# Poromechanics of the exploitation of an oilfield, a brief introduction

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At the beginning of oil exploitation, one just have to drill a well and oil will gush from the underground as in the picture of an American oilfield. However, this easy part does not last very long and secondary and tertiary techniques have to be used in order to recover the most of the oil. In this exercise we will try to understand the mechanisms of oil recovery and the different issues associated.
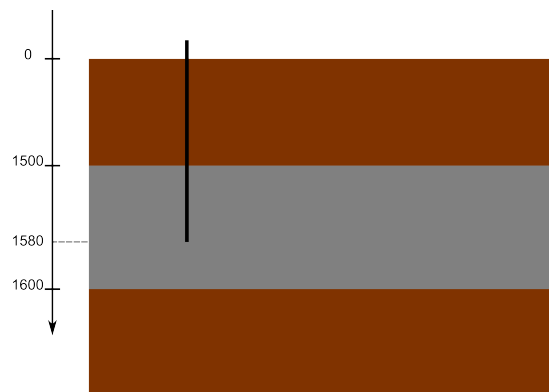
Let us consider an ideal 2D rectangular oilfield of thickness 100m and length 1km, situated at 1500m underground as represented in the figure above. The characteristics of the oilfield are in the following table. We will consider that the oil and water are behaving as newtonian fluids. The rock will be also considered as oil-wet.

Porosity	ϕ	20%
Biot coefficient	b	0.8
Biot Modulus	N	45 GPa
Poisson ratio	ν	0.3
Intrinsic Permability	k_0	600mD
Water residual saturation	S_{wr}	5 %
van Genuchten coefficient	m	0.8
air entry pressure	p_0	0.1MPa
Temperature	T	70°C
Oil residual saturation	S_{or}	30 %
Oil Viscosity	η	10 mPa.s
Oil Bulk modulus	K_O	1.36 GPa
Oil density at 1 bar	ρ_{atm}	0.850
Henry constant	K_H	200 MPa
Molar mass of the oil	M_O	100 g/mol
Residual gas saturation	S_{gr}	5 %

1 - We will consider at first that the field is saturated with oil. The density of the rock layer is 2500 kg.m^{-3}. Calculate the oil pore pressure at the bottom of the well considering that there are no deformation on the horizontal axis.

2 - Considering the oil bulk modulus, can we neglect the oil compressibility ?

3 - The well has a diameter of 1m. Compare the hydraulic resistance of the formation and the well and conclude of the limiting transport process.

4 - We will consider that the pressure will decrease homogeneously in the field. Calculate the pressure evolution with time. What is the characteristic time of pressure decay ? What is the percentage of oil extracted ? If we install a pumping system allowing to set the downhole pressure at p_{atm} what is the new percentage of oil obtained ?

5 - Actually, one of the main recovery process for oil is the expansion of the gas cap and the degasing of the oil when the pressure is lowered. We consider that we can neglect the change of porosity and that the initial gas quantity is equal to the residual gas saturation. Calculate the quantity of oil recovered without and with the pumping system, considering that there is no production of gas and that we can neglect capillary pressure. What observations can you make ?

6 - The depletion of oilfields usually creates a subsidence. Calculate the change of altitude of the ground considering that there is no horizontal deformation.

7 - In order to continue producing oil, another identical well is drilled at the other end of the oilfield and water is injected. What is the wettability of water compared to this of the gas and the oil ?
Calculate the capillary number considering an injection of water of 10 L/s. What kind of behavior can you expect ? One of the main issue with the waterflooding is the residual oil saturation, especially in the case of oil-wet reservoirs. What kind of solutions can you design to decrease this residual oil saturation and then recover more oil.

8 - In the case of oil-wet reservoirs, instead of water, CO_2 is used. This gas is usually completely miscible in the oil. What are the advantages of using CO_2 instead of water to continue producing oil ?