Башкирский государственный университет
ФИЗИКО-ТЕХНИЧЕСКИЙ ИНСТИТУТ
Кафедра прикладной физики

HIGH-PRESSURE AIR INJECTION

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DEPARTMENT OF APPLIED PHYSICS

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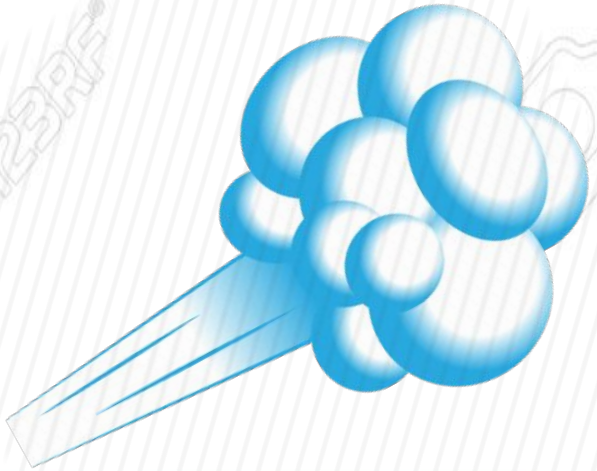

IN-SITU COMBUSTION VS HPAI

ФИЗИКО-ТЕХНИЧЕСКИЙ ИНСТИТУТ БашГУ
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GLOSSARY

High-pressure air injection	Термогазовое воздействие
In-situ combustion	Фронт горения в пласте
Bond scission	Разрыв связей
Oxygen addition	Дозирование кислорода
Gasflood	Нагнетание газа
Steam injection	Нагнетание пара в пласт
Flue-gas flood	Поток топочного газа
Miscible oil	Смешивающийся агент
GOR	gas/oil ratio

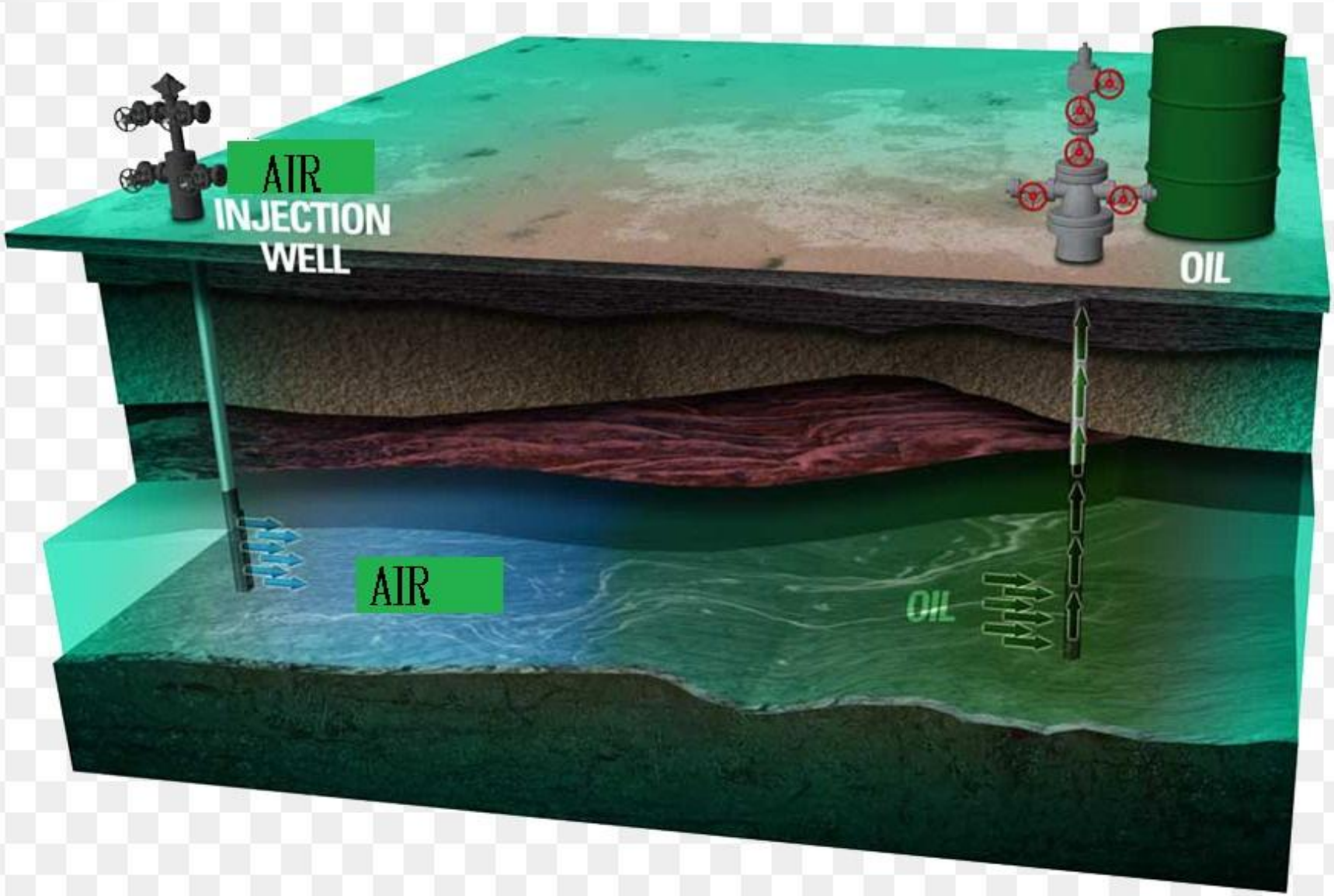
INTRODUCTION

High-pressure air injection (HPAI) is an enhanced oil recovery process in which compressed air is injected into reservoir.

HISTORY

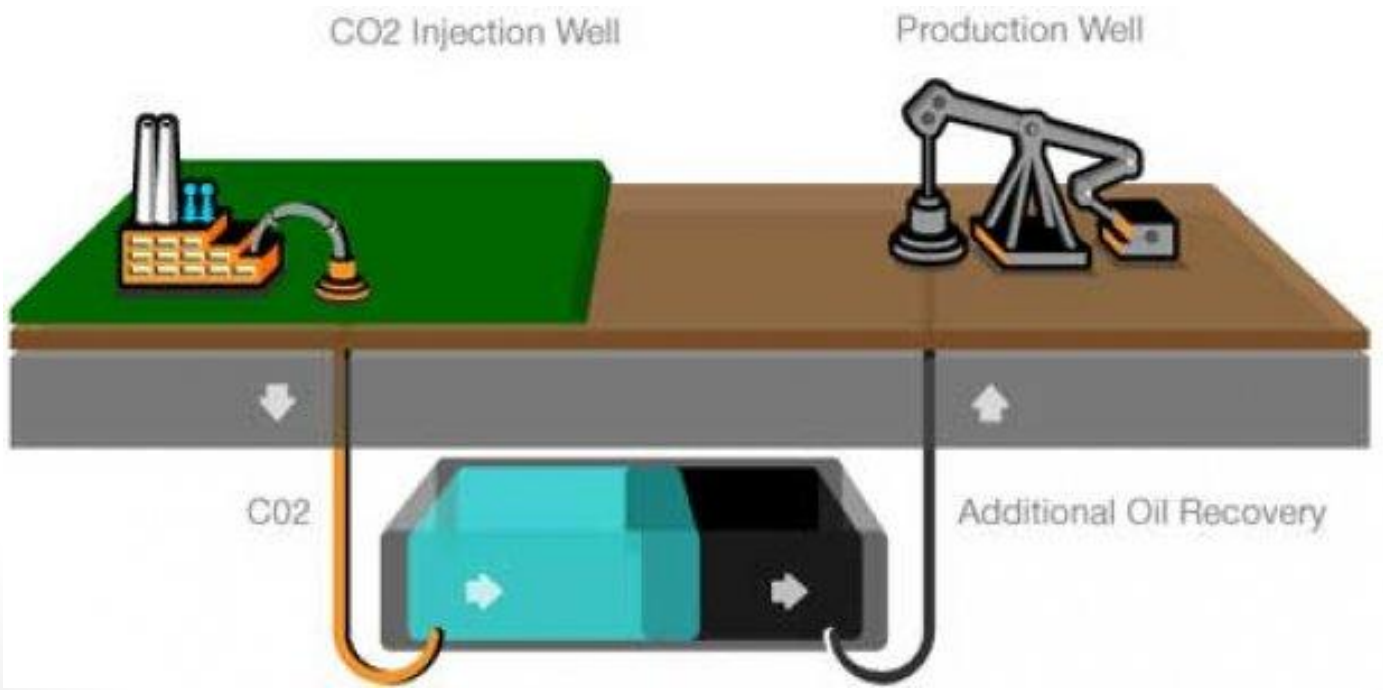
1. 1979, Buffalo, USA, recovery – 64%
2. 2002, North Ceder Hills, USA, recovery – 60%
3. 2003, Little Beaver, USA, recovery – 58%
4. 2001, West Medicine Pole, USA, recovery – 40%
5. 1985, Medicine Pole Hills, USA, recovery – 38%

HPAI Process Overview



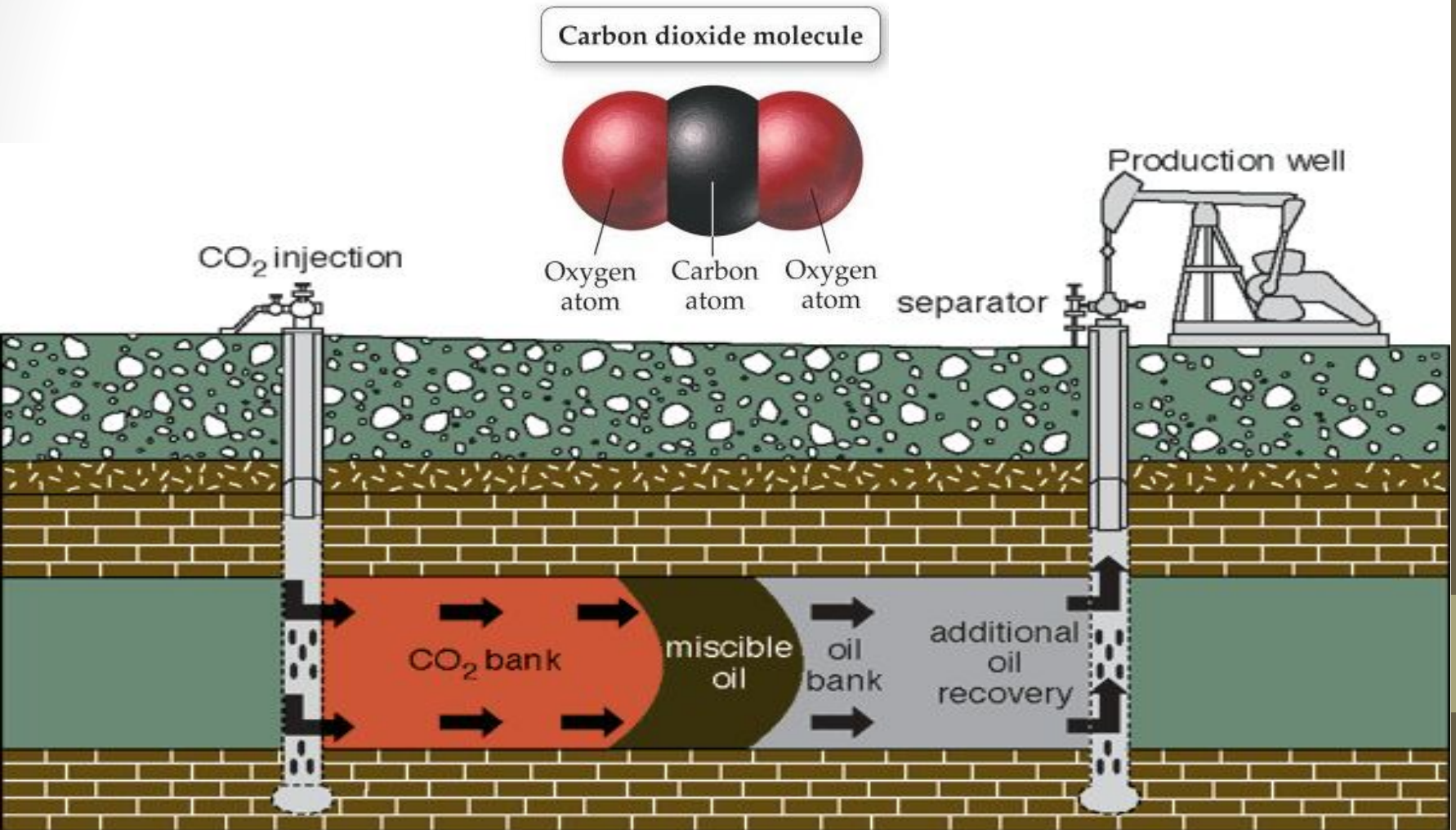
HPAI Process Overview

During the interaction between oxygen and oil, two possible reaction pathways exist: the first is referred to as “bond scission” reaction and the second is called the “oxygen addition” reaction.



HPAI Process Overview

During bond scission reactions, the oxygen reacts with the hydrocarbon molecules to produce carbon dioxide, water and energy.



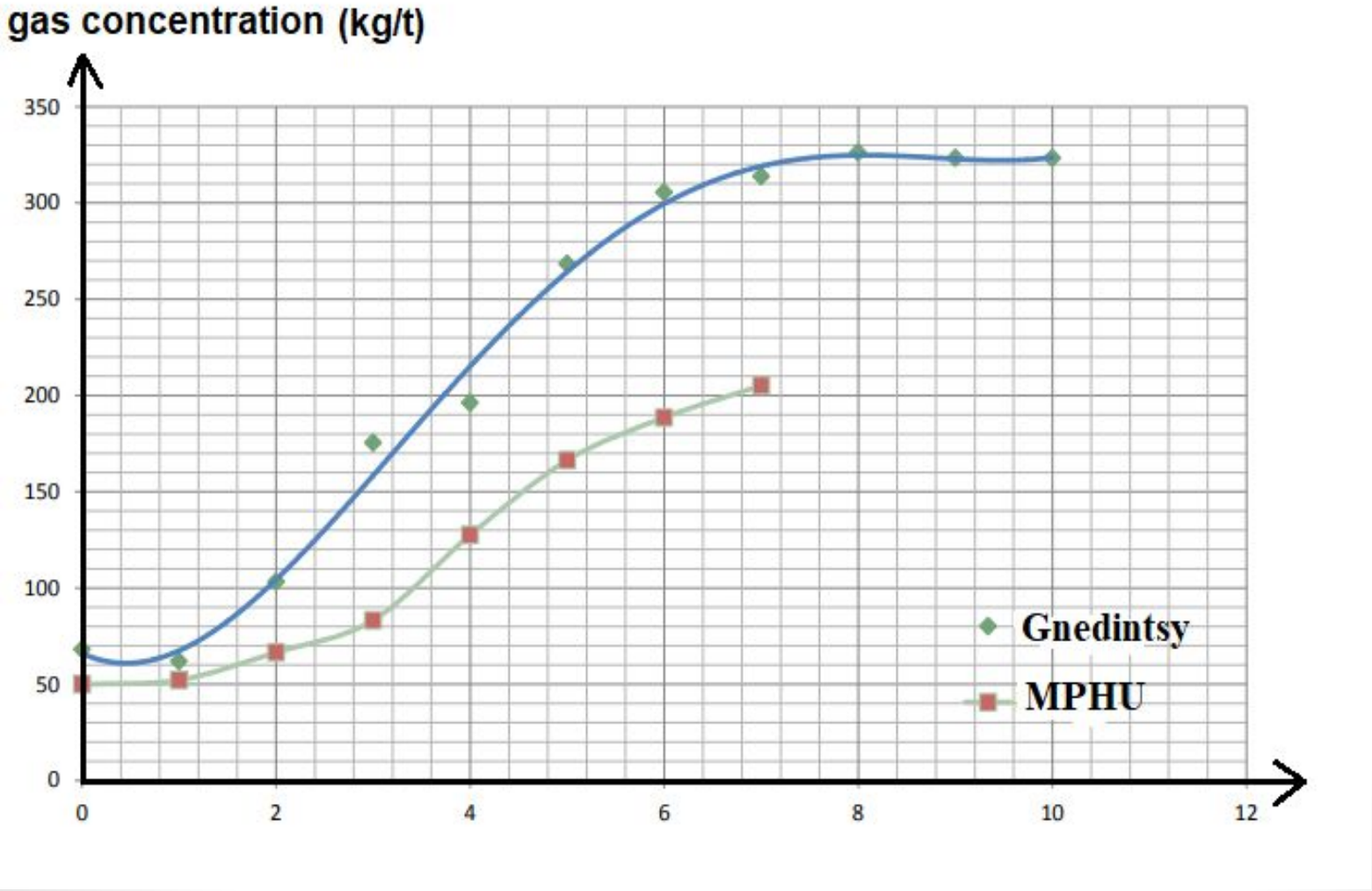
HPAI applicability

OILFIELDS	TEMPERATURE	ACHIEVED RESULTS
Gnedintsy (UKRAINE)	48°C	Increasing oil production 2-4 times more; additional extraction of light fractions - 25%; full utilization of oxygen; oil recovery - 68%.
MPHU (USA)	110°C	Increasing oil production 2-4 times more; additional extraction of light fractions - 15%; full utilization of oxygen; oil recovery - 60%.

Oil recovery by tradition methods - 3-5 %

HPAI applicability

Dynamics of the gas concentration during HPAI process.



HPAI advantages

- Reservoir pressurization
- Production response within a short time period
- Consumption of 7 to 10% of oil in place can lead potentially to recovery of all remaining oil
- Potential to enhance oil recovery after depletion or waterflooding

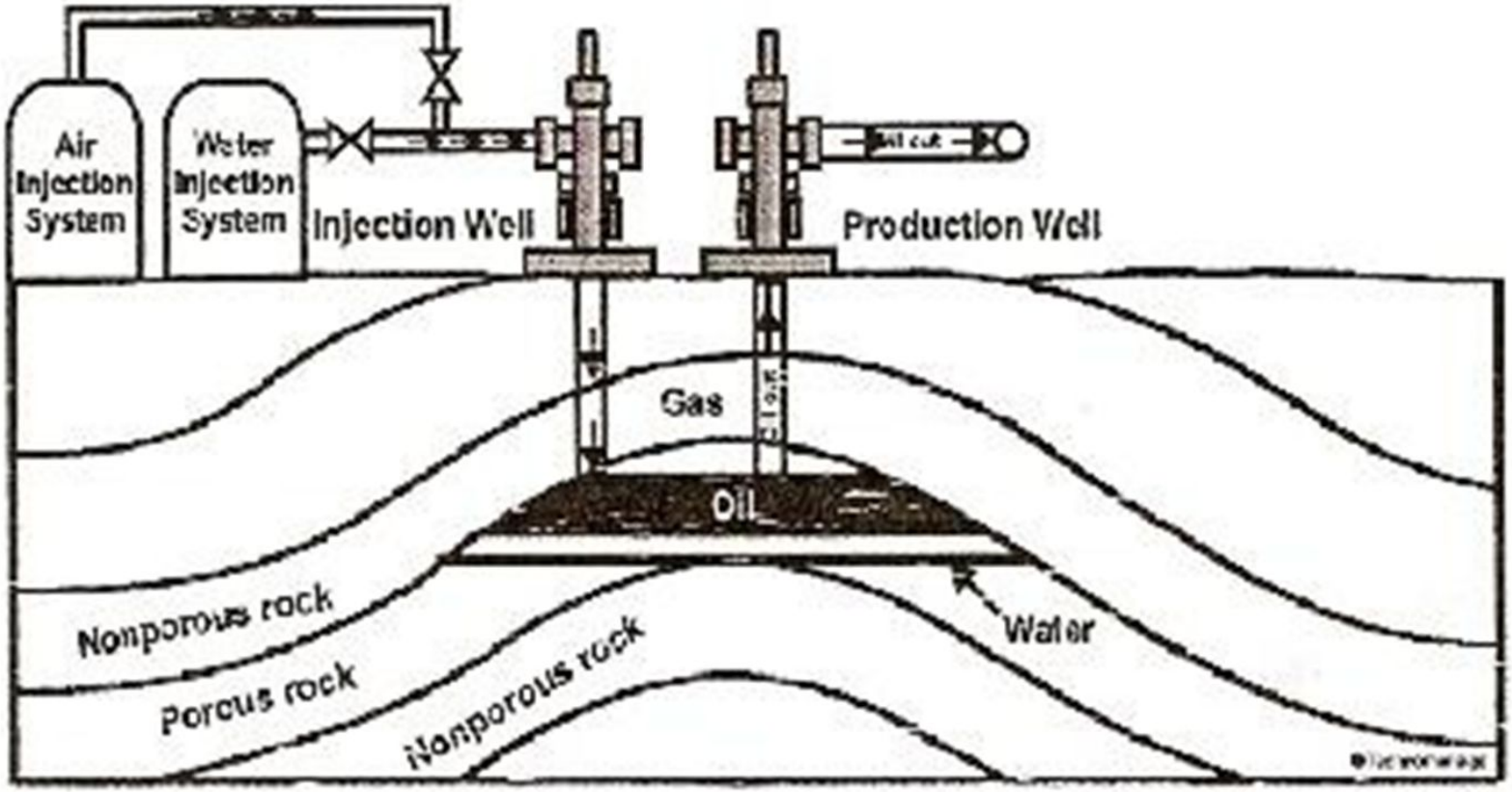
HPAI disadvantages

- Air compression and operation could be expensive
- Complex process: multiphase flow, heat transfer and chemical reactions. It is difficult to model.
- It requires special (non-conventional) laboratory tests
- No offshore experience
- Operationally challenging (i.e. emulsion treatment, risk of explosions, etc.)

Why reconsider HPAI today?

- Thermally, it is the most efficient oil recovery process
- Availability of air (cheap injection fluid)
- Proven technology in different reservoir settings (shallow heavy oil and deep light oil reservoirs)
- High displacement efficiency
- It can be applied in cases where waterflooding or steam injection are not effective

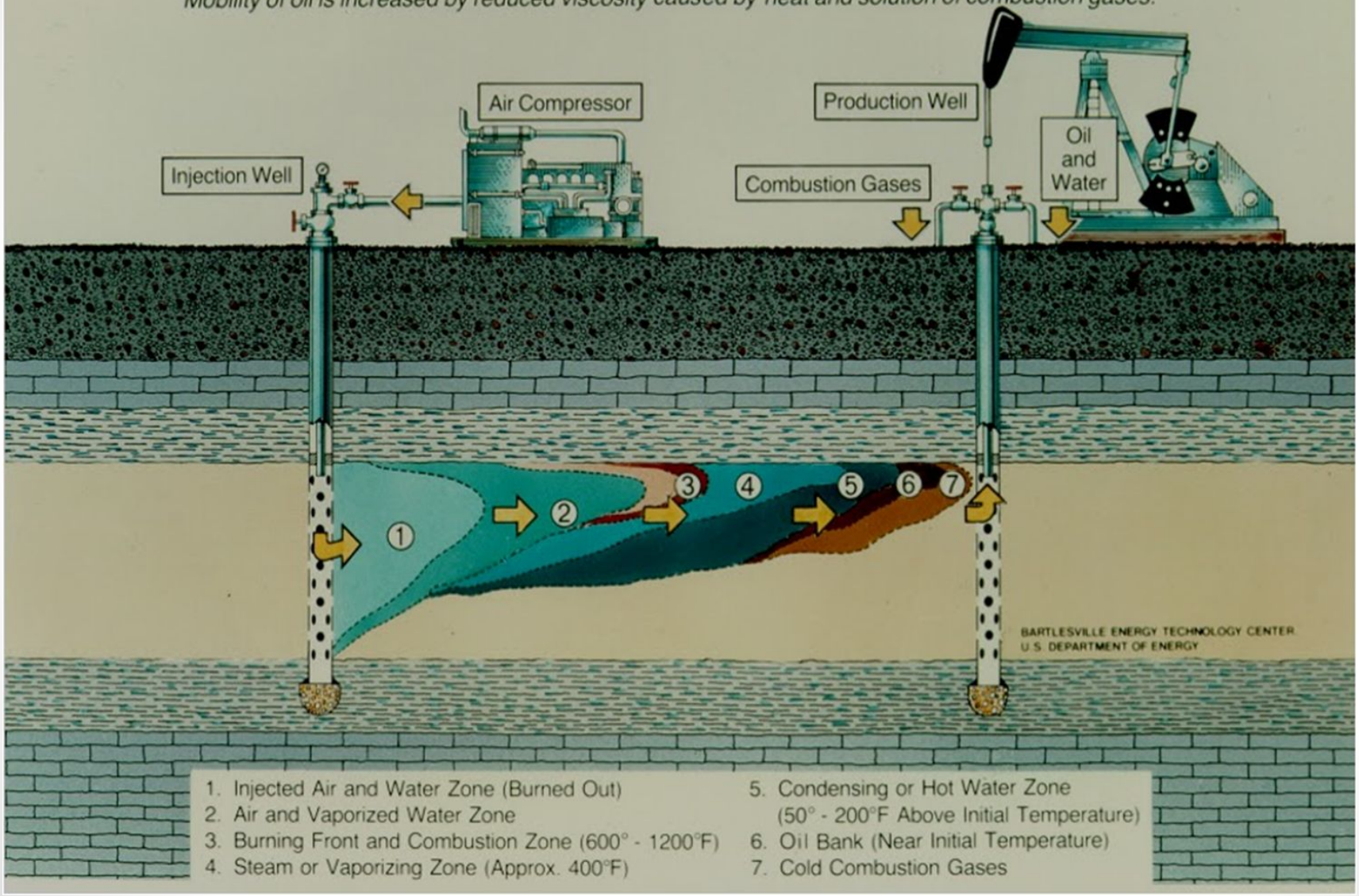
In-situ Combustion



IN-SITU COMBUSTION

Heat is used to thin the oil and permit it to flow more easily toward production wells. In a fireflood, the formation is ignited, and by continued injection of air, a fire front is advanced through the reservoir.

Mobility of oil is increased by reduced viscosity caused by heat and solution of combustion gases.

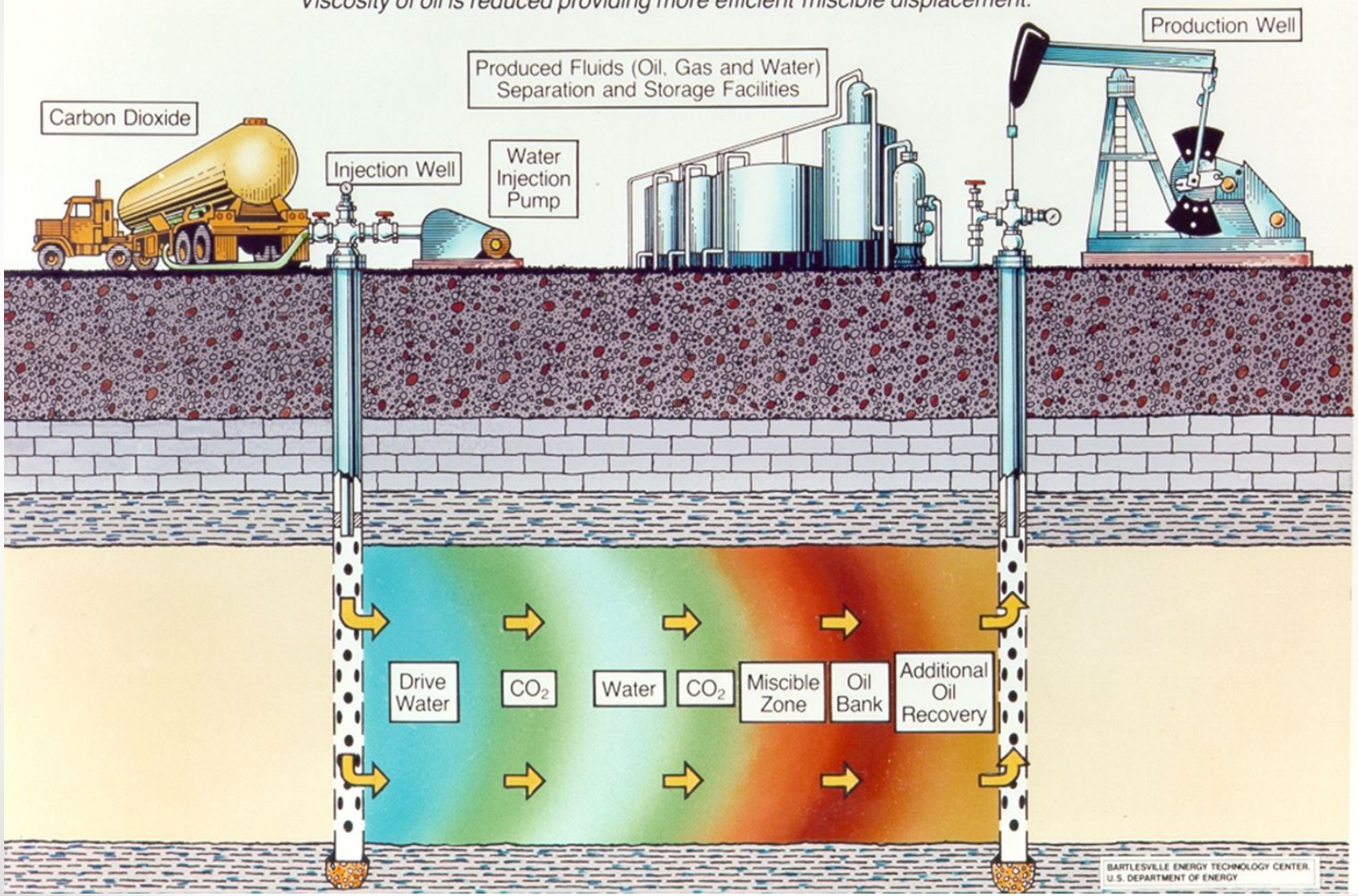


1. Injected Air and Water Zone (Burned Out)
2. Air and Vaporized Water Zone
3. Burning Front and Combustion Zone (600° - 1200°F)
4. Steam or Vaporizing Zone (Approx. 400°F)
5. Condensing or Hot Water Zone (50° - 200°F Above Initial Temperature)
6. Oil Bank (Near Initial Temperature)
7. Cold Combustion Gases

CARBON DIOXIDE FLOODING

This method is a miscible displacement process applicable to many reservoirs. A CO_2 slug followed by alternate water and CO_2 injections (WAG) is usually the most feasible method.

Viscosity of oil is reduced providing more efficient miscible displacement.



ISC advantages

1. Transition to the gas phase of some (lightest) components of oil saturating the rock before the combustion front.
2. Splitting (cracking) of some hydrocarbons that make up oil.
3. Combustion of coke-like residue formed as a result of cracking process.
4. Melting of paraffins and asphaltenes in the pores of the rock.
5. Transition to the vapor phase of formation water, located in front of the front.
6. Reduction of oil viscosity in front of the front as a result of its heating and mixing with light oil fractions carried by the gas flow from the combustion front.
7. The condensation of the products of the distillation of crude oil and the formation of the movable zones of high oil saturation ahead of the combustion front at the lower temperatures.

ISC disadvantages

- to take measures to protect the environment and disposal of combustion products
- to prevent corrosion of equipment
- gas locking
- difficult emulsions.

QUESTIONS

1. What the main purpose of the oxygen in the HPAI process?
2. When the HPAI method was developed and tasted?
3. What type of oil was extracted in the MPHU?