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Source Rock Potential of Lower Goru in Well Bobi-4 Lower Indus Basin, Pakistan

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ABSTRACT

Organic petrographic and geochemical analysis of nine samples of Lower Goru Formation from well Bobi-4 were carried out to estimate maturity and source rock potential. Total organic content indicates good to excellent hydrocarbon source potential. The maceral comprised liptinite (>50%), vitrinite (15-34%) and inertinite (<10%). The organic matter can be classified as kerogene type II. Vitrinite reflectance and Tmax values indicate that the formation is at the onset of hydrocarbon generation.

INTRODUCTION

Goru Formation is divided into two parts: Upper Goru and Lower Goru. The Lower Goru acts as a reservoir in the Lower Indus Basin. Source rock potential of the Lower Goru Formation has also been identified (Raza et al., 1991; Eickhoff and Alam, 1991). Maturity and source rock potential of the Lower Goru Formation in well Bobi-4 has been assessed based on analysis of samples from a cored interval of 2682-2690.5 meter at one meter spacing.

METHODS

Sample Preparation

The whole rock samples were crushed to a particle size of less than 1mm. The samples were embedded in araldite and polished sections were made. The sample preparation technique of the Organic Petrographic Laboratory of the Federal Institute for Geosciences and Natural Resources (BGR), Hannover (Germany) has been followed. A general description of the procedure is given in Stach et al., (1982).

Procedure

Reflectance analysis of the dispersed organic matter in polished grain sections was carried out using a reflected light Leitz MPV 3 microscope equipped with white (halogen) and fluorescent light sources. Blue-UV irradiation BG 12-filter (2mm) and a 530 mm barrier filter were used for qualitative observations of fluorescence properties of organic matter. The microscope is equipped with digital VT 100 microcomputer. R-Reflex computer program made by Leitz-BGR was used for measuring vitrinite reflectance. The classification and determination of the composition of the organic matter is followed as described by Hufnagel and Porth (1988). For maceral analysis, a binocular reflected light microscope, fitted with a 40x oil immersion objective, was used. The 8x occular having a 20 point angular graticule after Blaschke, were used.

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Results

The amount, type and maturity of organic matter were determined by organic petrography and geochemical methods. The results are tabulated in Tables 1-3 and described below;

Rock Type

The dominant lithology is light gray to gray, fine-grained argillaceous sandstone with intercalation of gray to dark gray mudstone. Angular to subrounded green, unidentified rock particles are often present. Fine to coarse grains of unweathered pyrite commonly occur. Calcite is an accessory mineral.

Organic Petrography

Organic matter (O.M.) is little to abundant. Its concentration is high in mudstone, whereas in clean sandstone facies it is rare to absent. It occurs in indistinct layers. Results from maceral analysis showed that the organic matter is in general characterized by low inertinite contents, intermediate amounts of vitrinite macerals and high amount of macerals of the liptinite group. Liptinite consists of alginite, sporinite, resinite, cutinite, fluorinite and liptodetrinite.

Alginite is derived from solitary algae (Figure 1). Sporinite is formed mainly from disaccate pollen (Figure 2) which are of Gymnospermous origin. Thick walled cutinite (Figure 3) is present which also shows that it is derived from land plant. Liptodetrinite is derived from alginite and sporinite. Small percentage of bituminite is also present. Fluoresence color of liptinite macerals are yellow to dark yellow. Vitrinite is the second main maceral which consists of telinite, telocollinite, gelinite and vitrodetrinite. Pyrite is usually associated with vitrinite (Figure 1 & 2). Inertinite is present in small amount and comprises semi-inertinite and fusinite.

Geochemical Results

Total organic carbon (TOC) for most of the samples ranges from 0.5% to 1.9% , with a margin of 5.1% of a sample from 2690.5 m and 0.30% of a sample from 2685 m depth. Extractable organic matter is, however, low and ranges from

Table 1. Organic petrographic investigations*.

Laboratory No. K-	HDIP Sample No.	Depth m	Stratigraphy	Abundance	ORGANIC MATTER Composition: Main types Lip	Bit	Mib	Vit	Ine	Liptinite Alg	Spo	oLi	Bituminite flu	nfl	Maturity: Fluorescence Alg	Spo	oLi	Vitrinite reflectance % Rr	Qual	Remarks
19906	205	2682	L.Goru	3	20	--	--	20	5	4	3	4	--	--	4	4	--	.62		
19906-a	205a	2682	L.Goru	3	50	--	--	20	5	5	2	3	--	--	3-4	--	3	.62		
19907	206	2683	L.Goru	2	20	--	--	5	20	3	1	2	--	--	3	4	4	.63		
19907-a	206a	2683	L.Goru	2	20	--	--	5	20	3	1	3	--	--	3-4	3	3	.64		
19908	207	2684	L.Goru	2	5	--	--	20	20	2	2	1	--	--	3	3-2	3	.65		
19909	208	2685	L.Goru	1	1	--	--	--	--	1	--	--	--	--	3-4	--	4-3	n.d.		o.m. rare to absent.
19910	209	2686	L.Goru	4	50	--	--	20	5	5	4	4	--	--	4	3-4	5-3	.66		good vitrinite
19911	210	2687	L.Goru	2	5	--	--	50	5	--	3	3	--	--	--	3	3-4	.63		MOGf
19912	211	2688	L.Goru	4	50	--	--	20	5	4	3	4	--	--	4	3-2	2-3	.64		
19913	212	2689	L.Goru	1	--	--	--	--	--	--	--	--	--	--	--	--	--	n.d.		
19914	213	2690.5	L.Goru	3	20	1	--	20	5	3	1	3	--	--	3-4	4-3	4	.63		resinitic vitrinite

* Explanations are given on the next page

Table 2. Maceral analysis.

SAMPLE NO.	VITRINITE %	INERTINITE %	SPORINITE %	ALGINITE %	RESINITE %	FLUORINITE %	CUTINITE %	LIPTODETRINITE %
K-19906	28	11	6	30	1	0	6	18
K-19910	15	10	10	40	7	0	0	18
K-19912	34	5	3	24	5	0	0	29
K-19914	31	6	9	21	6	2	1	24

Table 3. Results of geochemical analysis.

SAMPLE No.	TOC%	EOM (ppm)	S1 (mg/g)	S2(mg/g)	Tmax (^oC)	GP (kg/t)
V-205	1.91	820	---	---	---	---
V-206	1.33	606	0.18	0.36	430	0.54
V-207	0.83	473	---	---	---	---
V-208	0.28	---	---	---	---	---
V-209	1.73	378	0.15	0.45	441	0.22
V-210	0.55	---	---	---	---	---
V-211	0.98	511	---	---	---	---
V-212	0.52	---	---	---	---	---
V-213	5.10	757	0.18	4.69	441	4.87

Explanations for table "Organic-petrographic investigations"

Organic matter - abbrevations

Main types

Lip	=	liptinite
Bit	=	bituminite
Mib	=	migrabitumen
Vit	=	vitrinite
Ine	=	inertinite

Liptinite composition

Alg	=	alginite
Spo	=	sporinite
oLi	=	other liptinite (resinite etc., liptodetrinite)

Bituminite composition

flu	=	fluorescing
nfl	=	non fluorescing

Organic matter - Abundance

Total quantity

5	=	very abundant
4	=	abundant
3	=	common
2	=	little
1	=	very little to barren

Main types

50	=	≥50 %
20	=	20 - 50 %
5	=	5 - <20 %
1	=	< 5 %

Quantities of liptinites and bituminites

5	=	predominant to exclusive
4	=	considerable
3	=	average
2	=	little
1	=	very little

Maturity

Fluorescence intensity

5	=	very strong
4	=	strong
3	=	intermediate
2	=	weak
1	=	very weak
0	=	none
3-4	=	average to strong
4;3	=	strong; subordinate average

Vitrinite - reflectance

Rr'	=	random reflectance
Rmax	=	maximum reflectance
Qual	=	qualifier for the reliability of Rr
5	=	very high
4	=	high
3	=	medium
2	=	low
1	=	very low
0	=	not determinable or not derivable
6	=	derived from migrabitumen R
7	=	estimated from palynomorph fluorescence
8	=	derived from monochromatic palynomorph fluorescence
9	=	derived from spectral palynomorph fluorescence

378 ppm to 820 ppm. Genetic potential (GP) is also low and only one sample (K-19914) reads 4.87 Kg/Ton.

Maturity

Since all the samples analysed were taken from a nine meter thick section, so there was not much difference in their maturity. Random vitrinite reflectance varies between 0.62% to.66%. The Rock- Eval pyrolysis of a sample at 2683m depth has 430°C Tmax while other two samples from 2686 m and 2690.5 m have 441°C Tmax. Both Tmax and vitrinite reflectance results indicate that the sediments are early mature for hydrocarbon generation.

Fluoresence measurements carried out on different liptinite macerals showed that the red/green quotient (Q) of sporinite, cutinite, fluorinite and resinite increases with increasing rank (Stach et al., 1982, 247p). The values of red/green quotient of alginite calculated from two samples K-19906 and K-199014 are 1.4 and 1.5. These quotient are in normal range of the liptinite maceral (Stach et al., 1982, 246p) and corresponds to our Tmax and vitrinite reflectance values.

CONCLUSIONS

1. The amount of organic matter varies from sample to sample but the type of organic matter is the same. According to maceral analysis, liptinite is the major maceral group and considerable amount of vitrinite is also present. The amount of inertinite is very low. This composition of organic matter can be correlated with kerogene type II(Bustin et al., 1988) and has mixed source potential both for oil and gas.

2. Total organic carbon content is good but extractable organic matter (also called bitumen) is comparatively low, the possible reasons are that liptinite macerals (main source of liquid hydrocarbon) are of terrestrial origin and organic matter is not fully mature for hydrocarbon generation (random vitrinite reflectance 0.61%- 0.66% and Tmax 430°C & 441°C).

3. The O.M. is present mainly in silty mudstone whereas in pure sandstone facies it is rare to absent (K-19909 & K-19913, Table-3). So, it is concluded that the mudstone facies of the Lower Goru Formation has good source potential, provided it attains sufficient thickness and maturity. It is, therefore, suggested that a detailed sedimentological study of the Lower Goru Formation should be carried out which will help to estimate its source potential in different areas of the Lower Indus basin.

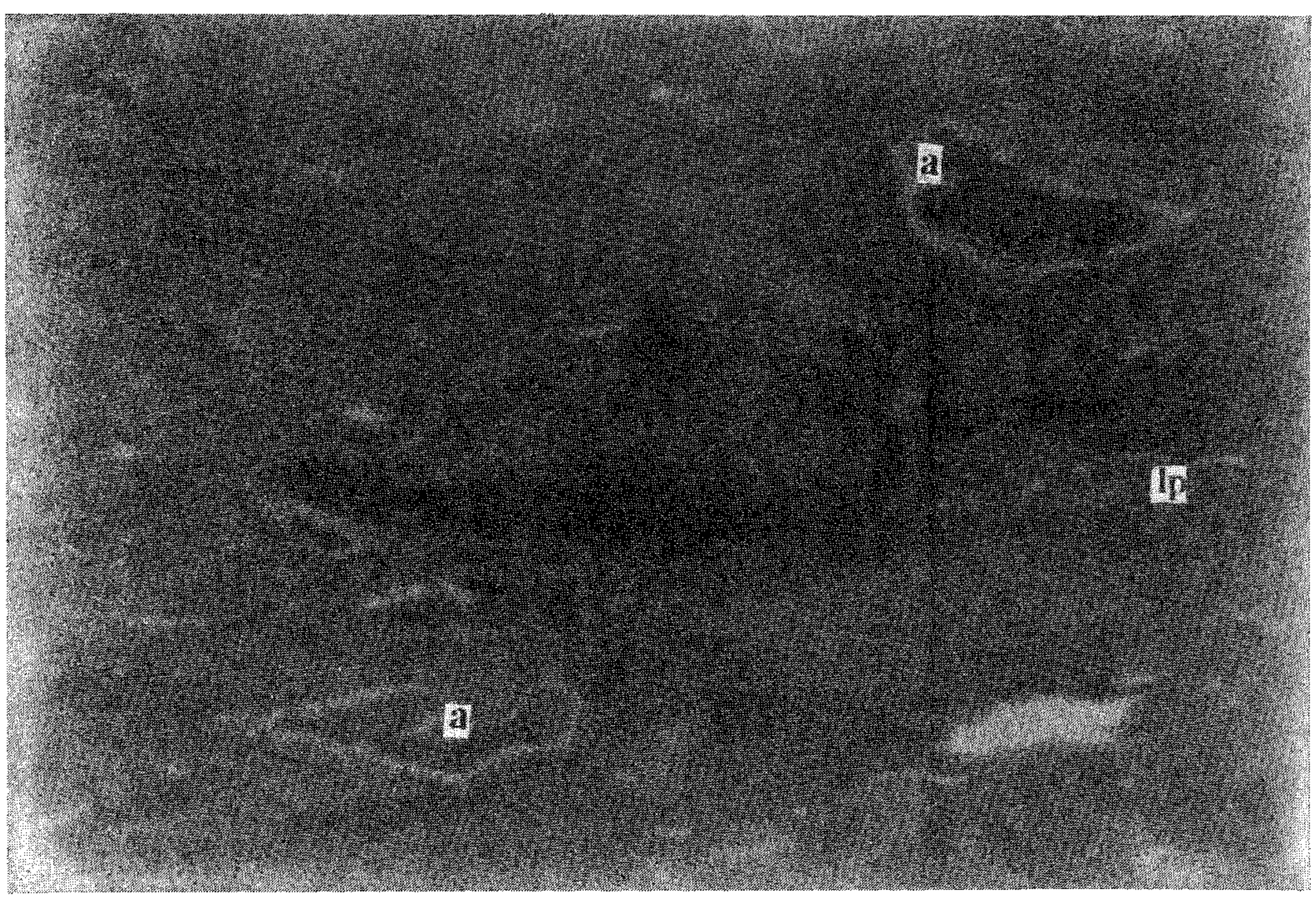

Figure 1- Alginite (a) and liptodetrinite (lp), under blue light irradiation. oil immersion, 600x, Sample K-19914.

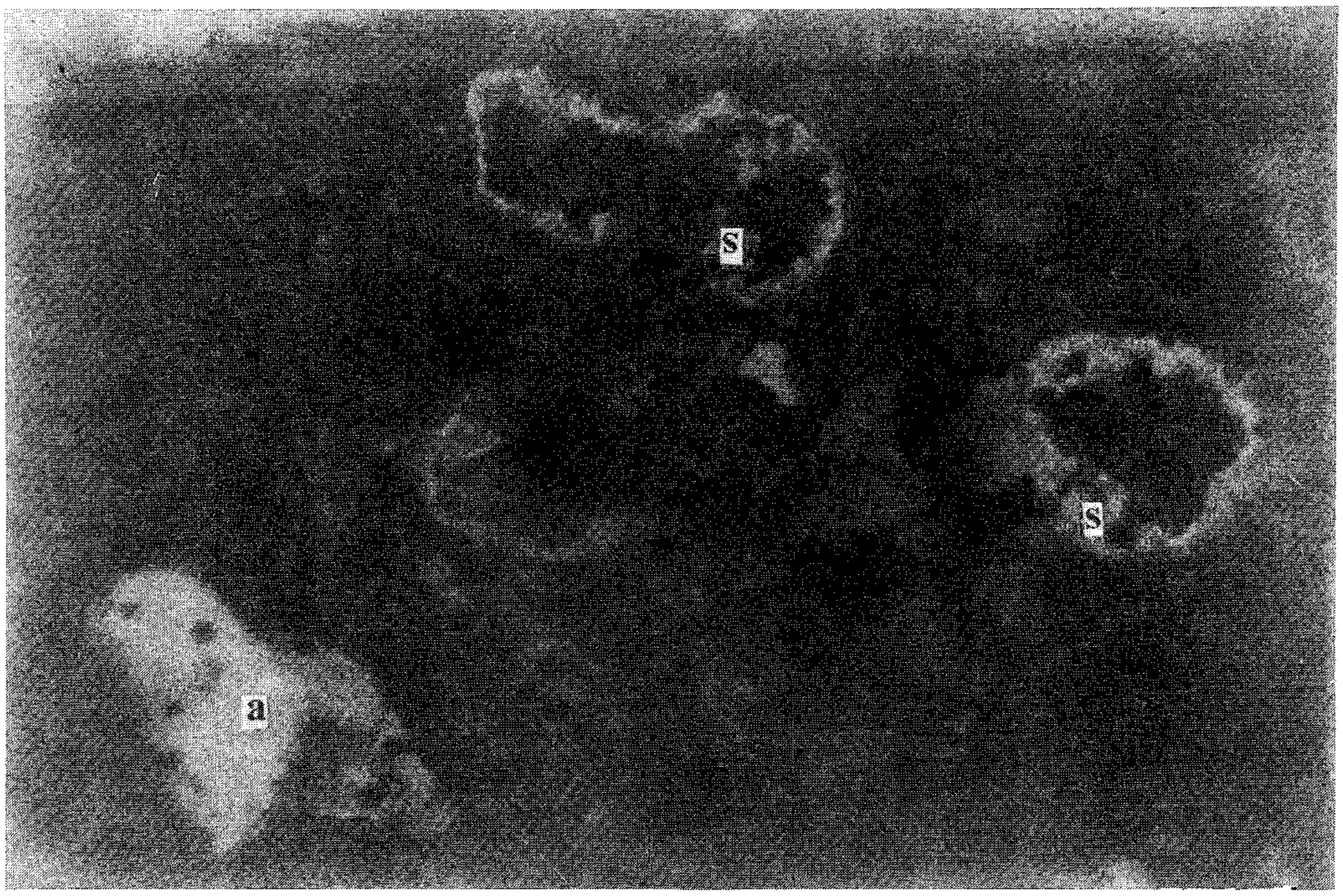

Figure 2- Sporinite (s) derived from disaccate pollen and Botryococcus alginite (a), normal reflected light. oil immersion, 600x, Sample K-19910.

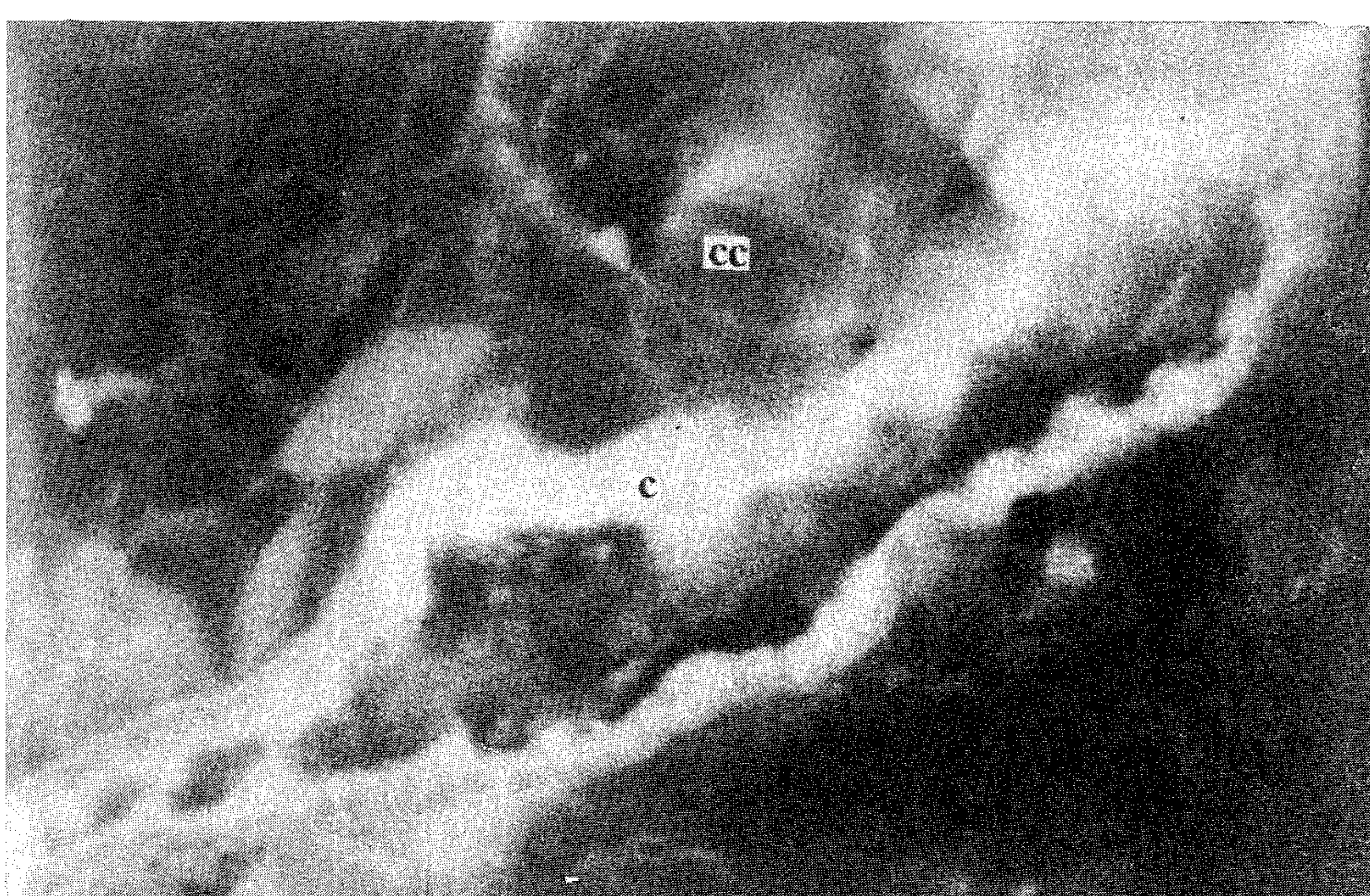

Figure 3- Leaf cross sections with thick walled cutinite (c), calcite (cc) crystal also gives greenish yellow fluorescence, normal reflected light. oil immersion, 600x, Sample K-19906.

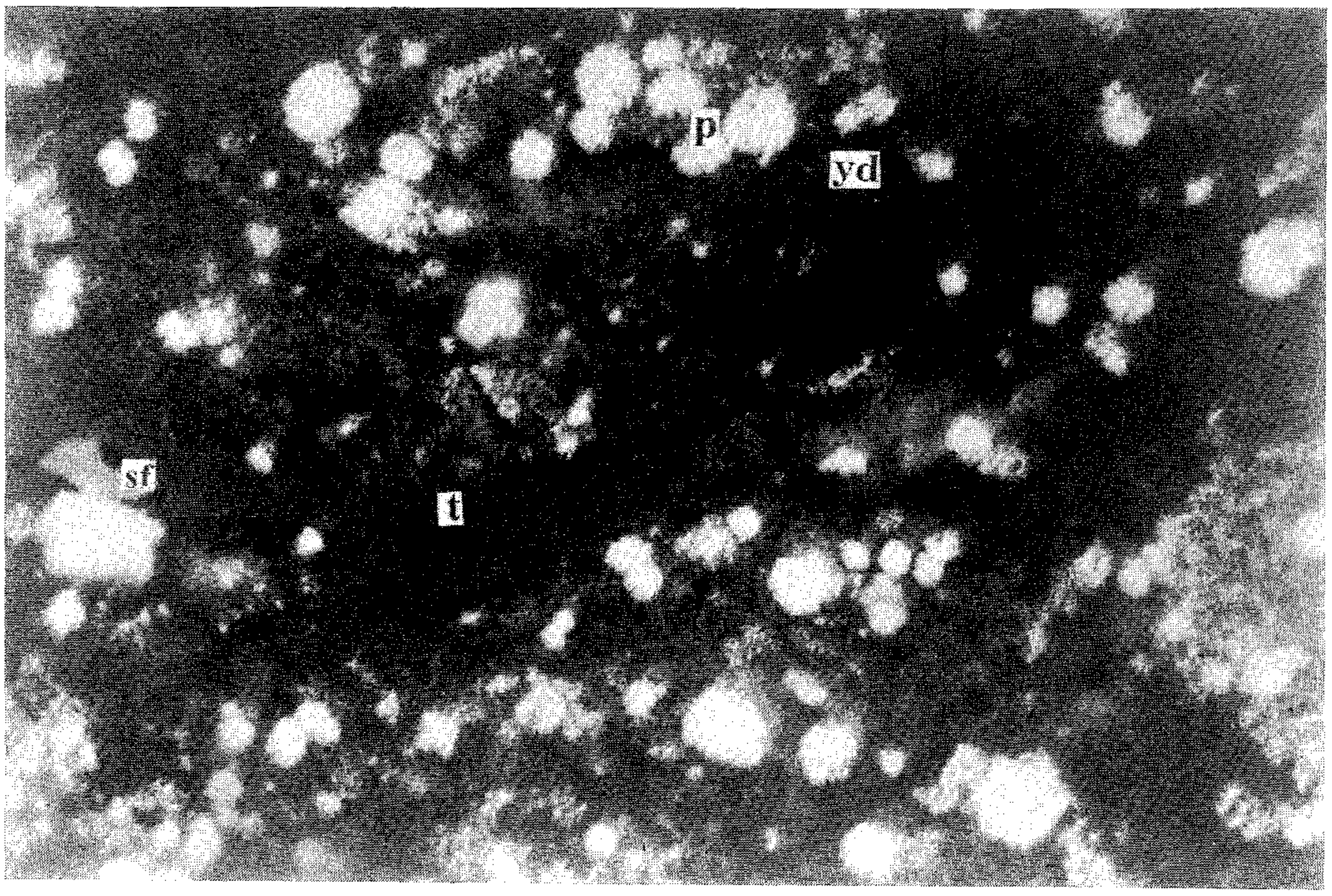

Figure 4- Enrichment of framboidal pyrite crystals (p) associated with telinite (t),vitrodetrinite (vd) and semi-fusinite (sf), normal reflected light. oil immersion, 600x, Sample K-19906.

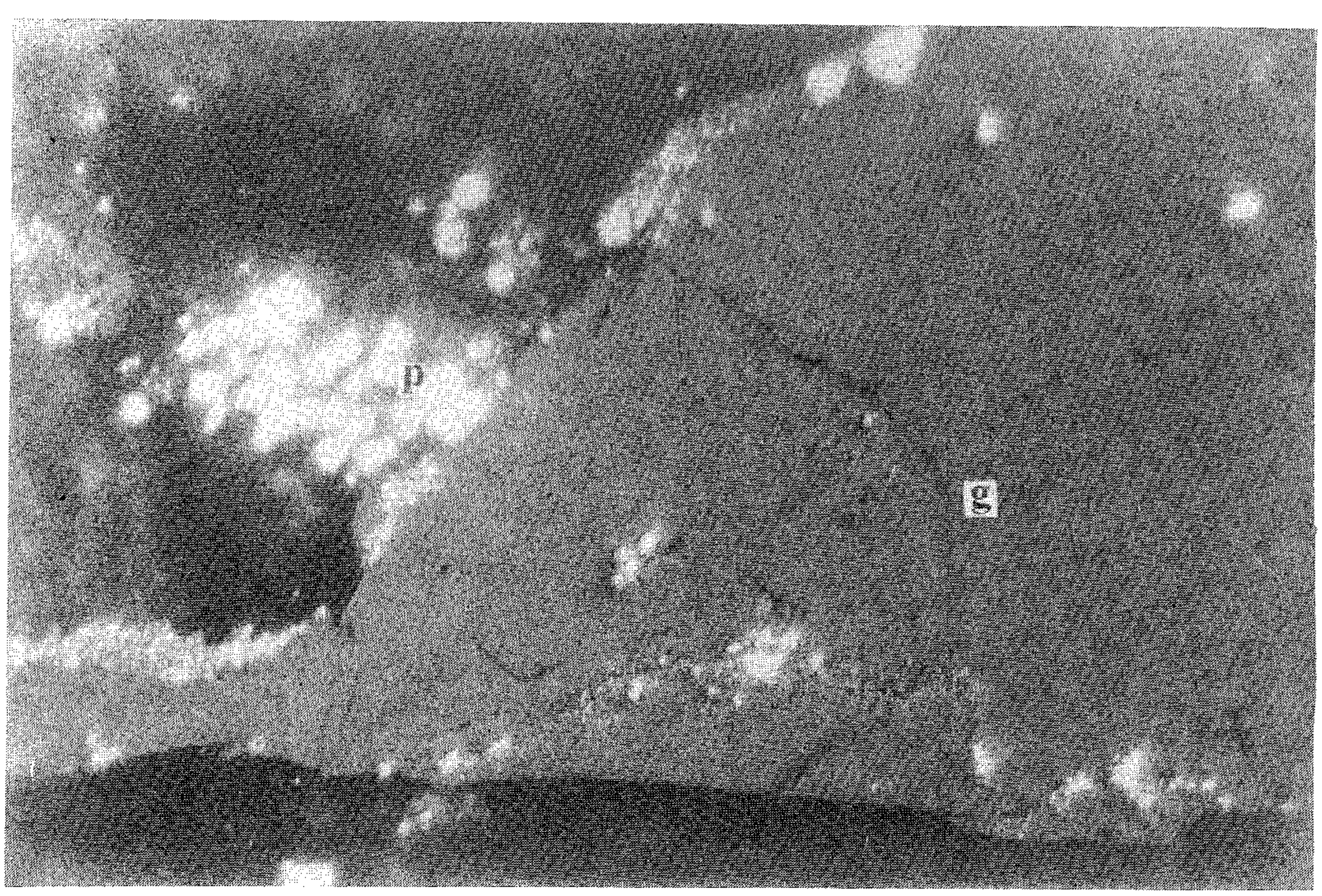

Figure 5- Pyrite crystal cluster in and around gelinite (g), normal reflected light. oil immersion, 600x, Sample K-19914.

REFERENCES

Bustin, R.M., A.R. Cameron, D.A. Grieve and Kalkreuth, 1988, Coal petrology its principles, methods, and applications, 2nd. ed, 206p.

Eickhoff, G. and S. Alam, 1991, On the petroleum geology and prospectivity of Kirthar Range and Sibi Trough, southern Indus Basin, Pakistan. BGR/HDIP Report: p.88; Hannover (Germany).

Hufnagel, H. and H. Porth, 1988, Organopetrographic studies in the Visayan Basin Philippines. Geol Jb. B 70, p349-384.

Hussain Moinuddin, L.G. Steven and R. Oliver, 1991, Hydrocarbon accumulation parameters in central portion of the Lower Indus Basin of Pakistan: *in* New directions and strategies for accelerating petroleum exploration and production in Pakistan; 116p.

Raza, H.A., S.M. Ali and R. Ahmad, 1991, Petroleum geology of Kirthar Sub-Basin and part of Kutch Basin, Pakistan.

Stack, E., Mackowsky M., Th., R, Teichmuller, G.H. Taylor, D. Chandra and R. Teichmuller, 1982, Stack's textbook of coal petrology, 3rd. ed, p.245-247. Berlin, Stuttgart (Brontraiger).