Chapter 8

World Coal Quality Inventory: Bolivia, Ecuador, Paraguay, and Uruguay

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Chapter 8 of

World Coal Quality Inventory: South America

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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 (^{o}F)	Centigrade (^{o}C) = [(^{o}F-32)x5]/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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Introduction

The U.S. Geological Survey (USGS), in cooperation with many of the world's coal producing countries has undertaken a project called the World Coal Quality Inventory (WoCQI). The WoCQI contains coal and ancillary information on sample obtained from major and minor coal-producing regions throughout the world. No representative samples were collected for the countries of Bolivia, Ecuador, Paraguay, and Uruguay. Coal is not commercially produced in these countries, but each contains some currently sub-economic deposits.

Coal in Bolivia, Ecuador, Paraguay, and Uruguay

Bolivia, Ecuador, Paraguay, and Uruguay (fig. 1), do not contain coal deposits of economic importance (Cardona, 1977; Alvarado, 1980; Baruya and Clarke, 1996). However, the coal resources of these nations have never been systematically evaluated in detail (Lopes and Ferreira, 2000). Energy demands primarily are met by hydroelectric power (Ecuador, Paraguay, and Uruguay), or by domestic oil and natural gas reserves (Bolivia), and there is no dependence on imported coal as an energy resource. Use of the limited domestic coal resources, other than for small-scale domestic heating and cooking, has been limited to historical lime firing in Ecuador and Bolivia (O’Rourke, 1978; Flores-Williams, 1978). Uruguay currently imports small amounts (<2 metric tons per year) of coal for use in industrial applications (Baruya and Clarke, 1996).

Bolivia

Bolivian coal deposits are reported from the Copacabana Peninsula-Isla del Sol area near the southeastern

margin of Lake Titicaca (fig. 2) (Ahlfeld, 1954). The coal is reported to be “anthracite” in rank (Flores-Williams, 1978; Montes de Oca, 1989; Weaver and Wood, 1994), and occurs in the LateCarboniferous-Permian Copacabana Formation, described as a thick (>400 m) sequence of marine and continental sediments deposited in a western Gondwana back-arc basin (Grader and others, 2000). Coal occurs in cm-scale lenses within a 10 m thick black slate at the base of the Permian within the Copacabana (Flores-Williams, 1978). Weaver and Wood (1994) listed two other Permian “anthracite” occurrences in Bolivia which apparently are of a similarly restricted sub-economic nature (Weaver, 1993). Weaver and Wood (1994) reported the calorific value of the Copacabana-Isla del Sol deposit to be 8,330 Btu/lb (reporting basis not given); this would suggest that the coal deposit is of significantly lower rank than “anthracite”. Furthermore, the calorific value of an outcrop sample collected from near the Copacabana by USGS personnel was determined to be only 7,780 Btu/lb (as-received basis), also suggesting that coal rank in this area is not “anthracite.”

Flores-Williams (1978) reported that the “anthracite” of Copacabana contains 30-50 weight percent ash and 0.5-1.3 weight percent sulfur, citing the original work of Ahlfeld (1954) and unpublished reports from the Corporación Minera de Bolivia, the national mining company. The U.S. Department of Energy (2003a) estimates the “anthracite and bituminous” coal reserves of Bolivia to be approximately 0.9 million metric tons.

Apart from the reported “anthracite” occurrences of the Copacabana peninsula, Bolivia also hosts numerous deposits of poor quality (high ash and sulfur) peat and lignite, widely distributed in small, intermontane basins of the Andes. Weaver and Wood (1994) listed 24 Pliocene-Pleistocene occurrences which generally have been described as thin (5-90 cm), immature (maximum calorific value of 5,400 Btu/lb; reporting basis not given), and high in ash (25-85 weight percent) and sulfur (0.5-8.0 weight percent) (Flores-Williams, 1978; Weaver, 1993; Weaver and Wood, 1994). Weaver (1993) noted that the Bolivian government appeared ready to promote a study of lignite resources and suggested that the peat-lignite deposits of Bolivia possibly could be developed as an alternative energy source for domestic or industrial use with the

infusion of foreign investment dollars; however, this has not materialized at the time of this writing.

Ecuador

Tertiary coal deposits of southern Ecuador (fig. 3) are reported to be primarily of subbituminous and lignite rank (Sosa, 1983; Putzer, 1985), and to occur in small intermontane basins of the Andes, the largest of which is only 20 by 100 km (O'Rourke, 1978). Reserves are estimated by the U.S. Department of Energy (2003b) to be 23.6 million metric tons. The small basins which contain coal deposits are at relatively high elevations (2000-3000 m), and lack the necessary infrastructure to support commercial coal development (International Energy Agency Coal Research, 1983). In addition, most of the exposed coal beds are lenticular, steeply dipping, fault-truncated, and sheared (O'Rourke, 1978). Thickness of the exposed coal beds in most basins usually ranges from between 0.6-1.1 m (Putzer, 1985), reaching as thick as 5 m (O'Rourke, 1978). Based on evidence from geologic mapping, O'Rourke (1978) hypothesized that flat-lying, undisturbed portions of the Cañar-Azuay basin (fig. 3) may contain unfaulted coal beds with significant lateral extent; however, drilling of two exploratory holes to depths of 363 and 325 m did not penetrate coal in the western Cañar-Azuay basin.

Previous summaries of the coal deposits of Ecuador primarily have focused on the Malacatos, Loja, and Cañar-Azuay basins (fig. 3) (O'Rourke, 1978; Weaver, 1993), where limited quality analyses indicate that average calorific value of the various deposits ranges from 3,780-9,360 Btu/lb (O'Rourke 1978; reporting basis not given). Sulfur content is reported to be 6-8 weight percent and ash yield is 15-45 weight percent (O'Rourke, 1978; reporting basis not given).

Development of coal resources as an energy resource in Ecuador does not appear to be imminent, given the country's vast hydroelectric and moderate oil and gas resources (Baruya and Clarke, 1996). However, O'Rourke (1978) pointed out that the known exposed coal beds may be suitable for in situ gasification, were this to prove economic. In addition, if the intermontane basins do contain laterally extensive coal beds buried at moderate depth, these may prove amenable to coal bed gas exploration and development.

Paraguay

Small, sub-economic lower Permian coal deposits in Paraguay (fig. 4) are mentioned in summary reports on the coals of South America (Cardona, 1977; Alvarado, 1980). The coals are interpreted to be laterally correlative with economic subbituminous-bituminous deposits of the Paraná basin of adjacent Brazil (fig. 1) (Lopes and Ferreira, 2000). As best as can be ascertained at the time of this writing, there exists no public report describing in any detail the geology or quality of the coal deposits of Paraguay, presumably owing to a general lack of exploration.

In neighboring Brazil, correlative lower Permian coals are described as occurring in small, isolated sub-basins of the large (1.2 billion km) Paraná basin (Olive, 1978; Fulfaro and others, 1997). Olive (1978) reported that ash and sulfur content of run-of-mine Paraná basin coals are high due to the presence of numerous partings, typically requiring beneficiation prior to utilization. Coal beds occur in the Río Bonito Formation in the State of Río Grande du Sul in Brazil (fig. 1). The Río Bonito is a deltaic unit composed of approximately 70-300 m of sandstones and shales, with 2-4 interspersed coal beds of 2-3 m thickness (Abreu, 1962; Olive, 1978; Lopes and Ferreira, 2000). As Brazil has been successful in the commercial development of the poor-quality (high ash and sulfur) coals of the southern Paraná basin, the same might eventually prove true for Paraguay, given that future exploration successfully finds deposits which can be exploited and locally utilized. However, the currently-mined deposits in Brazil are approximately 600 km distant from the location of inferred correlative deposits in Paraguay.

Weaver and Wood (1994) list four Jurassic peat and lignite occurrences in Paraguay, but no description or documentation of these occurrences is given. No other mention is made of Jurassic coal occurrences in Paraguay in the few available pertinent public references examined during the compilation of this report. A fairly recent summary report on Paraguay's geology, written by in-country experts, makes no mention of any coal deposits, despite devoting significant attention to the nation's other mineral and fossil fuel resources (Palmieri and Velázquez, 1982).

Uruguay

Small deposits of sub-economic subbituminous coal have been reported from the Permian strata of northeastern Uruguay (fig. 5). These deposits also are interpreted to be correlative to the Río Bonito coals of southern Brazil (Martínez Macchiavello, 1976, 1977; Weaver, 1993; Lopes and Ferreira, 2000). This southwestward continuation of the Paraná basin is called the Paraná Chaco basin in Uruguay and neighboring Argentina (fig. 1) (Milani and Filho, 2000).

Small-scale mining of coal deposits in Uruguay was first reported in the late 19th century (Maeso, 1882; Bureau of the American Republics, 1893), but at the time of these reports it was asserted that there were no longer any mining activities. A limited subsurface exploration program was conducted in the first part of the 20th century (Schroeder, 1935). This investigation found that the coal deposits were very high in ash yield (60-80 weight percent), similar to the other Paraná basin coal deposits of Brazil and Paraguay.

Weaver (1993) reported that a subsurface exploration program was conducted in 1981, and coals were encountered in at least some of the 18 holes that were drilled. However, Weaver (1993) asserted that the accuracy and uniformity of the exploration program data were in question.

Conclusions

The countries of Bolivia, Ecuador, Paraguay, and Uruguay each contain small, currently sub-economic coal deposits. The deposits are Tertiary in the Andean ranges of Bolivia and Ecuador and are lower Permian in the Paraná basin of Paraguay and Uruguay. A Permian deposit also occurs in the Copacabana-Isla de Sol area of Bolivia. These coal deposits have never been developed for commercial use, with the exception of small-scale lime firing for local cement production in Bolivia and Ecuador. The coal deposits have never been systematically evaluated in detail and, in general, are of relatively poor quality, containing high ash and sulfur, and low energy content. Field investigations, primarily the drilling, sampling, and analysis of subsurface deposits, would be needed in each nation to accurately determine resource quantities, and to accurately characterize these resources so that possible avenues for utilization could be decided.

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Figure 1. Map of South America showing countries discussed in this report shaded in gray. Outline of Parana Chaco basin from Milani and Filho (2000).

Figure 2. Simplified geologic map of Bolivia showing location of Copacabana coal occurrence. Geology from Schenk and others (1999).

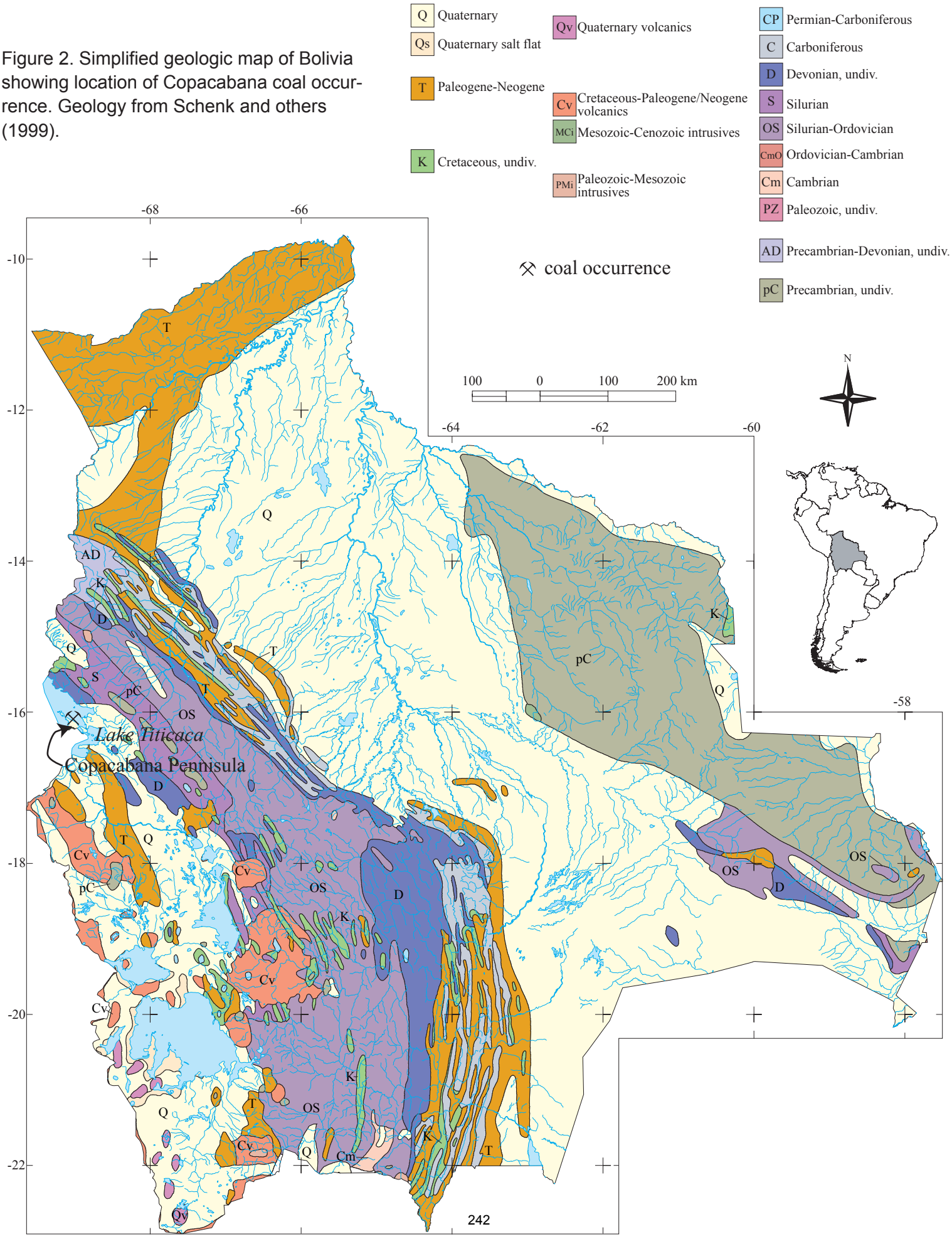
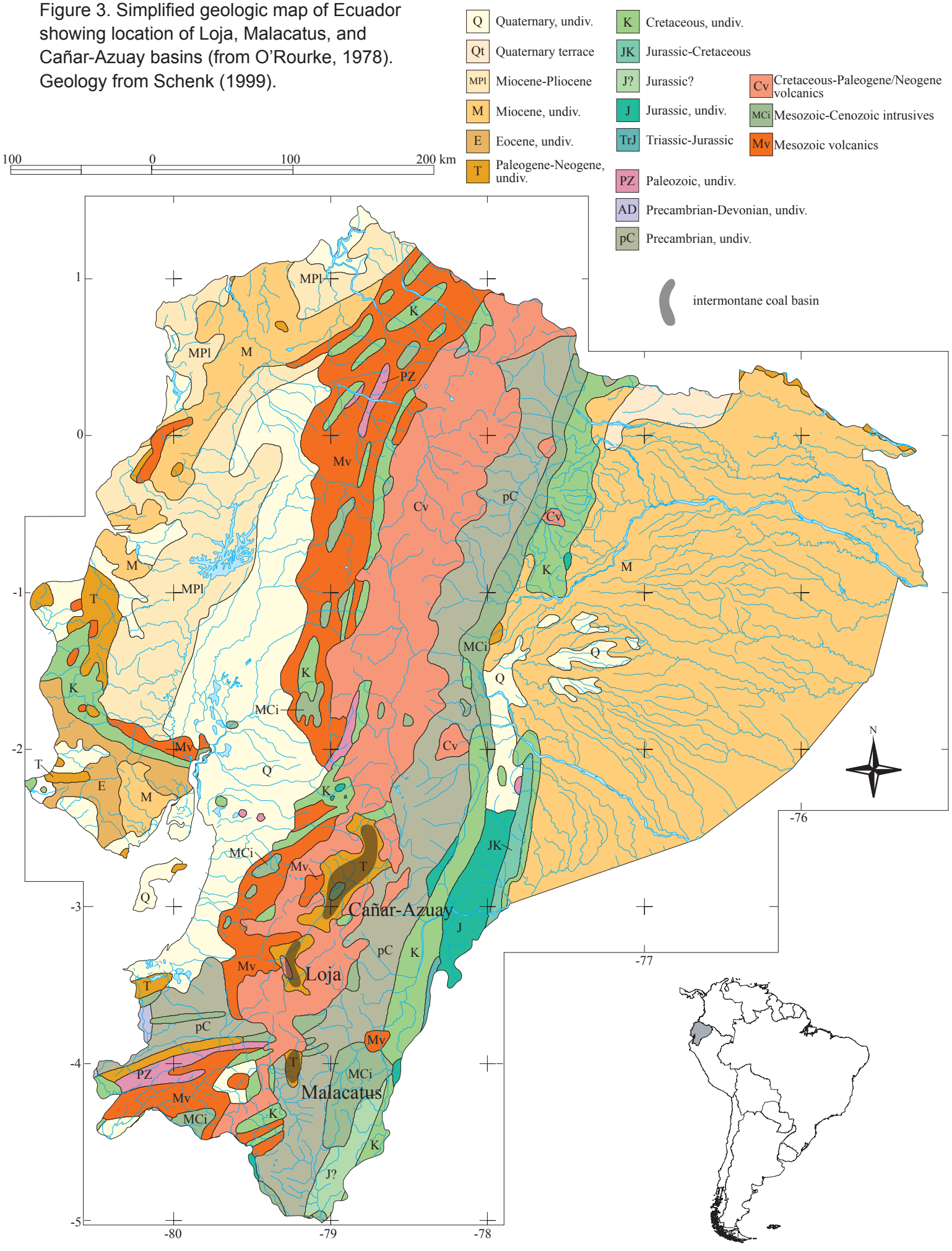


Figure 3. Simplified geologic map of Ecuador showing location of Loja, Malacatus, and Cañar-Azuay basins (from O'Rourke, 1978). Geology from Schenk (1999).



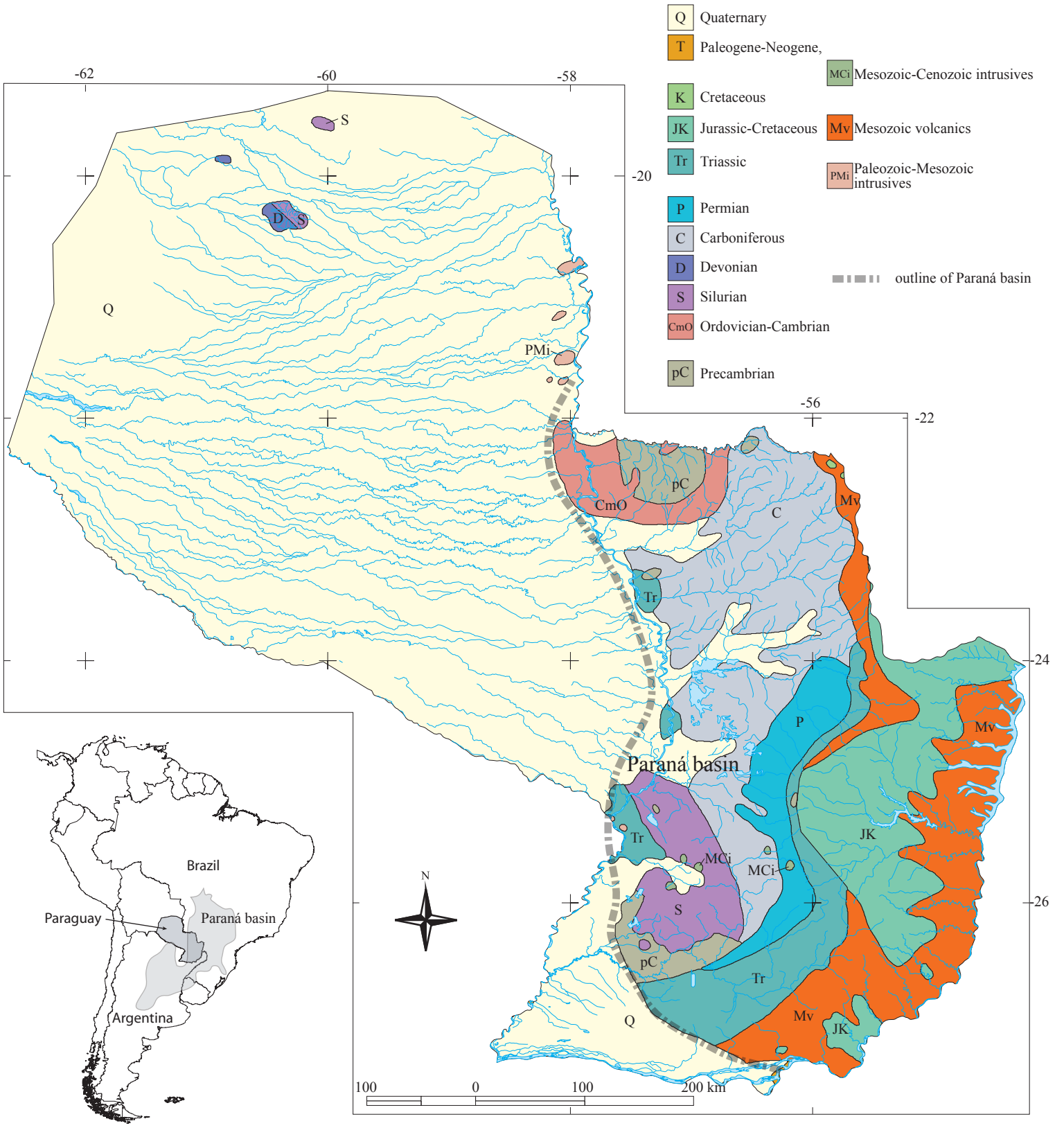


Figure 4. Simplied geologic map of Paraguay showing outline of Paraná basin. Geology from Schenk (1999).

Figure 5. Simplified geologic map of Uruguay showing location of coal occurrences (from Weaver and Wood, 1994), and outline of Paraná basin. Geology from Schenk (1999).