



Chapter 1

World Coal Quality Inventory: South America – Executive Summary

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Chapter 1 *of*

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Metric Conversion Factors

Imperial Units	SI conversion
acre	4,046.87 square meters
acre-foot.....	1,233.49 cubic meters
British thermal unit (Btu)	1,005.056 joules
British thermal unit / pound (Btu / lb)	2,326 joules / kilogram
Fahrenheit (°F)	Centigrade (°C) = $[(^{\circ}\text{F}-32)\times 5]/9$
foot (ft)	0.3048 meters
inch (in)	0.0254 meters
mile (mi)	1.609 kilometers
pound (lb)	0.4536 kilograms
short ton (ton)	0.9072 metric tons
short tons / acre-foot	0.7355 kilograms / cubic meter
square mile (mi ²).....	2.59 square kilometers

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Executive Summary

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Introduction

The concepts of a global environment and economy are strongly and irrevocably linked to global energy issues. Worldwide coal production and international coal trade are projected to increase during the next several decades in an international energy mix that is still strongly dependent on fossil fuels. Therefore, worldwide coal use will play an increasingly visible role in global environmental, economic, and energy forums.

Policy makers require information on coal, including coal quality data, to make informed decisions regarding domestic coal resource allocation, import needs and export opportunities, foreign policy objectives, technology transfer policies, foreign investment prospects, environmental and health assessments, and byproduct use and disposal issues. The development of a worldwide, reliable, coal quality database would help ensure the most economically and environmentally efficient global use of coal. The U.S. Geological Survey (USGS), in cooperation with many agencies and scientists from the world's coal producing countries, originally undertook a project to obtain representative samples of coal from most of the world's producing coal provinces during a limited period of time (roughly 1998-2005), which is called the World Coal Quality Inventory (WoCQI). The multitude of producing coal mines, coal occurrences, or limited accessibility to sites in some countries can preclude collecting more than a single sample from a mine. In some areas, a single sample may represent an entire coal mining region or basin. Despite these limitations in sampling and uneven distribution of sample collection, the analytical results can still provide a general overview of world coal quality. The USGS intends to present the WoCQI data in reports and, when possible, in Geographic Information System (GIS) products that cover important coal bearing and producing regions.

Methods

Samples are usually collected by foreign collaborators, following USGS collection guidelines, when possible. These guidelines include the following:

- 1) Select appropriate sample type for collection conditions or opportunity: run-of-mine, channel, core;
- 2) Obtain sample according to specified procedures [channel (in accordance with ASTM Standard D4596), core (in accordance with ASTM Standard D5192), run-of-mine or preparation plant sample (in accordance with ASTM Standard D2234)];
- 3) Document all aspects of the sample;
- 4) Transmit sample in appropriate air-tight containers and in a timely fashion to USGS;
- 5) Provide full documentation for sample location, stratigraphic occurrence, and source, including the following items:

- Collector's name
- Date collected
- Date shipped
- Country Province or equivalent
- County or equivalent
- Latitude
- Longitude
- Map – published geologic or topographic map of the area (with scale)
- Coal Province or equivalent
- Coal Basin or equivalent
- Formation
- Group
- Bed
- Member
- Geologic Age – System, Series, Stage
- Mine name and type (underground/surface)
- Annual production
- Depth to top of bed (in meters)
- Thickness of bed
- Sample type – core, channel, run-of-mine, conveyor belt, grab, full bed or bench, etc.
 - For bench samples – how many samples in series, thickness of bench
 - Partings – included or excluded – thickness
- Comments on collection procedure
- Diagram of coal bed depicting sampling scheme

Estimated rank
General comments

Some samples do not meet stringent collection procedures (individual chapters will denote these deviations), plus some samples do not adhere to the definition of coal with less than 50 percent ash yield (Wood and others, 1981). Upon receipt of the samples in the United States, a USGS laboratory analyzes all samples, following the analytical scheme shown in figure 1, thereby establishing an internally consistent data set. The laboratory follows American Standard for Testing and Materials (ASTM, 2002) procedures, which are shown by method number on figure 1. The major analytical techniques of the USGS laboratory include: Inductively Coupled Plasma—Atomic Emission Spectroscopy (ICP-AES), Inductively Coupled Plasma—Mass Spectroscopy (ICP-MS), Atomic Absorption Spectroscopy (AAS), and Molecular Absorption Spectroscopy (MAS) (see Bullock and others, 2002).

Ultimate and proximate analyses are performed by a commercial lab on many of the samples. Petrography, low-temperature ashing and x-ray diffraction are performed on selected samples, based on interest by our foreign collaborators or USGS personnel. Available information on sample location, stratigraphic source, and the analytical data generated from samples are then combined. The WoCQI currently contains coal quality and ancillary information on samples obtained from major and minor coal-producing regions throughout the world (Finkelman and Lovern, 2001a,b). The WoCQI website (http://energy.er.usgs.gov/coal_quality/wocqi/index.html) lists the current status of sample collection and international collaboration.

South American Coal Summary

South America has abundant energy resource potential and this report contains information on the geology, production, use, quality, and environmental significance of the coal resources in South American countries. Available information on coalbed methane resources or production is also reported.

A total of 135 coal samples were collected and analyzed for this WoCQI report and the data are presented in individual country chapters (with number of samples in parentheses) for Argentina (7),

Brazil (57), Chile (23), Colombia (16), Peru (16), and Venezuela (16). The coal samples described in this report were collected for WoCQI between 1999 and 2002; analytical results were generated through 2004. In a few countries, obtaining representative samples was extremely difficult. A single summary chapter briefly describes the coal resources of Bolivia, Ecuador, Paraguay, and Uruguay - countries from which no representative samples were collected for the WoCQI. Individual chapters present chemical data generated for the South American samples collected for WoCQI in the following order: 1) proximate, ultimate, calorific value, and forms of sulfur on an as-received basis; 2) major- and minor- oxides on an as-determined ash basis; and 3) major-, minor-, and trace-element values calculated to a dry, whole-coal basis (data below detection or reporting limits on an as-determined basis were also converted; Bullock and others, 2002). Appendix 1 contains additional coal quality information that is not discussed in most chapters, this information includes the lab identification numbers, free swelling indices, and ash deformation temperatures in degrees Fahrenheit.

Weaver and Wood (1994) compiled a map of the South American continent showing coal mines, occurrences and coal quality. In lieu of any new information gathered for the WoCQI, their work remains the cornerstone for this study. Additional work for the WoCQI continues in western Venezuela at the time of this report.

Figure 2 shows the distribution of coal-bearing areas in South America. The major coal deposits are situated on the western side of the South American continent and are associated with basins that evolved along the convergent margin of the plate (da Cunha Lopes and Ferreira, 2000). These Andean Cordillera coals generally range in age from Mesozoic to Cenozoic. In the continental interior, coal deposits are found in the Paraná basin, a large intracratonic basin and are of Paleozoic age. Coal ranks range from peat to anthracite, although most are subbituminous to bituminous. Anthracite deposits are restricted to basins in the central Andes region.

Although widely extensive, EIA (2006) stated that South America coal production in 2004 represented only 1.3% of world's coal. Although many South American countries depend little on coal for domestic use and use hydroelectric power internally, Colombia, Venezuela, and Brazil export coal outside the continent. Most of the coal is transported to sea ports and delivered by ship. The availability and stability of infrastructure available for mining and export of coal varies in each country in South America.

Acknowledgments

The following is a list of South American collaborators, either individuals or agencies, who assisted this study through sample collection or provided other information.

Universidad Nacional de Ingenieria, (Rolando Carrascal Miranda), Peru

Instituto Geologico Minero y Metalurgico, (Romulo Mucho), Peru

Instituto Nacional de Geologia y Mineria, (Eligio Gonzales), Venezuela

Instituto de Geologia Economica Aplicada, Universidad de Concepcion,
(Guillermo H. Alfaro), Chile

Instituto de Investigacion e Informacion Geocientifica, Mineroambiental y
Nuclear (Lucy Barros de Ferriera), Colombia

Departamento de Geologia, Instituto de Geociencias Universidade Federal
do Rio Grande do Sul, (Wolfgang Kalkreuth), Brazil

References

- American Society for Testing and Materials (ASTM), 2002, Annual Book of ASTM Standards 2002, v. 05.06, 650 p.
- Bullock, J.H., Jr., Cathcart, J.D., and Betterton, W.J., 2002, Analytical methods utilized by the United States Geological Survey for the analysis of coal and coal combustion by-products: U.S. Geological Survey Open-File Report 02-389, 15 p. <http://pubs.usgs.gov/of/2002/ofr-02-389/> (Accessed December, 2005).
- Da Cunha Lopes, Ricardo, and Ferreira, J.A., 2000, An overview of the coal deposits of South America, *in* Cordani, U.G., Milani, E.J., Thomaz Filho, A., and Campos, D. de Almeida, eds., Tectonic Evolution of South America: Proceedings of the 31st International Geological Congress, p. 719-723.
- Energy Information Administration, 2003, World energy database: Energy Information Administration database available at website: <http://www.eia.doe.gov/emeu/international/coalproduction.html> (Accessed January, 2006).
- Finkelman, R.B., and Lovern, V.S., 2001a, The world coal quality inventory (WoCQI): U.S. Geological Survey Fact Sheet FS-155-00.
- Finkelman, R.B., and Lovern, V.S., 2001b, Inventario mundial de la calidad del carbón mineral (WoCQI): U.S. Geological Survey Fact Sheet FS-058-01.
- Weaver, J.N., and Wood, Jr., G.H., 1994, Coal Map of South America: U.S. Geological Survey Coal Investigations Map C-145, one sheet, scale: 1:7,500,000
- Wood, G.H., Jr., Kehn, T.M., Carter, M.D., and Culbertson, W.C., 1983, Coal resource classification system of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p.

List of Figures

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2. Map of South American coal basins with country boundaries (modified from Weaver and Wood, 1994).

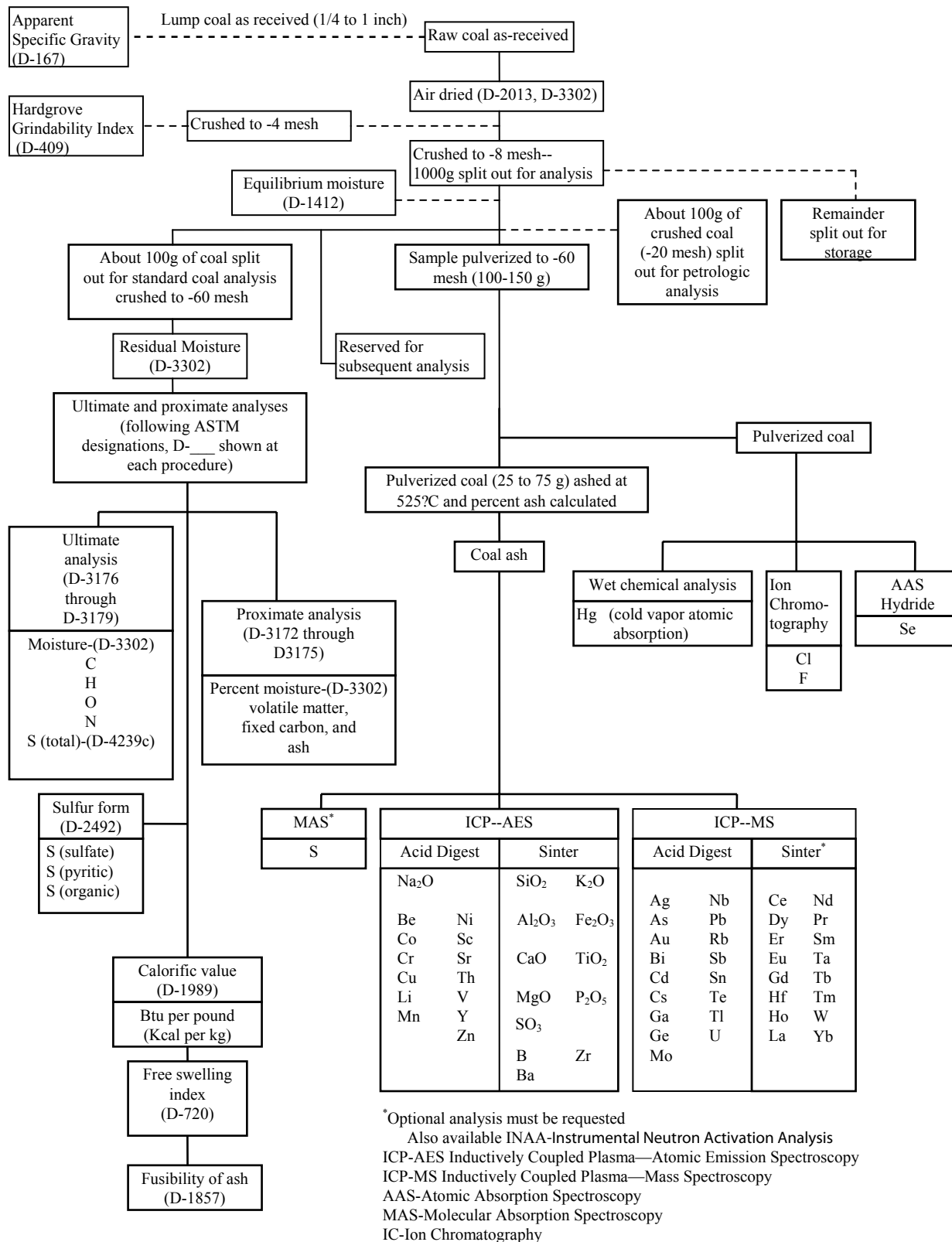


Figure 1. Flow diagram of procedures used after December 1994, for the analysis of coal samples collected. Dashed lines indicate non-routine analyses performed based on available funds and costs. (Current ASTM procedures effective July, 1991) (ASTM-American Society for Testing and Materials, USGS-United States Geological Survey.)

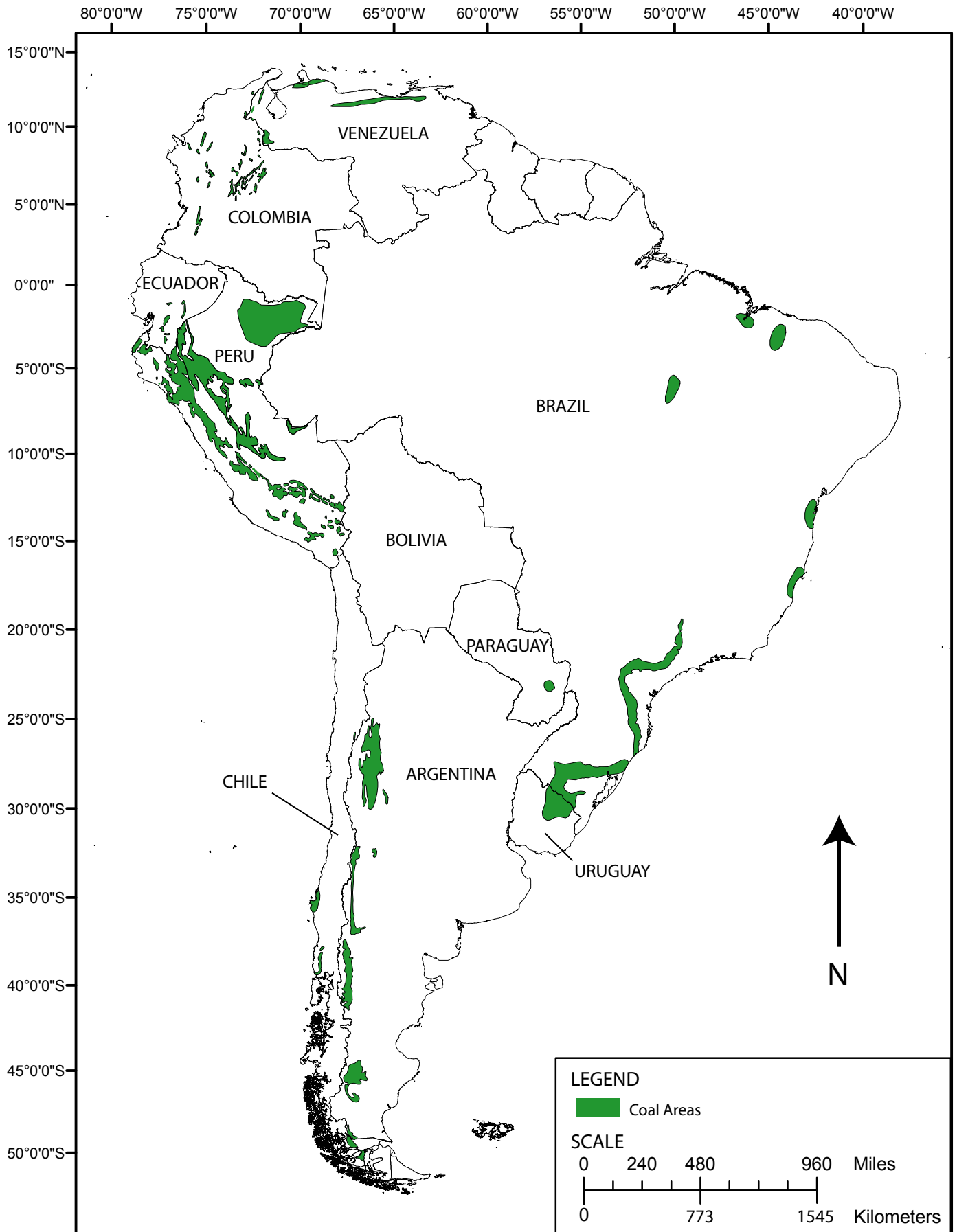


Figure 2. Map of South American coal basins with country boundaries (modified from Weaver and Wood, 1994).

Appendix 1a. Supplementary analytical data from ASTM laboratory, on an as-received basis, for seven Argentinean coal samples.

[Abbreviations: ERT=Energy Resources Team, Labid=laboratory identification number, Fieldid=Field identification number, ASTM=American Society for Testing and Materials; %=weight percent, Temp=Temperature, °=degrees, F=Fahrenheit, +=greater than, nd=no data.

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Argentina	E185769	Argentina-BA0101	01-035830	Argentina-BA0101	10.77	8.07	2.94	nd	2800+	2800+	2800+	2800+	0.5	nd	nd	nd	02/08/2001
Argentina	E185770	Argentina-BA0201	01-035831	Argentina-BA0201	10.11	7.83	2.47	nd	2230	2370	2420	2500	2.0	nd	nd	nd	02/08/2001
Argentina	E185771	Argentina-BA0301	01-035832	Argentina-BA0301	7.65	5.35	2.43	nd	2090	2220	2350	2430	2.0	nd	nd	nd	02/08/2001
Argentina	E185772	Argentina-BA0401	01-035833	Argentina-BA0401	17.61	14.39	3.76	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	02/08/2001
Argentina	E185773	Argentina-BA0501	01-035834	Argentina-BA0501	8.18	6.71	1.58	nd	2800+	2800+	2800+	2800+	0.5	nd	nd	nd	02/08/2001
Argentina	E185774	Argentina-BA0601	01-035835	Argentina-BA0601	9.80	7.80	2.17	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	02/08/2001
Argentina	E185775	Argentina-BA0701	01-035836	Argentina-BA0701	3.96	2.36	1.64	nd	2330	2340	2350	2360	0.0	nd	nd	nd	02/08/2001

Appendix 1b. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 57 Brazilian coal samples.

[Abbreviations: ERT=Energy Resources Team, Labid=laboratory identification number, Fieldid=Field identification number, ASTM=American Society for Testing and Materials; %=weight percent, Temp=Temperature, °=degrees, F=Fahrenheit, +=greater than, nd=no data.]

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Brazil	E004024	WK-38-98	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E133068	99-035	99-016114	Brazil Candiota Mine Seam Sample # 99-035	11.48	7.24	4.57	nd	2560	2690	2720	2800+	0.0	nd	nd	nd	06/03/1999
Brazil	E133067	99-036	99-016113	Brazil Candiota Mine Seam Sample # 99-036	10.57	7.12	3.71	nd	2710	2780	2800	2800+	0.0	nd	nd	nd	06/03/1999
Brazil	E167728	99-105	01-036101	Brazil 99-105	1.23	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	02/20/2001
Brazil	E167729	99-115	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167730	99-136	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167731	99-144+146	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167732	99-163	01-036102	Brazil 99-163	4.89	nd	nd	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	02/20/2001
Brazil	E167733	99-167	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167734	99-175	01-036103	Brazil 99-175	0.76	nd	nd	nd	1910	1940	2250	2310	1.0	nd	nd	nd	02/20/2001
Brazil	E167735	99-176	01-036104	Brazil 99-176	1.23	nd	nd	nd	2260	2480	2610	2660	1.0	nd	nd	nd	02/20/2001
Brazil	E167736	99-178	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167737	99-182	01-036105	Brazil 99-182	1.39	nd	nd	nd	2120	2160	2190	2230	0.0	nd	nd	nd	02/20/2001
Brazil	E167738	99-187	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167739	99-190	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Appendix 1b. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 57 Brazilian coal samples—continued.

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Brazil	E167740	99-217	00-025640	99-217	11.00	9.31	1.86	nd	2800+	2800+	2800+	2800+	0.5	nd	nd	nd	02/11/2000
Brazil	E167741	99-218	00-025641	99-218	10.38	8.76	1.78	nd	1950	2030	2170	2430	0.5	nd	nd	nd	02/11/2000
Brazil	E167742	99-219	00-025642	99-219	11.31	9.73	1.75	nd	2800	2800+	2800+	2800+	0.5	nd	nd	nd	02/11/2000
Brazil	E167743	99-220	00-025643	99-220	12.35	10.66	1.89	nd	1990	2030	2130	2260	0.5	nd	nd	nd	02/11/2000
Brazil	E167744	99-221	00-025644	99-221	10.65	8.88	1.94	nd	2150	2250	2400	2500	0.5	nd	nd	nd	02/11/2000
Brazil	E167745	99-222	00-025645	99-222	10.67	9.01	1.82	nd	2800+	2800+	2800+	2800+	0.5	nd	nd	nd	02/11/2000
Brazil	E167746	99-223	00-025646	99-223	9.14	7.78	1.48	nd	2800+	2800+	2800+	2800+	0.5	nd	nd	nd	02/11/2000
Brazil	E167747	99-224	00-025647	99-224	11.60	9.44	2.38	nd	2440	2490	2530	2630	1.0	nd	nd	nd	02/11/2000
Brazil	E167748	99-225	00-025648	99-225	14.29	12.40	2.16	nd	2430	2600	2660	2710	1.0	nd	nd	nd	02/11/2000
Brazil	E167749	99-226	00-025649	99-226	9.33	7.55	1.92	nd	1900	1920	1950	2350	0.5	nd	nd	nd	02/11/2000
Brazil	E167750	99-250	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167751	99-255	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167752	99-266	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167753	99-270	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167754	99-284	01-036106	Brazil 99-284	5.51	nd	nd	nd	2750	2800+	2800+	2800+	0.0	nd	nd	nd	02/20/2001
Brazil	E167755	99-296	01-036107	Brazil 99-296	7.41	nd	nd	nd	2360	2570	2620	2730	0.0	nd	nd	nd	02/20/2001
Brazil	E167756	99-308	01-036108	Brazil 99-308	7.28	nd	nd	nd	2650	2780	2800+	2800+	0.0	nd	nd	nd	02/20/2001
Brazil	E167757	99-313			nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167758	99-317			nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167759	99-326	01-036109	Brazil 99-326	5.34	nd	nd	nd	2590	2790	2800+	2800+	0.0	nd	nd	nd	02/20/2001

Appendix 1b. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 57 Brazilian coal samples—continued.

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Brazil	E167760	99-331	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167761	99-336	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167762	99-341	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E167763	99-345	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Brazil	E227738	00-23	03-057133	Brazil 00-23	9.13	7.42	1.85	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	03/19/2003
Brazil	E214268	02-292	02-053195	Brazil, 292-02	1.53	0.70	0.84	nd	2520	2560	2610	2690	0.0	nd	nd	nd	10/18/2002
Brazil	E214269	02-295	02-053196	Brazil, 295-02	2.01	0.82	1.20	nd	2070	2120	2490	2510	0.0	nd	nd	nd	10/18/2002
Brazil	E227739	02-296	03-057134	Brazil 02-296	2.10	1.12	0.99	nd	2280	2410	2680	2700	0.0	nd	nd	nd	03/19/2003
Brazil	E214270	02-297	02-053197	Brazil, 297-02	2.03	0.91	1.13	nd	2700	2760	2790	2800	1.0	nd	nd	nd	10/18/2002
Brazil	E227740	02-298	03-057135	Brazil 02-298	1.52	0.76	0.77	nd	2630	2700	2760	2780	1.0	nd	nd	nd	03/19/2003
Brazil	E214271	02-299	02-053198	Brazil, 299-02	1.41	0.66	0.76	nd	2600	2650	2690	2750	1.0	nd	nd	nd	10/18/2002
Brazil	E227741	02-300	03-057136	Brazil 02-300	1.22	0.63	0.59	nd	1980	2040	2270	2360	4.0	nd	nd	nd	03/19/2003
Brazil	E214272	02-301	02-053199	Brazil, 301-02	1.17	0.28	0.89	nd	2800+	2800+	2800+	2800+	1.0	nd	nd	nd	10/18/2002
Brazil	E227742	02-302	03-057137	Brazil 02-302	1.48	0.76	0.73	nd	2800+	2800+	2800+	2800+	2.0	nd	nd	nd	03/19/2003
Brazil	E214273	02-303	02-053200	Brazil, 303-02	2.07	1.01	1.07	nd	2730	2760	2800	2800+	0.5	nd	nd	nd	10/18/2002
Brazil	E227743	02-304	03-057138	Brazil 02-304	1.53	0.67	0.87	nd	2800+	2800+	2800+	2800+	1.0	nd	nd	nd	03/19/2003
Brazil	E214274	02-305	02-053201	Brazil, 305-02	4.32	2.81	1.55	nd	2420	2500	2680	2720	0.5	nd	nd	nd	10/18/2002
Brazil	E227744	02-419	03-057139	Brazil 02-419	1.96	0.97	1.00	nd	2540	2610	2680	2700	0.0	nd	nd	nd	03/19/2003
Brazil	E227745	02-420	03-057140	Brazil 02-420	1.28	0.50	0.78	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	03/19/2003
Brazil	E227746	02-421	03-057141	Brazil 02-421	1.36	0.65	0.71	nd	2530	2570	2590	2620	1.0	nd	nd	nd	03/19/2003

Appendix 1b. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 57 Brazilian coal samples—continued.

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Brazil	E227747	02-422	03-057142	Brazil 02-422	1.31	0.55	0.76	nd	2000	2080	2090	2110	1.0	nd	nd	nd	03/19/2003
Brazil	E227748	02-429	03-057143	Brazil 02-429	4.13	2.72	1.45	nd	2030	2070	2280	2540	0.5	nd	nd	nd	03/19/2003

Appendix 1c. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 23 Chilean coal samples.

[Abbreviations: ERT=Energy Resources Team, Labid=laboratory identification number, Fieldid=Field identification number, ASTM=American Society for Testing and Materials, %=weight percent, Temp=Temperature, °=degrees, F=Fahrenheit, +=greater than, nd=no data.]

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Chile	E183904	Chile-3	00-033739	Chile, Arauco Basin, Trongol Mine	3.68	2.37	1.34	nd	1950	1970	1980	2000	3.5	nd	nd	nd	11/14/2000
Chile	E203815	Manto Alto, Carbile Lebu	02-045697	Chile, Manto Alto Carbile Lebu	2.46	1.30	1.18	nd	1890	1930	1940	1990	5.0	nd	nd	nd	02/22/2002
Chile	E203816	Manto Chico, Carbile Lebu	02-045698	Chile, Manto Chico Carbile Lebu	2.88	1.42	1.48	nd	1860	1890	1910	1950	5.5	nd	nd	nd	02/22/2002
Chile	E203817	Manto Chiflon, Carbile Lebu	02-045699	Chile, Manto Chiflon Carbile Lebu	2.64	1.28	1.38	nd	2800+	2800+	2800+	2800+	1.5	nd	nd	nd	02/22/2002
Chile	E203818	Manto Huitrero, Carbile Lebu	02-045700	Chile, Manto Huitrero Carbile Lebu	2.77	1.48	1.31	nd	2800+	2800+	2800+	2800+	4.0	nd	nd	nd	02/22/2002
Chile	E206907	Lebu #1	02-049635	Chile Bituminous Lebu #1	3.94	2.21	1.77	3.63	1910	1930	1940	1980	3.5	1.27	nd	nd	06/22/2002
Chile	E206908	Lebu #2	02-049636	Chile Bituminous Lebu #2	2.08	1.02	1.07	2.09	2280	2380	2440	2500	4.0	1.33	nd	nd	06/22/2002
Chile	E183902	Chile-1	00-033737	Chile, Valdivia Basin, Malpun Mine	20.12	14.96	6.07	nd	2390	2400	2410	2430	0.5	nd	nd	nd	11/14/2000
Chile	E203810	Malpun 3004	02-045644	Chile Sample Malpun 3004	13.26	10.36	3.24	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	02/21/2002
Chile	E203811	Malpun 3005	02-045645	Chile Sample Malpun 3005	12.78	10.01	3.08	nd	2040	2080	2100	2150	0.0	nd	nd	nd	02/21/2002
Chile	E203812	Milahuillin	02-045646	Chile Sample Milahuillin	20.35	13.52	7.90	nd	1820	1900	1930	2060	0.0	nd	nd	nd	02/21/2002
Chile	E203813	Malihue	02-045695	Chile, Malihue	8.82	5.91	3.09	nd	2100	2170	2210	2250	0.0	nd	nd	nd	02/22/2002
Chile	E203814	Malpun 3006	02-045696	Chile, Malpun 3006	16.74	9.78	7.72	nd	2620	2740	2760	2780	0.0	nd	nd	nd	02/22/2002
Chile	E183903	Chile 2	00-033738	Chile Magallanes Basin, Pecket Mine	24.02	18.39	6.90	nd	2430	2460	2480	2510	0.5	nd	nd	nd	11/14/2000
Chile	E203803	1	02-045638	Chile Sample 1	21.41	14.17	8.44	nd	2080	2170	2290	2460	0.0	nd	nd	nd	02/21/2002

Appendix 1c. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 23 Chilean coal samples—continued.

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Chile	E203804	2A	02-045639	Chile Sample 2A	22.16	12.99	10.54	nd	2140	2200	2330	2400	0.0	nd	nd	nd	02/21/2002
Chile	E203805	2B	02-045640	Chile Sample 2B	23.68	15.93	9.22	nd	2130	2170	2250	2390	0.0	nd	nd	nd	02/21/2002
Chile	E203806	3	02-045641	Chile Sample 3	20.26	14.30	6.96	nd	2060	2110	2200	2310	0.0	nd	nd	nd	02/21/2002
Chile	E203807	4	02-045642	Chile Sample 4	19.64	13.67	6.91	nd	2170	2220	2260	2450	0.0	nd	nd	nd	02/21/2002
Chile	E203808	5	02-045637	Chile Sample 5	22.02	15.46	7.76	nd	2240	2290	2320	2380	0.0	nd	nd	nd	02/21/2002
Chile	E203809	6	02-045643	Chile Sample 6	21.09	15.60	6.51	nd	2340	2410	2420	2430	0.0	nd	nd	nd	02/21/2002
Chile	E206909	Pecket #1	02-049633	Chile Subbituminous Pecket #1	25.54	15.11	12.29	25.70	2120	2100	2200	2410	0.0	1.49	nd	nd	06/22/2002
Chile	E206910	Pecket #2	02-049634	Chile Bituminous Pecket #2	24.71	12.56	13.9	25.16	2270	2330	2360	2600	0.0	1.46	nd	nd	06/22/2002

Appendix 1d. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 16 Colombian coal samples.

[Abbreviations: ERT=Energy Resources Team, Labid=laboratory identification number, Fieldid=Field identification number, ASTM=American Society for Testing and Materials; %=weight percent, Temp=Temperature, °=degrees, F=Fahrenheit, +=greater than, nd=no data.]

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Colombia	E177447	Interlab 200	00-032567	Colombia Sample #0200 Valle de Cauca	1.70	nd	nd	nd	2010	2080	2170	2410	2.5	nd	nd	nd	10/11/2000
Colombia	E177448	IGM1084C	00-032568	Colombia Sample #0300 Boyca Zone	1.03	nd	nd	nd	2800+	2800+	2800+	2800+	7.0	nd	nd	nd	10/11/2000
Colombia	E183907	IGM 1077	00-034305	Colombia Sample #IGM 1077 San Luis Paz del Rio Boyaca	0.85	nd	nd	nd	2800+	2800+	2800+	2800+	8.5	nd	nd	nd	12/08/2000
Colombia	E183908	IGM 1237	00-034306	Colombia Sample #IGM 1037 Cesar Coal	4.55	nd	nd	nd	2590	2790	2800+	2800+	1.5	nd	nd	nd	12/08/2000
Colombia	E183909	IGM 1238	00-034307	Colombia Sample #IGM 1038 Puerto Bolivar Coal, Cordoba	12.81	nd	nd	nd	1990	2410	2420	2430	0.0	nd	nd	nd	12/08/2000
Colombia	E183910	IGM 1241	00-034308	Colombia Sample #IGM 1241 Maturin N4 Coal, North of Santander	1.67	nd	nd	nd	2780	2800+	2800+	2800+	4.5	nd	nd	nd	12/08/2000
Colombia	E183911	IGM 1242	00-034309	Colombia Sample #IGM 1242 La Esmeralda Coal, North of Santander	2.03	nd	nd	nd	2800+	2800+	2800+	2800+	2.5	nd	nd	nd	12/08/2000
Colombia	E183912	IGM 1247	00-034310	Colombia Sample #IGM 1247 Santa Cecilia, North of Santander	1.16	nd	nd	nd	2800+	2800+	2800+	2800+	8.0	nd	nd	nd	12/08/2000
Colombia	E191337	IGM 0071C	01-040846	Colombia 71C/Manto 70 Cerrejon/Guajira	3.09	nd	nd	nd	2800+	2800+	2800+	2800+	2.0	nd	nd	nd	08/22/2001
Colombia	E191338	IGM 0073C	01-040847	Colombia 73C/Manto 75 Cerrejon/Guajira	3.66	nd	nd	nd	2800+	2800+	2800+	2800+	2.5	nd	nd	nd	08/22/2001

Appendix 1d. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 16 Colombian coal samples—continued.

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Colombia	E191339	IGM 0067C	01-040848	Colombia 67C/Manto 115 Cerrejon/Guajira	3.89	nd	nd	nd	1980	1990	2010	2040	2.0	nd	nd	nd	08/22/2001
Colombia	E191340	IGM 0074C	01-040849	Colombia 74C/Manto 130 Cerrejon/Guajira	3.99	nd	nd	nd	2800+	2800+	2800+	2800+	0.5	nd	nd	nd	08/22/2001
Colombia	E191341	IGM 0016	01-040850	Colombia 16/InterLab 400 Norte de Santander	1.35	nd	nd	nd	2800+	2800+	2800+	2800+	6.0	nd	nd	nd	08/22/2001
Colombia	E191342	IGM 0032	01-040851	Colombia 32C/InterLab 101 Cundinamarca	2.09	nd	nd	nd	2800+	2800+	2800+	2800+	3.0	nd	nd	nd	08/22/2001
Colombia	E191343	Interlab 201	01-040852	Colombia/InterLab 201 Cordoba/Antioquia	13.52	nd	nd	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	08/22/2001
Colombia	E191344	IGM 0318	01-040853	Colombia 318/InterLab 301 Cauca/El Hoyo	5.53	nd	nd	nd	2080	2310	2370	2390	0.0	nd	nd	nd	08/22/2001

Appendix 1e. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 16 Peruvian coal samples. Sample BP2300 was weathered and BP2700 was a briquette.

[Abbreviations: ERT=Energy Resources Team, Labid=laboratory identification number, Fieldid=Field identification number, ASTM=American Society for Testing and Materials; %=weight percent, Temp=Temperature, °=degrees, F=Fahrenheit, +=greater than, nd=no data.]

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Peru	E178577	BP2300	nd	Peru Sample #BP2300	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Peru	E178578	BP2400	00-031795	Peru Sample #BP2400	5.07	3.56	1.57	3.02	2800+	2800+	2800+	2800+	0.0	1.7	0.006	0.01	09/19/2000
Peru	E178579	BP2500	00-031796	Peru Sample #BP2500	5.77	4.35	1.48	2.88	2410	2450	2480	2790	0.0	1.56	0.004	0.01	09/19/2000
Peru	E178580	BP2700	nd	Peru Sample #BP2700	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Peru	E178581	BP2900	00-031797	Peru Sample #BP2900	3.22	1.09	2.15	1.11	2420	2590	2750	2790	0.0	1.98	0.009	0.02	09/19/2000
Peru	E178582	BP3100	00-031798	Peru Sample #BP3100	4.41	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	09/19/2000
Peru	E178583	BP3200	00-031799	Peru Sample #BP3200	2.12	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	09/19/2000
Peru	E186579	B0101	01-037175	Peru BP 0101 La Galgada	4.28	2.36	1.97	nd	2620	2800+	2800+	2800+	0.0	nd	nd	nd	04/03/2001
Peru	E186580	B0102	01-037176	Peru BP 0201 La Limena 2	7.02	5.28	1.84	nd	2290	2560	2640	2750	0.0	nd	nd	nd	04/03/2001
Peru	E186581	B0103	01-037177	Peru BP 0301 La Limena 1	5.95	3.81	2.22	nd	2140	2360	2480	2560	0.0	nd	nd	nd	04/03/2001
Peru	E186582	B0104	01-037178	Peru BP 0401 Cocabal	4.37	3.03	1.38	nd	2380	2570	2660	2760	0.0	nd	nd	nd	04/03/2001
Peru	E186583	B0105	01-037179	Peru BP 0501 Villon	2.60	2.19	0.42	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	04/03/2001
Peru	E186584	B0106	01-037180	Peru BP 0601 Caraz	5.09	4.50	0.62	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	04/03/2001
Peru	E186585	B0107	01-037181	Peru BP 0701 San Raque	5.59	4.92	0.70	nd	2800+	2800+	2800+	2800+	0.0	nd	nd	nd	04/03/2001
Peru	E186586	B0108	01-037182	Peru BP 0801 Sta. Julia	15.78	12.00	4.30	nd	1990	2150	2240	2420	0.0	nd	nd	nd	04/03/2001
Peru	E199455	BP0501	01-040976	Peru Sample #BP 0501	4.72	1.94	2.83	nd	2650	2730	2800+	2800+	0.0	nd	nd	nd	08/25/2001

Appendix 1f. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 16 Venezuelan coal samples.

[Abbreviations: ERT=Energy Resources Team, Labid=laboratory identification number, Fieldid=Field identification number, ASTM=American Society for Testing and Materials; %=weight percent, Temp=Temperature, °=degrees, F=Fahrenheit, +=greater than, nd=no data.]

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Venezuela	E205914	M1-QP	02-047825	Venezuela M1-QP Quebrada Palmital	3.49	2.22	1.30	nd	1990	2030	2060	2080	4.0	nd	nd	nd	04/26/2002
Venezuela	E205915	M2-CDLV	02-047826	Venezuela M2-CDLV Carretera Las Dantas La Vega	2.03	1.24	0.80	nd	2030	2100	2160	2180	2.0	nd	nd	nd	04/26/2002
Venezuela	E205916	M3-RE	02-047827	Venezuela M3-RE Rio Escalante	6.75	4.46	2.40	nd	2380	2500	2510	2520	1.0	nd	nd	nd	04/26/2002
Venezuela	E205917	M4-QPA	02-047828	Venezuela M4-QPA Quebrada Palmichosa	11.25	6.84	4.73	nd	2290	2320	2430	2500	1.0	nd	nd	nd	04/26/2002
Venezuela	E205918	M5-RP	02-047829	Venezuela M5-RP Rio Pajitas	1.46	0.86	0.61	nd	2080	2130	2150	2210	6.0	nd	nd	nd	04/26/2002
Venezuela	E205919	M6-FA	02-047830	Venezuela M6-FA Finca Familia Arelland	4.47	3.20	1.31	nd	2530	2650	2730	2770	0.5	nd	nd	nd	04/26/2002
Venezuela	E205920	M7-LC	02-047831	Venezuela M7-LC Caliche (Cuchilla3)	0.93	0.53	0.40	nd	2090	2100	2120	2130	4.5	nd	nd	nd	04/26/2002
Venezuela	E205921	M8-M1LA	02-047832	Venezuela M8-M1LA Carretera Peracal-Rubio	6.48	4.34	2.24	nd	2800+	2800+	2800+	2800+	0.5	nd	nd	nd	04/26/2002
Venezuela	E205922	M8-M2LA	02-047833	Venezuela M8-M2LA Carretera Peracal-Rubio	3.82	2.41	1.44	nd	2410	2490	2540	2590	1.0	nd	nd	nd	04/26/2002
Venezuela	E205923	M10-LC	02-047834	Venezuela M10-LC Galerias Campamento Kopex	16.66	10.39	7.00	nd	2390	2450	2460	2470	0.5	nd	nd	nd	04/26/2002

Appendix 1f. Supplementary analytical data from ASTM laboratory, on an as-received basis, for 16 Venezuelan coal samples—continued.

Country	ERT Labid	ERT Fieldid	ASTM Labid	ASTM Fieldid	Total Moisture (%)	Air Dry Loss (%)	Residual Moisture (%)	Equilibrium Moisture (%)	Initial Fusion Temp (°F)	Softening Fusion Temp (°F)	Hemi-spherical Fusion Temp (°F)	Fluid Fusion Temp (°F)	Free Swelling Index	Apparent Specific Gravity (%)	Fluorine (%)	Chlorine (%)	Analysis Date
Venezuela	E205924	M11-HV	02-047835	Venezuela M11-HV Hato De La Virgen	1.10	0.70	0.40	nd	2280	2340	2360	2420	1.5	nd	nd	nd	04/26/2002
Venezuela	E205925	M12-CA	02-047836	Venezuela M12-CA Casadero	0.69	0.39	0.30	nd	2800+	2800+	2800+	2800+	1.0	nd	nd	nd	04/26/2002
Venezuela	E205926	M13-LP	02-047837	Venezuela M13-LP Mina La Pajarita	0.72	0.54	0.18	nd	2750	2800+	2800+	2800+	0.5	nd	nd	nd	04/26/2002
Venezuela	E205927	M14-SC	02-047838	Venezuela M14-SC Silla De Capote	4.61	3.33	1.32	nd	2640	2720	2730	2790	0.5	nd	nd	nd	04/26/2002
Venezuela	E205928	Guajira	02-047839	Venezuela Mina Guajira	2.78	2.28	0.51	nd	2800+	2800+	2800+	2800+	6.0	nd	nd	nd	04/26/2002
Venezuela	E205929	Guasare	02-047840	Venezuela Mina Guasare	3.04	2.33	0.73	nd	1960	2030	2080	2230	6.5	nd	nd	nd	04/26/2002