ABERDEEN DRILLING MANAGEMENT LTD

COAL

By

Dr Mike Richards

ABERDEEN DRILLING MANAGEMENT LTD

SHORT CV

- Aged 64
- First Went Underground 1959
- At least 6 generations in mining…..the last
- BSc Mining Engineering – PhD Mining Gas Release on Coal Faces
- 1975 – 1983 Production Management UK
- 1983 – 1995 Senior Lecturer University of Nottingham
- Consultant Mining Engineer

ABERDEEN DRILLING MANAGEMENT LTD

SHORT CV CONTINUED

- Production Experience in Longwall, and Room and Pillar Coal Mining
- Open Cast Coal
- Other minerals include gold, platinum, uranium, diamonds, chromite and manganese
- Specialise in mine safety including mine gases and fires
- Most recently looking at unconventional gas

ABERDEEN DRILLING MANAGEMENT LTD

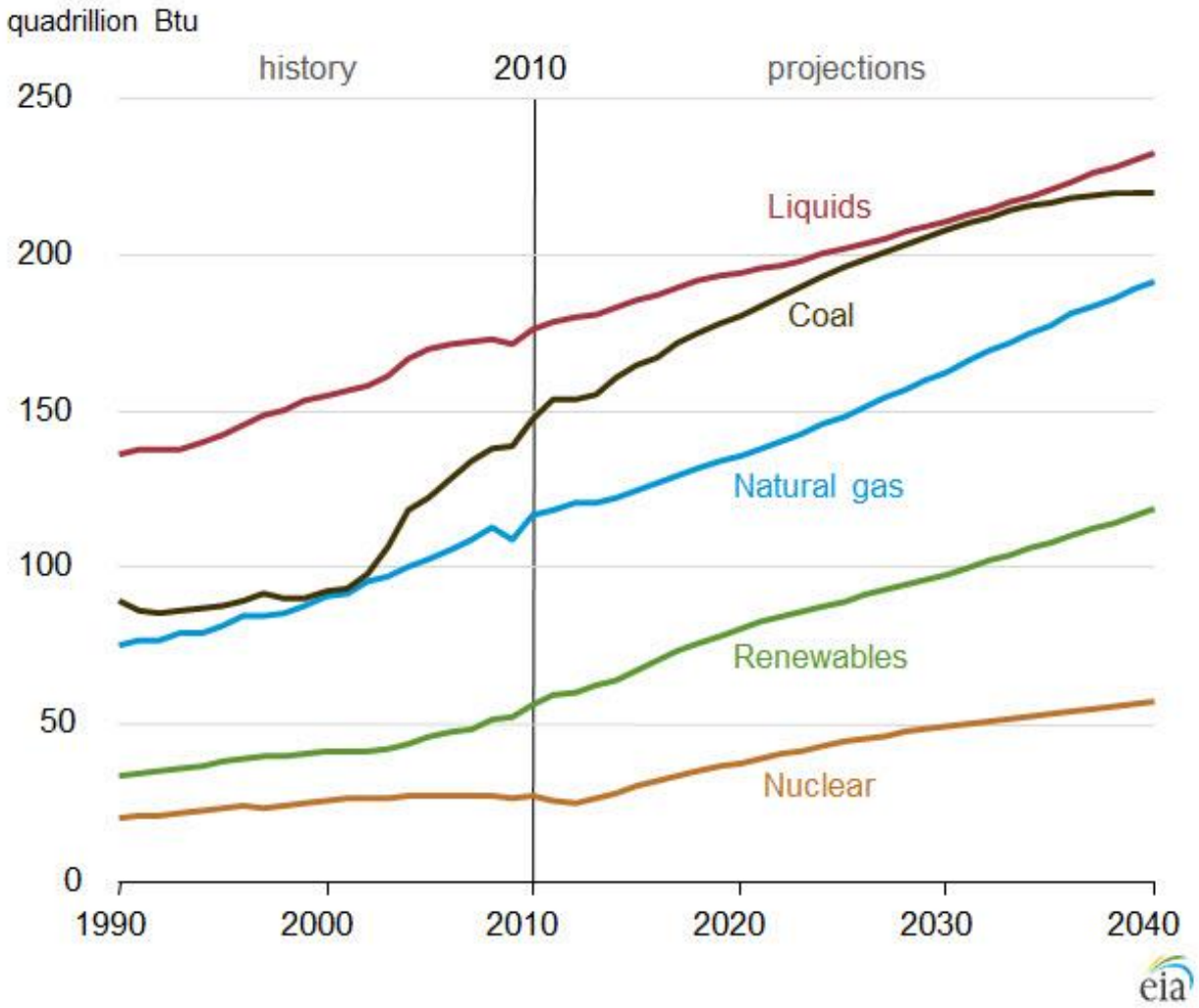
WHY COAL?

ABERDEEN DRILLING MANAGEMENT LTD

1. Coal has a consumption in the world in energy values almost equal to oil.

ABERDEEN DRILLING MANAGEMENT LTD

Figure 2. World energy consumption by fuel type, 1990-2040



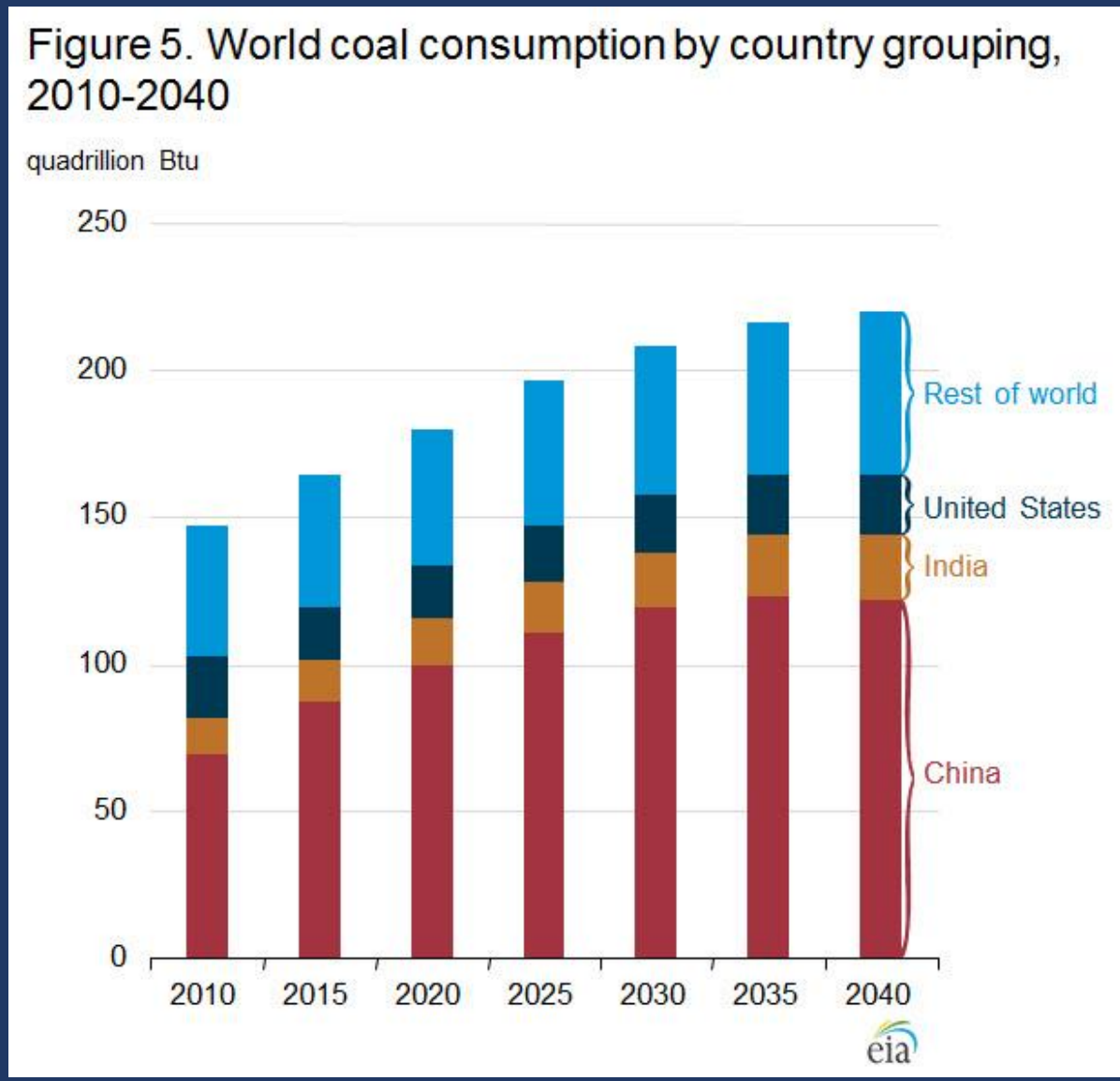
I Btu=1.055 kJ=0.0002931 kWh

ABERDEEN DRILLING MANAGEMENT LTD

1. Coal has a consumption in the world in energy values almost equal to oil.
2. China will be the largest consumer but other remain important

ABERDEEN DRILLING MANAGEMENT LTD

Figure 5. World coal consumption by country grouping, 2010-2040

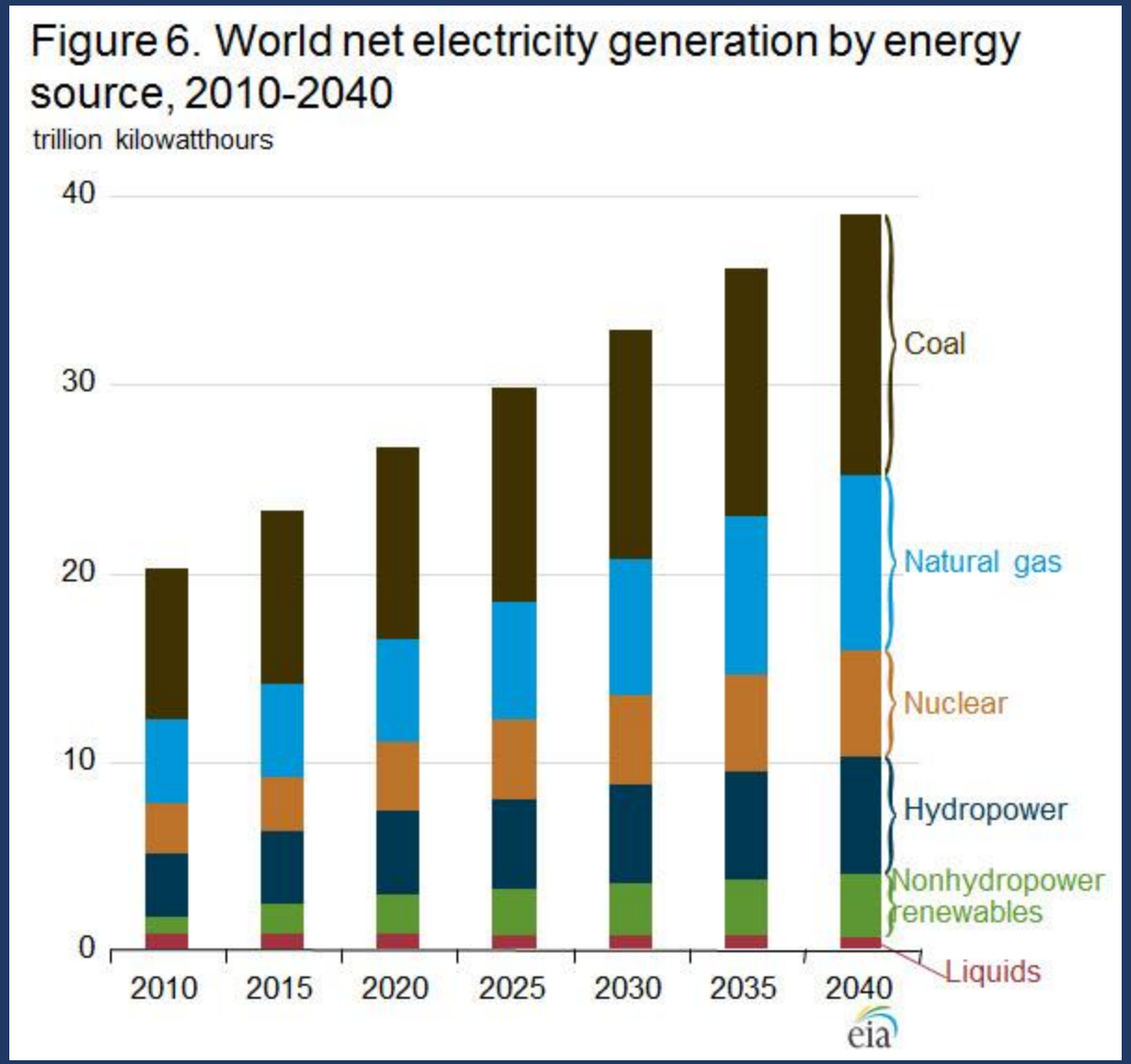


I Btu=1.055 kJ=0.0002931 kWh

ABERDEEN DRILLING MANAGEMENT LTD

1. Coal has a consumption in the world has a consumption in the world in energy values almost equal to oil.
2. China is the largest consumer.
3. About a 33% of electricity is generated from Coal in the world

ABERDEEN DRILLING MANAGEMENT LTD



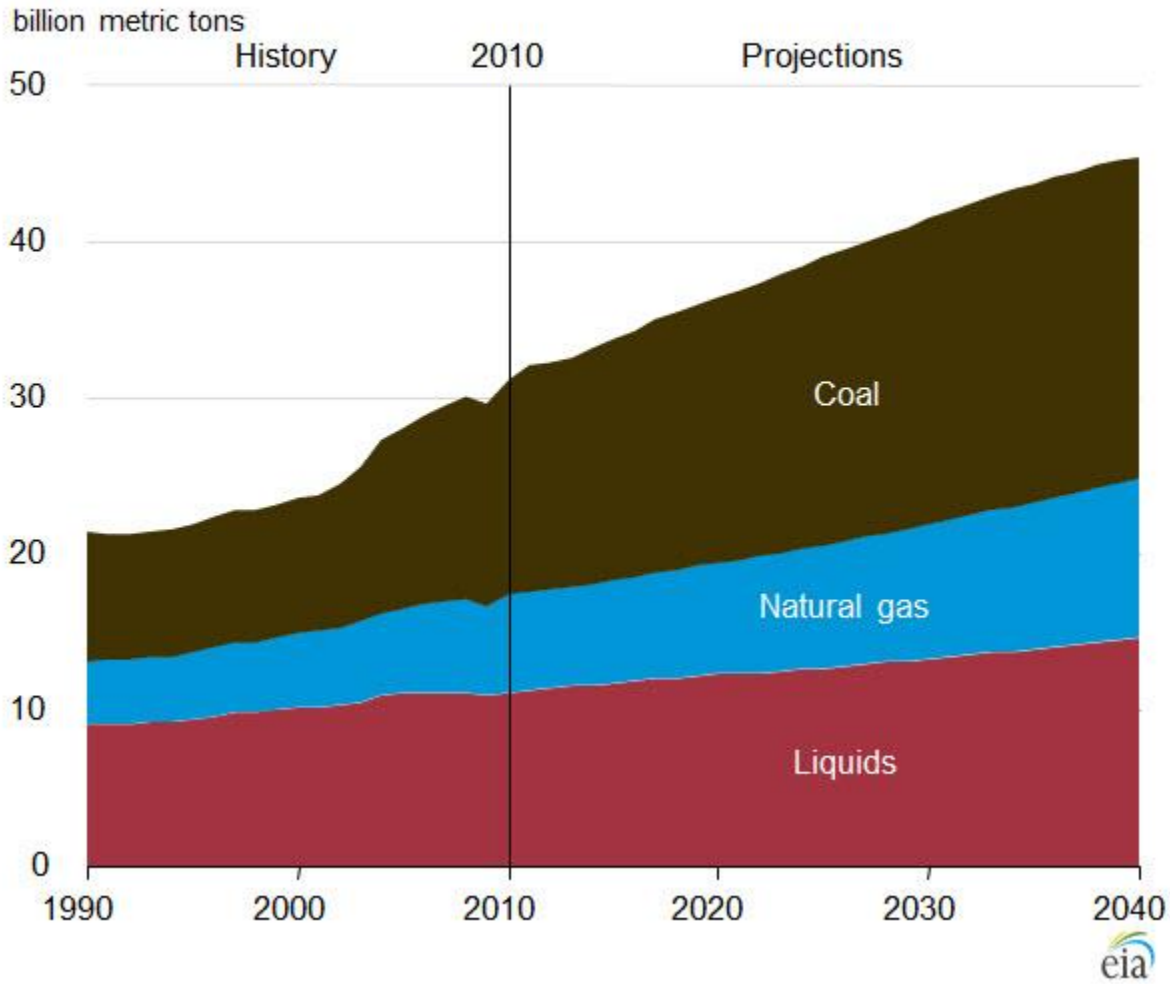
I Btu=1.055 kJ=0.0002931 kWh

ABERDEEN DRILLING MANAGEMENT LTD

1. Coal has a consumption in the world has a consumption in the world in energy values almost equal to oil.
2. China is the largest consumer.
3. About a 33% of electricity is generated from Coal in the world.
4. Coal has a problem! Carbon Dioxide

ABERDEEN DRILLING MANAGEMENT LTD

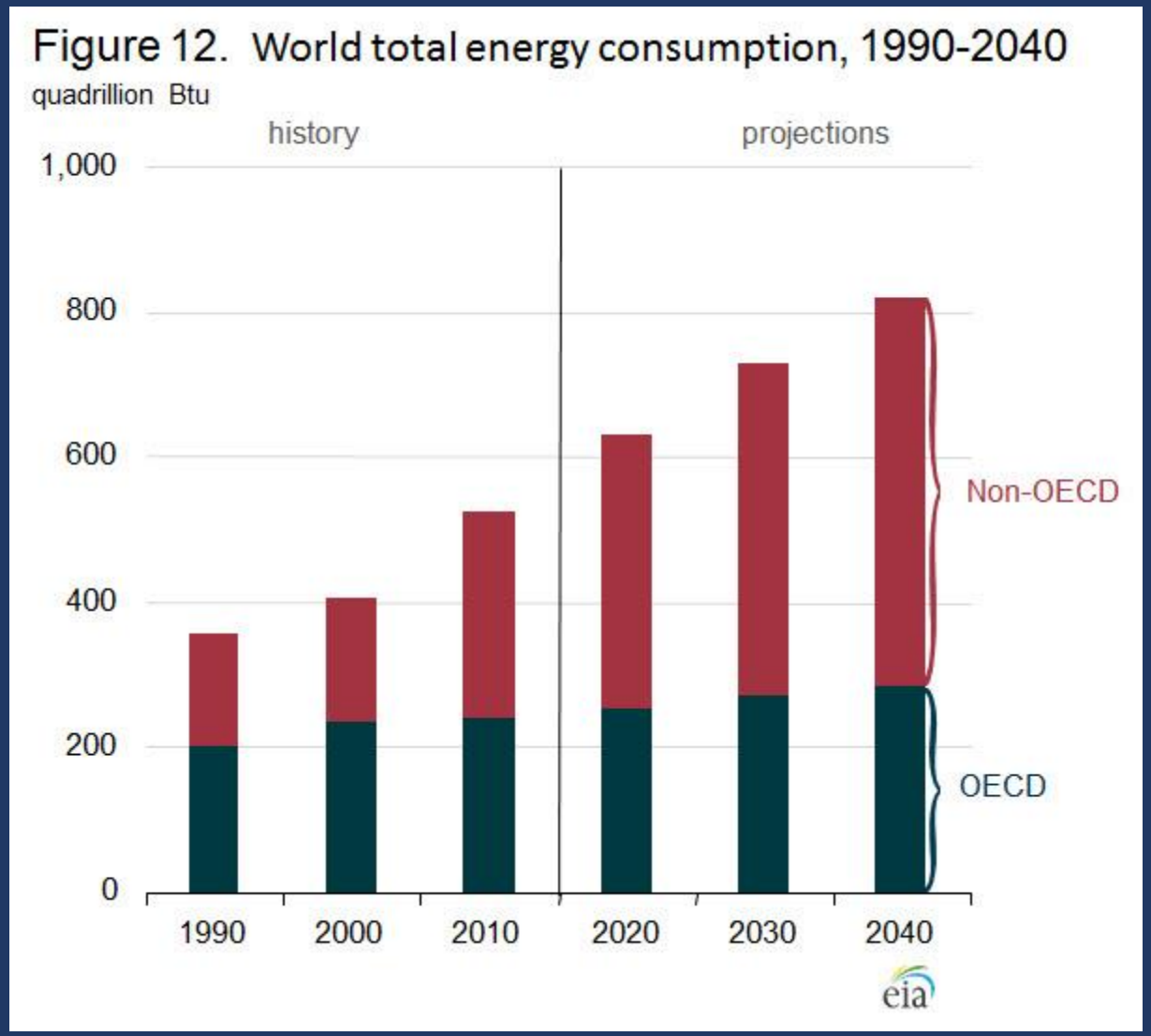
Figure 10. World energy-related carbon dioxide emissions by fuel type, 1990-2040



ABERDEEN DRILLING MANAGEMENT LTD

1. Coal has a consumption in the world has a consumption in the world in energy values almost equal to oil.
2. China is the largest consumer.
3. About a 33% of electricity is generated from Coal in the world.
4. Coal has a problem! Carbon Dioxide.
5. World Energy Consumption Continues to Rise.

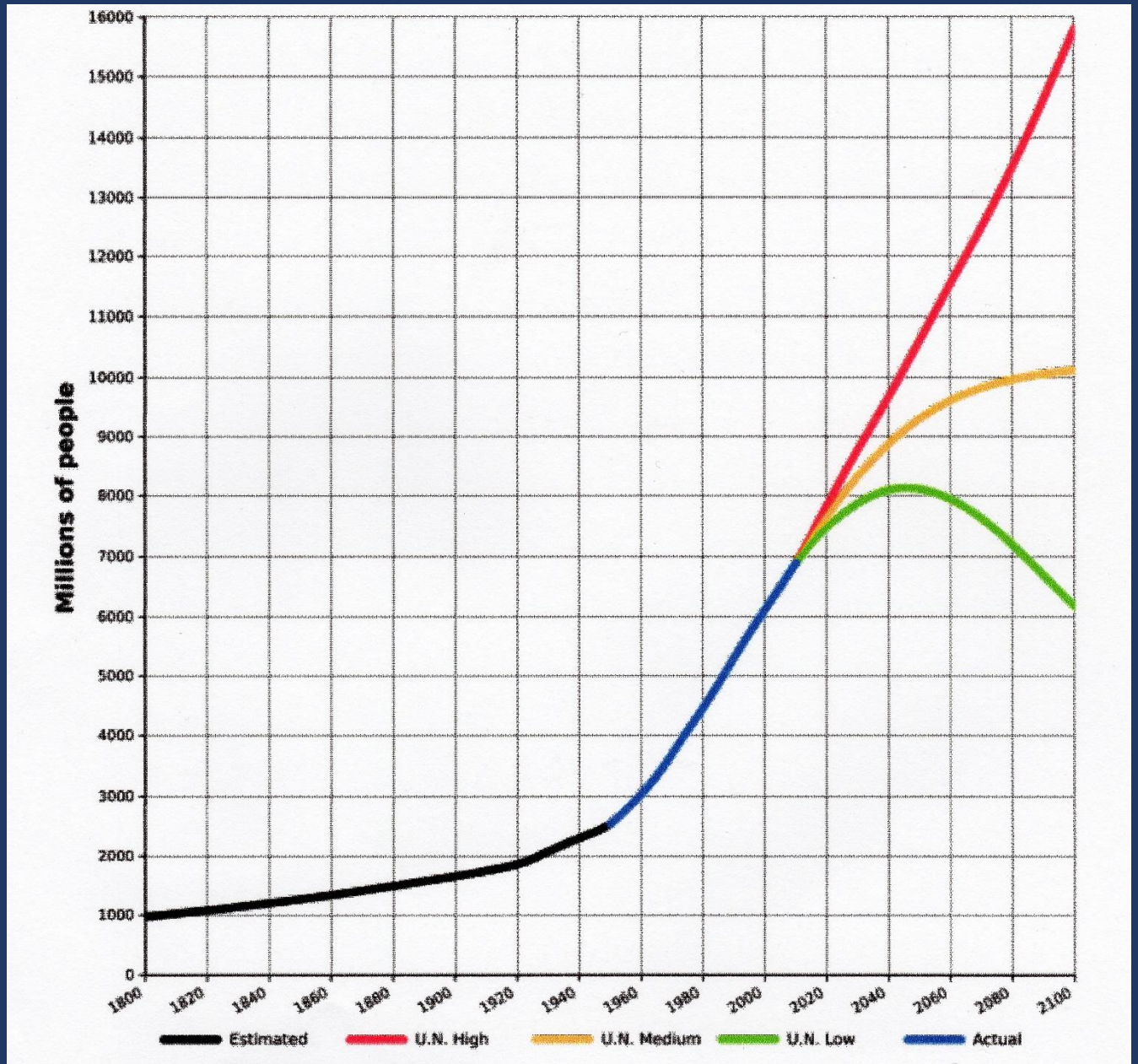
ABERDEEN DRILLING MANAGEMENT LTD



I Btu=1.055 kJ=0.0002931 kWh

ABERDEEN DRILLING MANAGEMENT LTD

World Population



ABERDEEN DRILLING MANAGEMENT LTD

Lecture Content

1. Geology and Formation of Coal
2. Rank of Coal
3. Coal Qualities
4. Reserves and Resources
5. History of Coal Mining
6. Mining Techniques
   - Underground
   - Openpit - Strip Mining
7. Health and Safety
8. Environmental Issues
9. Conclusion……Why Coal

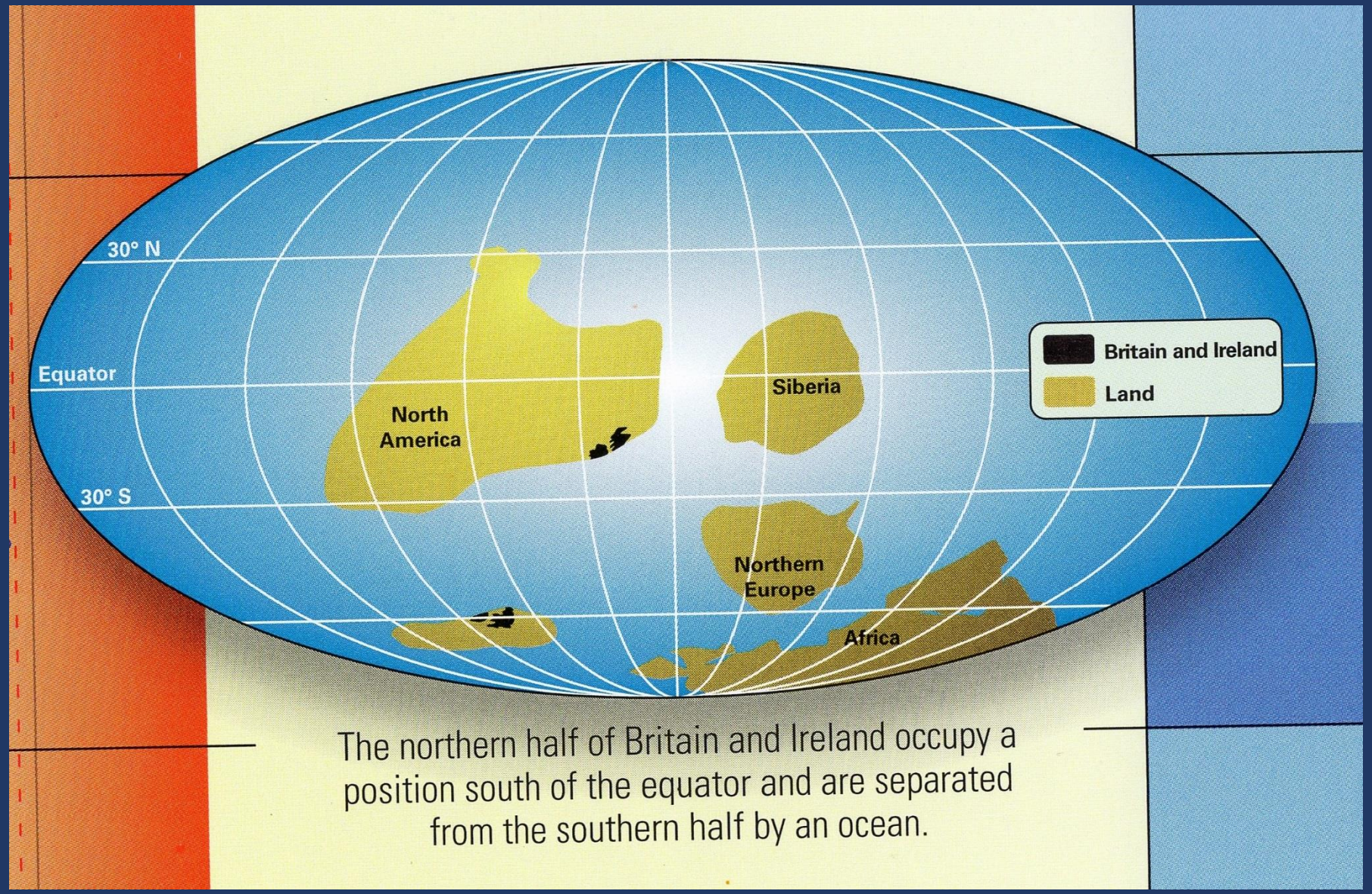
ABERDEEN DRILLING MANAGEMENT LTD

Coal Geology

1. Geological Time Frames
2. Continental Drift Effect
3. Coal Formation
4. Coal Maturation

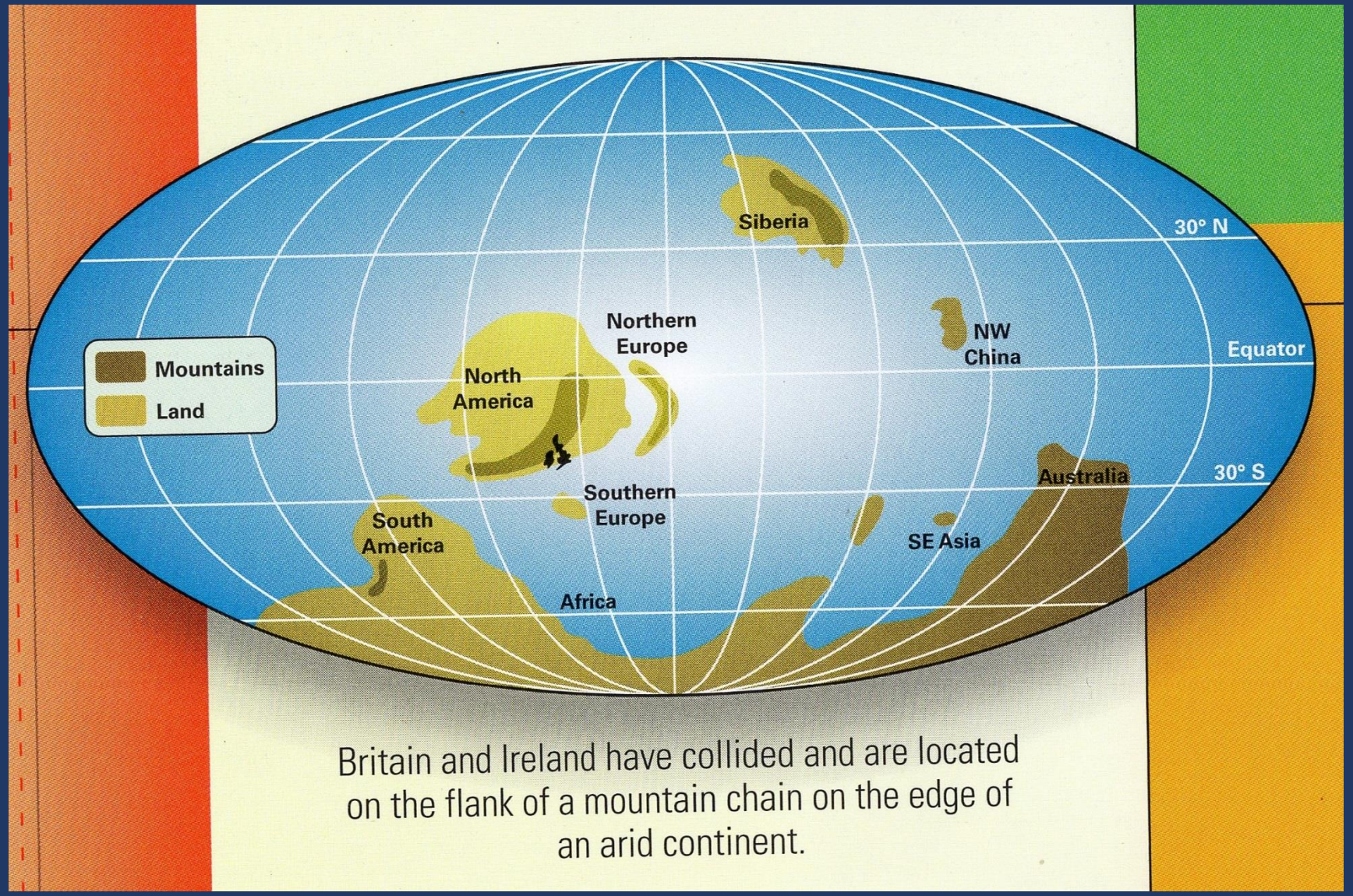
ABERDEEN DRILLING MANAGEMENT LTD

ABERDEEN DRILLING MANAGEMENT LTD



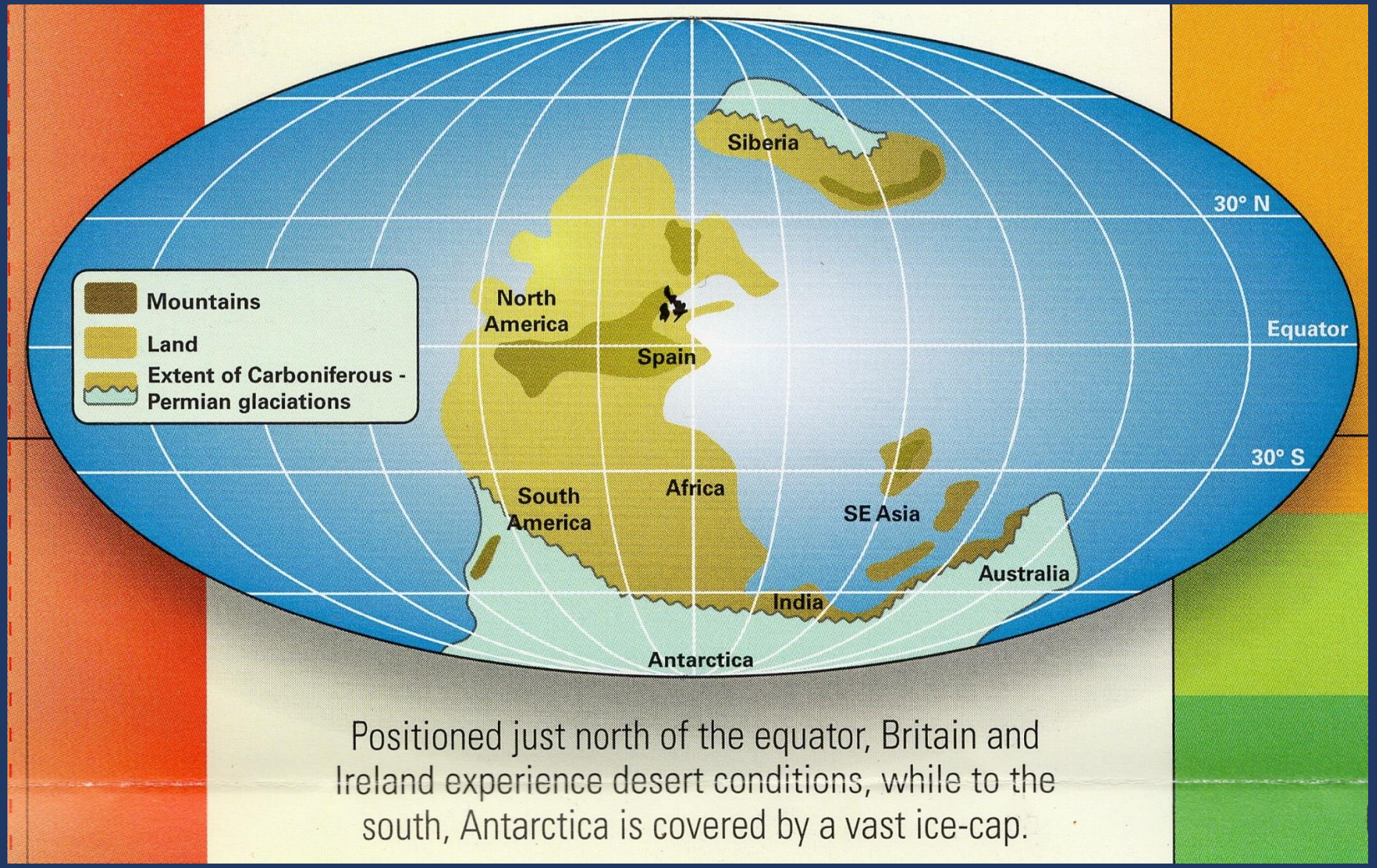
The northern half of Britain and Ireland occupy a position south of the equator and are separated from the southern half by an ocean.

ABERDEEN DRILLING MANAGEMENT LTD



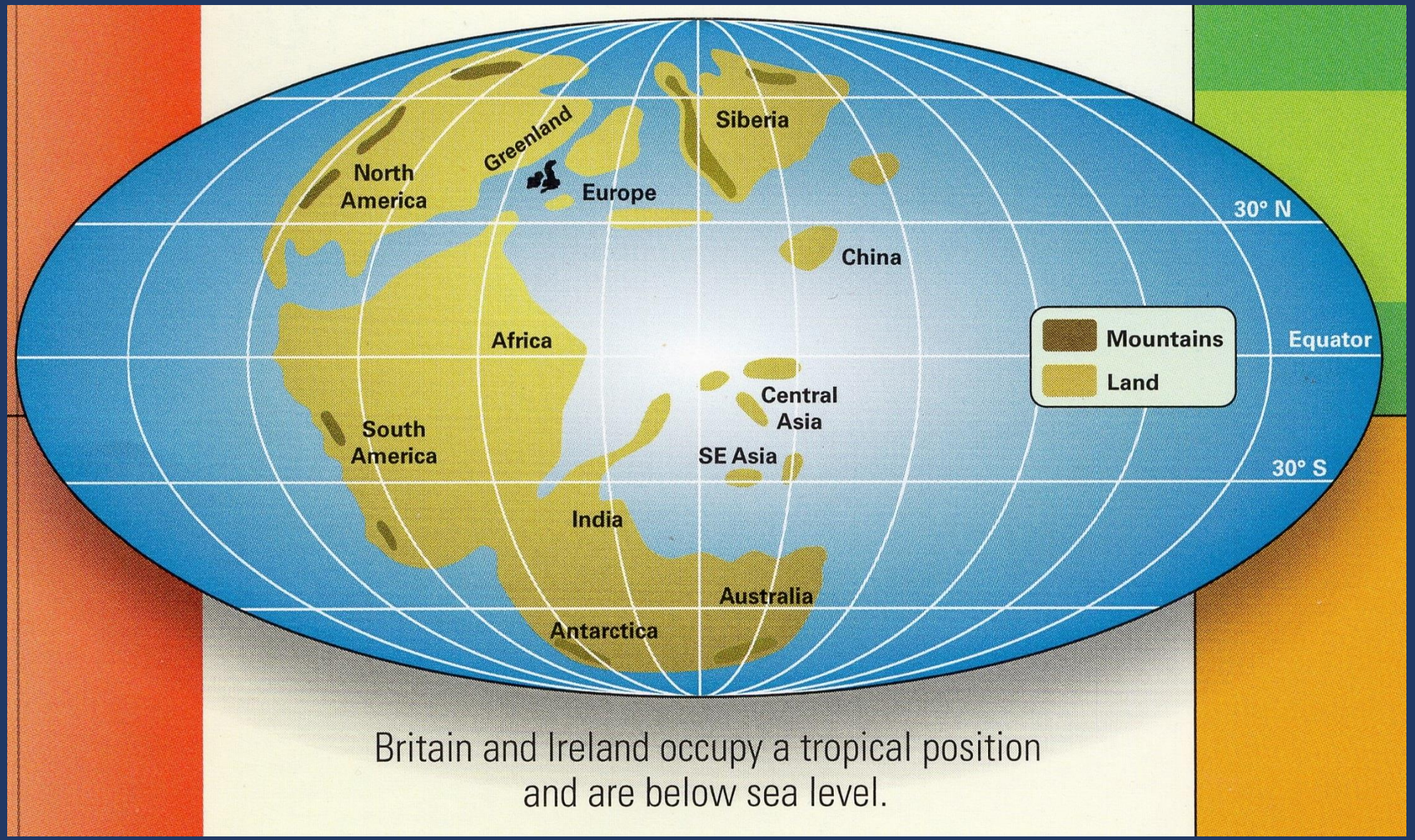
Britain and Ireland have collided and are located on the flank of a mountain chain on the edge of an arid continent.

ABERDEEN DRILLING MANAGEMENT LTD



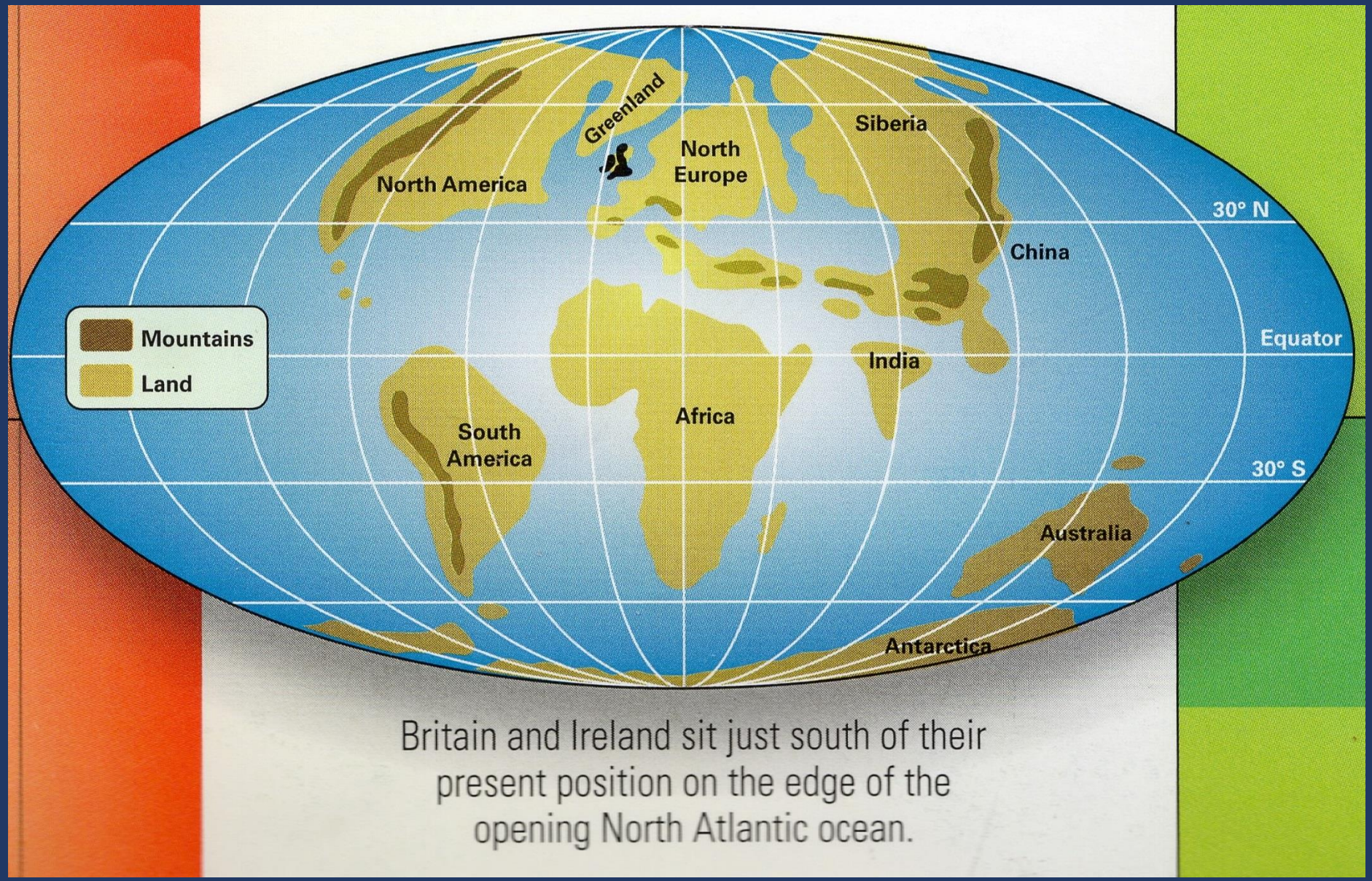
Positioned just north of the equator, Britain and Ireland experience desert conditions, while to the south, Antarctica is covered by a vast ice-cap.

ABERDEEN DRILLING MANAGEMENT LTD



Britain and Ireland occupy a tropical position and are below sea level.

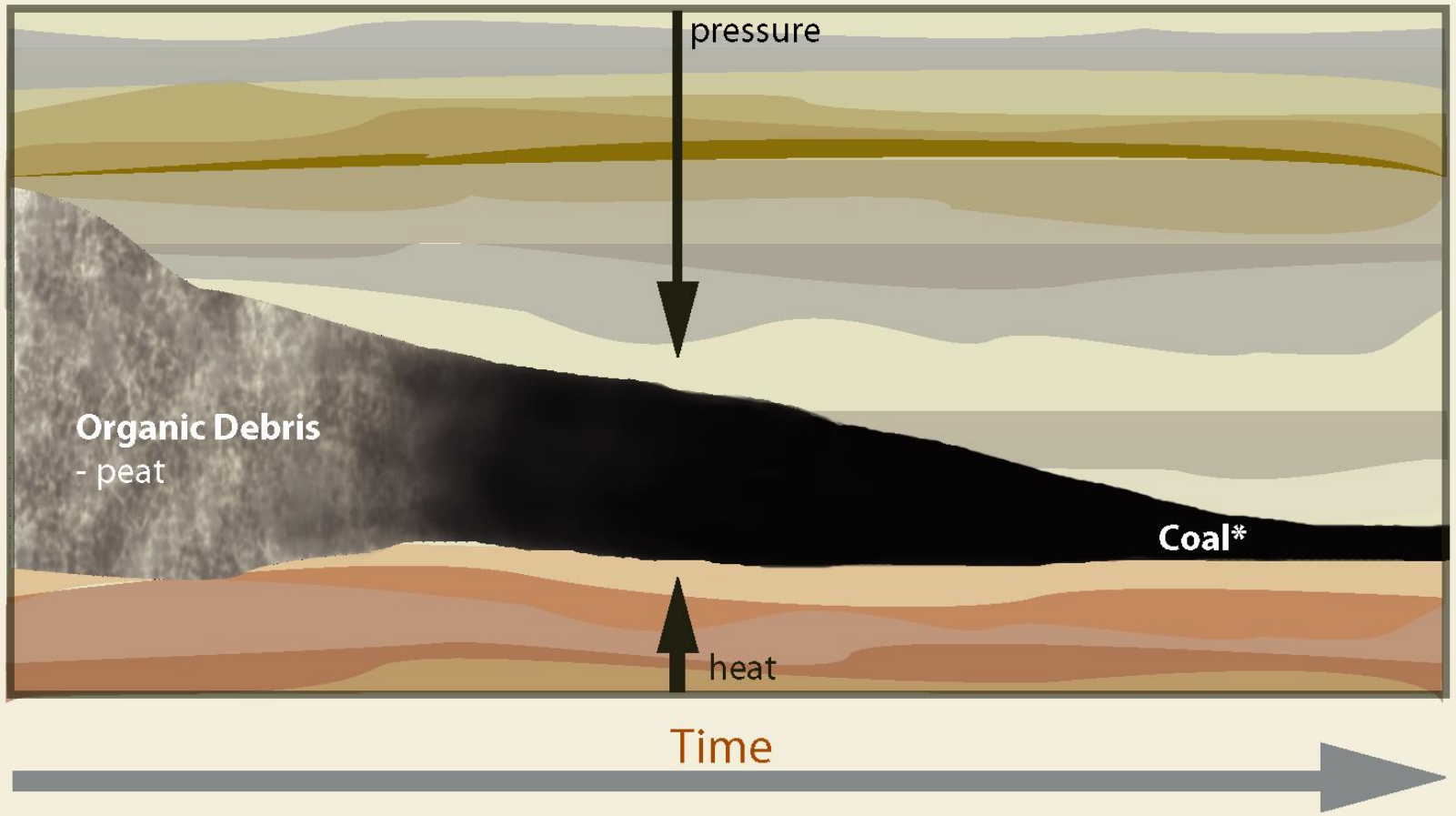
ABERDEEN DRILLING MANAGEMENT LTD



Britain and Ireland sit just south of their present position on the edge of the opening North Atlantic ocean.

ABERDEEN DRILLING MANAGEMENT LTD

Coalification Process



ABERDEEN DRILLING MANAGEMENT LTD

COAL RANK

- Equivalent to Maturation in Oil
- As rank increases then various changes on the coal takes place
- Initially plant material decays with oxygen supported bacterial (aerobic)
- Then bacterial action without oxygen (anaerobic)
- Deep burial giving heat and pressure

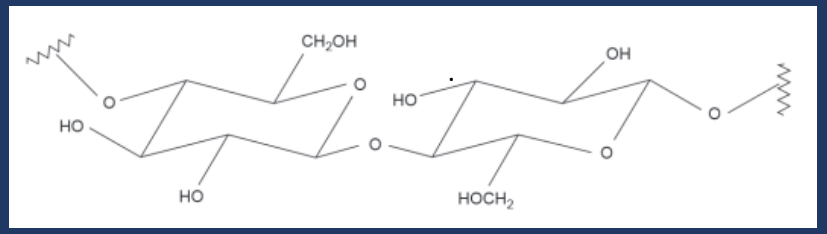
ABERDEEN DRILLING MANAGEMENT LTD

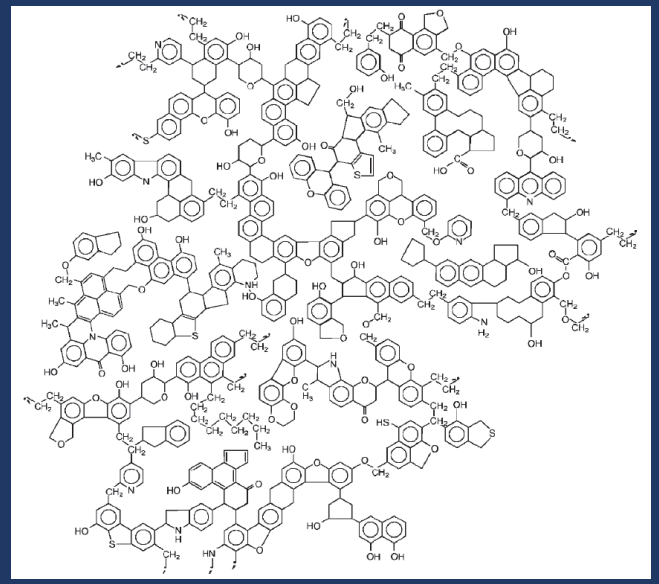
COAL RANK CONTINUED

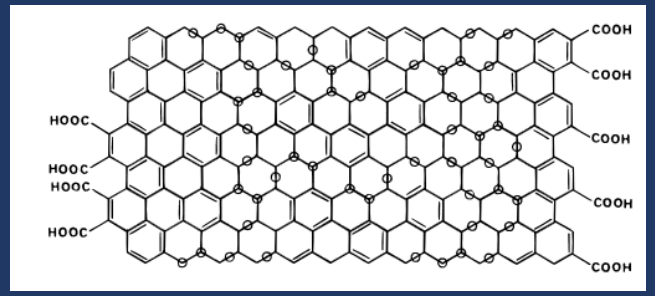
- Coal has been laid down over a 400 million year period
- Devonian through to Tertiary
- Most European bituminous coals are Carboniferous Period
- Most European brown coals (lignite) are Tertiary
- Age of Coal does not define rank
- Depth of burial and temperature give rank

ABERDEEN DRILLING MANAGEMENT LTD

COALIFICATION PROCESS







Cellulose Monomer

Bituminous Coal

Graphite Oxide

ABERDEEN DRILLING MANAGEMENT LTD

COALIFICATION PROCESS

Coalification →

	Wood →	Peat →	Lignite →	Bituminous →	Anthracite →	Graphite
C/%	48	55	70	80 - 90	92	≈100
H/%	6	10	8 - 5	6 - 4	3	<1
O/%	45	35	25	10 - 5	2	<1
C_{ar}/C_{tot}			≈0.5	0.6	0.95	≈1
H:C ratio			1		0.5	≈0

Inherent Moisture/%	50	Up to 75	35-55	8-18	7-9	
CV GJ/t daf	16	15	10-20	20-30	32.5	32.8

ABERDEEN DRILLING MANAGEMENT LTD

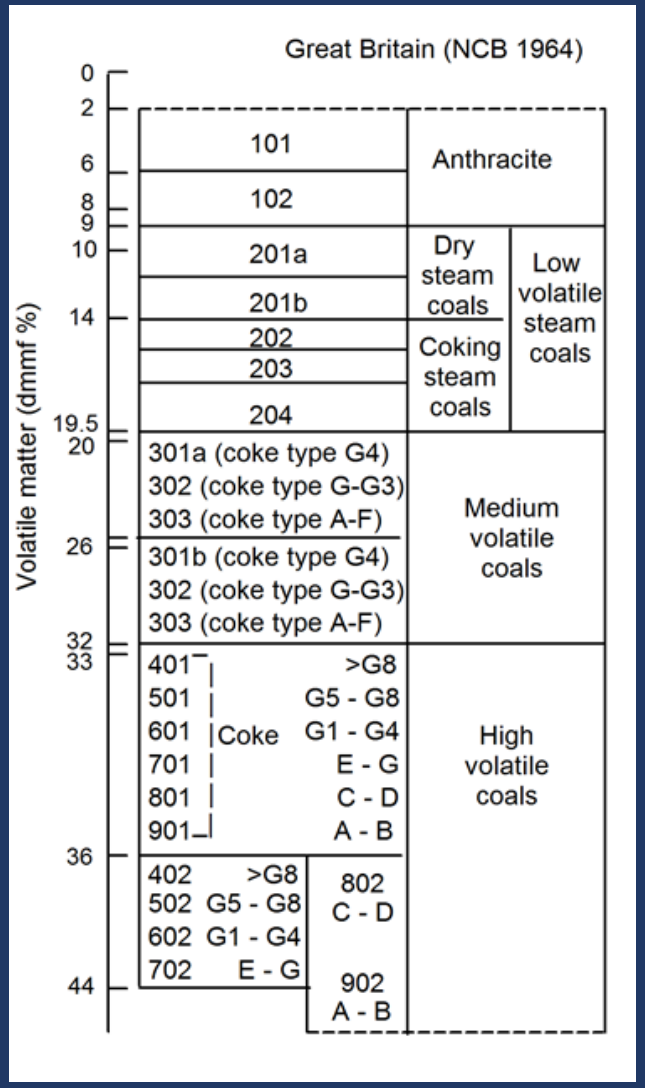
COAL RANKING SYSTEMS

- Many Ranking Systems
- American and UK Discussed
- Russian and derivatives used in most former communist countries. Uses such parameters as vitrinite reflectance and the plastic layer thickness during coking
- Chinese classification system

ABERDEEN DRILLING MANAGEMENT LTD

UK COAL RANKS

NCB Ranking System
Modified 1964



ABERDEEN DRILLING MANAGEMENT LTD

American Ranking System ASTM D388

Coal Rank	Fixed carbon/dmmf%	Volatile matter/dmmf%	Gross Calorific value/btulb^{-1} (mmmf)	Gross Calorific value/GJtonne^{-1} (mmmf) [non ASTM]
Meta-anthracite	>98	<2		
Anthracite	92 - 98	2 - 8		
Semi-anthracite	86 - 92	8 - 14		
Low volatile bituminous	78 - 80	14 - 22		
Medium volatile bituminous	69 - 78	22 - 31		
High volatile A bituminous	< 69	>31	>14000	>32.6
High volatile B bituminous			13000 - 14000	30.2 - 32.6
High volatile C bituminous			10500 - 13000	24.4 - 30.2
Sub-bituminous A coal			10500 - 11500	24.4 - 26.7
Sub-bituminous B coal			9500 - 10500	22.1 - 24.4
Sub-bituminous C coal			8300 - 9500	19.3 - 22.1
Lignite A			6300 - 8300	14.7 - 19.3
Lignite B			<6300	<14.7

ABERDEEN DRILLING MANAGEMENT LTD

COAL QUALITY

- Rank is only one quality determining the coal's value on the market
- Sulphur important as it produces acid rain. Many new power stations fitted with Flue Gas Desulphurisation Plants and old power stations are retrofitted with FGC.
- High sulphur in coking coal not desirable for metallurgical processes
- Chlorine in the form of NaCl causes corrosion in power plants
- Phosphorous not satisfactory of metallurgical coal
- High inherent ash content lowers the CV of the coal
- Poor washability of the coal can make it difficult to remove ash from the raw product (ROM)
- Grindability indices are important as hard coals are costly to grind
- Soft coal used to be difficult to sell into the house coal market.

ABERDEEN DRILLING MANAGEMENT LTD

RESERVES AND RESOURCES

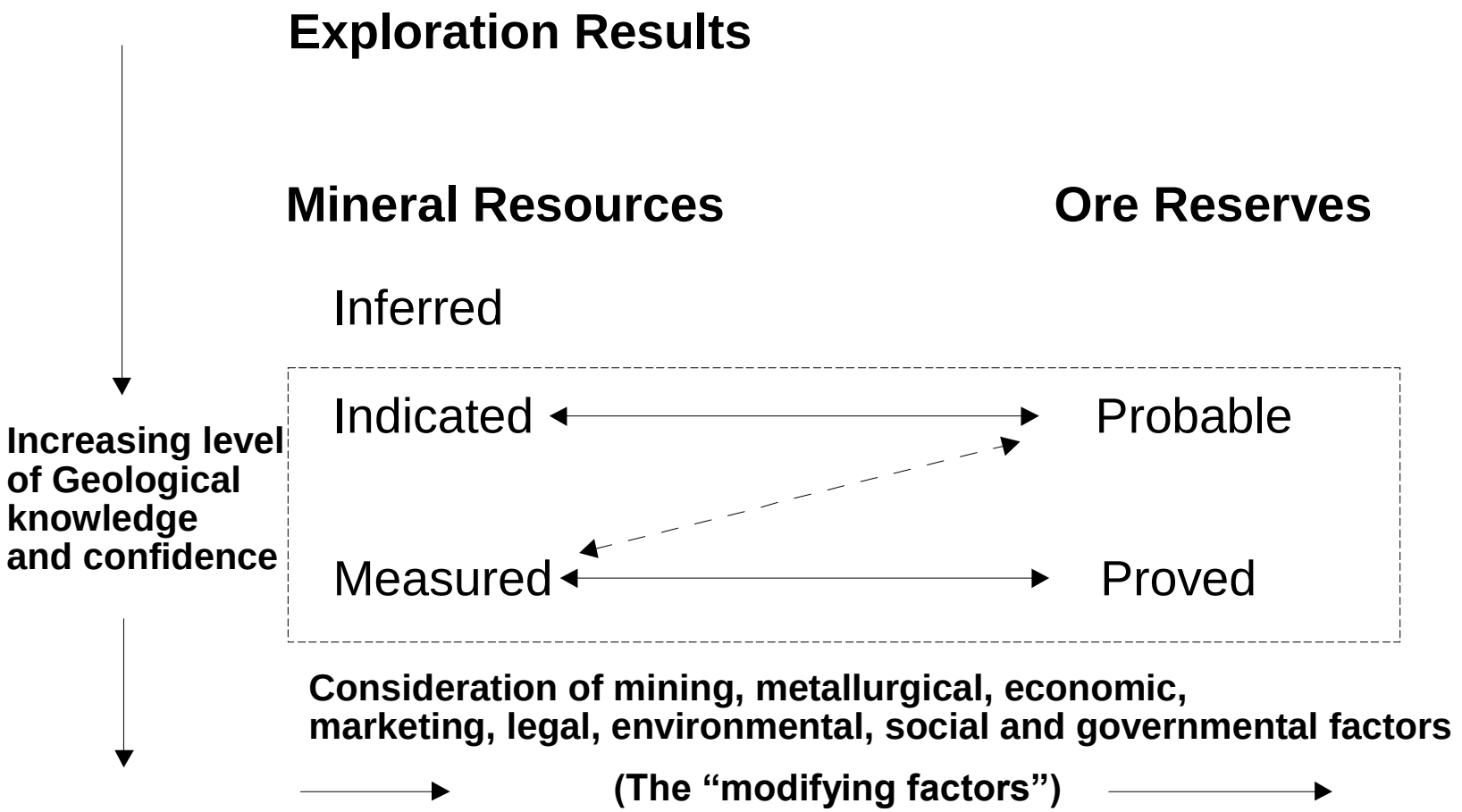
- Resources follow from exploration giving size, shape, quality, thickness, quantity, grade, continuity that there are reasonable prospects of extraction.
- In Australia, Canada, USA, South Africa, UK and Ireland the Joint Ore Reserves Committee (JORC) issue guidelines.
- There are three levels of Resource. These are on confidence and has to be shown.
- **Measured Resource:** Highest Level of confidence.
- **Indicated Resource:** Lower level of confidence eg drill holes to far apart for full confidence
- **Inferred Resource:** Lowest Level of confidence so that continuity may reasonably be certain but qualities and other parameters are unknown
- Only Measured and Indicated resources can considered for Reserves consideration.

ABERDEEN DRILLING MANAGEMENT LTD

RESERVES

- Only Measured and Indicated Resources can be used in calculating resources.
- It has to be demonstrated that mining the coal deposit can be undertaken and make a profit. If not it is not a Reserve.
- **Proved Reserve:** This is the highest category and only measured resources can be used in this .
- **Probable Reserve**: Usually Indicated Resources are used in this category but some Measured may be included. No inferred resources can be included in a reserve.
- This system varies from the oil risk levels.

ABERDEEN DRILLING MANAGEMENT LTD



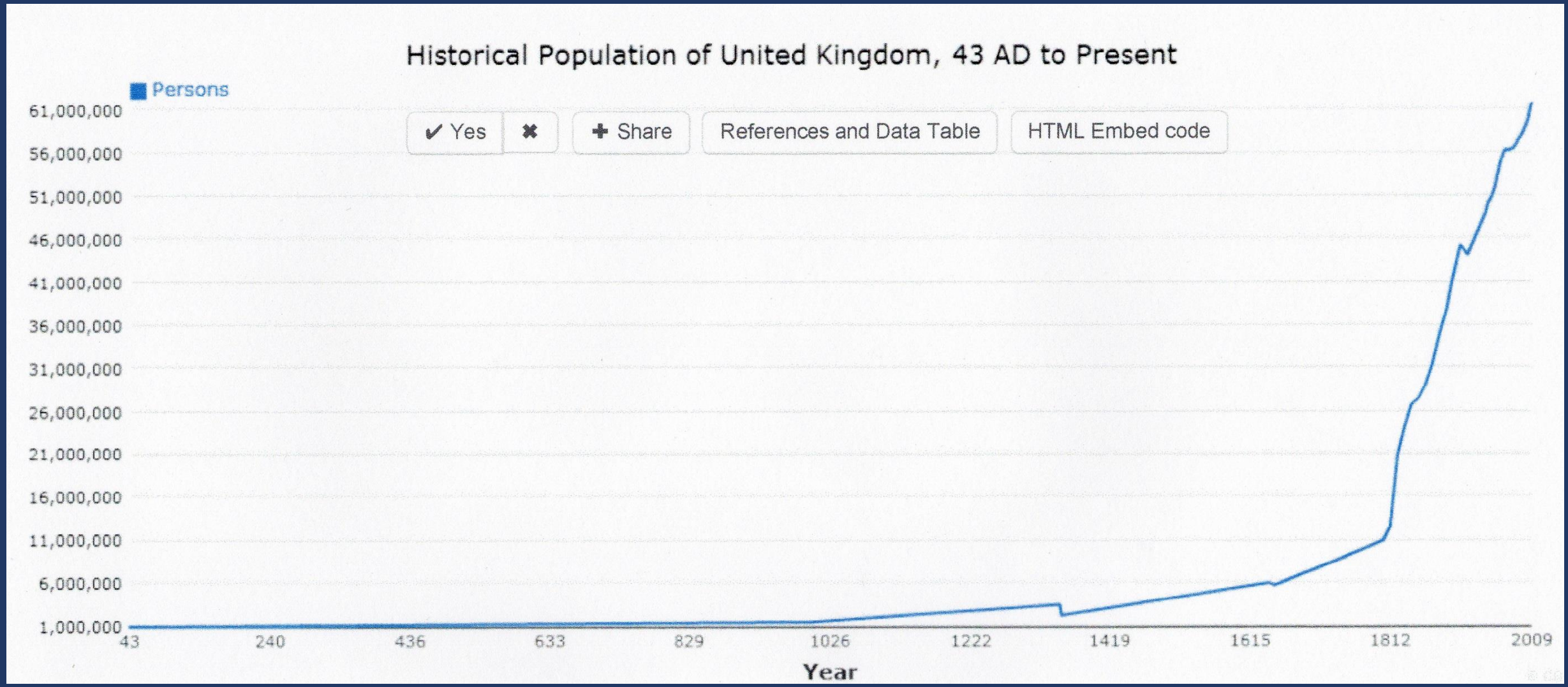
ABERDEEN DRILLING MANAGEMENT LTD

HISTORY OF COAL USE

- Prior to coal the world relied overwhelmingly on renewables wind, water, animal power and manpower.
- Historically small use was made of coal eg porcelain in China and evidence that coal was used in heating.
- Where did industrial use of coal start and why?
- Western Europe and the UK in particular is the answer to where.
- The why takes a little longer to explain.
- Combination of population growth, climate and social climate.

ABERDEEN DRILLING MANAGEMENT LTD

UK POPULATION GROWTH



ABERDEEN DRILLING MANAGEMENT LTD

POPULATION OF UK

1. AD 43 invasion by Rome population 1,000,000
2. AD 436 small increase but country developed
3. AD 436 to AD 1,000 “Dark Ages”. Small kingdoms continuous wars and incursions from the north east.
4. AD 1066 last time UK was fully invaded.
5. Step change in population growth.

ABERDEEN DRILLING MANAGEMENT LTD

POPULATION OF UK

6. Late 1300's the Bubonic Plague (Black Death) took out 20% of the population.
7. Stable conditions in the country to mid 1600's
8. Second "Black Death" Plague
9. Then stable political conditions and a further step change in population.
10. Early 20th Century lost Southern Ireland

ABERDEEN DRILLING MANAGEMENT LTD

PRESSURE TO FEED POPULATION

1. Very temperate climate – one crop a year
2. Slow growing trees
3. Need to improve agriculture
4. Change in political situation freeing population to leave land
5. Agricultural Revolution

ABERDEEN DRILLING MANAGEMENT LTD

PRESSURE ON FORESTS 1400's ONWARDS

1. High demand for wood for building, keeping warm, cooking and smelting of iron.
2. Slow growing forests.
3. High population in south east.
4. Start of coal mining in an organised way in north east to supply London.
5. Not popular in London smoke!

ABERDEEN DRILLING MANAGEMENT LTD

SHORTAGE OF WOOD – COAL USE INCREASES

1. Deforestation and even systematic management of woodland led to high prices and strangling the iron industry.
2. High demand for iron in mid 1700's.
3. Perfection of the use of coke from coal in iron making mid 1700's.

ABERDEEN DRILLING MANAGEMENT LTD

START OF THE STEAM AGE

1. Mine owners were looking for a way of improving water drainage in mines.
2. Not just coal but also copper and tin in the west.
3. 1698 Thomas Savery “Atmospheric Pump”
4. 1713 Newcomen Pump “High Pressure Pump”
5. Mechanisation of Industry using steam
6. Moving vehicles powered by steam - the railways

ABERDEEN DRILLING MANAGEMENT LTD

UK REALLY WAS THE LEADER IN INDUSTRIALISATION

COAL PRODUCTION OF THE GLOBE IN 1866.

Name of Country.		Tons.
United Kingdom (England, Ireland, and Scotland),		101,630,544
Other countries of Europe—		
Prussia,	17,000,000	
France,	11,300,000	
Belgium,	12,000,000	
Austria,	4,000,000	
Saxony,	2,500,000	
Hesse, Bavaria, Hanover, Russia, Spain, Italy, &c.,	4,000,000	
		50,800,000
North America,		15,000,000
Other countries of the globe—		
India, China, Japan, Australia, Chile, &c.,	3,000,000	
		68,800,000
Total,		170,430,544

ABERDEEN DRILLING MANAGEMENT LTD

80 YEARS LATER

TABLE 6.—AVAILABILITY AND CONSUMPTION OF COAL, 1938 to 1946

(Million Tons)

	1938	1939	1940	1941	1942	1943	1944	1945	1946
Mined Coal—									
Production	227 · 0	231 · 3	224 · 3	206 · 3	203 · 6	194 · 5	184 · 1	174 · 7	181 · 2
Change in colliery stocks	Not available	Not available	— 0 · 7	— 1 · 1	— 0 · 4	+ 0 · 1	— 0 · 5	— 0 · 3	— 0 · 8
Tonnage available	227 · 0	231 · 3	225 · 0	207 · 4	204 · 0	194 · 4	184 · 6	175 · 0	182 · 0
Opencast coal disposal	—	—	—	—	1 · 1	2 · 9	7 · 3	9 · 3	9 · 2
Total	227 · 0	231 · 3	225 · 0	207 · 4	205 · 1	197 · 3	191 · 9	184 · 3	191 · 2
Consumption—									
Gas works	19 · 1	19 · 3	18 · 0	19 · 3	20 · 6	20 · 7	20 · 6	21 · 0	22 · 7
Electricity †	14 · 9	15 · 9	18 · 1	20 · 4	22 · 3	22 · 6	24 · 1	23 · 5	26 · 2
Waterworks	0 · 4 *	0 · 4 *	0 · 4	0 · 4	0 · 4	0 · 4	0 · 4	0 · 4	0 · 4
Railways ‡	13 · 2	12 · 9	13 · 4	14 · 0	14 · 7	14 · 9	15 · 2	14 · 9	15 · 0
Coke ovens (coal carbonised)	19 · 1	20 · 4	22 · 3	21 · 1	21 · 6	20 · 9	20 · 1	20 · 1	20 · 1
Collieries	11 · 9	12 · 1	12 · 3	12 · 1	12 · 0	11 · 6	11 · 1	10 · 6	10 · 7
Iron and steel industry §	42 · 0 *	43 · 0 *	45 · 0 *	11 · 6	11 · 3	11 · 3	10 · 3	9 · 5	9 · 6
Engineering industry §				3 · 9	5 · 2	4 · 9	4 · 5	4 · 0	3 · 7
Other industry §				30 · 6	29 · 2	27 · 7	26 · 8	26 · 4	29 · 6
Non-industrial establishments §	3 · 8 *	3 · 8 *	3 · 8 *	3 · 8 *	3 · 7	3 · 5	3 · 4	3 · 3	3 · 6
Domestic ‖ (i) House coal	44 · 2 *	43 · 3 *	44 · 4	43 · 7	40 · 6	36 · 3	33 · 2	29 · 9	28 · 7
(ii) Anthracite and boiler fuel	1 · 6 *	1 · 6 *	1 · 8	2 · 0	2 · 1	2 · 1	2 · 2	2 · 3	2 · 4
Miners' coal	4 · 6	4 · 6	4 · 8	4 · 7	4 · 7	4 · 5	4 · 6	4 · 6	4 · 8
Coastwise bunkers	1 · 3	1 · 2	1 · 2	1 · 3	1 · 3	1 · 2	1 · 2	1 · 2	1 · 0
Miscellaneous (*including* Service Departments)	2 · 4	3 · 9	8 · 1	4 · 6	5 · 4	5 · 2	7 · 1	5 · 1	5 · 3
Total (Great Britain)	178 · 5	182 · 4	193 · 6	193 · 5	195 · 1	187 · 8	184 · 8	176 · 8	183 · 8
Shipments to Northern Ireland	2 · 2	2 · 4	2 · 5	2 · 5	2 · 4	2 · 6	2 · 5	2 · 5	2 · 5
Overseas shipments and bunkers ¶	46 · 3	46 · 5	26 · 6	9 · 4	7 · 8	8 · 0	6 · 1	8 · 6	8 · 9
Total consumption and shipments	227 · 0	231 · 3	222 · 7	205 · 4	205 · 3	198 · 4	193 · 4	187 · 9	195 · 2
Change in distributed stocks	Not available	Not available	+ 2 · 3	+ 2 · 0	— 0 · 2	— 1 · 1	— 1 · 5	— 3 · 6	— 4 · 0
Total	227 · 0	231 · 3	225 · 0	207 · 4	205 · 1	197 · 3	191 · 9	184 · 3	191 · 2

ABERDEEN DRILLING MANAGEMENT LTD

COAL USES

1. Lighting William Murdoch
2. Smokeless fuels anthracite and soft cokes
3. Foundation of the chemical industry
4. Liquids for lighting
5. Cooking and heating
6. Even the internal combustion engine “Otto Engine” 1860’s. This ran on coal gas.
7. Start of 20th Century Electricity Generation

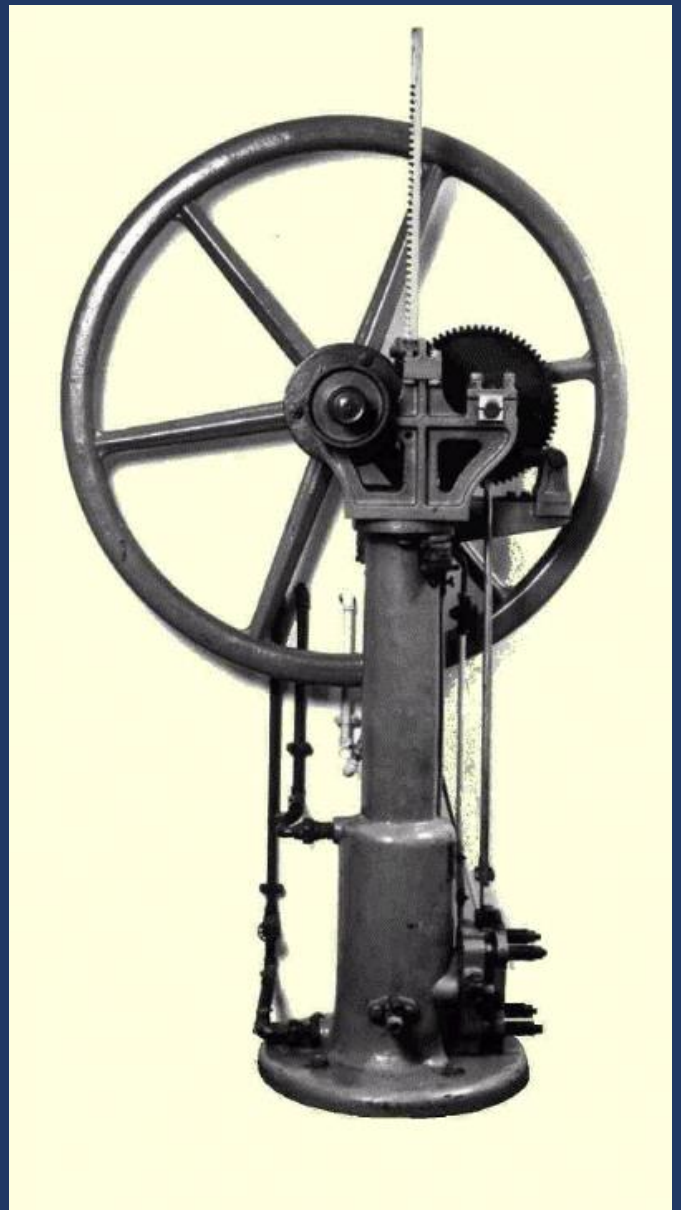
ABERDEEN DRILLING MANAGEMENT LTD

COMPETITION FOR COAL

1. Large scale oil and development of the internal combustion engine 1860's onwards.
2. Natural gas in UK from late 1960's and elsewhere
3. Nuclear power from early 1950's
4. Renewables from the 1990's and CO_2 issues
5. Deindustrialisation of the west from 1970's
6. Concerns for Health and Safety of miners
7. Environmental Issues

ABERDEEN DRILLING MANAGEMENT LTD

THE ATMOSPHERIC OTTO ENGINE



ABERDEEN DRILLING MANAGEMENT LTD

COMPETITION FOR COAL

Fig. 21.—Oil-wells at Tar Farm, Pennsylvania.

ABERDEEN DRILLING MANAGEMENT LTD

COMPETITION FOR COAL

- Initially oil exploited for kerosene
- Lighter fractions disposed of as being of no use and dangerous!
- Killed the liquids from coal market immediately except as by-products.
- The invention of the carburettor paved the way for the automobile.

ABERDEEN DRILLING MANAGEMENT LTD

COMPETITION ON COAL

BUT STILL COAL PRODUCTION IN THE WORLD INCREASES

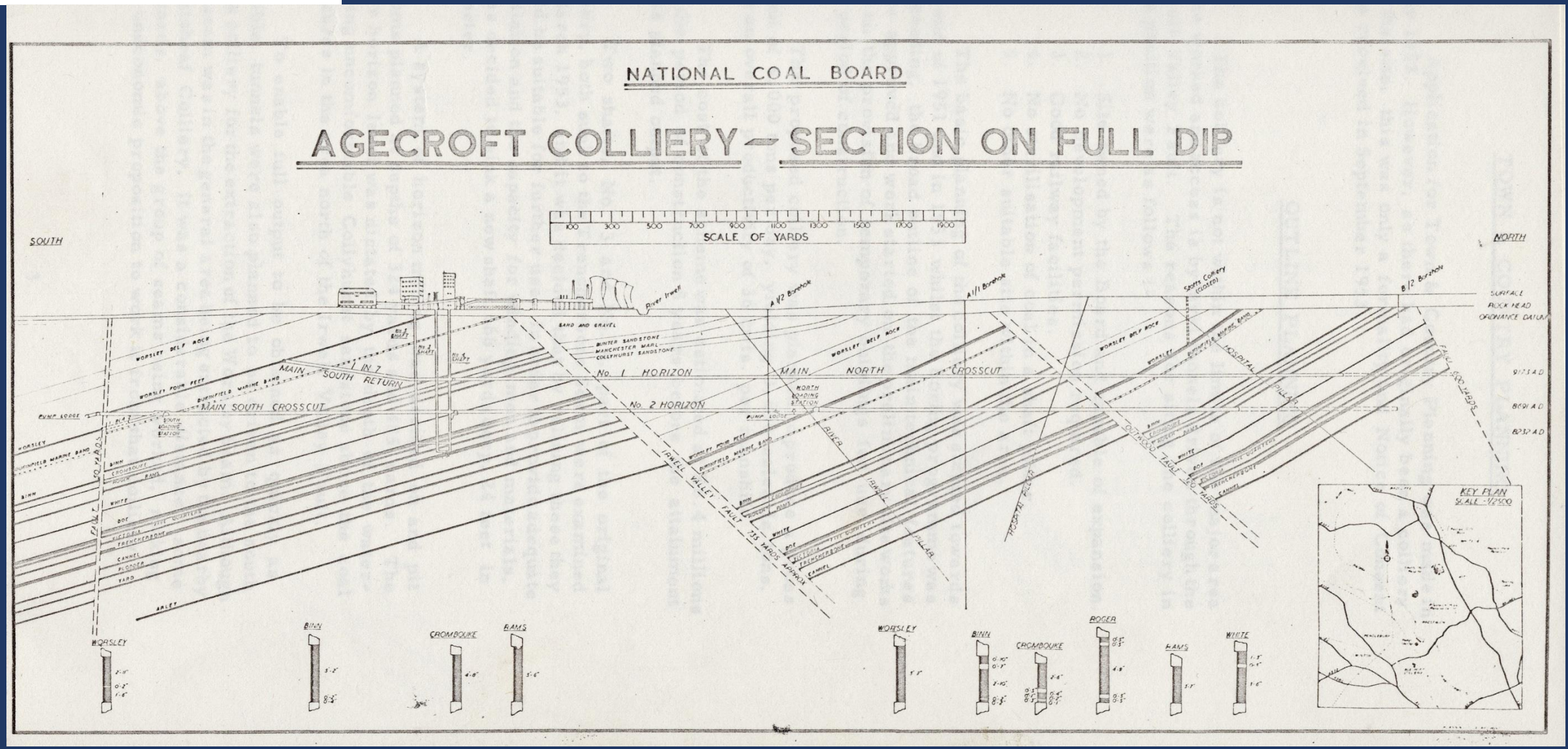
ONLY IN THE WEST DOES IT DECREASE

WHY?

I WILL LEAVE THAT TO YOU!

ABERDEEN DRILLING MANAGEMENT LTD

NATURE IS NOT ALWAYS KIND



ABERDEEN DRILLING MANAGEMENT LTD

ABERDEEN DRILLING MANAGEMENT LTD

ABERDEEN DRILLING MANAGEMENT LTD

MINING COAL

Mining by under ground methods came before opencast mining.

WHY?

ABERDEEN DRILLING MANAGEMENT LTD

MINING COAL

Mining by under ground methods came before opencast mining.

WHY?

Because there were no methods to move large quantities of overburden.

ABERDEEN DRILLING MANAGEMENT LTD

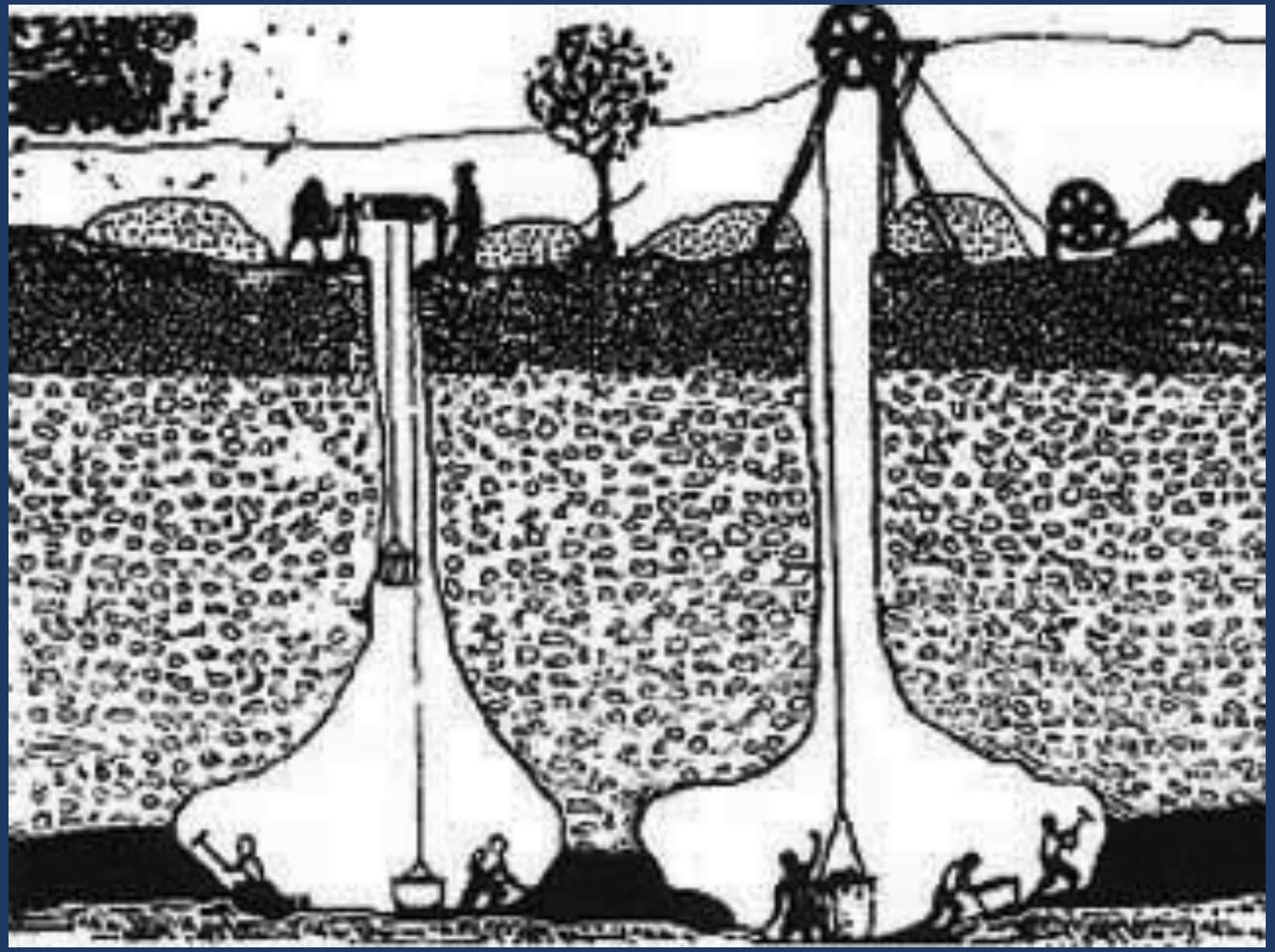
UNDERGROUND COAL MINING

Only three basic methods and the mechanised equivalents!

- Bell Pit – long obsolete possibly artisan miners use in some countries still.
- Room and Pillar – US excels but abandoned in UK as a method except in specialist circumstances.
- Longwall – Developed in UK because of difficulties in deep mines using Room and Pillar

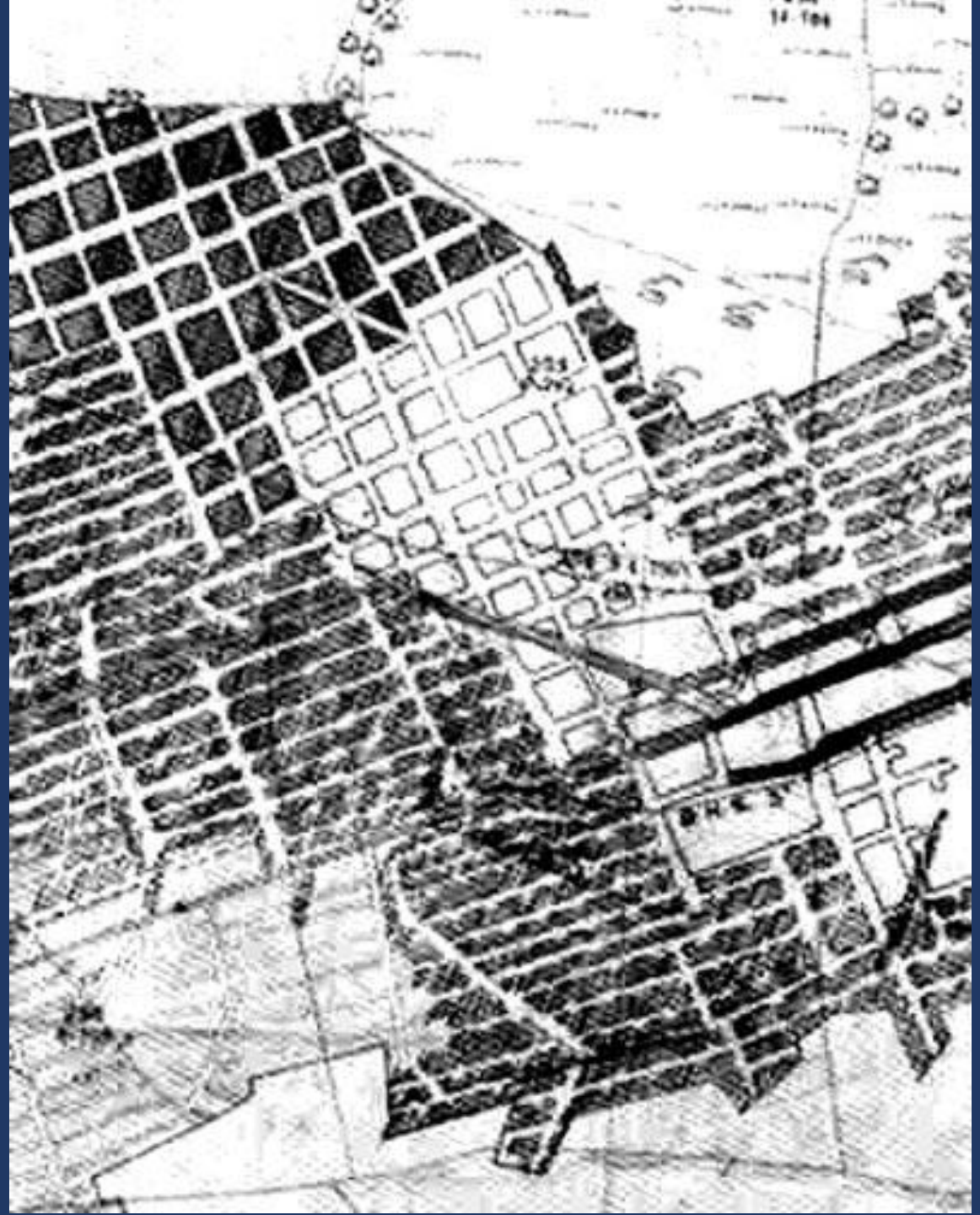
ABERDEEN DRILLING MANAGEMENT LTD

THE BELL PIT



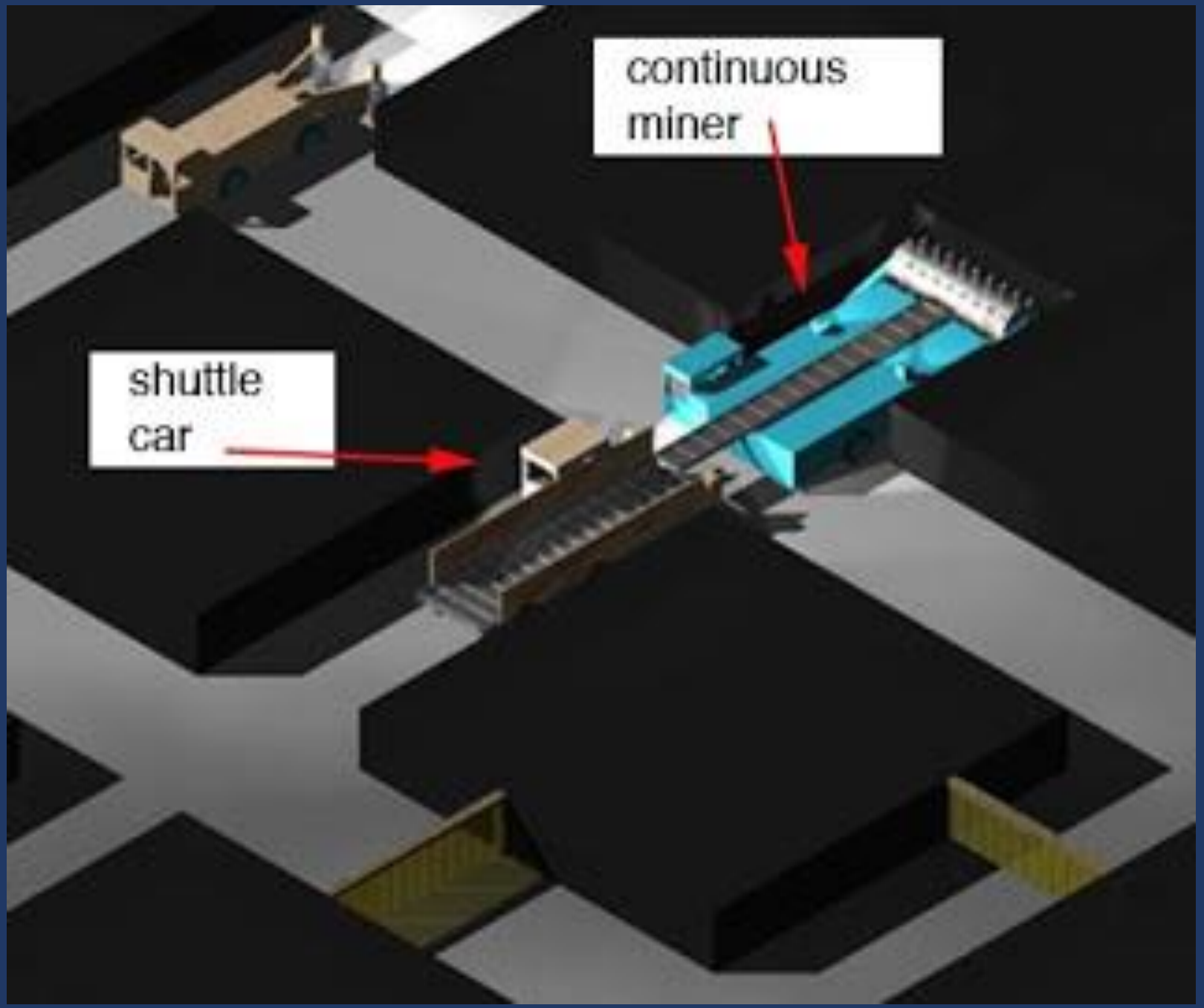
ABERDEEN DRILLING MANAGEMENT LTD

ROOM & PILLAR (PILLAR AND STALL UK) NONMECHANISED



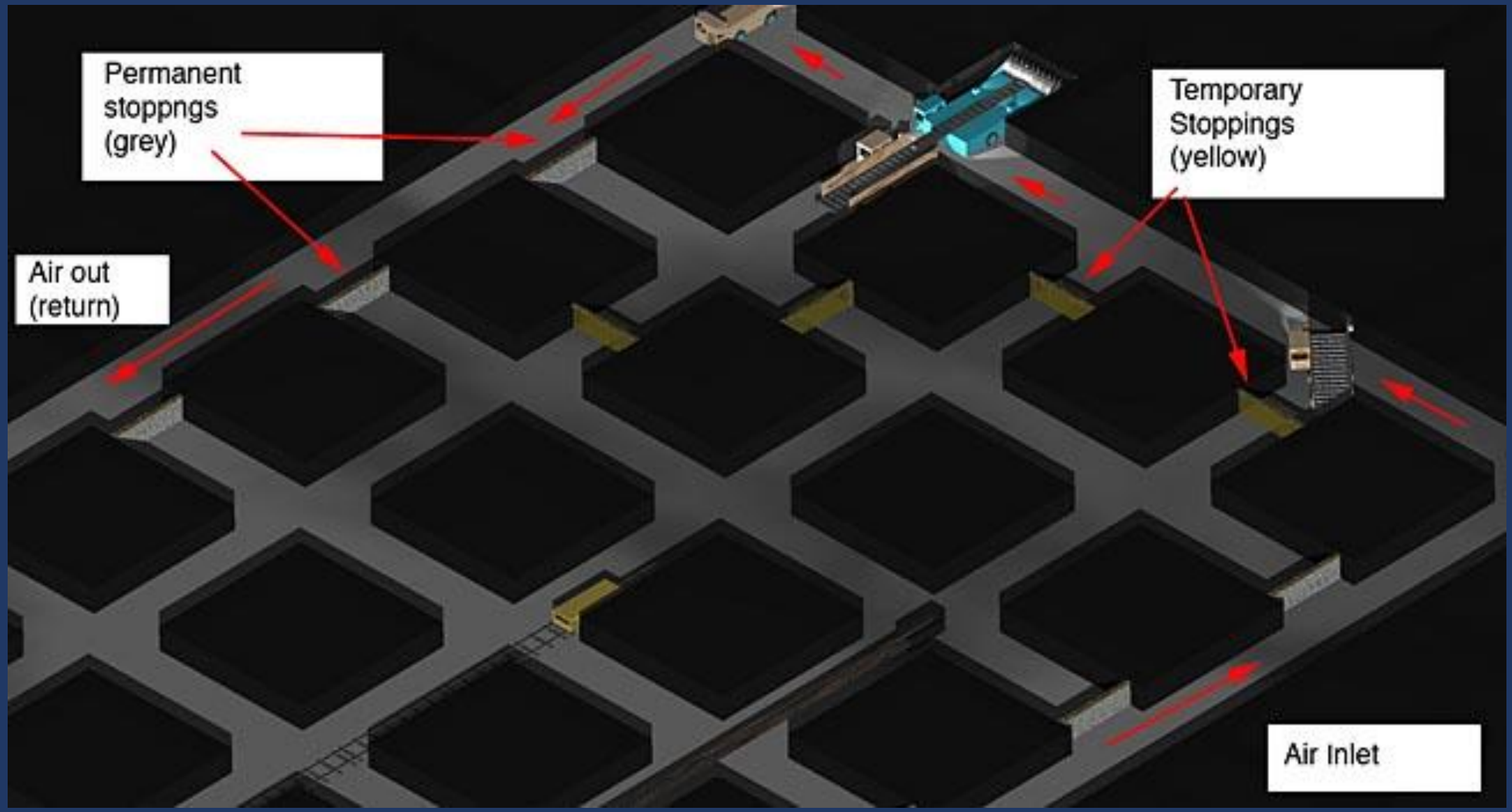
ABERDEEN DRILLING MANAGEMENT LTD

ROOM & PILLAR MECHANISED



ABERDEEN DRILLING MANAGEMENT LTD

ROOM & PILLAR MECHANISED WITH VENTILATION

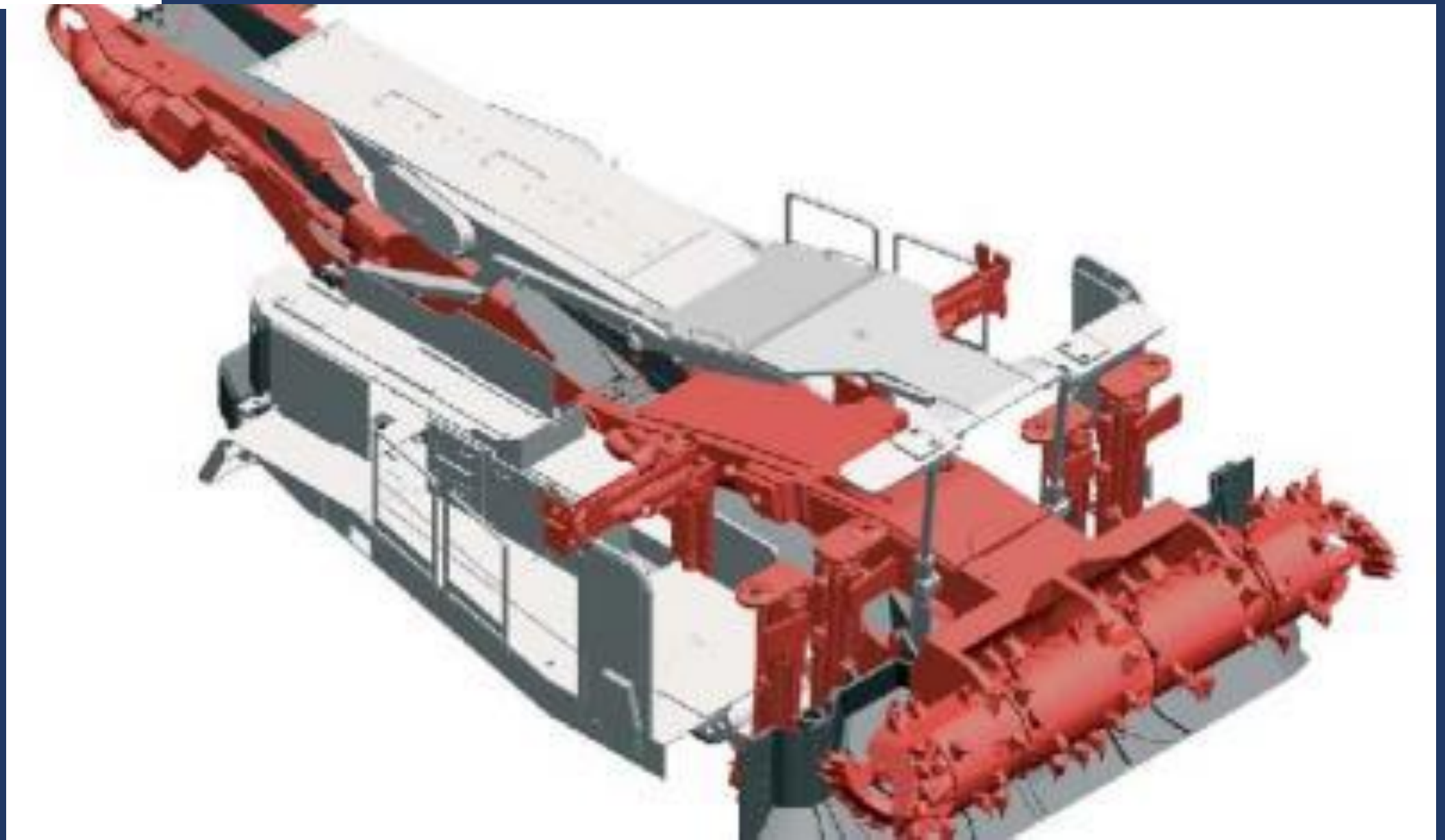


ABERDEEN DRILLING MANAGEMENT LTD

CONTINUOUS MINER

ABERDEEN DRILLING MANAGEMENT LTD

BOLTER MINER



ABERDEEN DRILLING MANAGEMENT LTD

LIMITS ON ROOM AND PILLAR MINING

1. Depth – About 400 m as pillars get bigger and support systems get more onerous
2. Very heavy gas conditions
3. Gradient up to 15°

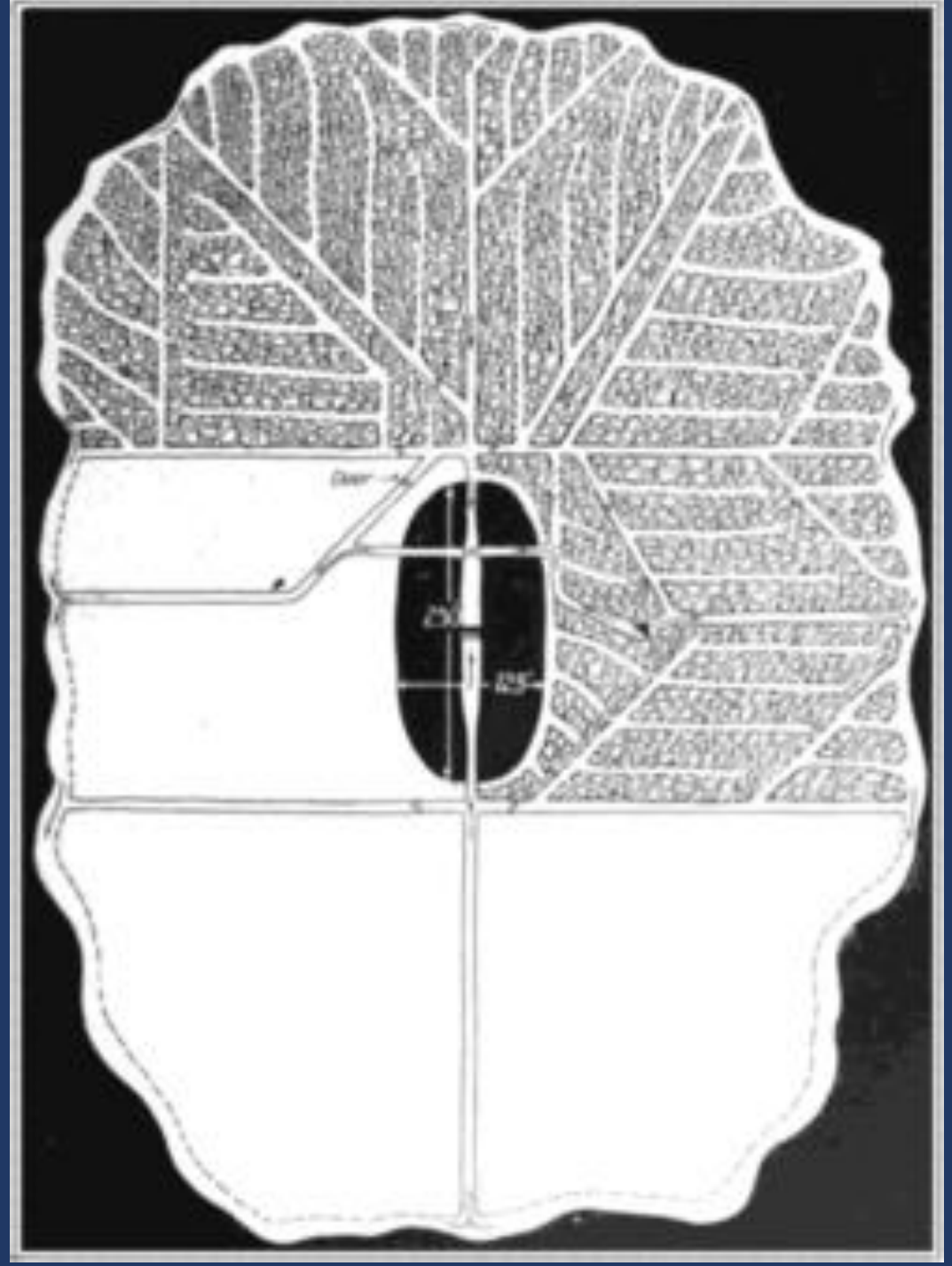
ADVANTAGES

1. Permanent Support on surface unless decide to depillar
2. Cheap to mechanise (relatively)
3. Productivity has fallen in the US as H & S demands have increased

So longwall was adopted in the UK using first non-mechanised and gradually fully mechanised systems

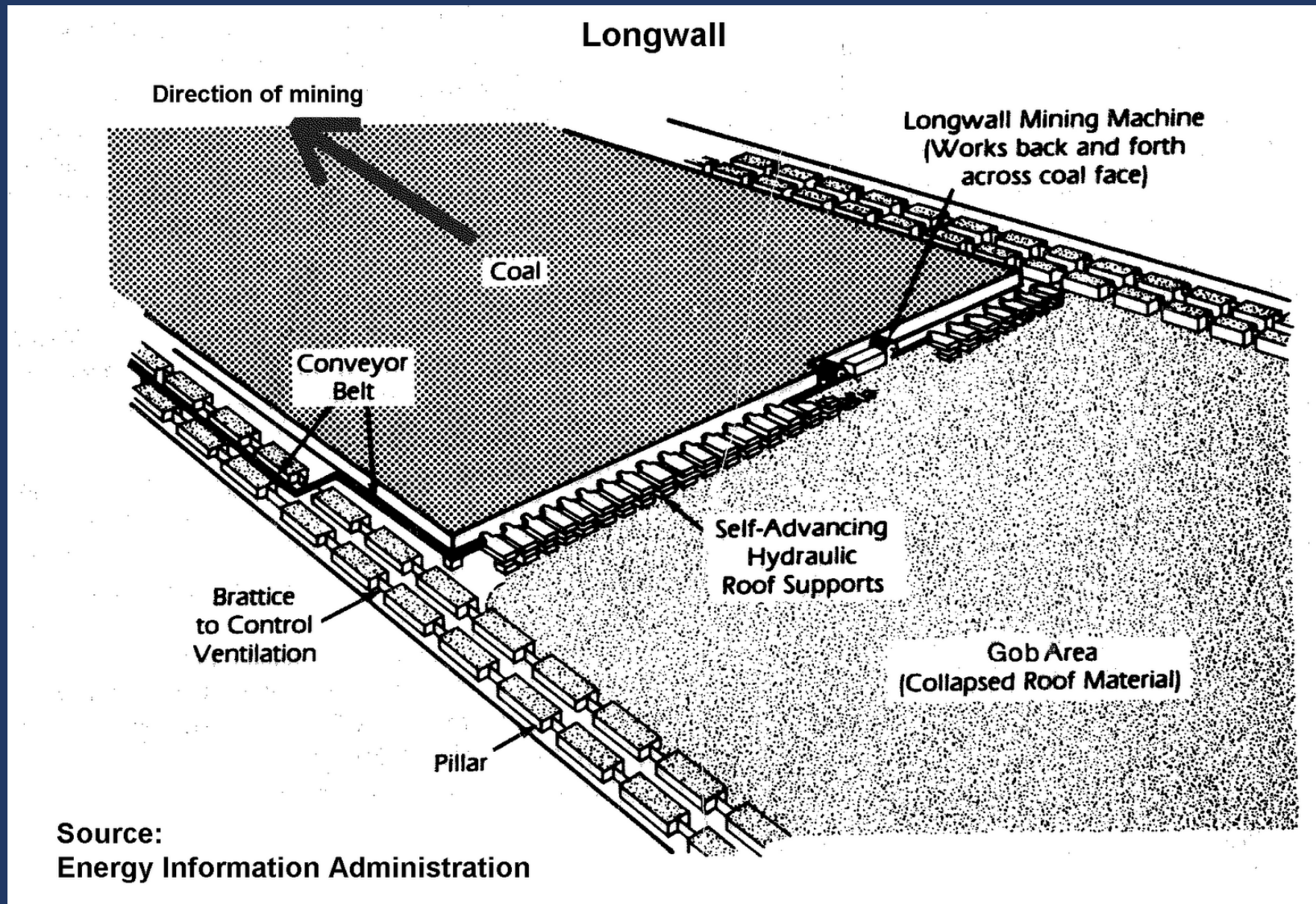
ABERDEEN DRILLING MANAGEMENT LTD

Longwall Mining Pre-mechanisation



ABERDEEN DRILLING MANAGEMENT LTD

LONGWALL MINING MECHANISED



ABERDEEN DRILLING MANAGEMENT LTD

LONGWALL MINING EQUIPMENT

ABERDEEN DRILLING MANAGEMENT LTD

LONGWALL MINING EQUIPMENT - SUPPORT AND CONVEYOR

ABERDEEN DRILLING MANAGEMENT LTD

LONGWALL MINING EQUIPMENT - SHEARER

ABERDEEN DRILLING MANAGEMENT LTD

LONGWALL MINING EQUIPMENT - PLOUGH

ABERDEEN DRILLING MANAGEMENT LTD

LONGWALL MINING EQUIPMENT - PLOUGH

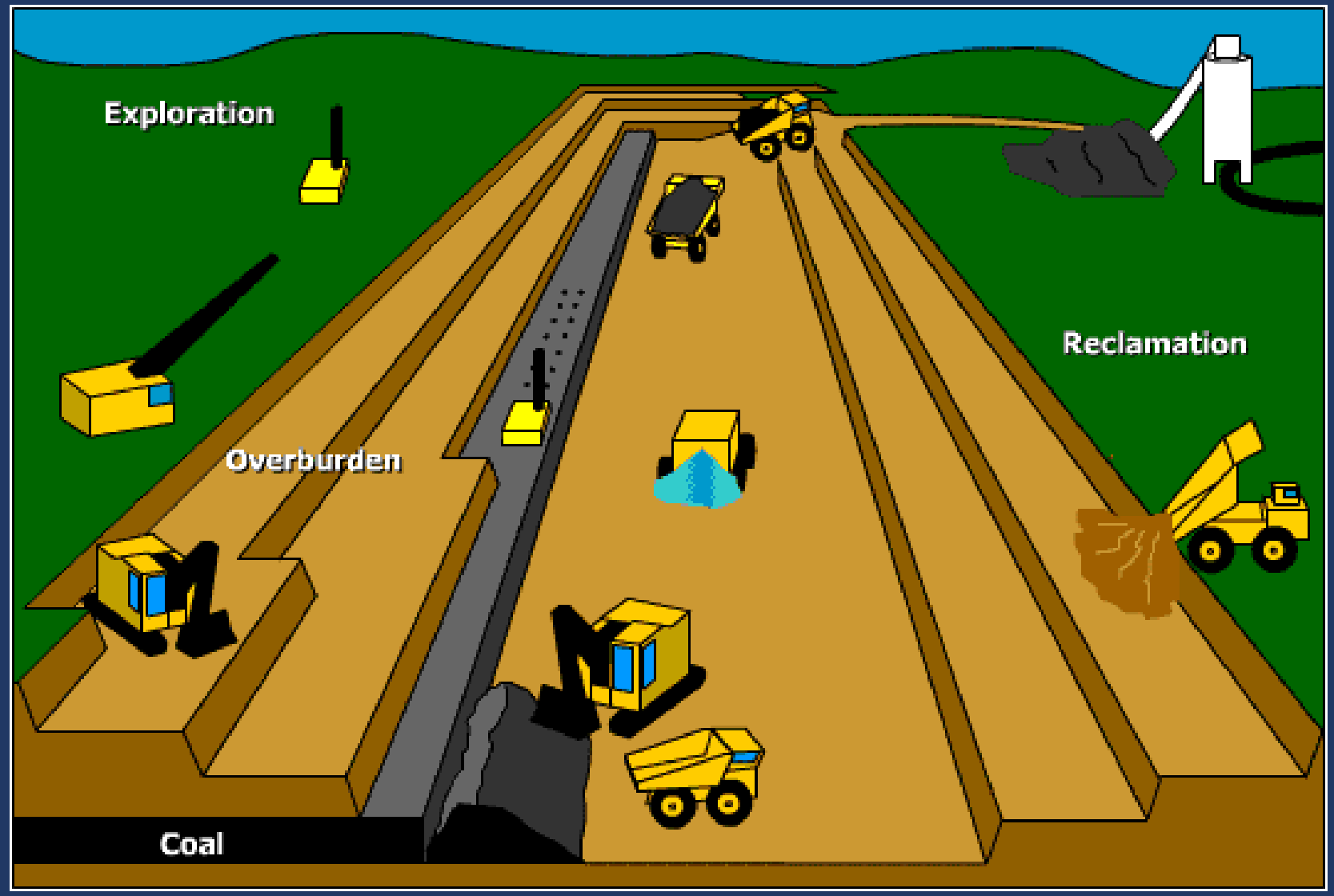
ABERDEEN DRILLING MANAGEMENT LTD

LONGWALL COMMENTS

1. Suitable for gradients up to 45°
2. Face heights up 6 m
3. Face lengths up to 350 m
4. High productivity 7 -8 million tonnes from a single face!
5. Automation
6. Depths down to 1,500 – Face supports only support a small zone
7. Suitable for very gassy mines
8. Very expensive on capital
9. Surface subsidence

ABERDEEN DRILLING MANAGEMENT LTD

Opencast Mining – Strip Mining



ABERDEEN DRILLING MANAGEMENT LTD

Opencast Mining – Dragline

ABERDEEN DRILLING MANAGEMENT LTD

Opencast Mining – Rope Shovel

ABERDEEN DRILLING MANAGEMENT LTD

Opencast Mining – Hydraulic Shovel

ABERDEEN DRILLING MANAGEMENT LTD

Opencast Mining – Comments

- Cheapest mining where it can be done
- Even with restoration it severely disturbs the ground
- Limit on depth – Stripping ratio
- In large operations very capital intensive
- Dust and noise issues
- Can be used to clear up old mining sites

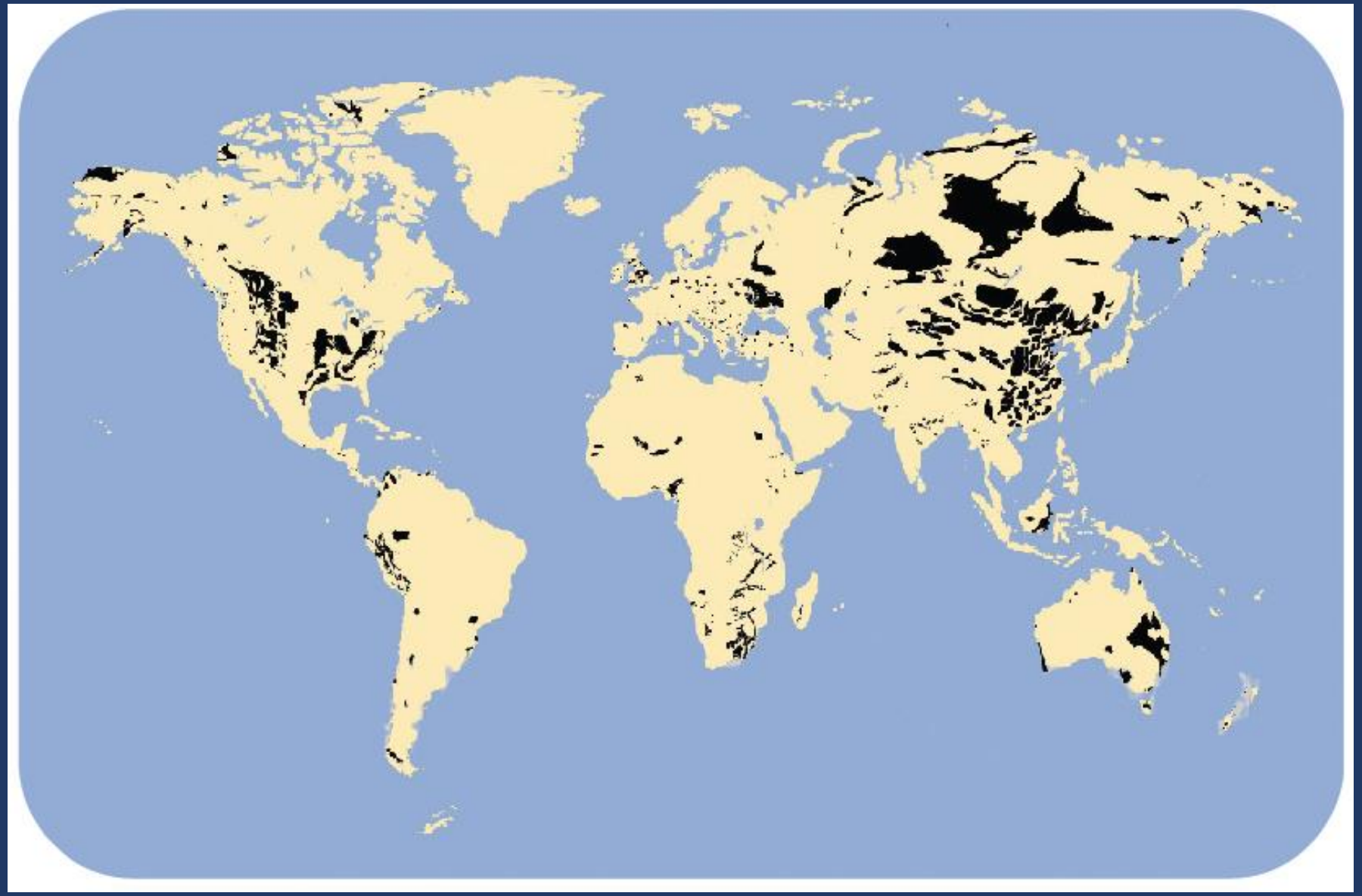
ABERDEEN DRILLING MANAGEMENT LTD

Health and Safety Issues

- Methane is an explosive gas. Use of explosive proof equipment
- Coal dust even more violent in explosion.
- Coal dust and rock dust causes lung desease
- Falls of roof
- Confined space working

ABERDEEN DRILLING MANAGEMENT LTD

WHERE IS COAL FOUND - WORLD



ABERDEEN DRILLING MANAGEMENT LTD

WORLD COAL RESOURCES

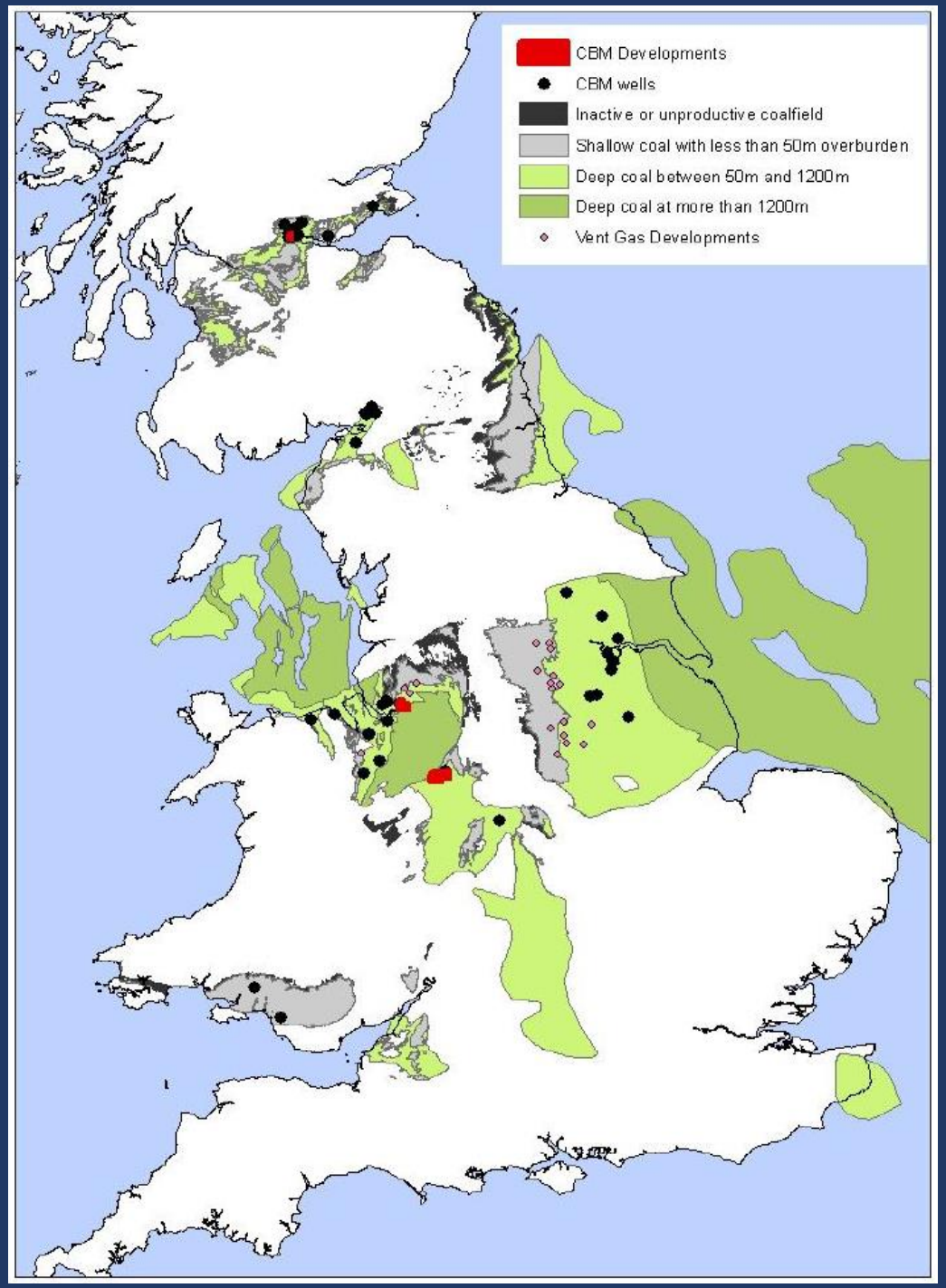
ARE

GREATER THAN ANY OTHER HYDOCARBON

ABERDEEN DRILLING MANAGEMENT LTD

WHERE IS COAL FOUND –UK

Estimate 35 Billion tonnes mined
Claim only 200 million tonnes of resrves



ABERDEEN DRILLING MANAGEMENT LTD

Alternatives to Mining

- Can see that coal has H and S issues
- Not touched on environmental issues
- Coal Bed Methane – Less than 1% of the energy contained in the coal
- Coal Mine Methane and Abandoned Mine Methane
- Underground Coal Gasification current trials but very big environmental issues

Are there any other methods?

ABERDEEN DRILLING MANAGEMENT LTD

SO WHY COAL?
I THINK YOU CAN SEE WHY

IT WILL BE WITH US AS AN ENERGY SOURCE FOR MY LIFE AND YOURS