Tutorial on Underground Coal Gasification (UCG)

Supported by the Australian Government through the Asia Pacific Partnership (AP6) Coal Mining Task Force

12th December 2006
Kolkata, India

Outline of today's activities

9:00 Session 1:
- Introductions
- Fundamentals & UCG design

10:45 Morning tea

11:00 Inauguration of Workshop by Shri Shibu Soren, Hon'ble Minister of Coal, India & Keynote address by :Shri H.C. Gupta, Secretary (Coal)

11:20 Session 2:
- Behaviour prediction
- Process performance & economic viability

1:00 Lunch

2:00 Session 3:
- Groundwater & surface impacts
- Site selection & characterisation
- Social perceptions

3:30 Afternoon tea

3:45 Session 4:
- Case study
- Discussion

5:00 Finish

Session 1A: Introduction

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Introduction – Dr Andrew Beath

Dr Andrew Beath is a chemical engineer with a varied range of experience in industry and research. Over the last 7 years he has developed models to predict the growth of UCG cavities and the product gas properties, as well as simulation of processes which could utilise the product gas.

Introduction – Dr Cliff Mallett

Dr Cliff Mallett is a geologist with a long and varied career in research. Until recently he was Deputy Chief of CSIRO Exploration and Mining, where he initiated the research programme into underground coal gasification. He is now Executive General Manager of Carbon Energy, a company launched to commercialise the outcomes of CSIRO's UCG research.

Research background

The CSIRO UCG research programme commenced in 1998. The major outcome has been a series of models and methodologies for:

- Site characterisation
- Cavity growth and gas production
- Geotechnical behaviour
- Hydrogeological flows
- Overall process performance

The rights to commercial use of these are now owned by Carbon Energy.

Session 1B: Fundamentals

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Fundamentals of Coal Gasification

❖INPUTS

- Coal
- Oxygen/Air
- Water

❖OUTPUTS

- Synthesis/Fuel gas H_2,CH_4,CO,CO_2
- Char, Tar & Water
- Heat

Characteristics of UCG

❖Underground coal gasification is like other coal gasification techniques, except that the geological strata form the reaction vessel.

❖This adds a level of complexity to analysis of the behaviour of the process and leads to extra uncertainty due the geological environment.

A simple guide to UCG

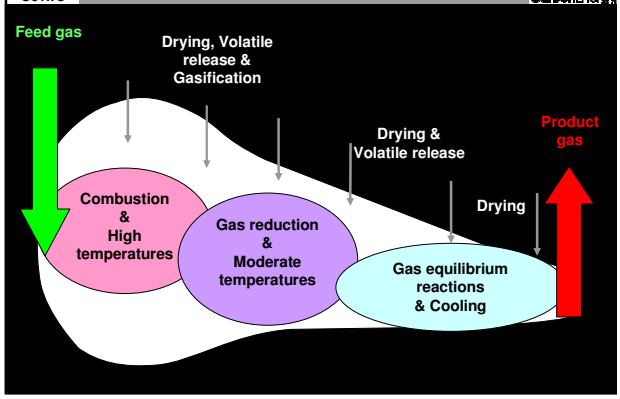
UCG can be condensed to two areas of analysis that are indicated on the next two slides:

❖Reaction processes

❖Physical site changes

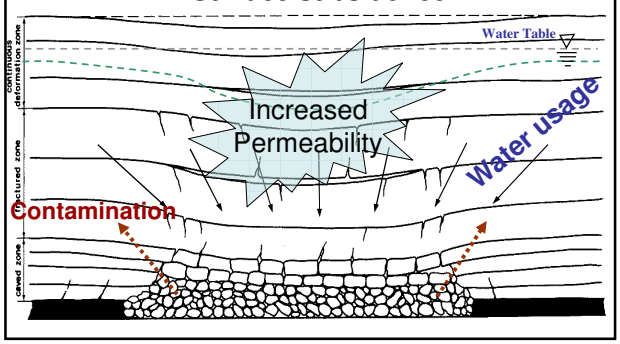
Each can be considered separately, but it is interaction of these that makes UCG analysis complex.

Reaction Processes

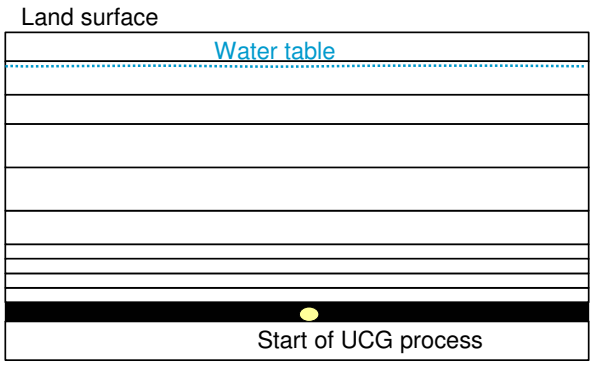


Physical Site Changes

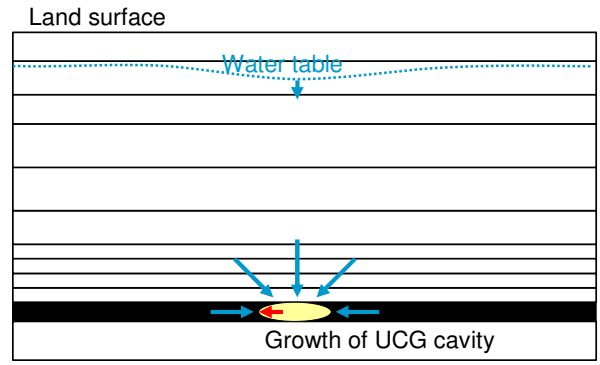
Surface subsidence



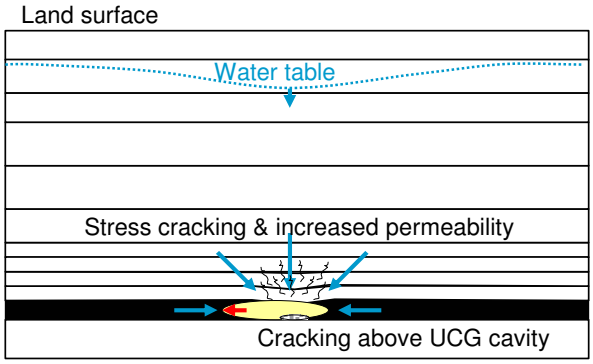
UCG Process - Start



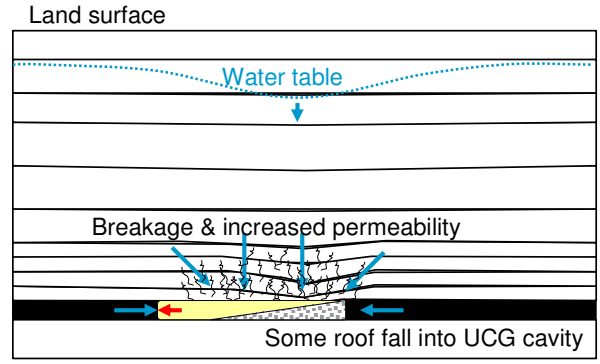
UCG Process - Growth



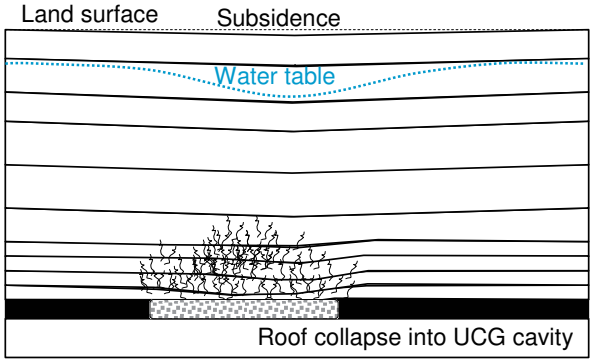
UCG Process - Cracking



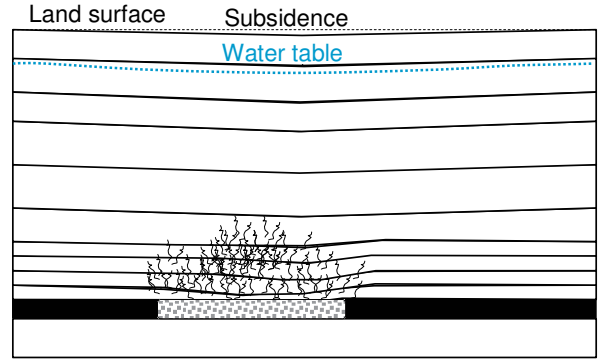
UCG Process - Breakage



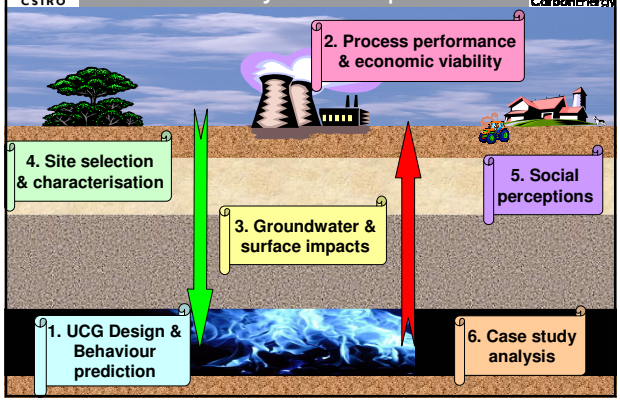
UCG Process – Closure/Collapse



UCG Process - Recovery



Outline of key UCG topics



Session 1C: UCG Design

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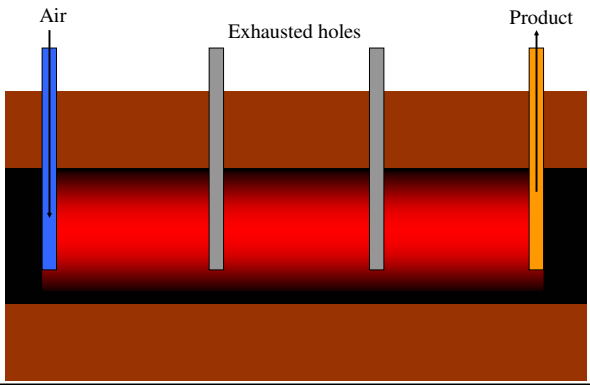
What affects UCG design?

- Coal seam dip (slope)
- Coal seam depth
- Coal permeability
- Overburden properties
- Drilling capabilities
- Required production volume
- Restrictions on subsidence and groundwater consumption
- Process stability requirements

Historical UCG designs

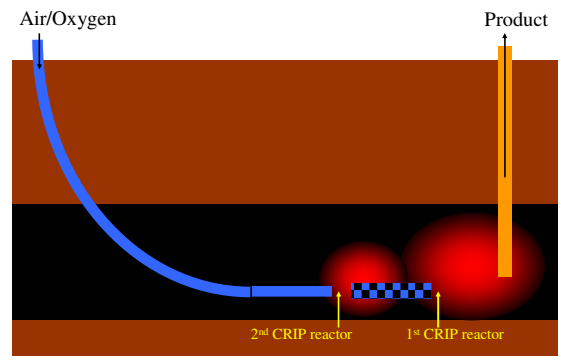
- Vertical Wells
- CRIP (Controlled Retracting Injection Point)
- SDB (Steeply Dipping Bed)
- Knife edge CRIP
- Tunnel

Vertical wells

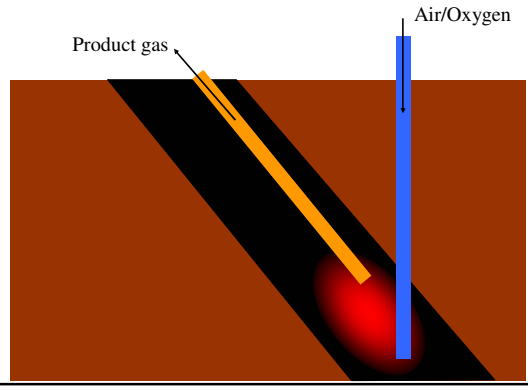


CRIP

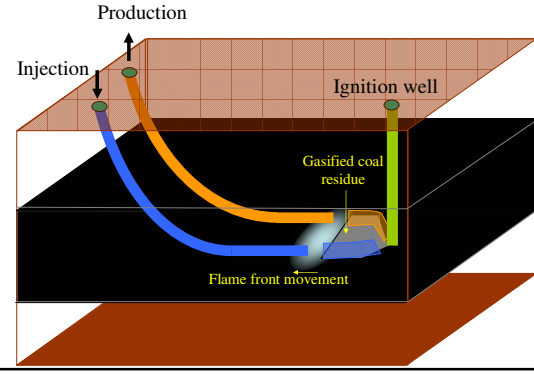
(Controlled Retracting Injection Point)



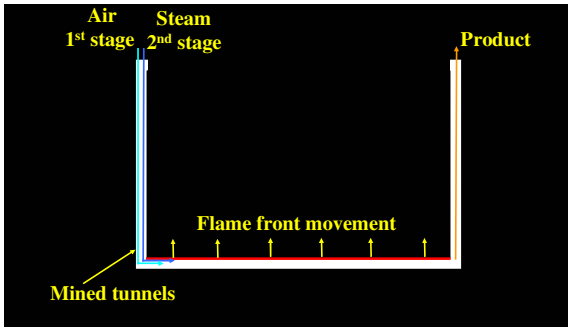
SDB (Steeply Dipping Bed)



Knife edge CRIP



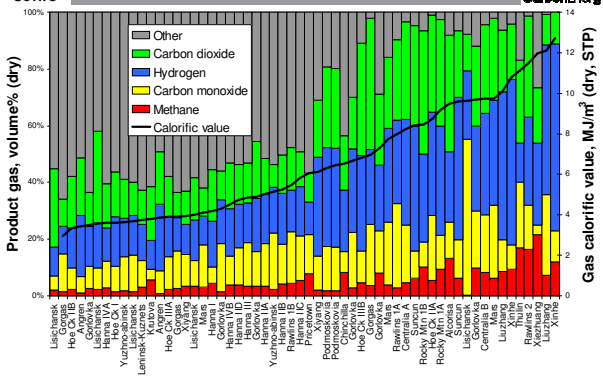
Tunnel



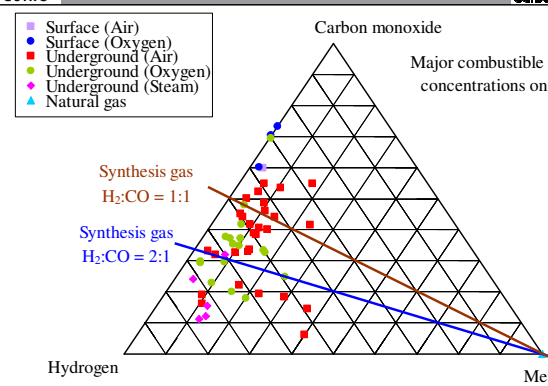
Behaviour prediction

- There is a large quantity of historical data available, including Soviet era texts detailing performance of UCG in a wide range of coal seams, that can be used to provide indications of likely behaviour
- Detailed cavity growth and gas production predictions require complex models covering a wide range of scientific disciplines

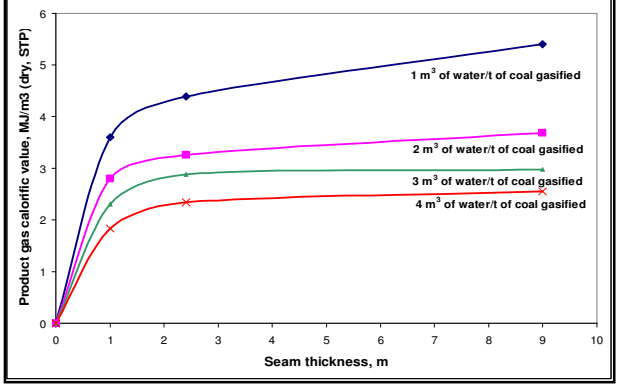
Variability in historical data



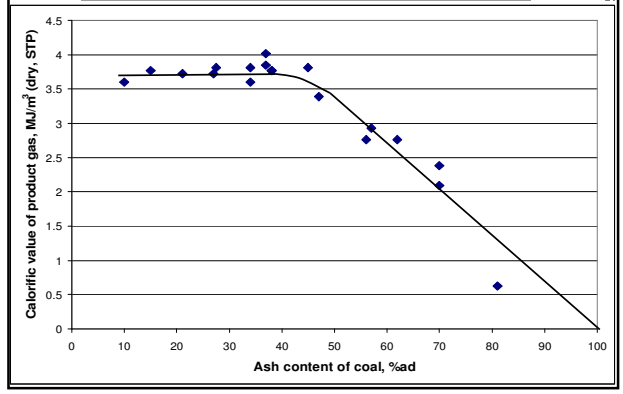
Another way of looking at it…



Literature trend from Skafa (1960) -Gas quality vs Seam thickness



Literature trend from Skafa (1960) -Gas quality vs Ash content



Summary

Some of the more obvious features that impact on UCG product gas quality are:

- **Seam thickness**
- **Water influx**
- **Ash content**
- **Feed gas composition**

Why do these have impact?

- **Energy balance**
  - Heat loss to overburden
  - Vaporisation of water
- **Mass balance**
  - Ratio of C:H:O in reactions
  - Coal recovery efficiency

Ash content impact

Ash content has an unusual impact:

- **Ash replaces carbonaceous material, so reduces the effective quantity of coal and would be expected to reduce the efficiency**
- **But, this does not happen until ash contents over 40% occur**
- **Ash provides a thermal repository that stabilises gasification and can have a beneficial effect in some circumstances (eg. thin clay or stone bands in the coal seam)**

The End

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