DAFTAR PUSTAKA

Best, G.M., (2003), *Igneous And Metamorphic Petrology Second Edition,* Boston: Blackwell Science Ltd.

Browne, P. R. L. (1978). *Hydrothermal alteration in active geothermal fields*. *Annual review of earth and planetary sciences,* New Zealand: *6*, 229-250.

Corbett, G, (2018) *Epithermal Gold-Silver and Porphyry Copper-Gold Exploration*: Short Course Manual.

Corbett*, G*.J. dan Leach, T.M., (1996), *Southwest Pacific Rim Gold/Copper System: Structure, Alteration and Mineralization.* A workshop presented for the Society Exploration Geochemist, Townsville, 185 h.

Dickson, M. H, dan Fanelli, M., (2003), *Geothermal Energy: utilization and technology,* Paris: UNESCO Publishing.

Effendi, A. C. dan Bawono, W. A. J., (1997), *Peta Geologi Lembar Manado, Sulawesi Utara, Skala 1:250.000,* Bandung: Pusat Penelitian dan Pengembangan Geologi.

Ellis, A. J., dan Mahon, W. A. J., (1977), *Chemistry and geothermal systems*, New York: Academic Press.

Goff, Fraser., dan Janik, Cathy., (2000), *Geothermal System*. Dalam Haraldur Sigurdsson, *Encyclopedia of Volcanoes*, San Diego: Academic Press, p. 817-834.

Gudmundsson, J. S., dan G. Olsen, (1987), *Water-Influx Modeling of the Svartsengi Geothermal Field, Iceland.* SPE Res Eng *2* (1987): 77–84.

Hamilton, W.B., (1979), *Tectonics of the Indonesian Region (Geological Survey Professional Paper 1078*), Washington: United States Government Printing Office, p: 345.

Hochstein, M. P., (1990), *Classification And Assesment of Geothermal Reseources,* New Zealand: Geothermal Institute, University of Auchland, p. 31-59.

Hochstein, Manfred., dan Browne, Patrick, R. L., (2000), *Surface Manifestation of Geothermal System With Volcanic Heat Source*. Dalam Haraldur Sigurdsson, *Encyclopedia of Volcanoes*, San Diego: Academic Press, 835-855.

Koestono, H. (2010). *Lahendong geothermal field, Indonesia : geothermal model based on wells LHD-23 and LHD-28*. Master Thesis.

Lecuyer, (1997). *Active tectonics of north-east Sulawesi (Indonesia) and structural control of the Tondano caldera*, Comptes Rendus De L Academie Des Sciences Serie Ii Fascicule A-sciences De La Terre Et Des Planetes, volume 8.

Marisa, dkk, (2016), *Karakterisasi Feed Zone dan Potensi Produksi Sumur Panas Bumi ML-XX Muara Laboh, Solok Selatan,* Jurnal Fisika Unand, 5(4):313-321.

Meyer, C., Hemley, J.J. (1967), *Wall rock alteration, in Geochemistry of hydrothermal ore deposits*, Barnes H.L., ed., Holt, Rinehart and Winstone, p. 166-232, New York

Moechtar, H., Pratomo, I., Mulyana, H., dan Poedjoprajitno, S., (2007), *Gerakan struktur dan kaitannya dengan faktor kendali tektonik, berdasarkan analisis stratigrafi; Studi kasus geologi kuarter terhadap fase perkembangan Danau Tondano purba sepanjang Remboken-Kakas, Kec. Remboken dan Kec. Kakas, Kab. Tomohon, Sulawesi Utara*. Bandung: *Indonesian Journal on Geoscience*, *2*(3), 177-190.

Nicholson, K. (1993), *Geothermal systems. In Geothermal Fluids*, Springer, Berlin: Heidelberg.

Okbatsion, M. A., (2010), *Analysis Of Temperature And Pressure Characteristics Of The Hverahlíd Geothermal Field In The Hengill Geothermal System, Sw-Iceland*, Geothermal Training Programme, United Nations University.

Qarinur, dkk, (2020), *Predictions of Rock Temperature Evolution at the Lahendong Geothermal Field by Coupled Numerical Model with Discrete Fracture Model Scheme,* Energies, 13,3282.

Revil, dkk, (2019), *Induced Polarization of Volcanic Rocks. Imagining Clay Cap Properties In Geothermal Fields*, Geophys. J. Int, 218, 1398-1427.

Reyes, A.G., (1990), *Petrology of Philippines geothermal systems and the application of alteration mineralogy to their assessment*: Journal of Volcanology and Geothermal Research, v. 43, p. 279-309.

Reyes, A.G. (1998) *Petrology and Mineral Alteration in Hydrothermal Systems: from Diagenesis to Volcanic Catastrophes*. United Nations University.

Richards M.C, Blackwell D.D, (2002), *A difcult search: Why basin and range systems are hard to find* Geotherm Resour Council Bull. P. 31:143–6.

Saptadji, N. M. (2002). *Catatan Kuliah "Tenik Panas Bumi"* . Bandung: Penerbit ITB.

Silitonga, S. M., (2016), *Analisis Karakteristik Geologi Bawah Permukaan Berdasarkan Composite Log Serta Data Tekanan dan Suhu Untuk Penentuan Perlakuan Sumur LHD-34*, Lapangan Panas Bumi Lahendong, Sulawesi Utara, Semarang: Universitas Diponegoro.

Simandjuntak T.O.,(1986), *Sedimentology and tectonics of the collision complex in the East arm of Sulawesi*, thesis, University of London, 1986, 346 p.

Siahaan, E.E., 2003, *Geological Map of the Lahendong Geothermal Area*. Pertamina's internal file

Stefánsson, V., dan Steingrímsson, B., (1990), *Geothermal logging I: An introduction to techniques and interpretation (3rd edition) Orkustofnun*, Reykjavík, report OS-80017/JHD-09, 117 pp.

Tester, J. (2006), *The future of geothermal energy*, massachusetts institute of technology.

United Nations Environment Programme, (1982), *Geothermal Energy*. Dalam Robin Clarke, *More Than Enough An Optimistic Assesment of World Energy*, Paris: UNESCO, p. 73-80.

Utami, P., (2011), *Hydrothermal Alteration and the Evolution of the Lahendong Geothermal System*, North Sulawesi: Indonesia. Ph.D. Thesis. The University of Auckland, p: 449 .

White, D.E., (1965), *Geothermal Energy,* Washington: USGS Circular.

Zarrouk, S. J., dan McLean, K., (2019). *Geothermal well test analysis: fundamentals, applications and advanced techniques,* United Kingdom, Academic Press.

L A M P I R A N

TABEL DATA PRESSURE DAN TEMPERATURE TEST SUMUR LHD-A

DEPTH			TEMPERATURE		
mMD	mTVD	mRSL	TEMP/011	PRES/011	BPD/011
			(°C)	(bar)	(°C)
0	0	855.0	29.35	1.96	132.32
100	100.0	755.0	100.70	11.05	187.92
200	200.0	655.0	139.12	20.28	215.39
300	300.0	555.0	154.81	29.28	234.25
400	399.8	455.2	163.51	38.17	249.01
400	499.0	356.0	156.71	46.91	261.20
400	596.1	258.9	94.23	55.83	271.99
400	689.0	166.0	83.32	64.71	281.51
400	777.5	77.5	113.96	73.06	289.61
400	860.7	-5.7	154.76	80.71	296.43
400	940.4	-85.4	216.93	87.62	302.19
400	1019.6	-164.6	270.99	93.77	307.02
400	1100.1	-245.1	289.10	99.67	311.44
400	1182.8	-327.8	279.20	105.68	315.74
400	1265.9	-410.9	264.49	112.00	320.06
400	1346.5	-491.5	268.53	118.17	324.11
400	1426.4	-571.4	271.37	124.22	327.91
400	1509.2	-654.2	273.19	130.42	331.67
400	1550.5	-695.5	274.10	133.54	333.50
400	1591.8	-736.8	274.85	136.66	335.30
400	1632.9	-777.9	275.12	139.76	337.06
1900	1673.7	-818.7	274.38	142.85	338.78
1950	1714.2	-859.2	272.17	145.92	340.46
2000	1754.7	-899.7	268.82	148.99	342.12
2050	1795.2	-940.2	264.52	152.10	343.77
2100	1835.9	-980.9	259.80	155.25	345.40
2150	1877.1	-1022.1	254.80	158.45	347.04
2200	1918.3	-1063.3	250.00	161.67	348.67
2250	1959.5	-1104.5	244.64	164.97	350.30
2300	2000.7	-1145.7	240.16	168.32	351.93
2350	2042.7	-1187.7	235.91	171.72	353.56
2400	2084.9	-1229.9	232.10	175.13	355.17
2450	2127.0	-1272.0	228.77	178.59	356.77
2500	2169.1	-1314.1	225.61	182.09	358.37
2550	2211.5	-1356.5	222.12	185.63	359.95
2600	2253.7	-1398.7	219.29	189.18	361.52
2650	2296.0	-1441.0	216.54	192.77	363.07

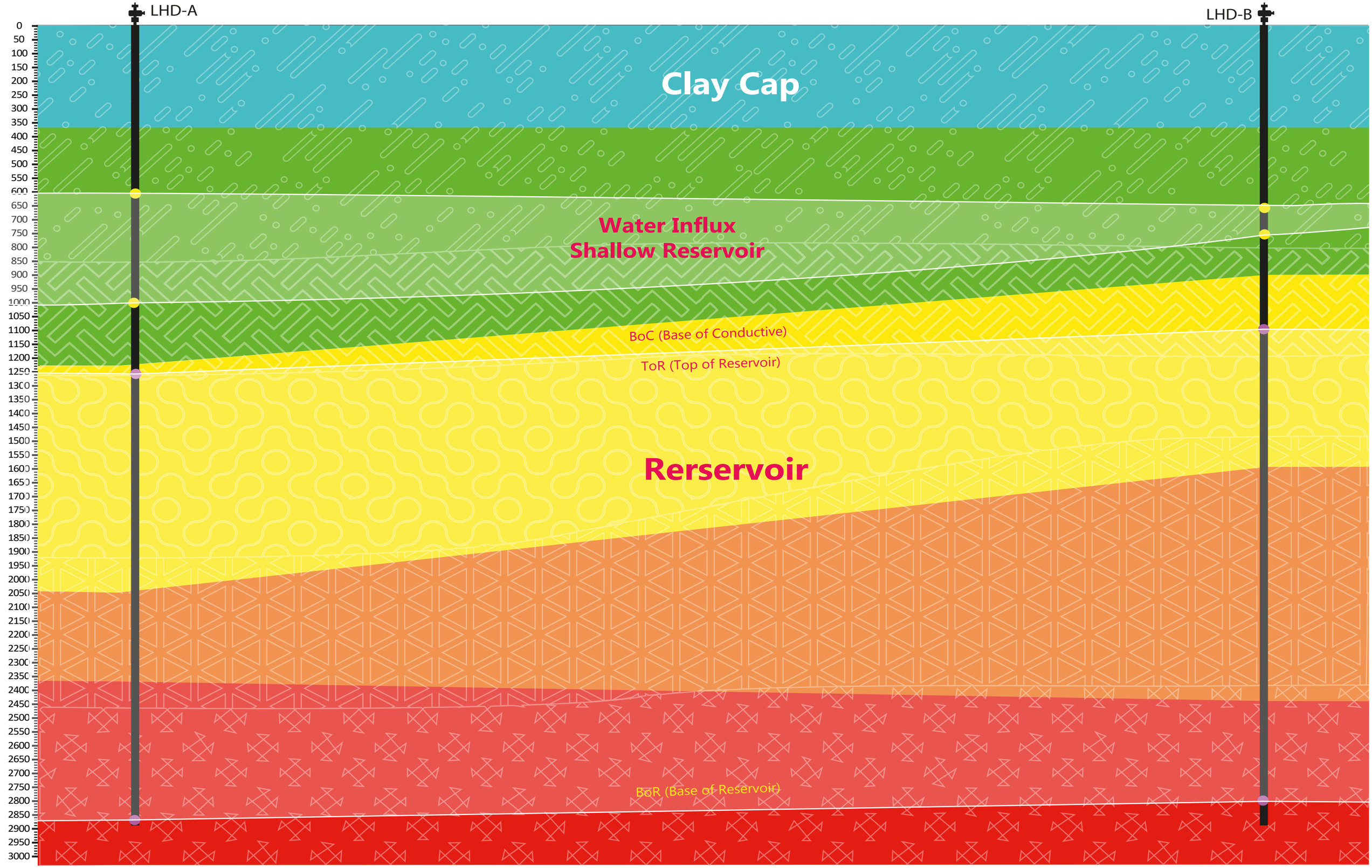
2700	2338.1	-1483.1	214.73	196.34	364.60
2750	2380.1	-1525.1	212.77	199.93	366.11
2800	2422.1	-1567.1	212.42	203.53	367.59
2850	2464.2	-1609.2	212.92	207.11	369.04
2900	2506.2	-1651.2	213.91	210.68	370.47
2950	2507.2	-1652.2	215.80	214.24	371.86

TABEL DATA PRESSURE DAN TEMPERATURE TEST SUMUR LHD-B

DEPTH			TEMPERATURE		
mMD	mTVD	mRSL	TEMP/005	PRES/005	BPD/005
			(°C)	(bar)	(°C)
0	0	855.0	38.46	43.36	256.47
100	100.0	-100.0	101.13	44.11	257.50
200	200.0	-200.0	128.86	44.74	258.34
300	300.0	-300.0	140.70	45.30	259.10
400	399.9	-399.9	157.22	48.12	262.75
500	499.7	-499.7	143.45	57.23	273.57
600	599.1	-599.1	102.14	66.15	282.96
700	696.4	-696.4	106.35	75.34	291.69
800	790.4	-790.4	128.01	84.07	299.27
900	881.5	-881.5	174.30	92.31	305.90
1000	971.5	-971.5	273.24	99.74	311.49
1100	1061.4	-1061.4	306.11	106.13	316.05
1200	1151.6	-1151.6	317.24	112.13	320.15
1300	1242.9	-1242.9	322.69	117.97	323.97
1400	1334.0	-1334.0	327.15	124.00	327.77
1500	1425.0	-1425.0	330.51	129.16	330.91
1600	1516.1	-1516.1	333.61	134.49	334.05
1700	1606.6	-1606.6	334.92	140.00	337.20
1750	1651.7	-1651.7	333.19	142.81	338.76
1800	1696.9	-1696.9	330.43	145.64	340.31
1850	1742.2	-1742.2	326.72	148.53	341.87
1900	1787.6	-1787.6	324.20	151.51	343.46
1950	1833.1	-1833.1	324.33	154.49	345.01
2000	1878.7	-1878.7	320.51	157.51	346.56
2050	1924.1	-1924.1	313.33	160.58	348.12
2100	1969.2	-1969.2	302.60	163.73	349.69
2150	2014.3	-2014.3	284.05	167.01	351.30
2200	2059.3	-2059.3	282.27	170.37	352.92
2250	2104.2	-2104.2	-	-	-
2300	2148.9	-2148.9	-	-	-
2350	2193.5	-2193.5	-	-	-

2400	2237.9	-2237.9	-	-	-
2450	2282.2	-2282.2	-	-	-
2500	2326.5	-2326.5	-	-	-
2550	2370.8	-2370.8	-	-	-
2600	2414.9	-2414.9	-	-	-
2650	2458.9	-2458.9	-	-	-
2700	2502.8	-2502.8	-	-	-
2750	2546.4	-2546.4	-	-	-
2800	2589.9	-2589.9	-	-	-
2850	2633.3	-2633.3	-	-	-
2900	2676.7	-2676.7	-	-	-
2950	2720.2	-2720.2	-	-	-

PENAMPANG BAWAH PERMUKAAN LAPANGAN PANAS BUMI LAHENDONG SUMUR LHD-A DAN LHD-B AWAL BEROPERASI



Reservoir Sebelumnya :

Intermediate Argillic
Advance Argillic
Phyllitic
Outer Prophyllitic
Inner Prophyllitic

Smectite Group
Chloride-Adularia Group (Transition Zone)
Ilite-Smectite Group
Epidote-Serisit Group
Actinolite-Epidote Group

PENAMPANG BAWAH PERMUKAAN LAPANGAN PANAS BUMI LAHENDONG SUMUR LHD-A DAN LHD-B SETELAH BEROPERASI

LHD-A

LHD-B

0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
2050
2100
2150
2200
2250
2300
2350
2400
2450
2500
2550
2600
2650
2700
2750
2800
2850
2900
2950
3000

Clay Cap

Water Influx
Shallow Reservoir

BoC (Base of Conductive)

Tor (Top of Reservoir)

Rerservoir

BoR (Base of Reservoir)

Reservoir saat ini :

Smectite Group

Chloride-Adularia Group (Transition Zone)

Ilite-Smectite Group

Epidote-Serisit Group

Actinolite-Epidote Group

COMPOSITE LOG MINERALISASI SUMUR LHD-A

Litology | Alteration Intencity | Mineral Alterasi: Smkt, Kaol, Ilit, Calt, SecQ, Crsb, Alnt, Adlr, Trid, Aktn, Epdt, Zeol, Pyrt, Seri, SecB, Chlr, Anhd, IOks, Dckt, Wair, Hemt | Temperature (Reyes,1990) | Ataration Zone (Reyes,2000) | Ataration Zone (Corbett & Leach,1998)

Sample Source

- XRD
- Cutting

Alteration Zone

- Intermediate Argillic Alteration
- Advance Argillic Alteration
- Phylitic Alteration
- Inner Propilitic Alteration
- Outer Propilitic Alteration

Lithology

- Andesit Basaltis Terubah
- Breksi Andesit Terubah
- Breksi Tufa Terubah
- Andesit Terubah
- Tufa Terubah

Mineral Zone

- Smectite Zone
- Chloride-Adularia Zone
- Epidote-Anhidrite Zone
- Epidote-Serisit Zone
- Actinolite- Epidote Zone

Alteration Mineral

Smkt=Smektite	SecQ=Secondary Quartz	Aktn=Aktinolite	Wair=Wairakite
Kaol=Kaoline	Krsb=Kristobalite	Epdt=Epidote	SecB=Secondary Biotite
Ilit	Caln=Calsedone	Hemt=Hematite	Chlr=Chlorite
Calt=Calcite	Trid=Tridimite	Pyrt=Pyrite	Anhd=Anhidrite
IOxd=Iron Oxide			

COMPOSITE LOG MINERALISASI SUMUR LHD-B

Litology

Alteration Intencity (0, 50, 100)

Mineral Alterasi: Smkt, Kaol, Ilit, Calt, SecQ, Krsb, Alnt, Adlr, Trid, Aktn, Epdt, Zeol, Pyrt, Seri, SecB, Chlr, Anhd, IOks, Plg, Wair, Hmt

Temperature (Reyes,1990) (0, 50, 100, 150, 200, 250, 300, 350)

Ataration Zone (Reyes,2000)

Ataration Zone (Corbett & Leach,1998)

0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 2100 2150 2200 2250 2300 2350 2400 2450 2500 2550 2600 2650 2700 2750 2800 2850 2900 2950 3000

Sample Source

- XRD
- Cutting

Alteration Zone

- Intermediate Argillic Alteration
- Advance Argillic Alteration
- Phylitic Alteration
- Inner Propilitic Alteration
- Outer Propilitic Alteration

Lithology

- Andesit Basaltis Terubah
- Breksi Andesit Terubah
- Breksi Tufa Terubah
- Andesit Terubah
- Tufa Terubah

Mineral Zone

- Smectite Zone
- Chloride-Adularia Zone
- Epidote-Anhidrite Zone
- Epidote-Serisit Zone
- Actinolite- Epidote Zone

Alteration Mineral

Smkt=Smektite	SecQ=Secondary Quartz	Aktn=Aktinolite	Wair=Wairakite
Kaol=Kaoline	Krsb=Kristobalite	Epdt=Epidote	SecB=Secondary Biotite
Ilit	Caln=Calsedone	Hemt=Hematite	Chlr=Chlorite
Calt=Calcite	Trid=Tridimite	Pyrt=Pyrite	Anhd=Anhidrite
IOxd=Iron Oxide			