THE COALBED METHANE POTENTIAL OF THE SANTA TEREZINHA COALFIELD, RIO GRANDE DO SUL, BRAZIL

WOLFGANG KALKREUTH AND MICHAEL HOLZ

ABSTRACT Coalbed methane is a worldwide exploration target in the petroleum industry and is currently produced economically from a number of coal basins in the United States. In Brazil, coal measures occur in the southern Paraná Basin with proven coal resources in the order of 32 Billion tons. Based on coal distribution, reservoir depths and coal rank, the Chico Lomã and Santa Terezinha Coalfields in Rio Grande do Sul appear to be the prime candidates for coalbed methane exploration in this country. Preliminary results on the evaluation of coalbed methane in the Santa Terezinha Coalfield suggest that there may be as much as 19 Billion m^3 coalbed methane in the coalfield, based on the distribution of the 3 major seams at a depth level ranging from 400 to 950 m.

Keywords: Paraná Basin, Brazil, Coalbed methane

INTRODUCTION Coal is a unique fossil rock being the source and reservoir for large amounts of methane formed during the process of coalification. In the U.S.A. "coalbed methane" (CBM) is economically produced from a number of coal basins (Murray, 1996), with CBM production estimated to reach 3 Billion Cubic feet (0.08 Billion m^3) by the year 2000. In many other countries such as Australia, Germany, Russia and Canada deep-lying coal deposits have been evaluated for their CBM potential (Dawson & Kalkreuth 1994, Kalkreuth *et al*. 1994, Fails 1996, Marshall *et al*.1996, Johnson & Flores 1998) and are currently the exploration targets of the petroleum industry.

Coal reserves in Brazil are in the order of 32 Billion tons, of which the majority (89%) occur in the state of Rio Grande do Sul (Informativo Anual da Indústria Carbonífera 1996). The preliminary results reported here are part of a regional project to outline areas of high coalbed methane potential in the Permian coal measures based on coal rank, coal quality and coal distribution.

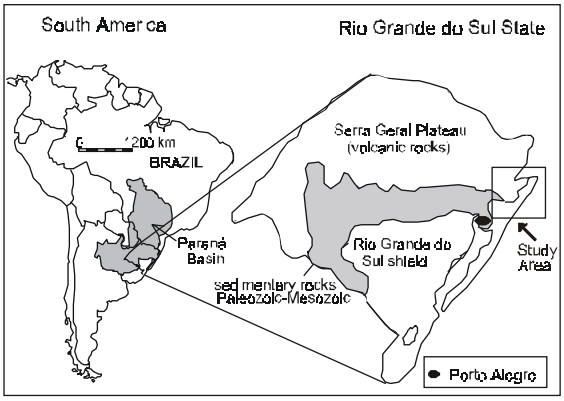
The coalfield selected for CBM evaluation is that of Santa Terezinha, Rio Grande do Sul (Fig. 1) which appears to have the highest CBM potential of the Paraná basin coals (Kalkreuth *et al*. 1998) based on coal rank (high volatile A bituminous-anthracite), coal distribution (cumulative coal thickness of > 10 m, a total of seven coal zones with individual beds of up to 3.0 m in thickness), and depth range of the coal seams (300-950 m).

Evaluation of Coalbed Methane Volume Resources of coalbed methane (CBM), i.e. methane trapped within the porous system of coal seams, may be as high as 250 x 10^{12} m^3 (Murray 1996) and are as such many times greater than the collective reserves of all known conventional gas fields of the world.

To assess the CBM potential of coal-bearing strata the most important parameters are: a) basin geology including reservoir size, depth and coal distribution; b) coal characteristics such as coal rank, coal type and coal grade; c) estimation of in-situ methane content based on gas desorption and adsorption tests.

METHODS The coalbed methane generation and retention potential of coal seams is defined by three basic parameters: coal rank, coal type (macerals), and coal grade (mineral content). In nature methane may occur in coal seams in form of biogenetic gas or thermally generated from coal during the process of coalification. In the bituminous coals and anthracites the quantities of generated methane are such that only a portion is maintained in the porous system of the coal (Meissner 1984), whereas the remainder migrates in the associated rocks and may eventually accumulate to form natural gas deposits.

In the context of this study coalbed methane volumes are estimated based on Companhia de Pesquisas de Recursos Minerais (CPRM), Brazil coal resource figures, coal rank, depth of the coal seams and an



Stage	Lithostratigraphy	
KUNGURIAN	Passa Dois Group	Irati Formation
	Guatá Group	Palermo Formation
ARTINSKIAN		Rio Bonito Formation
SAKMARIAN	Itararé Group	Rio do Sul Formation

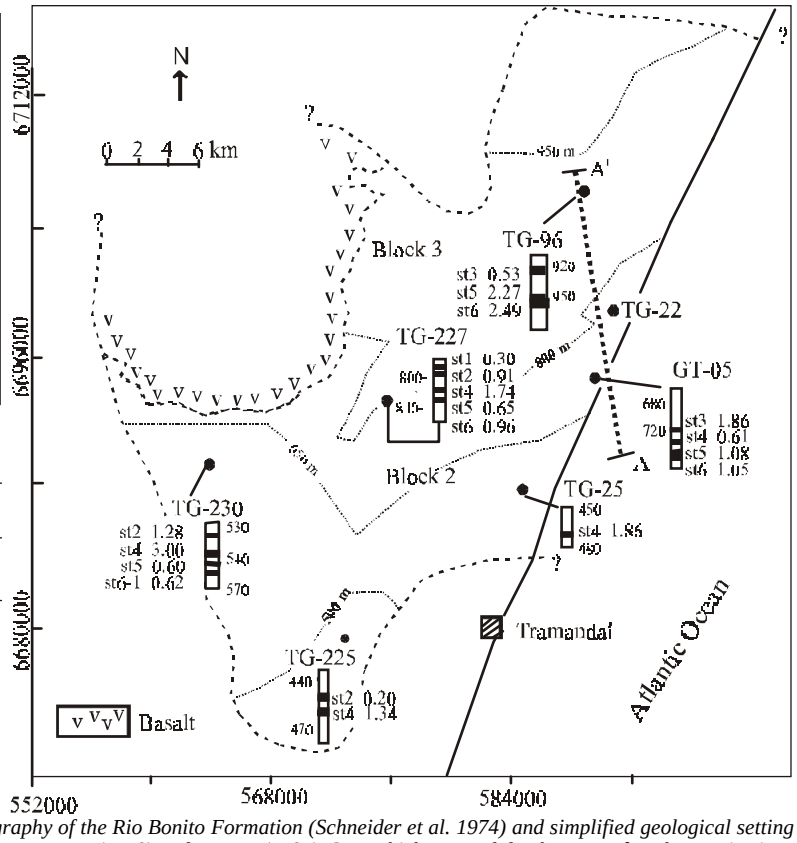


Figure 1 - Map showing location of the Paraná Basin, lithostratigraphy of the Rio Bonito Formation (Schneider et al. 1974) and simplified geological setting of the Santa Terezinha Coalfield. Coalfield map modified from CPRM Report (1978) and DNPM (1986). Seam thickness and depth range of coal zones is given for selected boreholes (all numbers in meters).

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averaged ash yield of 50 wt.%. The coalbed methane volumes were calculated using a computer program developed by Ryan (1992), which is based on the empirical relationships between lost and desorbed gas volumes, coal rank and depth (Kim 1978, Eddy *et al*. 1982).

Extensive regional exploration in the 1970' by the Brazilian Agency CPRM has defined 7 major coal seams in the deposit (ST1-ST7), of which the ST4, ST5 and ST6 seams are the most important (Fig. 2). The current CBM estimates are based on the coal volume and depth occurrences of these three seams (Table 1).

RESULTS AND DISCUSSION Basin Geology - Coal-bearing Strata of the Paraná Basin The southern region of Brazil, comprising Paraná, Santa Catarina and Rio Grande do Sul states (Fig.1), has been known for its abundant and economically important coal seams since the beginning of the century (White 1908). The study area is part of a tectonic unit in southwestern Gondwana known as the Paraná Basin, a large intracratonic basin (*e.g.* Milani *et al.* 1994). This basin is located in the central-eastern part of the South-American Platform and covers a surface area about 1,700,000 km^2, has a NE-SW elongated shape, and is approximately 1,750 km long and 900 km wide (Fig. 1).

The coal occurrences are historically assigned to the Rio Bonito Formation, a fluvial to marine sandstone and shale-prone lithostratigraphic unit of Early Permian age (Artinskian), Fig. 1. In the Santa Terezinha coalfield (Fig. 2) the Rio Bonito Formation has up to seven seams with cumulative a coal thickness in excess of 10 m.

Table 1 - Calculation of coal resources for the major coal seams of the deposit (from DNPM, 1986)

	Block 2	**Block 3**	**Total**
Area (km^2)	473	309	782
Depth Range (m)	300-800	>800	--
	Coal Resources (10 x 6 t)		
Seam			
St2	22.8	18.6	41.4
St3	134.7	74.0	208.7
St4	1401.7	461.3	1863.0
St5	287.6	682.1	969.7
St6	422.9	777.8	1200.7
Total	2269. 7	2013. 8	4283. 5

Coal Distribution and Coal Rank The simplified coalfield map shows the subdivision of the coalfield into two blocks covering 782 km^2 (DNPM 1986), Fig. 1. In the south (Block 2) the coals occur in a depth interval from 400-800 m, whereas in Block 3 to the north, the coal seams are developed at a depth ranging from 800 - 950 m. Total coal resources are in the order of 4,3 Billion tons (Table 1).

Assessment of coal rank at this point is based on Araújo et al. (1995). This study showed that vitrinite reflectances increase from SW

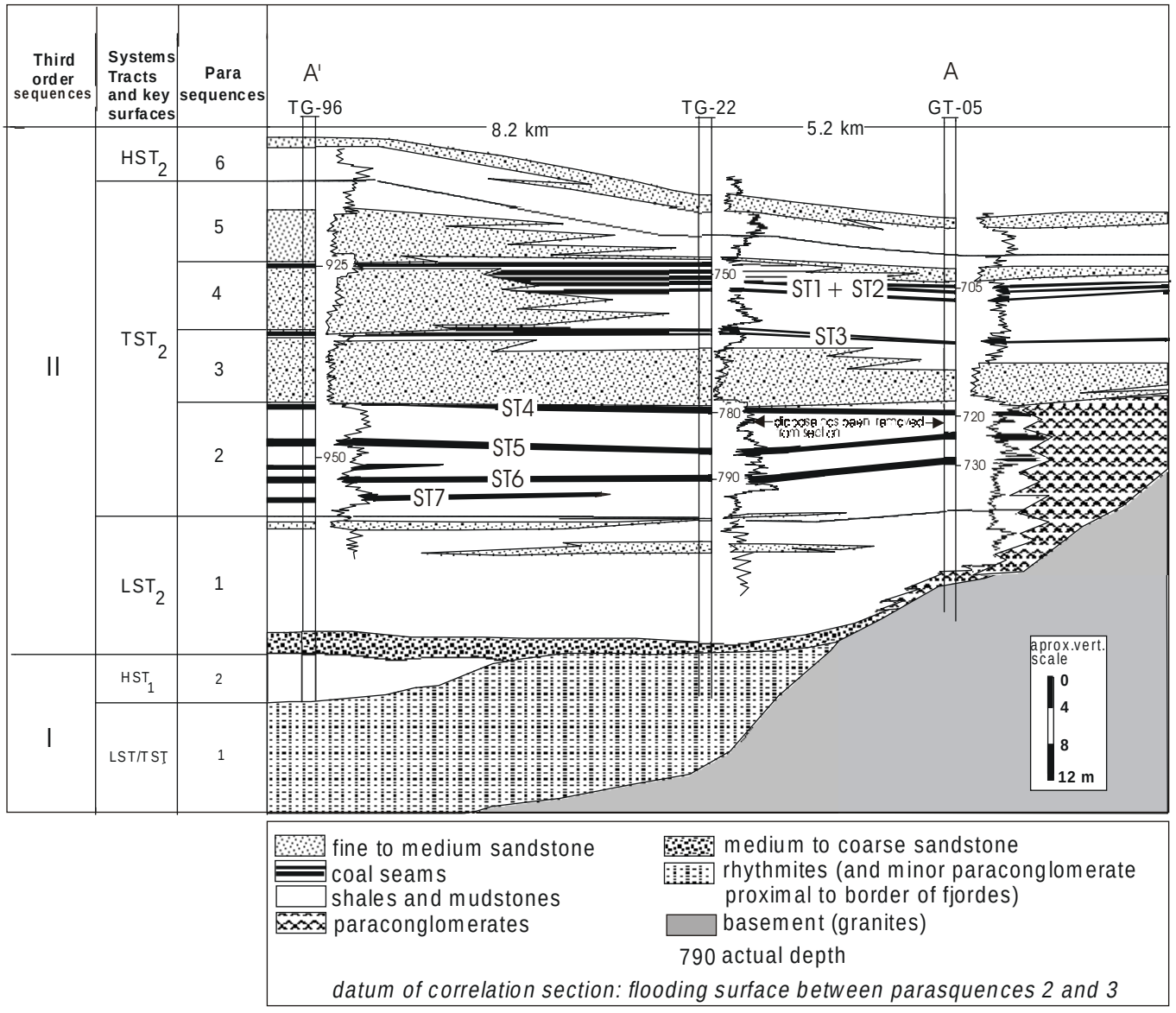

Figure 2 - Predominant lithologies, stratigraphic position and depth range of the major coal seams in the northern part of the Santa Terezinha Coalfield. For location of section A - A' see Fig. 1.

to NE across the coalfield. The reflectance values (0.73-0.99 % Rrandom) indicate high volatile A bituminous coals. Locally, diabase intrusions have altered the rank of the coal seams to anthracite, with vitrinite reflectances of up to 5 %. The depth to rank (vitrinite reflectance) relationships for one of the boreholes analyzed (Araújo et al. 1995) are shown in figure 3. The figure also shows estimated CBM contents for each depth interval and the effect of local intrusions on coal rank (vitrinite reflectance). The effect on gas holding capacities of these thermally altered coals is unknown at the present time.

Calculation of Coalbed Methane Volumes Table 2 shows the integration of coal reserve data with estimated CBM contents. For each depth interval the coal resources of the three major seams (ST4, ST5, ST6) were calculated. The average CBM content for each depth interval was calculated by Ryan's (1992) computer program, based on the following parameter: vitrinite reflectance at 400 m depth = 0.70%, at 950 m = 0.89%, coalification gradient = 0.04%/100m, moisture content = 5 wt.%, ash yield = 50 wt%. The results show for shallow depth an estimated CBM content of 3.19 m^3/t and for greater depths a value of 5.53 m^3/t (Table2). The next step was to multiply the estimated CBM values by the coal tonnage determined for each depth interval. The results are shown in the right column of Table 2 indicating that as much as 19 Billion m^3 of coalbed methane could be contained in the three major coal seams of the Santa Terezinha Coalfield.

If this gas volume is indeed contained in the deposit and can be produced at a reasonable rate, it would offer an alternative source of energy for the southern part of the country. Further research is currently done at the Coal and Organic Petrology Laboratories, UFRGS to substantiate these preliminary considerations.

Table 2 - Calculated coal resources for seams ST4, ST5 and ST6 for depth intervals 400 to 950 m, average vitrinite reflectance level, and estimated averaged coalbed methane contents.

Depth Range (m)	Resources (10^6 t)	Rrandom (%)	Methane Content (m^3/t)	Total Methane (10^6 m^3)
400-500	125	0,72	3,19	399
500-650	1095	0,77	4,14	4533
650-800	730	0,82	4,89	3570
800-950	1920	0,88	5,53	10618
			Total	19119

CONCLUSIONS Coal rank (high volatile A bituminous - anthracite), coal volume (4.2 Billion t) and depth of the deposit (300-950 m) make the Santa Terezinha the prime candidate for coalbed methane exploration in Brazil. A preliminary CBM assessment based on coal rank, coal volume and depth range of the 3 major seams of the deposit (ST4, ST5,ST6) suggests that as much as 19 Billion m^3 of coalbed methane may be associated with the three seams.

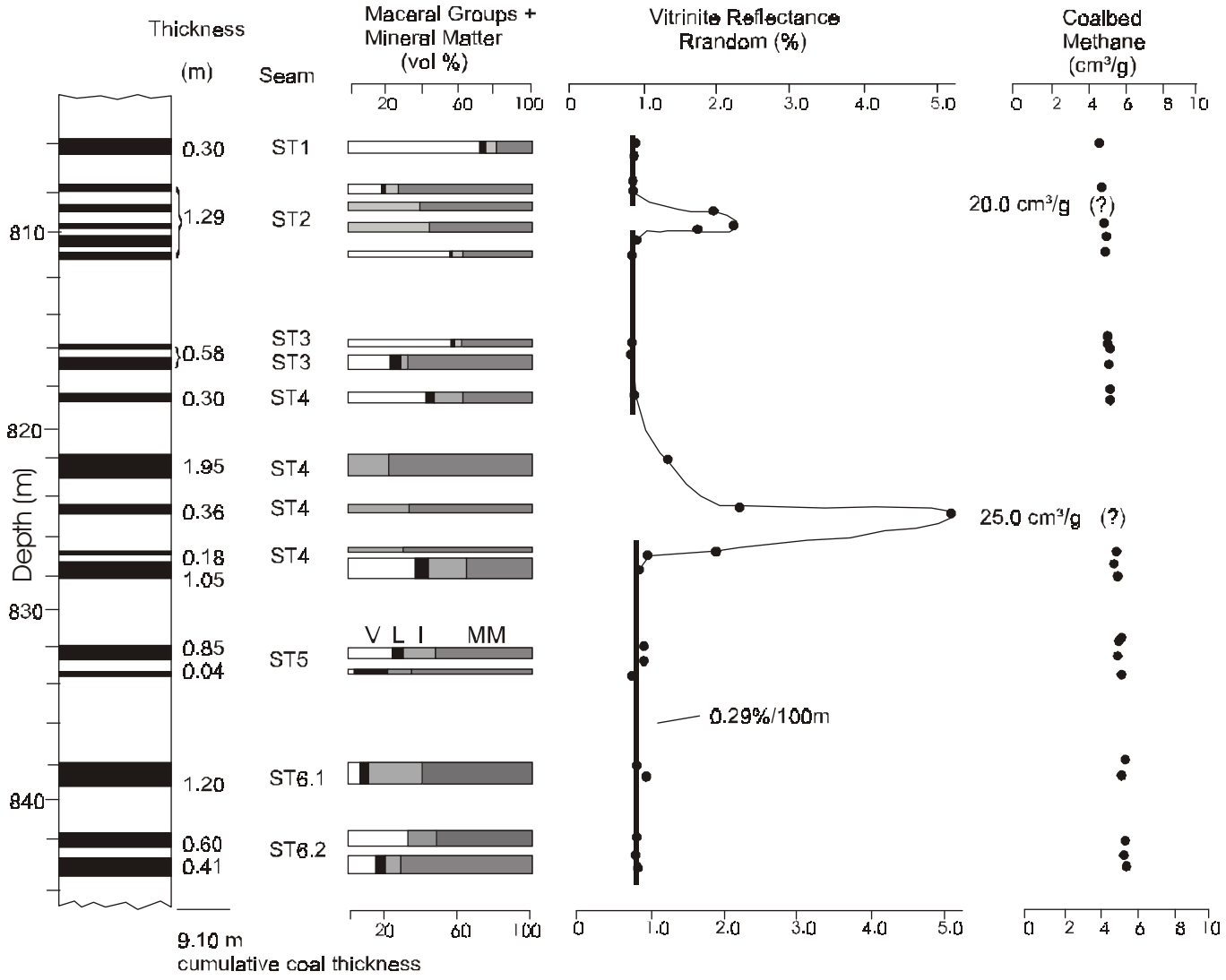

Figure 3 - Coal seam distribution and depth range in borehole 2TG-227-RS, maceral composition and mineral matter content (V= vitrinite, L= liptinite, I= inertinite, MM = mineral matter) and vitrinite reflectance (from Araújo et al., 1995) and estimated coalbed methane contents. For location of borehole see Fig. 1.

Current research on coal distribution, coal characterization and isotherm experimentation to study the gas adsorption capacities of the seams will have to substantiate these preliminary considerations.

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