Lecture on Monday 30-3-2020

Maturation of source rocks (kerogen to oil to gas)

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- Kerogen: (insoluble components, composed of C, H, and O compounds)

is composed of large hydrocarbon molecules that are stable at low temperatures,

but will break down into smaller molecules of liquid and gaseous hydrocarbon compounds with progressive higher temperatures.

Factors control the maturation of source rocks

- The transformation to **smaller** and **lighter** compounds is controlled by the **strength of the bonds** between the atoms and thus the **energy required to break** those bonds.

- **1- Temperature is the most important control**
- **2- Pressure**
- **3- Nature of kerogen**
- **4- Abundance of kerogen**
- **5- Catalysts (V, Mo, Ni)**
- **6- Radioactive minerals (U, Th, K)**
- **7- Bacterial action**

Temperature

- In sedimentary basins, temperature increases with depth.

- Average **temperature gradients** for sedimentary basins fall mainly between 20 degree/km and 40 degree / km.

- There are exceptions: "cool" basins, with gradients of less than 20 degree/km.

Temperature

- "Hot" basins with gradients of more than 40 degree/km.
- hot basins are underlain by thinned lithosphere.
- The source of the heat in the sediments comes primarily from the mantle, coupled with a local contribution from the decay of radioactive elements (commonly in clays).

Temperature

- In the laboratory, the temperature needed to generate oil from a source rock is around 430-460 C degree, whereas in a typical sedimentary basin time is expressed in millions of years and temperatures are in the range 80—150 C degree.

- In other words, **there is a combination of time and temperature that must be integrated** if we are to **make an assessment of the thermal maturity of a source rock**, and **determine its petroleum generation history and any remaining potential.**

Reaction products

- 1- Early alteration of kerogen in the shallow subsurface (generally less than 1.0 km) results in the production of CO_2 and H_2O (**Digenesis**).

- 2- Then, the products are dominated by a mixture of oils and gases at depths of 2.0 km and greater.

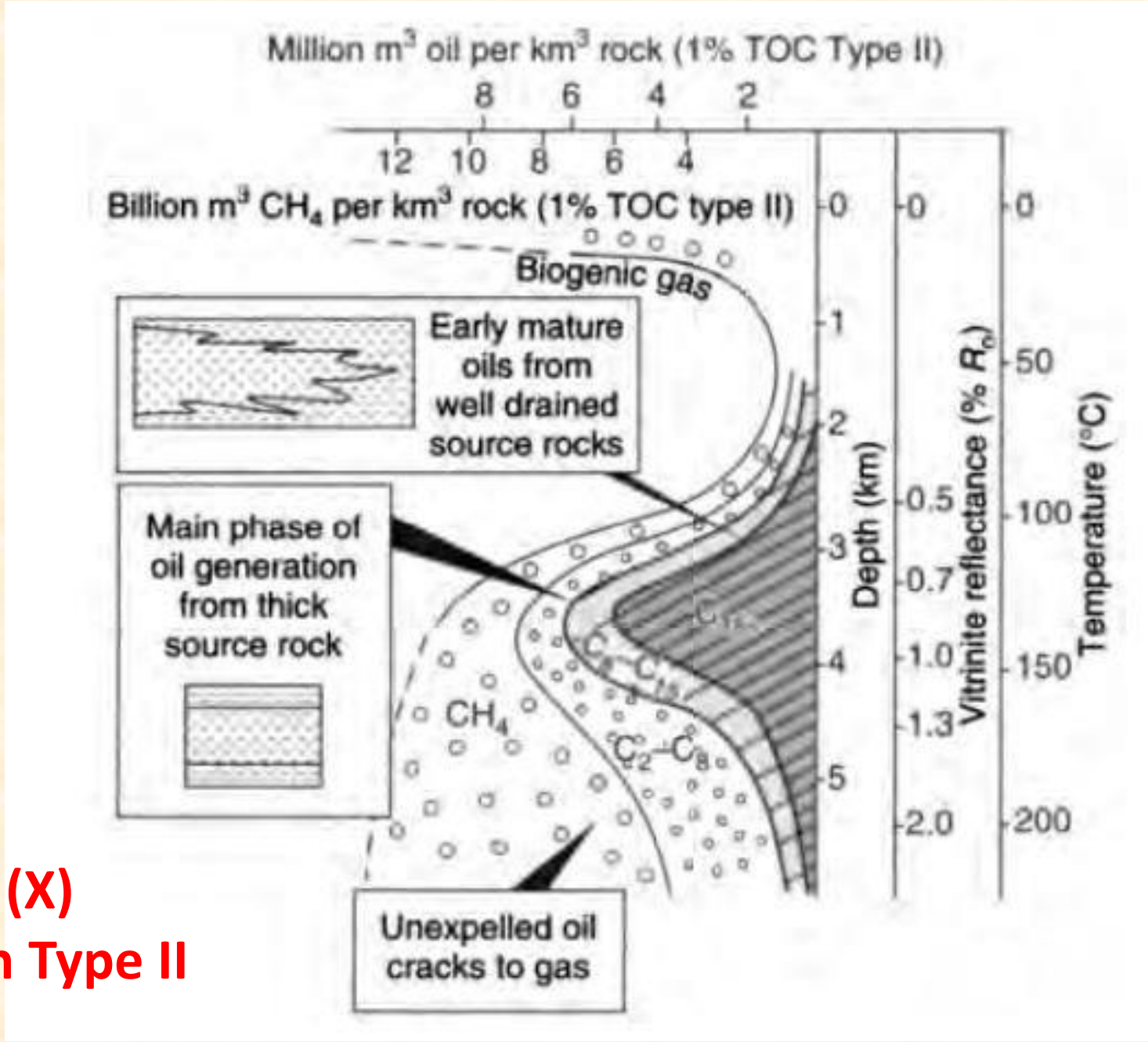


fig. (X)

Kerogen Type II

Comment on fig. (X)

- peak oil-generation phase followed by a phase of wet gas, and finally peak of gas generation from a typical Type II source rock.
- **"Dry Gas"** is composed essentially of Methane and little of Ethane.
- "**wet gas**" **Natural gas that contains less methane (typically less than 85% methane) and more ethane and other more complex hydrocarbons.**
- With increasing temperature, the product mix moves increasingly toward dry gas.
- **Gas is derived as a result of direct alteration of kerogen (as the primary product in Type III kerogen, and as a secondary reaction in Types I and II), and by cracking of the remaining oil.**

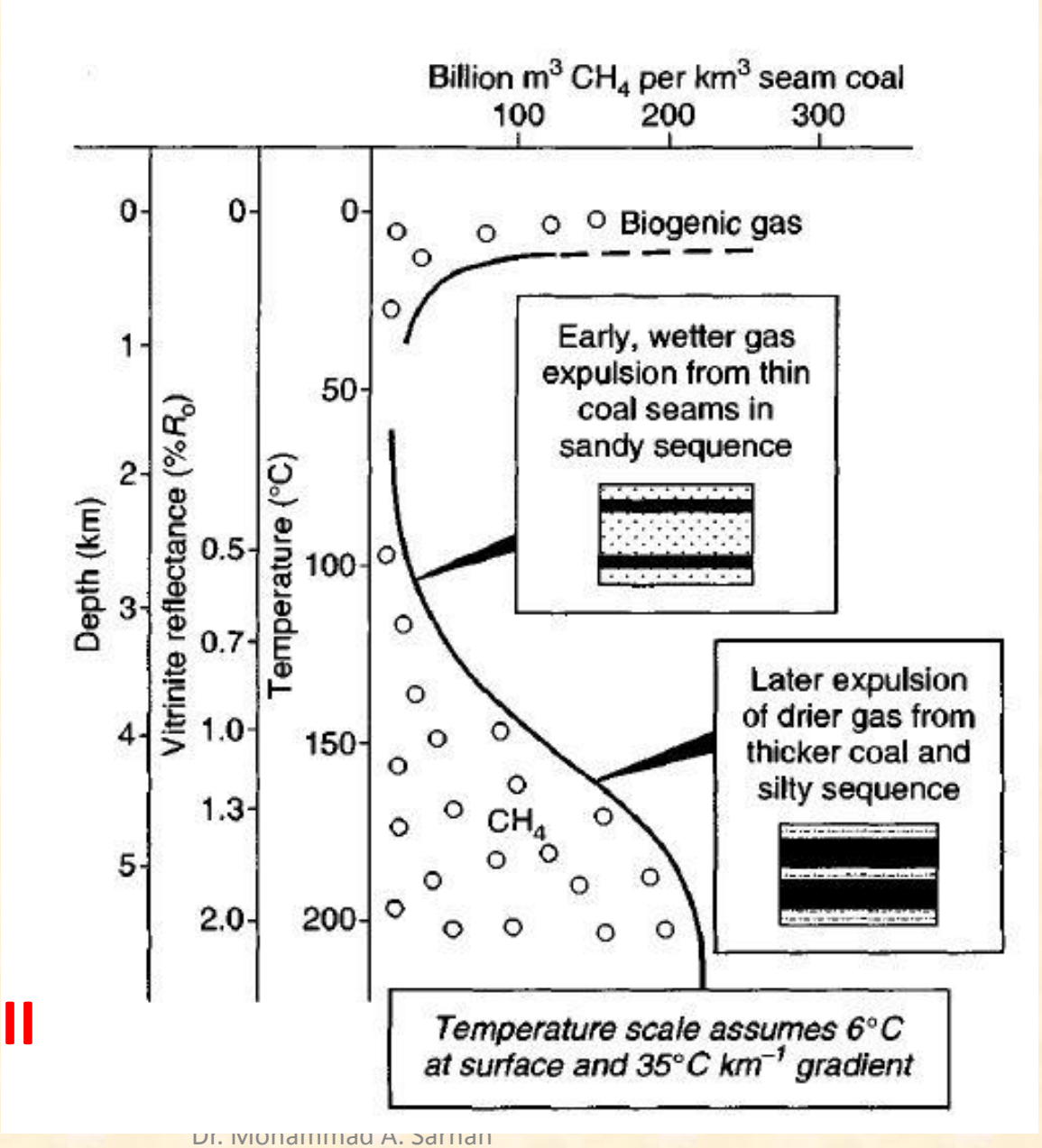


fig. (XX)
Kerogen Type III

Comment on fig. (XX)

- For gas-prone sources (Vitrinite "Kerogen type III"), **little fluid** is produced and the first major product of maturation is abundant gas, with a low molecular weight (Fig. XX).

Cracking

- **cracking** is the process whereby complex organic molecules (kerogens) or (long chain hydrocarbons) are broken down into simpler molecules (light hydrocarbons) by the breaking of carbon-carbon bonds .

- I.e. hydrocarbon cracking is the process of breaking a long-chain of hydrocarbons into short ones.

- The rate of cracking and the end products depend on the temperature .

Note:

- Oil that has migrated from the source rock and trapped may be influenced by increases in temperature, and convert into gas dominated by methane (CH_4).

Note:

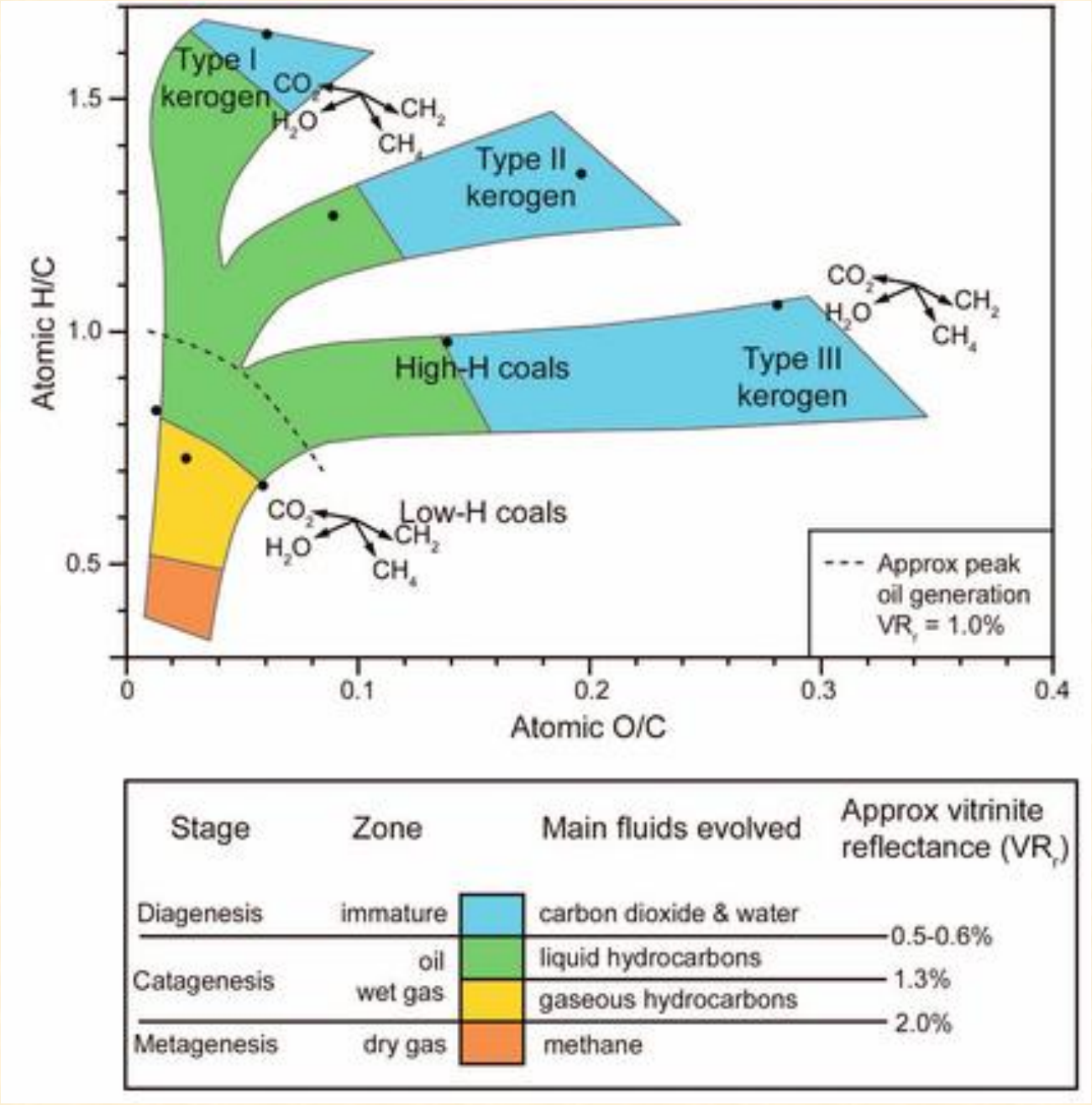
- Oil may be destroyed (i.e. converted into Bitumens) by:

- 1- late influx of gas into an oil-filled reservoir (forms tar mats) whithin which the increased gas saturation leads to a lower solubility of dissolved heavy compounds.

- 2-or by bacterial degradation.

- 3- water-washing of oil in a shallow reservoir.

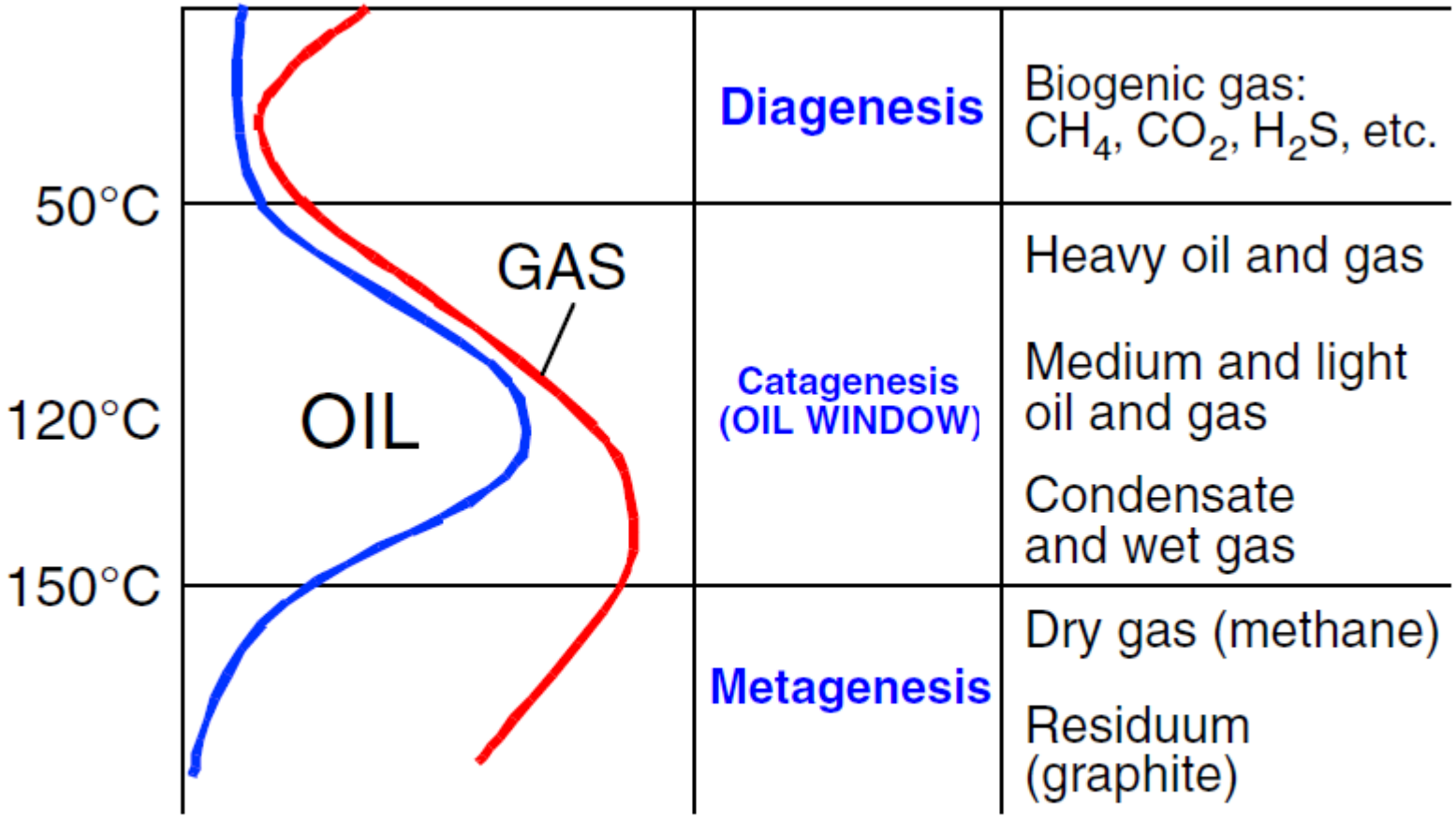
Van Krevelen Diagram



Van Krevelen Diagram

- Conversion of kerogen to petroleum needs temperatures of at least 50°–70°C (equivalent to 1–2 km of burial) and a long period of geological time.

- The best temperature range for **maturation** is 80–130°C, equivalent to burial depth of about 3–4 km for a typical geothermal gradient (i.e. 25–30°C).



The oil window

Thank you