DAFTAR PUSTAKA

Anyadike, N., (2002), Nickel: An Industry on the Brink of Expansion, Cambridge: Woodhead Publishing.

Arif, I., (2018). *Nikel Indonesia*. PT Gramedia Jakarta, p. 92 – 119.

Asy'ari, M.A., Hidayatullah, R., Zulfadli, A., (2013), ―Geologi dan estimasi sumberdaya nikel laterit menggunakan metode ordinary kriging di PT. Aneka Tambang, Tbk‖, *Jurnal INTEKNA Tahun XIII*, 1, 7-15.

Barkas, J. (2010). Drivers and Risks for Nickel Demand Still Relying on China, (May).

Brand, N. W., Butt, C., R., M., *and* Elias, M., (1998), *Nickel laterites: classification and features AGSO Journal of Australian Geology & Geophysics*, 17 (4), 81-88.

Butt, C. R. & Cluzel, D., 2013. Nickel Laterite Ore Deposits: Weathered serpentinites. *Elements An International magazine of Mineralogy, Geochemistry, and Petrology*, Volume 9, pp. 123-128.

Das, G. K., & de Lange, J. A. B., 2011. Reductive atmospheric acid leaching of West Australian smectitic nickel laterite in the presence of sulphur dioxide and copper (II). Hydrometallurgy, 105(3), 264–269.

Davis, J. R. (2000). *ASM Specialty Handbook: Nickel, Cobalt, and Their Alloys*. Ohio, Ohio: ASM International.

Dry M., 2015, Technical & Cost Comparison Of Laterite Treatment Processes Part 3, *Proceedings Of Alta 2015 Nickel-Cobalt-Copper Conference*, 6th Annual Nickel-Cobalt-Copper Event

Elias, M. (2002). Nickel Laterite Deposits - Geological Overview, Resources, and Exploitation. *CODES Special Publication 4*, 205-220.

ESDM, K., 2020. *Bijih Nikel Tidak Boleh Diekspor Lagi Per Januari 2020*, Jakarta: Kementerian Energi dan Sumber Daya Mineral Republik Indonesia.

Fan, R., *and* Gerson, A., R., (2013), Mineralogical Characteridation of Indonesia Laterites Prior to and post Atmospheric Leaching, *Hidrometallurgy*, 134-135, 102-109.

Febrini, V., R. & G., 2014. Pengaruh Kalsinasi Terhadap Struktur Kristal Serpentin yang Terhadap di Jorong Sungai Padi Nagari Lubuak Gadang Kecamatan Sangkir Kabupaten Solok Selatan. *Pillar Of Physics*, 4 November.pp. 97-104.

Golightly, J.P. (1981). Nickeliferous laterite deposits. Economic Geology. 75. 710-735.

Granda, A.G., Lapidus, G.T., 2018. *The effect of calcination as pre treatment to enchance the nickel extraction from low-grade laterites*. Minerals Engineering 120, Pp127-131.

Gupta, C.K. and Mukherjee., 1991, *Hydrometalurgy in Extraction Processes, Vol. I.* CRC Press., London.

Hannis, S.; & Bide, T. (2009). *Mineral Profile Cobalt*. Nottingham, England, United Kingdom: British Geological Survey.

John Edward Cantle. (1982). *Atomic Absorption Spectrometry*. New York: Elsevier Science Publishing Company Inc.

Kusuma, G., D., (2012), Pengaruh Reduksi *Roasting* dan Konsentrasi *Leaching* Asam Sulfat Terhadap *Recovery* Nikel dari Bijih Limonit, Program Studi Teknik Metalurgi Dan Material, UI, Depok.

Kyle, J., (2010), *Nickel Laterite Processing Technologies*, ALTA 2010 Nickel/Cobalt/Copper.

LAPI ITB. 2013. *Laporan Akhir: Kajian Tekno-Ekonomi Pembangunan Pabrik Pengolahan dan Pemurnian di Indonesia-Komoditas Nikel.* Jakarta: LAPI ITB & API-IMA.

Li, G., Rao, M., Li, Q., Peng, Z., & Jiang, T., 2010. Extraction of cobalt from laterite ores by citric acid in presence of ammonium bifluoride. Transaction of nonferrous metals societyof China, 8(12), 1517–1520.

Loye, H., (2013), X-ray Difraction How It Works, University of South Carolina, Caroline.

Luo, J., Li, G., Rao, M., Peng, Z., Zhang, Y., & Jiang, T., 2015. Atmospheric leaching characteristics of nickel and iron in limonitic laterite with sulfuric acid in the presence of sodium sulfite. Minerals Engineering, 78, 38–44.

M., T., Zainuri, M. & D., 2012. UJI SRD DAN XRD PADA BAHAN MENERAL (BATUAN DAN PASIR) SEBAGAI SUMBER MATERIALCERDAS (CaCO3 DAN SiO2). *Jurnal Penelitian Fisika dan Aplikasinya (JPFA)*, JUni, Volume 2, p. 1.

McDonald, R. G., Whittington, B. I., (2008). *Atmospheric Acid Leaching of Nickel Laterites Review Part I. Sulphuric acid Technologies*. Hydrometallurgy 91, Pp35-55.

McDonald, R.G., Whittington, B.I., (2008), *"Atmospheric acid leaching of nickel laterites review : Part II. Sulphuric acid technologies"*, *Hydrometallurgy*, 91,56-69.

McGraw-Hill. (2003). *Dictionary of Scientific & Technical Terms 6E*. https://encylopedia2.thefreedictionary.com/Leaching. Diakses pada tanggal 09 Oktober 2023.

Mcrae, M., E., (2019), *Nickel statistics and information*, U.S. Geological Survey, Mineral Commodity Summaries: USA,

http//www.usgs.gov/centers/nmic/nickel-statistics-and-information. Diakses pada tanggal 11 Oktober 2023.

Meshram, M., Abhilash , and Pandey, B.D., (2019), Advanced Review on Extraction of Nickel from Primary and Secondary Sources, *Mineral Processing And Extractive Metallurgy Review 2019*, Vol. 40, No. 3, 157–193.

Mudd, G.M., (2010), Global trends and environmental issues in nickel mining: sulfides versus laterites, Ore Geol. Rev. 38 (1–2), 9–26.

Munasir, Triwikantoro, Zainuri, M. & Darminto, 2012, *Uji XRD dan XRF pada Bahan Mineral (Batuan dan Pasir) Sebagai Sumber Material Cerdas ($CaCO_3$ dan SiO_2)* Jurnal Penelitian Fisika dan Aplikasinya, 2 (1).

Nayiroh, N., (2014). Analisis Puncak Difraksi Sinar X ., https://academia-edu/bagaimana-cara-mengindetifikasikan-mineral-dari-pattern-xrd/file/pdf., Diakses pada tanggal 15 Oktober 2023.

Nicholls, D., (1973), The Chemistry of Iron, Cobalt and Nickel Comprehensive Inorganic Chemistry. United Kingdom: Pergamon.

Oxley, A., Barcza, N., (2013), *Hydro-Pyro Integration In The Processing Of Nickel Laterites, Minerals Engineering*, 1-12.

Pournaderi, S., (2014), *Optimization of Ferronickel Production from SIvrIhIsar Nickel Laterite Ore (Doctor of Philoshopy)*, Middle East Technical Univrsity, Ankara.

Prasetyo, P., 2016. Tidak Sederhana Mewujudkan Industri Pengolahan Nikel Laterit Kadar Rendah di Indonesia Sehubungan dengan Undang-Undang MINERBA 2009. *Jurnal Teknologi Mineral dan Batubara*, 12(3), pp. 195-207.

Prasetyo, P., dan Ronald, N., (2011), Masih Terbukanya Peluang Penelitian Proses Caron Untuk Mengolah Nikel Laterit Kadar Rendah Di Indonesia, *Majalah Metalurgi, 26*, 35-44.

Rodrigues, F. M., (2013), *Investigation Into The Thermal Upgrading Of Nickeliferous Laterite Ores.* A thesis submitted to the Robertbuchan Departement of Mining In Corminity with the requirements for The degree of Master of applied Sciece, Queens University, Kingston, Toronto, Canada.

Rudi Subagja, F. Firdiyono,.(2016). “Kinetika reaksi pelarutan nikel dari hasil reduksi nikel laterit,” *Metalurgi.*, Vol. 30, No. 2.

Sari, N.K., (2010), *Analisa Instrumentasi*, Klaten: Yayasan Humaniora. Cantle, J.E., 1982. Techniques And Instrumentation In Analytical Chemistry - Volume 5 Atomic Absorption Spectrometry. New York: Elsevier.

Setiawan, I., (2016), Pengolahan Nikel laterit Secara Pirometalurgi: Kini dan Penelitian Kedepan, *Seminar Nasional Sains dan Teknologi 2016*, 8 November, p, 1.

Shirane, Y., Kawahara, M., Mitsune, Y., 1983. *The mechanism of liberation of nickel oxide from garnierite ore by means of adding iron steam roasting*. Journal of the mining and metallurgical institute of Japan 99, Pp999-1003.

Shofi, A.S., (2003). Pembuatan nickel pig iron (NPI) dari bijih nikel laterit Indonesia menggunakan blast furnace LIPI di UPT Balai Pengolaha Mineral Lampung-LIPI‖, Laporan Akhir Insentif Riser SINas 2013.

Stoeppler, M. (1980). Analisis nikel dalam bahan biologis dan perairan alami. Dalam: Nriagu, JO ed. Nikel di lingkungan, New York, Chichester, Brisbane, Toronto, John Wiley & Sons, hal.661-821.

Sufriadin, 2013. *Mineralogi, Geokimia dan sifat "Leaching" pada endapan laterit Nikel Soroako, Sulawesi Selatan, Indonesia.* Yogyakarta: Universitas Gadjah Mada.

Sukla, L. B., Das, R. P., 1987. *Kinetics of nickel dissolution from roasted laterites*. Transaction of the Indian Institute of Metals 40, Pp351-353.

Sutisna, D.T., Sunuhadi, D.N., Pujobroto, A., Herman, D.Z., (2006), ―Perencanaan eksplorasi cabakan nikel laterit di daerah Wayamli, Teluk Buli, Halmahera Timur sebagai model perencanaan eksplorasi cebakan nikel laterit di Indonesia‖, *Buletin Sumber Daya Geologi Volume 1 Nomor 3*, 48—56.

Thubakgale, C. K., Mbaya, R. K. & Kabongo, K., 2012. Leaching Behavior of a Low-grade South African Nickel Laterite. *International Journal of Chemical, Nuclear, Material and Metallurgica; Engineering* , 6(8), pp. 761-765.

Udristioiu, A. A. B. E. G. and Aboul. E. H. Y.(2015). "X-Ray Diffraction:Instrumentation and Applications," *Crit. Rev. Anal. Chem.*, vol. 45, no. 4, hlm. 289–299.

Widyawati. (2012). Prinsip Kerja XRD., http://academiaedu/search/-prinsipkerjax raydiffraction,, diakses pada tanggal 03 Agustus 2022.

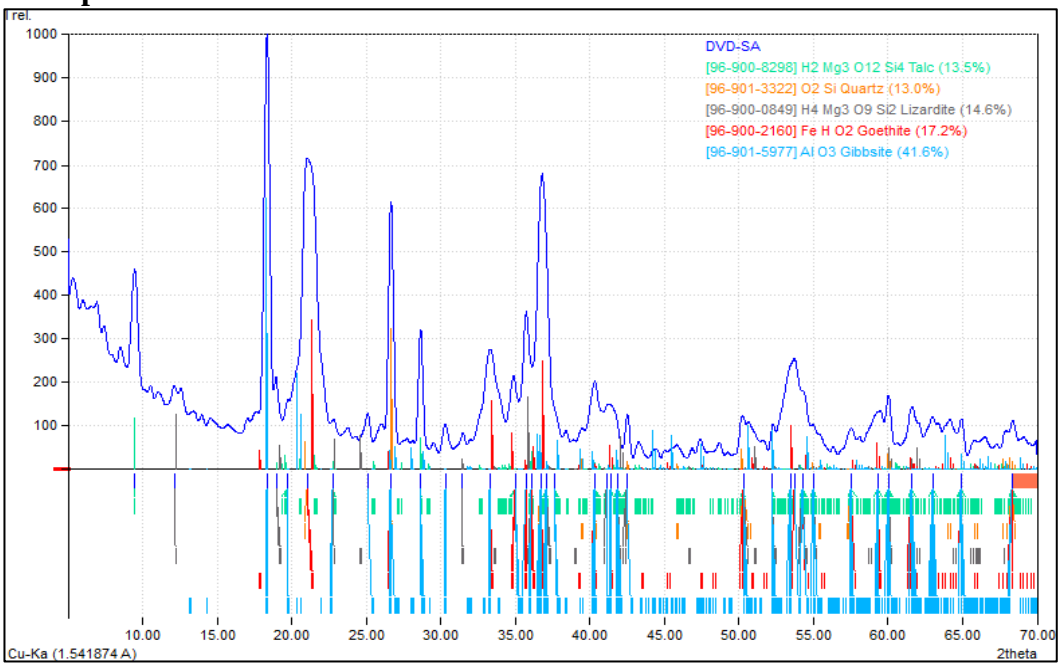
Zhu, D.Q., Cui, Y., Vining, K., Hapugoda, S., Douglas, J., Pan, J., & Zheng, G.L., (2012). Upgrading low nickel content laterite ores using selective reduction followed by magnetic separation. Elsevier International Journal of Mineral Processing, Australia.

LAMPIRAN

LAMPIRAN A

HASIL ANALISIS XRD (*X-Ray Diffraction*)

Sampel Awal



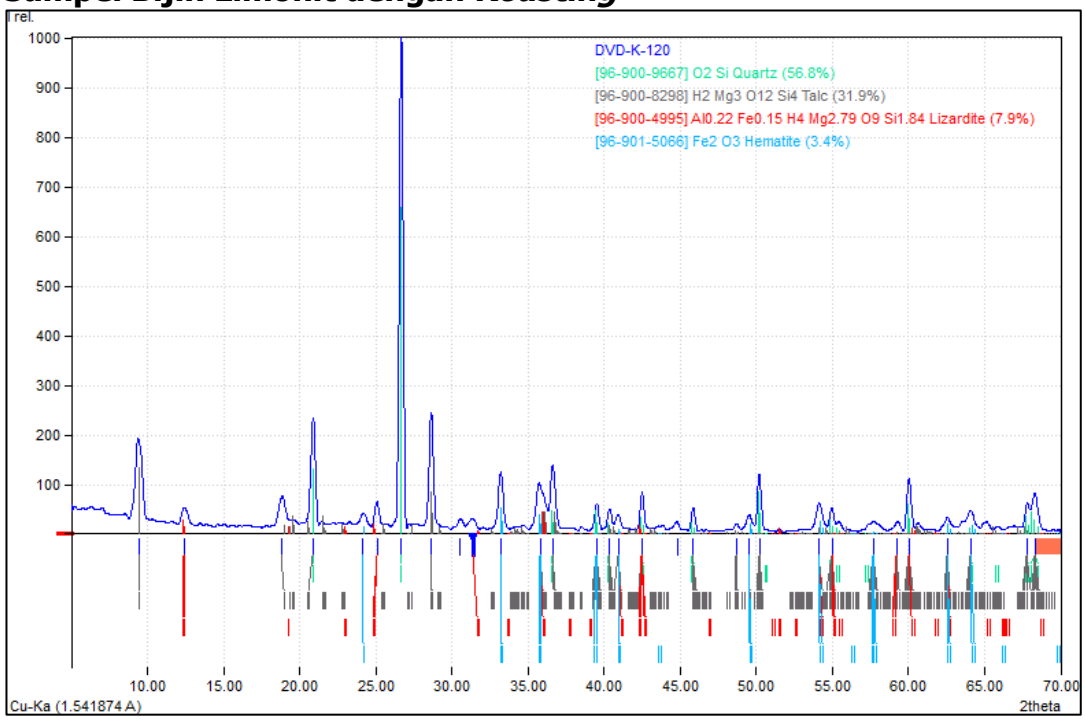
Index	*Amount (%)*	*Name*	*Formula sum*	*Element*	*Amount (weight %)*
A	13.5	Talc	H2 Mg3 O12 Si4	*O*	*54.2%(*)*
B	13.0	Quartz	O2 Si	Al	15.0%
C	14.6	Lizardite	H4 Mg3 O9 Si2	Si	13.1%
D	17.2	Goethite	Fe H O2	Fe	10.8%
E	41.6	Gibbsite	Al O3	Mg	6.5%
	2.0	*Unidentified peak area*		*H*	*0.5%(*)*

Peak List

No.	*2theta [°]*	*d [Å]*	*I/I0 (peak height)*	*Counts (peak area)*	*FWHM*	*Matched*
1	9.48	9.3291	288.34	20.75	0.4128	A
2	12.14	7.2906	52.73	6.02	0.6550	C
3	18.35	4.8343	1000.00	68.84	0.3948	E
4	19.02	4.6673	84.70	4.84	0.3277	A,C
5	19.68	4.5111	6.83	0.26	0.2200	A,E
6	21.10	4.2106	700.21	118.38	0.9697	B,D
7	22.80	3.9004	37.61	3.66	0.5579	A,C,E
8	25.11	3.5463	101.56	2.59	0.1461	E
9	26.67	3.3429	667.58	34.36	0.2952	B,D,E

No.	*2theta [°]*	*d [Å]*	*I/I0 (peak height)*	*Counts (peak area)*	*FWHM*	*Matched*
10	28.66	3.1153	333.68	14.84	0.2551	A,E
11	30.32	2.9484	48.23	1.85	0.2200	E
12	31.46	2.8437	19.38	0.62	0.1825	C
13	33.28	2.6922	219.56	31.14	0.8135	D,E
14	34.98	2.5651	124.30	42.41	1.9569	A,D,E
15	35.72	2.5141	511.48	19.62	0.2200	C,D,E
16	36.11	2.4873	148.17	5.68	0.2200	A,C,D,E
17	36.75	2.4456	571.21	63.19	0.6345	A,B,D,E
18	37.10	2.4236	218.94	19.85	0.5201	A,C,E
19	37.68	2.3873	0.53	0.02	0.2200	A,E
20	40.36	2.2348	150.17	37.96	1.4500	A,B,D,E
21	41.16	2.1932	62.90	1.66	0.1510	A,C,E
22	41.42	2.1800	90.20	4.04	0.2567	A,D,E
23	41.84	2.1591	150.96	5.79	0.2200	A,C,E
24	42.50	2.1271	153.02	4.87	0.1824	A,B,C,E
25	50.34	1.8127	94.05	15.26	0.9306	A,B,C,D,E
26	52.22	1.7517	51.90	15.41	1.7027	A,C,E
27	53.46	1.7126	254.65	19.53	0.4400	A,D,E
28	53.74	1.7043	157.99	12.12	0.4400	A,D,E
29	54.26	1.6892	136.75	10.49	0.4400	A,C,D,E
30	55.02	1.6690	144.20	5.53	0.2200	A,B,C,E
31	57.56	1.6012	58.15	7.19	0.7094	A,B,D,E
32	59.29	1.5585	98.96	20.49	1.1876	A,D,E
33	60.04	1.5409	125.10	5.33	0.2446	A,B,C,E
34	61.62	1.5052	96.86	15.87	0.9398	A,C,D,E
35	63.06	1.4742	70.59	26.41	2.1462	A,D,E
36	64.90	1.4367	89.63	5.16	0.3305	A,D,E
37	68.34	1.3726	58.18	10.67	1.0515	A,B,D,E

Sampel Bijih Limonit dengan *Roasting*



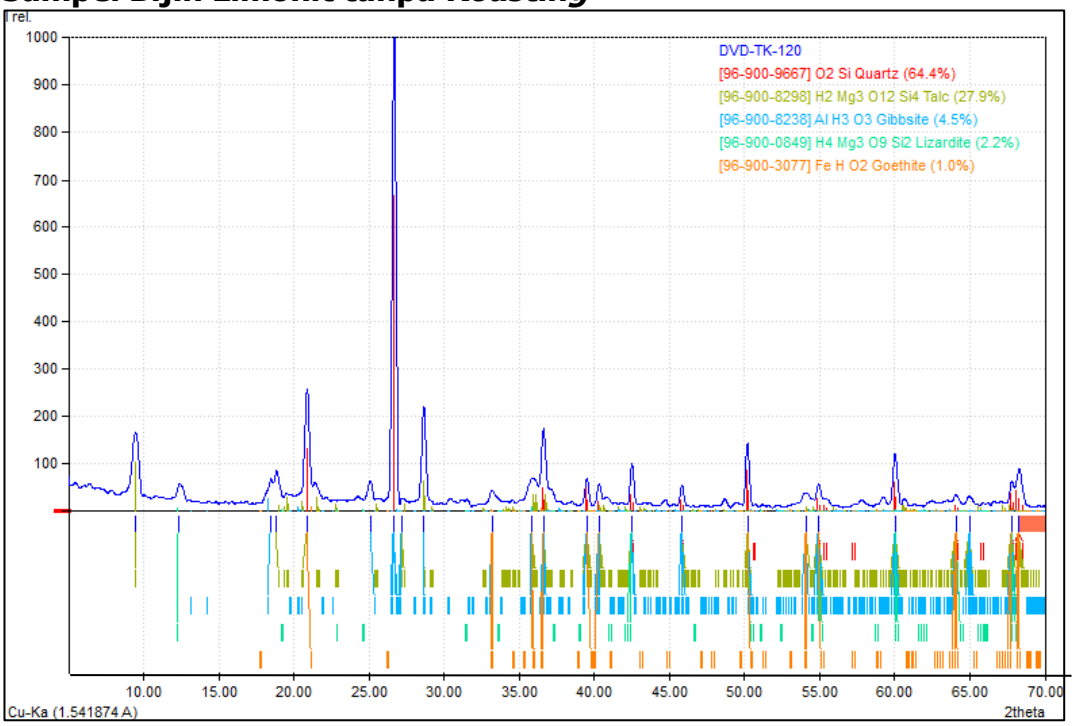
Index	*Amount (%)*	*Name*	*Formula sum*	*Element*	*Amount weight (%)*
A	56.8	Quartz	O2 Si	Si	37.4%
B	31.9	Talc	H2 Mg3 O12 Si4	Mg	8.0%
C	7.9	Lizardite	Al0.22 Fe0.15 H4 Mg2.79 O9 Si1.84	Fe	2.6%
D	3.4	Hematite	Fe2 O3	*H*	*0.3%(*)*
	10.8	*Unidentified peak area*		Al	0.2%

Peak List

No.	*2theta [°]*	*d [Å]*	*I/I0 (peak height)*	*Counts (peak area)*	*FWHM*	*Matched*
1	9.44	9.3698	162.53	101.16	0.4450	B
2	12.45	7.1105	32.33	17.44	0.3857	C
3	18.86	4.7060	58.49	37.08	0.4533	B
4	20.89	4.2525	221.05	94.75	0.3065	A,B
5	24.17	3.6817	26.97	14.56	0.3858	D
6	25.08	3.5509	50.77	19.87	0.2798	C
7	26.68	3.3412	1000.00	361.32	0.2583	A
8	28.65	3.1160	234.30	93.98	0.2868	B
9	30.54	2.9272	19.33	9.98	0.3692	
10	31.42	2.8472	18.43	8.99	0.3487	C
11	33.21	2.6976	115.71	53.11	0.3282	D
12	35.80	2.5080	88.44	70.39	0.5691	B,C,D
13	36.63	2.4530	123.45	55.15	0.3194	A,B

No.	*2theta [°]*	*d [Å]*	*I/I0 (peak height)*	*Counts (peak area)*	*FWHM*	*Matched*
14	39.52	2.2802	52.75	18.48	0.2505	A,B,D
15	40.36	2.2347	41.09	14.08	0.2450	A,B
16	40.93	2.2051	29.26	13.91	0.3399	B,C,D
17	42.51	2.1268	75.45	26.51	0.2512	A,B,C
18	44.80	2.0231	16.32	7.47	0.3273	
19	45.86	1.9789	45.24	15.44	0.2440	A,B
20	48.70	1.8698	13.15	5.38	0.2926	B
21	49.51	1.8409	31.26	14.92	0.3412	B,D
22	50.20	1.8173	116.26	40.87	0.2514	A,B
23	54.13	1.6943	54.94	32.57	0.4238	B,C,D
24	54.97	1.6704	42.03	19.98	0.3398	A,B,C
25	57.70	1.5977	16.05	21.48	0.9568	B,D
26	59.26	1.5593	17.37	7.65	0.3151	B,C
27	60.03	1.5411	104.09	42.28	0.2904	A,B,C
28	62.56	1.4849	23.42	15.07	0.4599	B,C,D
29	64.08	1.4532	37.71	28.16	0.5338	A,B,D
30	67.79	1.3824	45.33	19.04	0.3004	A,B
31	68.29	1.3735	69.78	42.30	0.4334	A,B

Sampel Bijih Limonit tanpa *Roasting*



Index	*Amount (%)*	*Name*	*Formula sum*	*Element*	*Amount (weight %)*
A	64.4	Quartz	O2 Si	*O*	*52.7%(*)*
B	27.9	Talc	H2 Mg3 O12 Si4	Si	38.8%
C	4.5	Gibbsite	Al H3 O3	Mg	6.0%
D	2.2	Lizardite	H4 Mg3 O9 Si2	Al	1.5%
E	1.0	Goethite	Fe H O2	Fe	0.6%
	14.1	*Unidentified peak area*		*H*	*0.4%(*)*

Peak List

No.	*2theta [°]*	*d [Å]*	*I/I0 (peak height)*	*Counts (peak area)*	*FWHM*	*Matched*
1	9.46	9.3449	138.41	82.93	0.4407	B
2	12.38	7.1498	32.91	19.59	0.4378	D
3	18.48	4.8012	52.33	42.35	0.5952	C
4	18.84	4.7103	58.24	60.08	0.7587	B
5	20.89	4.2521	244.00	109.26	0.3294	A,B,E
6	25.08	3.5510	50.10	25.84	0.3793	C
7	26.69	3.3404	1000.00	362.75	0.2668	A,C
8	27.20	3.2786	13.70	4.95	0.2749	B,C
9	28.66	3.1151	212.85	81.89	0.2830	B,C
10	33.26	2.6936	30.13	26.02	0.6353	C,E
11	35.86	2.5043	54.01	51.50	0.7013	B,C,D,E
12	36.64	2.4530	150.13	72.20	0.3537	A,B,C,E

No.	*2theta [°]*	*d [Å]*	*I/I0 (peak height)*	*Counts (peak area)*	*FWHM*	*Matched*
13	39.51	2.2807	60.33	19.73	0.2406	A,B,C,E
14	40.34	2.2358	47.55	17.40	0.2691	A,B,C,E
15	42.52	2.1263	94.60	30.21	0.2349	A,B,C,D
16	45.84	1.9795	45.71	14.93	0.2403	A,B,C
17	50.20	1.8173	138.73	45.95	0.2436	A,B,C,D,E
18	54.08	1.6957	27.57	21.64	0.5774	B,C,D,E
19	54.95	1.6709	42.19	23.68	0.4128	A,B,C,D,E
20	60.03	1.5413	112.10	44.38	0.2912	A,B,C,D
21	64.07	1.4535	21.42	11.68	0.4012	A,B,C,D,E
22	64.98	1.4352	19.83	9.63	0.3573	B,C
23	67.78	1.3826	40.87	12.92	0.2325	A,B,C,D,E
24	68.28	1.3737	70.64	41.68	0.4340	A,B,E

LAMPIRAN B
HASIL ANALISIS AAS

AISPEKTRA LABORATORY SERVICES (ALS)
Office : Kompeks Taman Telkomas
Jl Telkom IX Blok C/250, Makassar 90245 Sulawesi Selatan
Telp/Fax. +62 8994478 Email : info@aispektra.co.id

LAPORAN ANALISIS
(Report of Analyisis)

NO. SERTIFIKAT : 000172023
PELANGGAN : PHETER DAVID

SAMPEL : ORE NICKEL
KETERANGAN SAMPEL : Botol Packing (Cair) dan Plastic Packing (Padat)

TANGGAL TERIMA : 21 April 2023
TANGGAL ANALISA : 14 Mei 2023
METODE ANALISA : AAS (Atomic Absorption Spectroscopy)

Result

Kode Sampel	Hasil Analisa				Remarks
	Ni (mg/kg)	Co (mg/kg)	Fe (mg/kg)	Al (mg/kg)	
ORE	8249.78	783.09	-	-	

Kode Sampel	Hasil Analisa				Remarks
	Ni (mg/L)	Co (mg/L)	Fe (mg/L)	Al (mg/L)	
K30	290.78	20.68	-	-	
TK30	159.85	19.51	-	-	
K60	296.58	23.41	-	-	
TK60	168.98	20.44	-	-	
K90	349.20	25.22			
TK90	220.22	22.81			
K120	371.42	29.48			
TK120	232.75	24.71			

HASIL ANALISA TERSEBUT DIATAS HANYA MERUJUK PADA SAMPEL YANG DISERAHKAN DIMANA PENGAMBILAN SAMPEL TERSEBUT TIDAK DILAKUKAN OLEH AISPEKTRA LABORATORY

Analis

ARHAM

LAMPIRAN C

PERHITUNGAN KADAR NI DAN CO

Kadar Ni dan Co dihitung dengan rumus sebagai berikut:

$$\text{Kadar (\%)} = \frac{\text{Hasil AAS (mg/Kg) x fp x volume (Kg)}}{\text{massa sampel (mg)}} \text{ x } 100\%$$

1. Kadar sampel awal

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/Kg) x fp x volume (Kg)}}{\text{massa sampel (mg)}} \text{ x } 100\%$$

$$\text{Kadar Ni (\%)} = \frac{8249{,}78\ (\text{mg/Kg}) \times 0{,}01(\text{Kg})}{10000(\text{mg})} \times 100\%$$

$$\text{Kadar Ni (\%)} = 0{,}82\%$$

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/Kg) x fp x volume (Kg)}}{\text{massa sampel (mg)}} \text{ x } 100\%$$

$$\text{Kadar Co (\%)} = \frac{783{,}09\ (\text{mg/Kg}) \times 0{,}01(\text{Kg})}{10000(\text{mg})} \times 100\%$$

$$\text{Kadar Co (\%)} = 0{,}08\%$$

2. *Roasting* 30 menit

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = \frac{290{,}78\ (\text{mg/L}) \times 0{,}10(\text{L})}{10000(\text{mg})} \times 100\%$$

$$\text{Kadar Ni (\%)} = 0{,}29078\%$$

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = \frac{20{,}68\ (\text{mg/L}) \times 0{,}10(\text{L})}{10000(\text{mg})} \times 100\%$$

Kadar Co (%) = 0,02068%

3. *Roasting* 60 menit

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = \frac{296{,}58\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Ni (%) = 0,29658%

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = \frac{23{,}41\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Co (%) = 0,02341%

4. *Roasting* 90 menit

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = \frac{349{,}20\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Ni (%) = 0,3492%

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100$$

$$\text{Kadar Co (\%)} = \frac{25{,}22\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Co (%) = 0,02522%

5. *Roasting* 120 menit

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = \frac{371{,}42\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Ni (%) = 0,37142%

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = \frac{29{,}48\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Co (%) = 0,02948%

6. Tanpa *Roasting* 30 menit

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = \frac{159{,}85\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Ni (%) = 0,15985%

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = \frac{19{,}51\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Co (%) = 0,01951%

7. Tanpa *Roasting* 60 menit

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = \frac{168{,}98\text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Ni (%) = 0,16898%

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = \frac{20{,}44\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

Kadar Co (%) = 0,02044%

8. Tanpa *Roasting* 90 menit

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = \frac{220{,}22\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = 0{,}22022\%$$

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = \frac{22{,}81\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = 0{,}02281\%$$

9. Tanpa *Roasting* 120 menit

$$\text{Kadar Ni (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = \frac{232{,}75\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

$$\text{Kadar Ni (\%)} = 0{,}23275\%$$

$$\text{Kadar Co (\%)} = \frac{\text{Hasil AAS (mg/L)} \times \text{fp} \times \text{volume (L)}}{\text{massa sampel (mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = \frac{24{,}71\ \text{(mg/L)} \times 0{,}10\text{(L)}}{10000\text{(mg)}} \times 100\%$$

$$\text{Kadar Co (\%)} = 0{,}02471\%$$

LAMPIRAN D

PERHITUNGAN LAJU EKSTRAKSI NI DAN CO

Laju ekstraksi Ni dan Co dapat dihitung dengan rumus sebagai berikut:

$$\text{Laju ekstraksi} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

1. *Roasting* 30 menit

$$\text{Laju ekstraksi Ni} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Ni} = \frac{0{,}29078\%}{0{,}82\%} \times 100\%$$

Laju ekstraksi Ni = 35,46%

$$\text{Laju ekstraksi Co} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Co} = \frac{0{,}02068\%}{0{,}08\%} \times 100\%$$

Laju ekstraksi Co= 25,85%

2. *Roasting* 60 menit

$$\text{Laju ekstraksi Ni} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Ni} = \frac{0{,}29658\%}{0{,}82\%} \times 100\%$$

Laju ekstraksi Ni = 36,16%

$$\text{Laju ekstraksi Co} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

Laju ekstraksi Co $= \frac{0{,}02341\%}{0{,}08\%} \times 100\%$

Laju ekstraksi Co= 29,26%

3. *Roasting* 90 menit

Laju ekstraksi Ni $= \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$

Laju ekstraksi Ni $= \frac{0{,}3492\%}{0{,}82\ \%} \times 100\%$

Laju ekstraksi Ni = 42,58%

Laju ekstraksi Co $= \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$

Laju ekstraksi Co $= \frac{0{,}02522\%}{0{,}08\%} \times 100\%$

Laju ekstraksi Co = 31,52%

4. *Roasting* 120 menit

Laju ekstraksi Ni $= \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$

Laju ekstraksi Ni $= \frac{0{,}37142\%}{0{,}82\%} \times 100\%$

Laju ekstraksi Ni = 45,29%

Laju ekstraksi Co $= \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$

Laju ekstraksi Co $= \frac{0{,}02948\%}{0{,}08\%} \times 100\%$

Laju ekstraksi Co = 36,85%

5. Tanpa *Roasting* 30 menit

$$\text{Laju ekstraksi Ni} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Ni} = \frac{0{,}15985\%}{0{,}82\%} \times 100\%$$

$$\text{Laju ekstraksi Ni} = 19{,}49\%$$

$$\text{Laju ekstraksi Co} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Co} = \frac{0{,}01951\%}{0{,}08\%} \times 100\%$$

$$\text{Laju ekstraksi Co} = 24{,}38\%$$

6. Tanpa *Roasting* 60 menit

$$\text{Laju ekstraksi Ni} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Ni} = \frac{0{,}16898\%}{0{,}82\%} \times 100\%$$

$$\text{Laju ekstraksi Ni} = 20{,}60\%$$

$$\text{Laju ekstraksi Co} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Co} = \frac{0{,}02044\%}{0{,}08\%} \times 100\%$$

$$\text{Laju ekstraksi Co} = 25{,}55\%$$

7. Tanpa *Roasting* 90 menit

$$\text{Laju ekstraksi Ni} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Ni} = \frac{0{,}22022\%}{0{,}82\%} \times 100\%$$

$$\text{Laju ekstraksi Ni} = 26{,}85\%$$

$$\text{Laju ekstraksi Co} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Co} = \frac{0{,}02281\%}{0{,}08\%} \times 100\%$$

$$\text{Laju ekstraksi Co} = 28{,}51\%$$

8. Tanpa *Roasting* 120 menit

$$\text{Laju ekstraksi Ni} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Ni} = \frac{0{,}23275\%}{0{,}82\%} \times 100\%$$

$$\text{Laju ekstraksi Ni} = 28{,}38\%$$

$$\text{Laju ekstraksi Co} = \frac{\text{Kadar hasil pelindian}}{\text{Kadar awal}} \times 100\%$$

$$\text{Laju ekstraksi Co} = \frac{0{,}02471\%}{0{,}08\%} \times 100\%$$

$$\text{Laju ekstraksi Co} = 30{,}88\%$$

LAMPIRAN E

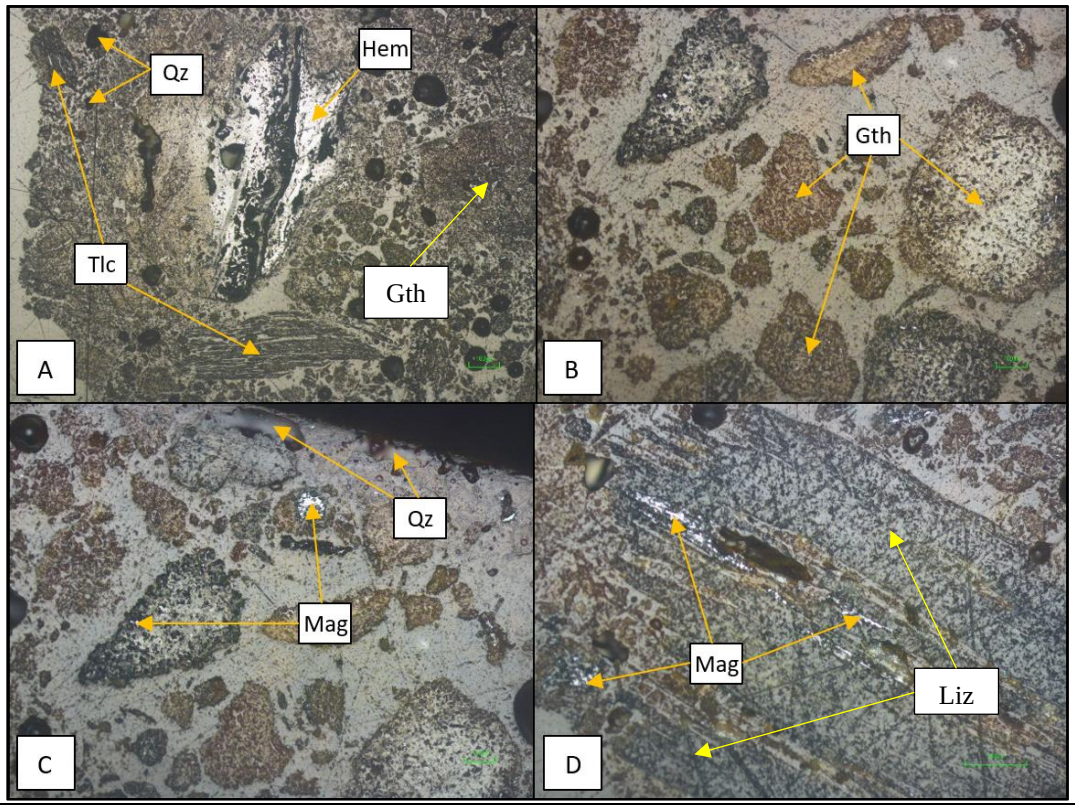
HASIL ANALISIS MIKROSKOPIS

Lokasi sampel : PT	**Kode Sampel : SA**
Tipe Mineralisasi	**: Tersebar**
Mineral Bijih	**: goetit, kuarsa, talk, hematit dan magnetit**

Deskripsi Mineralogi Bijih

Kenampakan mikroskopis memperlihatkan mineral goetit, kuarsa, talk, hematit, magnetit, dan lizardit

Foto



Komposisi Mineral	Jumlah (%)	Keterangan optik mineral
Goetit (Gth)		Sistem kristal ortorombik, berwarna hitam kecoklatan dengan bentuk (*subhedral*), ukuran mineral yang tampak yaitu 50 µm-100 µm.
Talk (Tlc)		Sistem kristal trigonal, berwarna abu-abu kehijauan (*anhedral-subhedral*), ukuran mineral yang tampak yaitu 30 µm-70 µm
Kuarsa (Qz)		Sistem kristal trigonal, putih abu-abu terang dengan bentuk (*anhedral-subhedral*), ukuran mineral yang tampak yaitu 20 µm-40 µm
Hematit (Hem)		sistem kristal trigonak, berwarna abu-abu terang hingga kuning dengan bentuk (*anhedral-subhedral*). ukuran mineral yang tampak yaitu 20 µm-50 µm
Magnetit (Mag)		Sistem kristal isometrik, berwarna putih keabu-abuan dengan bentuk (*subhedral*), ukuran mineral yang tampak yaitu 10 µm-40 µm
Lizardit (Liz)		Sistem kristal trigonal, berwarna abu-abu terang hingga kuning dengan bentuk (*anhedral-subhedral*). ukuran mineral yang tampak yaitu 85 µm-95 µm