Geochemistry of Selected Coal Samples from Sumatra, Kalimantan, Sulawesi, and Papua, Indonesia

By Harvey E. Belkin and Susan J. Tewalt

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Harvey E. Belkin, Eastern Energy Resources Team, 956 National Center,
U.S. Geological Survey, Reston, VA 20192 phone: 703 648 6162 email hbelkin@usgs.gov

Susan J. Tewalt, Eastern Energy Resources Team, 956 National Center,
U.S. Geological Survey, Reston, VA 20192 phone: 703 648 6437 email stewalt@usgs.gov

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Cover photograph = Kaltrim Prima Mine adapted from http://*www.petrosea.com*

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Appendix A

Excel Spreadsheet
A series of spreadsheets that includes;

Conversion Factors

Multiply	By	To obtain
Length		
mile (mi)	1.609	kilometer (km)
kilometer (km)	0.6215	mile (mi)
foot (ft)	0.3048	meter (m)
meter (m)	3.2808	foot (ft)
Mass		
ton, short (2,000 lb)	0.9072	megagram (Mg) or ton, metric (Mt)
ton, long (2,240 lb)	1.016	megagram (Mg) or ton, metric (Mt)
megagram (Mg) or ton, metric (Mt)	1.102	ton, short (2,000 lb)
megagram (Mg) or ton, metric (Mt)	0.907	ton, long (2,240 lb)
pound, avoirdupois (lb)	0.4536	kilogram (kg)
kilogram (kg)	2.2046	pound, avoirdupois (lb)
Volume		
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic meter (m^3)	35.311	cubic foot (ft^3)

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Introduction

Indonesia is an archipelago of more than 17,000 islands that stretches astride the equator for about 5,200 km in southeast Asia (figure 1) and includes major Cenozoic volcano-plutonic arcs, active volcanoes, and various related onshore and offshore basins. These magmatic arcs have extensive Cu and Au mineralization that has generated much exploration and mining in the last 50 years. Although Au and Ag have been mined in Indonesia for over 1000 years (van Leeuwen, 1994), it was not until the middle of the nineteenth century that the Dutch explored and developed major Sn and minor Au, Ag, Ni, bauxite, and coal resources. The metallogeny of Indonesia includes Au-rich porphyry Cu, porphyry Mo, skarn Cu-Au, sedimentary-rock hosted Au, epithermal Au, laterite Ni, and diamond deposits. For example, the Grasberg deposit in Papua has the world's largest gold reserves and the third-largest copper reserves (Sillitoe, 1994).

Coal mining in Indonesia also has had a long history beginning with the initial production in 1849 in the Mahakam coal field near Pengaron, East Kalimantan; in 1891 in the Ombilin area, Sumatra, (van Leeuwen, 1994); and in South Sumatra in 1919 at the Bukit Asam mine (Soehandojo, 1989). Total production from deposits in Sumatra and Kalimantan, from the 19th century to World War II, amounted to 40 million metric tons (Mt). After World War II, production declined due to various factors including politics and a boom in the world-wide oil economy. Active exploration and increased mining began again in the 1980's mainly through a change in Indonesian government policy of collaboration with foreign companies and the global oil crises (Prijono, 1989).

This recent coal revival (van Leeuwen, 1994) has lead Indonesia to become the largest exporter of thermal (steam) coal and the second largest combined thermal and metallurgical (coking) coal exporter in the world market (Fairhead and others, 2006). The exported coal is desirable as it is low sulfur and ash (generally <1 and < 10 wt.%, respectively). Coal mining for both local use and for export has a very strong future in Indonesia although, at present, there are concerns about the strong need for a major revision in mining laws and foreign investment policies (Wahju, 2004; United States Embassy Jakarta, 2004).

The World Coal Quality Inventory (WoCQI) program of the U.S. Geological Survey (Tewalt and others, 2005) is a cooperative project with about 50 countries (out of 70 coal-producing countries world-wide). The WoCQI initiative has collected and published extensive coal quality data from the world's largest coal producers and consumers. The important aspects of the WoCQI program are; (1) samples from active mines are collected, (2) the data have a high degree of internal consistency with a broad array of coal quality parameters, and (3) the data are linked to GIS and available through the world-wide-web. The coal quality parameters include proximate and ultimate analysis, sulfur forms, major-, minor-, and trace-element concentrations and various technological tests. This report contains geochemical data from a selected group of

Indonesian coal samples from a range of coal types, localities, and ages collected for the WoCQI program.

Indonesia Coal

Indonesia has significant coal resources. In 2000, the Directorate of Coal, Ministry of Energy and Mineral Resources (United States Embassy Jakarta, 2000) estimated coal deposits at 38.8 billion Mt with 21.1 billion Mt in Kalimantan, 17.8 billion Mt in Sumatra, and the balance in Sulawesi, Java, and Papua. Table 1 shows the breakdown among resources, reserves, and operators as of 2000. Recent 2006 estimates by the Directorate of Mineral, Coal, and Geothermal Resources puts the resource potential at 57 billion Mt (Setiawan, 2006).

In 2005 (Setiawan, 2006), the distribution of coal mining operators was as follows: State-owned enterprises – 2 companies; private national companies – 65 companies; and foreign mining companies – 18 companies. Indonesia has achieved an impressive growth rate in coal production and export in the last 20 years. Exports equaled six million Mt in 1991 whereas in 2005, Indonesia exported 93 million Mt (Setiawan, 2006) with a total production of 134 million Mt. Indonesia has grown from the position in 1992 of sixth largest exporter of thermal coal (Sherer, 1994) to be the largest thermal coal exporter and the second largest combined metallurgical and thermal coal exporter after Australia in 2005 (Fairhead and others, 2006); Indonesian export coal is lower in ash and particularly sulfur than most Australian export coal (Fairhead and others, 2006). The Indonesia export is primarily to Japan and Taiwan, with lesser amounts to South Korea, the Philippines and China (Hong Kong). The number of coal terminals is now 17 with a capacity between 5,000 and 200,000 DWT (deadweight tons) with plans for increasing access and shipping potential as coal export increases.

Most of the coal deposits are geologically young (Cenozoic) and this is reflected in their rank distribution: lignite – 58%; sub-bituminous – 27%; bituminous – 14%; and anthracite - <0.5% (U.S. Embassy Jakarta, 2000). Most of the coal mined for export has heat values that range from 5,000 to 7,000 kcal/kg, with low ash and sulfur (United States Embassy Jakarta, 2000). Low grade coals are characterized by high moisture contents (20 to 40 %) and a low calorific value of less than 5,000 kcal/kg.; these coals are currently considered uneconomic for export due to a high moisture content. Kalimantan has higher quality coal and is the site for much exploration and development although certain areas such as Papua with pressing energy needs are also being explored and developed.

Geology of Indonesian Coal Basins

Early Paleogene rifting along the margins of Sundaland, a back-arc setting of the Indian Ocean plate (Kusnama and others, 1993; Cole and Crittenden, 1997), produced various shallow basins. Initial fluviatile sequences were followed by coastal plain and/or lacustrine deposits depending on location. The lithologies that were deposited, probably starting in Early Eocene, includes carbonate, clastics and coal. Coal sequences of Eocene age are known from the following basins: Barito (Central Kalimantan), Pasir and Asam Asam (South and East Kalimantan), Upper Kutai [also spelled Kutei] (East and Central Kalimantan), Melawi and Ketungau (West Kalimantan), Tarakan (East Kalimantan), Ombilin (West Sumatera), Central Sumatra Basin (Riau), and generally thin coal seams from small basins in Java and South Sulawesi.

Marine transgression and deposition ended the Early-Paleogene rifting and coal-forming environment. After this extensive transgression, uplift and compression led to basin formation by the Middle Miocene. Miocene (and perhaps younger) coal-bearing sequences are being mined from Kutai [also spelled Kutei] Basin (Kalimantan), Barito Basin (Central Kalimantan), South Sumatra Basin (South Sumatra), Bengkulu Basin (Bengkulu), and in the Tarakan Basin (East Kalimantan). The Miocene coal is exceptionally low ash and sulfur and is low rank unless affected by igneous activity. Their environment of formation has been modeled whereby ombrogenous peat formed above the water table producing coals free from the influence of water-borne detritus and sulfur input from brackish waters similar to modern ombrogenous peat deposits in Indonesia (e.g., Cobb and Cecil, 1993; Esterle and Ferm, 1994).

The Paleogene and Neogene Indonesian export coals are markedly low ash and sulfur. Details of their petrogenesis has been extensively studied in order to understand the environment of formation that leads to this characteristic (Cobb and Cecil, 1993) and for more detailed discussion of their local geologic setting, the reader is referred to Friederich and others (1999) and Soehandojo (1989) and references therein. The majority of coal currently mined in Indonesia is derived from Eocene and Miocene strata from two islands, Sumatra and Kalimantan. Cenozoic coal-bearing sequences also exist in Java and Sulawesi and Neogene (Steenkool Formation) and Permian coal occurs in Papua (Figure 2).

Sample Location

The run-of-mine or representative exploration-site samples (~1 kg each) (Table 2) described in this report were collected in 2000 by Hadiyanto, now Director of Mineral Resources Inventory, Directorate of Mineral Resources Inventory, Ministry of Energy and Mineral Resources, Directorate General of Geology and Mineral Resources, Bandung, Indonesia. For the sample locations, we have used the most recent Indonesian province designations; seven provinces were created since 2000 and where appropriate, we also give the former province name. Figure 1 indicates the sample location.

Sample Description

Sample CQ01

The Ombilin mine, located 57 km northeast of Padang, West Sumatra is owned by state-owned PT Tambang Batubara Bukit Asam (PTBA) and includes both underground and surface operations mining Eocene age coal. The underground mine uses a long-wall retreating system with semi-mechanized equipment, operated manually, and long-wall fully mechanized equipment, operated hydraulically. The open mine uses a back filling system with truck and loader. The sample CQ01 is from the open-pit operation.

The Ombilin Basin, a small (20 x 60 km) Paleogene onshore basin, is located just west of the much larger Central Sumatra Basin. It contains thick Eocene to Miocene marine and terrestrial sediments that share a similar tectonic and stratigraphic history which is similar to all of the rift basins on Sumatra. The economic coal occurs within the Eocene Sawahlunto Formation which is composed of gray mudstone and siltstone and coal seams with minor quartz-rich sandstone (Friederich and others, 1999). Three coals seams, locally up to 8 m thick, occur in the upper part of the Sawahlunto Formation and are the main units mined.

Sample CQ02

The local state-owned PT Tambang Batubara Bukit Asam (PTBA) currently mines a Miocene age coal deposit at Banko (also spelled Bangko). The South Sumatra coal basin is one of the most important coal mining regions in Indonesia (Thomas, 2005). This basin is tectonically active and the coal in some parts has been affected by igneous activity. The basin formed in Early Paleogene as a back-arc basin northeast of the Barisan Mountains. The Oligocene to middle Miocene Gumai Formation is composed of fossiliferous marine shale with thin, glauconitic limestone that represents a rapid, widespread maximum transgression. The middle Miocene Air Benakat Formation was deposited during the regression that ended deposition of the Gumai Shale. The Air Benakat Formation changes upward from deep marine to shallow marine conditions. Marine glauconitic clays decrease in frequency and marine sands increase. The formation ranges from 1,000 to 1,500 m thick. Coal beds mark the upper contact with the overlying Muara Enim Formation. The average porosity of the sandstone is 25% (Bishop, 2000). The Late Miocene to Pliocene Muara Enim Formation, also known as the Middle Palembang Formation, was deposited as shallow marine to continental sands, muds, and coals. The formation thins to the north from a maximum of 750 m in the south. Uplift of the Barisan Mountains provided source terrains for clastics from the south and southwest during deposition of the Muara Enim Formation (Bishop, 2000). The Muara Enim Formation is the main coal-bearing unit being mined.

Sample CQ03

The exploration site of Kota Tengah has sampled coal of Miocene to Pliocene age. The exploration site is in the South Sumatra basin and the geological description is the same as for sample CQ02.

Sample CQ04

The Kandui village exploration site is located in Central Kalimantan Province in the North Barito district, Gunung Timang subdistrict, which has large reserves of high-quality Miocene age coal. Recently Mitrais Mining News (2005) indicated that two companies, CV Sigma Tunggal Perkasa with 1,000 hectares and CV Anugerah Baratama with 3,494 hectares, have concession areas in the Kandui village in the Gunung Timang district.

Sample CQ05

The Kaltim Prima coal mine, operated by Kaltim Prima Coal PT (KPC), the largest Indonesian coal mine, is owned by an Indonesian Company, PT Bumi Resources, who bought out British Petroleum (BP) and Rio Tinto coal-mining interests in 2003. This operation in Sangatta (also spelled Sangata), East Kalimantan, has produced Miocene age thermal coal from the initiation of operations in 1991. Plans for expansion to the nearby Bengalon area were announced in 2004 (Mining-Technology.com, 2006). A total of 13 seams range in thickness from 1 to 15 m; typically in the range of 2.4 to 6.5 m. Seam dips vary from 3º to 20º at the outcrop. The coal occurs in the Balikpapan and Pulubalang Formations and the three main coal seams are called Kedapat, Pinang, and Sangatta (Soehandojo, 1989). The coal is generally low-ash and low-sulfur and has low in-situ moisture content. In some parts, the coal rank has been increased, by igneous intrusion, to a high-volatile bituminous coal. As of mid-2004, PT Bumi cited reserves at 462 million Mt at Sangatta, plus 157 million Mt at Bengalon. The company also has measured and indicated resources of some 2,200 Mt (Mining-Technology.com, 2006).

Sample CQ06

The Senakin mine, South Kalimantan, operated by PT Arutmin Indonesia mines Eocene age coal. This economically important coal occurs near the base of the T2 member of the Tanjung Formation The laterally continuous basal coal unit is up to 9 m thick, but is more typically 4 to 6 m (Friederich and others, 1999). The lower part of the Eocene seam is low in sulfur, whereas the upper part has higher levels due to increased pyrite content or subsequent sulfate alteration. The coal bed varies vertically in ash and sulfur content but this variation is laterally consistent and predictable (Friederich and others, 1995). At Senakin (also spelled Senaking), the workings are two underground operations. The concession area, known as Kalimantan Block 6, covers narrow strips of land in the southeast corner of Kalimantan Island plus the northern tip of neighboring Pulau Laut Island. PT Arutmin operates other nearby mines at Satui and Batulicin.

Sample CQ07

The Timika coal sample, Papua, is from an exploration site along the southern or Australasian plate side of the main suture zone in western New Guinea. This coal is Permian age and the associated floras have Gondwana affinities as described by Rigby (1998). Permian coal in West Irian Jaya (the province west of Papua) also has been investigated as source rock for oil and gas (Sutriyono and Hill, 2000). Coal production in the Mimika regency containing the Timika site is important to support the PT Freeport Indonesia Company and the mining in the Tembagapura district. In May 2006, PLN (Perusahaan Listrik Negara; Indonesia State Electricity Company) announced an additional coal-fired power project in Timika with a capacity of 14 MW (United States Embassy Jakarta, 2006).

Sample CQ08

The Malawa exploration locality is situated near the Palae river, a tributary of the Batuputih, near the village of Telampenua, South Sulawesi. The geology consists of mainly sandstones, slates, marls, and some greywackes. Intercalated with these rocks are layers or lenses of coal, some of which are up to 1.5 m thick. Together these form the Malawa Formation of Eocene age. It overlies unconformably the Balangbura Formation of Cretaceous age and is itself overlain conformably by the limestone of the Tonasa Formation (Radja, 1970). These formations are part of an early Paleogene rift basin that extends offshore of South Sulawesi and has been the target of oil and gas exploration (Cucci and others, 1994).

Methods

The following methods used to determine parameters shown in Appendix A are routine and are fully described in ASTM (2004): proximate analysis D3172, ultimate analysis hydrogen, carbon, and nitrogen D5373, ultimate analysis sulfur D4239, ultimate analysis oxygen D3176, ultimate analysis ash D3174, heating value (BTU/lb) D 1989, forms of sulfur D2492, free swelling index D720, ash fusion D1857 and mercury D6414 method A. Major, minor, and trace elements, selenium, and chlorine analyses were done at the U.S. Geological Survey using in-house techniques (Bullock and others, 2002).

Geochemistry

The discussion of coal geochemistry will be in two parts, (1) proximate-ultimate analysis, and (2) trace elements with emphasis on the hazardous air pollutants (HAPS) elements.

Analytical data of Indonesian coals that provide proximate and ultimate data (ASTM, 2004), which are important to characterize thermal and metallurgical coals, can be found in publications (e.g., Soehandojo, 1989; Friederich and others, 1999; Amijaya, 2005; Thomas, 2005) and in tabulation on internet web-sites (e.g., APBI-ICMA, 2006). The rank classification assigned to our Indonesian coal samples is based on ASTM (2004) standard D388; rank classifications for similar Indonesian coal samples in the literature may differ somewhat. Table 3 summarizes these proximate analytical values for the eight samples.

The values shown in Table 3 and Appendix A are consistent with published values for active mining locations and with the coal geology in exploration sites in Indonesia (APBI-ICMA, 2006). Paleogene coals tend to be bituminous rank; younger Neogene coals are sub-bituminous and lignite. Exceptions, coal of higher rank, are likely to be Neogene coals affected by tectonic and igneous activity.

South Sumatra basin, a region with shallow Neogene coals, has Plio-Pleistocene igneous activity in some areas. Thermal metamorphism associated with this activity has increased the coal rank from sub-bituminous to bituminous and anthracite (Susilawati and Ward, 2006). Sample CQ02, from Banko, has been affected by this metamorphism and is now a high volatile bituminous coal. Sample CQ01, a high volatile bituminous coal from Ombilin, is from a small basin in a tectonically active area in West Sumatra. Some Ombilin coal has been affected by local andesite intrusions and their proximity has increased the coal rank up to anthracite (Darman and Sidi, 2000).

Trace element geochemistry of coal is extremely important to assess and model coal combustion and the potential for pollution. The 1990 Amendments (United States Public Law, 1990) to the 1970 Clean Air Act name 189 substances as hazardous air pollutants (HAPS), including 14 elements or their compounds found in coal in trace concentrations. We have determined various minor and trace elements in the coal samples (Appendix A). Table 4 shows a comparison of the HAPs element abundance in the studied Indonesian coals compared to the world range and U.S. coal average (Swaine, 1990; Finkelman, 1993). For all elements, the abundance in the 8 Indonesian coal samples is in the lower part of the world range. This is especially noticeable for those elements that are usually related to the ash content such as Pb and Sb. In addition, those HAPS elements with usual organic affinities, such as Be, also tend to be in low abundance. Inspection of all the trace element data in Appendix A shows generally low concentrations of all trace elements. We know of no other published trace element data for Indonesian coals, although meeting talks featuring data may have been given (Sappel and Hariyanto, 2004).

Coalbed Methane Prospective

Although the coal from Indonesia tends to be shallow and low rank, conventional oil and gas wells that drill though the coal seams tend to experience blow outs and log gas spikes, both good indicators for coalbed methane (CBM). A recent assessment of the potential CBM resources in Indonesia identified 12.7 trillion m^3 (450 Tcf) within eleven onshore basins (Stevens and Hadiyanto, 2004). More detailed analysis of the coal rank, geochemistry, and geology in Indonesia has led to an increased estimate in Indonesia CBM potential (Nugroho and Arsegianto, 1993; Stevens and others, 2001; Stevens and Hadiyanto, 2004). Stevens and Hadiyanto (2004) ranked six basins with high CBM potential; South Sumatra basin, Central Sumatra basin, Barito basin, Kutei basin, Berau basin, and North Tarakan basin. They recommend testing, using in-country mining rigs to drill expendable core holes, for coal seam gas measurement content and permeability followed by production pilot wells. The government of Indonesia is moving rapidly to settle the regulations and terms for CBM production, as the demand for clean energy in Indonesia continues to grow. Accurate coal characterization is critical and necessary to support CBM research and development.

Future of Indonesia Coal

Indonesia coal export and production is expected to steadily increase for the following reasons: (1) the coal is environmentally friendly (low ash and low sulfur); (2) the emerging domestic and international market for coal (Indonesia has an energy shortage and has plans to increase power production through coal-fired plants); (3) with the high petroleum prices increasing coal demand, especially in Asia, Indonesia is well suited geographically to supply the Asia-Pacific region; and (4) at present, Indonesia is economically and politically stable. In Indonesia, growth in coal production will also be driven by an expansion of supply to the domestic sector for the power industry, cement plants, and the pulp industry. While falling in most regions, coal's contribution to the fuel mix is expected to rise significantly in the ASEAN (Association of South East Asian Nations, comprising Brunei, Cambodia, Indonesia, Lao People's Democratic Republic, Myanmar, Malaysia, the Philippines, Singapore, Thailand and Viet Nam) region. The shift to coal fired generation in the ASEAN region —particularly in Malaysia and Thailand — is driven by the development of independent power projects and energy security considerations that are leading to a shift from lignite and oil to sub-bituminous and/or bituminous coal-fired generation and, to a lesser extent, natural gas in the fuel mix (Ekawan and others, 2006). Currently, the abundant Indonesian lignite (calorific value < 5000 kcal/kg) is uneconomic although the Indonesian Government is developing plans to utilize lignite for (1) mine-mouth power plants, (2) upgrading to higher caloric values, and (3) coal briquettes (Umar and others, 2005). This scenario of increased production, domestic use, and export of Indonesian coal will require more detailed coal geochemistry and petrography to adequately characterize the current mines and future exploration seams.

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Figures

Figure 1. Map showing the location of the 8 Indonesian coal samples.

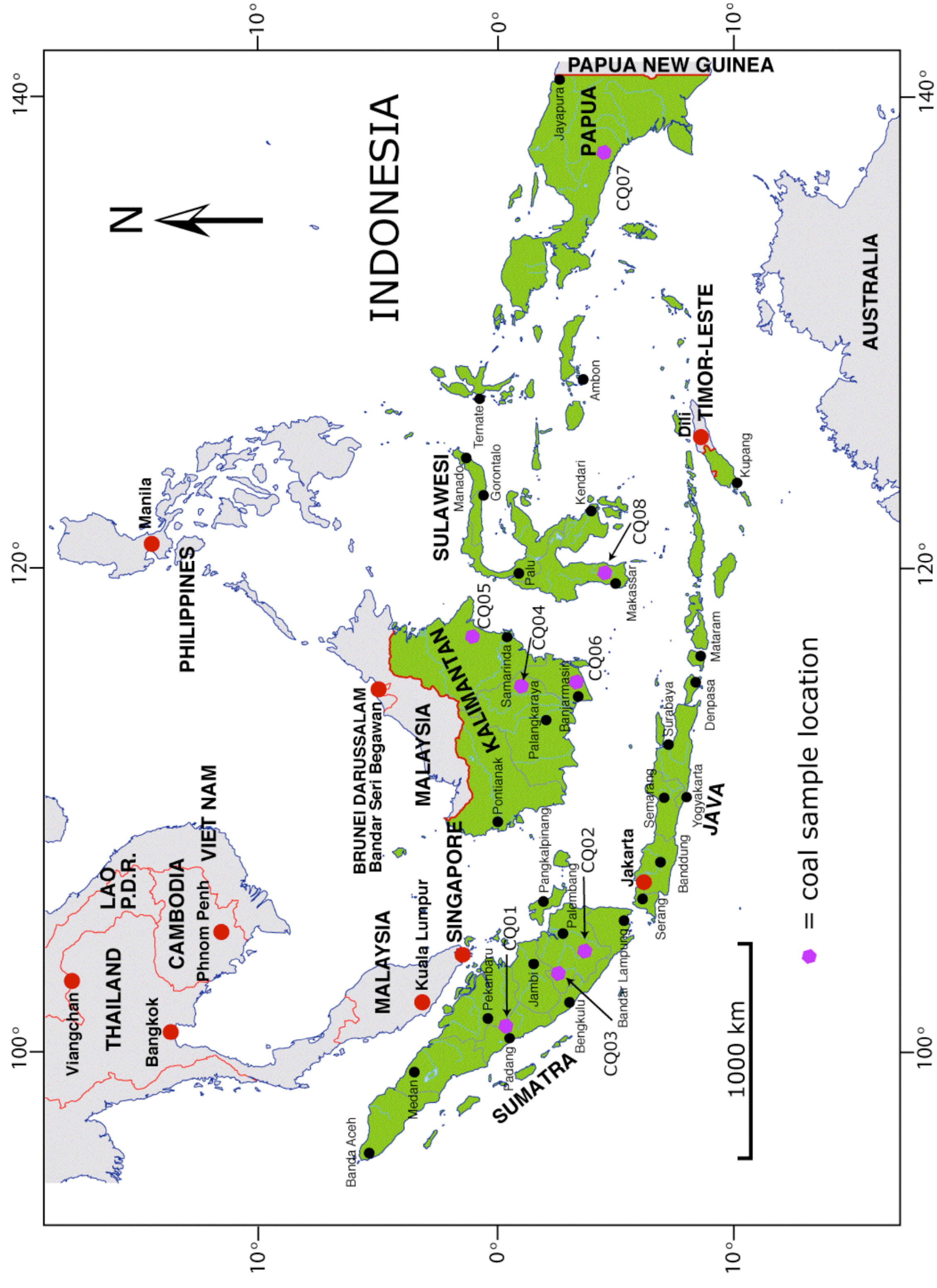
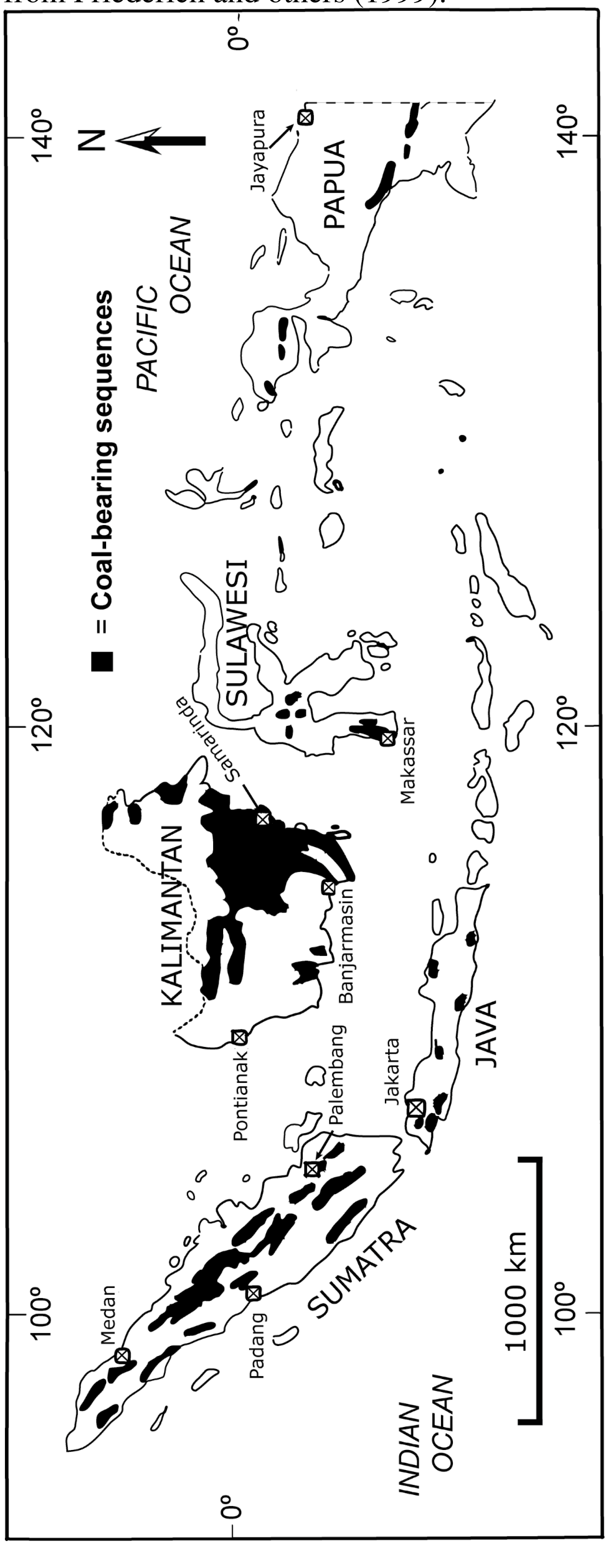


Figure 2. Map showing the generalized location of coal-bearing sequences in Indonesia. Adapted from Friederich and others (1999).



Tables

Table 1. Estimated resources and reserves (1,000 Mt) of Indonesian coal.

Operator	Resources			Mineable
	Measured	Indicated	Total	Reserves
PTBA	1,902	4,657	6,559	2,804
Contractors	8,998	22,185	31,183	2,054
Others	584	442	1,026	504
Total	11,484	27,284	38,768	5,362

PTBA = State Coal Company, Source = United States Embassy Jakarta 2000.

Table 2. Locations of eight coal samples from Indonesia.

Sample	Location or Mine name	Province	Province Indonesian name	Latitude	Longitude
CQ01	Ombilin	West Sumatra	Sumatera Barat	0^0 40' S	100^0 45' E
CQ02	Banko	South Sumatra	Sumatera Selatan	3^0 45' S	103^0 47' E
CQ03	Kota Tengah	South Sumatra	Sumatera Selatan	2^0 25' S	103^0 15' E
CQ04	Kandui	Central Kalimantan	Kalimantan Tengah	1^0 20' S	115^0 10' E
CQ05	Sangatta	East Kalimantan	Kalimantan Timur	0^0 27' N	117^0 35' E
CQ06	Senakin	South Kalimantan	Kalimantan Selatan	2^0 58' S	116^0 16' E
CQ07	Timika	Papua	Papua (formerly Irian Jaya)	4^0 42' S	136^0 55' E
CQ08	Malawa	South Sulawesi	Sulawesi Selatan	4^0 50' S	119^0 52' E

Table 3. Proximate analyses and apparent rank of Indonesia coal samples.

Sample	Total moisture wt.%	Ash wt.%	Volatile matter wt.%	Fixed carbon wt.%	Sulfur wt.%	Calorific value kcal/kg	Apparent rank
CQ01	3.10	7.33	42.8	46.7	0.51	7340	high volatile *A* bituminous
CQ02	18.0	9.68	39.9	32.4	0.24	4780	sub-bituminous *B*
CQ03	9.68	10.1	41.0	39.3	2.21	6290	high volatile *C* bituminous
CQ04	26.5	5.38	33.0	35.1	1.00	4610	sub-bituminous *C*
CQ05	19.4	4.33	35.0	41.3	0.37	5580	sub-bituminous *B*
CQ06	5.29	12.6	42.6	39.5	0.79	6490	high volatile *B* bituminous
CQ07	5.23	3.54	7.48	83.8	0.61	7500	semi-anthracite
CQ08	48.3	2.99	25.4	23.3	0.14	3280	lignite *B*

All values on an as-received basis except rank which is estimated from a moist, mineral-matter-free basis

Table 4. HAPS element comparison.

Element	World coal* range (ppm)	U.S. Coal** mean (ppm)	8 Indonesia samples mean (ppm)	range (ppm)
Sb	0.05-10	1.2	0.29	0.06-0.79
As	0.5-80	24	3.6	0.4-11
Be	0.1-15	2.2	0.54	0.13-1.5
Cd	0.1-3	0.47	0.02	0.01-0.04
Cl	50-2000	614	260	<150-300
Cr	0.5-60	15	7.4	1.1-24.9
Co	0.5-30	6.1	3.6	1.2-9.2
Pb	2-80	11	3	0.4-10
Mn	5-300	43	88	3.6-246
Hg	0.02-1	0.17	0.10	0.02-0.19
Ni	0.5-50	14	7.3	0.8-16
Se	0.2-1.4	2.8	0.64	0.24-1.4
Tl	<0.2-1	1.2	0.12	0.01-0.49
U	0.5-10	2.1	0.49	0.19-1.2

* Swaine, 1990, Table 6.1; ** Finkelman, 1993, Table 1
arithmetic means
all values are whole-coal as-determined on air-dried or oven-dried basis

Appendix A

Excel Spreadsheets

A series of spreadsheets that includes;

1. Sample information.
2. Proximate-Ultimate data, on an as-received basis.
3. Element data, on a dry, whole-coal basis.
4. Ash oxide data on a dry ash basis.
5. Element data, original, as-determined ash basis, except for Hg, Se, and Cl which are on an as-determined whole-coal basis.
6. Quality Assurance and Quality Control data.

APPENDIX A

SAMPLE INFORMATION						
Field no.	Coal area description	Age	Source	Collector	Latitude	Longitude
Indonesia-CQ01	Ombilin, West Sumatra	Eocene	existing mining	Hadiyanto	0^{0} 40' S	100^{0} 45' E
Indonesia-CQ02	Banko, South Sumatra	Miocene	existing mining	Hadiyanto	3^{0} 45' S	103^{0} 47' E
Indonesia-CQ03	Kota Tengah, South Sumatra	Miocene	exploration	Hadiyanto	2^{0} 25' S	103^{0} 15' E
Indonesia-CQ04	Kandui, Central Kalimantan	Miocene	exploration	Hadiyanto	1^{0} 20' S	115^{0} 10' E
Indonesia-CQ05	Sangatta, East Kalimantan	Miocene	existing mining	Hadiyanto	0^{0} 27' N	117^{0} 35' E
Indonesia-CQ06	Senakin, South Kalimantan	Eocene	existing mining	Hadiyanto	2^{0} 58' S	116^{0} 16' E
Indonesia-CQ07	Timika, Papua	Permian	exploration	Hadiyanto	4^{0} 42' S	136^{0} 55' E
Indonesia-CQ08	Malawa, South Sulawesi	Eocene	exploration	Hadiyanto	4^{0} 50' S	119^{0} 52' E

APPENDIX A

PROXIMATE AND ULTIMATE ANALYSES, AS-RECEIVED BASIS, UNITS ARE PERCENT, EXCEPT WHERE NOTED													
Lab1 No.	Field no.	Lab1 Date	Total Moisture	Residual Moisture	Air Dry Loss	Ash	Volatile Matter	Fixed Carbon	Hydrogen	Carbon	Nitrogen	Sulfur
035325	Indonesia - CQ01	16-Jan-01	3.10	1.05	2.07	7.33	42.84	46.73	5.41	73.16	1.35	0.51
035326	Indonesia - CQ02	16-Jan-01	18.02	6.40	12.41	9.68	39.93	32.37	3.74	50.69	0.77	0.24
035327	Indonesia - CQ03	16-Jan-01	9.68	2.42	7.44	10.05	40.99	39.28	5.02	62.37	0.96	2.21
035328	Indonesia - CQ04	16-Jan-01	26.49	7.36	20.65	5.38	33.03	35.10	3.42	48.38	0.94	1.00
035329	Indonesia - CQ05	16-Jan-01	19.36	3.39	16.53	4.33	34.99	41.32	4.10	57.47	1.31	0.37
035330	Indonesia - CQ06	16-Jan-01	5.29	1.63	3.72	12.63	42.58	39.50	5.33	63.69	1.10	0.79
035331	Indonesia - CQ07	16-Jan-01	5.23	1.16	4.12	3.54	7.48	83.75	2.07	84.28	0.84	0.61
035332	Indonesia - CQ08	16-Jan-01	48.27	10.68	42.09	2.99	25.42	23.32	2.56	34.87	0.52	0.14
Lab 1 = Geochemical Testing, Somerset, PA USA												

Oxygen	Calorific Value Btu/pound	Calorific Value MJ/kg	Calorific Value kcal/kg	---- Forms of Sulfur ---- Sulfate	Pyritic	Organic	Apparent rank	---- Ash Fusing Tempera Init	Soft
9.14	13200	30.70	7340	0.01	0.05	0.45	high volatile *A* bituminous	2800+	2800+
16.9	8610	20.02	4780	0.01	0.01	0.22	sub-bituminous *B*	2120	2170
9.71	11330	26.34	6290	0.09	0.77	1.35	high volatile *C* bituminous	2240	2320
14.4	8300	19.31	4610	0.17	0.05	0.78	sub-bituminous *C*	2080	2110
13.1	10050	23.37	5580	0.03	0.02	0.32	sub-bituminous *B*	2190	2410
11.2	11680	27.17	6490	0.02	0.16	0.61	high volatile *B* bituminous	2800+	2800+
3.43	13510	31.41	7500	0.01	0.07	0.53	semi-anthracite	2020	2040
10.7	5910	13.74	3280	0.01	0.01	0.12	lignite *B*	2060	2080

ıture, degrees F ----		Free Swelling
Hemi	Fluid	Index
2800+	2800+	7.0
2190	2400	0.0
2340	2380	0.0
2120	2250	0.0
2420	2610	0.0
2800+	2800+	0.0
2050	2160	0.0
2090	2100	0.0

MAJOR-, MINOR-, AND TRACE-ELEMENT ANALYSES ON A DRY, WHOLE-COAL BASIS											
Lab 2 No.	Field No.	Lab 2 Date	Si	Al	Ca	Mg	Na	K	Fe	Ti	P
Units			Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
E-185023	Indonesia-CQ01	1-Mar-01	1.75	1.33	0.0436	0.0429	0.0298	0.139	0.333	0.0481	0.00109
E-185024	Indonesia-CQ02	1-Mar-01	2.33	1.24	0.746	0.130	0.498	0.0757	0.218	0.0568	0.0089
E-185025	Indonesia-CQ03	1-Mar-01	1.74	1.31	0.766	0.0994	0.0175	0.0449	1.43	0.0593	0.00103
E-185026	Indonesia-CQ04	1-Mar-01	1.10	0.513	0.587	0.145	0.023	0.0225	0.938	0.0362	0.00643
E-185027	Indonesia-CQ05	1-Mar-01	1.07	0.685	0.121	0.0823	0.0931	0.0861	0.229	0.0265	0.0381
E-185028	Indonesia-CQ06	1-Mar-01	2.87	2.73	0.0919	0.0314	0.0386	0.0284	0.278	0.164	0.00239
E-185029	Indonesia-CQ07	1-Mar-01	0.856	0.285	0.101	0.0585	0.0159	0.0225	0.557	0.00873	0.00247
E-185030	Indonesia-CQ08	1-Mar-01	0.904	0.242	0.721	0.233	0.0100	0.0151	0.832	0.0179	0.000512
Lab 2 = U.S. Geological Survey Laboratories, Lakewood, CO USA											

Ag	As	B	Ba	Be	Bi	Cd	Cl	Co	Cr	Cs	Cu	Ga	Ge	Hg	Li	Mn	Mo	Nb
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
<0.17	0.426	68.8	38.0	0.385	0.0920	0.0259	0.033	1.91	6.91	2.26	9.95	3.45	1.01	0.022	12.0	3.92	1.20	0.920
<0.24	1.86	189	165	0.252	0.0839	0.0204	<0.017	1.33	1.19	0.24	1.56	2.99	0.839	0.043	13.2	253	0.432	0.947
<0.24	5.23	145	45.1	1.51	0.129	0.0377	<0.016	4.77	25.5	0.483	38.6	4.68	7.62	0.14	12.8	44.3	1.68	0.494
<0.16	2.79	98.4	134	0.581	0.0690	0.0109	<0.017	3.91	4.36	0.155	4.44	1.85	1.60	0.13	2.81	144	0.690	0.357
<0.11	2.66	201	75.3	0.136	0.0502	0.00982	<0.016	1.87	6.00	0.633	2.30	1.58	0.317	0.051	6.99	7.10	0.420	0.448
<0.28	4.13	124	34.2	0.766	0.0657	0.0315	<0.016	5.29	12.0	0.192	8.70	6.13	0.917	0.19	26.8	5.54	0.575	3.76
<0.081	11.8	7.28	64.3	0.586	0.0566	0.0404	0.022	9.34	2.90	0.109	3.51	0.781	0.032	0.17	3.53	33.5	3.35	0.307
<0.12	1.23	134	70.4	0.299	0.0369	0.00938	<0.017	1.61	2.77	0.0504	0.815	0.651	0.457	0.088	0.95	273	0.211	0.328

Ni	Pb	Rb	Sb	Sc	Se	Sn	Sr	Te	Th	Tl	U	V	Y	Zn	Zr
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
6.77	3.91	10.8	0.552	2.93	0.78	0.619	12.4	0.0794	1.53	0.0803	0.376	20.5	3.98	4.85	17.2
2.17	2.05	3.24	0.228	2.05	0.57	0.743	119	0.0600	1.76	0.0192	0.492	13.3	3.73	10.5	31.5
9.96	3.41	2.97	0.330	8.04	1.4	0.424	145	0.165	2.61	0.118	1.26	73.0	20.2	21.2	16.6
4.13	0.504	1.64	0.217	1.70	0.64	0.380	79.8	0.0682	1.56	0.140	0.566	10.6	5.15	8.76	15.3
6.39	0.841	6.33	0.0655	1.69	0.25	0.562	111	0.0240	0.682	0.0655	0.366	13.3	1.15	9.72	9.12
16.1	2.52	1.71	0.164	6.03	0.81	1.31	30.8	0.0465	2.08	0.493	0.588	34.5	13.4	7.63	105
13.6	10.6	1.59	0.797	1.59	0.33	0.259	38.1	0.0295	0.578	0.0526	0.194	4.85	6.96	23.1	5.78
0.885	1.17	0.727	0.0938	0.868	0.55	0.199	92.0	0.0363	1.17	0.0141	0.270	5.80	3.71	10.1	12.8

APPENDIX A

ASH OXIDE DATA ON A DRY ASH BASIS													
Lab No.	Field No.	% Ash	SiO_2/A	Al_2O_3/A	CaO/A	MgO/A	Na_2O/A	K_2O/A	*Fe_2O_3/A	TiO_2/A	P_2O_5/A	SO_3/A	Total Oxides
units		(525°C)	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %	Weight %
E-185023	Indonesia-CQ01	7.70	44.7	30.1	0.73	0.85	0.48	2.0	5.7	0.96	0.03	1.0	86.6
E-185024	Indonesia-CQ02	11.20	41.6	19.5	8.7	1.8	5.6	0.76	2.6	0.79	0.17	4.0	85.5
E-185025	Indonesia-CQ03	11.50	31.7	21.0	9.1	1.4	0.2	0.46	17.4	0.84	<0.02	11.1	93.2
E-185026	Indonesia-CQ04	7.20	30.4	12.5	10.6	3.1	0.4	0.35	17.3	0.78	0.19	17.4	93.0
E-185027	Indonesia-CQ05	5.30	41.8	23.7	3.1	2.5	2.3	1.9	6.0	0.81	1.6	7.3	91.0
E-185028	Indonesia-CQ06	13.60	44.9	37.7	0.94	0.38	0.38	0.25	2.9	2.0	0.04	1.4	90.9
E-185029	Indonesia-CQ07	4.00	45.3	13.3	3.5	2.4	0.53	0.67	19.7	0.36	0.14	7.4	93.3
E-185030	Indonesia-CQ08	5.30	33.0	7.80	17.2	6.6	0.23	0.31	20.3	0.51	<0.02	9.5	95.5
*Total iron as Fe_2O_3													

ORIGINAL AS-DETERMINED BASIS, ALL ELEMENTS ON AN ASH BASIS, EXCEPT FOR Cl, Hg, AND Se								
WHICH ARE ON AN AS-DETERMINED WHOLE-COAL BASIS.								
U.S. Geological Survey Laboratories, Lakewood, CO, USA								
	Method	**E_% Ash**	**E_% Moisture**	**E_Cl IC**	**E_Hg CVAA**	**E_ICPAES ACID**	**E_ICPAES ACID**	**E_ICPAES ACID**
Lab No.	**Field No.**	**% Ash**	**% Moisture**	**Cl**	**Hg**	**Na2O/A**	**Be/A**	**Co/A**
		%	%	%	ppm	%	ppm	ppm
E-185023	Indonesia-CQ01	7.7	7.9	0.03	0.02	0.48	4.6	22.9
E-185024	Indonesia-CQ02	11.2	6.6	<0.015	0.04	5.6	2.1	11.1
E-185025	Indonesia-CQ03	11.5	2.3	<0.015	0.14	0.2	12.8	40.5
E-185026	Indonesia-CQ04	7.2	7.1	<0.015	0.12	0.4	7.5	50.5
E-185027	Indonesia-CQ05	5.3	2.9	<0.015	0.05	2.3	2.5	34.2
E-185028	Indonesia-CQ06	13.6	0.6	<0.015	0.19	0.38	5.6	38.7
E-185029	Indonesia-CQ07	4	1.1	0.022	0.17	0.53	14.5	231
E-185030	Indonesia-CQ08	5.3	9.6	<0.015	0.08	0.23	5.1	27.5
Techniques involving IC, CVAA, ICPAES ACID, ICPAES SINT, ICPMS ACID, and Hyd are explained in Bullock and others, (2002).								

E_ICPAES ACID	**E_ICPAES ACID**	**E_ICPAES ACID**	**E_ICPAES ACID**	**E_ICPAES ACID**	**E_ICPAES ACID**	**E_ICPAES ACID**	**E_ICPAES ACID**
Cr/A	**Cu/A**	**Li/A**	**Mn/A**	**Ni/A**	**Sc/A**	**Sr/A**	**Th/A**
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
82.7	119	143	46.9	81	35	148	18.3
9.9	13	110	2110	18.1	17.1	995	14.7
217	328	109	376	84.6	68.3	1230	22.2
56.2	57.3	36.2	1860	53.3	21.9	1030	20.1
110	42.2	128	130	117	30.9	2030	12.5
87.4	63.6	196	40.5	118	44.1	225	15.2
71.6	86.7	87.2	829	337	39.2	943	14.3
47.3	13.9	16.2	4650	15.1	14.8	1570	19.9

E_ICPAES ACID	**E_ICPAES ACID**	**E_ICPAES ACID**	**E_ICPAES_SINT**	**E_ICPAES_SINT**	**E_ICPAES_SINT**	**E_ICPAES_SINT**	**E_ICPAES_SINT**
V/A	**Y/A**	**Zn/A**	**Al2O3/A**	**CaO/A**	**Fe2O3/A**	**K2O/A**	**MgO/A**
ppm	ppm	ppm	%	%	%	%	%
245	47.6	58	30.1	0.73	5.7	2	0.85
111	31.1	87.4	19.5	8.7	2.6	0.76	1.8
620	172	180	21	9.1	17.4	0.46	1.4
137	66.5	113	12.5	10.6	17.3	0.35	3.1
244	21	178	23.7	3.1	6	1.9	2.5
252	98.1	55.8	37.7	0.94	2.9	0.25	0.38
120	172	570	13.3	3.5	19.7	0.67	2.4
98.9	63.2	172	7.8	17.2	20.3	0.31	6.6

E_ICPAES_SINT	**E_ICPAES_SINT**	**E_ICPAES_SINT**	**E_ICPAES_SINT**	**E_ICPAES_SINT**	**E_ICPAES_SINT**	**E_ICPAES_SINT**	**E_ICPMS ACID**
P2O5/A	**SiO2/A**	**SO3/A**	**TiO2/A**	**B/A**	**Ba/A**	**Zr/A**	**Ag/A**
%	%	%	%	ppm	ppm	ppm	ppm
0.03	44.7	1	0.96	823	454	206	<2
0.17	41.6	4	0.79	1580	1380	263	<2
<0.02	31.7	11.1	0.84	1230	383	141	<2
0.19	30.4	17.4	0.78	1270	1730	198	<2
1.6	41.8	7.3	0.81	3680	1380	167	<2
0.04	44.9	1.4	2	906	250	764	<2
0.14	45.3	7.4	0.36	180	1590	143	<2
<0.02	33	9.5	0.51	2280	1200	218	<2

E_ICPMS ACID	E_ICPMS ACID	E_ICPMS ACID	E_ICPMS ACID	E_ICPMS ACID	E_ICPMS ACID	E_ICPMS ACID	E_ICPMS ACID	E_ICPMS ACID
As/A	**Bi/A**	**Cd/A**	**Cs/A**	**Ga/A**	**Ge/A**	**Mo/A**	**Nb/A**	**Pb/A**
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
5.1	1.1	0.31	27	41.3	12.1	14.3	11	46.8
15.5	0.7	0.17	2	24.9	7	3.6	7.9	17.1
44.4	1.1	0.32	4.1	39.8	64.7	14.3	4.2	29
36	0.89	0.14	2	23.9	20.6	8.9	4.6	6.5
48.7	0.92	0.18	11.6	29	5.8	7.7	8.2	15.4
30.2	0.48	0.23	1.4	44.8	6.7	4.2	27.5	18.4
291	1.4	1	2.7	19.3	0.79	82.8	7.6	263
20.9	0.63	0.16	0.86	11.1	7.8	3.6	5.6	20

E_ICPMS ACID	**E_ICPMS ACID**	**E_ICPMS ACID**	**E_ICPMS ACID**	**E_ICPMS ACID**	**E_ICPMS ACID**	**E_Se Hyd**
Rb/A	**Sb/A**	**Sn/A**	**Te/A**	**Tl/A**	**U/A**	**Se**
ppm	ppm	ppm	ppm	ppm	ppm	ppm
129	6.6	7.4	0.95	0.96	4.5	0.72
27	1.9	6.2	0.5	0.16	4.1	0.53
25.2	2.8	3.6	1.4	1	10.7	1.4
21.2	2.8	4.9	0.88	1.8	7.3	0.59
116	1.2	10.3	0.44	1.2	6.7	0.24
12.5	1.2	9.6	0.34	3.6	4.3	0.81
39.3	19.7	6.4	0.73	1.3	4.8	0.33
12.4	1.6	3.4	0.62	0.24	4.6	0.5

QUALITY ASSURANCE AND QUALITY CONTROL DATA										
ICP-AES acid QA/QC data										
reference to standards and methods = Bullock and others (2002)										
CLB-1, 1632-C, 1633-B, and 1635 are standard reference materials										
NA = values less than detection limit make comparison not appropriate										
Date	Job #	element_ICPAES line	Mn 257.610	Na 588.995	Be 313.042	Cr 283.563	Co 228.616	Cu 327.393	Li 670.784	Ni 221.648
03/01/01	ERP-133	CLB-1 actual	134.1	0.34	18.3	164.1	103.4	168.2	123.6	283.6
		CLB-1 reference	127	0.31	17.5	154	111	159	127	286
		% difference	5.57	11.02	4.72	6.57	-6.83	5.80	-2.68	-0.84
		element_ICPAES line	Mn 257.610	Na 588.995	Be 313.042	Cr 283.563	Co 228.616	Cu 327.393	Li 670.784	Ni 221.648
		1632-C actual	174.5	0.53	14.1	201.0	50.8	79.1	107.5	130.2
		1632-C reference	182.2	0.56	14	191.8	48.6	84	111.8	130.2
		% difference	-4.24	-5.27	0.37	4.79	4.46	-5.79	-3.83	-0.02
		element_ICPAES line	Mn 257.610	Na 588.995	Be 313.042	Cr 283.563	Co 228.616	Cu 327.393	Li 670.784	Ni 221.648
		1633-B actual	128.1	0.19	13.5	194.7	55.2	115.1	181.1	118.0
		1633-B reference	132	0.2	13.6	198	50	113	180.5	121
		% difference	-2.97	-3.99	-0.72	-1.64	10.35	1.83	0.33	-2.46
Duplicate data		element_ICPAES line	Mn 257.610	Na 588.995	Be 313.042	Cr 283.563	Co 228.616	Cu 327.393	Li 670.784	Ni 221.648
		ERP-133 E-185030	4653.96	0.23	5.08	47.29	27.47	13.94	16.22	15.07
		DUP 030	4655.46	0.21	5.18	50.80	26.66	12.10	16.47	25.97
		% difference	-0.03	11.82	-1.94	-6.90	3.06	15.19	-1.51	-41.95
ICP-AES sinter QA/QC data										
Date	Job #	element_ICPAES line	Al 308.215	Ca 317.933	Fe 273.955	Mg 285.213	K 766.490	P 214.914	S 181.975	Si 212.412
3/22/01	ERP-133	CLB-1 actual	24.1	3.7	21.5	0.74	1.2	1.2	4.6	41.3
		CLB-1 reference	23.96	3.49	19.84	0.75	1.21	1.11	4.6	39.83
		% difference	0.58	6.02	8.37	-1.33	-0.83	8.11	0.00	3.69
		element_ICPAES line	Al 308.215	Ca 317.933	Fe 273.955	Mg 285.213	K 766.490	P 214.914	S 181.975	Si 212.412
		1632-C actual	23.1	2.7	13.7	0.78	1.7	0.45	2.7	45.0
		1632-C reference	24.2	2.83	14.7	0.78	1.85	0.47	2.73	49.4
		% difference	-4.55	-4.59	-6.80	0.00	-8.11	-4.26	-1.10	-8.91

		element_ICPAES line	Al 308.215	Ca 317.933	Fe 273.955	Mg 285.213	K 766.490	P 214.914	S 181.975	Si 212.412
		1633-B actual	15.6	1.6	8.3	0.51	1.9	0.22	0.30	23.9
		1633-B reference	15.05	1.51	7.78	0.48	1.95	0.23	0.21	23
		% difference	3.65	5.96	6.68	6.25	-2.56	-4.35	42.86	3.91
Duplicate data		element_ICPAES line	Al 308.215	Ca 317.933	Fe 273.955	Mg 285.213	K 766.490	P 214.914	S 181.975	Si 212.412
		ERP-133 E-185030	7.8	17.2	20.3	6.6	0.31	< 0.02	9.5	33.0
		DUP 030	7.7	16.8	19.6	6.4	0.30	0.08	9.5	32.6
		% difference	1.30	2.38	3.57	3.12	3.33	NA	0.00	1.23
QA/QC data for Cl by ion chromatography										
data	job #		CLB-1	1632-C	1632-B					
36943	ERP133	actual value	1077	1133	1144					
		reference value	1070	1139	1137					
		% difference	0.65	-0.53	0.62					
Duplicate data			Cl-%							
		ERP-133 E-184030	<0.015							
		ERP-133 E-184030D	<0.015							
		% difference	NA							
reference value refers to the best known value, be it certified, recommended, informational, or laboratory average										
ICP-MS acid QA/QC data										
Date	Job #	element	Ga	Ge	As	Rb	Nb	Mo	Ag	Cd
3/12/01	ERP133	CLB-1 actual	46.0	217	223	79.2	16.6	153	< 2	1.3
		CLB-1 reference	47.6	191.00	206	82.5	15.9	143	1.10	1.40
		% difference	-3.36	13.61	8.25	-4.00	4.40	6.99	NA	-7.14
		element	Ga	Ge	As	Rb	Nb	Mo	Ag	Cd
		1632-C actual	43.9	62.9	79.4	99.1	17.9	10.1	< 2	0.98
		1632-C reference	41.9	70	86.3	105	18.4	11.2	1.4	1.01
		% difference	4.77	-10.14	-8.00	-5.62	-2.72	-9.82	NA	-2.97
		element	Ga	Ge	As	Rb	Nb	Mo	Ag	Cd
		1633-B actual	56.6	17.2	134	150	20.5	15.0	< 2	0.84

		1633-B reference	57.78	17.60	136	140	19.40	15.17	0.57	0.78
		% difference	-2.04	-2.27	-1.47	7.14	5.67	-1.14	NA	7.69
Duplicate data		element	Ga	Ge	As	Rb	Nb	Mo	Ag	Cd
		ERP-133 E-185030	11.1	7.8	20.9	12.4	5.6	3.6	< 2	0.16
		DUP 030	11.3	4.3	20.8	12.6	5.8	3.4	< 2	0.19
		% difference	-1.77	81.40	0.48	-1.59	-3.45	5.88	NA	-15.79
	reference value refers to the best known value, be it certified, recommended, informational, or laboratory average									
QA/QC data for Se ppm by hydride generation AA										
DATE	job #	standard	CLB-1	1632-B	1632-C	1635				
2/20/01	ERP133	observed value	2.31	1.19	<0.2	0.93				
		reference value	2.5	1.29	1.31	0.9				
		% difference	-7.60	-7.75	NA	3.33				
Duplicate data			Se-ppm							
		E-185030	0.47							
		E-185030 DUP	0.52							
		% difference	-9.62							
reference value refers to the best known value, be it certified, recommended, informational, or laboratory average										

Sc 424.683	Sr 460.733	Th 401.913	V 292.402	Y 324.227	Zn 213.857		
31.5	1148.9	21.6	197.3	75.1	772.3		
31.7	1065	22.2	191	72.8	762		
-0.75	7.83	-2.57	3.29	3.23	1.35		
Sc 424.683	Sr 460.733	Th 401.913	V 292.402	Y 324.227	Zn 213.857		
38.5	915.8	20.8	309.0	56.9	168.7		
40.6	891.3	19.6	331.4	56.3	169		
-5.18	2.75	6.19	-6.77	1.02	-0.17		
Sc 424.683	Sr 460.733	Th 401.913	V 292.402	Y 324.227	Zn 213.857		
41.4	1034.3	24.6	311.2	79.0	201.8		
41	1041	25.7	296	84.5	210		
1.06	-0.64	-4.28	5.12	-6.50	-3.92		
Sc 424.683	Sr 460.733	Th 401.913	V 292.402	Y 324.227	Zn 213.857		
14.83	1572.81	19.86	98.90	63.18	172.48		
15.19	1624.77	22.56	104.67	64.78	144.45		
-2.41	-3.20	-12.01	-5.51	-2.46	19.41		
Ti 334.940	Ba 233.527	B 249.772	Zr 339.197				
1.3	587	56.8	202				
1.24	540	78.26	178.61				
4.84	8.70	-27.42	13.09				
Ti 334.940	Ba 233.527	B 249.772	Zr 339.197				
1.0	495	900	216				
1.2	537	866	224				
-16.67	-7.82	3.93	-3.57				

Ti 334.940	Ba 233.527	B 249.772	Zr 339.197				
0.84	720	74.0	304				
0.79	709	76.12	217.98				
6.33	1.55	-2.78	39.46				
Ti 334.940	Ba 233.527	B 249.772	Zr 339.197				
0.51	1200	2280	218				
0.50	1200	2270	229				
2.00	0.00	0.44	-4.80				
Sn	Sb	Te	Cs	Tl	Pb	Bi	U
12.2	25.4	0.80	4.8	12.8	83.2	1.5	8.1
12.10	23.8	0.84	4.97	12.45	79.3	1.47	8.7
0.83	6.72	-4.76	-3.42	2.81	4.92	1.80	-6.90
Sn	Sb	Te	Cs	Tl	Pb	Bi	U
14.6	6.2	0.73	8.2	5.1	51.3	1.8	6.9
14	6.4	0.7	8.3	5.6	52.9	1.4	7.2
4.29	-3.13	4.29	-1.20	-8.93	-3.02	28.57	-4.17
Sn	Sb	Te	Cs	Tl	Pb	Bi	U
10.5	5.7	0.34	11.5	6.7	68.3	1.2	9.9

12.50	6	0.45	11	5.9	68.2	1.31	8.8
-16.00	-5.00	-24.44	4.55	13.56	0.15	-8.52	12.50
Sn	Sb	Te	Cs	Tl	Pb	Bi	U
3.4	1.6	0.62	0.86	0.24	20.0	0.63	4.6
4.6	1.5	0.71	0.88	0.17	16.8	0.64	4.6
-26.09	6.67	-12.68	-2.27	41.18	19.05	-1.56	0.00