Application of Hydrous Pyrolysis Technique in Evaluating Coalbed Methane Prospects*

Mario Garcia-Gonzalez[1]

Search and Discovery Article #80071 (2009)
Posted January 25, 2010

*Adapted from oral presentation at AAPG Convention, Denver, Colorado, June 7-10, 2009

[1]Geology, Universidad Industrial de Santander, Bucaramanga, Colombia (mgarciag@uis.edu.co)

Abstract

Hydrous pyrolysis (HP) tests on immature coal samples allow reproducing the natural maturation or coalification process that takes place during burial of coal-bearing sequences. These HP experiments generate oil and gases which can be measured to determine the generation potential and also produce a coal residue to be analyzed with vitrinite reflectance and other techniques.

The standard HP technique requires a set of 9 experiments at constant temperatures ranging from 290 to 360 degrees C during 72 hours to obtain coal residues with vitrinite reflectance (Ro) ranging between 0.8 and 1.8%, or even higher Ro values if experiments longer than 72 hours are set up. These HP experimental results with coal samples allow measurements of the generation potential for gas and oil in terms of cubic feet of gas per ton of coal (cft/ton coal) and barrels of oil per ton of coal (Bbl/ton coal) at a given vitrinite reflectance value. In addition, the hydrocarbons artificially generated during HP experimentation are analyzed by gas chromatography and other geochemical techniques.

Different coalbed sites have been evaluated indicating that the gas generation potential of coal varies between 30 cft/ton coal at a Ro value of 0.8% to 2,400 cft/ton coal at a Ro of 1.8%. These figures can be used to evaluate the gas in place resources of a coalbed area.

The gas composition of the gases generated from coals in HP experiments greatly changes from methane dominated to CO_2 dominated, and also the volume of wet and condensate gases varies in each coal-bearing formation. These changes in the gas composition are related to the maceral composition of the coalbed.

Application of Hydrous Pyrolysis Technique in Evaluating Coalbed Methane Prospects

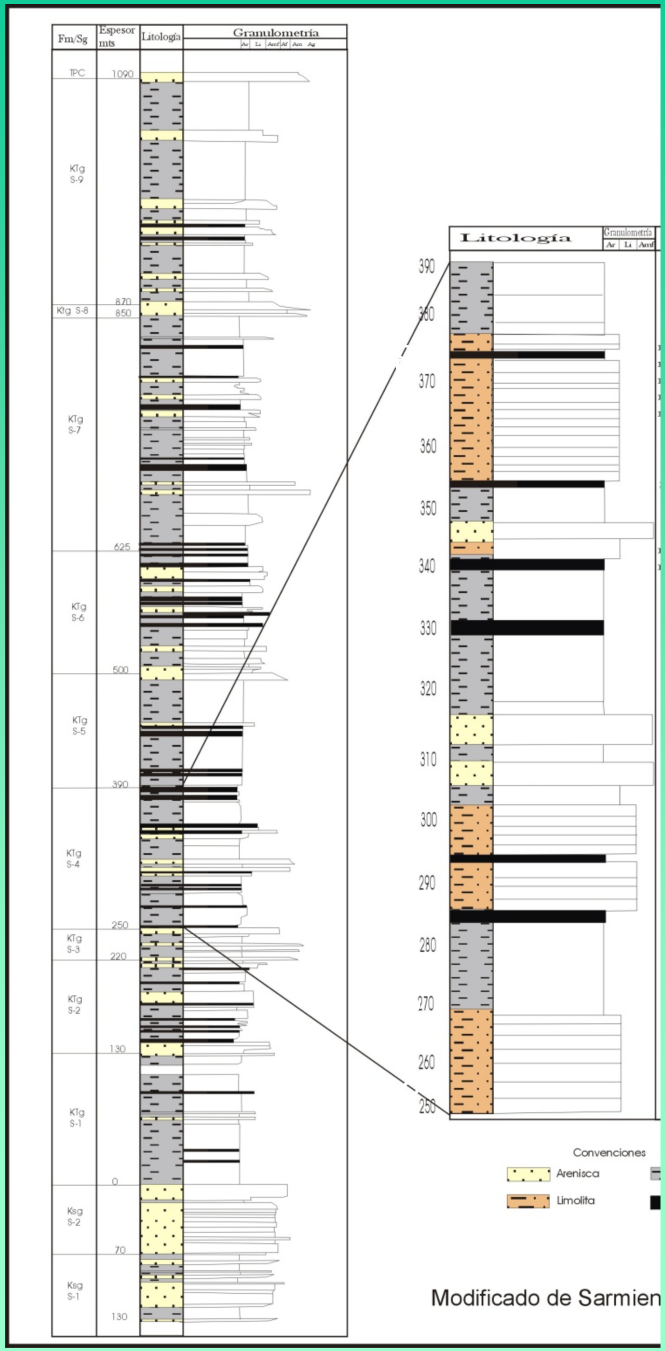
Mario García-González

Research Group on Hydrocarbon and Coal Geology

UNIVERSIDAD INDUSTRIAL DE SANTANDER

OUTLINE

- COAL SAMPLING
- INSTRUMENTATION
- METHODOLOGY
- RESULTS
- APPLICATIONS
- CONCLUSIONS



SAMPLING

1.Coal samples should come from one or several coal seams.

2. Coal samples should be representative of the entire coal seam from top to bottom

3. The stratigraphic position as well as the geographic position should be known

4. Vitrinite reflectance should be 0.5% or lower

5. An homogenized 200 gr samples is used to run the H.P. tests

EQUIPMENT
Parr Reactor

Isothermal experiment run for 72 hours at:

290, 300, 310, 320

330, 340, 345, 350

360 $_{o}$C

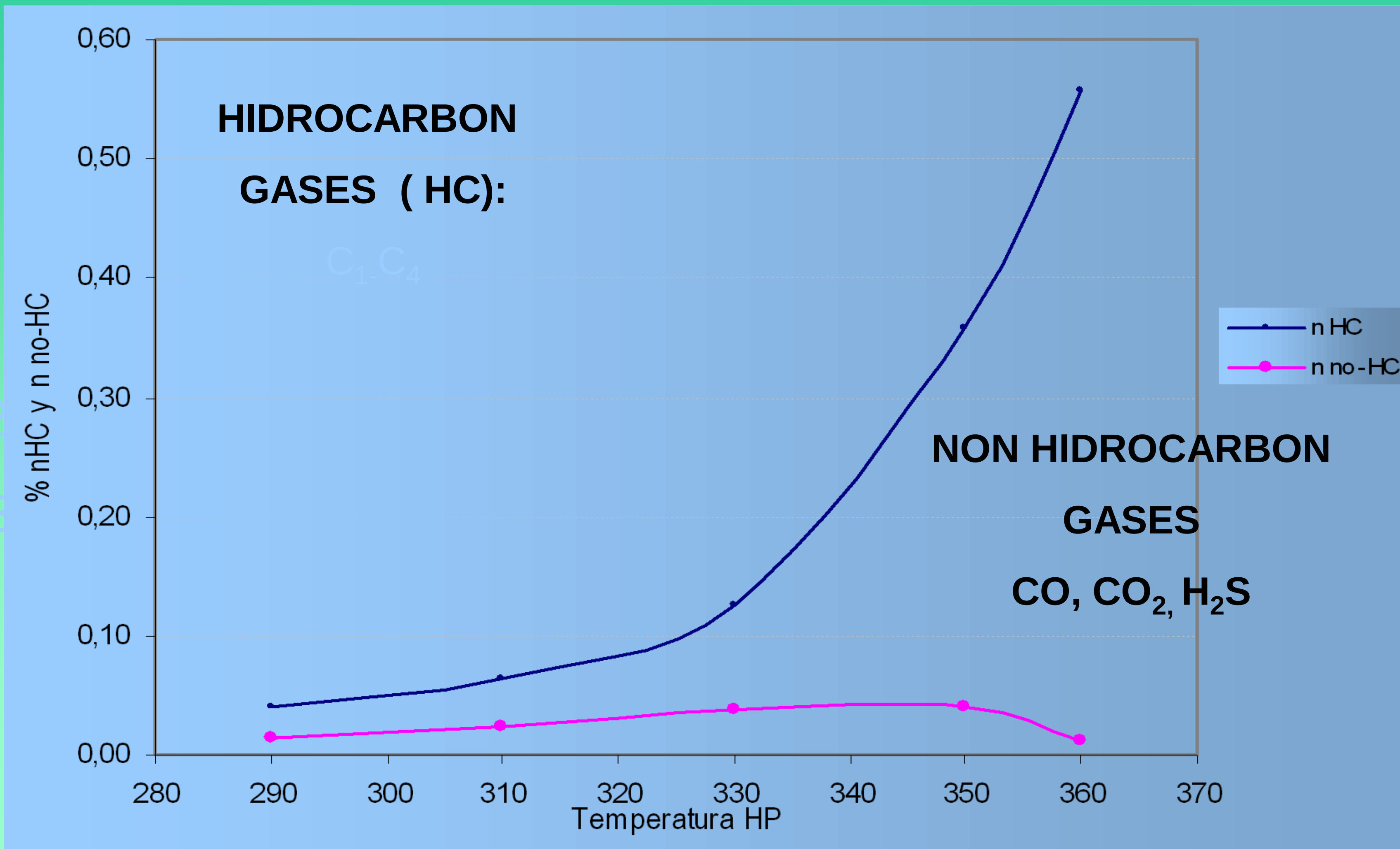
A 290^{O},300^{O},

HYDROUS PYROLYSIS PRODUCTS

- gas phase
- Oil phase
- Aqueous phase
- Coal solid residue



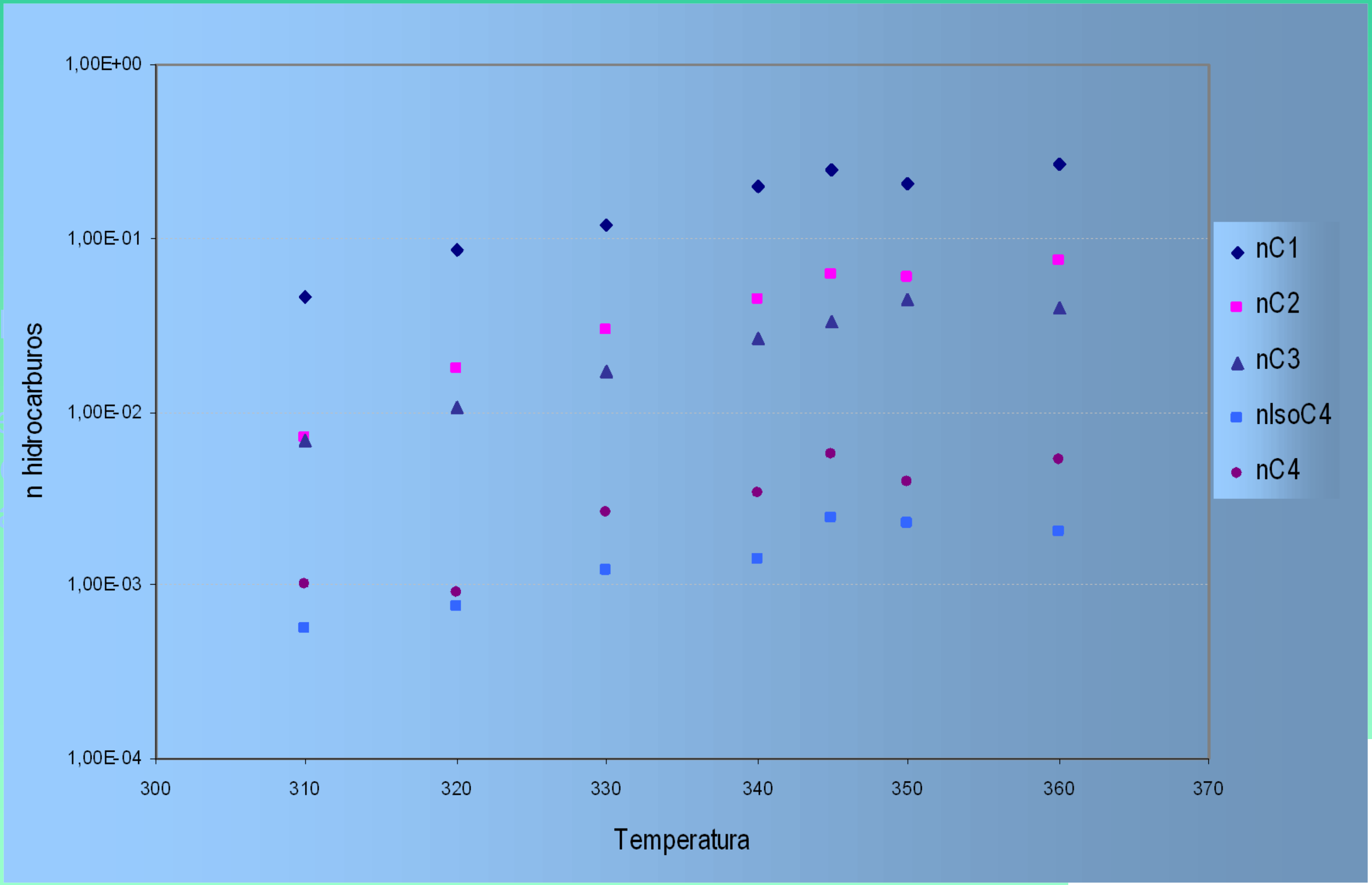
RESULTS



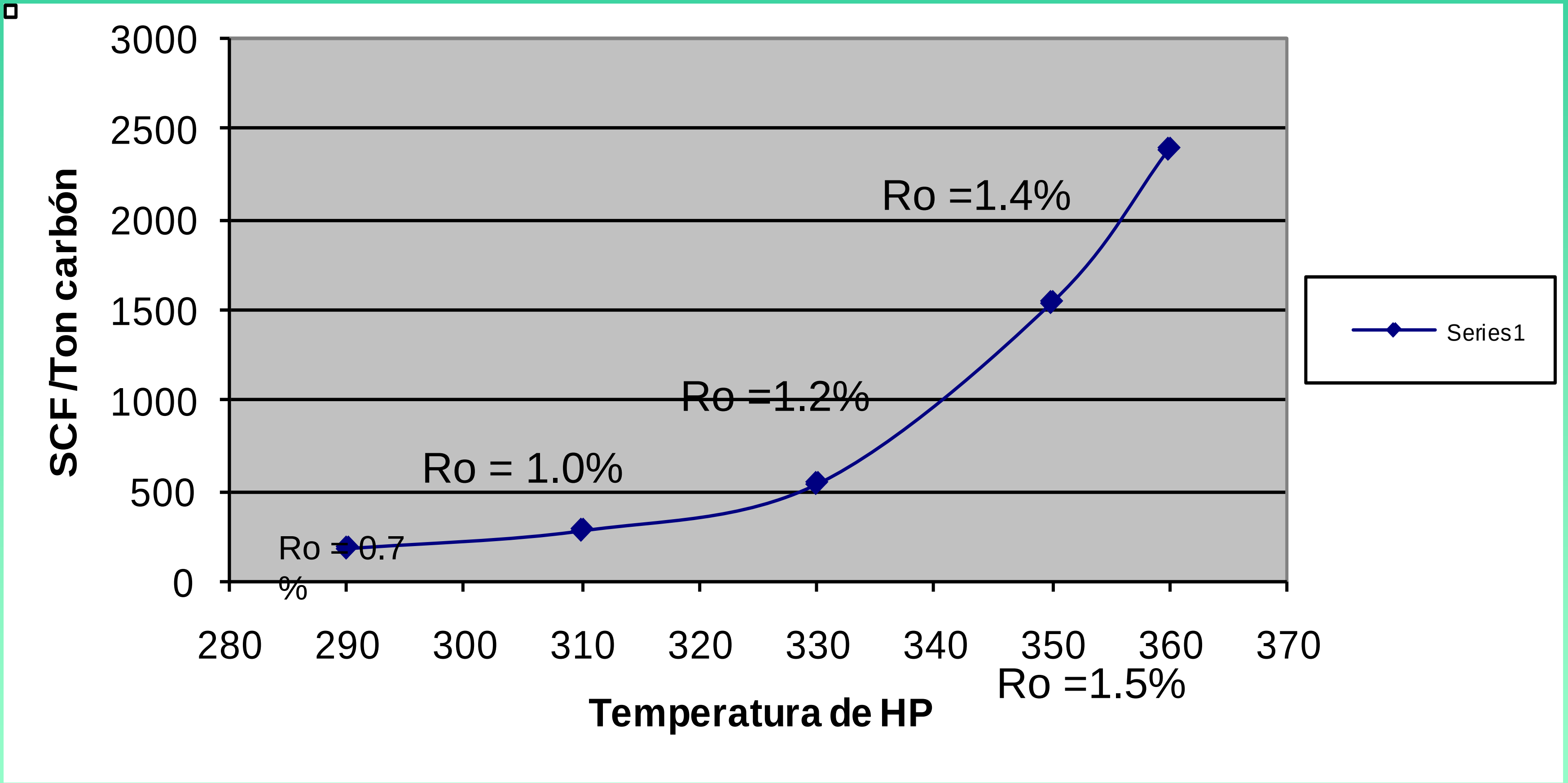
HIDROCARBON
GASES (HC):
NON HIDROCARBON
GASES
CO, CO2, H2S
n HC
n no-HC
% nHC y n no-HC
Temperatura HP
0,00
0,10
0,20
0,30
0,40
0,50
0,60
280
290
300
310
320
330
340
350
360
370

RESULTS

Gas Composition



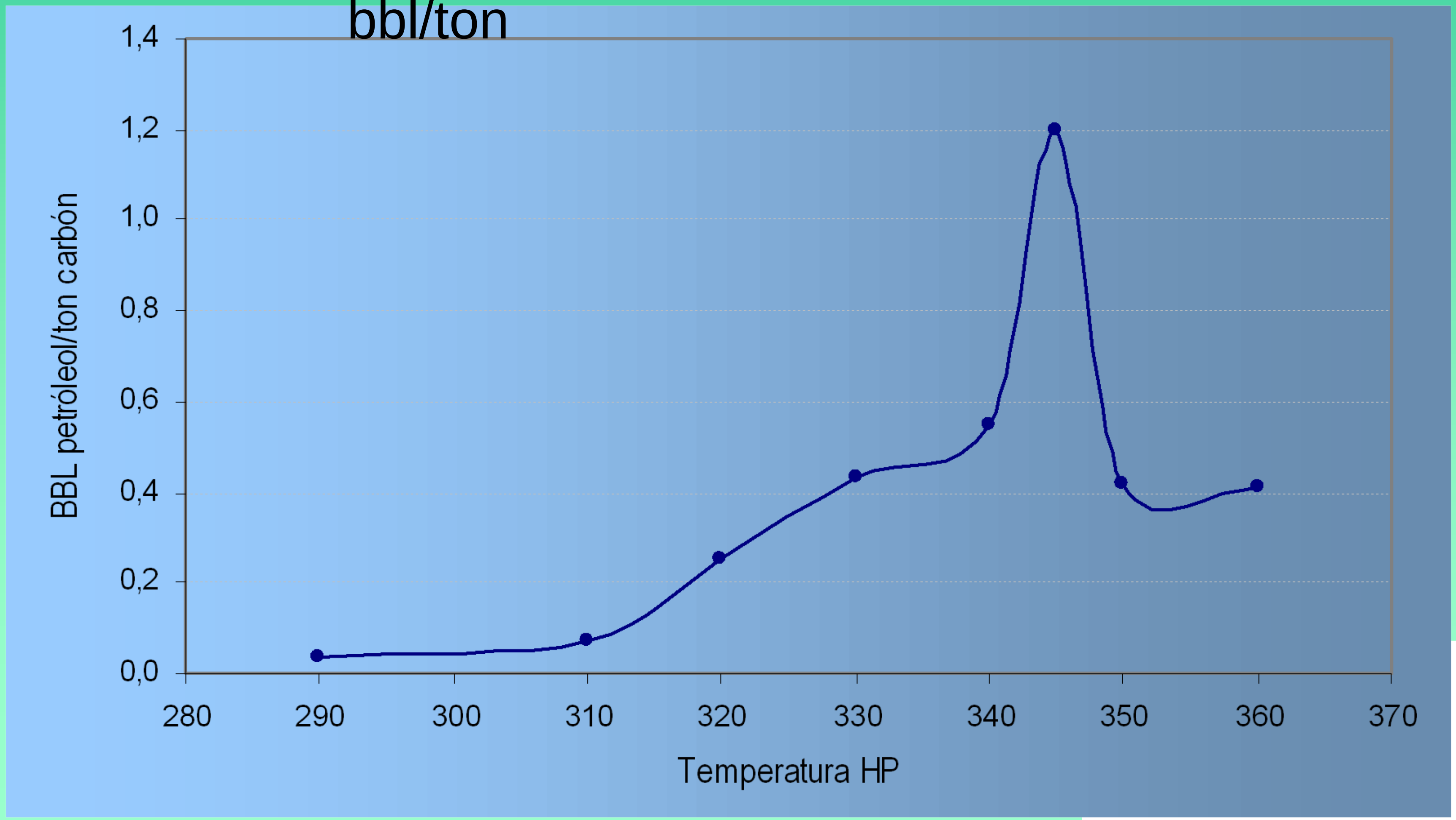
GAS GENERATION POTENTIAL



OIL GENERATION POTENTIAL

Ro 0.7%=0.036 bbl/ton

Ro 1.4% = 1.2 bbl/ton



EXAMPLES OF COALBED METHANE EVALUATIONS

Almond Formation Coal

Oligocene Coal of Colombia

ALMOND FORMATION COAL IN THE WASHAKIE BASIN WYOMING

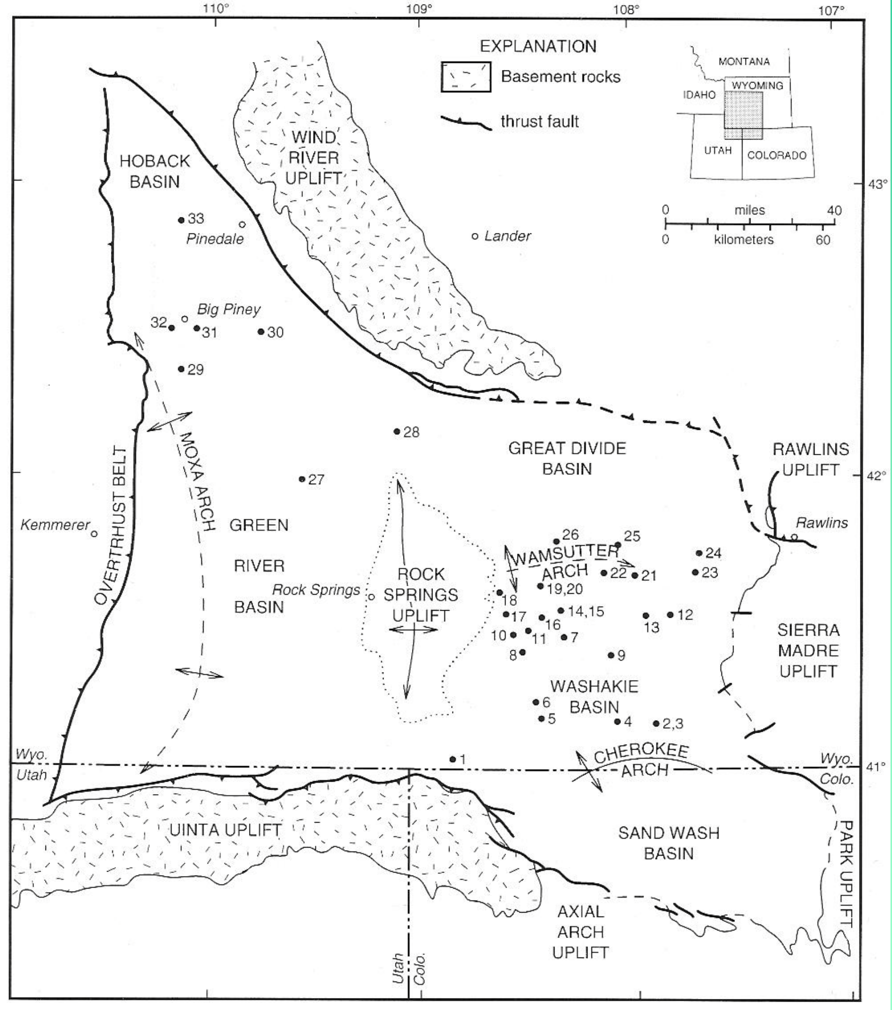


Figure 1. Map showing sample site locations. Numbers refer to list in table 1.

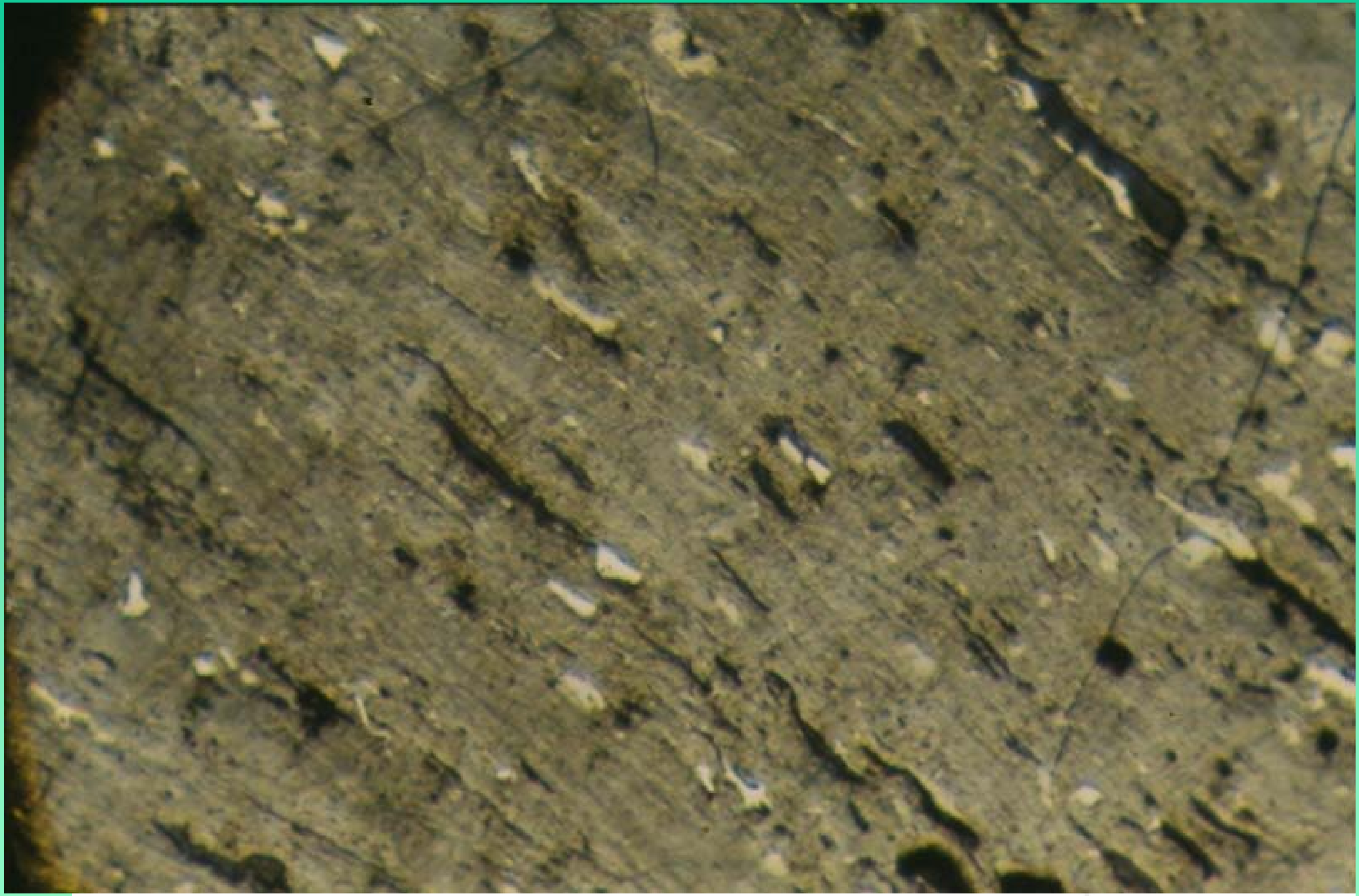


Figure 3. Photomicrograph of coal from an outcrop of the Almond Formation showing characteristic finely laminated texture of desmocollinite (d), with dispersed sporinite (sp), cutinite (cu), and inertinite (in) macerals. Reflected white light.

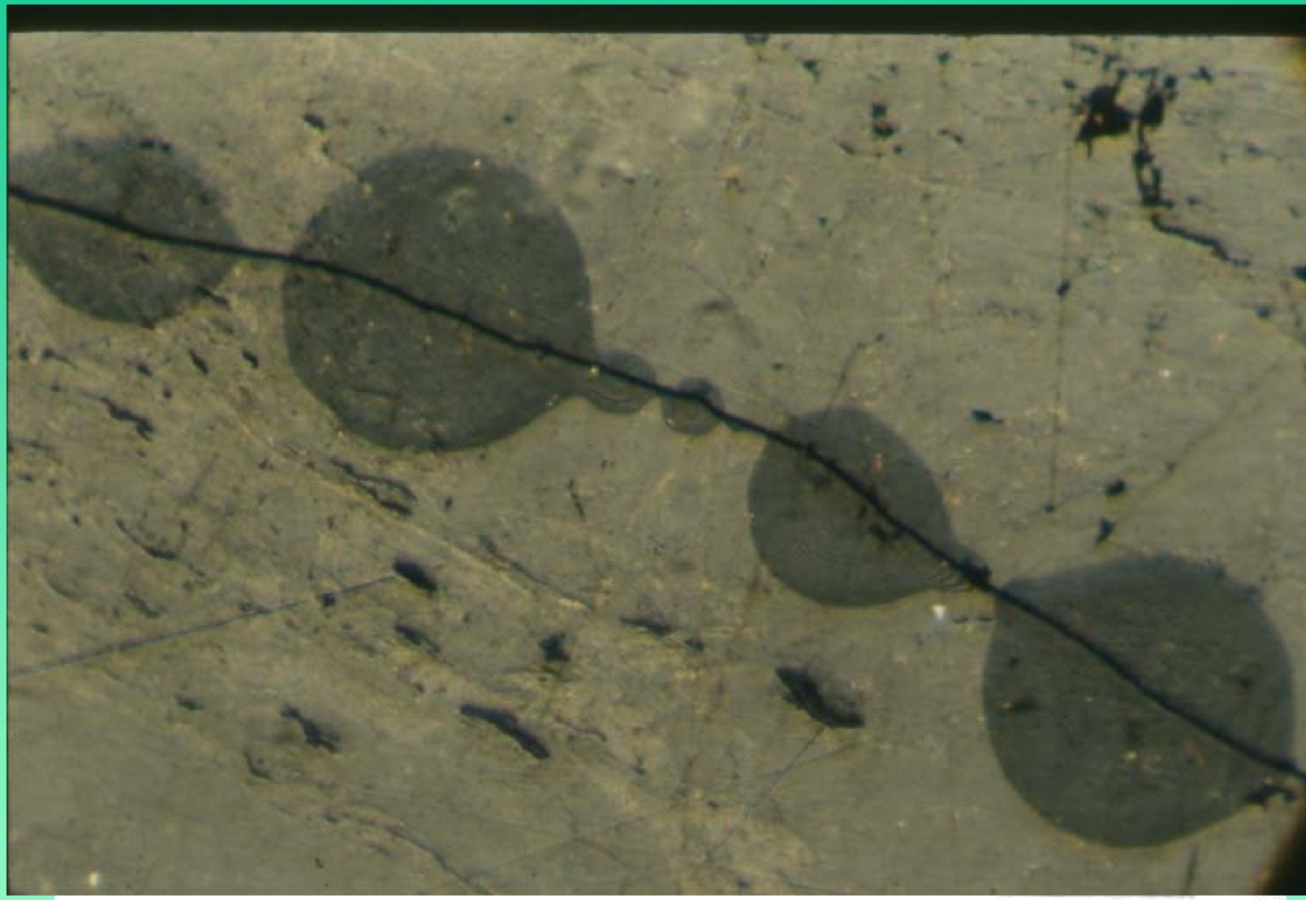


Figure 5. Photomicrograph of coal from the Almond Formation at a depth of 4,217 ft. Indigenous oil (ol) associated with fissures in vitrinite (v). Sporinite (sp). Reflected white light.

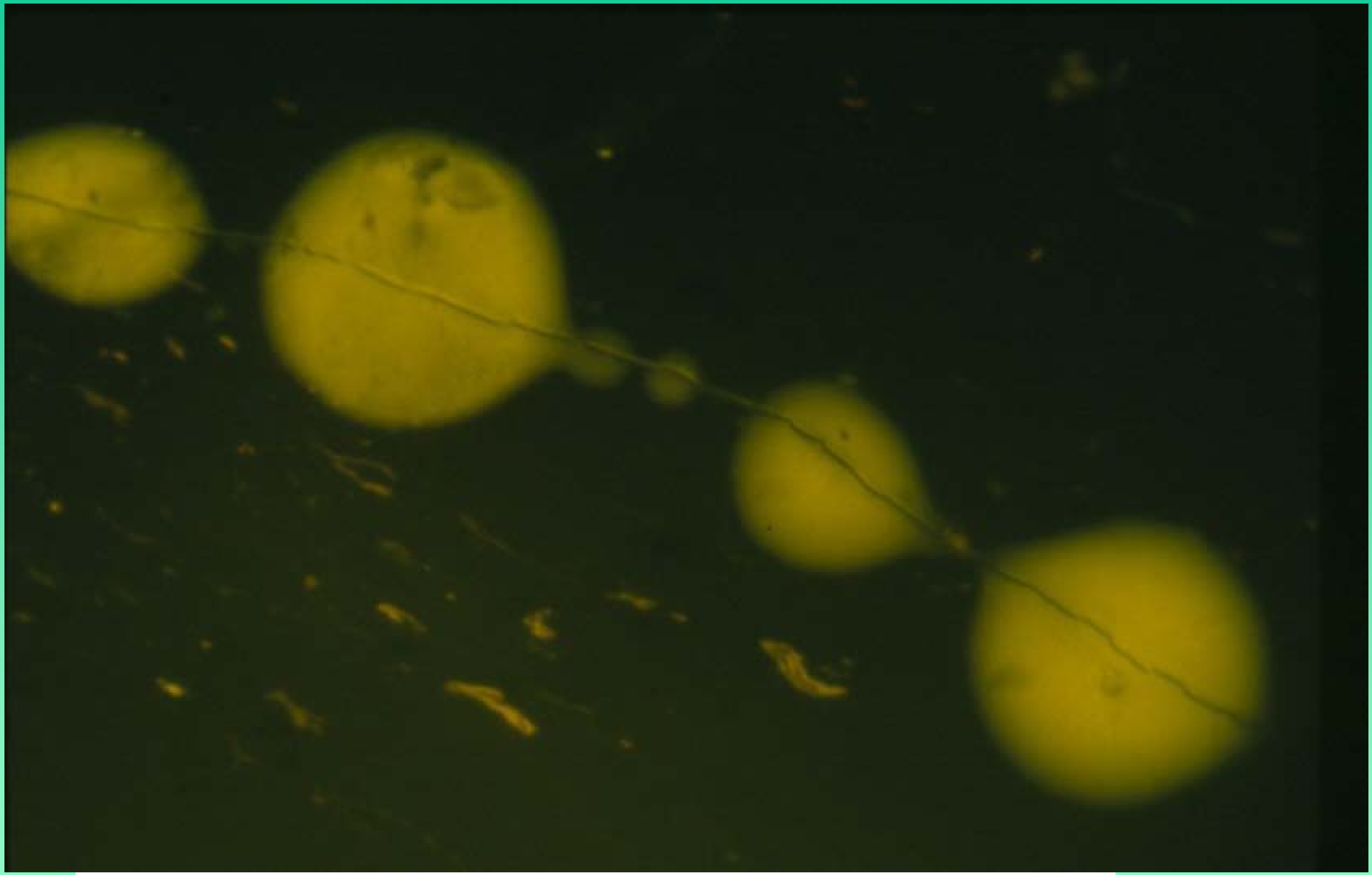


Figure 6. Photomicrograph of same feature as figure 5 under reflected blue light showing fluorescence of indigenous oil (ol) and sporinite (sp).

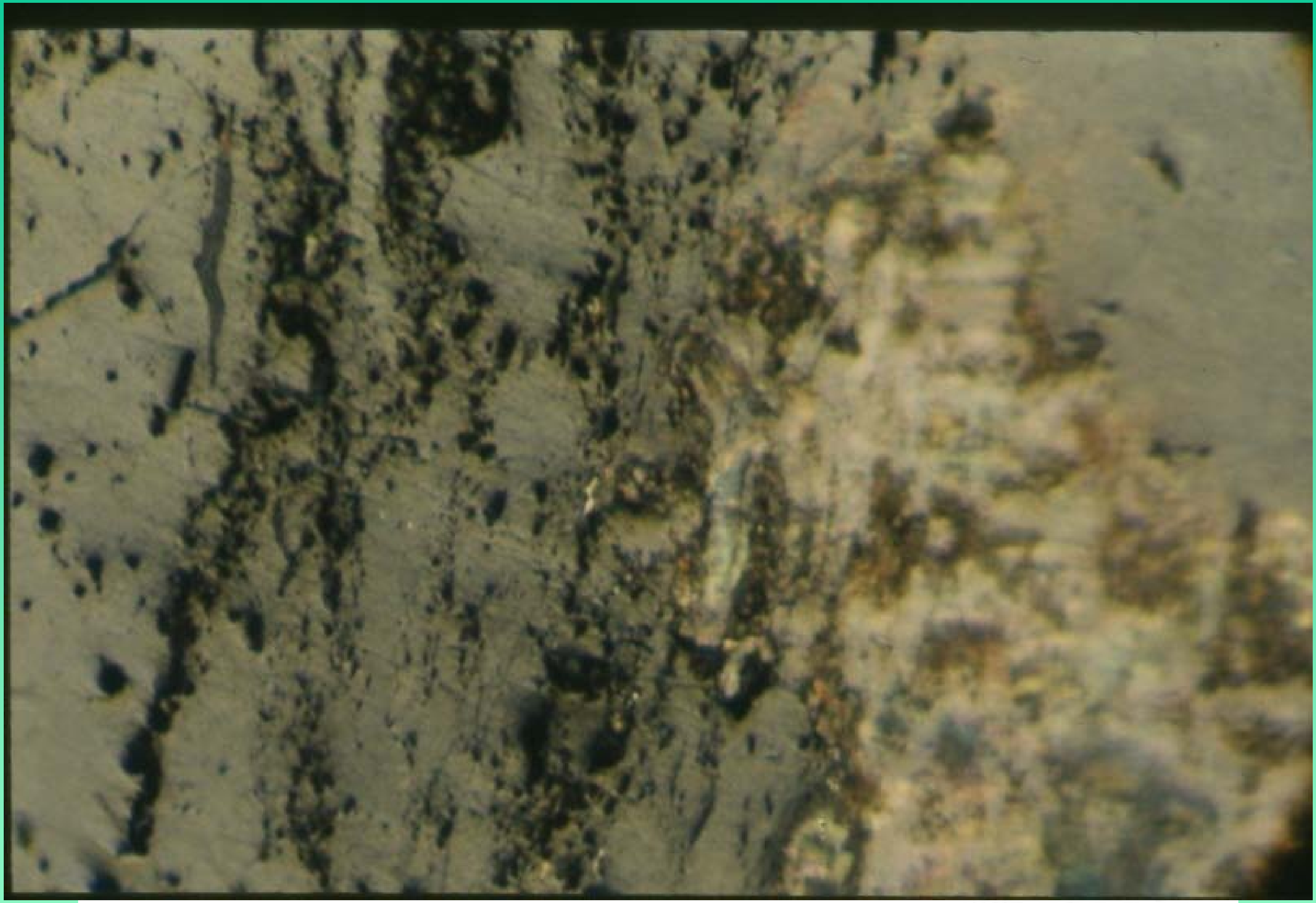


Figure 7. Photomicrograph of coal from the Almond Formation at a depth of 6,944 ft. Development of porous texture as exsudatinite (ex) starts to form. Vitrinite (v), sporinite (sp), indigenous oil (ol). Reflected white light.

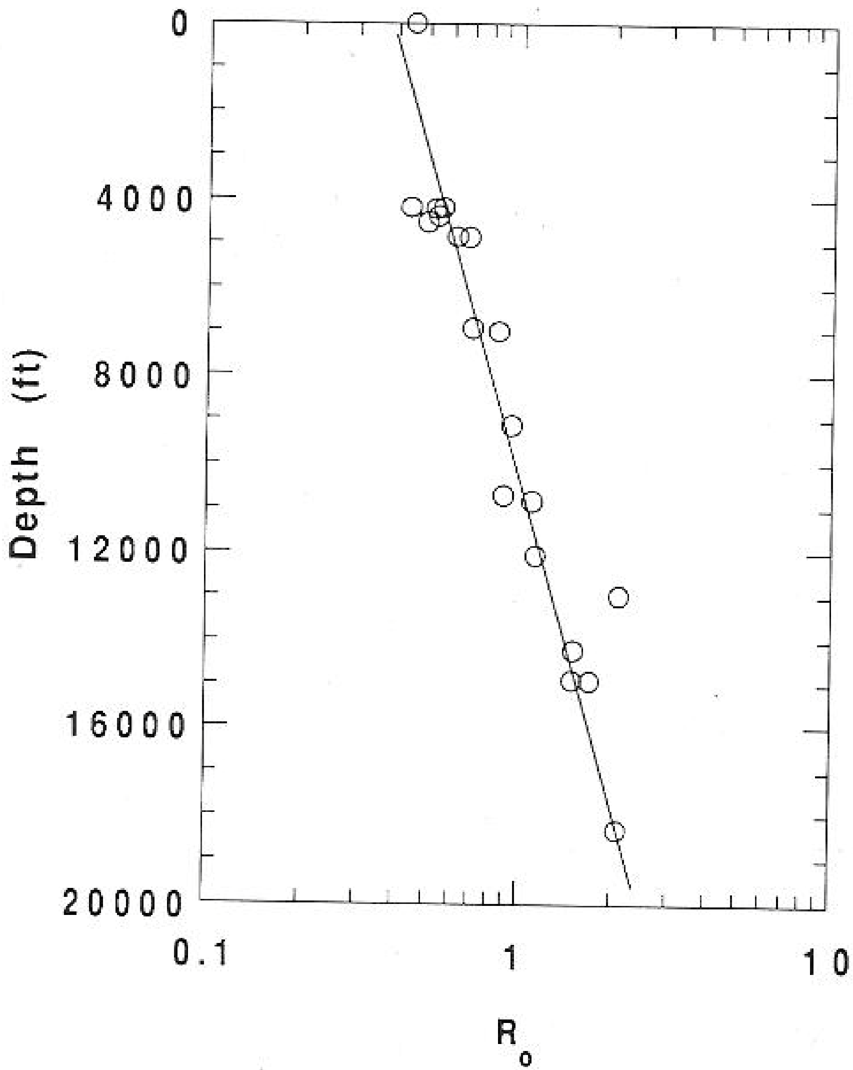


Figure 15. Mean vitrinite reflectance (R_o) versus depth for the Almond Formation shales and coals, Greater Green River Basin, Wyoming.

HYDROUS PYROLYSIS OF THE ALMOND FORMATION COALS

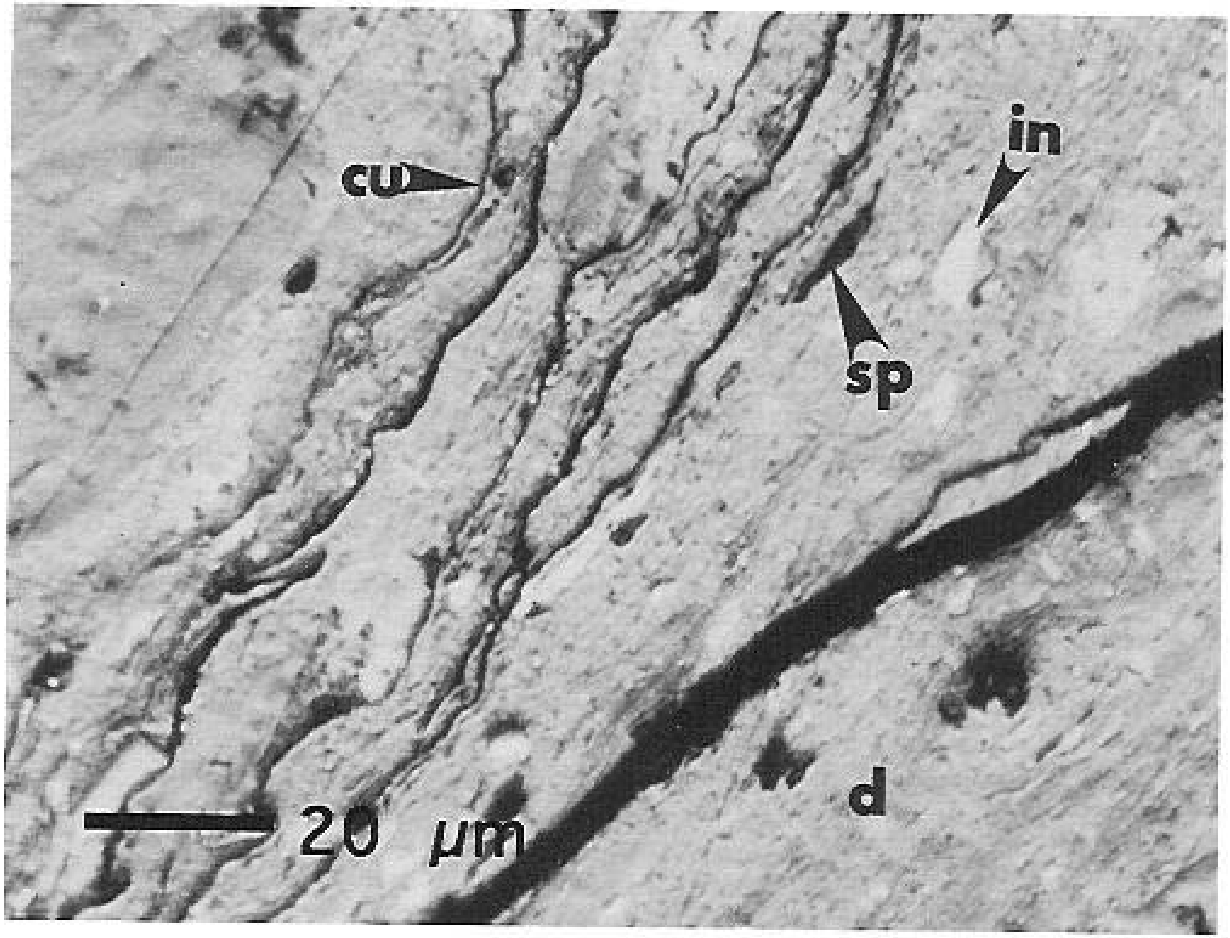


Figure 25. Photomicrograph of coal from an outcrop of the Almond Formation. Starting material for hydrous pyrolysis experiments. Finely laminated texture of desmocollinite (d) matrix with dispersed sporinite (sp) and cutinite (cu). Inertinite (in). Reflected white light.

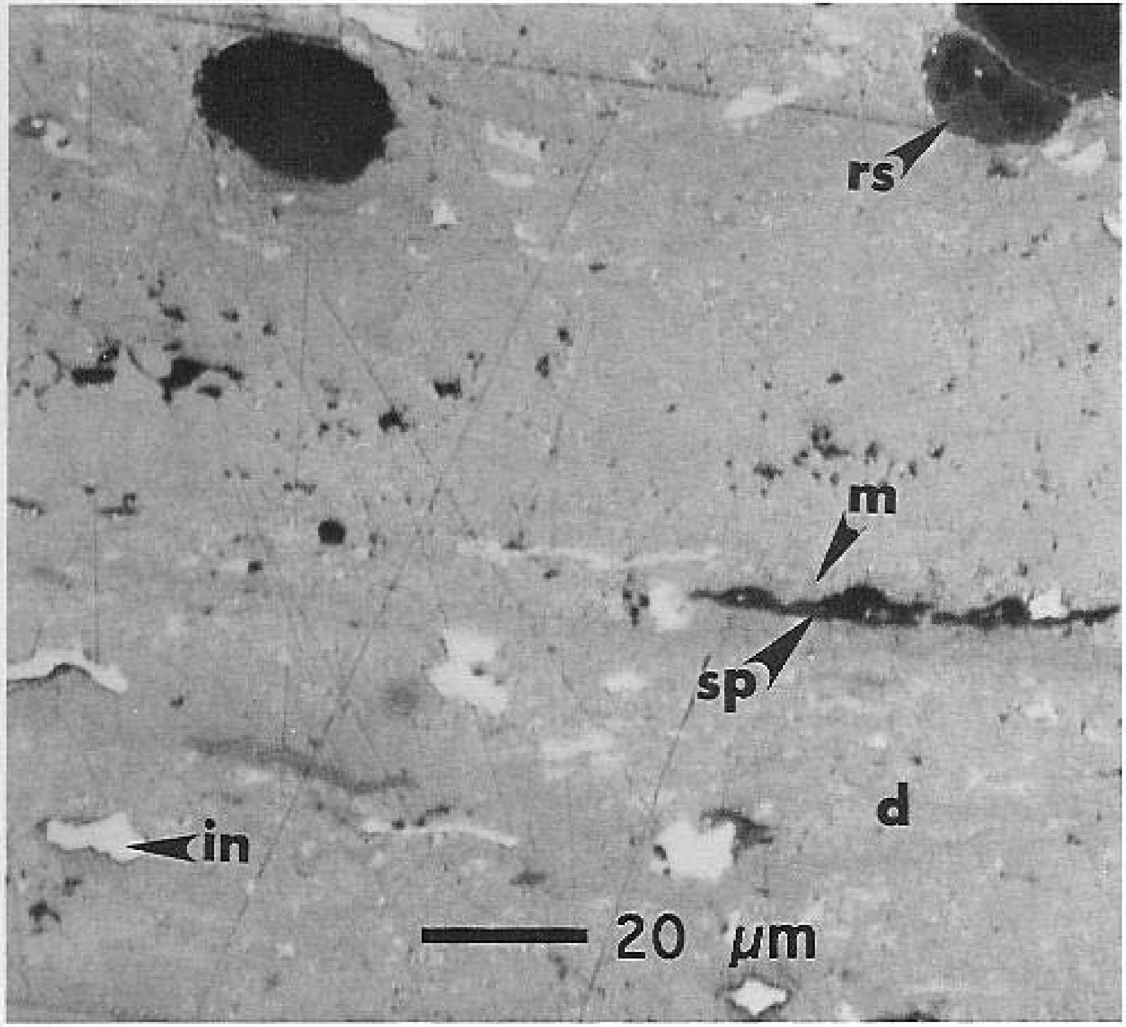


Figure 26. Photomicrograph of coal from the Almond Formation after hydrous pyrolysis at 290°C: Desmocollinite (d) loses its finely laminated texture. Micrinite (m) formed from sporinite (sp) macerals. Resinite (rs); inertinite (in). Reflected white light.

Figure 31. Photomicrograph of coal from the Almond Formation after hydrous pyrolysis at 360°C: Vesicular texture on semifusinite (sf). Vesicles filled with exsudatinite (ex). Reflected white light.

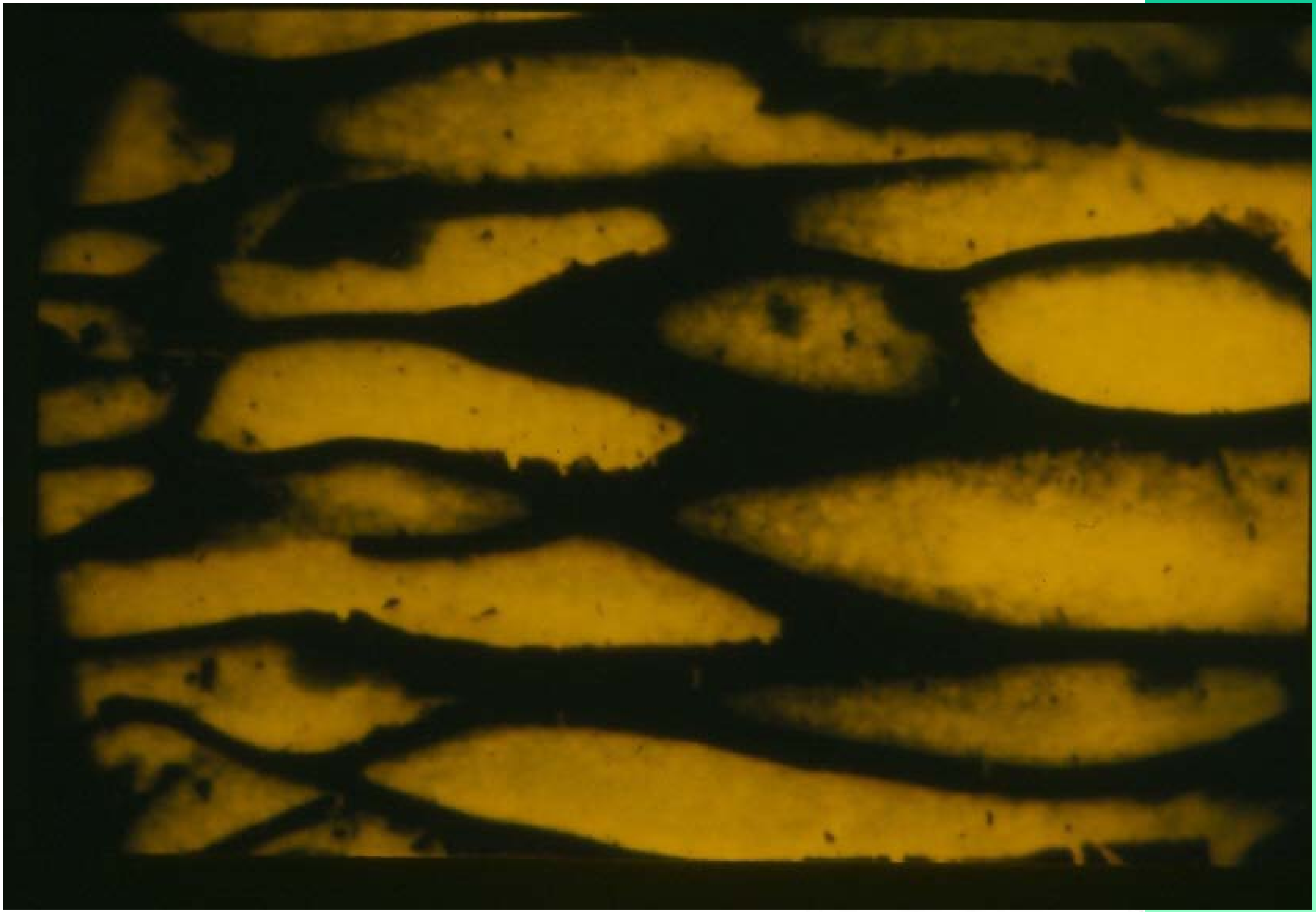


Figure 32. Photomicrograph of same feature as Figure 31 under reflected blue light showing strong fluorescence of exsudatinite (ex).

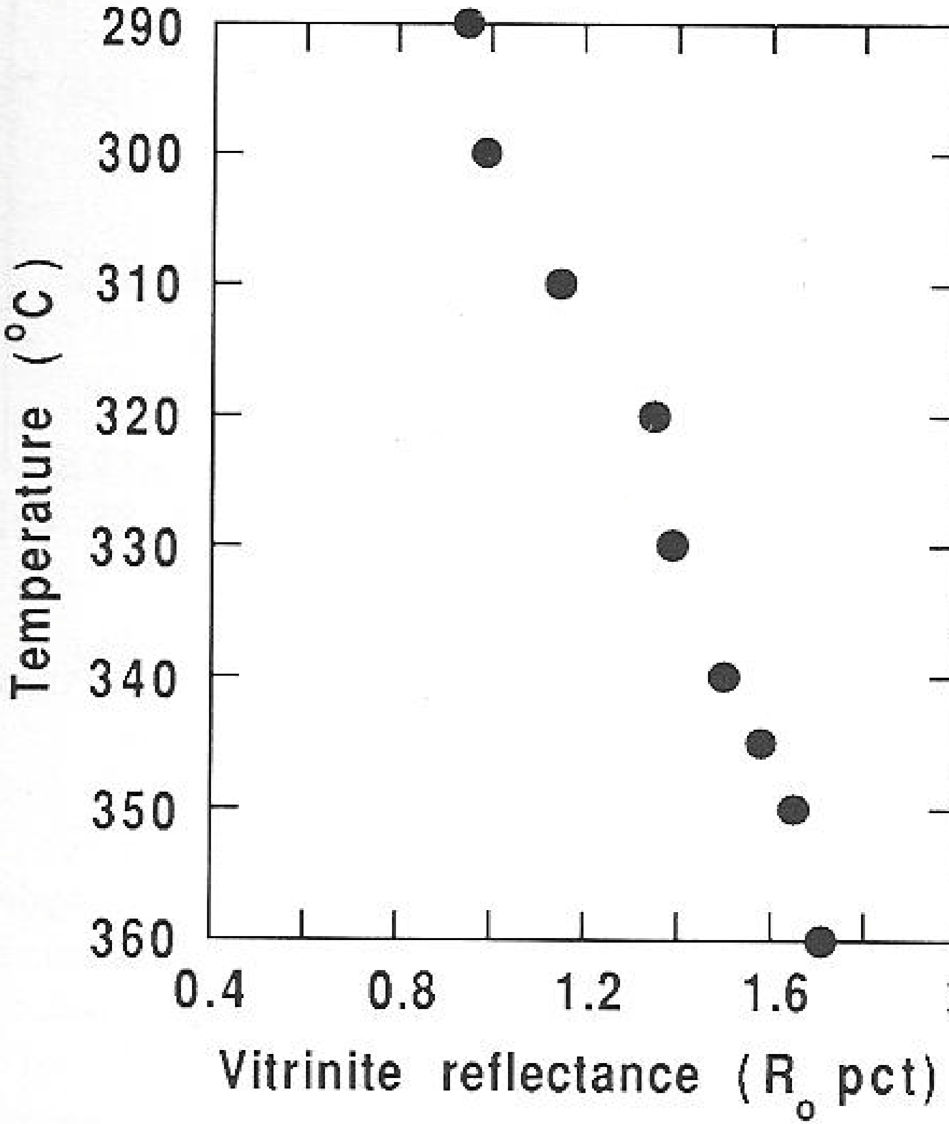


Figure 35. Vitrinite reflectances versus temperature obtained for Almond Formation coal after hydrous pyrolysis.

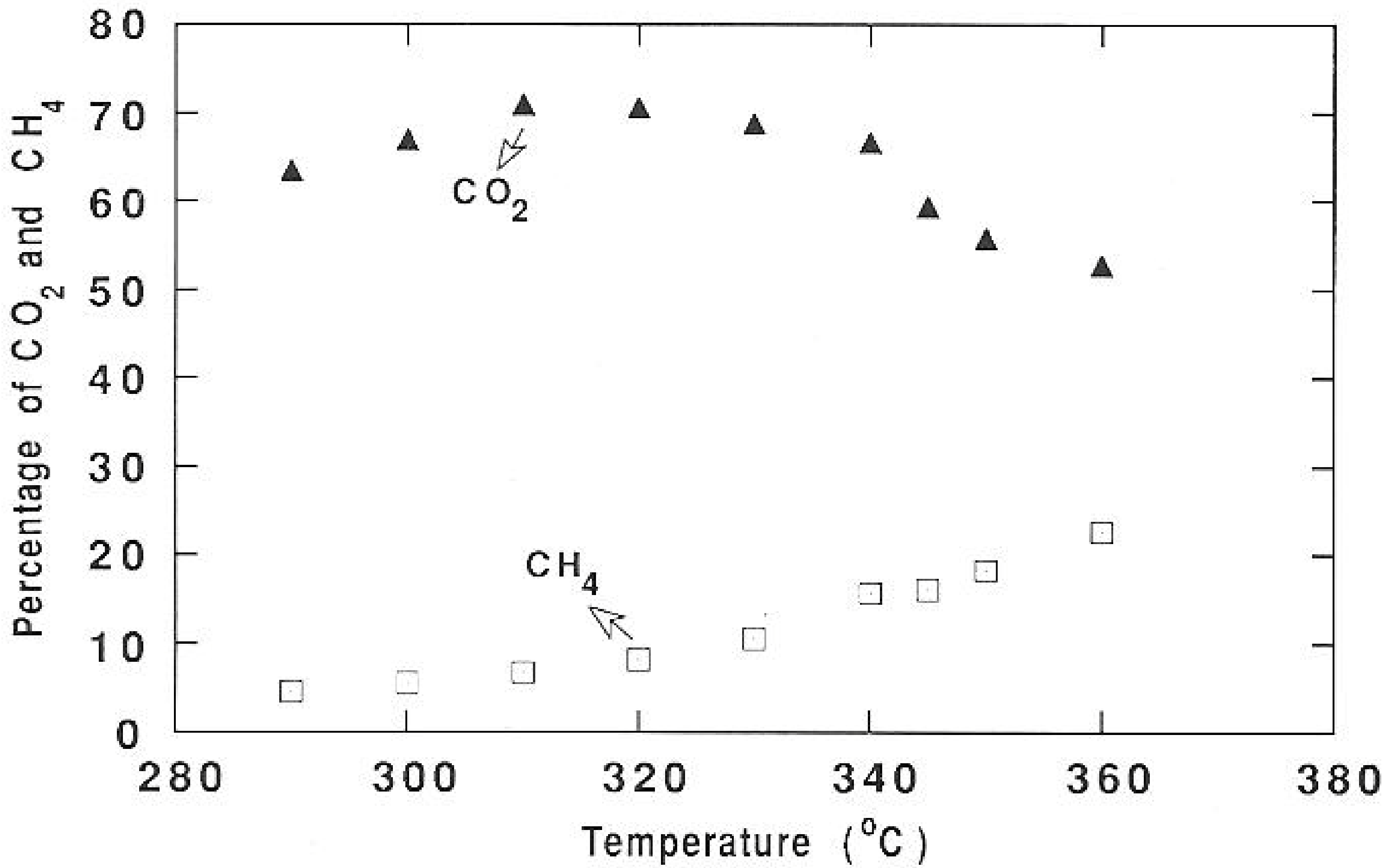


Figure 40. Almond Formation coal hydrous pyrolysis experiment percent CO_2 and CH_4 versus temperature.

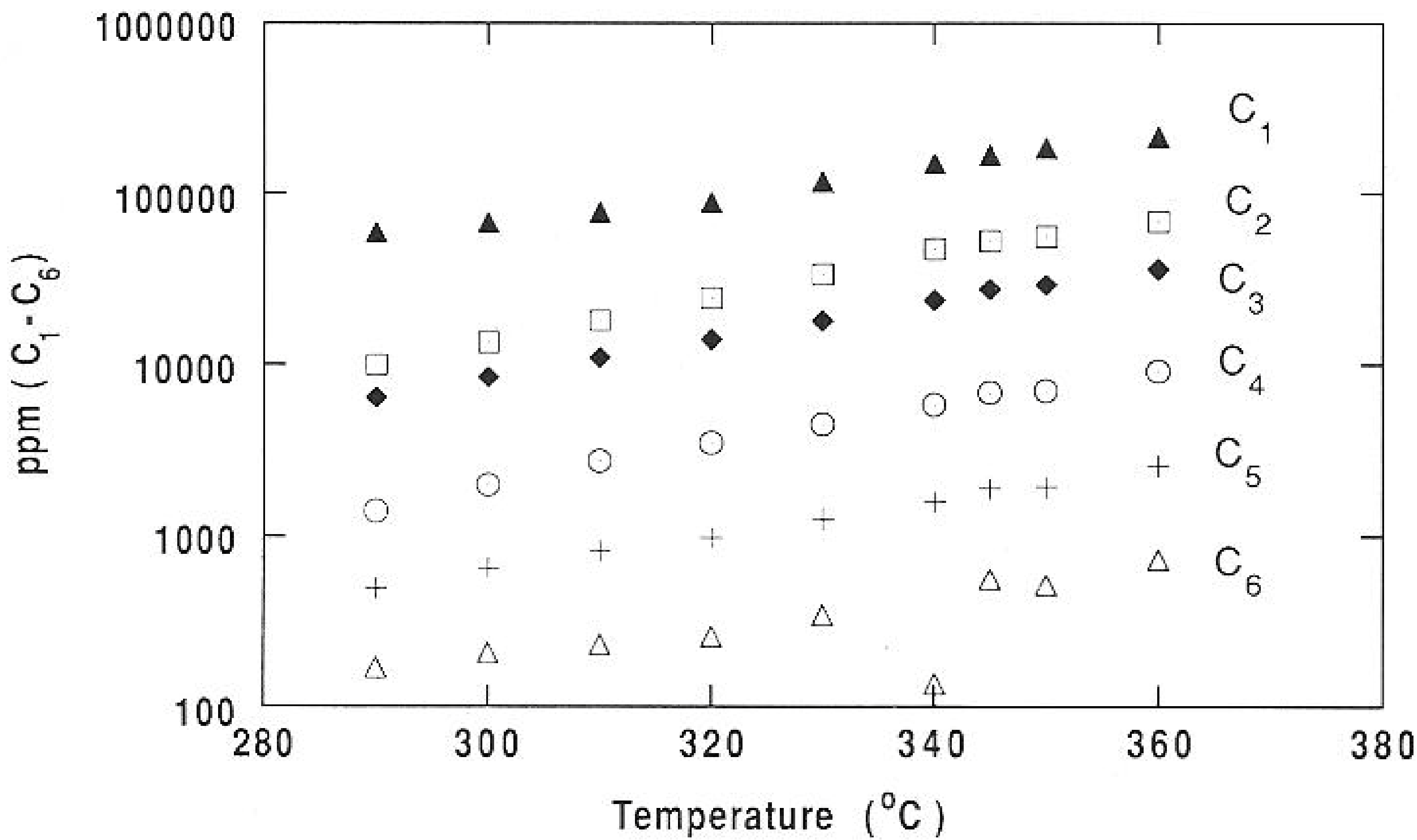
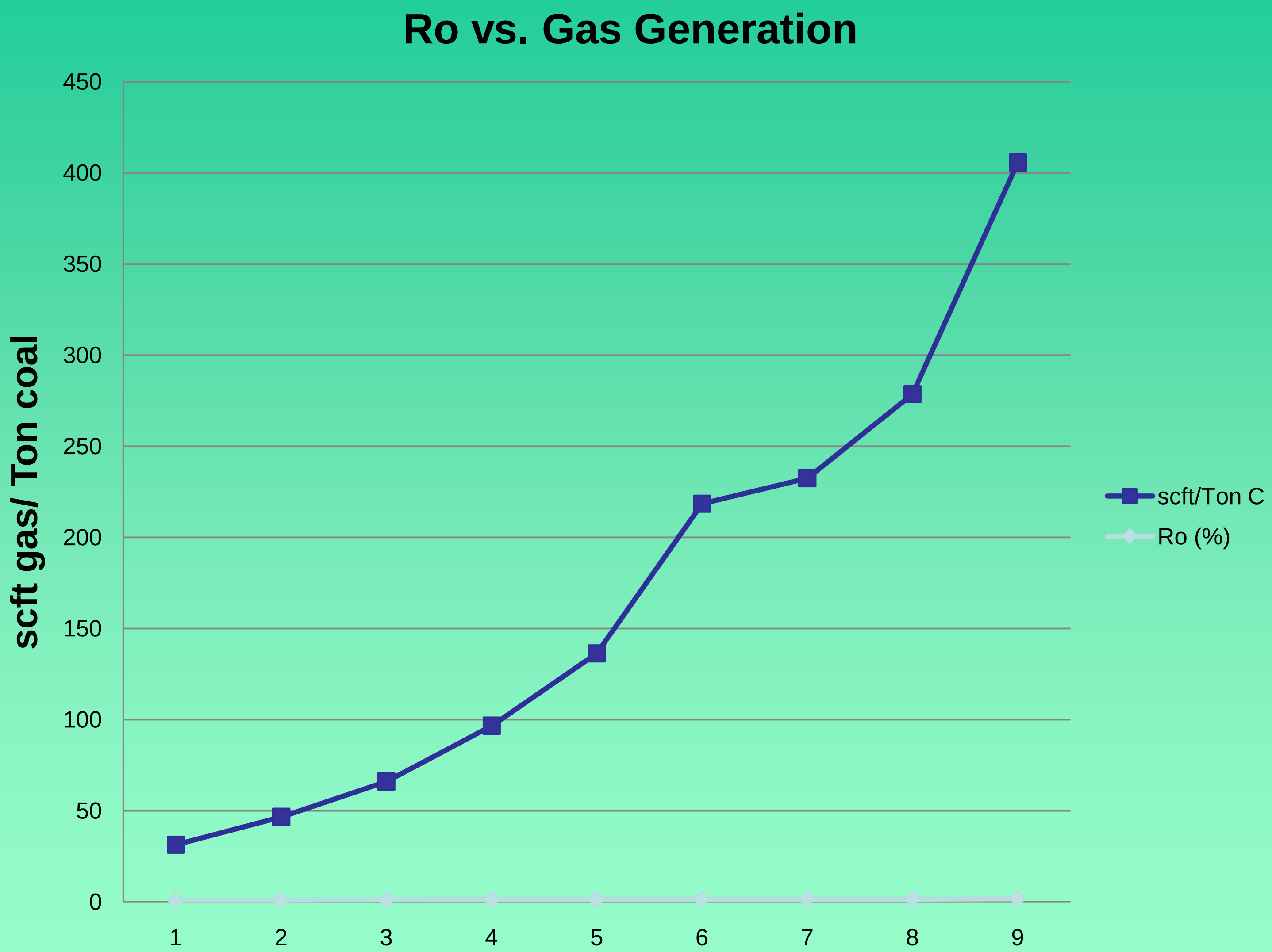


Figure 41. Almond Formation coal hydrous pyrolysis experiment: headspace hydrocarbon gas composition versus temperature.

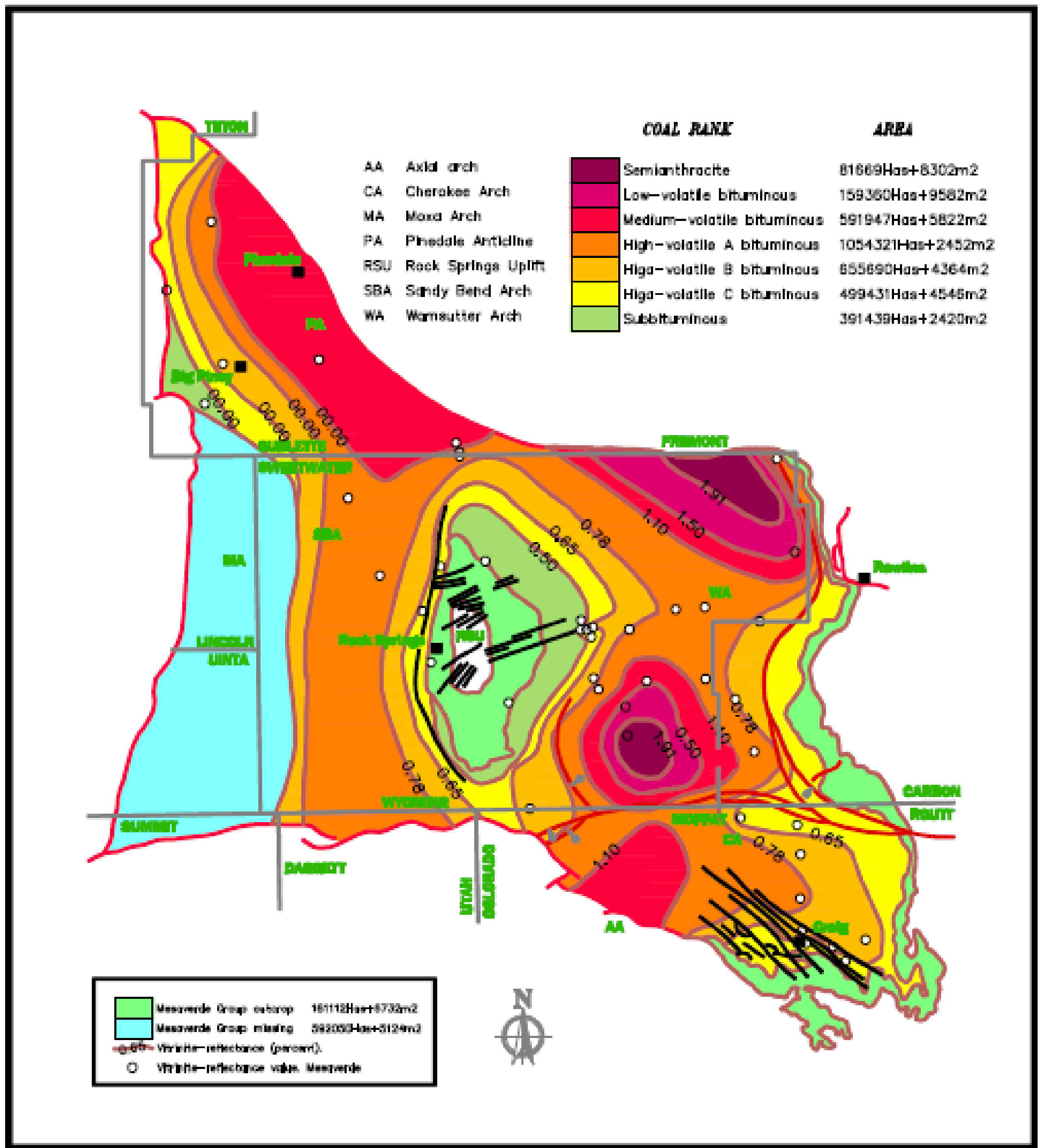
Volume of Gas and Oil generated by Hydrous Pyrolysis

Ro (%)	scft/Ton C	bll oil/Ton C
0.92	30.5	0.03
1.01	45.7	0.05
1.1	65	0.08
1.3	95.4	0.09
1.4	135	0.12
1.47	217	0.15
1.55	231	0.17
1.62	277	0.17
1.7	404	0.14

GAS GENERATION POTENTIAL OF THE ALMOND COALS



COAL RANK DISTRIBU-
TION OF UPPER
CRETACEOUS COALS
THE GGRB WYOMING



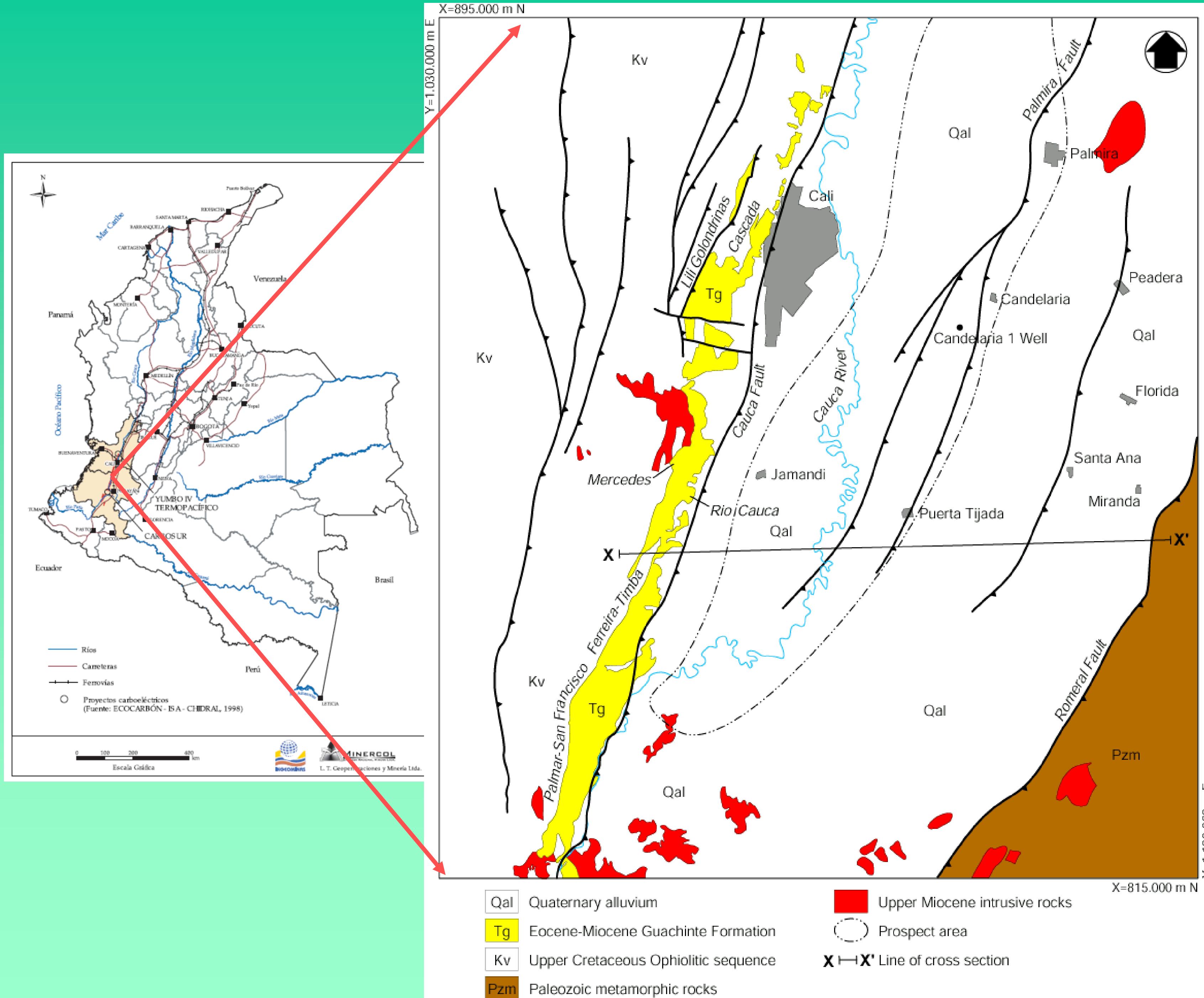
After GRI (1993)

UPPER CRETACEOUS COAL RESOURCES

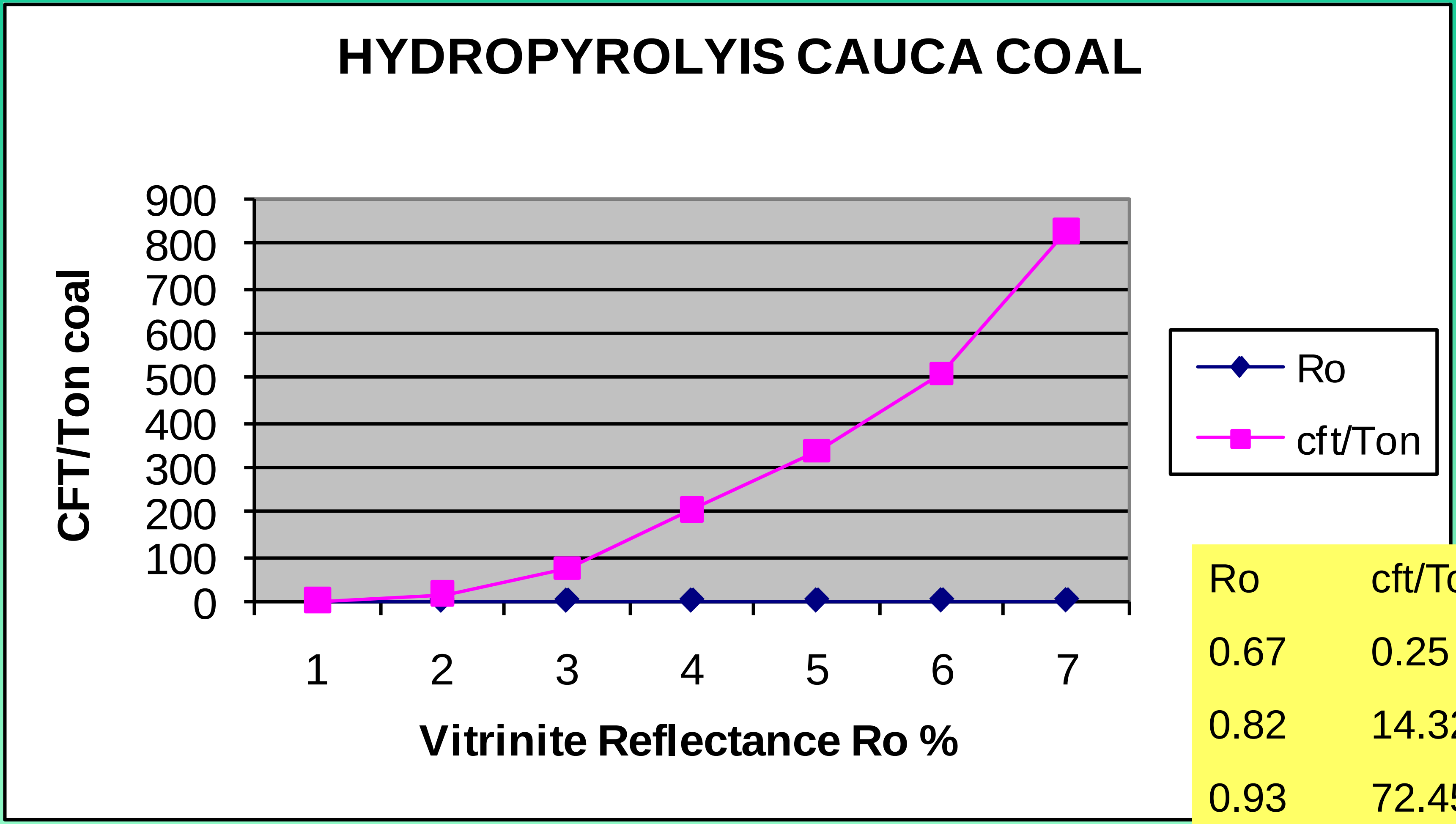
Ro (%)	area m2	Thick.	d	coal mass Tons
1.90	8.17E+08	35	1.5	4.29E+10
1.50	1.59E+09	35	1.5	8.09E+10
1.10	5.92E+09	35	1.4	2.90E+11
0.76	1.05E+10	35	1.4	5.17E+11
0.65	6.56E+09	35	1.4	3.17E+11
0.50	4.99E+09	35	1.4	2.36E+11
0.45	3.91E+09	35	1.3	1.78E+11

UPPER CRETACEOUS COALBED METHANE RESOURCESIN THE GGRB

Ro (%)	scft/ton	scft
1.90		
1.50	231	1.87E+13
1.10	65	1.89E+13
0.76	30	1.55E+13
0.65	20	6.33E+12
0.50		
0.45		
TOTAL		59.4 TCF



Mar Caribe
Venezuela
Panamá
Océano Pacífico
Ecuador
Brasil
Perú
YUMBO IV
TERMOPACÍFICO
CARBOSUR
Ríos
Carreteras
Ferrovías
Proyectos carboeléctricos
(Fuente: ECOCARBÓN - ISA - CHIDRAL, 1998)
Escala Gráfica
MINERCOL
X=895.000 m N
Y=1.030.000 m E
Kv
Qal
Palmira Fault
Palmira
Cali
Lili Golondrinas
Cascada
Tg
Peadera
Candelaria
Candelaria 1 Well
Florida
Cauca Fault
Cauca River
Santa Ana
Miranda
Jamandi
Mercedes
Rio Cauca
Puerta Tijada
X
X'
Ferreira-Timba
Palmar-San Francisco
Romeral Fault
Pzm
Y=1.100.000 m E
X=815.000 m N
Qal Quaternary alluvium
Tg Eocene-Miocene Guachinte Formation
Kv Upper Cretaceous Ophiolitic sequence
Pzm Paleozoic metamorphic rocks
Upper Miocene intrusive rocks
Prospect area
X X' Line of cross section



Ro	cft/Ton
0.67	0.25
0.82	14.32
0.93	72.45
1.1	207.76
1.31	337.23
1.52	510.26
1.67	833.24

Gas Generation Potential

GAS RESOURCES CAUCA BASIN (TCF)

Prospect	Área	Coal resources	Gas in Place
	km²	Ton x 10 ⁶	TCF
A	137.3	2347.5	1.34
B	42.8	732.2	0.13
C	12.4	211.4	0.18
D	5.9	101.1	0.01
E	69.3	1506.4	0.22
F	10.2	221	0.02
TOTAL	277.9		1.89

CONCLUSIONS

- Hydrous Pyrolysis technique allows to make a complete coalbed methane evaluation including characterization of gas, oil, water, and coal phases.
- CBM resources evaluation can be done in areas with few or none coal cores from wells.
- Gas generation kinetic can be calculated from HP experiments.