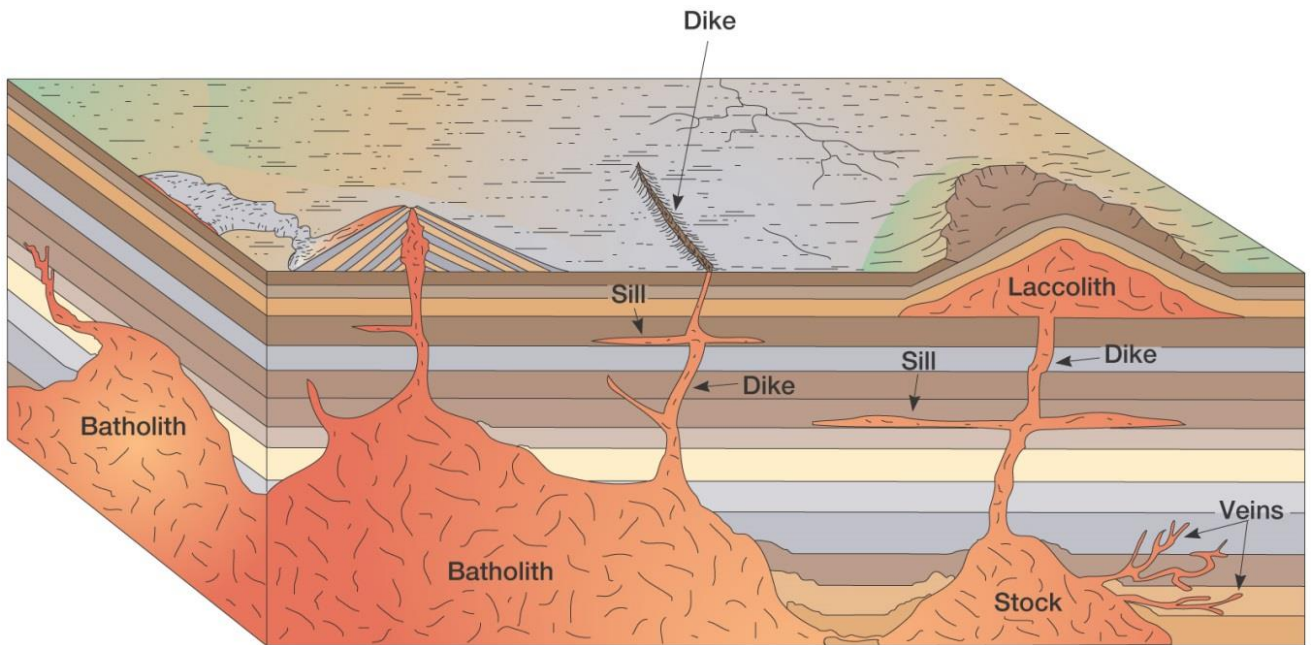


HYDROCARBON RESERVOIRS ASSOCIATED TO LAYERED INTRUSIVE BODIES

INTRODUCCION:

Magma is defined as a molten rock, which behaves as a viscous liquid generated multiple tectonic processes. The ascent to the fragile crust generates bodies of varying geometry.



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Fig. 1. Tipos de cuerpos magmáticos.

The morphology presented deployed such bodies depends on the viscosity, the amount of magma available, the list of regional efforts and magmas own composition. They can be classified in globular and lamellar bodies exist as transitional laccoliths.

The location of these in sedimentary basins has considerable economic importance globally because it generates fruitful hydrocarbon reservoirs. Examples of these are: Neuquen basin in Argentina, Rockall Basin in the Norwegian Sea and the Yellow Sea Basin in China.

FACTORS CONTROLLING THE EMPLACEMENT OF MAGMA.

The magmatic emplacement in the crust is not a freak of nature, it is controlled by a number of physical factors. It will highlight the constraints posed by the location of sedimentary basins subvolcanic due to the importance of these as part of hydrocarbon systems.

The focus of the article is aimed at magmatic bodies of small size (2-4 km in diameter and approximately 500 m thick) of lamellar geometries and disposal consistent with available subhorizontal sedimentary rocks.

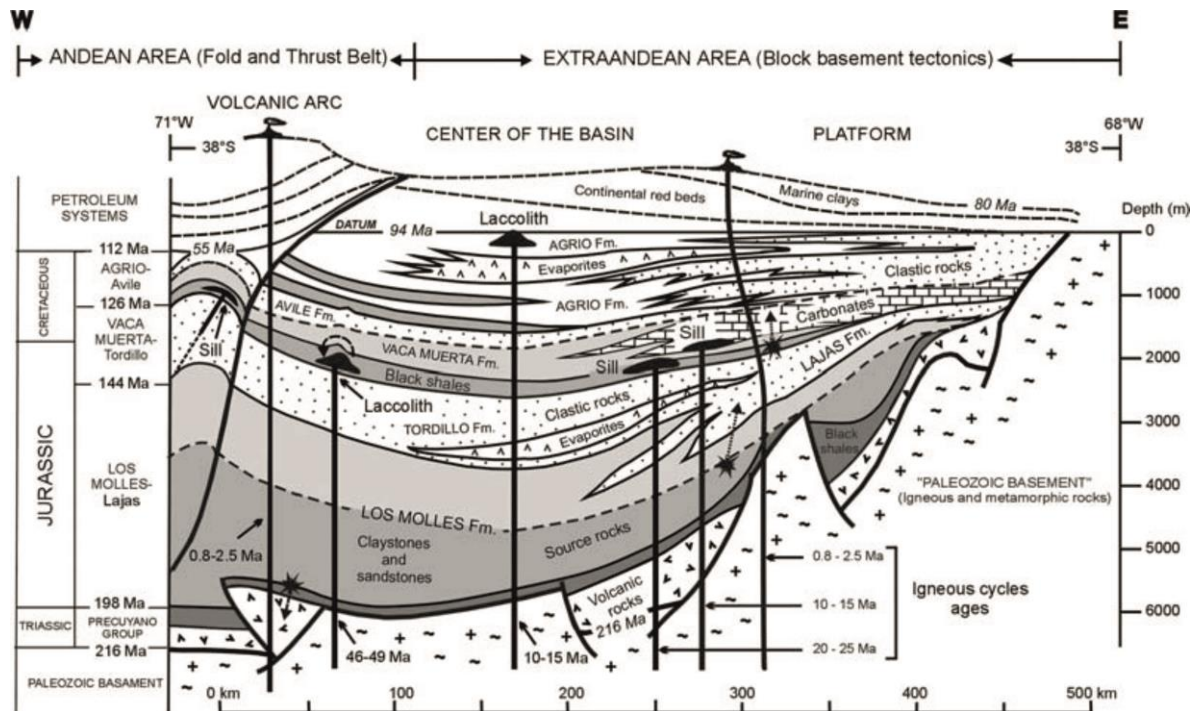


Figure 2 : Schematic profile of the Neuquen Basin, province of Neuquen, Argentina , where you can see the site of lamellar bodies of Cenozoic age.

Taken from Bermúdez & Delpino 2015.

Location factors are:

- **Tectonic:** the dynamics of plates associated sedimentary basin must have significant magmatic activity, with interspersed relaxation events in time and needed to climb it.

- **Physical:** the density difference between the magma (lower density) and the host rocks is a key factor. Archimedes' principle is the one who acts. The surrounding rocks exert an upward thrust that moves the crustal magma to levels where their density is equated with the host rocks. It may happen that the density remains below the rocks of the environment and that the magma is detained its vertical ascent, the factor involved here are **local efforts**. If the efforts of the magma pressure can not overcome the resistance of the rocks magma vertically looking for a new way of moving through a plane of weakness such as a stratigraphic unconformity, anisotropy of the medium as fault planes, hinges of folds, etc.



Figure 3: In this photograph the site of two sills can be seen in a bedrock (Vaca Muerta Fm). Right on the sector focuses it can be clearly seen intense fracturing of columnar pattern. Photo courtesy of Juan Spacapan.

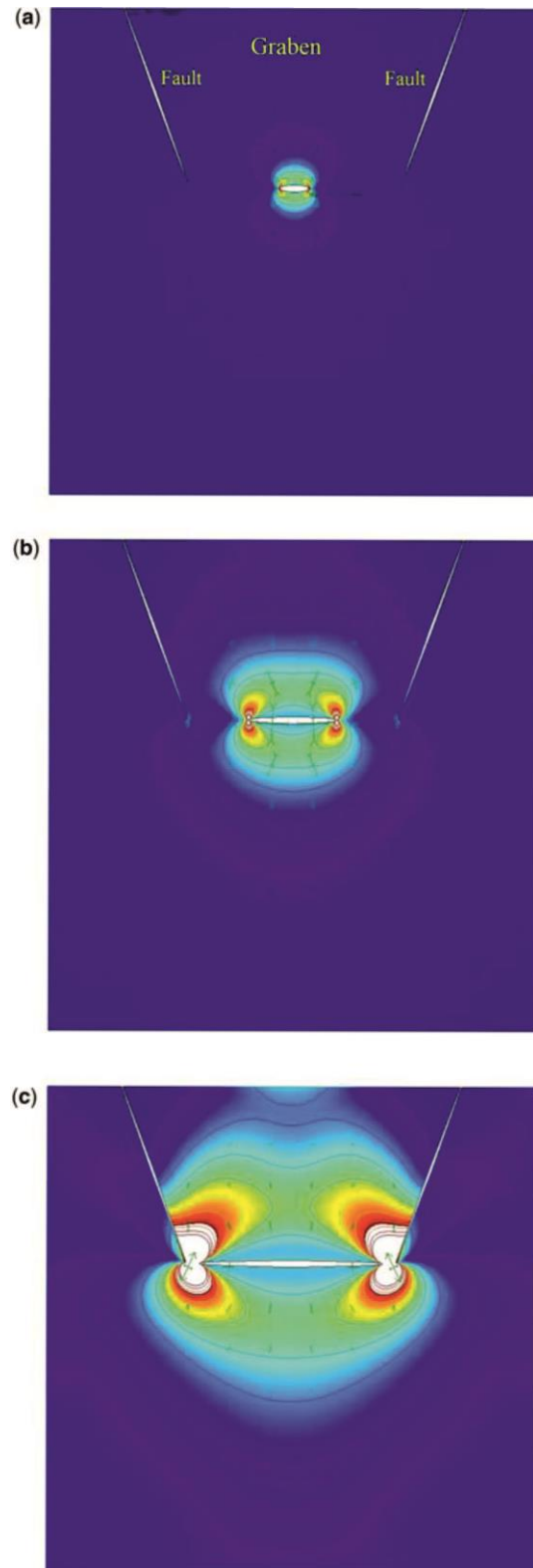


Figure 4: mathematical modeling where the stress distribution can be observed during the site of a sill. Taken from Gudmundsson & Løtveit 2012.

Another important physical factor is the **pore pressure**. In porous sedimentary rocks saturated with fluids such as water and hydrocarbons, fracture resistance is reduced. This is why it can almost be deduced that the location of the intrusive within a sedimentary basin would be concentrated within shale formations (high porosity) with plenty of oil.

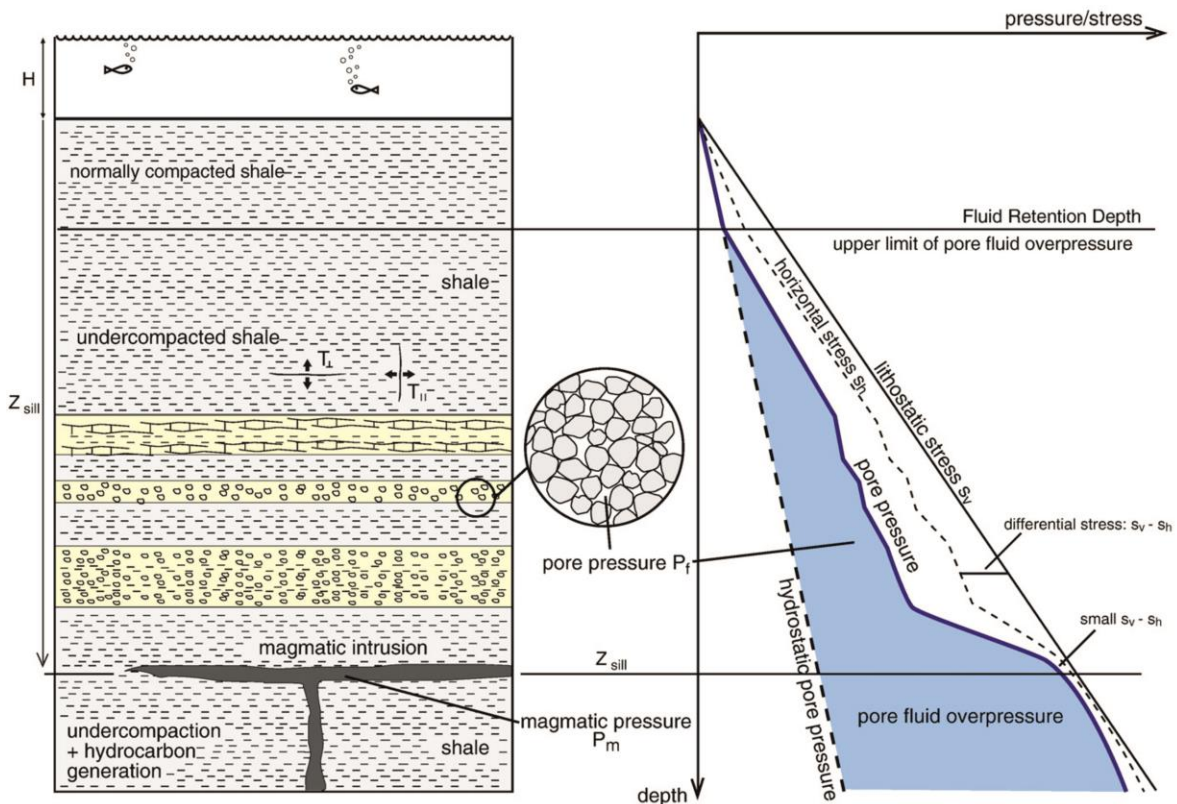


Figure 5: Diagram relating the fluid pressure with the decrease in resistance of the country rock with increasing depth. Notice how the anisotropy of the medium magnify the value of T (tensile stress) in the horizontal direction. Taken from Gressier et al 2010.

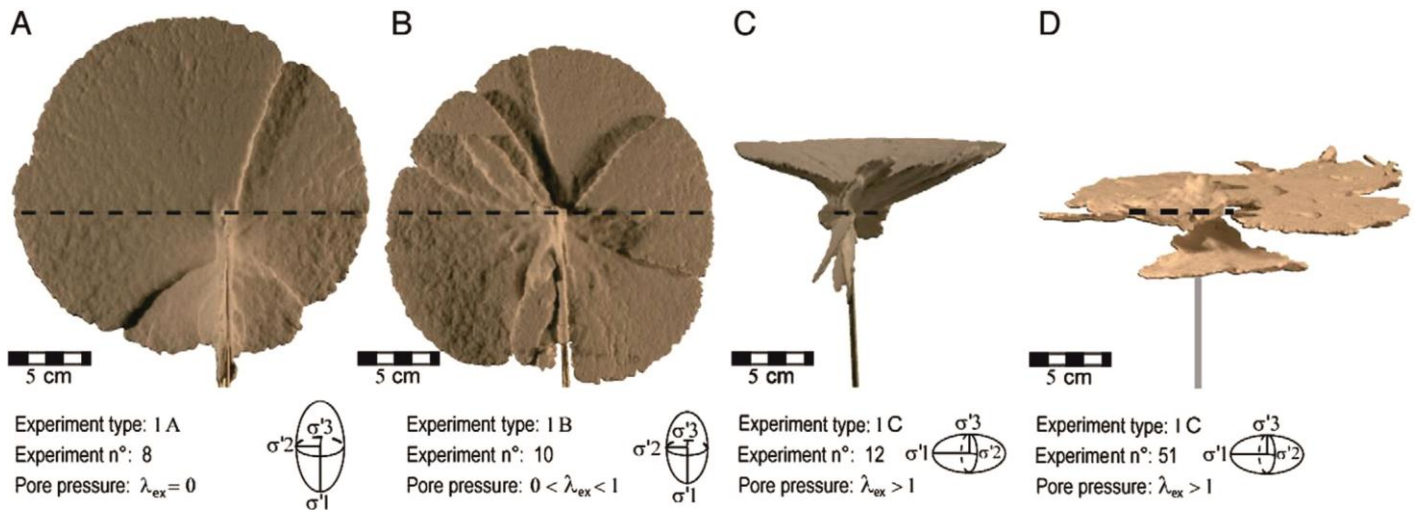


Figure 6: experiment by Gressier et al 2010 made into a powder through diatomaceous saturated and unsaturated to simulate fluid through the sediment site. Magma was simulated with silicone caulk which behaves as an ideal Newtonian fluid. The conclusion of this experiment is that in a supersaturated fluid medium and the main effort horizontally oriented sill development is full.

CONSEQUENCES OF CONSTRUCTION SILLS:

The location of magmatic sill type bodies within sedimentary lithologies has **four** major consequences:

- **Location in bedrock:** has been observed in numerous world sites, site of intrusive occurs in petroleum source rocks, whose cause is still not fully understood but presumably has to do with three factors: pore pressure, level weakness in the bedrock (being shale is less competent) and plan anisotropy generated in the shales facilitate deflection of the levees that are rising from lower levels.

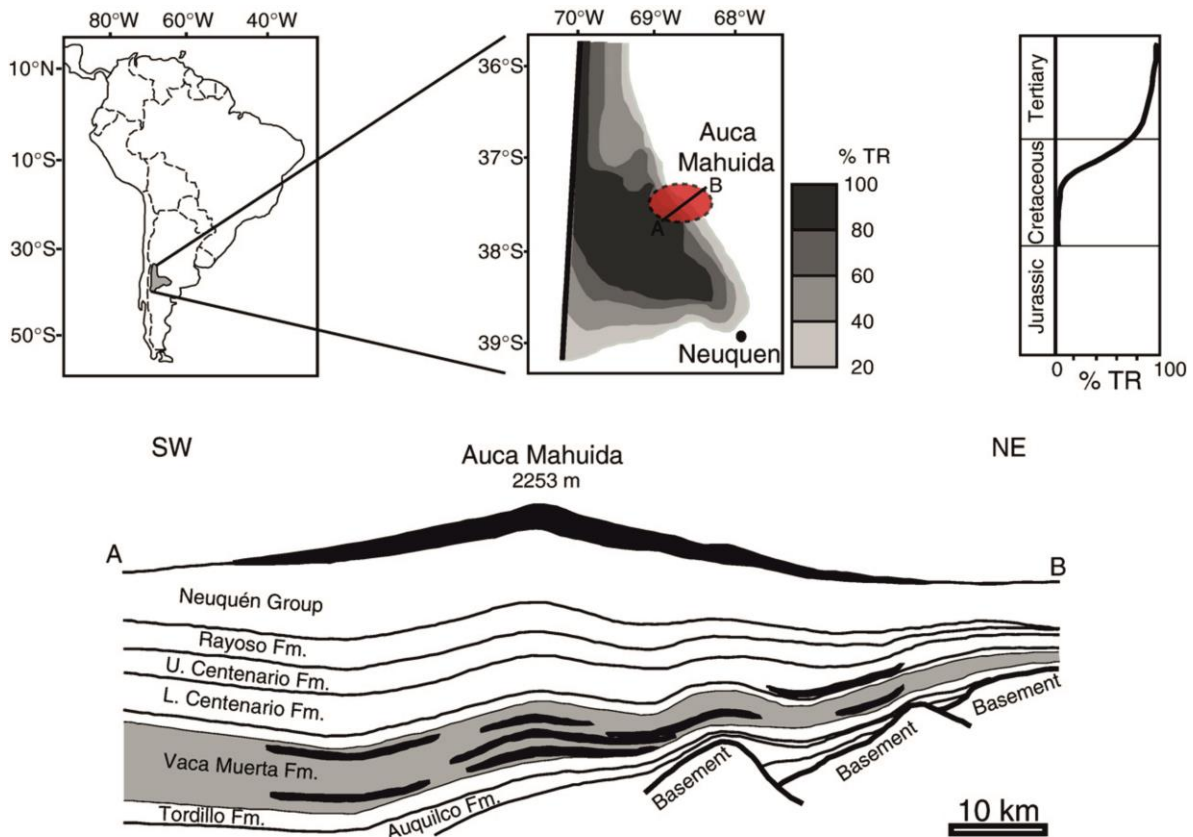


Figure 7: Scheme of northern Neuquen basin where it can be seen as most sills are deployed in the Vaca Muerta Formation (hydrocarbon source rock).

- **Fracturing:** as shown above for the location of magma is necessary to move adjacent sedimentary rock. The magma pressure is what generates the efforts for this to have committed and also achieved fracturing . Other efforts such as those generated by cooling the sill or by the circulation of metasomatic fluids are also responsible for much of the rock fracturing cash as the sill itself. We have studied the fracture patterns formed by these processes are explained below some.
 - ✓ **Radial fractures:** fracture pattern generated in the sediments by the efforts of the magma pressure, radiating from a central point.
 - ✓ **Fractures located at the corners of the sill:** as seen in Figure 4 the stress concentration at the ends of the sill is very rich and very intense fracturing in consequence.
 - ✓ **Concentric fractures:** generated at the edges of the sill and parts of the country rock by the circulation of metasomatic fluids or lithostatic decompression.
 - ✓ **Columnar or polygonal fractures:** are generated by cooling and solidification of magma, where its volume is reduced contraction columnar cells formed orthogonal to the surface through which heat is lost.

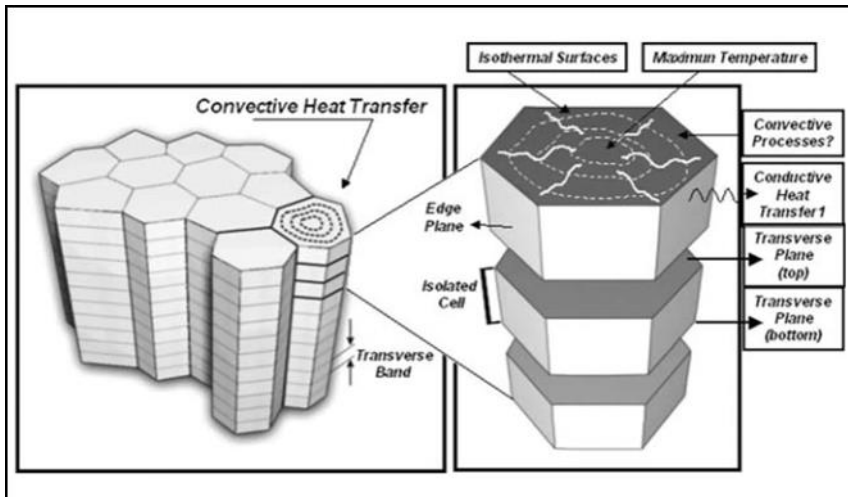


Figure 7: Scheme of columnar fractures. Taken from Bermúdez & Delpino 2015.

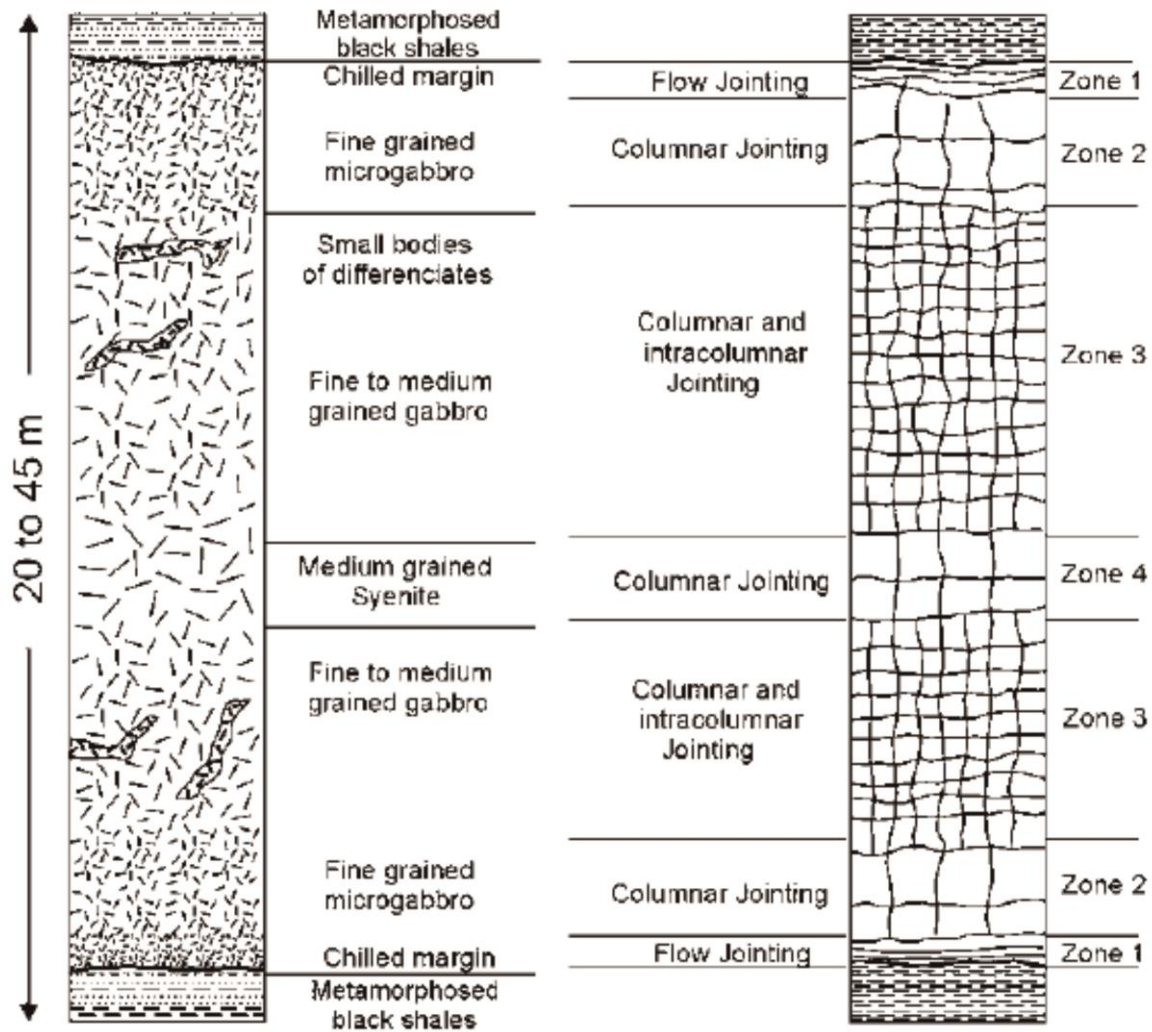


Figure 8: Variation of fracture patterns in a vertical section of a sill. Taken from Bermúdez & Delpino 2015.

- **Folding:** the movement of material not only produces fracturing but also the folding of the overlying material. These folds are important because they may constitute important reservoirs and traps, even exploited in several basins in the world.

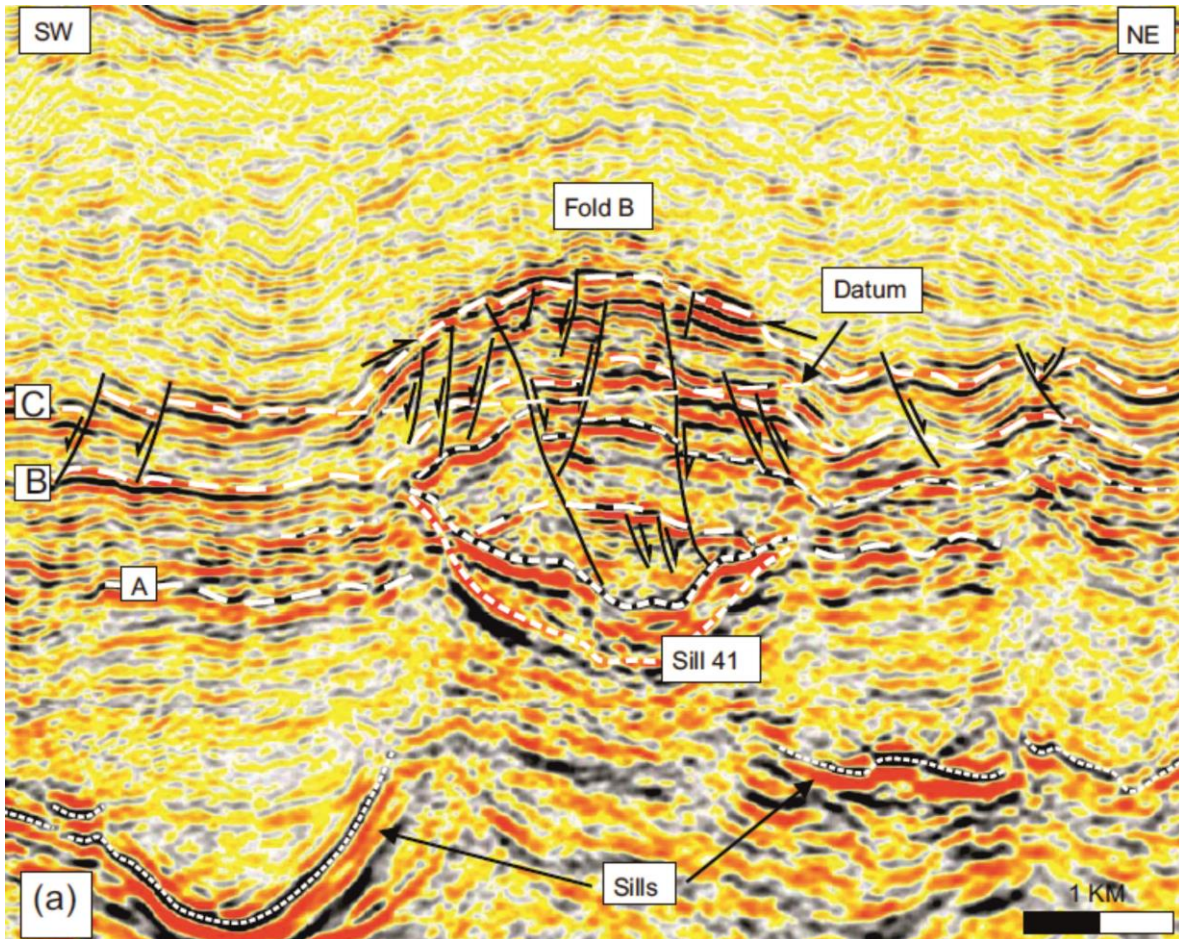


Figure 9: 2D seismic conducted northeast of Rockall basin, North Sea Norway. Observe normal faults as a product to accommodate the deformation of the fold. Taken from Hansen & Cartwright 2006.

- **Thermal Maturity:** the intrusion of magma of high temperatures (up to 1200 ° C) has a thermal effect on the country rock can get to promote maturation of hydrocarbons when diagenetic conditions are not optima .

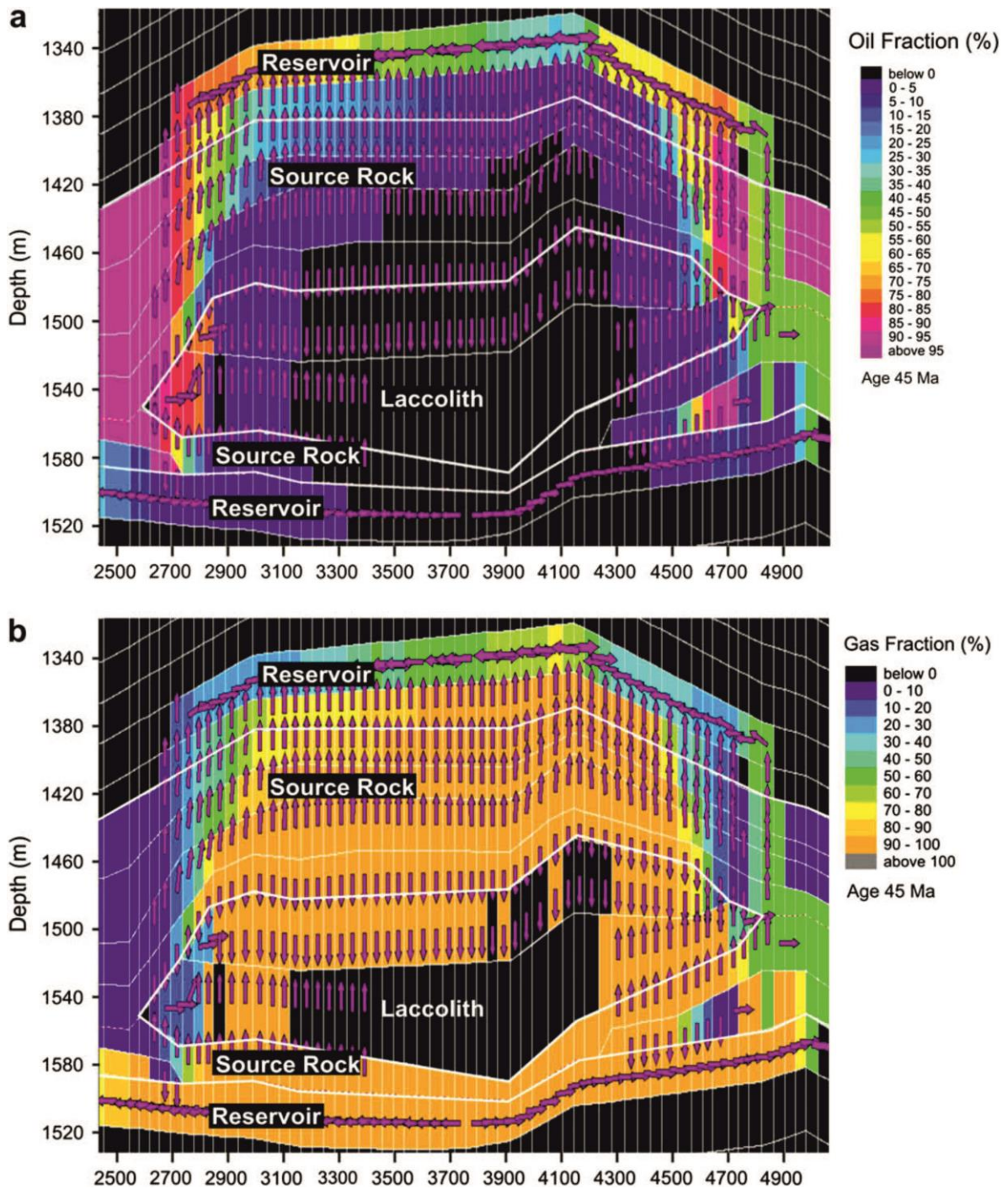


Figure 10: modeling of the distribution and direction of migration of oil and gas after the intrusion and cooling of a laccolith in the north of the Neuquen Basin and into the Vaca Muerta Fm province of Neuquen, Argentina

CONCLUSIONS:

The sill type intrusives are important reservoirs of hydrocarbons in sedimentary basins due to intense secondary porosity generated both in the country rock and the same intrusive given by fracturing the formation of stratigraphic traps as fold forced and effects thermal maturity they produce hydrocarbons by high temperature.

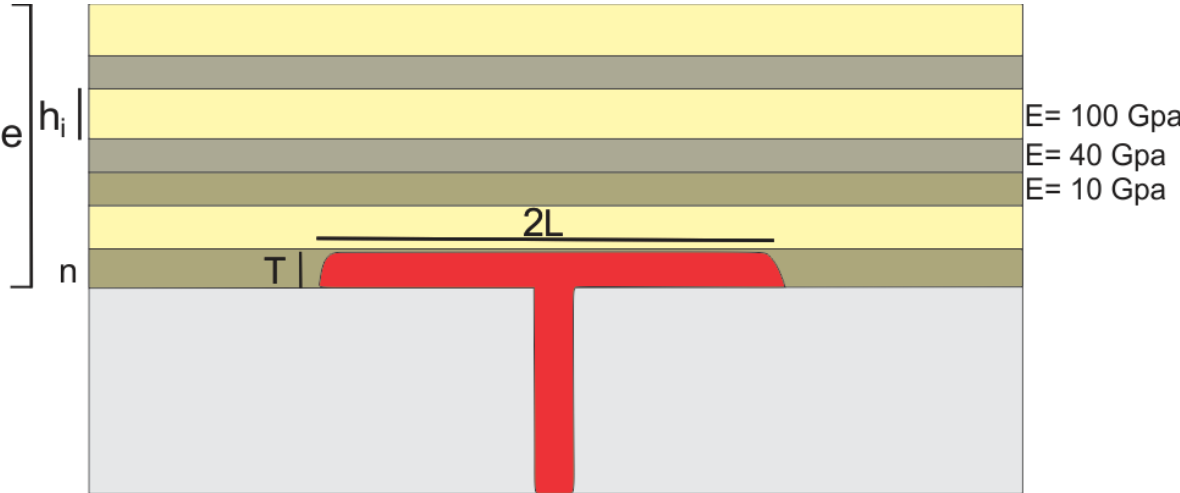


Figure 11: first stage in the construction of a sill. The levels correspond to greenish mudstones (E in very low resistance GPa) .

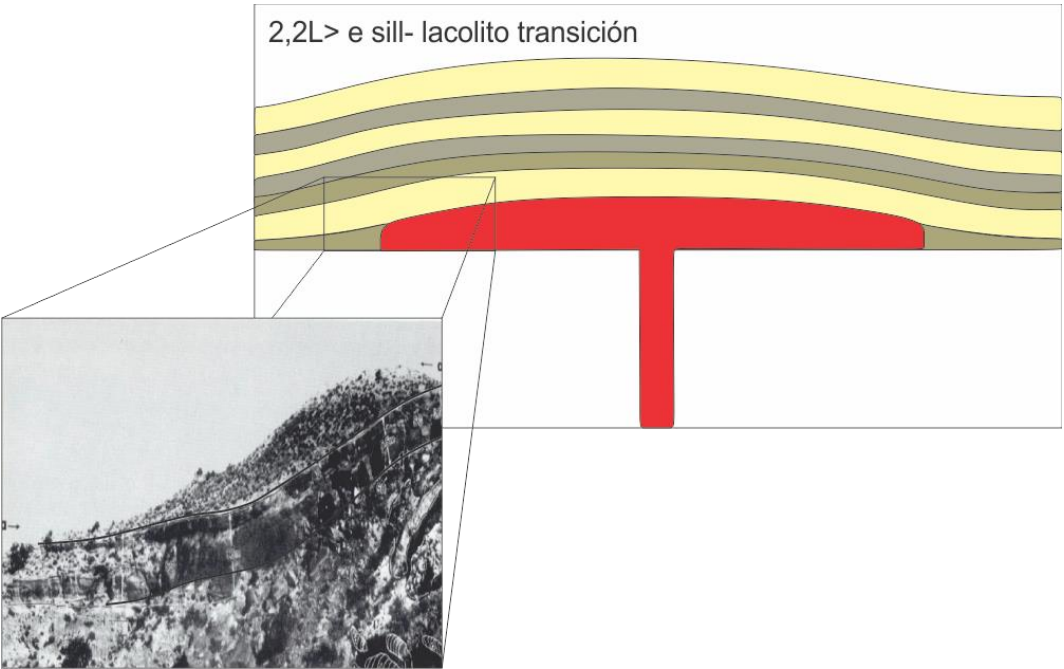


Figure 12: the sill by injection magmatic growing thicker generating a concavo- planar geometry type (lacolith) and buoyancy force to fold layers.

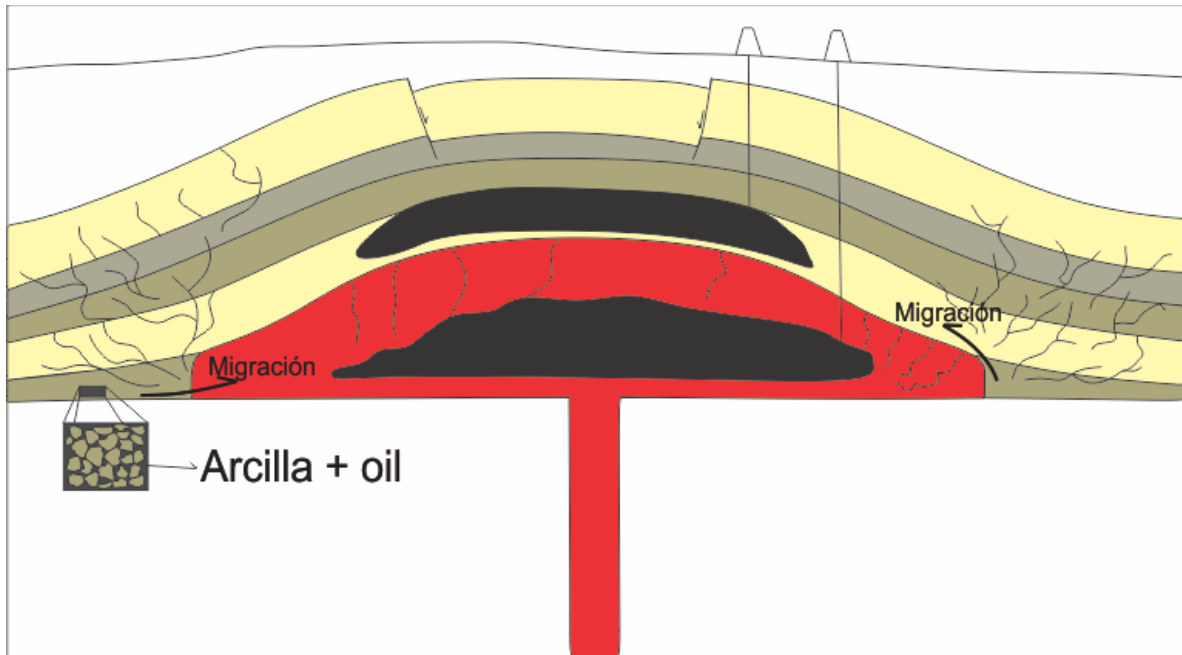


Figure 13: last stage of intrusion. Important fracturing is generated at the vertices of lacolith by cooling in turn internally fracture (fracture columnar) generating an internal reservoir and rock fractures box facilitates migration levels permeable sandy .

The study of these bodies is still a field of almost unexplored research, would be useful to extend the hydrocarbon resources more detailed analysis of them, because as mentioned above the sills tend to be located in source rocks generating a Natural fracking it.

ACKNOWLEDGEMENTS:

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