Contrasting Predrainage for Surface Based MRD with Underground In-Seam

ACARP Seminar

Mackay

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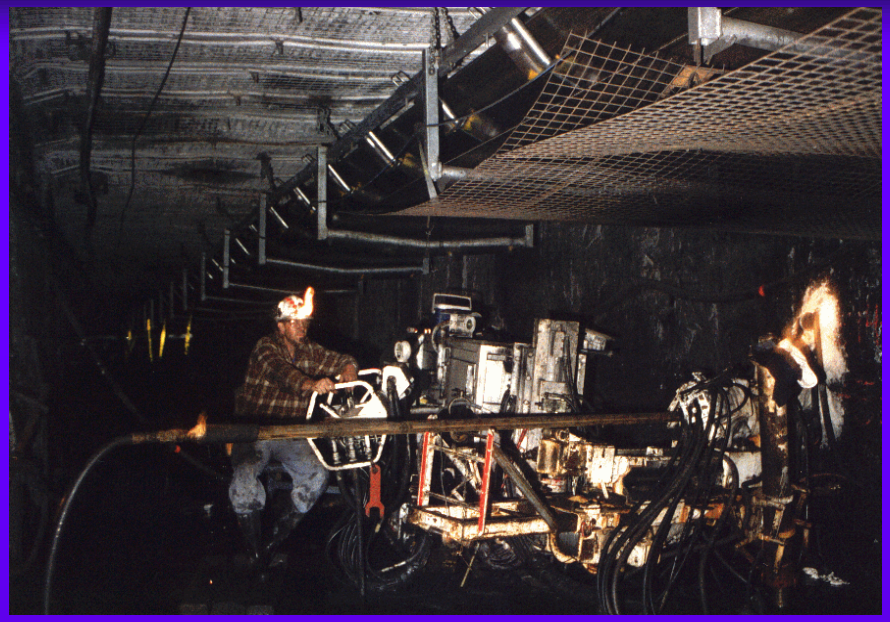
To Cover

- Description of methods
- Who has/is applying them
- Two Essentials
- Equivalent Circulation Density
- What happens during
  - Underground in-seam predrainage
  - Medium radius drilling predrainage
- Comparing the two
- Conclusions

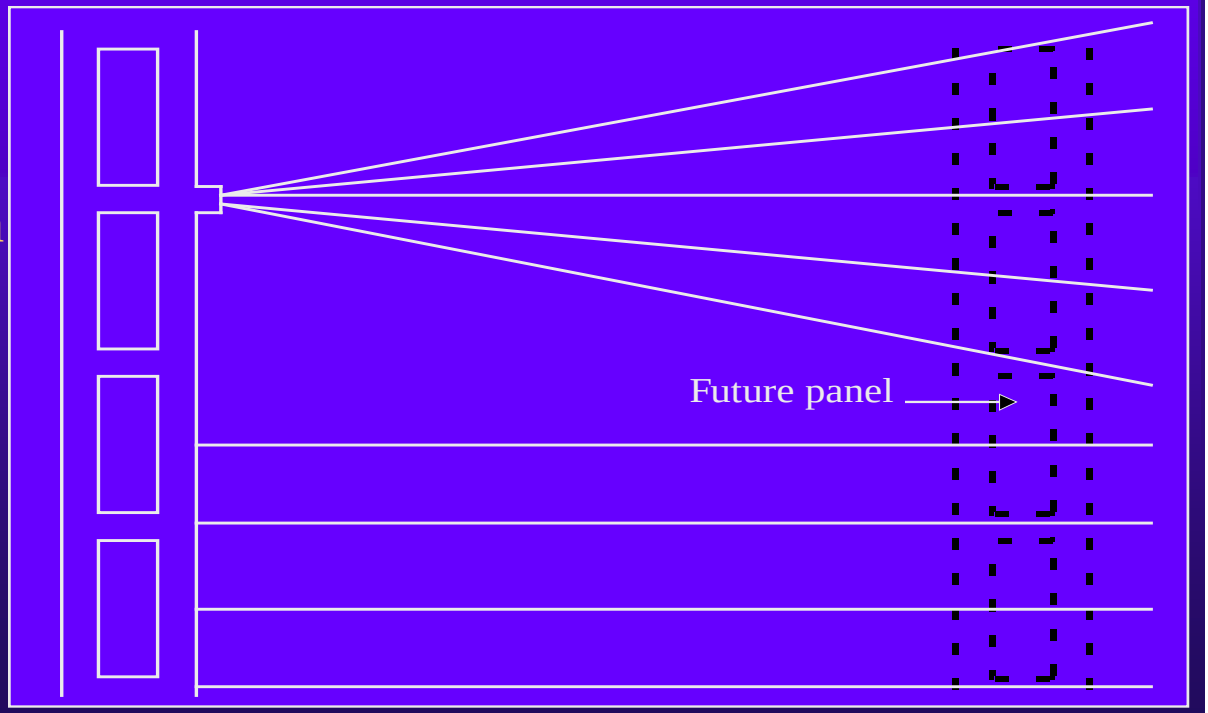
Description of Methods

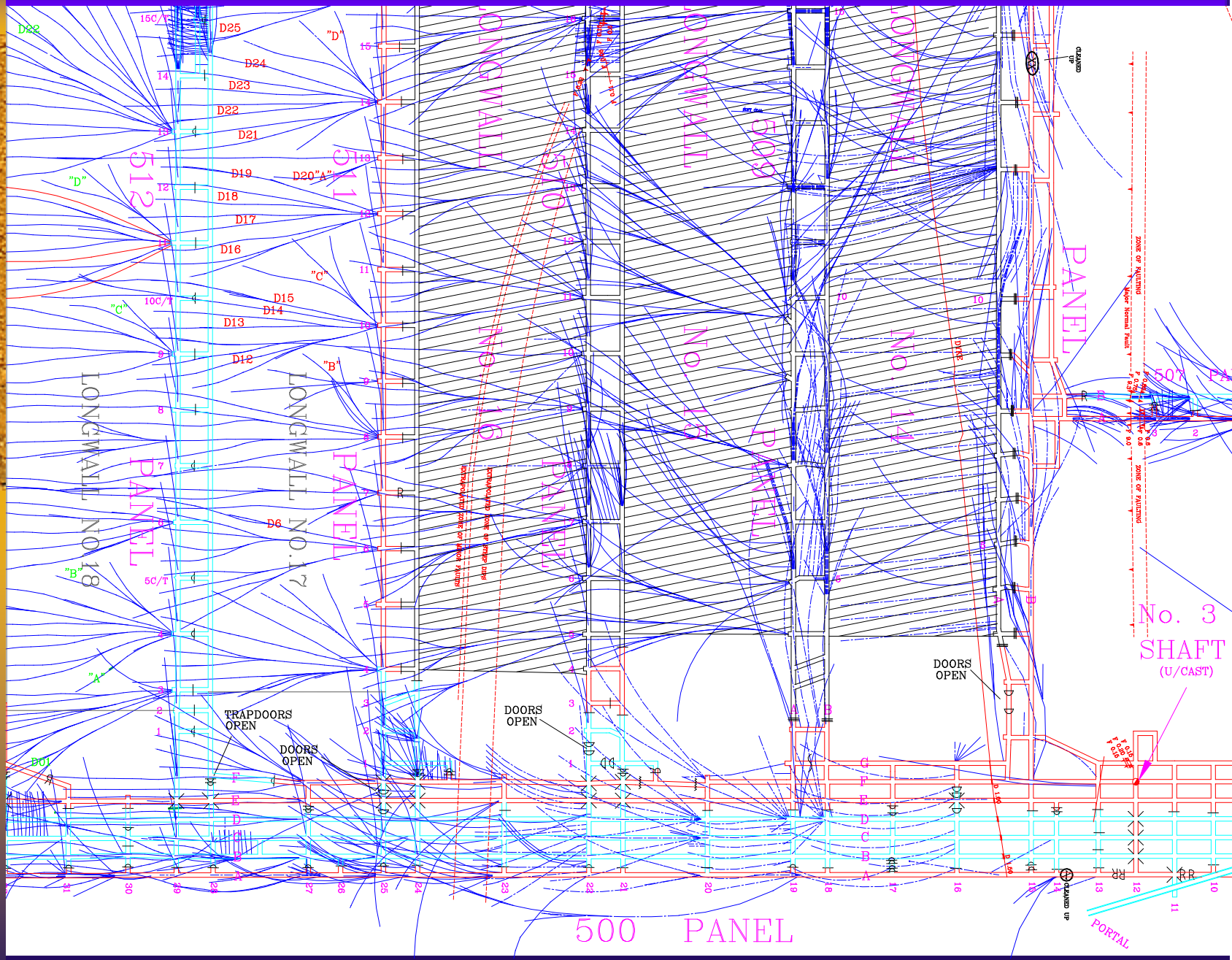
Underground In-Seam Predrainage



Underground, Cross Panel Predrainage

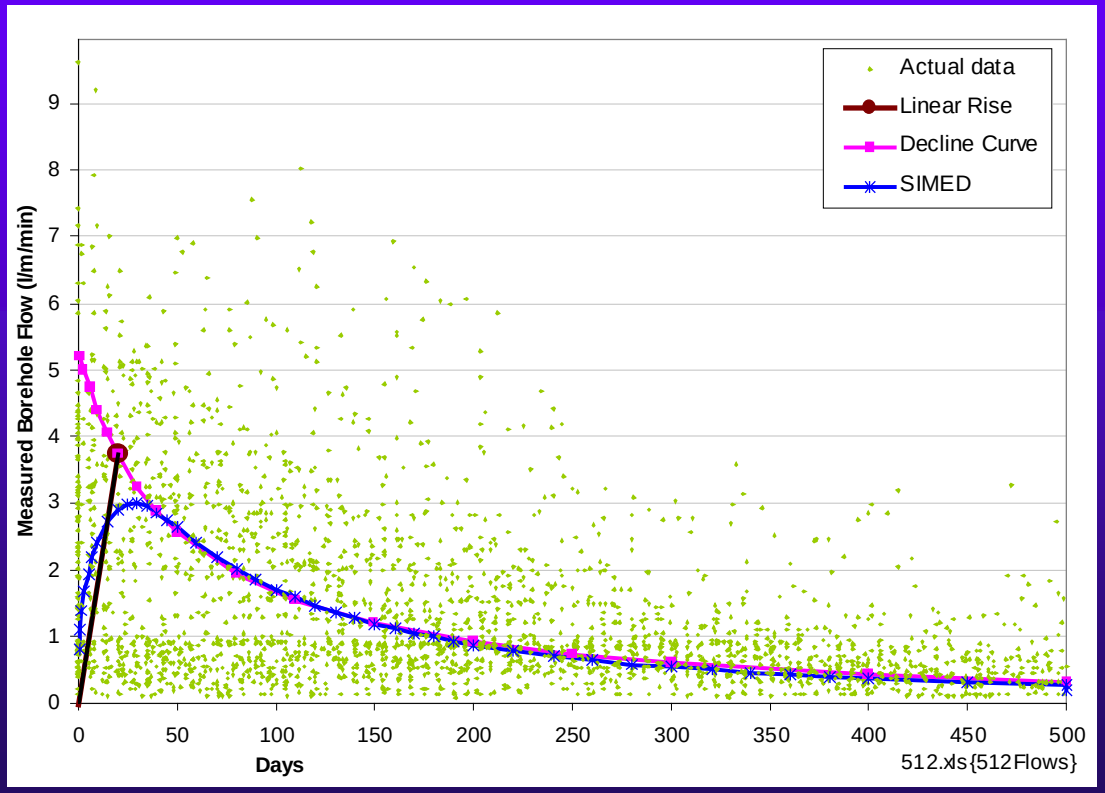
Typically:
Hole lengths to 400 m
Spacing 20-50 m




LONGWALL PANEL NO 18
LONGWALL NO. 17 PANEL
LONGWALL PANEL NO 16
LONGWALL PANEL NO 15
500 PANEL
507 PA
No. 3 SHAFT (U/CAST)
PORTAL
TRAPDOORS OPEN
DOORS OPEN
DOORS OPEN
DOORS OPEN
D22
D25
D24
D23
D22
D21
D19
D20"A"
D18
D17
D16
D15
D14
D13
D12
D6
D01
"A"
"B"
"C"
"D"
5C/T
10C/T
15C/T
CLEARED UP
ZONE OF FRACTURING

General Points

- Data gathered are gas flow, composition and purity (at best). Labour intensive.
- Flows are usually highly variable

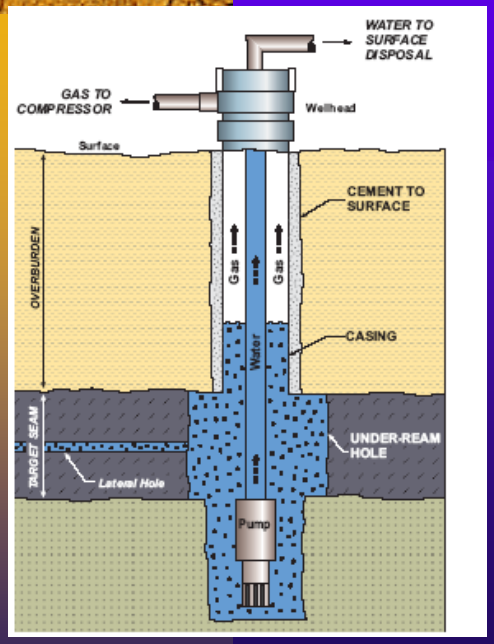


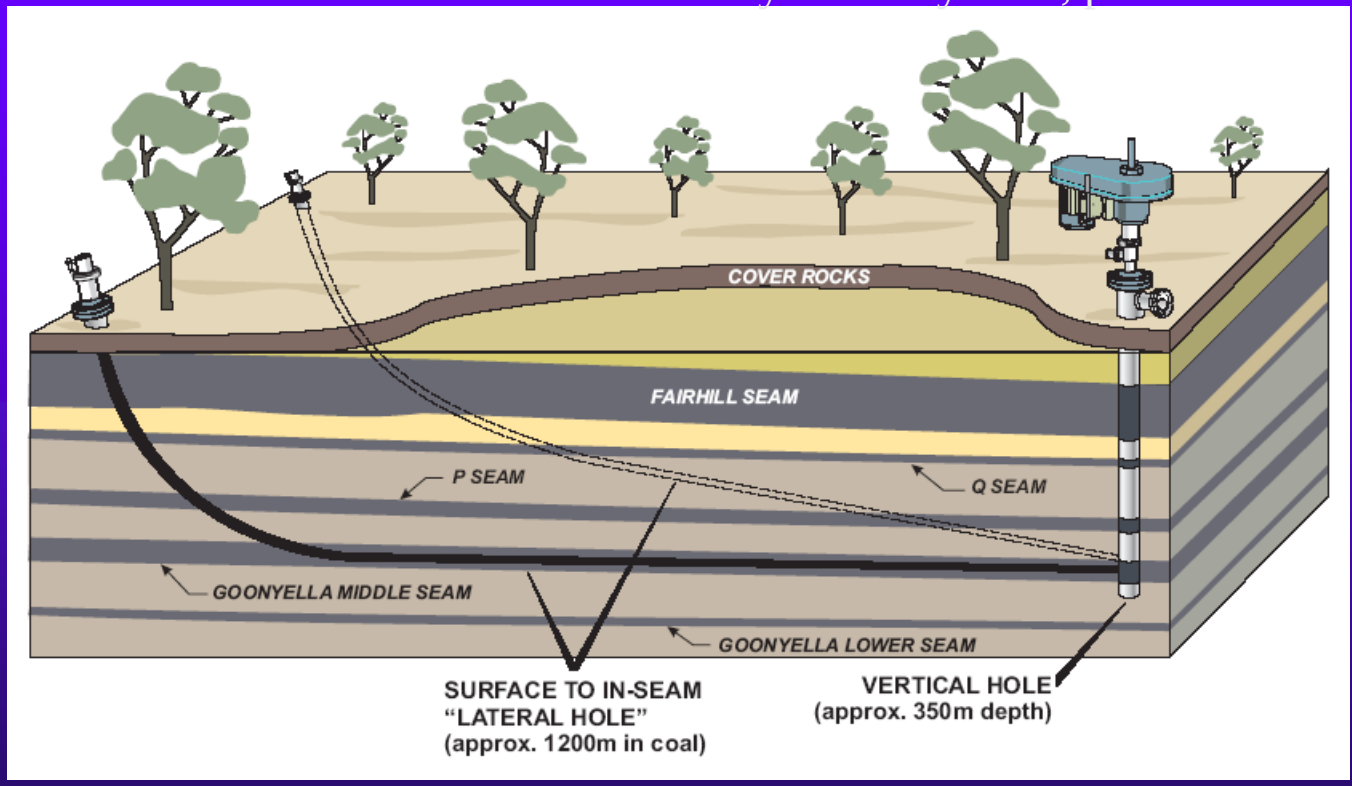
Description of Methods

Medium Radius Drilling Predrainage

Surface to In-Seam, Medium Radius Drilling

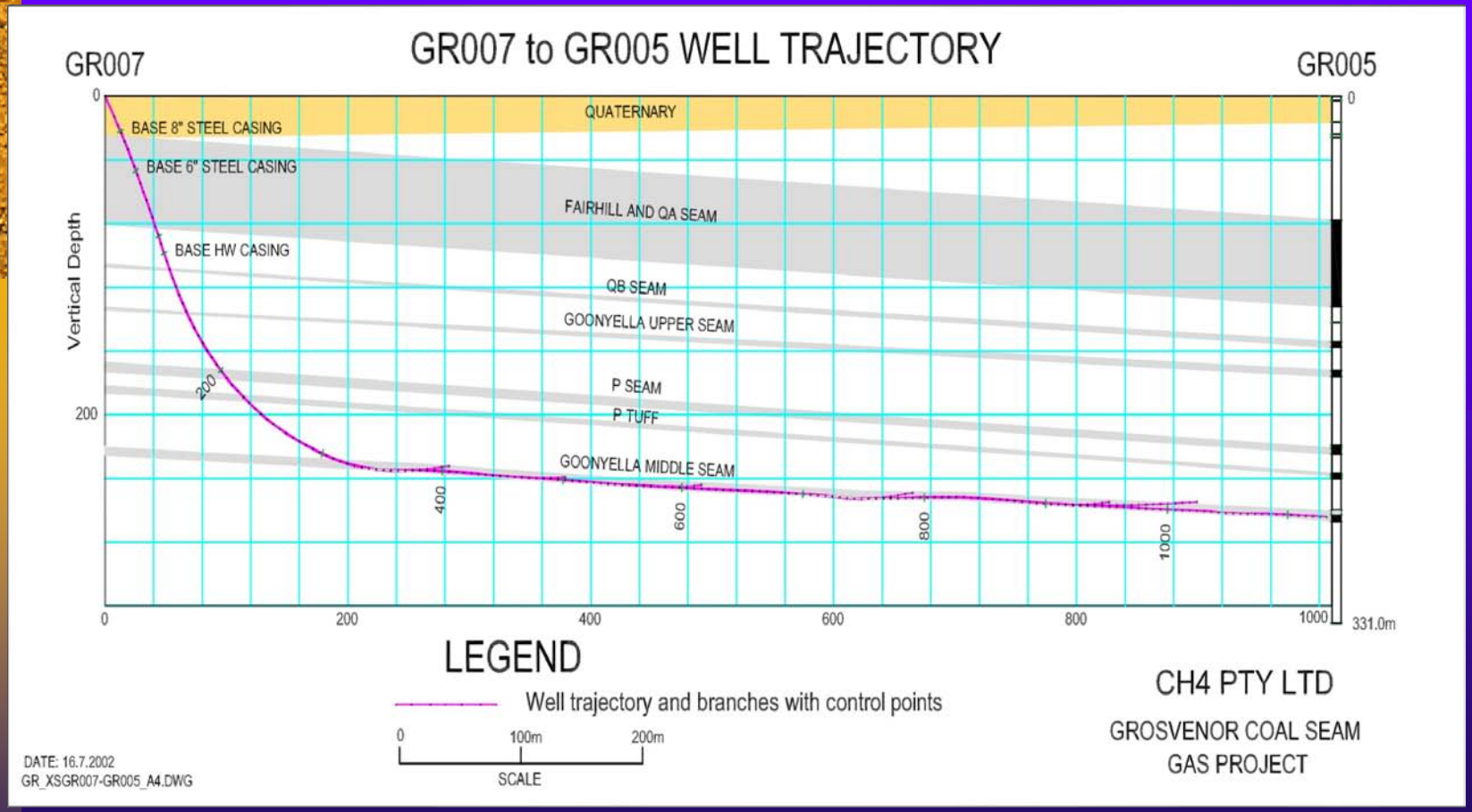
Pictures courtesy CH4 Pty. Ltd., public domain





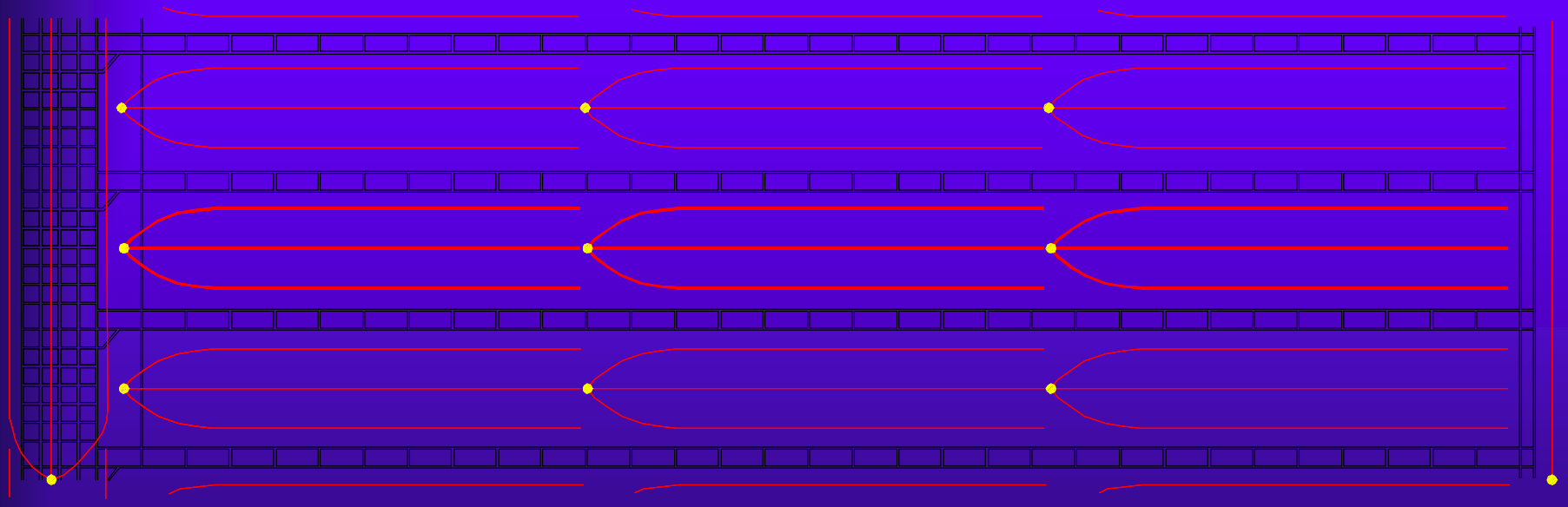
It's current application in coal seams was pioneered by CH_4 Pty. Ltd. and Mitchell Drilling at Moranbah in 2001.

MRD Plot



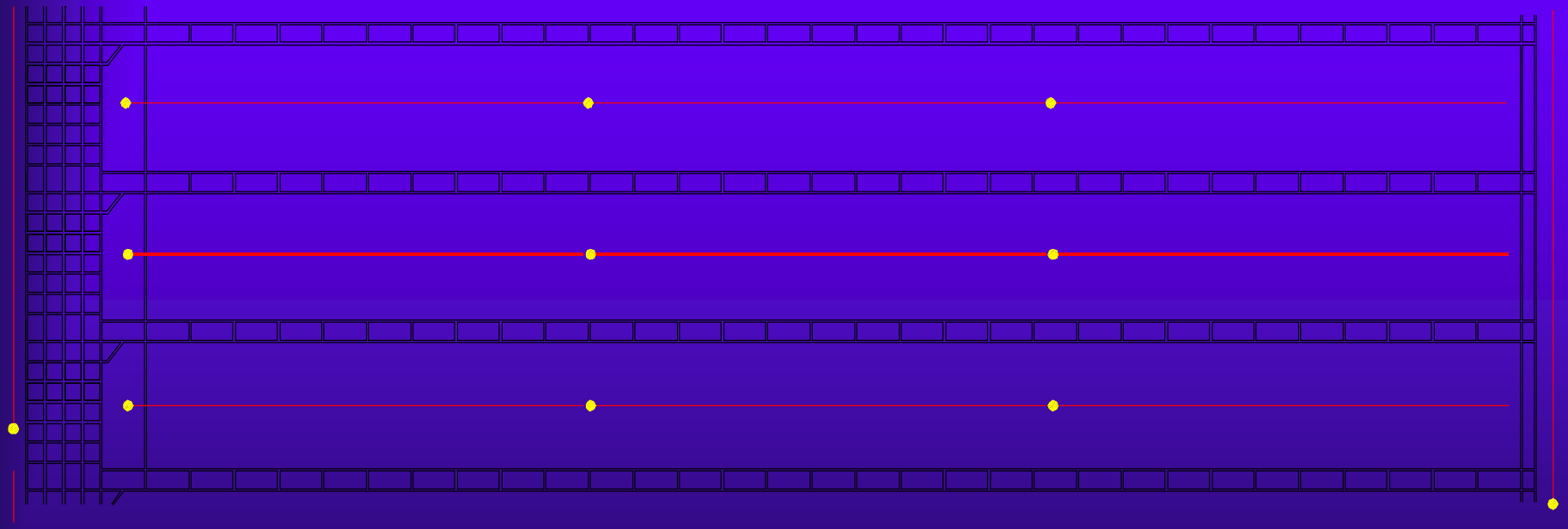
Pictures courtesy CH4 Pty. Ltd., public domain

MRD Examples



Low permeability and/or short lead time

MRD Examples



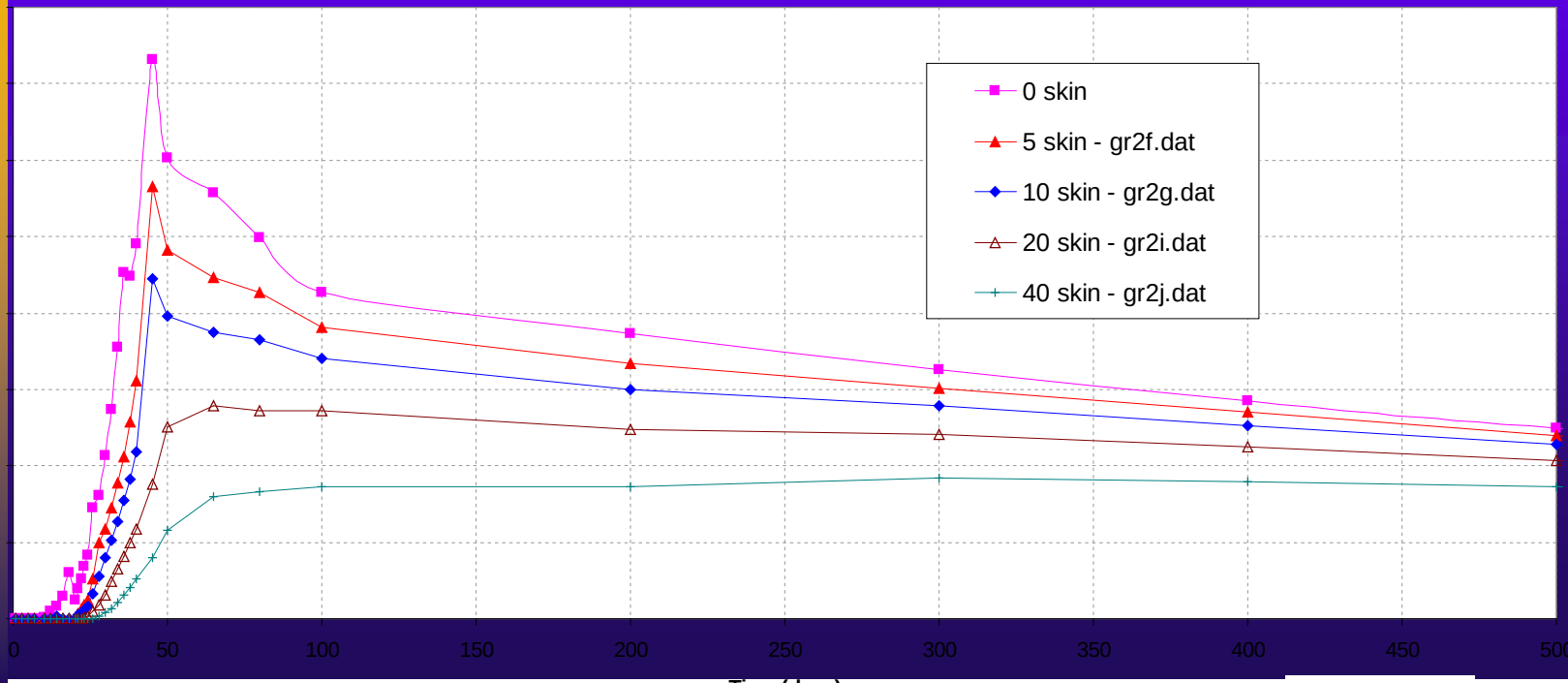
High permeability and/or high lead time

Who Has/Is Applying Them?

- Underground In-Seam
  - Central
  - Southern
  - North Goonyella
  - Oaky North
  - Oaky No.1
  - Moranbah North
  - Grasstree
  - Appin
  - West Cliff
  - Newlands South
- MRD
  - Newlands North
  - Moranbah North
  - Oaky North
  - Oaky No.1
  - Grasstree
  - West Cliff

Two Essentials

- Borehole must be clean and remain open to flow of gas and water. Pressure loss to be a minimum.
- Skin (formation) damage either through drilling or through gas desorption to be minimised.



Equivalent Circulation Density

All following ECD information is courtesy

Dick Dambergs,

Mitchell Drilling Contractors

Courtesy Dick Dambergs

- ECD is an Oilfield term and is generally quoted in lbs/ gallon of mud weight.
- Definition: **The drilling fluid density that would be required to produce the same effective borehole pressure resulting from the combination of fluid density, circulatory pressure and cuttings loading of the drilling fluid in the wellbore**
- For horizontal holes, **bottom or near bottom hole annular pressure is really what we are measuring and interested** in so maybe instead of ECD we should use BAP - Bottom Hole Annular Pressure. This is really what an ECD calculation measures.
- An ECD or BAP calculation is mostly used to keep the bottom hole annular pressure when drilling, below the pressure calculated to cause formation damage or fracture.

Courtesy Dick Dambergs

- It is more important to be careful and aware of ECD's when drilling shallow holes.

  This is because the Formation Breakdown Pressure is naturally lower at shallow depths compared to deeper depths typically experienced in vertical wells.

  We are drilling coal when "INSEAM" so we are therefore dealing with shallow , permeable formations which are very prone to fracturing, destabilizing, and fluid invasion from potentially elevated ECD’s.

Courtesy Dick Dambergs

Drilling parameters that will affect ECD figures are as follows:

1. Annular clearance (difference between the hole size and the drill pipe and the BHA outside diameter size)
2. Annular velocity (pump rate while drilling)
3. Length or depth of hole being drilled.

These three parameters have the most effect on ECD/BAP. Other parameters that also help to increase eventual BAP/ECD are:

4. Mud weight
5. Amount of suspended cuttings in the return drilling fluid
6. Vertical depth of the hole.
7. Viscosity of the drilling fluid.
8. Any other obstructions in annular clearance that causes back pressure or friction in the hole.

Courtesy Dick Dambergs

Depending upon the reservoir and depth conditions:

- ECD can start to cause problems after say 850 m to 900 m (site specific). These are manifested as:
  - Differential sticking of the drill string or BHA
  - Drilling fluid loss into the formation
  - Increased effort required to slide drill (ie without rotation)
  - Less directional steering ability due to slide drilling problems

What happens during:

Underground in-seam drilling and predrainage

Effect on pore pressure from mine workings

Underground in-seam holes:

- Are drilled with low ECD, albeit increasing with depth. The increasing ECD with depth should improve formation stability during drilling. (can ECD become too high in ultra long holes?)
- Are drilled into coal that contains free gas, at least initially.
- Have no control on gas desorption pressure.
- Are drilled into coal whose absolute permeability is reduced due to increased effective stress.

The main issue is:

- Lack of control of gas desorption pressure, resulting in potentially violent gas desorption, destruction of parts of the borehole and increased “skin” due to clogging of migration paths around the well bore by coal fines.

What happens during:

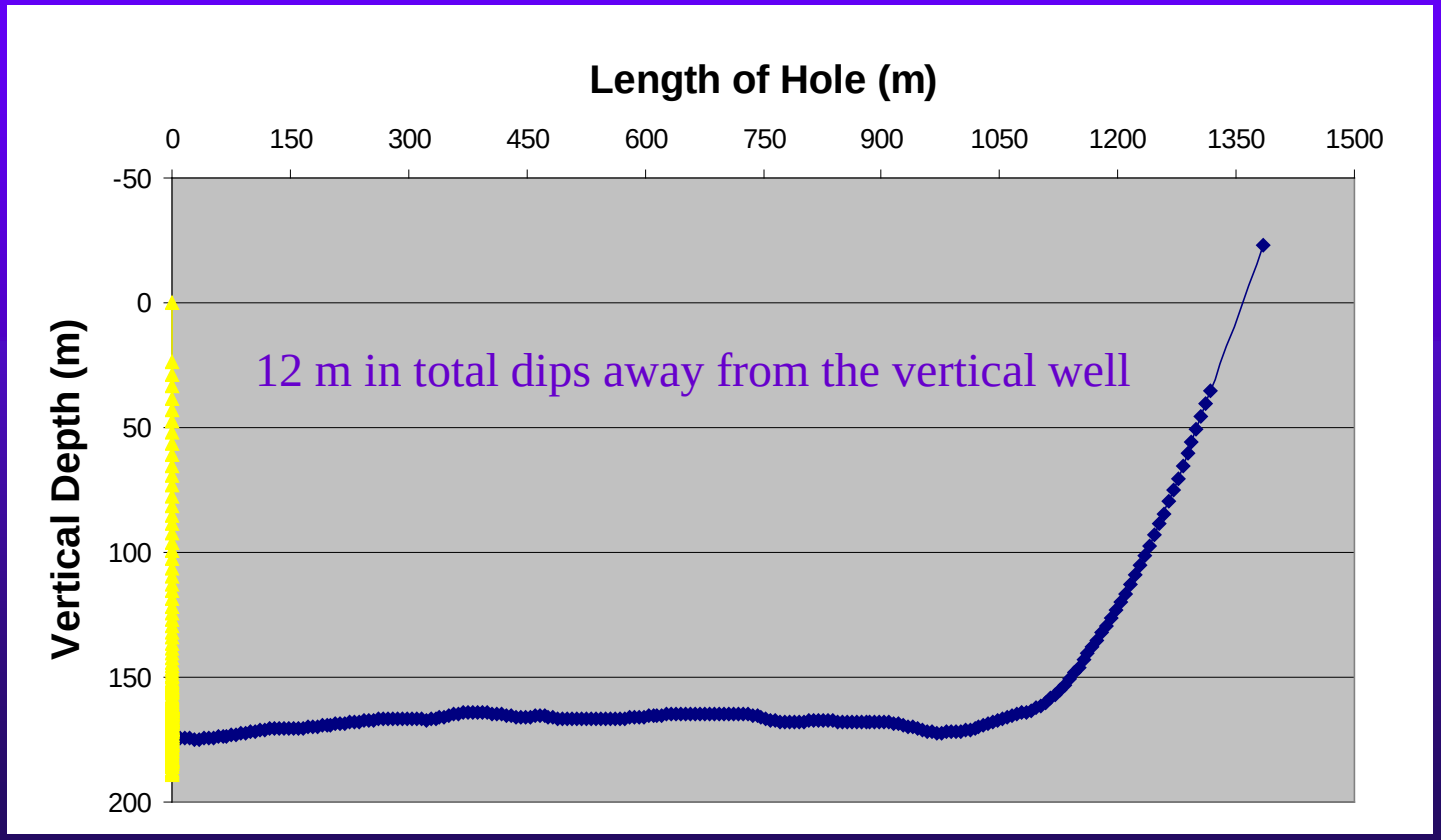
Medium radius drilling and predrainage

During Drilling

- Potential for damage to the formation from high ECD and fluid leak off into the formation.
  This condition is enhanced by:
  - High permeability (eg > 30 mD)
  - Shallow wells (eg < 250 m depth)
  - Long holes (eg > 900 m)
  - Other factors as indicated previously
- Problems become exacerbated when muds need to be applied.
- In-hole problems extend drilling times.
- Resulting well bore damage is a combination of ECD and time. Quantity of fluid lost to the formation is higher with resultant damage.

During Drilling (cont)

- In-seam section should dip continuously to the vertical well.
- Orient well parallel to gateroads or ensure gradient to vertical well?



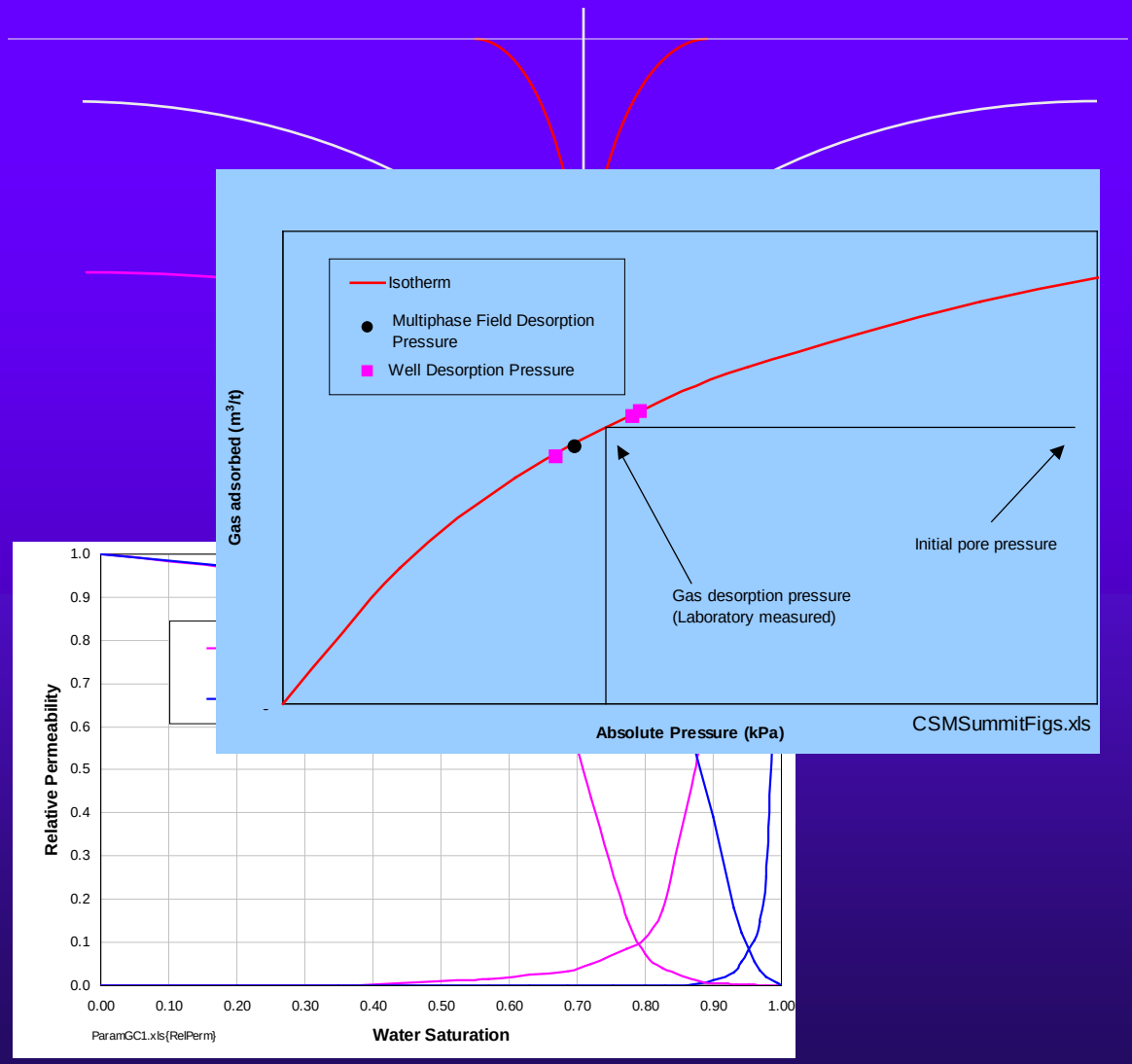
Completion

- Installation of slotted liner
- Flushing laterals and vertical well

A Few Draw Down Principles

- Avoid too rapid reduction in pore pressure prior to gas desorption → limited area of gas desorption near well bore → restriction of further water movement caused by lowering of water relative permeability.
- Gas desorption rate needs to be controlled to minimise damage to the formation (increased “skin”) caused by coal fines movement reducing permeability around the well bore.
- Slow reduction in pore pressure maintains higher absolute permeability near the well bore due to lower effective stress.

Dewatering Ahead of Gas Desorption

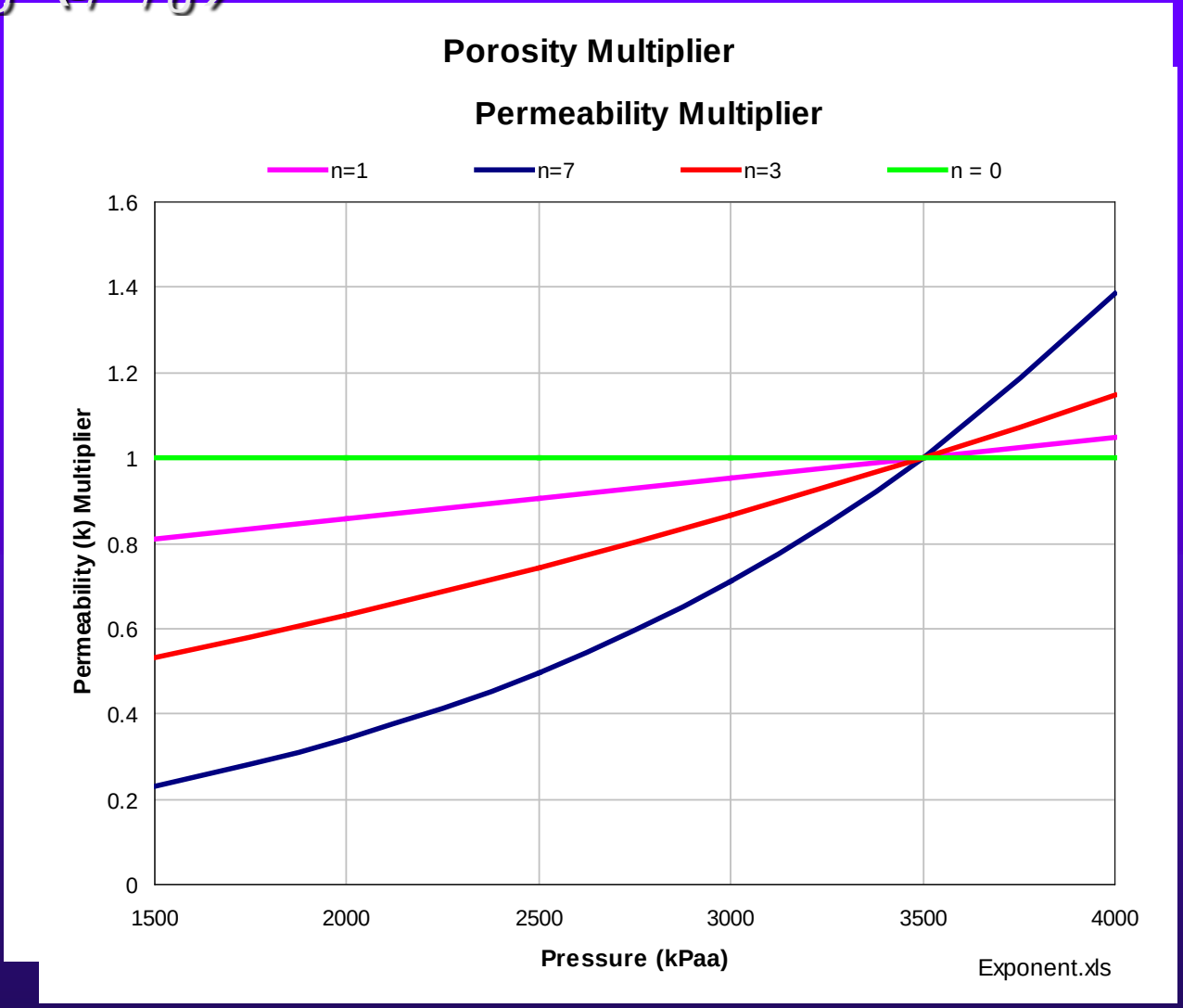


Porosity Compressibility Relationship

Permeability Porosity Relationship

$k/k_o = (\phi/\phi_o)^n$

$\phi = \phi_o(1+c(P-Po))$

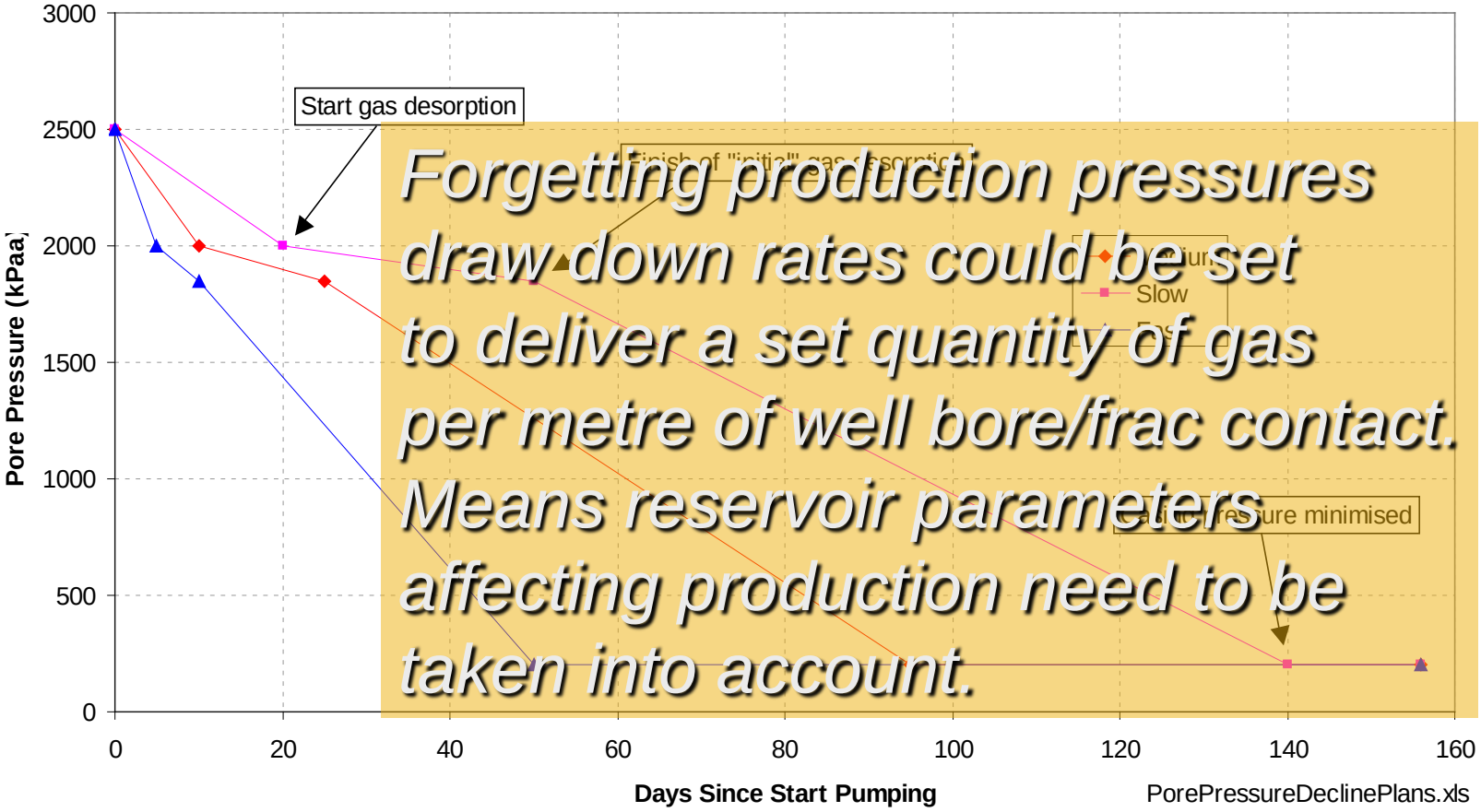


Double whammy?

Too rapid reduction in pore pressure can (theoretically) result in the reduced absolute permeability near the well bore and reduced gas relative permeability away from the well bore.

A Few Options

What's best?



Forgetting production pressures draw down rates could be set to deliver a set quantity of gas per metre of well bore/frac contact. Means reservoir parameters affecting production need to be taken into account.

Comparing the two…

Advantages

- Underground In-Seam
  - Proven effective
  - Built in redundancy
  - Services set up for supplementary drilling of tight zones
  - No surface environmental issues
  - PAYG
- Surface MRD
  - Segregation of gas drainage from mine operations
  - Potentially lower cost $/m^3 drained
  - Improved hole stability during drilling & drainage
  - Better control of well bore damage (skin).
  - Bonus exploration information
  - High purity gas for utilisation (pipe line spec)
  - Ease of monitoring and system maintenance - automation

Disadvantages

- Underground In-Seam
  - Poor efficiency with no control over pressure draw-down and drilling at gas desorption pressure
  - Interaction with mining
  - Greater chance of leaving steel in the ground
  - Difficult to monitor adequately and high maintenance
- Surface MRD
  - Up front capital
  - Surface environmental issues
  - New technology, still being understood and proven
  - Placing more eggs in one basket – limited redundancy, wells must work
  - Potential for mining into pressurised well

Conclusions

- MRD is an exciting new development for predrainage. May also have application in post drainage.
- Don’t get too excited about ultra long holes without sorting out ECD issues.
- It’s successful implementation in coal mining is likely to suffer from lack of resourcing and understanding (everyone is learning), especially DIY.
- Suggest MRD activities from drilling to drainage are best left to contractors who have the experience and are dedicated to the task.