough and wavy	3 entries
		5	0+036	Gneiss	69	177	-	<2	>3	Silty material	W1	Rough and wavy	Single entry
		11	0+066	Gneiss	56	151	-	2-4mm	>3	Silty material	W1	Rough and wavy	Single Entry
		12	0+072.7	Gneiss	87	151	0.1	2-4mm	>3	Silty material	W1	Rough and wavy	3 Entries
		15	0+087	Gneiss	40	170	0.3	2-30mm	>3	Silty material	W1	Rough and wavy	4 entries
		16	0+091	Gneiss	50	152	0.9	1-4mm	>2	Silty material	W1	Rough and wavy	3 entries

2.3 Weathering and relief

The horizontal thickness of moderately weathered rock mass in AD4 is approximately 2m, while in AD2 is about 27m. The inside rock mass is mainly slightly weathered and fresh.

Based on the opening of relief joints, combining with the spacing, the horizontal thickness of highly relief zone in AD4 is about 23m, while in AD2 is around 30m. According to the weathering, relief, together with the data reveled by the surface geological mapping, drill hole and geophysical survey, the geological profile of dam axis have been interpreted and shown in figure 4.

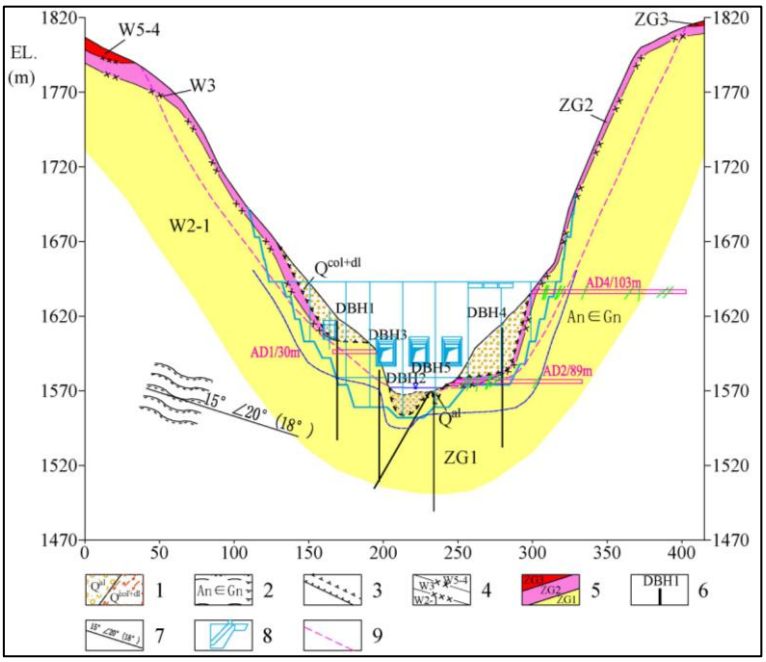


Figure 4 The geological profile of the abutment slope along dam axis

1. Alluvium, colluvium and slope wash 2. Gneiss; 3. Boundary of Quaternary; 4. Boundary of W5-4 and W3; 5. Geological zoning; 6. borehole; 7. Gneissosity; 8. Excavation lines; 9. The boundary of highly relief zone

2.4 Ground Water

There is no obvious water gushing and dripping phenomenon in adit AD4 on the upper abutment. However, there is a small amount of dripping water in AD2 on the lower abutment, but no obvious water flow exists. The total flow of 89m of the whole AD2 is less than 10L / min. The type of groundwater is bedrock fissure water.

2.5 Rock Mass Classification

During the excavation, the face mapping of each advance was carried by geologist. Based on the Q value of each advance, the statistical results are listed in Table 4.

Table 4 The statistical results of Q value of each advance at damsite

Q System	Class	Adit AD2		Adit AD4		Total	
		Length (m)	Percentage (%)	Length (m)	Percentage (%)	Length (m)	Percentage (%)
0.09 < Q≤1	Very poor	-	-	-	-		
1 < Q≤4	poor	1.60	3.0	-	-	1.60	1.1
4 < Q≤10	Fair	16.62	31.6	17.02	17.7	33.64	22.6
10 < Q≤40	Good	26.38	50.2	48.64	50.6	75.02	50.4
40 < Q	Very good	8.00	15.2	30.49	31.7	38.49	25.9
Total		52.6	100	96.15	100		
The sections without mapping		36.4		6.85			

From the statistical data, it can be seen that the dam abutment rock mass is mainly Good, accounting for 76.3%, followed by Fair, accounting for 22.6%, and the rock mass with poor quality only accounts for 1.1%, which is located in the moderately weathered and relief zone of the slope toe area.

2.6 Conclusion and suggestion

The rock mass at the dam abutment is intact gneiss. The gneissosity gently dip inward the right abutment slope. No obvious fault or weak fracture zone is found in the completed adits. The main adverse feature is joint, and the overall geological conditions are good.

It is suggested to carry out in-situ shear tests on some main joints in the next step while completing the remaining adits.

3. Engineering Geology of Powerhouse Site

The design length of the adit AD5 at the underground powerhouse site is 945m. As of May 20, 2020, the completed length of the powerhouse is 590m (Figure 5).

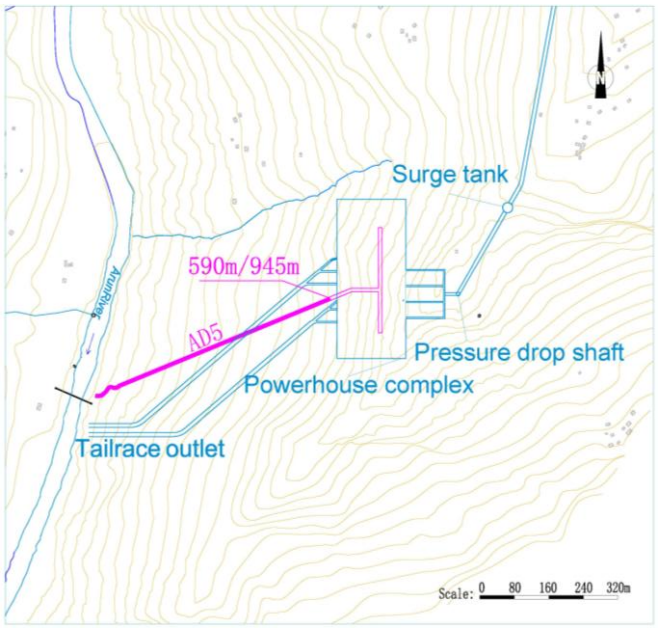


Figure 5 The location of AD5 at PH site

3.1 Formation Lithology

The rock mass revealed by AD5 mainly includes Augen gneiss (see Figure 6), mica schist (see Figure 7), amphibolic gneiss (see Figure 8), etc. Quartz vein can be seen along the bedding plane (see Figure 9).



Figure 6 Augen Gneiss（Ch5m）

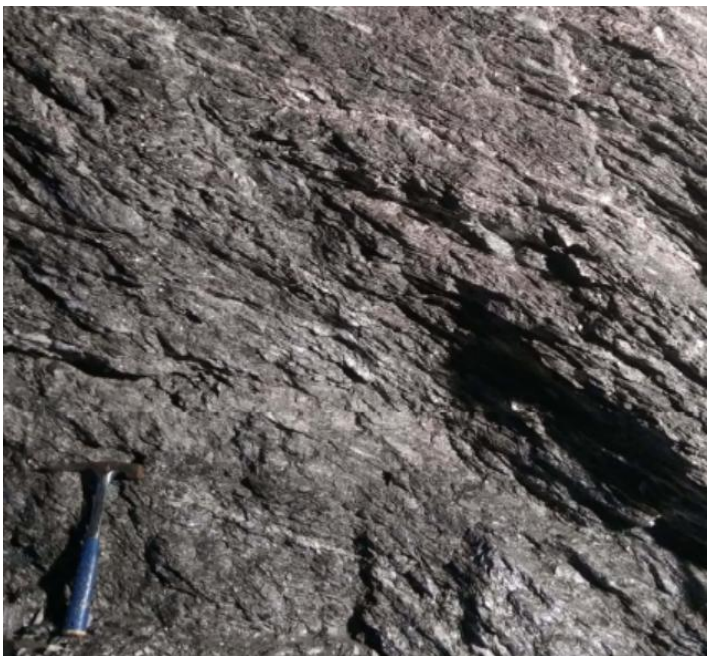


Figure 7 Mica Schist（Ch136m）



Figure 8 Amphibolic Gneiss（Ch133m）



Figure 9 Quartz vein（Ch137m）

Among them, the Augen gneiss is of coarse-grained structure and massive, which is distributed at and below the entrance of the adit. The surface layer is mainly moderately weathered rock mass. The rock mass is relatively intact with high strength. Mica schist is of coarse-grained and schistose structure, mainly distributed in ch5m ~ ch290m of AD5, mainly in slightly weathered and fresh state. The rock mass is well developed with schistosity and with low strength. The amphibolitic gneiss is of microcrystalline structure massive, and mainly distributed in ch290 ~ ch590 (face). The rock mass is mainly in slightly weathered and fresh state. The rock mass is relatively intact with high strength. The geological generalization map of the adits based on lithology and fault structure is shown in Figure 10.

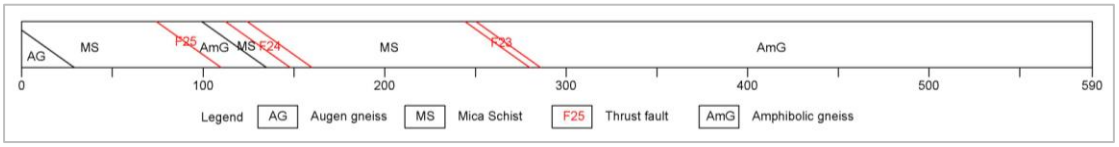


Figure 10 The geological generalization map of the adits based on lithology and fault structure

3.2 Geological Structure

The geological structure in AD5 at Powerhouse site consist of thrusts and joints. The main characteristics of the thrust faults, named F25, F24 and F23, and developed in test adit of AD5, are listed in Table 4.

Table 5 The main characteristics of the thrust faults in AD5

SN	Chainage	DD(°)	DA(°)	Width(m)	Description
F25	CH109	090	35	1	A thrust plane. The raw rock is mica schist. Mainly consist of debris and clay.
F24	CH148~CH160	090	35	7	A thrust fault zone. The material composition in the fault zone is mylonite and debris mixed with mud. The raw rock is mica schist. The spring water flow is about 5 L/min
F23	CH280~CH285	095	30	2.5	A thrust fault zone. The material composition in the fault zone is mylonite and debris mixed with mud. The raw rock is mica schist. The spring water flow is about 10 L/min

Total 142 entries of joints in schist section (CH5m~CH290m) were recorded ,

The stereo net of these joints are shown in Figure 11. Three sets of joints and some random joints are developed. The main characteristics of three dominant joints are listed in Table 5.

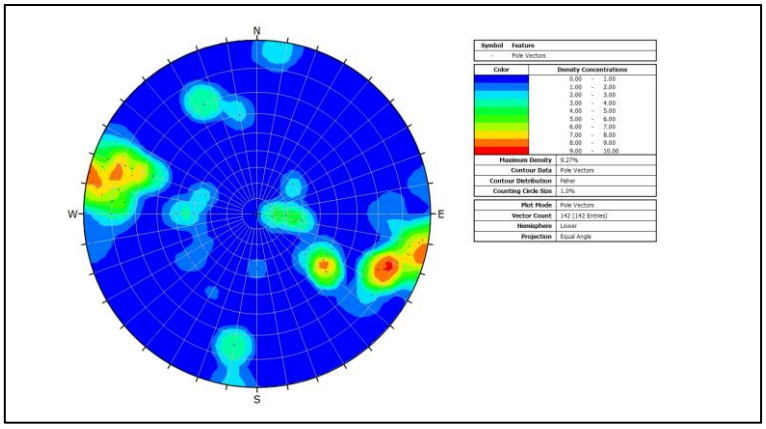


Figure 11 Stereo net of joints in schist section of AD5

Table 5 The main characteristics of three dominant joints in schist

S.N.	Strike	Dip direction(°)	Dip angle(°)	Spacing (m)	Description
J1	NNW	90~120	70~80	3~20	The joint set is perpendicular to the foliation. The persistence is mainly short and less than 3m. The aperture is up to 5cm, filling with silt soil.
J2	NNW	280~300	10~30	2~30	The joint set is perpendicular to the foliation. The persistence is short and less than 3m, the aperture is up to 8mm. Mainly filling with silt soil.
J3	NWW	0~15	70~80	5~20	The persistence is long and more

					than 3m, mainly tight, or filling with silt soil.

Total 286 entries of joints in gneiss section (CH290m~CH590m) were recorded，

The stereo net of these joints are shown in Figure 12. The main characteristics of three dominant joints are listed in Table 6.

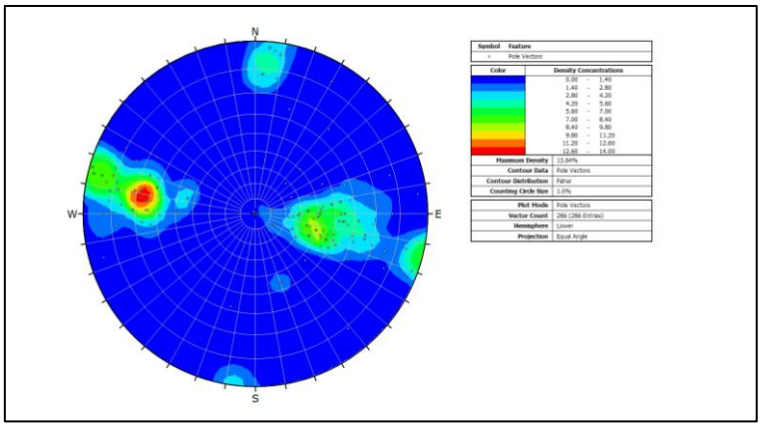


Figure 12 Stereo net of joints in gneiss section of AD5

Table 6 The main characteristics of three dominant joints in gneiss

S.N.	Strike	Dip direction(°)	Dip angle(°)	Spacing (m)	Description
J1	NNW	80~110	60~80	5~20	The joint set is perpendicular to the foliation. The persistence is mainly short and less than 3m. Mainly tight, or filling with rock debris.
J2	NNW	260~290	30~60	5~30	The joint set is perpendicular to the foliation. The persistence is mainly short and less than 3m. Mainly tight, or filling with rock debris.
J3	NWW	180~190	70~90	5~20	The persistence is long and more than 3m, mainly tight, or filling with silt soil.

3.3 Weathering and relief

The portal of the adit AD5 is located in the upper part of steep cliff near the tailrace exit. The horizontal thickness of moderately weathered rock mass is about 5m. Based on the opening of relief joints, combining with the spacing, the horizontal thickness of highly relief zone in AD5 is about 8m.

3.4 Ground Water

There are 15 springs developed in AD5. Based on the location and flow of springs, the groundwater distribution profile is shown in Figure 13. Generally, the spring water flow is less than 5L / min. However, influenced by faults F24 and F23, the spring water flow in three sections is between 5 and 10L / min, i.e. 145m-150m, 255m-264m and 280m-295m.

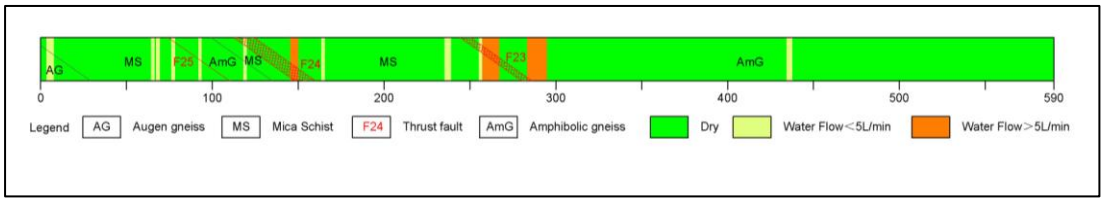


Figure 13 The water flow distribution of springs in AD5

3.5 Rock Mass Classification

According to the geological logging results of side wall of adit AD5, the rock quality of schist zone (Ch 0m - Ch 290m) is $1 < Q \leq 4$, however in fault zone and nearby, $0.09 < Q \leq 1$.

The face mapping of each advance by site geologists began at the Chainage 290m. The rock mass is mainly amphibolitic gneiss from Ch 290m to Ch 590m.Based on the Q value of each advance, the statistical results are listed in Table 7.

Table 7 The statistical results of Q value of each advance at the dam site

Q System	Class	Total	
		Total length（m）	Percentage（%）
0.09 < Q≤1	Very poor		
1 < Q≤4	poor	9.8	3.3
4 < Q≤10	Fair	42.4	14.1
10 < Q≤40	Good	119.2	39.7
40 < Q	Very good	129.1	43.0

3.6 Conclusion and suggestion

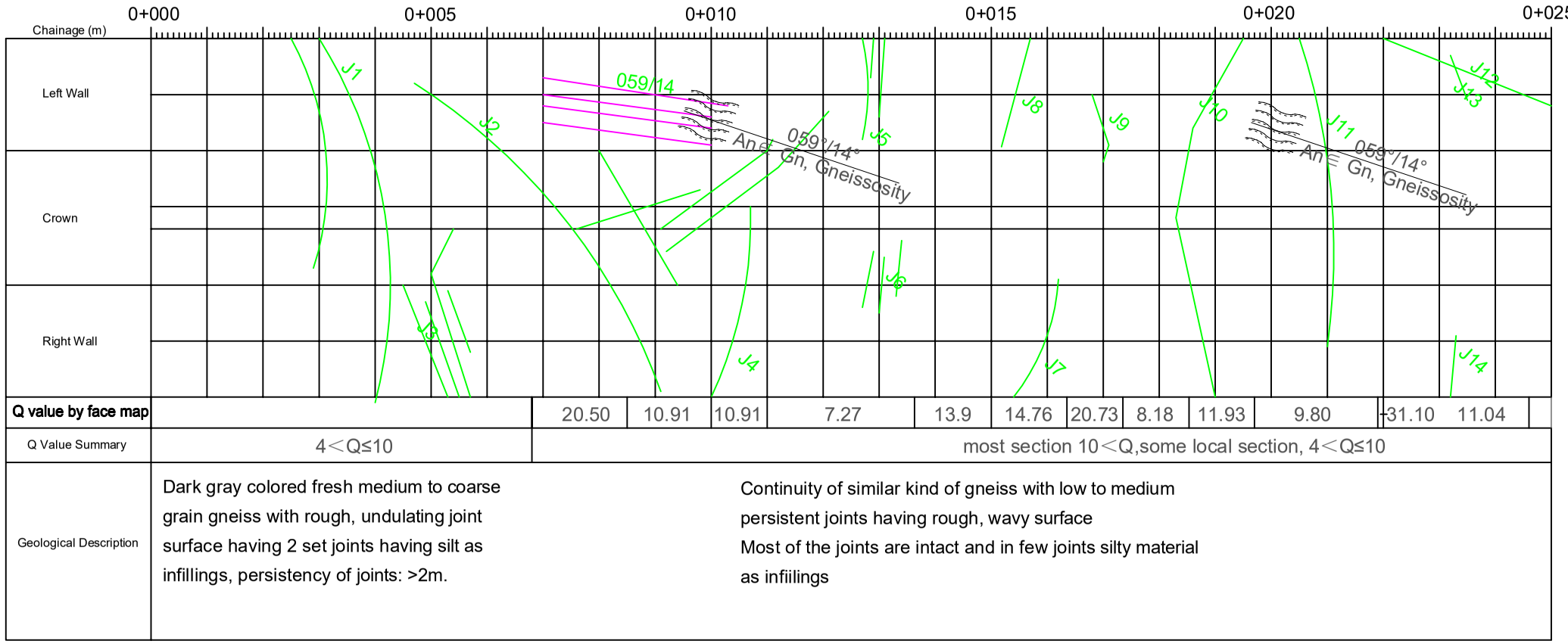
The rock mass from Ch 0m to Ch 290m mainly consists of schist with development of F25, F24 and F23, the overall rock mass condition is poor. However, the rock mass from Ch 290m to Ch 590mmainly consists of gneiss. Three dominant joint sets are developed in gneiss rock mass. No faults have been observed in this section, the rock mass is good at a whole.

Even though the adit has not been excavated into the powerhouse location, according to the preliminary investigation results, including the data of surface geological mapping and drilling, it is analyzed and interpreted that the lithology of the powerhouse site is the same as that revealed by the adit Ch 290m to Ch 590m.What's more, the terrain of the powerhouse site is closer to the ridge. It

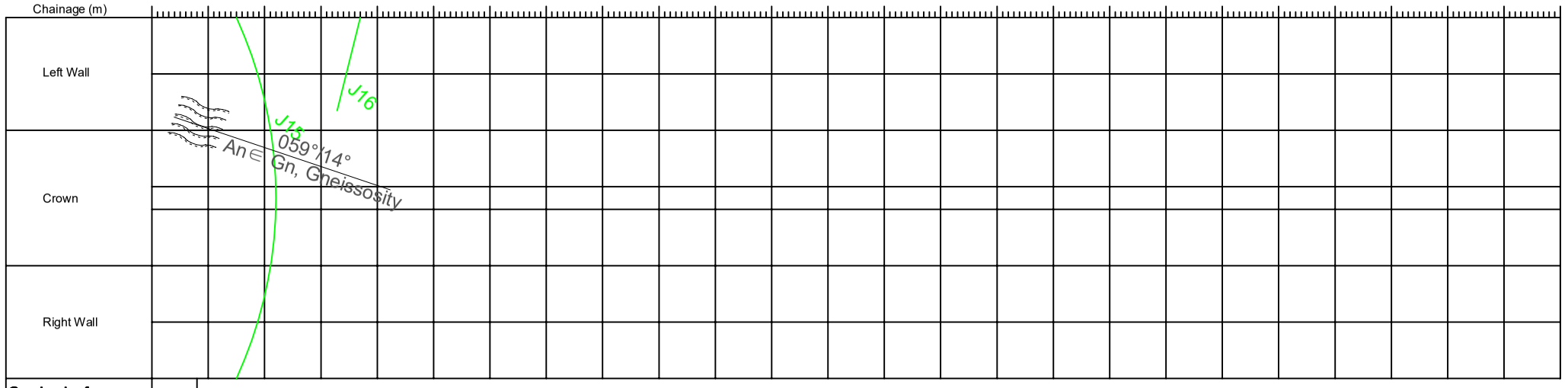
can be inferred that the rock mass conditions of the powerhouse are still good in general, and there should be no major engineering geological problems which restrict the layout of powerhouse.

In the next step, it is suggested to continue to excavate the adit to the powerhouse, and carry out in-situ stress tests, shear tests, etc.

Test adit 1, geological logging of UAHEP



Q value by face map		20.50	10.91	10.91	7.27	13.9	14.76	20.73	8.18	11.93	9.80	31.10	11.04
Q Value Summary	4＜Q≤10	most section 10＜Q,some local section, 4＜Q≤10											
Geological Description	Dark gray colored fresh medium to coarse grain gneiss with rough, undulating joint surface having 2 set joints having silt as infillings, persistency of joints: >2m.	Continuity of similar kind of gneiss with low to medium persistent joints having rough, wavy surface Most of the joints are intact and in few joints silty material as infiilings											



Q value by face map	5.3
Q Value Summary	10＜Q
Geological Description	Dark gray colored slightly weathered gneiss with 2 set joints Rough, wavy joint surface Silty material as infiiling

Legend

- An∈Gn — Gneiss of Precambrian
- Gneiss and its Gneissosity
- J6 — Joint trace, its Number and Orientation
- Foliation and Parallel Joints

Scale: 0 1 2 3 4 5m

Notes:
1.The geophysical profiles and the boreholes of 1991 FS and 1987FS in this map are located based on the ground features of previous geological maps, which only can be taken as a reference.
2.The coordinate system in 1991 FS can not be transfered to present coordinate system due to the data gaps.

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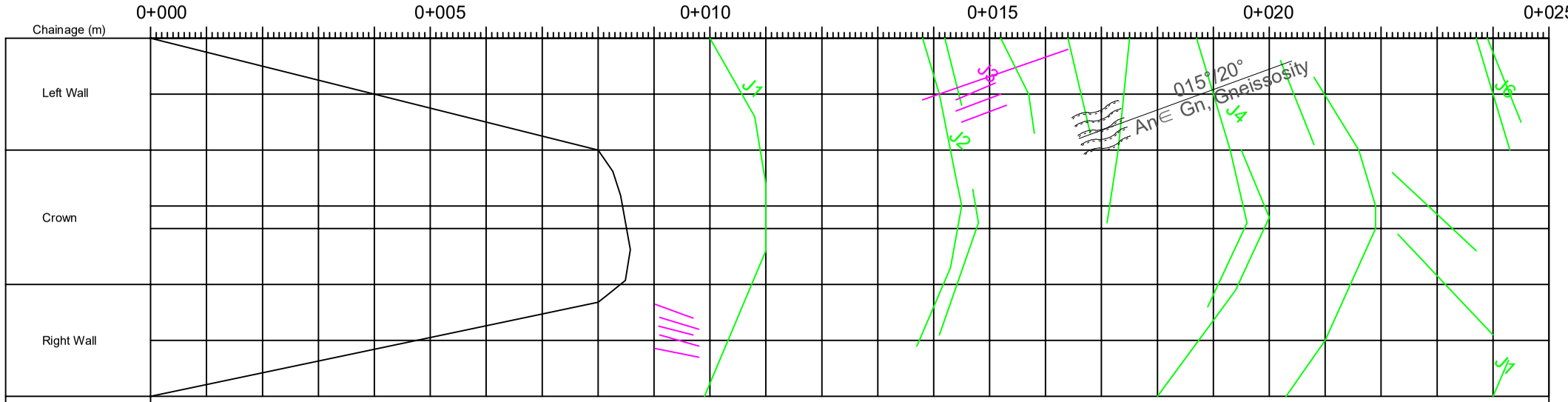
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Test adit geological logging of UAHEP

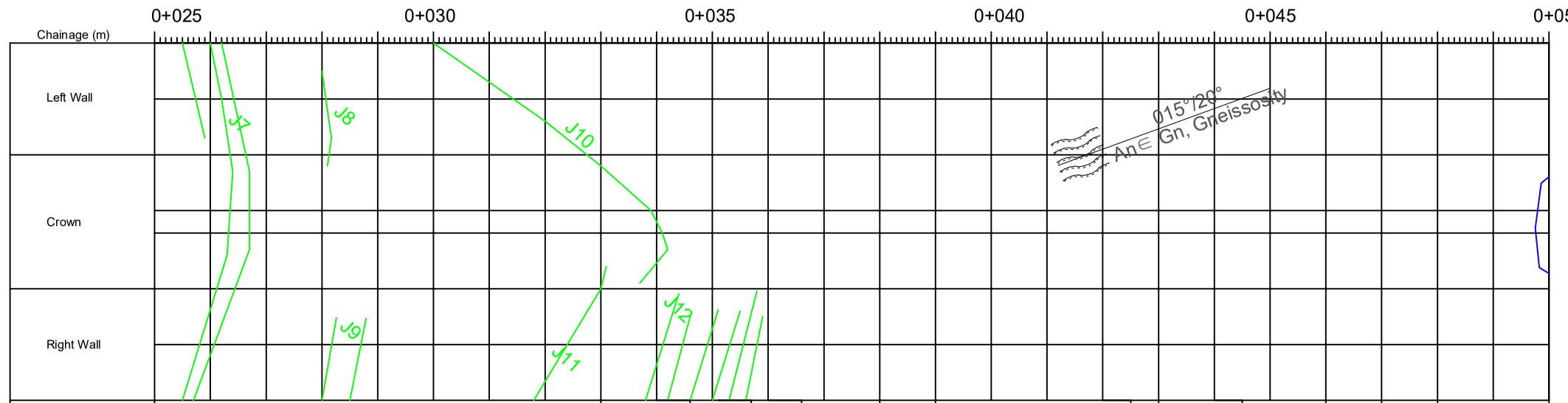
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Test adit 2, Geological Logging of UAHEP



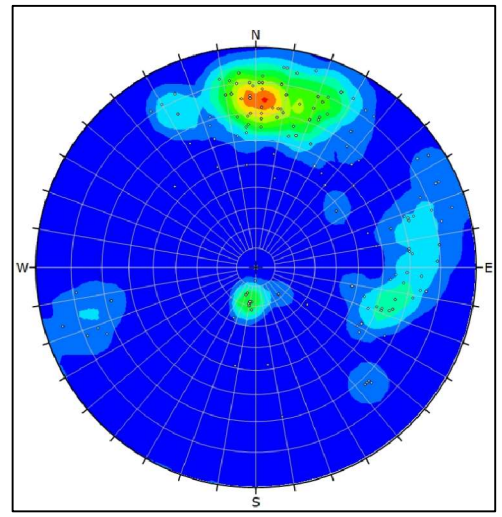
Q value by face map		
Q Value Summary		Most section, 4＜Q≤10, some local section, Q＜1.
Geological Description	**Open excavation, alluvium deposit, cobble and gravel.**	Dark Gray colored medium to coarse grained Gneiss, Slightly weathered, 2 joint sets having rough and wavy joint surface, silty material as infillings Jointed rock mass with yellowish weathering color having opening/ aperture of joints from 1mm-2mm, Silty material as infillings, rough and wavy joint surface.



Q value by face map			3.68	9.84	5.13	13.67	7.33	7.25	15.31	20.5	20.5	9.88	12.00	14.21	8.18
Q Value Summary	Most section, 4＜Q≤10, some local section, 10＜Q.														
Geological Description	Dark gray colored medium to coarse grained gneiss, weathering grade W2-W3, silty clay layer of thickness 2 to 10cm is seen as infilling in a joint parallel to the foliation plane. The continuity of silty clay infilling is observed from chainage of 0+030m to 0+040m							Overbreak of 2m to 4m is observed at the chainagae of 0+036m-0+048m. The rock mass at both left and right wall consist of mica-rich gneiss which are moderately to highly weathered. The rock mass is weak Minor seepage from crown part							

Legend

- An∈Gn — Gneiss of Precambrian
- Gneiss and its Gneissosity
- J6 — Joint trace, its Number and Orientation
- Foliation and Parallel Joints



Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00
Maximum Density	13.03%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	228 (228 Entries)
Hemisphere	Lower
Projection	Equal Angle

Scale: 0 1 2 3 4 5m

Notes:
1.The geophysical profiles and the boreholes of 1991 FS and 1987FS in this map are located based on the ground features of previous geological maps, which only can be taken as a reference.
2.The coordinate system in 1991 FS can not be transfered to present coordinate system due to the data gaps.

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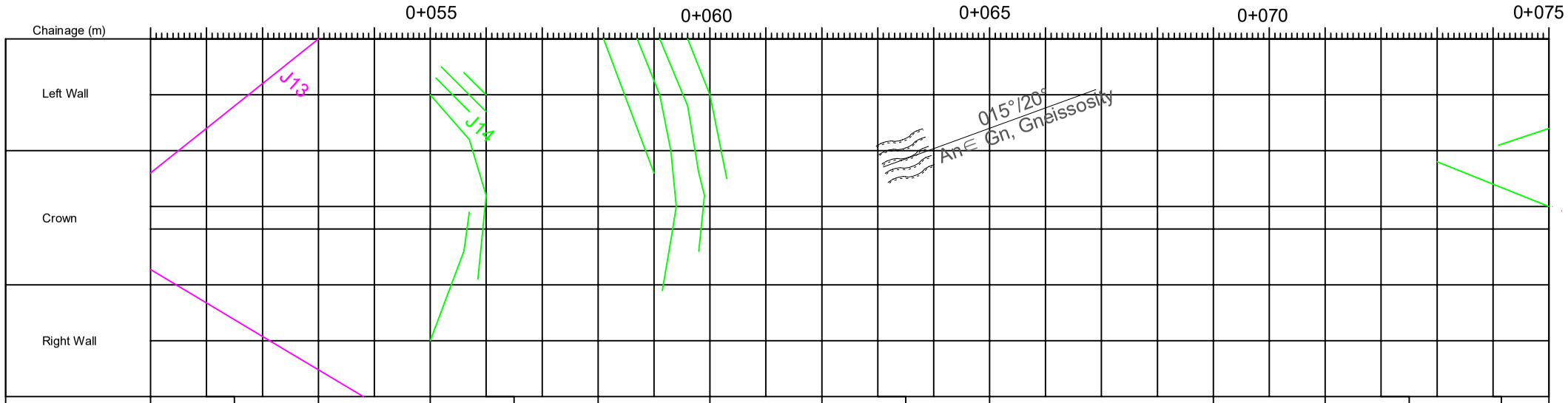
PROJECT
UPPER ARUN HYDROELECTRIC PROJECT

TITLE
Test adit geological logging of UAHEP

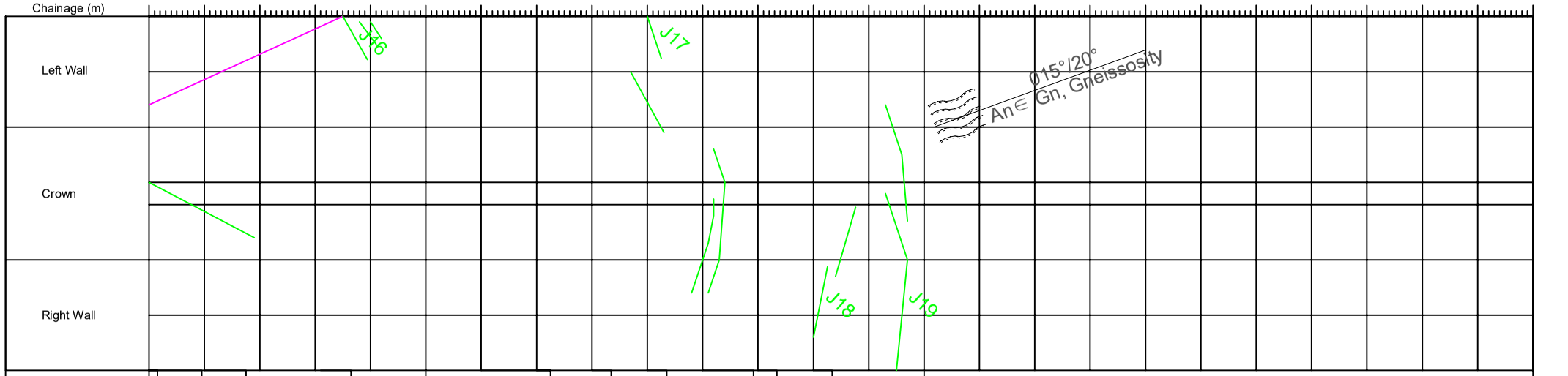
VALIDATED					
APPROVED		Geology			SECTION
CHECKED		SCALE		DATE	
DESIGNED		SIZE	A3	REVISION	
DRAWING NO.				SHEET NO.	1/1

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Test adit 2, Geological Logging of UAHEP



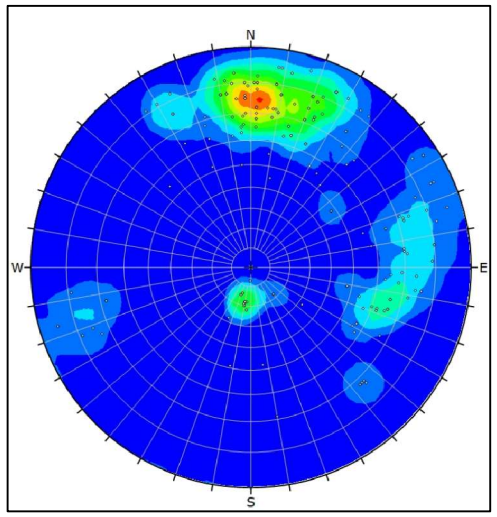
Q value by face map	5.83	10.25	11.04	92.75	82.00	39.40	26.15	18.85	62.2	78.70	6.53	10.43	12.28	**4.35**
Q Value Summary	Most section, 10＜Q, some local section 4＜Q≤10.													
Geological Description	Joints parralel to the foliation plane having silty clay infillings of thickness 2cm to 5cm. The rock mass is weak.					Dark gray colored medium to coarse grained gneiss. Silty material are present as infilling material. According to the Q-mass the rock class is good rock. Quartz vein parallel to the foliation plane low persistent joints (<70cm persistency) are also preset.				Dark Gray colored slighlty wethered gneiss having quartz vein parallel to the foliation plane. Weathering Grade: W1				



Q value by face map	18.53	5.45	4.90	6.91	56.86	10.91	9.26	9.81	13.07	39.26	11.04
Q Value Summary	4＜Q≤10, and most section 10＜Q. Rock mass belongs to Fair to Good.										
Geological Description	The rock mass contains dark gray colored gneiss having weathering grade W1. The rock mass is strong. Minor seepage from the crown part joint.										

Legend

- An∈Gn — Gneiss of Precambrian
- Gneiss and its Gneissosity
- J14 — Joint trace, its Number and Orientation
- Foliation and Parallel Joints



Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00

Maximum Density	13.03%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	228 (228 Entries)
Hemisphere	Lower
Projection	Equal Angle

Scale: 0 1 2 3 4 5m

Notes:
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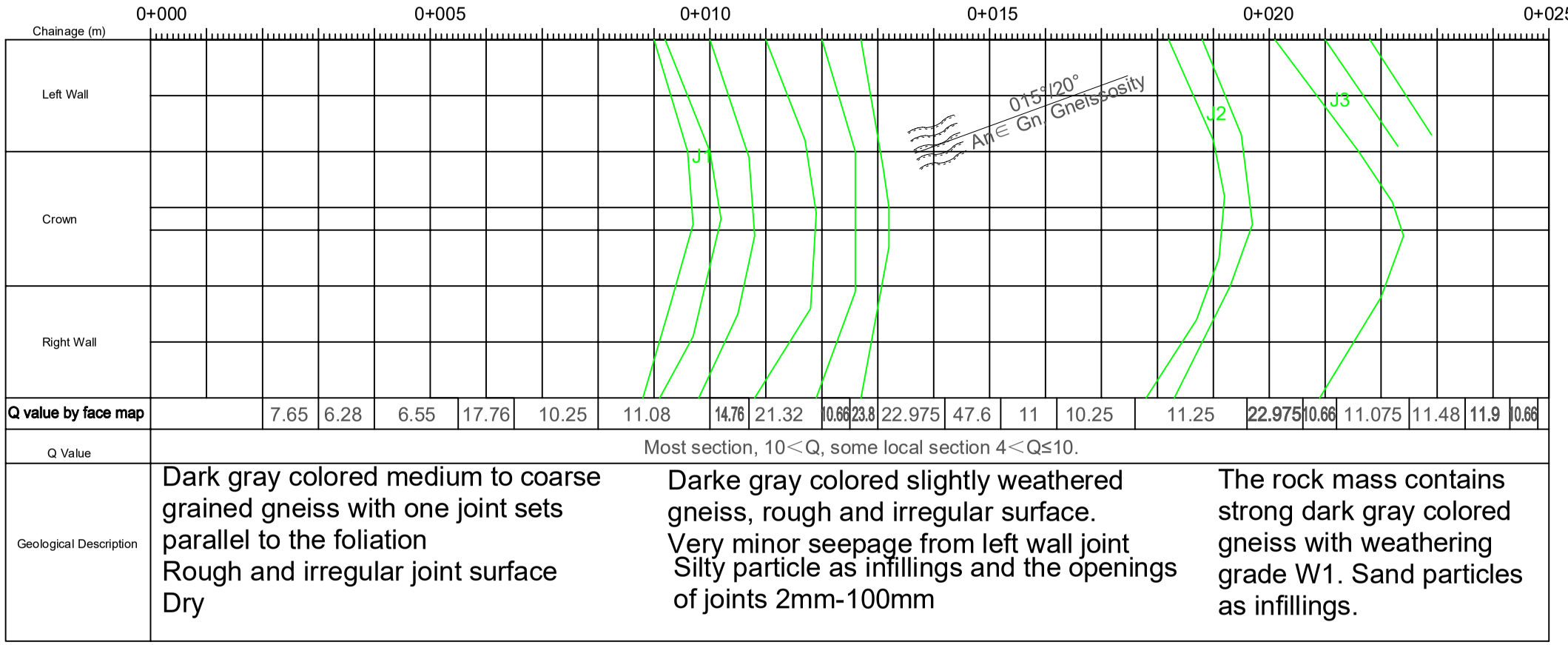
PROJECT: UPPER ARUN HYDROELECTRIC PROJECT

TITLE: Test adit geological logging of UAHEP

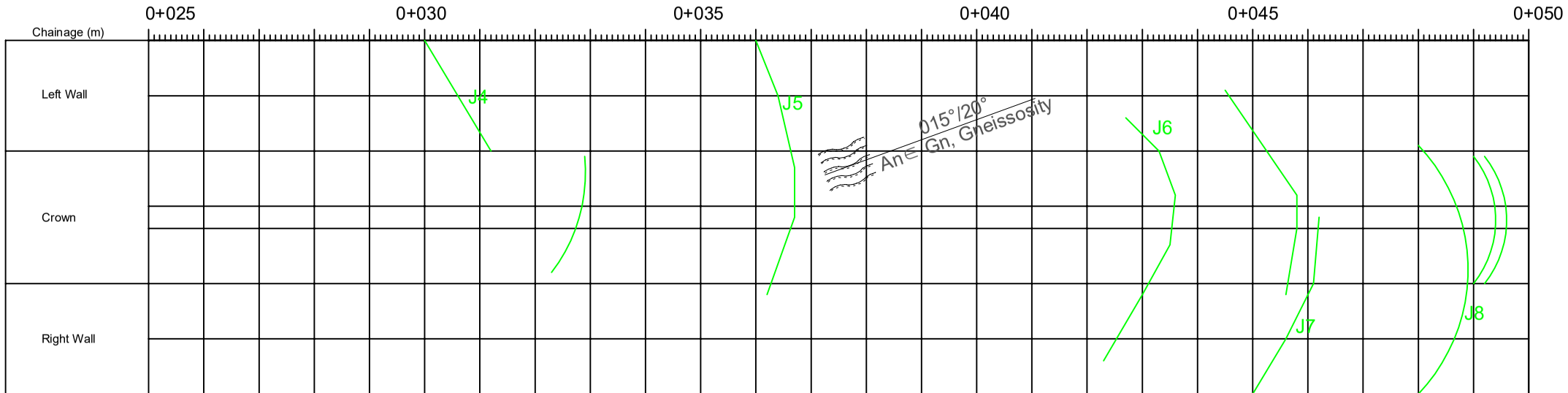
VALIDATED					
APPROVED		Geology		SECTION	
CHECKED		SCALE		DATE	
DESIGNED		SIZE	A3	REVISION	
DRAWING NO.				SHEET NO.	1/1

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Test adit 4, geological logging of UAHEP



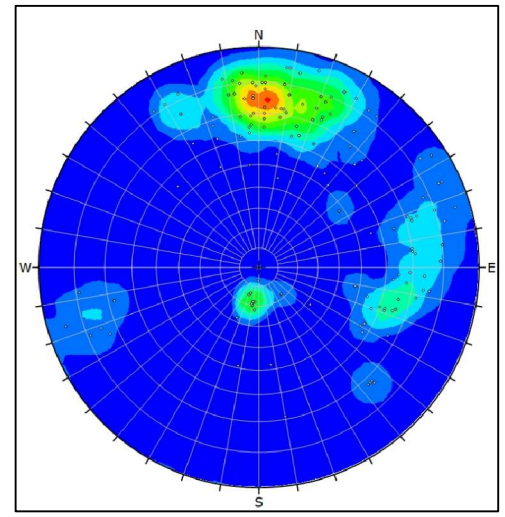
Q value by face map		7.65	6.28	6.55	17.76	10.25	11.08	14.76	21.32	10.66	23.8	22.975	47.6	11	10.25	11.25	22.975	10.66	11.075	11.48	11.9	10.66
Q Value	Most section, 10＜Q, some local section 4＜Q≤10.																					
Geological Description	Dark gray colored medium to coarse grained gneiss with one joint sets parallel to the foliation Rough and irregular joint surface Dry							Darke gray colored slightly weathered gneiss, rough and irregular surface. Very minor seepage from left wall joint Silty particle as infillings and the openings of joints 2mm-100mm								The rock mass contains strong dark gray colored gneiss with weathering grade W1. Sand particles as infillings.					



Q value by face map	88.6	42.65	11.48	11.48	10.125	10.62	10.875	10.62	11.48	10.66	11.48	11.9	24.62	49.25	85.3	57.25	82	75.4	39.26	82
Q Value	10＜Q																			
Geological Description	Dark gray colored medium to coarse grained gneiss slightly weathered Silty material as infiilings Aperture: tight to 2mm										Dark gray colored medium to coarse grained gneiss with one joint set having rough and irregular surface							Dark gray colored gneiss, 2mm to 5mm openings and silty material as infillings		

Legend

- An∈Gn — Gneiss of Precambrian
- Gneiss and its Gneissosity
- J6 — Joint trace, its Number and Orientation
- Foliation and Parallel Joints



Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00
Maximum Density	13.03%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	228 (228 Entries)
Hemisphere	Lower
Projection	Equal Angle

Scale: 0 1 2 3 4 5m

Notes:
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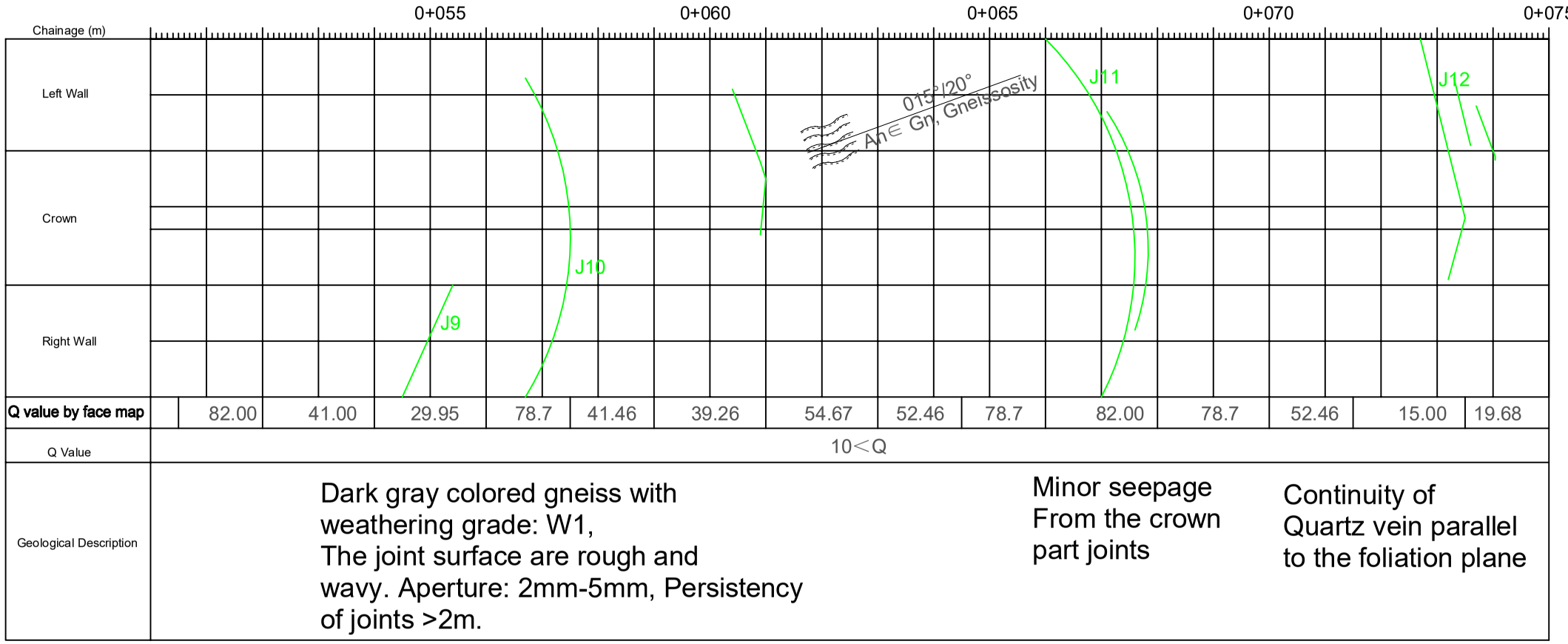
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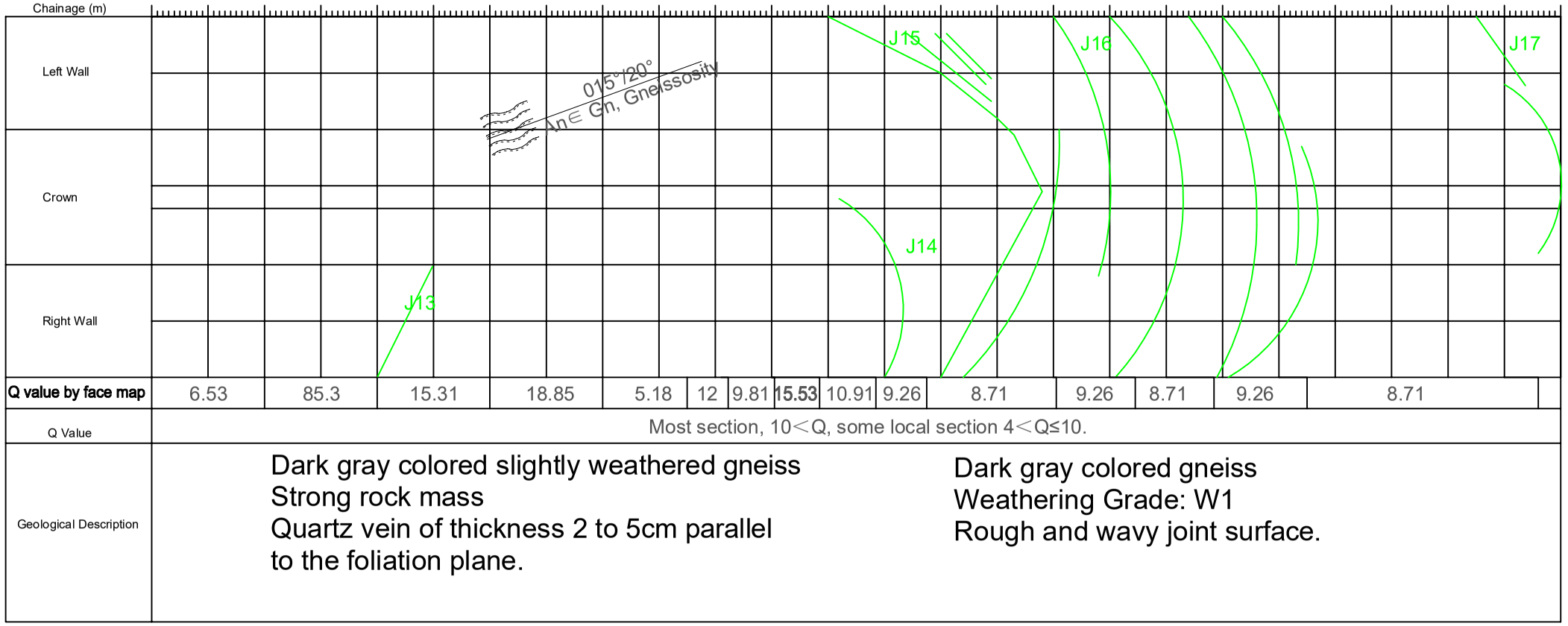
TITLE
Test adit geological logging of UAHEP

VALIDATED					
APPROVED		Geology			SECTION
CHECKED		SCALE		DATE	
DESIGNED		SIZE	A3	REVISION	
DRAWING NO.				SHEET NO.	1/1

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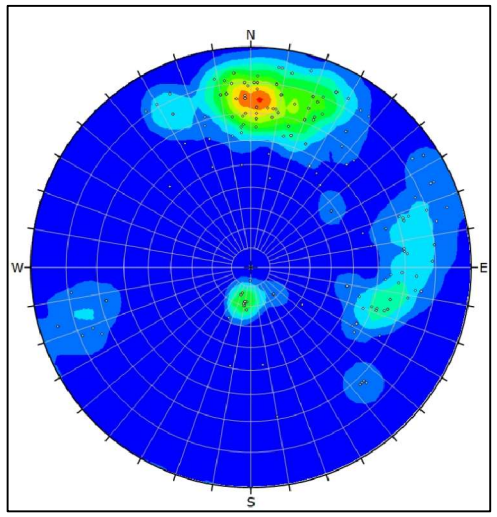
Test adit geological logging of UAHEP





Legend

- An∈Gn — Gneiss of Precambrian
- Gneiss and its Gneissosity
- J6 — Joint trace, its Number and Orientation
- Foliation and Parallel Joints



Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00

Maximum Density	13.03%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	228 (228 Entries)
Hemisphere	Lower
Projection	Equal Angle

Scale: 0 1 2 3 4 5m

Notes:
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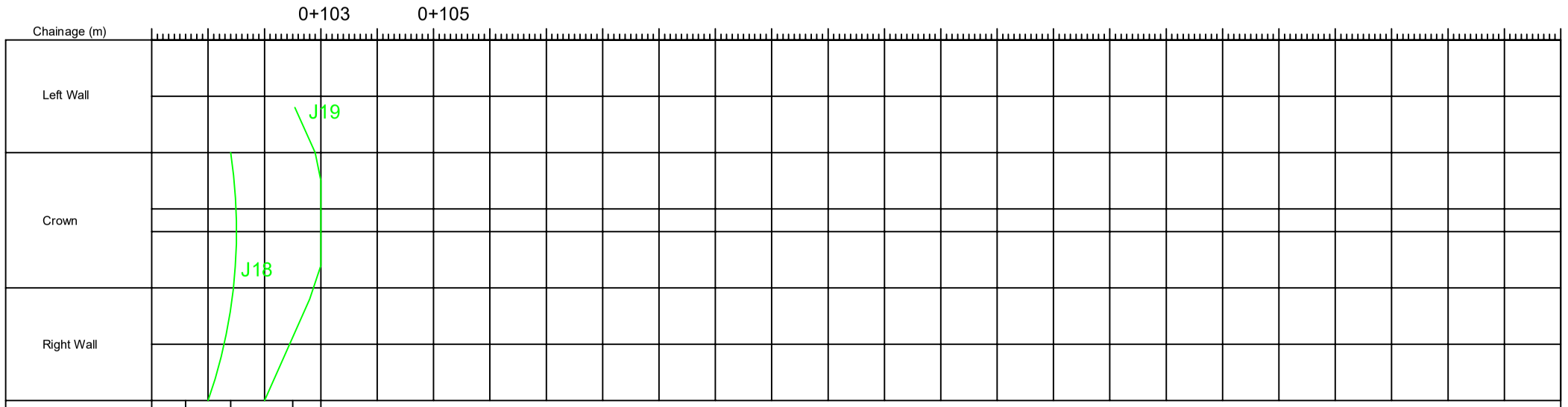
PROJECT
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TITLE
Test adit geological logging of UAHEP

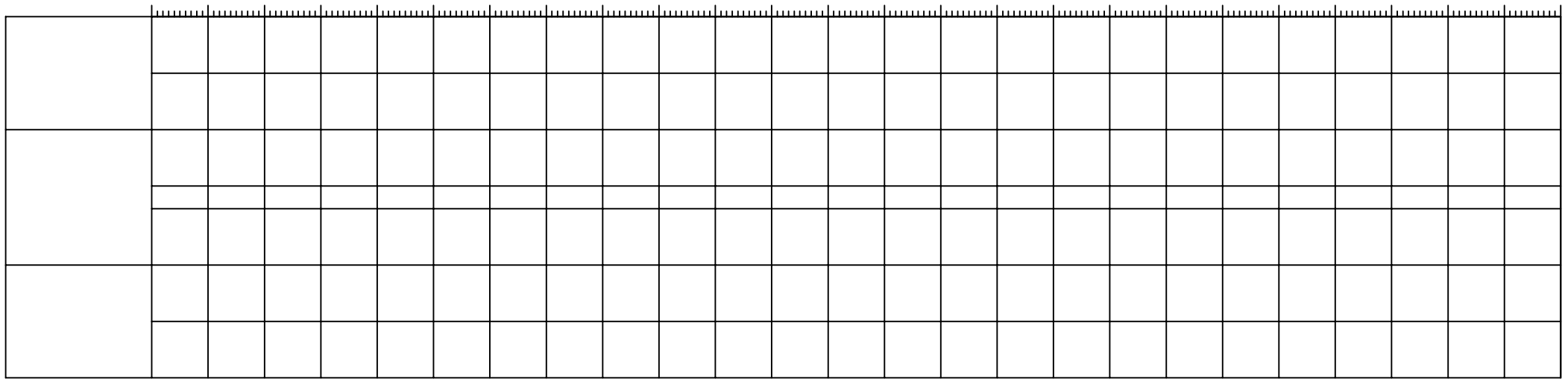
VALIDATED					
APPROVED		Geology		SECTION	
CHECKED		SCALE		DATE	
DESIGNED		SIZE	A3	REVISION	
DRAWING NO.				SHEET NO.	1/1

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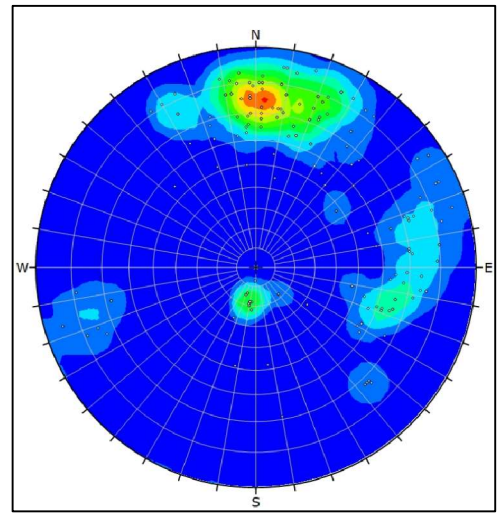


Q value by face map	9.26 13.07 9.77 13.66
Q Value	13.66
Geological Description	Medium to coarse grained gneiss Rock mass is strong Persistency of joints: >3m Silty material as infillings



Legend

- An∈Gn — Gneiss of Precambrian
- Gneiss and its Gneissosity
- J6 — Joint trace, its Number and Orientation
- Foliation and Parallel Joints



Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00
Maximum Density	13.03%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%
Plot Mode	Pole Vectors
Vector Count	228 (228 Entries)
Hemisphere	Lower
Projection	Equal Angle

Scale: 0 1 2 3 4 5m

Notes:
1.The geophysical profiles and the boreholes of 1991 FS and 1987FS in this map are located based on the ground features of previous geological maps, which only can be taken as a reference.
2.The coordinate system in 1991 FS can not be transfered to present coordinate system due to the data gaps.

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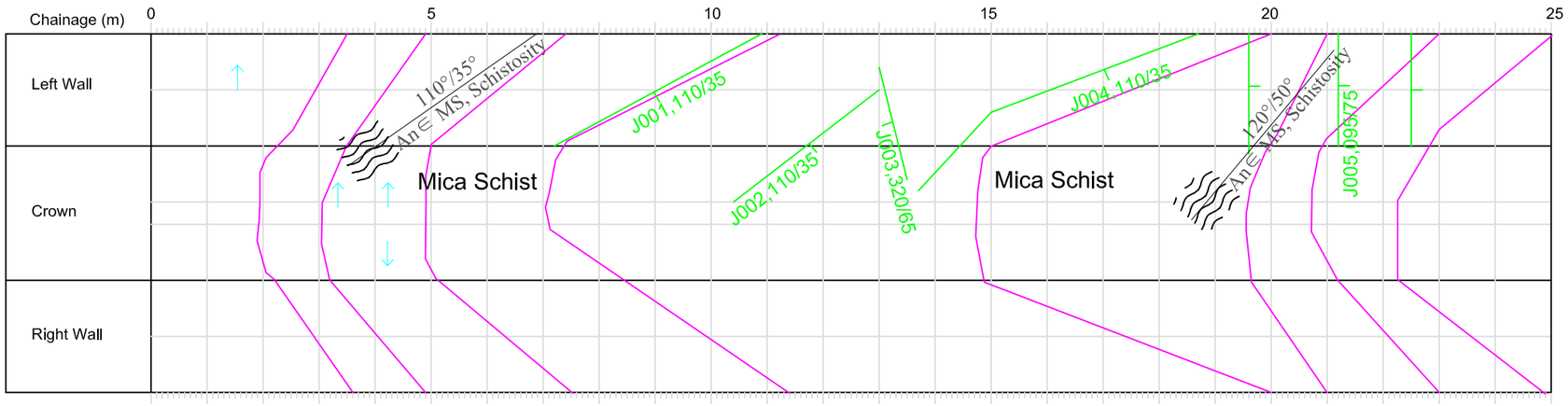
PROJECT
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TITLE
Test adit geological logging of UAHEP

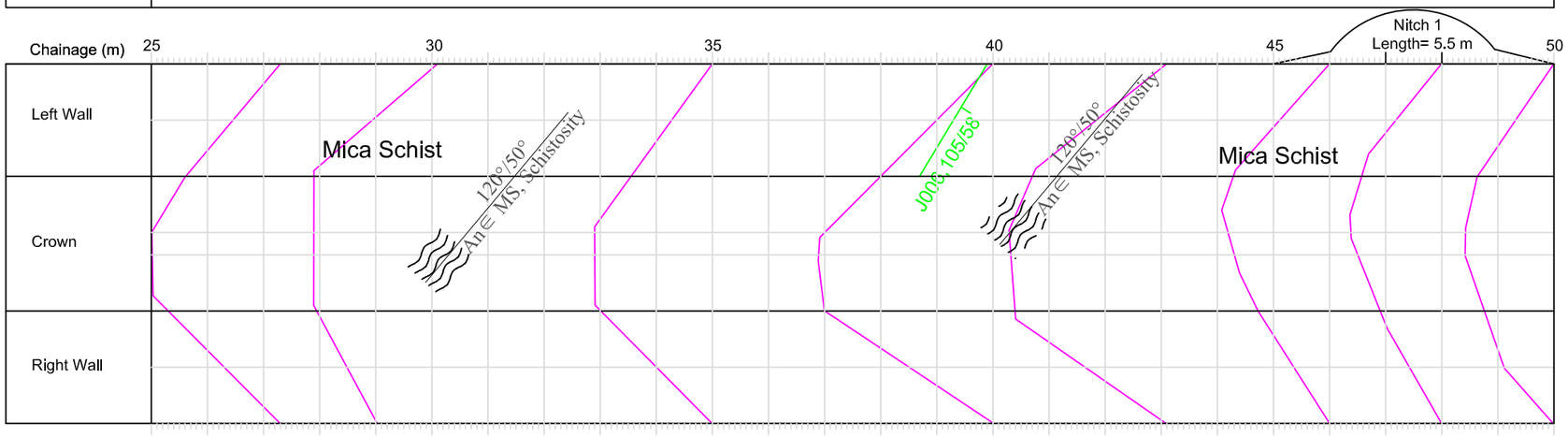
VALIDATED					
APPROVED		Geology			SECTION
CHECKED		SCALE		DATE	
DESIGNED		SIZE	A3	REVISION	
DRAWING NO.				SHEET NO.	1/1

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Test adit geological logging of UAHEP (AD5 at PH site)



Q value Summary	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Mica Schist, light grey colored, slightly weathered, moderate to thin foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages, the vein is 5 to 15 cm thick.



Q value Summary	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Mica Schist, light grey colored, slightly weathered, moderate to thin foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages, the vein is 5 to 15 cm thick.

Legend

- An∈Gn — Gneiss of Precambrian
- An∈MS — Mica Schist of Precambrian
- Gneiss and its Gneissosity
- Schist and its Schistosity
- Boundary of lithology
- J004,110/35 — Joint trace, its Number and Orientation
- Foliation and parallel joints
- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
1.The geophysical profiles and the boreholes of 1991 FS and 1987FS in this map are located based on the ground features of previous geological maps, which only can be taken as a reference.
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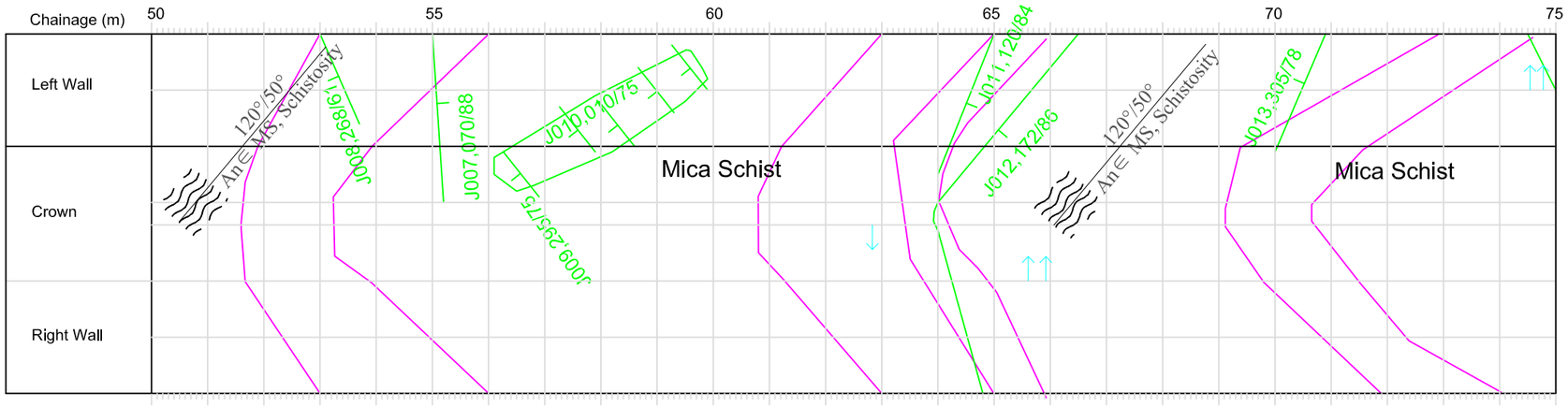
PROJECT: UPPER ARUN HYDROELECTRIC PROJECT

TITLE: Test adit geological logging of UAHEP

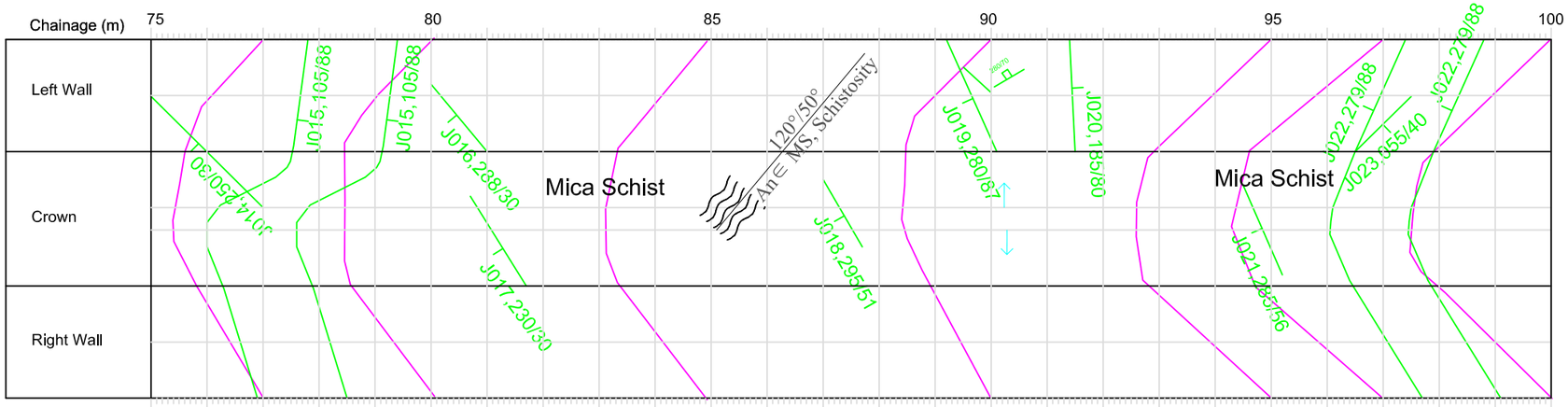
VALIDATED					
APPROVED		Geology		SECTION	
CHECKED		SCALE		DATE	
DESIGNED		SIZE	A3	REVISION	
DRAWING NO.				SHEET NO.	1/1

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Test adit geological logging of UAHEP (AD5 at PH site)



Q value Summary	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Mica Schist, light grey colored, slightly weathered, moderate to thin foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages, the vein is 5 to 15 cm thick.



Q value Summary	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Mica Schist, light grey colored, slightly weathered, moderate to thin foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages, the vein is 5 to 15 cm thick.

Legend

- An∈Gn — Gneiss of Precambrian
- An∈MS — Mica Schist of Precambrian
- Gneiss and its Gneissosity
- Schist and its Schistosity
- Boundary of lithology
- J004,110/35 — Joint trace, its Number and Orientation
- Foliation and parallel joints
- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
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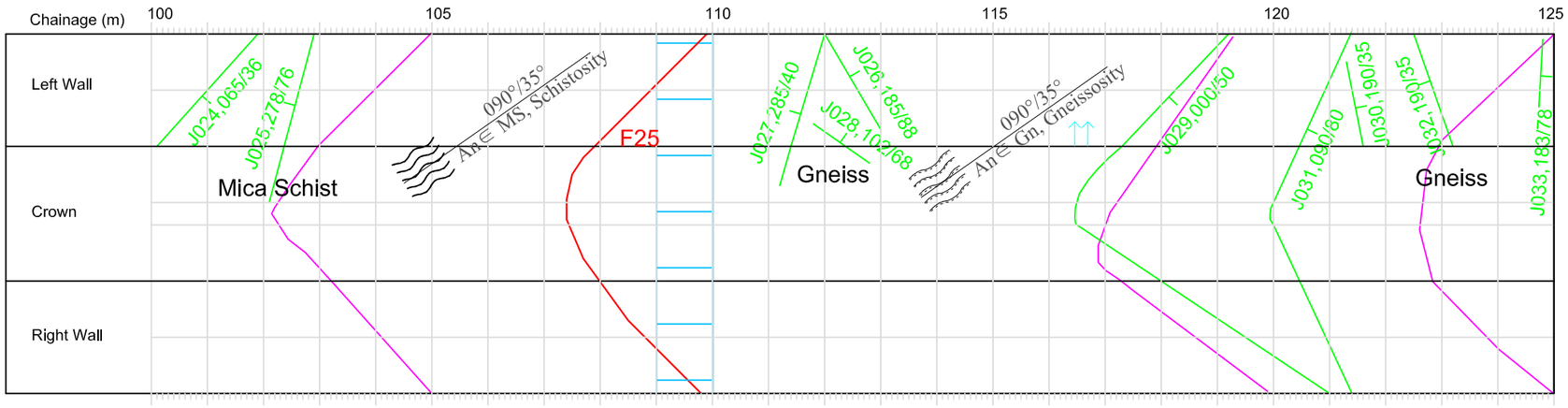
PROJECT: UPPER ARUN HYDROELECTRIC PROJECT

TITLE: Test adit geological logging of UAHEP

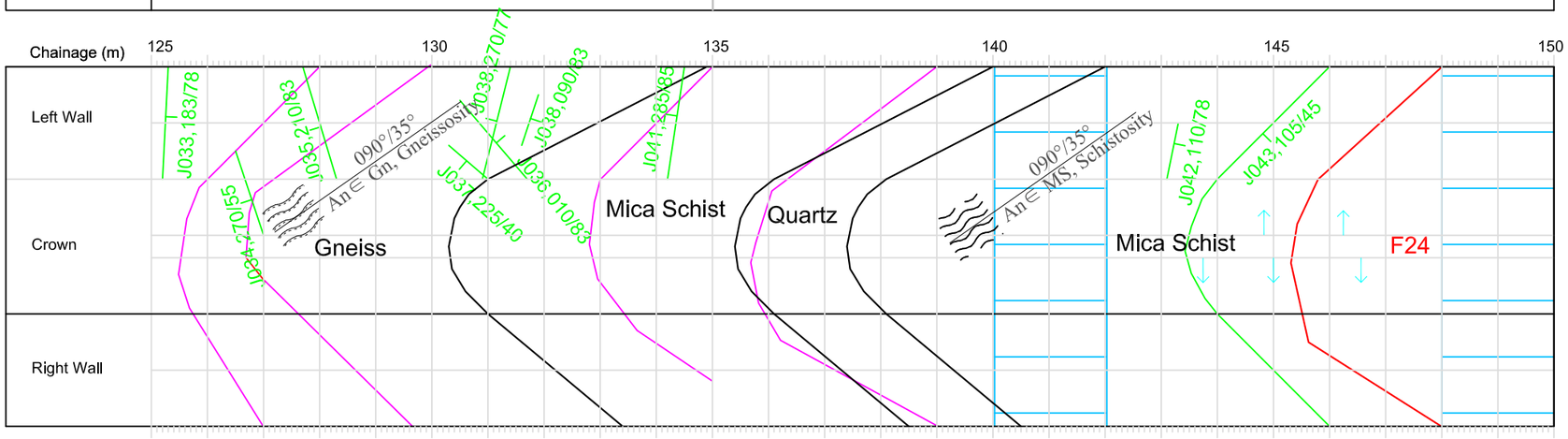
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APPROVED		Geology		SECTION	
CHECKED		SCALE		DATE	
DESIGNED		SIZE	A3	REVISION	
DRAWING NO.				SHEET NO.	1/1

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Test adit geological logging of UAHEP (AD5 at PH site)



Q value Summary	1＜Q≤4，locally 0.09<Q≤1	10＜Q≤40，locally 4<Q≤10
Geological Description	Mica Schist, light grey colored, slightly weathered, moderate to thin foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages, the vein is 5 to 15 cm thick. F25, a thrust can be observed. A overbreak with 10m high present between Ch105 and Ch110.	Gniess, light to dark grey colored, slightly weathered, moderately to thinly bedded, slightly foliated, strong rock.



Q value Summary	10＜Q≤40，locally 4<Q≤10	1＜Q≤4，locally 0.09<Q≤1	0.09＜Q≤1
Geological Description	Gniess, light to dark grey colored, slightly weathered, moderately to thinly bedded, slightly foliated, strong rock.	Mica Schist, light grey colored, slightly weathered, moderate to thin foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at chainage 140.	Faut 24, The composition are mylonite and debris mixed with soil. The raw rock is Mica Schist.The thickness of fault is around 7m, the water flaw around is about 5L/min.

Legend

- An∈Gn — Gneiss of Precambrian
- An∈MS — Mica Schist of Precambrian
- Gneiss and its Gneissosity
- Schist and its Schistosity
- Boundary of lithology
- J004,110/35 — Joint trace, its Number and Orientation
- Foliation and parallel joints
- F24 — Fault boundary and number
- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
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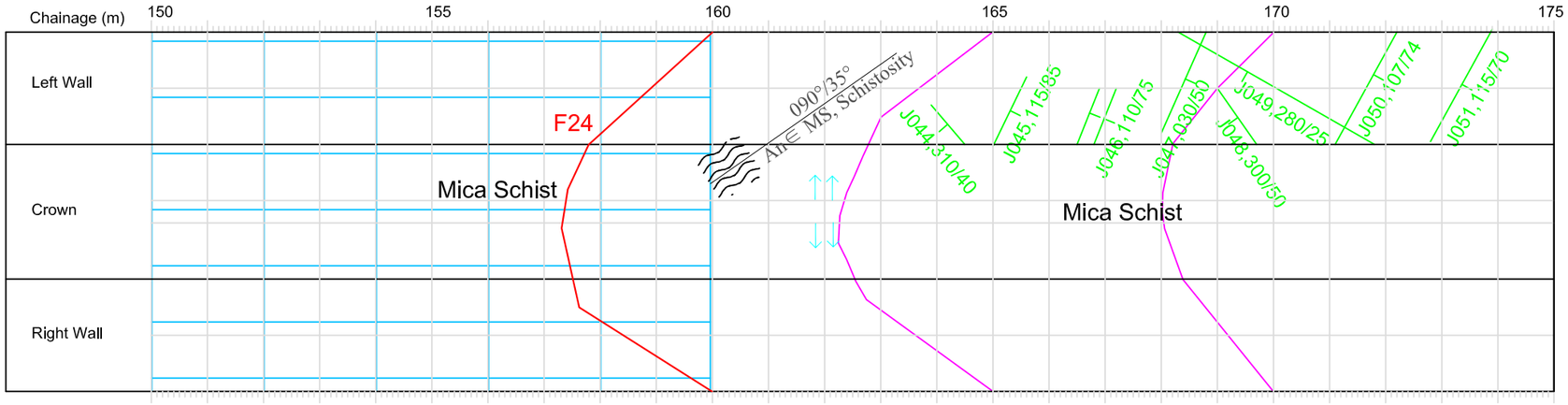
PROJECT: UPPER ARUN HYDROELECTRIC PROJECT

TITLE: Test adit geological logging of UAHEP

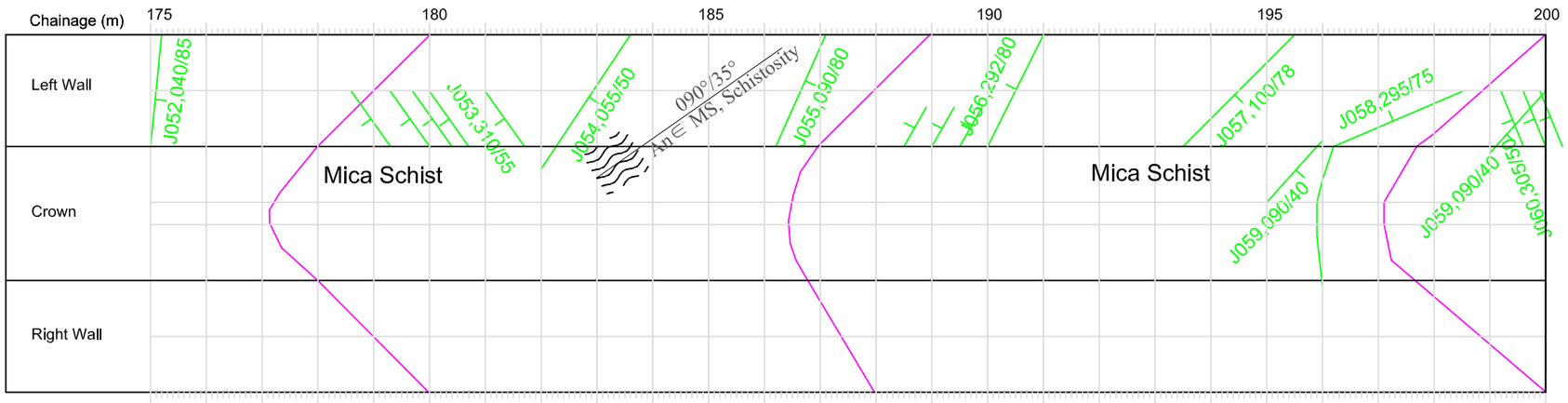
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APPROVED			Geology		SECTION	
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DESIGNED		SIZE	A3	REVISION		
DRAWING NO.				SHEET NO.	1/1	

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Test adit geological logging of UAHEP (AD5 at PH site)



Q value Summary	0.09＜Q≤1	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Faut 24, The composition are mylonite and debris mixed with soil. The raw rock is Mica Schist.The thickness of fault is around 7m, the water flaw around is about 5L/min.	Mica Schist, light grey colored, slightly weathered, foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages. There is a overbreak zone at chainage of 148m-160m, the height of highest section of the crown is about 10m. There may be a thrust around chainage of 155m.



Q value Summary	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Mica Schist, light grey to dark grey colored, slightly weathered, foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages. Some mica rich zone can be found.

Legend

- An∈Gn — Gneiss of Precambrian
- An∈MS — Mica Schist of Precambrian
- Gneiss and its Gneissosity
- Schist and its Schistosity
- Boundary of lithology
- J004,110/35 — Joint trace, its Number and Orientation
- Foliation and parallel joints
- F24 — Fault boundary and number
- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
1.The geophysical profiles and the boreholes of 1991 FS and 1987FS in this map are located based on the ground features of previous geological maps, which only can be taken as a reference.
2.The coordinate system in 1991 FS can not be transfered to present coordinate system due to the data gaps.

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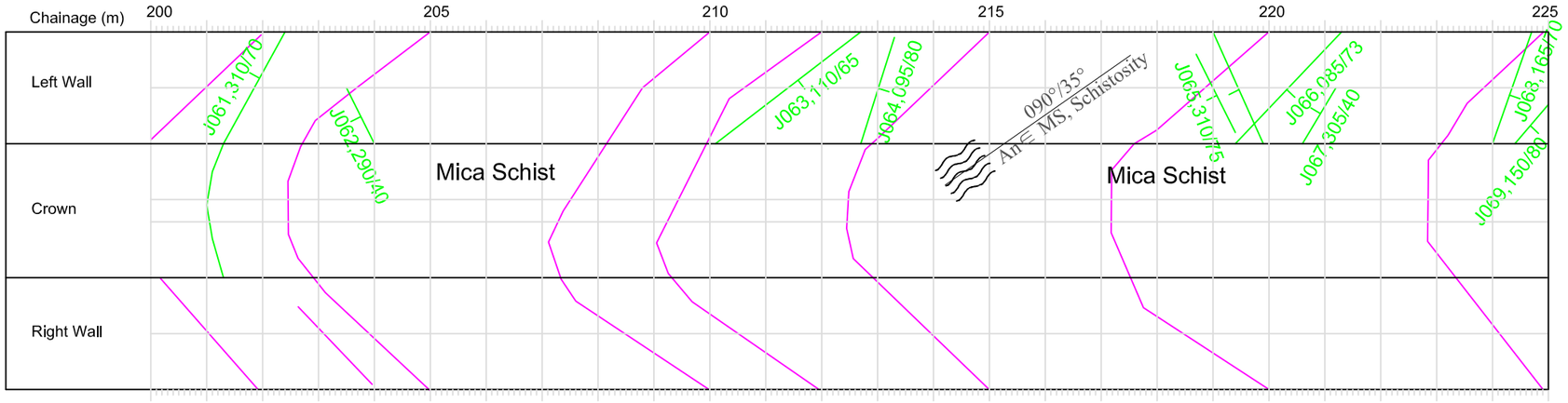
PROJECT: UPPER ARUN HYDROELECTRIC PROJECT

TITLE: Test adit geological logging of UAHEP

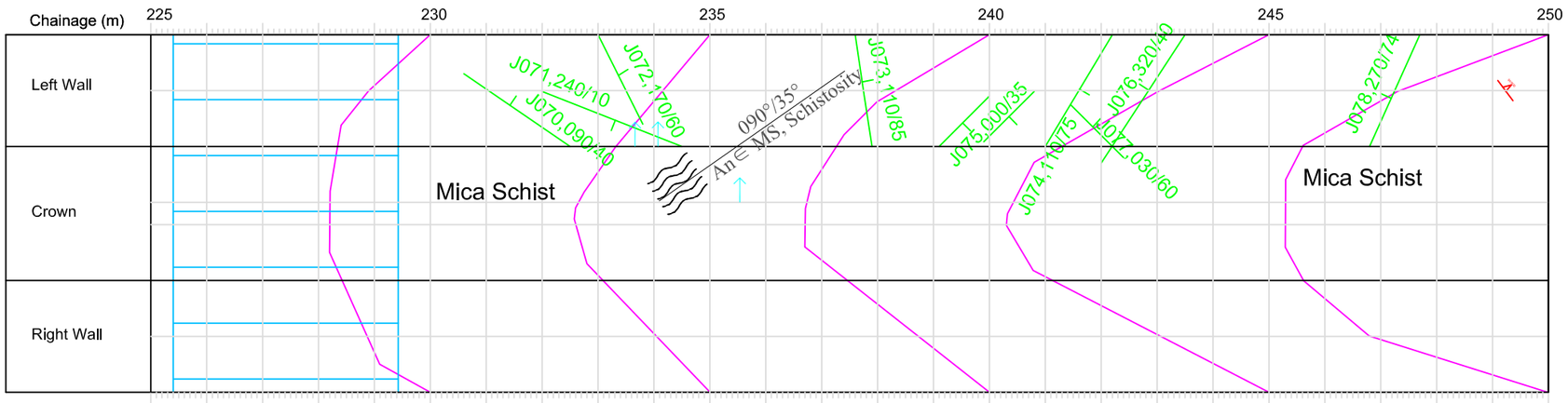
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DRAWING NO.				SHEET NO.	1/1

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Test adit geological logging of UAHEP (AD5 at PH site)



Q value Summary	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Mica Schist, light grey to dark grey colored, slightly weathered, foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages. Some mica rich zone can be found.



Q value Summary	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Mica Schist, light grey to dark grey colored, slightly weathered, foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages. Some mica rich zone can be found.

Legend

- An∈Gn — Gneiss of Precambrian
- An∈MS — Mica Schist of Precambrian
- Gneiss and its Gneissosity
- Schist and its Schistosity
- Boundary of lithology
- J004,110/35 — Joint trace, its Number and Orientation
- Foliation and parallel joints
- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
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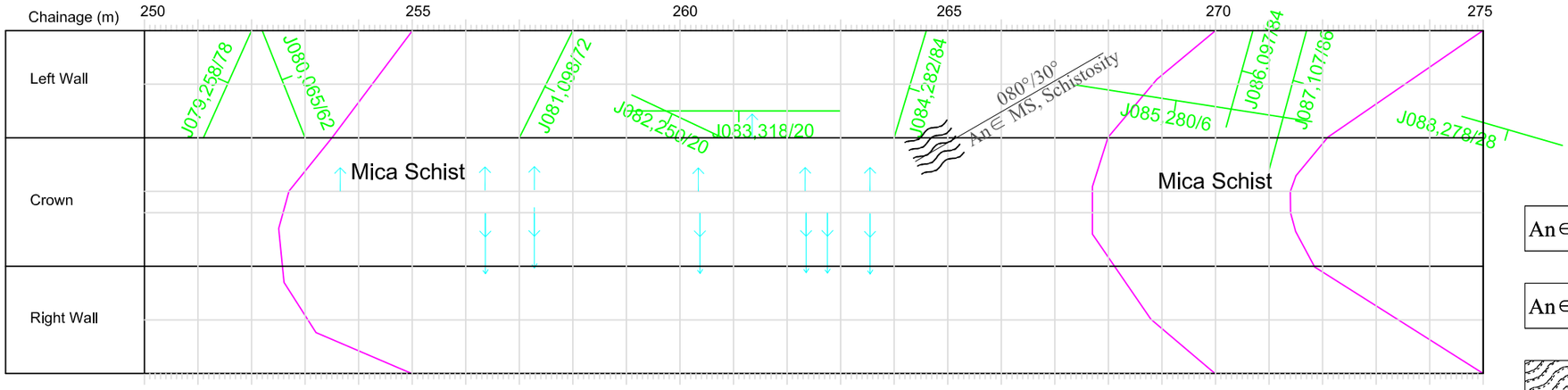
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TITLE: Test adit geological logging of UAHEP

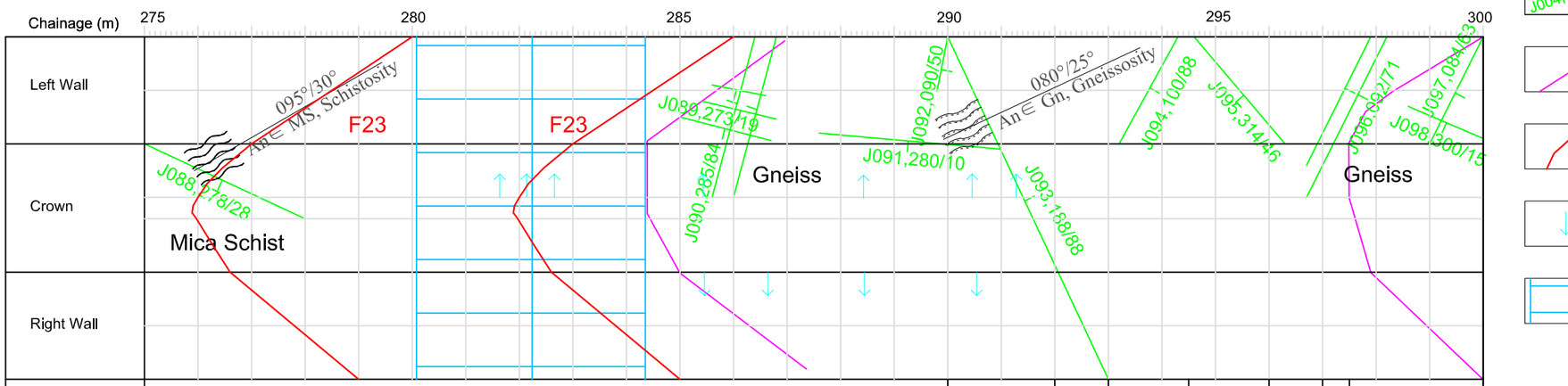
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DRAWING NO.				SHEET NO.	1/1

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Test adit geological logging of UAHEP (AD5 at PH site)



Q value Summary	1＜Q≤4，locally 0.09<Q≤1
Geological Description	Mica Schist, light grey to dark grey colored, slightly weathered, foliated, medium to coarse grained. Quartz vein parallel with foliation can be observed at different chainages. Some mica rich zone can be found.



Q value by face map		4.80	5.44	2.70	9.23	10.50	21	6.83
Q value Summary	mainly 0.09<Q≤1	10＜Q≤40，locally 4<Q≤10						
Geological Description	Faut 24, The composition are mylonite and debris mixed with soil. The raw rock is Mica Schist.The thickness of fault is around 2m, the water flaw around is about 10L/min.	Gniess, light to dark grey colored, slightly weathered, moderately to thinly bedded, Quartz vein parallel with foliation can be observed at different chainages. Strong rock.						

Legend

- An∈Gn — Gneiss of Precambrian
- An∈MS — Mica Schist of Precambrian
- Gneiss and its Gneissosity
- Schist and its Schistosity
- Boundary of lithology
- J004,110/35 — Joint trace, its Number and Orientation
- Foliation and parallel joints
- F24 — Fault boundary and number
- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
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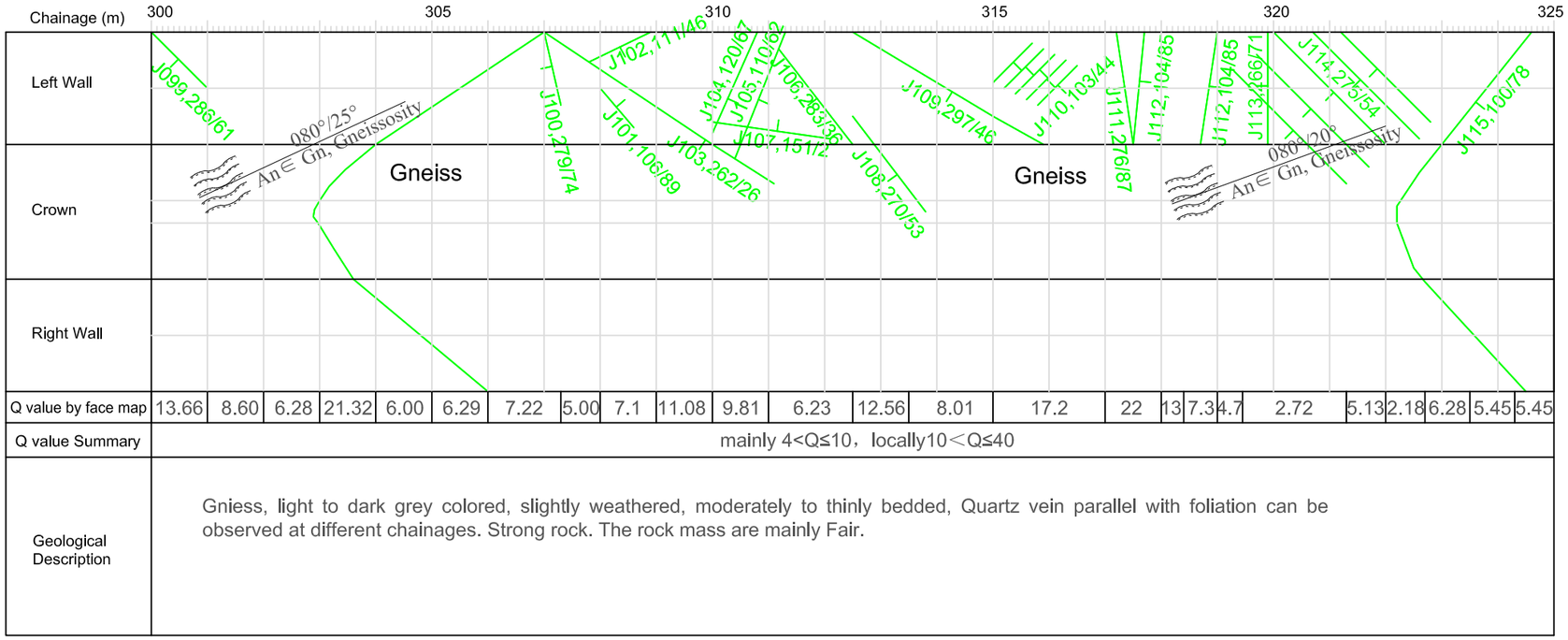
PROJECT: UPPER ARUN HYDROELECTRIC PROJECT

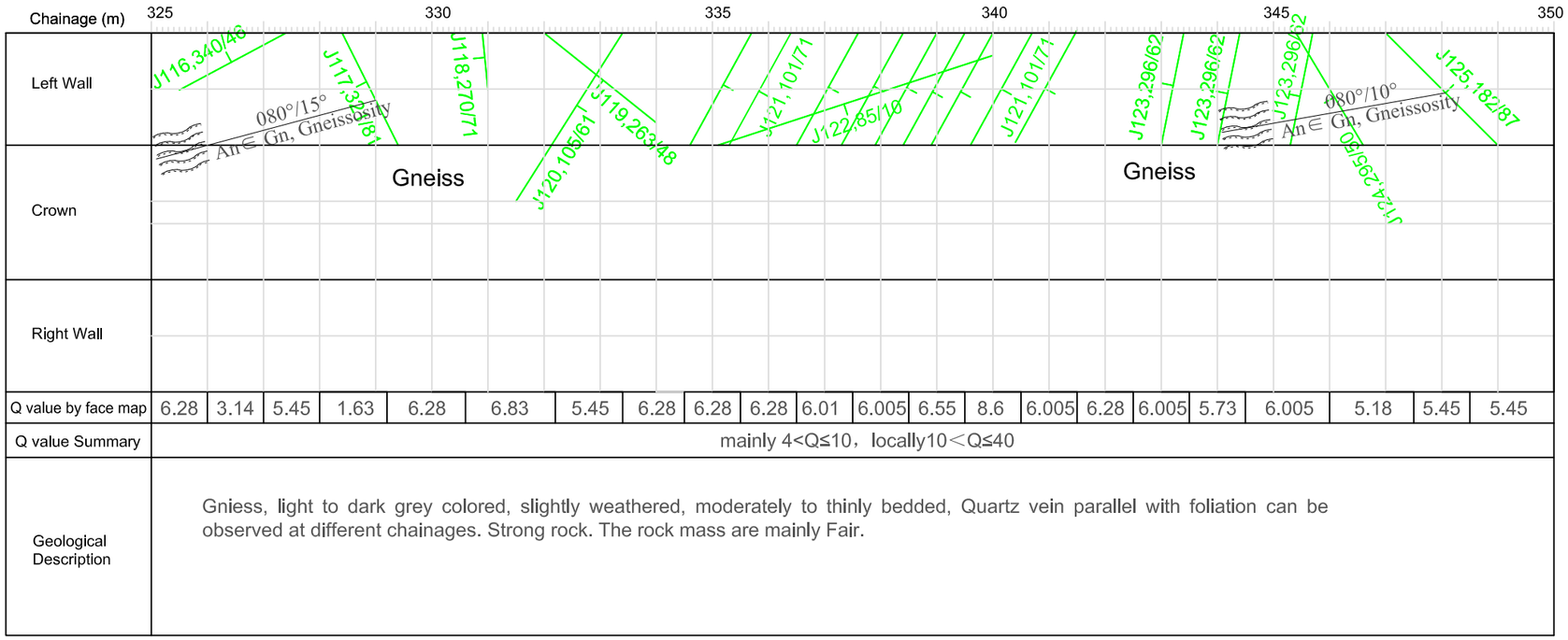
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APPROVED		Geology		SECTION	
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DESIGNED		SIZE	A3	REVISION	
DRAWING NO.				SHEET NO.	1/1

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Test adit geological logging of UAHEP (AD5 at PH site)





Legend

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- Schist and its Schistosity
- Boundary of lithology
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- Foliation and parallel joints
- Seepage
- Temporary supporting zone

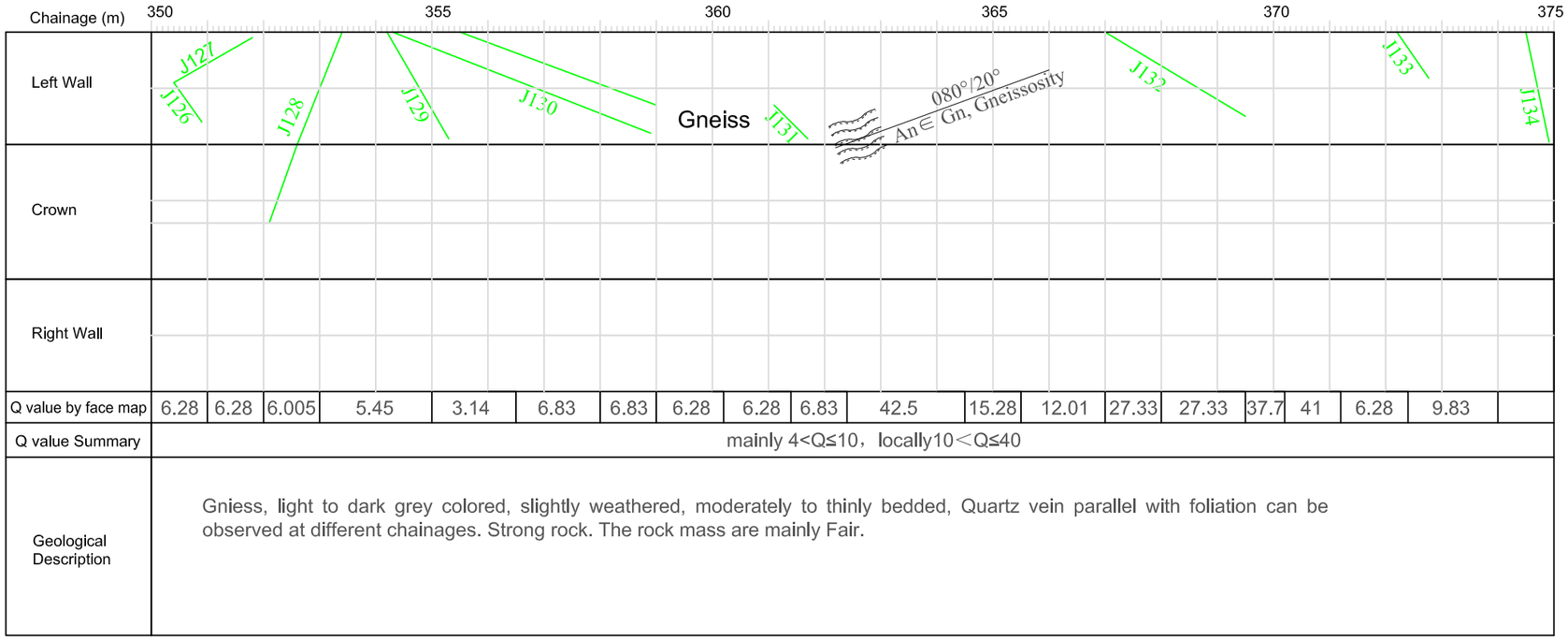
Scale: 0 1 2 3 4 5m

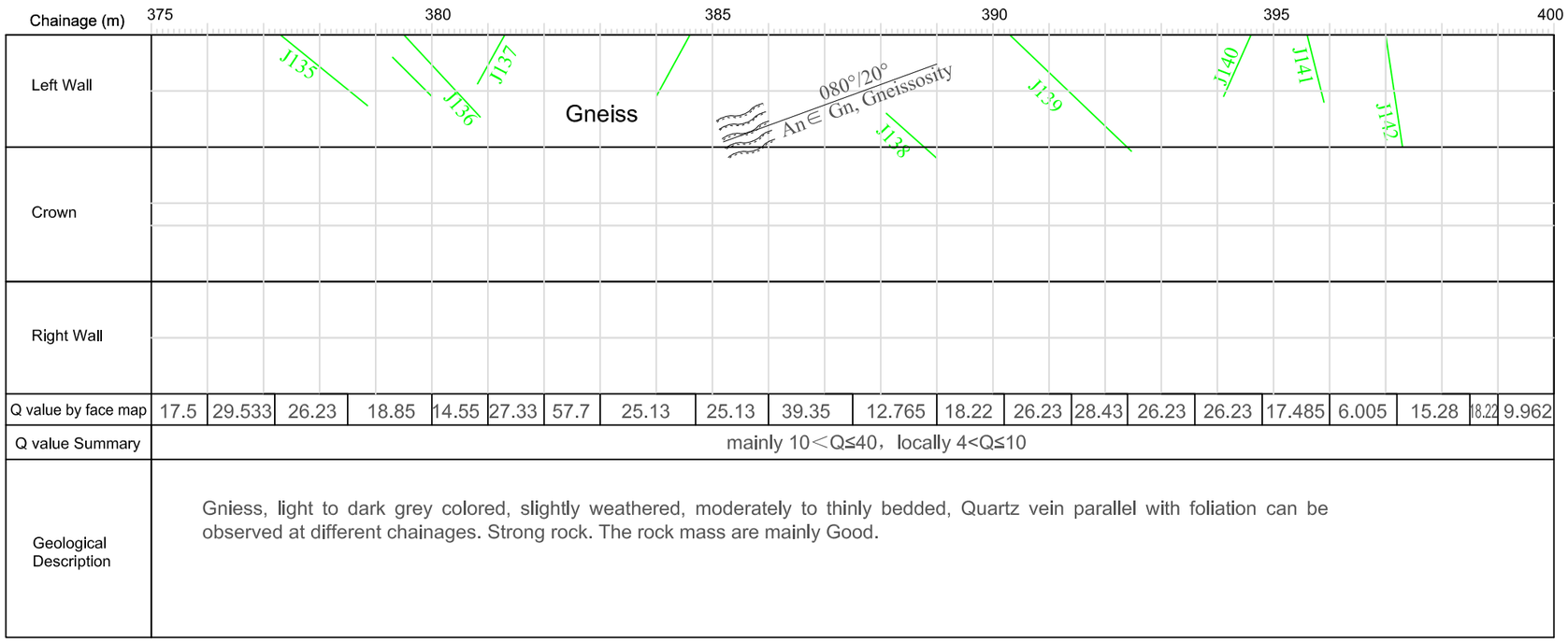
Notes:
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	长江勘测规划设计研究有限责任公司 CHANGJIANG SURVEY,PLANNING,DESIGN AND RESEARCH CO.,LTD.	TITLE	Test adit geological logging of UAHEP
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	Soil Test (P) Ltd.	APPROVED	Geology SECTION
		CHECKED	SCALE DATE
		DESIGNED	SIZE A3 REVISION
		DRAWING NO.	SHEET NO. 1/1

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Test adit geological logging of UAHEP (AD5 at PH site)





Legend

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- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
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CLIENT: नेपाल विद्युत प्राधिकरण Nepal Electricity Authority

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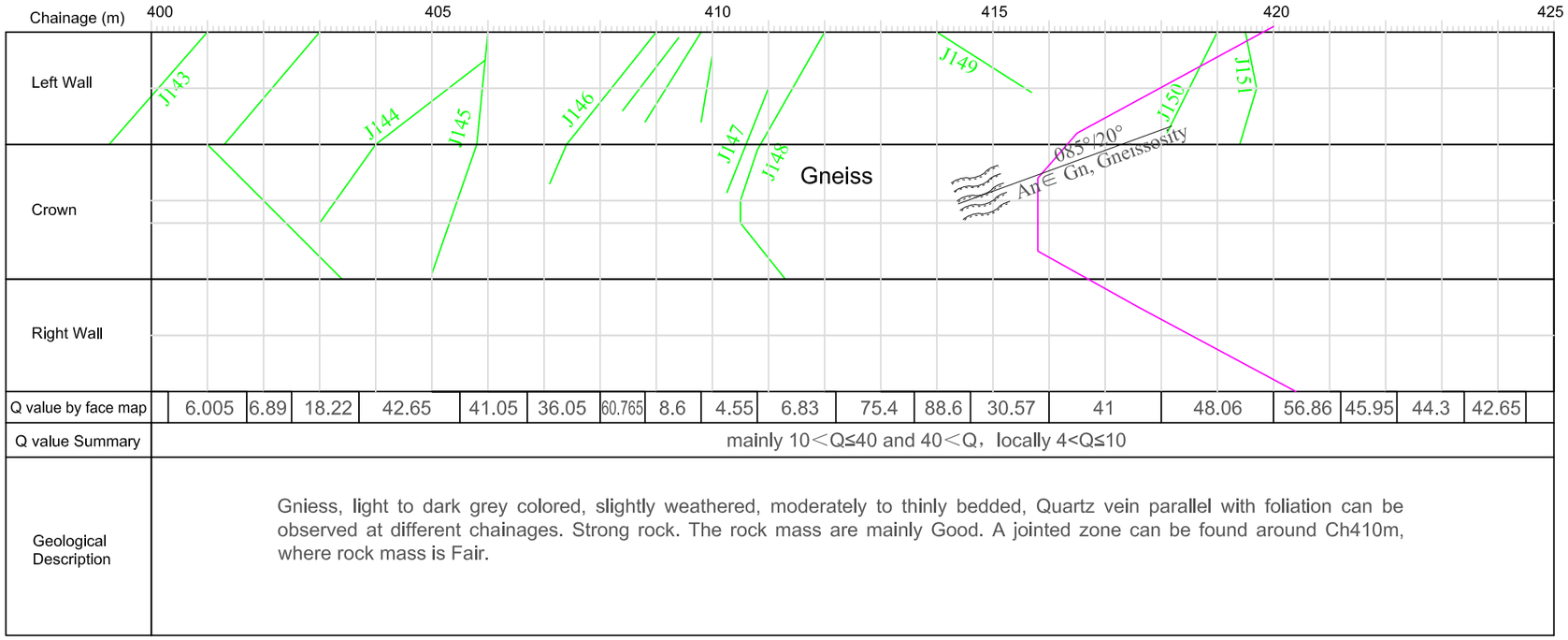
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TITLE: Test adit geological logging of UAHEP

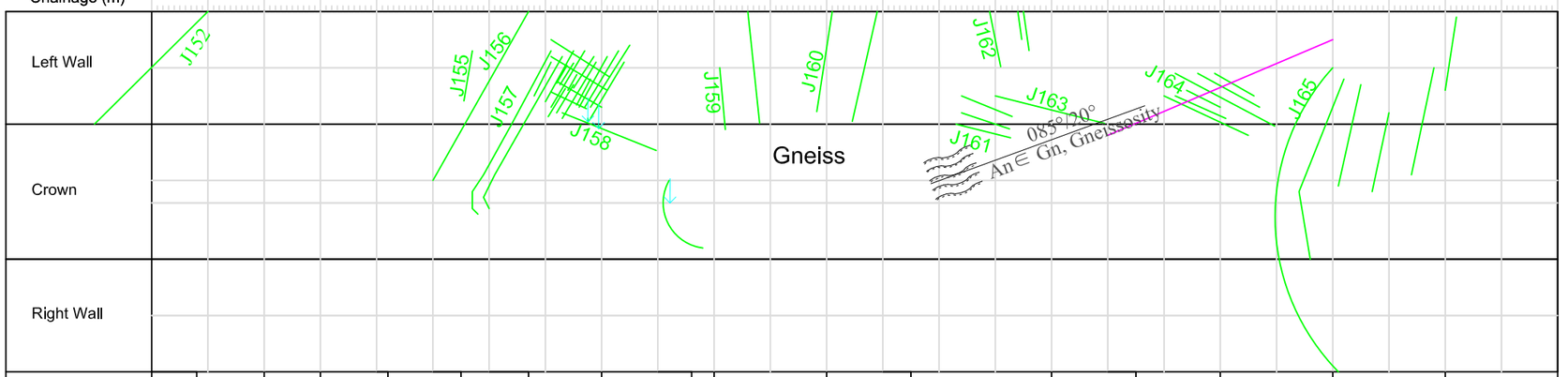
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Test adit geological logging of UAHEP (AD5 at PH site)



Q value by face map	6.005	6.89	18.22	42.65	41.05	36.05	60.765	8.6	4.55	6.83	75.4	88.6	30.57	41	48.06	56.86	45.95	44.3	42.65
Q value Summary	mainly 10＜Q≤40 and 40＜Q，locally 4<Q≤10																		
Geological Description	Gniess, light to dark grey colored, slightly weathered, moderately to thinly bedded, Quartz vein parallel with foliation can be observed at different chainages. Strong rock. The rock mass are mainly Good. A jointed zone can be found around Ch410m, where rock mass is Fair.																		



Q value by face map	42.65	45.56	8.6	9.42	4.63	16.33	21.83	2.59	5.7	5.65	8.18	5.18	8.6	11.46	13.33	13.11	13.66
Q value Summary	mainly 10＜Q≤40 and 40＜Q，locally 4<Q≤10																
Geological Description	Gniess, light to dark grey colored, slightly weathered, moderately to thinly bedded, Quartz vein parallel with foliation can be observed at different chainages. Strong rock. The rock mass are mainly Good. A jointed zone can be found around Ch433m, where rock mass is Fair.																

Legend

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- An∈MS — Mica Schist of Precambrian
- Gneiss and its Gneissosity
- Schist and its Schistosity
- Boundary of lithology
- J004,110/35 — Joint trace, its Number and Orientation
- Foliation and parallel joints
- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
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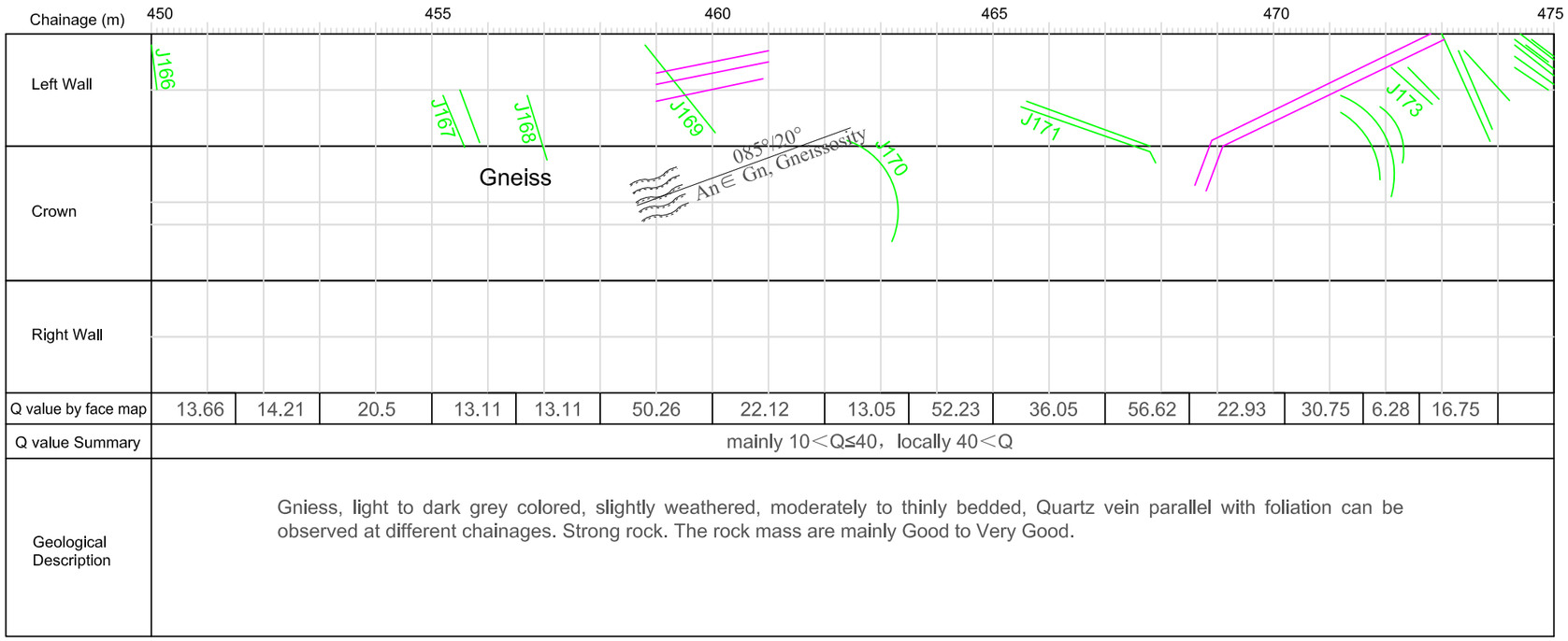
PROJECT: UPPER ARUN HYDROELECTRIC PROJECT

TITLE: Test adit geological logging of UAHEP

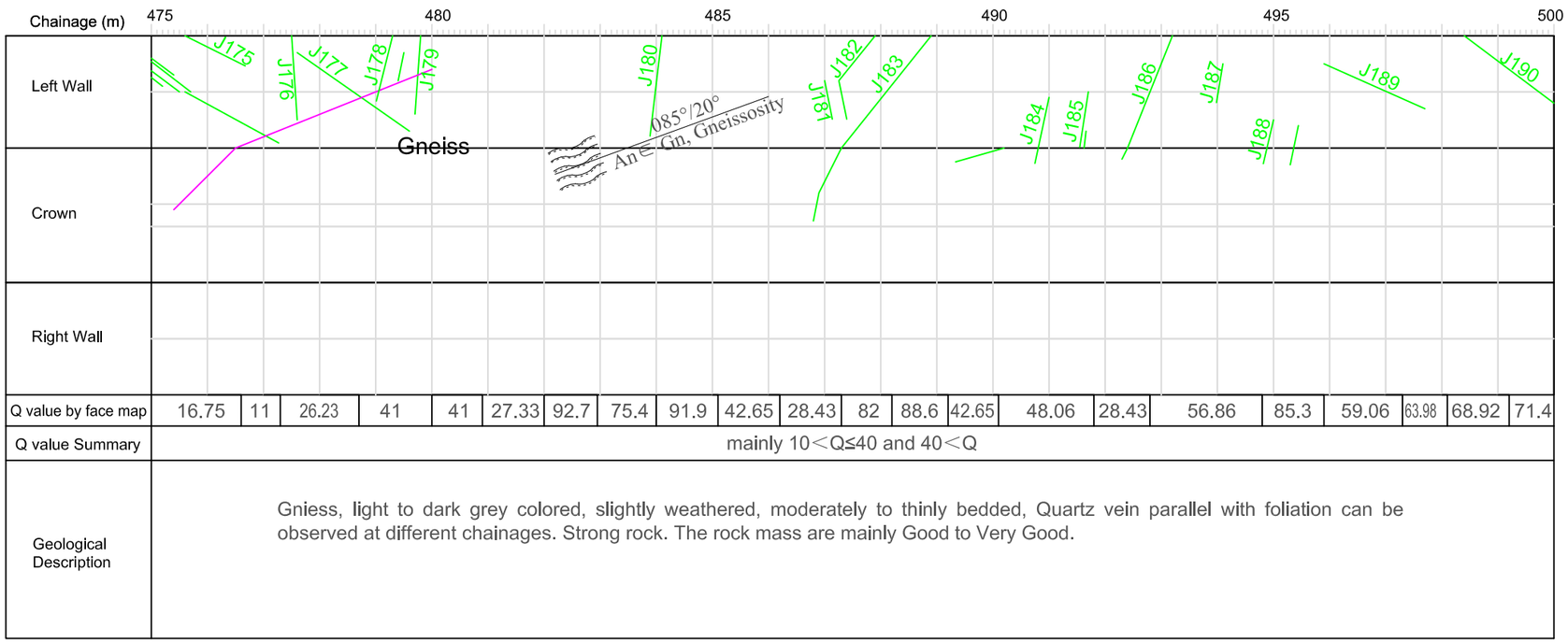
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Test adit geological logging of UAHEP (AD5 at PH site)



Q value by face map	13.66	14.21	20.5	13.11	13.11	50.26	22.12	13.05	52.23	36.05	56.62	22.93	30.75	6.28	16.75
Q value Summary	mainly 10＜Q≤40，locally 40＜Q														
Geological Description	Gniess, light to dark grey colored, slightly weathered, moderately to thinly bedded, Quartz vein parallel with foliation can be observed at different chainages. Strong rock. The rock mass are mainly Good to Very Good.														



Q value by face map	16.75	11	26.23	41	41	27.33	92.7	75.4	91.9	42.65	28.43	82	88.6	42.65	48.06	28.43	56.86	85.3	59.06	63.98	68.92	71.4
Q value Summary	mainly 10＜Q≤40 and 40＜Q																					
Geological Description	Gniess, light to dark grey colored, slightly weathered, moderately to thinly bedded, Quartz vein parallel with foliation can be observed at different chainages. Strong rock. The rock mass are mainly Good to Very Good.																					

Legend

- An∈Gn — Gneiss of Precambrian
- An∈MS — Mica Schist of Precambrian
- Gneiss and its Gneissosity
- Schist and its Schistosity
- Boundary of lithology
- J004,110/35 — Joint trace, its Number and Orientation
- Foliation and parallel joints
- Seepage
- Temporary supporting zone

Scale: 0 1 2 3 4 5m

Notes:
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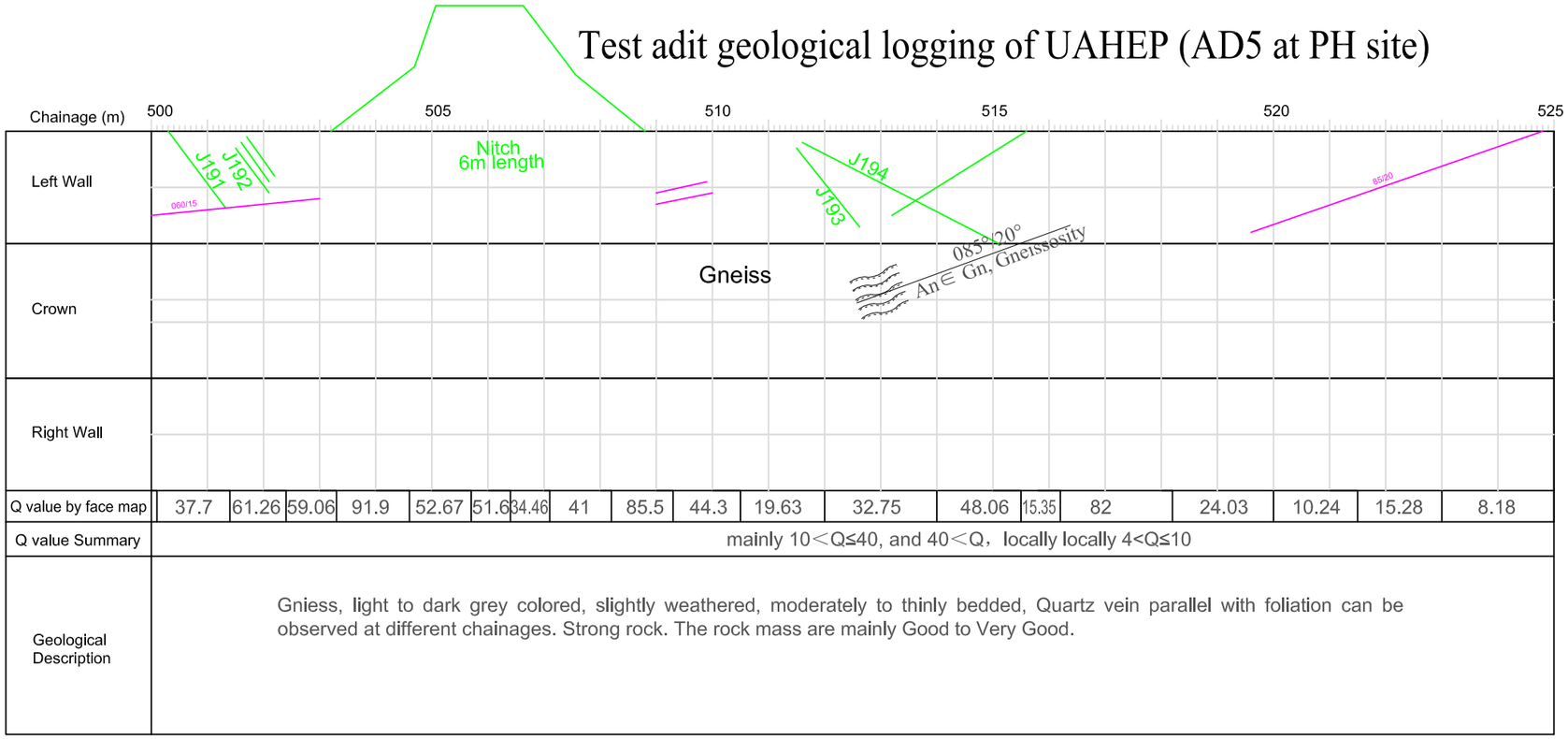
PROJECT: UPPER ARUN HYDROELECTRIC PROJECT

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Test adit geological logging of UAHEP (AD5 at PH site)



Legend

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- Temporary supporting zone

Scale: 0 1 2 3 4 5m

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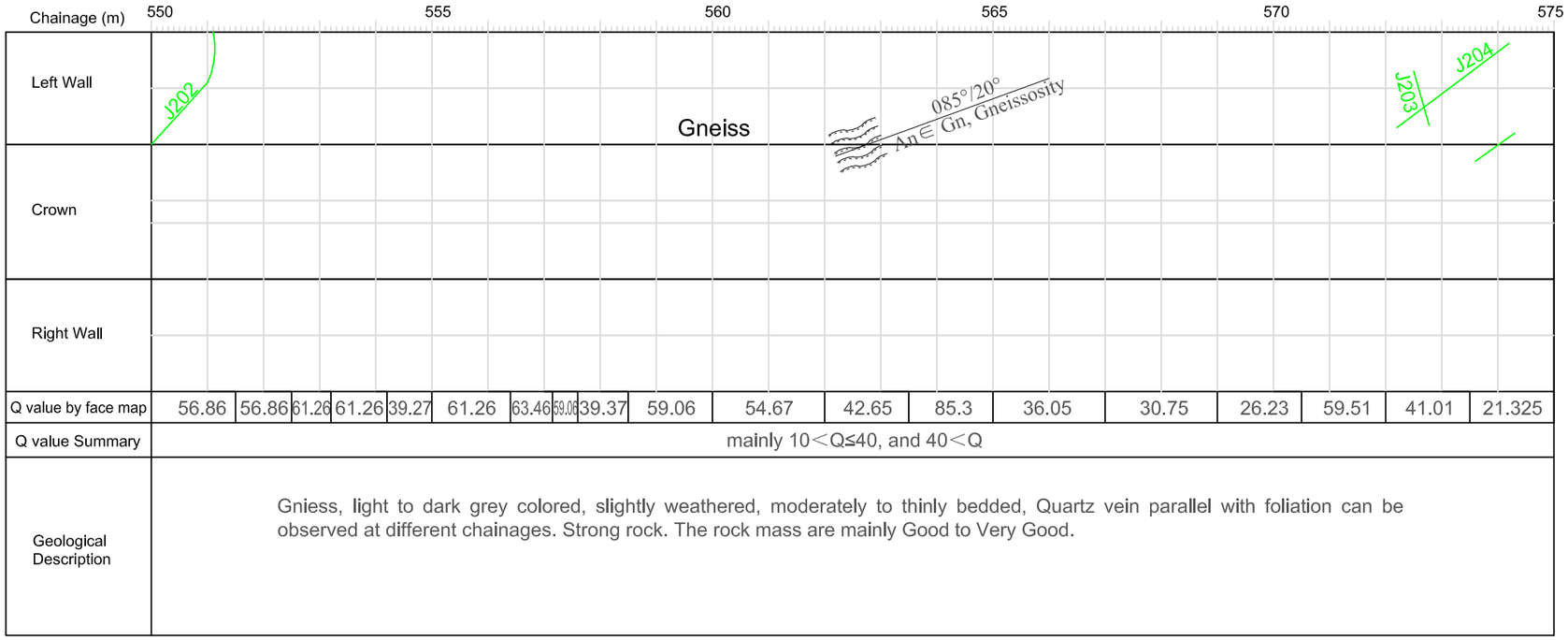
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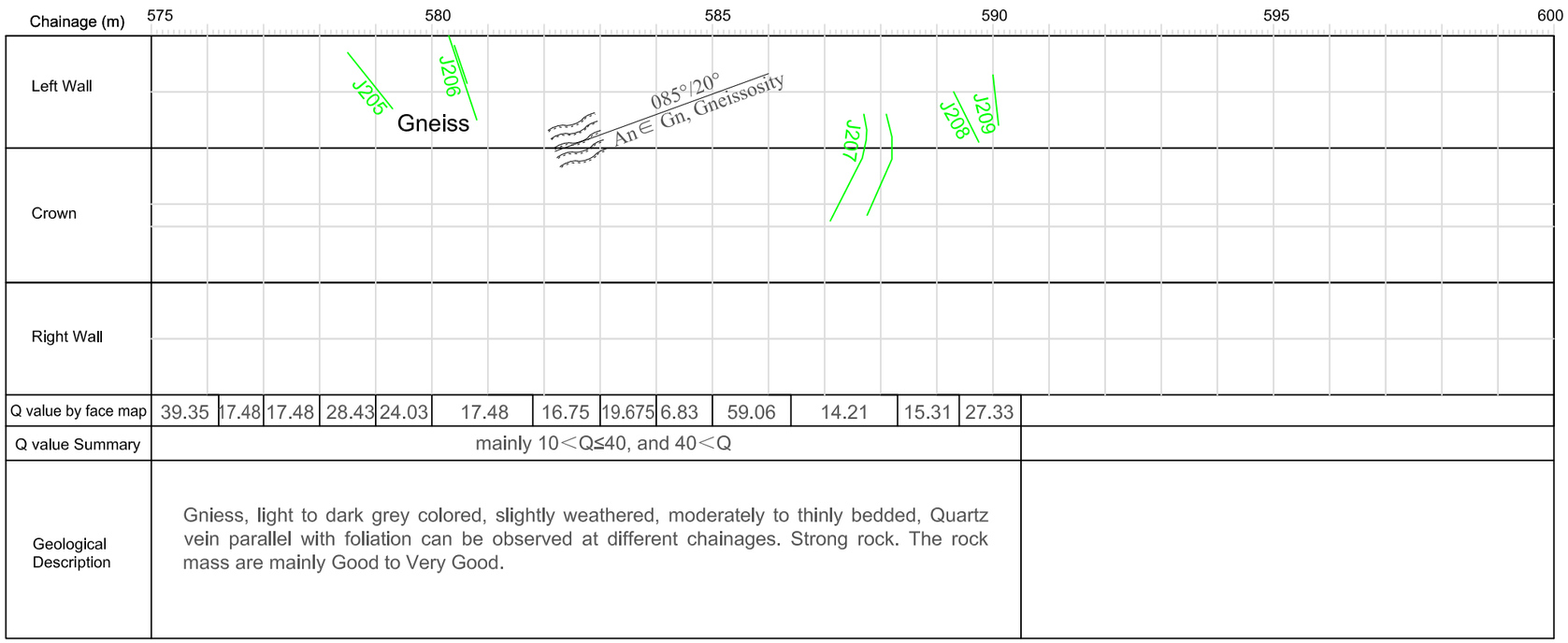
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Test adit geological logging of UAHEP (AD5 at PH site)





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Characteristics of joints in test adits (adit 1)

No.	Chainage	Lithology	DD (°)	DA (°)	Spacing (m)	Aperture/Opening (mm)	Persistence (m)	Infilling	Weathering	Roughness	Remarks
J1	0+003	Gneiss	15	67	0.3	2 to 20	>3	Silty material	Fresh	Rough, undulating	2 entries, left wall
J2	0+004.7	Gneiss	305	75	-	2 to 10	>3	Silty material	Fresh	Rough, undulating	Single entry, left wall
J3	0+005.3	Gneiss	140	80	0.1-0.2	2 to 10	>2	Silty material	W1	Rough, undulating	4 entries, right wall
J4	0+010	Gneiss	195	88	-	2	>2	Silty material	W1	Rough, undulating	Single entry, right wall
J5	0+012.7	Gneiss	190	88	0.3-0.7	tight	1.8	-	W1	Rough, undulating	3 entries, left walll
J6	0+013	Gneiss	190	82	0.1-0.3	tight	1	-	W1	Rough, undulating	3 entries, right wall
J7	0+015.4	Gneiss	333	61	-	tight	2	-	W1	Rough, undulating	Single entry, right wall
J8	0+015.7	Gneiss	141	82	-	tight	>2	-	W1	Rough, undulating	Single entry, left walll
J9	0+016.8	Gneiss	17	88	-	tight	1.2	-	W1	Rough, undulating	Single entry, left walll
J10	0+019.5	Gneiss	193	82	0.15	2	>3	Silty clay	W1	Rough, undulating	2 entries, yellowish weathering color
J11	0+020.5	Gneiss	318	77	0.3	2 to 4	>2	Silty material	W1	Rough, undulating	2 entries, left walll, yellowish weathering color
J12	0+022	Gneiss	316	51	0.6	2 to 5	>3	Silty material	W1	Rough, undulating	Single enrty, left wall
J13	0+023.2	Gneiss	196	88	-	2 to 5	>2	Silty material	W1	Rough, undulating	Single entry, left wall, yellow weathering color
J14	0+023.2	Gneiss	305	85	-	tight	1.1	-	W1	Rough, undulating	single entry, right wall
J15	0+026.5	Gneiss	195	88	-	2 to 10	>3	silty material	W1	Rough, undulating	2 entries, right wall
J16	0+028.7	Gneiss	185	89	0.2	2	1.7	silty material	W1	Rough, undulating	single entry, left walll

Joints characteristics of Adit 2

S.N.	Joint	Chainage(m)	Lithology	DA	DD	Spacing(m)	Aperture (mm)	Persistence (m)	Infilling	Weathering	Roughness	Remarks
1	J1	0+010	Gneiss	55	135	-	2-20mm	>3	Silty material	W1	Rough and wavy	Single entry
2	J2	0+013.8	Gneiss	77	190	0.1-0.2	2-10mm	>3	Silty material	W1	Rough and wavy	Five entries
3	J3	0+013.8	Gneiss	48	281	0.1	Tight	2.4	-	W1	Rough and wavy	Four entries
4	J4	0+018.7	Gneiss	83	206	1	5-10mm	>2	Silty material	W1	Rough and wavy	Four entries
5	J5	0+023.7	Gneiss	71	190	0.1	Tight	>2	-	W1	Rough and wavy	2 entries
6	J6	0+024	Gneiss	49	12	0.05	Tight	>0.7	-	W1	Rough and wavy	2 entry, Right wall
7	J7	0+026	Gneiss	68	182	0.1-0.5	Tight	>3	-	W1	Rough and wavy	3 entries
8	J8	0+028	Gneiss	74	215	-	Tight	>2	-	W1	Rough and wavy	2 entries, Right wall
9	J9	0+028	Gneiss	84	192	0.5	5-10mm	1.5	Silty clay	W1	Rough and wavy	Single entry
10	J10	0+030	Gneiss	45	192	-	2-10mm	>3	Silty clay	W2-W3	Rough and wavy	Single entry
11	J11	0+031.8	Gneiss	76	153	-	Tight	>2	Tight	W1	Rough and wavy	6 entries, Right wall
12	J12	0+033.8	Gneiss	77	172	0.1-0.2	2-5mm	1.5-2	Silty clay	W2	Rough and wavy	3 entries
13	J13	0+034	Gneiss	70	182	0.05	<2mm	1.2	Silty clay	W1-W2	Rough and wavy	Single Entry
14	J14	0+053	Gneiss	18	320	-	2-50mm	>5	Silty clay	W1-W2	Rough and wavy	>5 Entries
15	J15	0+055	Gneiss	63	204	0.1-0.5	Tight	>2	-	W1-W2	Rough and wavy	3 entries
16	J16	0+078.5	Gneiss	67	195	0.05-0.1	Tight	0.9	-	W1	Rough and wavy	2 entries
17	J17	0+084	Gneiss	73	203	0.15	Tight	0.8	-	W1	Rough and wavy	2 entries
18	J18	0+087	Gneiss	50	175	0.1	Tight	1.3	-	W1	Rough and wavy	2 entries, Right wall
19	J19	0+088.5	Gneiss	78	182	-	Tight	>2	-	W1	Rough and wavy	Single entry, right wall

Joints characteristics of Adit 4

S.N.	Joint Number	Chainage(m)	Lithology	DA	DD	Spacing(m)	Aperture (mm)	Persistence (m)	Infilling	Weathering	Roughness	Remarks
1	J1	0+009	Gneiss	73	171	0.5-1	2-100mm	>3	Silty material	W1	Rough and wavy	6 Entries
2	J2	0+018.2	Gneiss	66	169	0.5	2-20mm	>3	Silty material	W1	Rough and wavy	2 entries
3	J3	0+020.1	Gneiss	58	150	0.3-1.5	2-15mm	>3	Silty material	W1	Rough and wavy	3 entries
4	J4	0+030	Gneiss	54	160	-	Tight	>2	Tight	W1	Rough and wavy	Single entry
5	J5	0+036	Gneiss	69	177	-	<2	>3	Silty material	W1	Rough and wavy	Single entry
6	J6	0+042.7	Gneiss	24	160	-	Tight	>2	Tight	W1	Rough and wavy	Single entry
7	J7	0+045	Gneiss	76	162	0.1	<2	>3	Silty material	W1	Rough and wavy	2 entries
8	J8	0+048	Gneiss	57	122	0.2	2-5mm	>3	Silty material	W1	Rough and wavy	2 entries
9	J9	0+054.5	Gneiss	66	148	-	Tight	>2	Tight	W1	Rough and wavy	Single entry
10	J10	0+056.7	Gneiss	52	153	-	2-5mm	>3	Silty material	W1	Rough and wavy	Single Entry
11	J11	0+066	Gneiss	56	151	-	2-4mm	>3	Silty material	W1	Rough and wavy	Single Entry
12	J12	0+072.7	Gneiss	87	151	0.1	2-4mm	>3	Silty material	W1	Rough and wavy	3 Entries
13	J13	0+079	Gneiss	67	167	-	2	>2	Silty material	W1	Rough and wavy	Single entry
14	J14	0+088	Gneiss	81	176	-	2-4mm	>3	Silty material	W1	Rough and wavy	Single entry, Right wall
15	J15	0+087	Gneiss	40	170	0.3	2-30mm	>3	Silty material	W1	Rough and wavy	4 entries
16	J16	0+091	Gneiss	50	152	0.9	1-4mm	>2	Silty material	W1	Rough and wavy	3 entries
17	J17	0+098.5	Gneiss	51	184	0.2	2mm	1.5	Silty material	W1	Rough and wavy	Single entry
18	J18	0+0101	Gneiss	63	146	-	<2mm	>2	Tight	W1	Rough and wavy	Single entry
19	J19	0+102.5	Gneiss	58	145	-	2-20mm	>3	Silty material	W1	Rough and wavy	Single entry

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J001	0+11	mica-schist	110	35			> 3mm	mica rich	slightly weathered	smooth, wavy	
J002	0+13	mica-schist	110	35			3 m	altered, rock mass with clay	slightly weathered	smooth, wavy	brown color
J003	0+13.5	mica-schist	320	65		tight	1.3	silt-clay	W3	rough, undulating	brown joint face
J004	0+15	mica-schist	110	35			>3	mica rich	W2		
J005	0+20-22	mica-schist	95	75	20-40 cm	tight	> 3		W2	slightly wavy, smooth	brown color: 4 entries
J006	0+39.5	mica-schist				tight	2		W2-1	wavy, slightly rough	1 entry
J007	0+54	Gneiss+schist	80	88	20 cm	narrow	> 3	sand and clay	W4	wavy, smooth	brownish yellow color
J008	0+53	Gneiss	268	61		tight	1.5	clay	W2	wave, smooth	1 entry
J009	0+58.6	Gneiss	295	75	20-50 cm	tight	0.5	Fe	W3	slightly wavy, smooth	many entries
J010	0+58.6	Gneiss	10	75	10-20 cm	extremly narrow	20-100 cm	Fe3O4	W4	wavy, rough	many entries
J011	0+065	mica-schist	120	84	20 cm	tight	2.5		W2	wavy, smooth	light grey. No. of joint is 2 in 1 set
J012	0+66.5	mica-schist	172	86	> 3	narrow	> 3	rok debris, silt-clay	W4	slightly wavy, rough	brown color, 1 entry
J013	0+071	mica-schist	305	78		narrow	2	silt-clay	W3	wavy, smooth	1 entry
J014	0+075	mica-schist	250	30		extremly narrow	> 3	silt-clay	W3	wavy, rough	1 entry
J015	0+77.8	mica-schist	101	88	1.3	narrow	> 3	silt-clay	W3	wavy, rough	2 entries
J016	0+80	mica-schist	280	30		extremly narrow	1.5		W2-1	wavy, rough	1 entry
J017	0+081	mica-schist	230	30	10-20 cm	tight	1.5		W2-1	slightly wavy, rough	> 3 entries
J018	0+87	mica-schist	295	51		tight	1.5		W2-1	slightly wavy, smooth	1 entry
J019	0+089	mica-schist	280	87		tight	1.8		W2-1	wave, rough	1 entry

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J020	0+91.4	mica-schist	185	80		tight	> 3		W2-1	slightly wave, rough	1 entry
J021											The same as J007
J022	97.4	mica-schist	279	88	30-50 cm	tight	> 3		W2-1	slightly wavy, rough	2 - 5 entries
J023	97.4	mica-schist	55	40		extremly narrow	1		W2-1	wavy, smooth	1 entry
J024	100+2	mica-schist	65	36		open (2mm)	> 3	clay	W3	slightly wavy, smooth	1 entry
J025	103	mica-schist	278	75		tight	> 3		W2-1	slightly wavy,smooth	
J026	112	Gneiss	185	88	10 cm-1m	2-3 mm	> 3	clay	W4-5	slightly wavy, smooth	> 5 entries
J027	112	Gneiss	285	40	10 - 20 cm	tight	2	clay	W2-1	slighly wavy, smooth	> 5 entries
J028	112	Gneiss	102	68	10-20 cm	narrow	2-3 m	silt-clay	W3	slightly wavy, rough	> 8 entries
* J029	118	Gneiss	0	50		open	> 3	silt-clay, rock debris	W5		water flow during mansoon, 1 l/min
J030	121	Gneiss	190	35		tight	1.5		W2-1	slightly wavy, rough	1 entry
J031	120	Gneiss	90	80		tight	> 3		W2-1	slightly wavy, rough	1 entry
J032	122	Gneiss	285	70		tight	1.5		W2-1	wavy, rough	1 entry
J033	125	Gneiss	183	78	10-20 cm	tight	> 2		W2-1	wavy, rough	> 8 entries, the same set as J026
J034	126.2	Gneiss	270	55	20 cm	tight	1.2		W2-1	wavy, rough	2 entries
J035	127	Gneiss	210	83	10-30 cm	tight	2		W2-1	wavy, rough	> 3 entries
J036	130	Gneiss	10	83	40 cm	tight	1		W2-1	wavy, rough	2 entries
J037	131	Gneiss	225	40	40 cm	tight	1		W2-1	wavy, rough	2 entries
J038	131.5	Gneiss	90	83		open	2	rock debris, silt-clay	W3	wave, rough	1 entry

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J039	131.5	Gneiss	270	77		tight	1.5		W2-1	wave, rough	2 entries
J040	132.7	Gneiss	300	30	50 cm	tight	1		W2-1	slightly wavy, rough	2 entries
J041	134.6	mica-schist	285	85		tight	> 3		W2-1	slightly wavy, smooth	1 entry
J042	143	mica-schist	110	78	10 cm	tight	1		W2-1	slightly wavy, smooth	2 entries
J043	146	mica-schist	105	45		open	>3	clay	W3	slightly wavy,smooth	1 entry
J045	165.5	mica-schist	115	85		tight	2		W2-1	slightly wavy, smooth	1 entry
J044	165	mica-schist	310	40		tight	1		W2-1	wavy, rough	1 entry
J046	167.2	mica-schist	110	75	10-40 cm	tight	1.5		W2-1	wavy, smooth	3 entries
J047	168	mica-schist	30	50		tight	2		W2-1	wavy, smooth	1 entry
J048	169	mica-schist	300	50		tight	1			wavy, smooth	1 entry
J049	170	mica-schist	280	25		tight	> 3		W2-1	wavy, rough-smooth	1 entry
J050	172.2	mica-schist	107	74		tight	> 2		W2-1	wavy, smooth	1 entry
J051	173.2	mica-schist	154	70	10-50 cm	tight	> 3		W3	wavy, smooth	> 5 entries
J052	175	mica-schist	40	85	50-80 cm	tight	> 3		W3	wavy, slightly rough	1 entry
J053	179	mica-schist	310	55	30-40 cm	tight	> 3		W2-1	wavy, rough	> 8 entries
J054	182.6	mica-schist	55	50	50 cm	tight	> 3		W2-1	wavy, smooth	2 entries
J055	187.1	mica-schist	90	80		tight	2		W2-1	wavy, rough	1 entry
J056	189	mica-schist	292	80	20-40 cm	tight	2		W2-1	wavy, rough	> 5 entries
J057	195.5	mica-schist	100	78	1.5	tight	> 3		W2-1	wavy, smooth	2 entries

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J058	198	mica-schist	295	75	20 cm	tight	3		W2-1	wavy, rough	3 entries
J059	196.7	mica-schist	80	40					W2-1		
J060	200	mica-schist	305	50	1-2 m	tight	> 3		W2-1	wavy, rough	3 entries
J061	202	mica-schist	340	70			> 3		W2-1	wavy, rough	1 entries
J062	203.5	mica-schist	290	40			1		W2-1	wavy, rough	1 entries
J063	211.6	mica-schist	110	65	0.5-1 m	tight	> 3		W2-1	wavy, rough-smooth	>5 entries
J064	214.4	mica-schist	95	80	10 -20 cm	tight	2		W2-1	wavy, rough	>3 entries
J065	219	mica-schist	310	75	40 cm	tight	2		W2-1	wavy, rough	2 entries
J066	221	mica-schist	85	73			> 3		W2-1	wavy, smooth	1 entries
J067	222.1	mica-schist	305	40			1	clay	W2-1	wavy, smooth	1 entries
J068	224.7	mica-schist	165	70			2		W2-1	wavy, slighty rough-smooth	1 entries
J069	225	mica-schist	150	80			2		W2-1	wavy, slighty rough-smooth	1 entries
J070	229	mica-schist	90	40	20 cm	tight	> 3		W2-1	wavy, rough	2 entries
J071	231	mica-schist	240	10			> 3		W2-1	wavy, rough	1 entries
J072	235	mica-schist	170	60	10- 40 cm	tight	2		W2-1	wavy, rough	3 entries
J073	237.5	mica-schist	110	85	5m	tight	> 3		W2-1	wavy, rough	2 entries
J074	242	mica-schist	110	75					W2-1		2 entries
J075	240.9	mica-schist	0	35	1.8	tight	> 3		W2-1	wavy, rough	2 entries
J076	241	mica-schist	320	40		tight	1		W2-1	wavy, rough	1 entries

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J077	243.5	mica-schist	30	60	40-50	tight	> 3		W2-1	wavy, rough	1 entries
J078	247.8	mica-schist	270	74		tight	> 3		W2-1	wavy, rough	2 entries
J079	252	mica-schist	258	78		open	> 3	clay	W2-1	wavy, smooth	
J080	252.6	mica-schist	65	62		tight	> 3		W2-1	wavy, rough	1 entries
J081	258	mica-schist	98	72		tight	> 3		W2-1	wavy, rough	1 entries
J082	259	mica-schist	250	20		tight	> 3		W2-1	wavy, rough	1 entries
J083	262	mica-schist	310	20		tight	> 3		W2-1	wavy, rough	1 entries
J084	264.3	mica-schist	282	84		tight	> 3		W2-1	wavy, rough	1 entries
J085	267	mica-schist	280	6		tight	> 3		W2-1	wavy, rough	same as J082
J086	271	mica-schist	97	84		tight	1.5		W2-1	wavy, rough	
J087	272	mica-schist	107	86	1- 2m	tight	2		W2-1	wavy, rough	2 entries
J088	275	mica-schist	278	29	10-20 cm	tight	> 3		W2-1	wavy, rough	3
J089	285	Gneiss	273	19	40-50 cm	tight	1.5		W2-1	wavy, rough	>3
J090	286	Gneiss	285	84	1m	tight	2		W2-1	wavy, rough	2
J091	288	Gneiss	280	10	30- 40 cm	tight	>3		W2-1	wavy, rough	>3
J092	290	mica-schist	90	50	50 - 80 cm	tight	1.5		W2-1	wavy, rough	3
J093	290	mica-schist	188	89	40 cm	tight	>3		W2-1	wavy, rough	>3
J094	294.3	mica-schist	100	89		tight	2		W2-1	wavy, rough	1
J095	294.7	mica-schist	314	46		tight	>3		W2-1	wavy, rough	1

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J096	298.2	Gneiss	92	71	50 cm		>3		W2-1	wavy, rough	2
J097	300	Gneiss	84	63	10-30 cm		2		W2-1	wavy, rough	4
J098	300	Gneiss	300	15	30 cm		2		W2-1	wavy, rough	2
J099	300	Gneiss	286	61		tight	3		W2-1	wavy, rough	1
J100	307	Gneiss	299	14	5 cm	tight	1		W2-1	wavy, rough	3
J101	308	Gneiss	106	89	0.5- 1m	tight	1- 2m		W2-1	wavy, rough	>5
J102	309	Gneiss	111	46	0.5- 0.6 m	tight	1.5m		W2-1	wavy, rough	4
J103	309	Gneiss	292	26		tight	>3m		W2-1	wavy, rough	3
J104	310	Gneiss	120	67		tight	2m		W2-1	wavy, rough	1
J105	311	Gneiss	110	62		tight	>3m		W2-1	wavy, rough	1
J106	312	Gneiss	283	36		tight	1.5		W2-1	wavy, rough	1
J107	311	Gneiss	151	2		tight	2		W2-1	wavy, rough	3
J108	312.5	Gneiss	270	53		tight	>3		W2-1	wavy, rough	1
J109	314	Gneiss	297	46		tight	>3		W2-1	wavy, rough	1
J110	316	Gneiss	103	44		tight	1.5		W2-1	wavy, rough	>5
J111	317	Gneiss	276	87		tight	1		W2-1	wavy, rough	1
J112	317.5	Gneiss	104	85	60 cm	tight	2		W2-1	wavy, rough	2
J113	320	Gneiss	266	71		tight	1.5		W2-1	wavy, rough	1
J114	320	Gneiss	275	54	40 cm	tight	2		W2-1	wavy, rough	4

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J115	325	Gneiss	100	78		tight					Same as J112
J116	325	Gneiss	340	46		tight	>3		W2-1	wavy, rough	>4
J117	329	Gneiss	321	81		tight	2		W2-1	wavy, rough	1
J118	331	Gneiss	270	41		tight	1		W2-1	wavy, rough	>5
J119	332.6	Gneiss	263	48	0.5-1 m	tight	1.5		W2-1	wavy, rough	4
J120	333.4	Gneiss	105	61	0.5	tight	>3		W2-1	wavy, rough	2
J121	336	Gneiss	101	71	0.5	tight	>3		W2-1	wavy, rough	>4
J122	338	Gneiss	Foliation								Mica Schist (Mica 10 cm thick)
J123	341.4	Gneiss	296	62	1.5	tight	2		W2-1	wavy, rough	>3
J124	345.7	Gneiss	295	50	1.5	tight	2		W2-1	wavy, rough	2
J125	347	Gneiss	187	87		tight	>3		W2-1	wavy, rough	1
J126	350.4	Gneiss	176	81	0.4	tight	0.7	Silt	W1	wavy, rough	1
J127	351.8	Gneiss	100	72	0.4	tight	1	No infilling	W1	wavy, rough	1
J128	353.4	Gneiss	283	84	0.2	2	>3	Silt	W1	wavy, rough	1
J129	354.2	Gneiss	275	69	0.1	tight	2	No infilling	Fresh	wavy, rough	1
J130	354.3	Gneiss	189	77	0.3	1	>3	Silt	Fresh	wavy, rough	1
J131	359.2	Gneiss	221	66	0.3	tight	0.3	No infilling	Fresh	wavy, rough	1
J132	367	Gneiss	264	43	0.27	<1	>2	Silt	Fresh	wavy, rough	1
J133	372.2	Gneiss	286	47	0.3	tight	1	Silt	Fresh	wavy, rough	1

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J134	374.5	Gneiss	277	57		2	2	Silt	Fresh	wavy, rough	
J135	377.3	Gneiss	288	43		<1	2	No infilling	Fresh	Slickensided	1
J136	379.5	Gneiss	284	44		tight	2	No infilling	Fresh	rough	1
J137	381.3	Gneiss	89	58		tight	1	No infilling	Fresh	polished	1
J138	388.2	Gneiss	275	55		1	1	Silty clay	Fresh	wavy, rough	1
J139	390.3	Gneiss	252	57		tight	>3	Silt	W1	wavy, rough	1
J140	394.6	Gneiss	86	67		tight	1.2	Silt	W2	wavy, rough	1
J141	395.6	Gneiss	92	65		tight	>1	Silt	W3	wavy, rough	1
J142	397	Gneiss	92	64		tight	2	Silt	W4	wavy, rough	
J143	401	Gneiss	110	66	1	tight	>3	No infilling	W1	wavy, rough	3 entries
J144	406	Gneiss	293	78		2	>3	Silt	W1	wavy, rough	1 entry
J145	406	Gneiss	105	61	0.5	tight	>3	No infilling	W1	wavy, rough	2 entries
J146	409	Gneiss	104	85	1.1	tight	>3	No infilling	W1	wavy, rough	>4 entries
J147	411	Gneiss	292	87		tight	2	No infilling	W1	wavy, rough	1 entry
J148	412	Gneiss	15	58		tight	>3	No infilling	W1	wavy, rough	1 entry
J149	414	Gneiss	285	50		tight	>2	No infilling	W1	wavy, rough	1 entry
J150	419	Gneiss	85	78		tight	2	No infilling	W1	wavy, rough	1 entry
J151	419.5	Gneiss	287	80		tight	2	No infilling	W1	wavy, rough	1 entry
J152	426	Gneiss	108	81		tight	2	No infilling	W1	wavy, rough	1 entry

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J153	429.5	Gneiss	92	50	0.1-0.2	tight		No infilling	W1	wavy, rough	>5
J154	429.5	Gneiss	272	28	0.1-0.2	2		Silt	W1	wavy, rough	>5
J155	0+430.8	Gneiss	114	74	-	<2	0.9	Silty	W1	Rough, wavy	Single entry
J156	0+431.7	Gneiss	117	80	-	1	>3	Silty	W1	Rough, wavy	Single entry
J157	0+432.1	Gneiss	97	65	0.1-0.25	-	0.4-2	-	Fresh	Rough, wavy	17 entries
J158	0+432.4	Gneiss	267	34	0.3-0.4	2	0.7-1.8	Silty	Fresh	Rough, wavy	6 entries
J159	0+435.10	Gneiss	281	66	0.5	-	1m -2m	-	W1	Rough, wavy	2 entries
J160	0+437.1	Gneiss	98	68	0.8	-	1.8-2	-	W1	Rough, wavy	2 entries
J161	0+439.30	Gneiss	273	40	0.2-0.3	-	1	-	W1	Rough, wavy	3 entries
J162	0+439.9	Gneiss	264	67	0.10-0.50	-	0.5-1	-	Fresh to W1	Rough, wavy	3 entries
J163	0+440	Gneiss	313	43	-	1	2	Silty	Fresh to W1	Rough, wavy	Single entry
J164	0+443.20	Gneiss	290	47	0.15-0.30	-	0.6-2	-	Fresh to W1	Rough, wavy	6 entries
J165	0+446	Gneiss	104	88	0.15-1	-	1 to >2	-	Fresh	Rough, wavy	8 entries
J166	0+450	Gneiss	283	60	-	1	0.8	Silty	W1	Rough, wavy	Single entry
J167	0+455.2	Gneiss	275	52	0.3	-	1	-	W1	Rough, wavy	2 entries, yellowish weathering color
J168	0+456.7	Gneiss	262	58	-	-	1.2	-	W1	Rough, wavy	Single entry
J169	0+458.8	Gneiss	274	25	-	-	2	-	Fresh	Rough, wavy	Single entry
J170	0+462.4	Gneiss	246	46	-	-	>2	-	W1	Rough, wavy	Single entry
J171	0+465.5	Gneiss	189	86	0.1	-	>2	-	Fresh	Rough, wavy	2 entries

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J172	0+471.2	Gneiss	254	11	0.3	-	1 to 2	-	W1	Rough, wavy	3 entries
J173	0+472	Gneiss	262	53	0.2-0.3	-	1 to 2	-	Fresh	Rough, wavy	4 entries
J174	0+473.4	Gneiss	292	37	0.04-0.1	-	0.5-1.4	-	W1	Rough, wavy	9 entries
J175	0+475.6	Gneiss	283	34	0.6	-	1.2-1.9	-	Fresh	Rough, wavy	2 entries
J176	0+477.5	Gneiss	245	26	-	-	1.5	-	W1	Rough, wavy	Single entry
J177	0+477.6	Gneiss	240	79	-	-	2.4	-	W1	Rough, wavy	Single entry
J178	0+479.3	Gneiss	84	84	0.3	-	1.2	-	W1	Rough, wavy	2 entries
J179	0+479.8	Gneiss	74	85	-	-	1.4	-	W1	Rough, wavy	Single entry
J180	0+484.1	Gneiss	263	87	-	-	1.8	-	Fresh	Rough, wavy	Single entry
J181	0+487	Gneiss	267	68	0.26	-	0.7	-	Fresh	Rough, wavy	2 entries
J182	0+487.9	Gneiss	100	69	-	-	0.85	-	Fresh	Rough, wavy	Single entry
J183	0+488.9	Gneiss	94	76	-	-	>3	-	Fresh	Rough, wavy	Single entry
J184	0+491	Gneiss	290	88	-	-	1.2	-	Fresh	Rough, wavy	Single entry
J185	0+491.7	Gneiss	105	81	0.08	-	1	-	Fresh	Rough, wavy	2 entries
J186	0+493.2	Gneiss	99	81	-	-	>2	-	Fresh	Rough, wavy	Single entry
J187	0+494.1	Gneiss	103	79	-	-	0.7	-	Fresh	Rough, wavy	Single entry
J188	0+495	Gneiss	97	64	0.5	-	0.8	-	Fresh	Rough, wavy	2 entries
J189	0+495.9	Gneiss	267	42	-	-	1.4	-	Fresh	Rough, wavy	Single entry
J190	0+498.4	Gneiss	290	44	-	-	2	-	W1	Rough, wavy	Single entry

Joints characteristics of Adit 5

No.	Chainage	Lithology	DD	DA	Spacing (m)	Aperture (mm)	Persistency (m)	Infilling	Weathering	Roughness	Remarks
J191	0+500.3	Gneiss	269	29	-	Tight	1.7	No	W1	Rough, undulating	Single entry
J192	0+501.5	Gneiss	225	28	0.15-0.20	Tight	1	No	W1	Rough, undulating	3 enries
J193	0+511.5	Gneiss	198	65	-	Tight	1.8	No	W1	Rough, undulating	Single entry, yellow weathering color
J194	0+511.6	Gneiss	275	22	-	Tight	>8	No	W1	Rough, undulating	Single
J195	0+529.5	Gneiss	286	76	-	Tight	1.5	No	W1	Rough, undulating	Single
J196	0+532.7	Gneiss	283	83	-	Tight	>3	No	W1	Rough, undulating	Single
J197	0+533.8	Gneiss	12	80	-	Tight	0.7	No	W1	Rough, undulating	Single
J198	0+541.8	Gneiss	254	78	-	Tight	>3	No	W1	Rough, undulating	Single
J199	0+542.7	Gneiss	274	62	0.4	1	1	Silty Material	W1	Rough, undulating	2 entries
J200	0+543.8	Gneiss	283	66	0.1-0.2	Tight	1.2	No	W1	Rough, undulating	5 entries
J201	0+549.9	Gneiss	95	81	-	Tight	2	No	W1	Rough, undulating	Single entry
J202	0+551.1	Gneiss	102	83	-	Tight	1.9	No	W1	Rough, undulating	Single entry
J203	0+572.2	Gneiss	80	61	-	Tight	2	No	Fresh	Rough, undulating	Single entry
J204	0+572.5	Gneiss	289	51	-	Tight	1	No	W1	Rough, undulating	Single entry
J205	0+578.5	Gneiss	251	36	-	Tight	1.3	No	Fresh	Rough, undulating	Single entry
J206	0+580.3	Gneiss	291	53	0.12	Tight	1.5	No	Fresh	Rough, undulating	2 entries
J207	0+587.7	Gneiss	100	78	0.6	Tight	1.2	No	W1	Rough, undulating	2 entries
J208	0+589.3	Gneiss	275	37	-	Tight	1	No	Fresh	Rough, undulating	Single entry
J209	0+590	Gneiss	251	63	-	Tight	0.9	No	Fresh	Rough, undulating	3 entries
J210	0+590.5	Gneiss	278	55	0.25	Tight	2	No	Fresh	Rough, undulating	Single entry