



Generation of Biogenic Methane from Oil Shale

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Bioenergy – I

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Research Team

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Outline

- Oil Shale Deposit
- Biogenic Methane Production
- Enhancement of Biogenic Methane Production
- Challenges

Western Research Institute



Laramie, Wyoming

World Major Oil Shale Deposits

Country, region, and deposit	Age	In-place shale oil resources, × 10 ⁶ bbls	In-place shale oil resources, × 10 ⁶ tons	Date of estimation	Source of information and footnotes []
Bulgaria		125	18	1962	
Burma		2000	286	1924	
Canada					
<i>Manitoba-Saskatchewan</i>					
Favel-Boyne Formations	K	1250	191	1981	Macauley (1981,1984a, 1986) [4]
<i>Nova Scotia</i>					
Stellarton Basin	P-Pm	1174	168	1989	Smith & others (1989) [5]
Antigonish Basin		531	76	1990	Smith & Naylor (1990)
<i>New Brunswick</i>					
Albert Mines	M	269	38	1988	Ball & Macauley (1988) [6]
Dover	M	14	2	do	Ball & Macauley (1988) [6]
Rosevale	M	3	0.4	do	Ball & Macauley (1988) [6]
<i>Newfoundland</i>					
Deer Lake Basin	M			1984	Hyde (1984) [7]
<i>Northwest Territories</i>					
Sverdrup Basin	M			1988	Davies & Nassichuk (1988) [8]
<i>Ontario</i>					
Collingwood Shale	O	12000	1717	1986	Macauley (1986)
Kettle Point Fm	D			1986	Macauley (1986)
Chile		21	3	1936	
China		16000	2290	1985	Du & Nuttall (1985) [9]
Maoming	T	(2271)	(325)	1988	Guo-Quan (1988)
Fushun	T	(127)	(18)	1990	Johnson (1990)
Egypt					
Safaga-Quseir area	K	4500	644	1984	Troger (1984)
Abu Tartur area	K	1200	172	1984	Troger (1984)

World Major Oil Shale Deposits

Country, region, and deposit	Age	In-place shale oil resources, $\times 10^6$ bbls	In-place shale oil resources, $\times 10^6$ tons	Date of estimation	Source of information and footnotes []
Estonia					
Estonia deposit	O	3900	594	1998	Kattai & Lokk (1998) [10]
Dictyonema shale	O	12386	1900		
France		7000	1002	1978	
Germany		2000	286	1965	
Hungary		56	8	1995	Pápay (1998) [11]
Iraq					May be very large
Yarmouk	K				See Jordan
Israel		4000	550	1982	Minster & Shirav (1982) [12]
Italy		10000	1431	1979	
Sicily		63000	9015	1978	
Jordan					
El Lajjun	K	821	126	1997	Jaber & others (1997) [13]
Sultani	K	482	74	1997	Jaber & others (1997) [13]
Juref ed Darawish	K	3325	510	1997	Jaber & others (1997) [13]
Wadi Maghar	K	14009	2149	1997	Jaber & others (1997) [13]
Attarat Umm Ghudran	K	8103	1243	1997	Jaber & others (1997) [13]
Wadi Thamad	K	7432	1140	1997	Jaber & others (1997) [13]
Yarmouk	K		(Large)	1999	Minster (1999) [14]
Kazakhstan					
Kenderlyk field		2,837	400	1996	Yefimov (1996) [15]
Luxembourg	J	675	97	1993	Robl and others (1993)
Madagascar		32	5	1974	
Mongolia					
Khoot	J	294	42	2001	Avid and Purevsuren (2001)
Morocco					
Timahdit	K	11236	1719	1984	Bouchta (1984) [16]
Tarfaya, Zone R	K	42145	6448	1984	Bouchta (1984) [16]

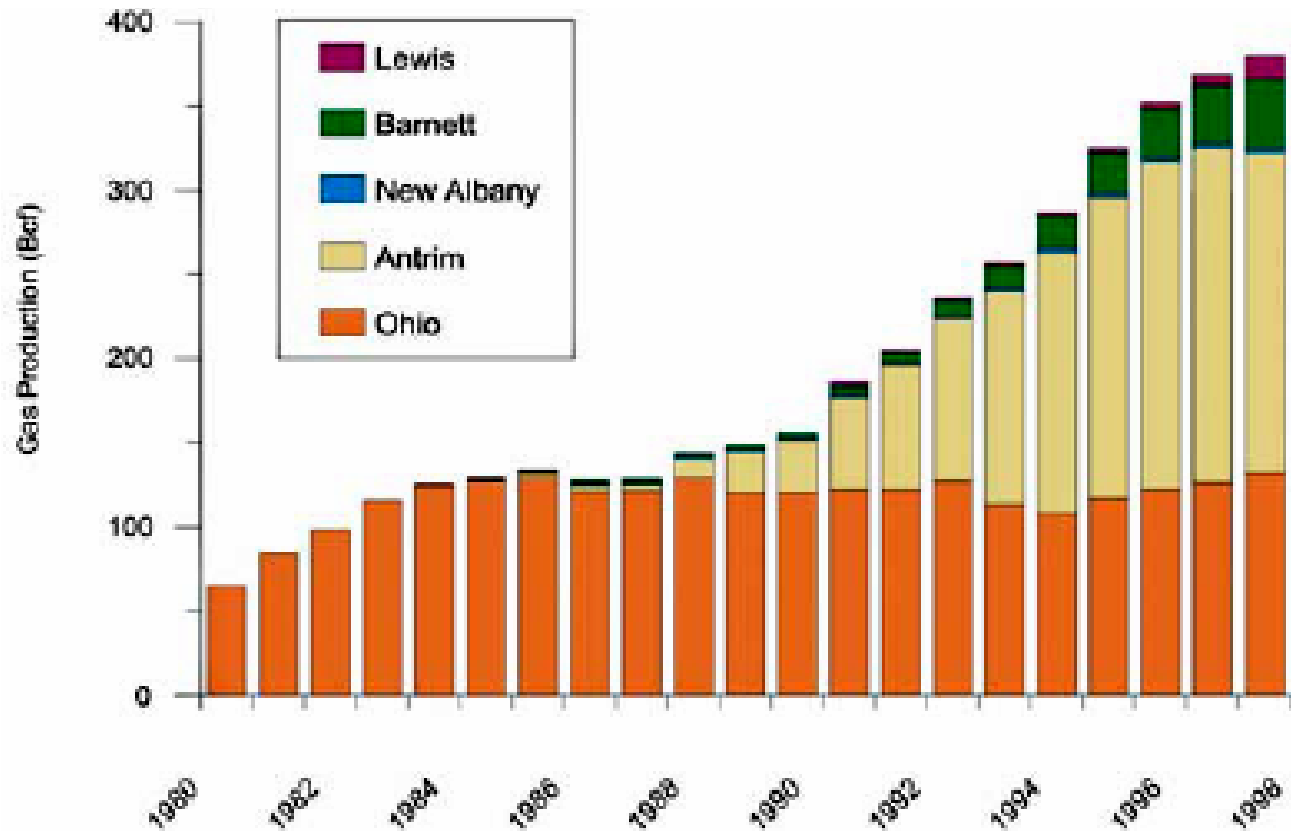
World Major Oil Shale Deposits

Country, region, and deposit	Age	In-place shale oil resources, $\times 10^6$ bbls	In-place shale oil resources, $\times 10^6$ tons	Date of estimation	Source of information and footnotes []
New Zealand		19	3	1976	
Poland		48	7	1974	
Russia					
St. Petersburg kukersite	O	25157	3600		
Pripyat basin	D	6988	1000		
Timano-Petchorsk basin	J	3494	500		
Vychegodsk basin	J	195967	2800		
Central basin	?	70	10		
Volga basin	?	31447	4500		
Turgai & Nizhneiljisk deposit	?	210	30		
Kyzylkum basin	Pm	8386	1200		
Amudarja basin	Pm	7687	1100		
Olenyok basin	C	167715	24000		
Other deposits	-	210	30		
South Africa		130	19	1937	
Spain		280	40	1958	
Sweden					
Närke	C	594	85	1985	Andersson & others (1985)
Östergötland	C	2795	400	1985	Andersson & others (1985)
Västergötland	C	1537	220	1985	Andersson & others (1985)
Öland	C	1188	170	1985	Andersson & others (1985)
Thailand					
Tak Province					
Mae Sot	T	6400	916	1988	Vanichseni & others (1988)
Lampoon Province					
Li	T	1		1988	Vanichseni & others (1988)

World Major Oil Shale Deposits

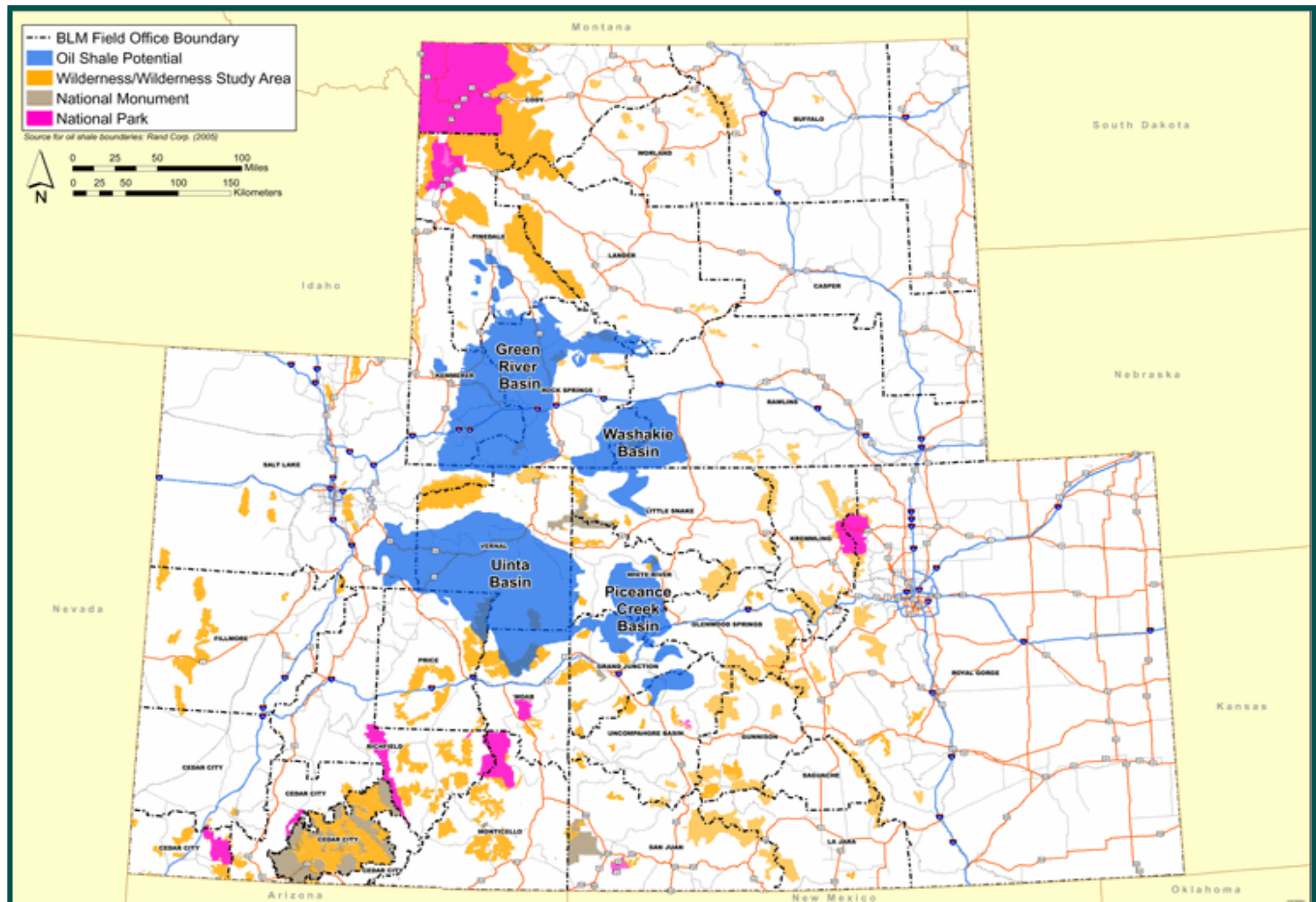
Country, region, and deposit	Age	In-place shale oil resources, × 10 ⁶ bbls	In-place shale oil resources, × 10 ⁶ tons	Date of estimation	Source of information and footnotes []
Turkey					
Deposit & (Province)					
Bahçecik (Izmit)	T	35	5	1993	Güleç & Önen (1993) [17]
Beypazari (Ankara)	T	398	57	1995	Sener & others (1995)
Burhaniye (Bahkesir)	T	28	4	1993	Güleç & Önen (1993)
Gölpazari (Bilecik)	T	126	18	1993	Güleç & Önen (1993)
Göynük (Bolu)	T	804	115	1995	Sener & others (1995)
Hatildag (Bolu)	T	203	29	1995	Sener & others (1995)
Seyitömer (Kütahya)	T	349	50	1995	Sener & others (1995)
Ulukisla (Nigde)	T	42	6	1993	Güleç & Önen (1993)
Ukraine					
Boltysh deposit					
United Kingdom		3500	501	1975	
Scotland					
United States					
Eastern Devonian shale	D	189000	27000	1980	Matthews & others (1980) [18]
Green River Fm	T	1499000	215000	1999	This report
Phosphoria Fm	Pm	250000	35775	1980	Smith (1980)
Heath Fm	M	180000	25758	1980	Smith (1980)
Elko Fm	T	228	33	1983	Moore & others (1983)
Zaire		100000	14310	1958	
TOTAL		2859090	410600		

Shale Gas Production in the US



Current production of shale gas accounts for ~3% overall production in the US.

Oil Shale Deposits in Colorado, Utah, and Wyoming



Oil Shale Oil

Conservative estimated to be 3.0 trillion barrels

Ubiquitous deposit but concentrated in certain regions

Majority difficult or infeasible to recover

Current Activity

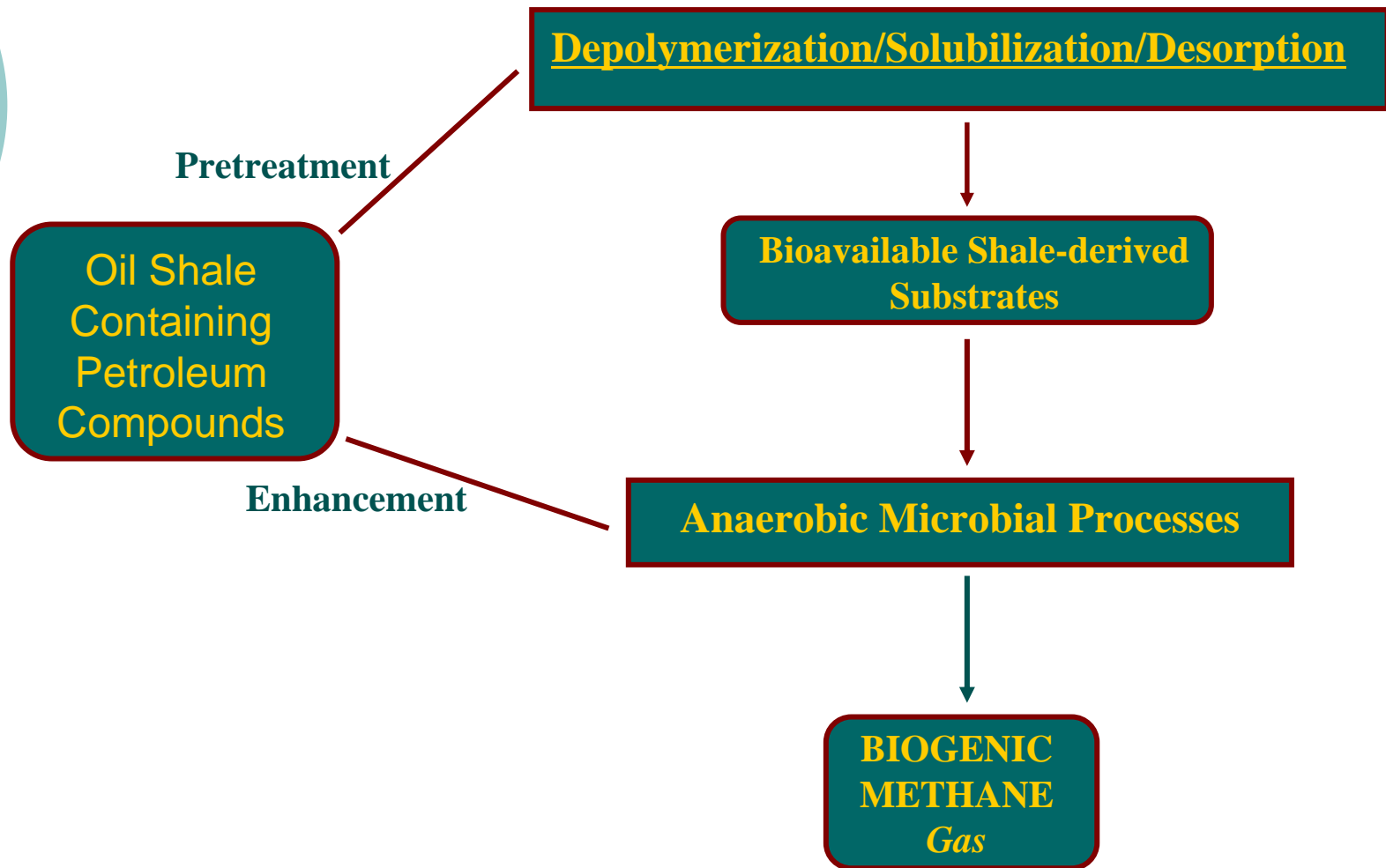
WRI partners with industrial sponsors to demonstrate the enhanced biogenic methane technology as an alternative to recover otherwise inaccessible oil in shale

Treatability Testing

Objectives: obtain the optimal treatment and enhancement design parameters

- Pretreatment tests with field samples to determine the dosage requirements and rate and extent of reaction.
- Microcosm tests with field samples to determine CBM production rates.
- Economical estimates and budget finalization for field testing.

Biogenic Methane Production from Oil Shale



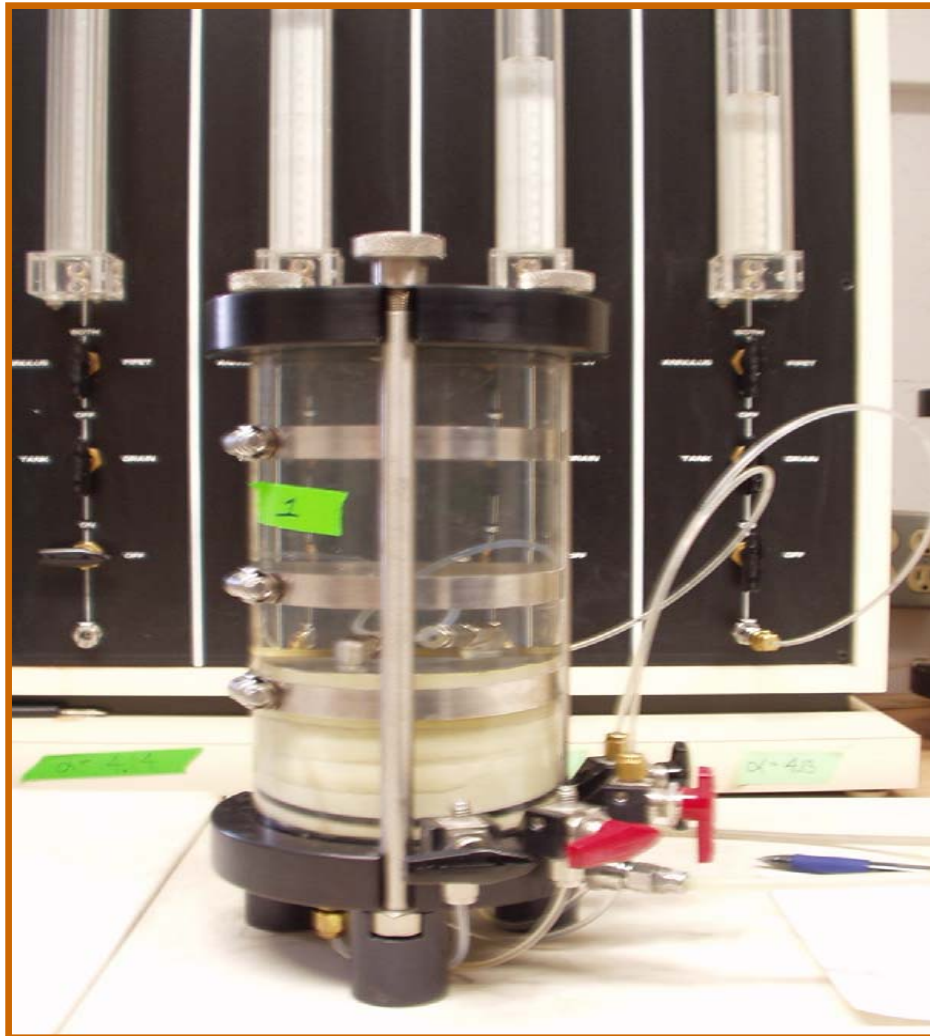
Biogenic Methane from Oil Shale

- Oil shale characterization
- Pretreatment of oil shale
- Enhancement of biological pathways
- Laboratory studies and field applications

Oil Shale Characterization (Green River, Wyoming, USA)

TPH	76300 mg/kg	NH₄⁺	3 mg/kg
TPH-GRO	17967 mg/kg	DOC	4201 mg/kg
TPH-DRO	55450 mg/kg	SO₄²⁻	906 mg/kg
NO₃⁺	ND (0.1 mg/kg)	SRB	18000 /ml
P	ND (0.1 mg/kg)	Methanogens	2880000

Bench Scale Reactor



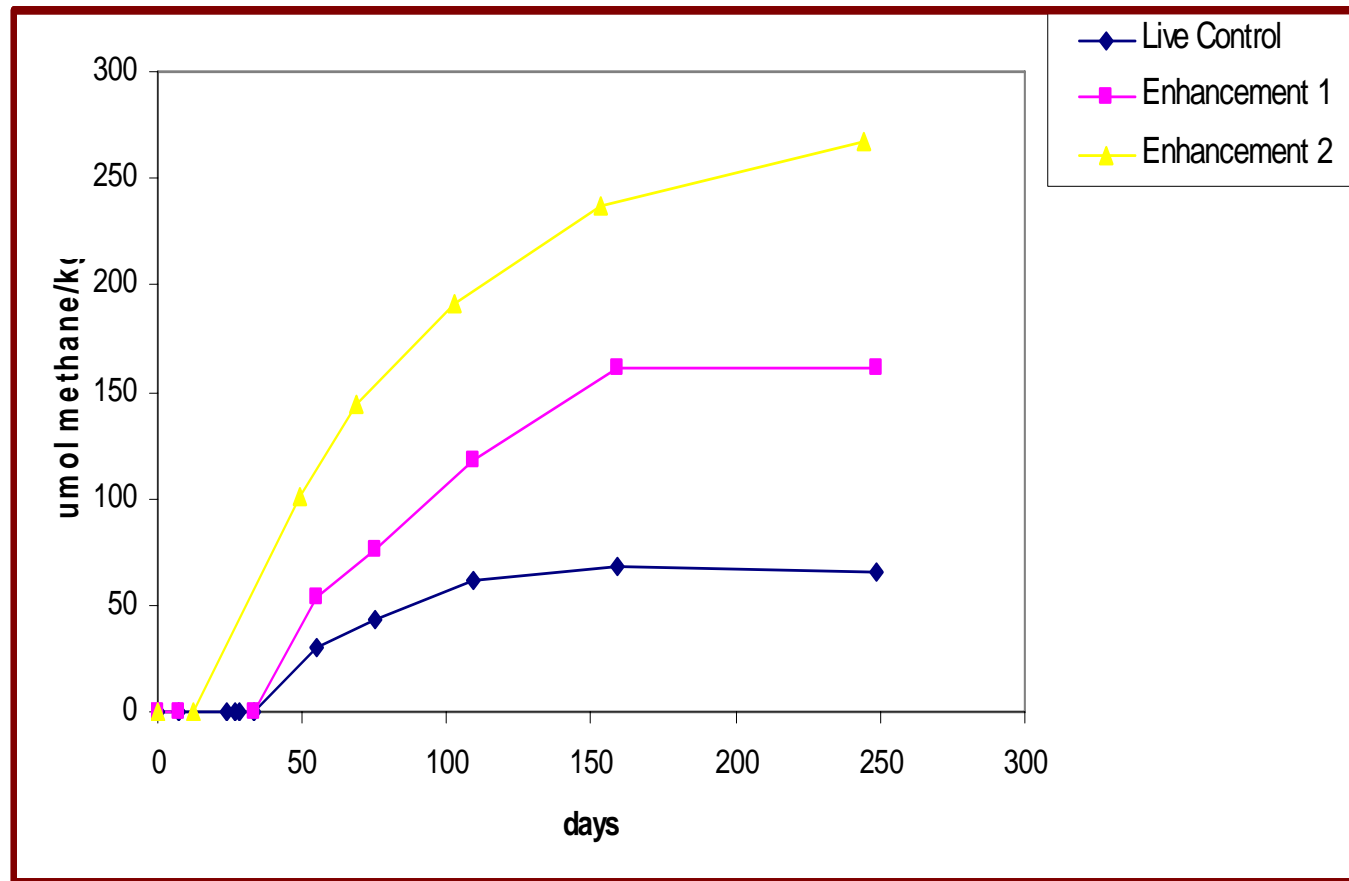
**Pressurized
Testing
System**

Bench Scale Reactor

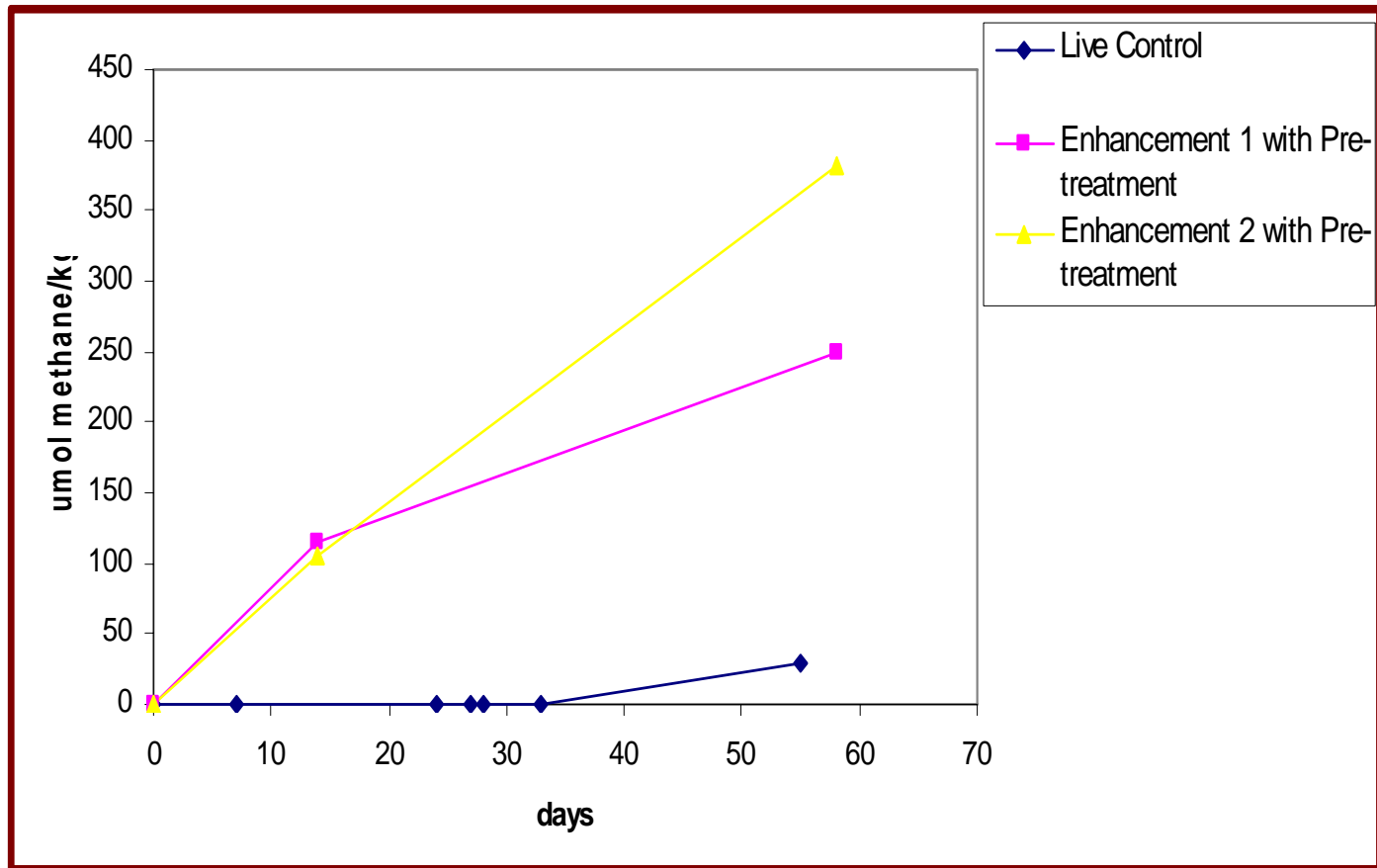


**Pressurized
Reactors**

Enhancement



Pretreatment/Enhancement



Pretreatment

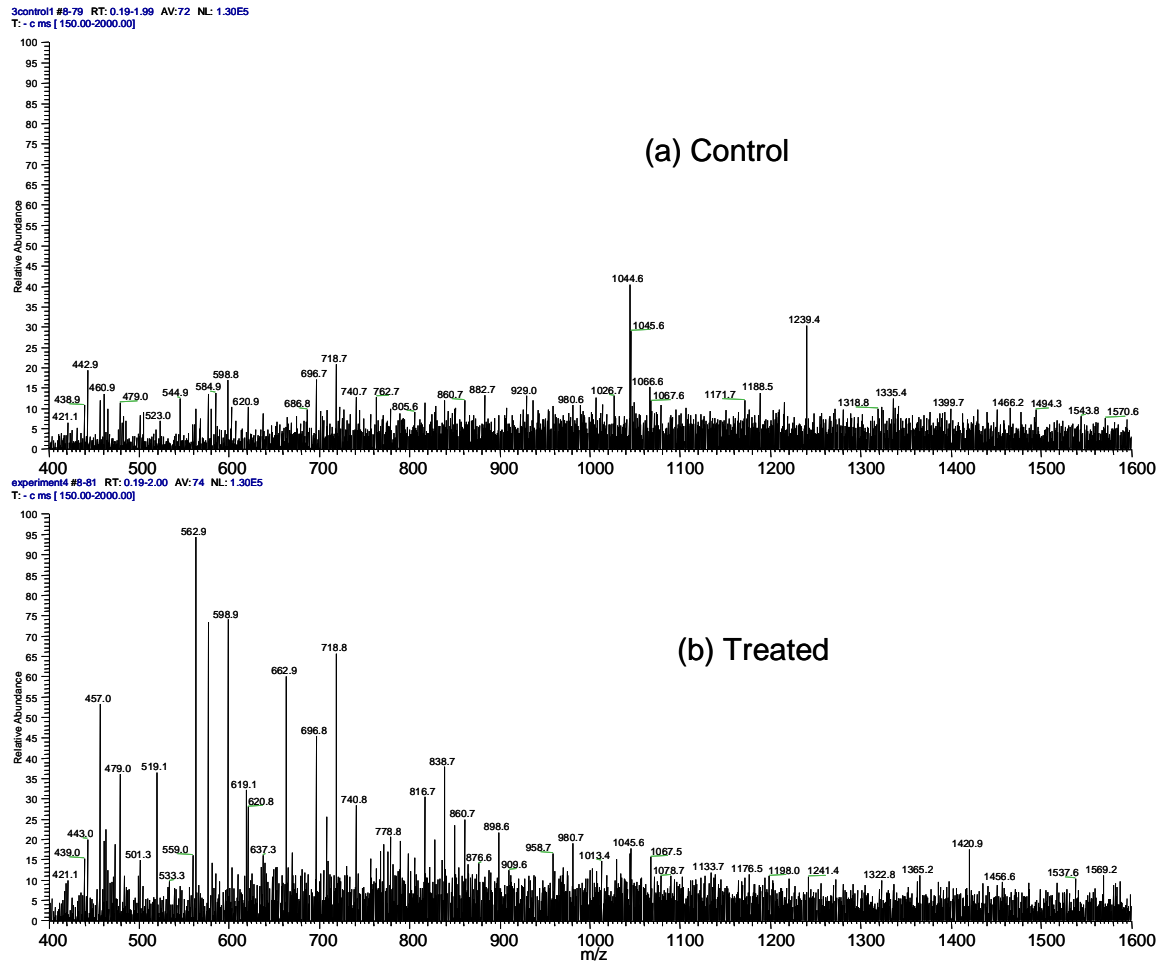
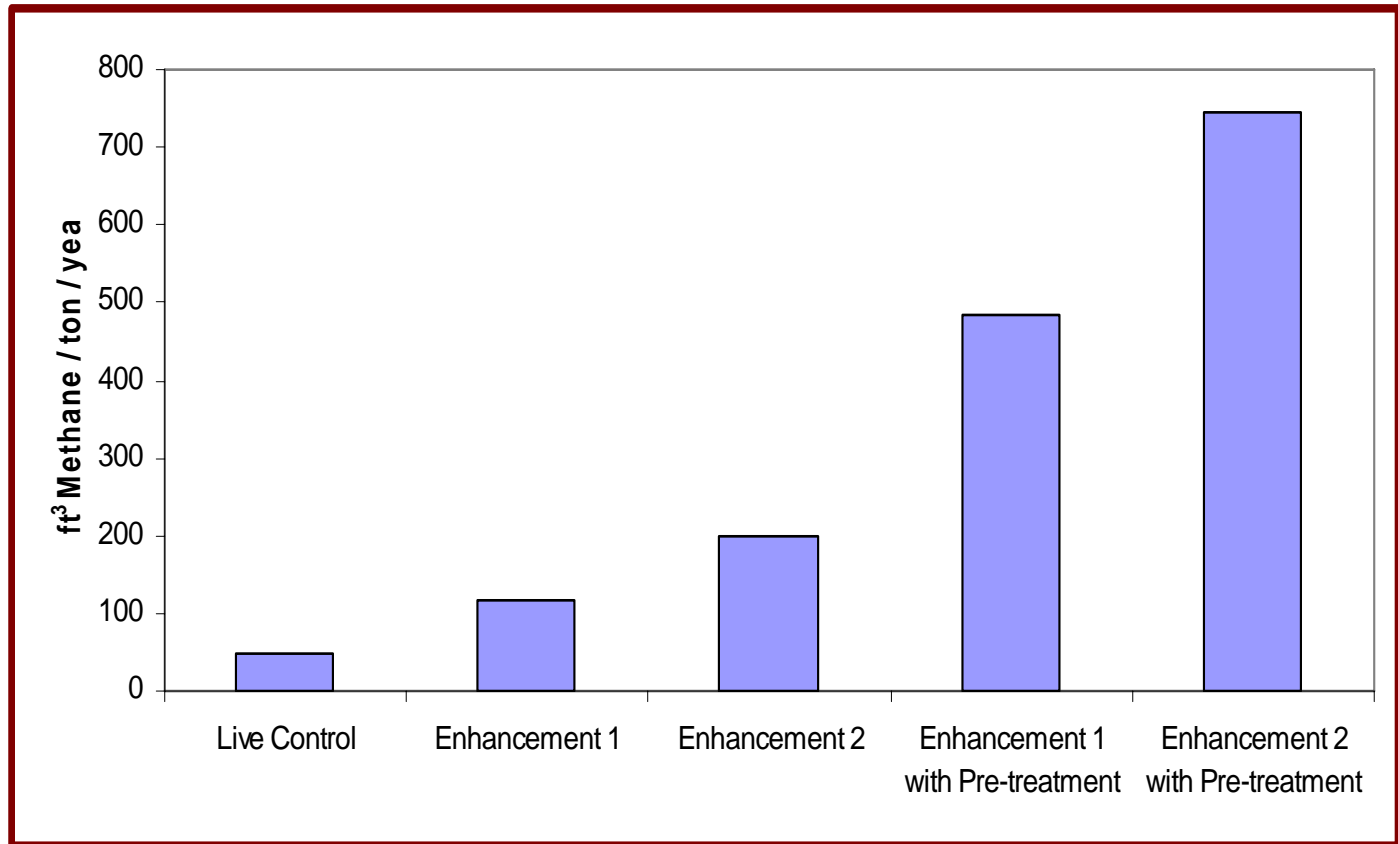


Figure 1. Negative Ion Electrospray Ionization (NI-ESI) Mass Spectra of (a) Control and (b) Treated Water-soluble Fraction in Coal Samples.

Pretreatment/Enhancement



Current: Field Pilot Testing

Objectives: obtain performance and economic data

- Test the feasibility of the approach and identify potential concerns.
- Optimize the delivery system.
- Provide an economical analysis.

Challenges

Field performance of the enhancement technology – accessibility, fracturing and collection

Optimal operation – frequent monitoring and adjustments