Submarine fan - reservoir quality description (Marine depositional environment)

Submarine fan - reservoir quality description

Accumulation ⇔ GU X has good reservoir potential

No accumulation ⇔ GU X has poor to no reservoir potential

has_good_reservoir_potential(GU):-

has_facies (GU, FA),

facies_porosity (FA, Por), higher_eq (Por, medium),

facies_permeability (FA, Perm), higher_eq (Perm, medium),

facies_lateral_continuity (FA, LAC), better_eq (LAC, moderate),

facies_vertical_conectivity (FA, FVC), better_eq (FVC, moderate).

%% Facies_porosity and facies_permeability depend on total grain volume and size and total clay content.

has_poor_to_no_reservoir_potential(GU):-

has_facies (GU, FA),

facies_porosity (FA, Por), lower_than (Por, medium),

facies_permeability (FA, Perm), lower_than (Perm, medium),

facies_lateral_continuity (FA, LAC), poorer_than(LAC, moderate),

facies_vertical_conectivity (FA, FVC), poorer_than (FVC, moderate).

Submarine fan - reservoir quality description

Effective migration through a carrier bed (GU X) ⇔ GU X has good carrier bed potential

Less effective to no migration through a carrier bed (GU X) ⇔ GU X has poor to no carrier bed potential

has_good_carrier_bed_potential (GU):-

has_facies(GU, FA), facies_permeability(FA, Perm), higher_than(Perm, medium),
facies_porosity (FA, Por), better_eq(Por, moderate),
facies_lateral_continuity(Fa, LAC), better_than(LAC, moderate),
faces_vertical_conectivity(FA, FVC), better_than(FVC, mderate).

has_poor_to_no_carrier_bed_potential (GU):-

has_facies(GU, FA), facies_permeability(FA, Perm), lower_than(Perm, medium),
facies_porosity (FA, Por), lower_than(Por, moderate),
facies_lateral_continuity(Fa, LAC), poorer_than(LAC, moderate),
faces_vertical_conectivity(FA, FVC), poorer_than(FVC, mderate).

Submarine fan - reservoir quality description

has_facies(GU, a).
has_facies(GU, b).
has_facies(GU, c).
has_facies(GU, d).
has_facies(GU, e).
has_facies(GU, g).

belongs_to_res_element(a, feeder_channel).
belongs_to_res_element(b, distributary_channel).
belongs_to_res_element(c, lobe).
belongs_to_res_element(c, sheet).
belongs_to_res_element(d, lobe_fringe).
belongs_to_res_element(e, levee).
belongs_to_res_element(g, basin_plain).

facies_porosity(a,medium).
facies_porosity(b,high).
facies_porosity(c,very_high).
facies_porosity(d,low).
facies_porosity(e,medium).
facies_porosity(g,very_low).

facies_permeability(a,very_high).
facies_permeability(b,high).
facies_permeability(c,high).
facies_permeability(d,low).
facies_permeability(e,medium).
facies_permeability(g,very_low).

facies_lateral_continuity(a,poor).
facies_lateral_continuity(b,moderate).
facies_lateral_continuity(c,good).
facies_lateral_continuity(d,good).
facies_lateral_continuity(e,poor).
facies_lateral_continuity(g,good).

facies_vertical_conectivity(a,poor).
facies_vertical_conectivity(b,moderate).
facies_vertical_conectivity(c,good).
facies_vertical_conectivity(d,poor).
facies_vertical_conectivity(e,poor).
facies_vertical_conectivity(g,good).

better_than(very_good,good).
better_than(good,moderate).
better_than(moderate,poor).
better_than(poor,very_poor).

higher_than(very_high,high).
higher_than(high,medium).
higher_than(medium,low).
higher_than(low,very_low).

poorer_than(very_poor, poor).
poorer_than(poor_moderate).
poorer_than(moderate, good).
poorer_than(good_very_good).

lower_than(very_low, low).
lower_than(low, medium).
lower_than(medium, high).
lower_than(high, very_high).

Reservoir quality in deep-marine system

Reservoir quality in deep-marine system is controlled by:

- The sediment depositional process
- Source of sediments area
- Burial history (temperature and burial depth history)

- Main **depositional processes** are:
  - High-density turbidity currents
  - Low-density turbidity currents
  - Strong sustained seafloor currents – well preserved reservoir quality
- Porosity and especially permeability are influenced by **grain size** and **total clay content.**
  - High-energy transport processes (high-density turbidity currents and strong sustained seafloor currents) deposited the coarsest and most clay-free sediment.
  - Dewatering removes some fines and give slightly better reservoir quality
- Sedimentary rocks that experienced higher thermal exposure have greater quartz cement abundances and poorer reservoir quality.

Reservoir quality in deep-marine system
Facies description (Mutti &Ricci)

Facies A

- **Debris flow,** consists of poorly sorted, mud-rich sst with subangular and pebbly mudstones; the large, subangular clast imply short transport distance; total grain volume is between 42-68%, total clay volume is between 18-40%.
- **Porosity** between **5-30%,** but mostly between **5-12%**
- **Permeability** from **0.1 to 1000mD,** but median is around **1mD.**

Facies B

- **Massive sst**, amalgamated, interbedded or dewatered, have grain size from fine to course-grained, but mostly **medium-grained**; have the least **total clay content**, between **8-26%,** the most **total grain volume**, between **48-82%.**
- Good depositional **porosity**, between **15-30%,** with a median porosity of 25 %.
- **Permeability** generally up to **10mD**, a bit lower in interbedded sst, and higher than 100 mD in dewatered sst.

Facies C and **Facies D**

- **Graded and laminated sst,** have grain size from **fine to medium-grained**, sometimes course-grained; have **total grain volume** between **52-68%,** but also lower, between 40-48%; **total clay content** ranges between **6-40%.**
- **Porosity** between 5-25%.
- **Permeability** between 0.1->1000mD; cross-laminated sst have almost have values lower than 1mD; graded sst have more than half values higher than 1 mD.

Reservoir quality in deep-marine system
Facies description (Mutti &Ricci)

Facies E

- **Heterolithic sediments** are made up of thin sst beds, < than 10 cm, very fine to fine-grained; **total grain volume** is between **30-68%,** and **total clay content** between **12-68%.**
- **Porosity** between **5-35%.**
- **Permeability** between 0.1 – 1000mD , but more than 90% values below 1mD.

Facies F

- **Deformed sst,** have a **total grain volume** of **54-76%, total clay content** between **14-22%.**
- **Porosity** is between 5-25%, with a median porosity of 13-14%.
- **Permeability** is between **0.1 – 100mD,** with injected sst having more values(40%) above 1mD than the slumps and slides (20%).

Submarine fan - reservoir quality description

We can use only a limited number of scenarios, like the 3 examples below, or we can simulate all possible scenarios based on proximal_than relationship.

Valid scenarios must take into account the distance from the source of sediments;

proximal to distal: feeder channe, distributary channel, lobe, lobe fringe, basin plane.

proximal_than(feeder_channel, districbutary_channel).
proximal_than(distributary_channel, lobe).
proximal_than(lobe, lobe_fringe).
proximal_than(lobe_fringe, basin_plain).

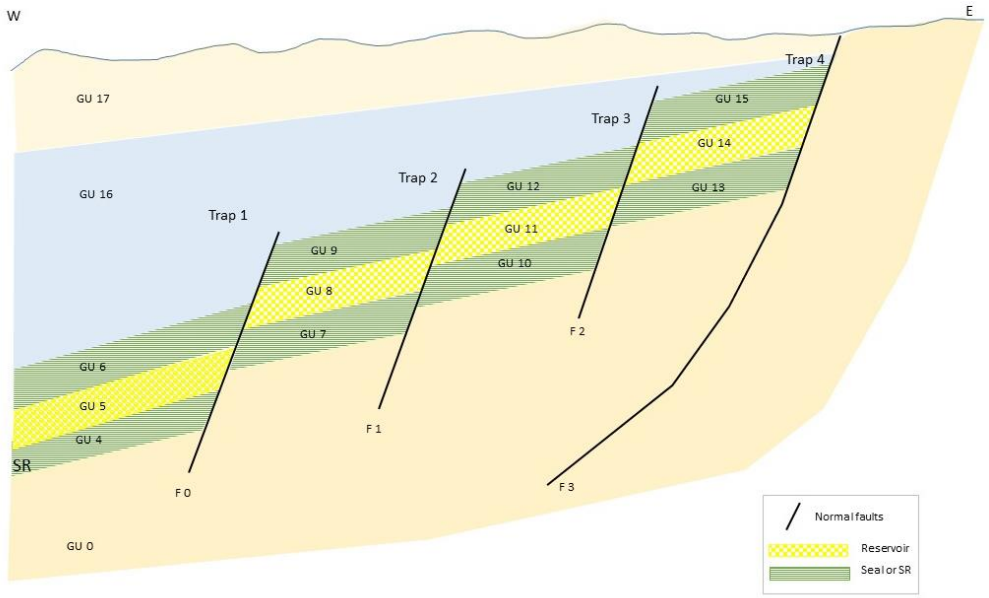
proximal_than(GU14, GU11).
proximal_than(GU11, GU8).
proximal_than(GU8, GU5).

Scenario1
Belongs_to_res_element({GU5, GU8, GU11, GU14}, lobe).

Scenario 2 belongs_to_res_element(GU5, lobe).
belongs_to_res_element(GU8, lobe).
belongs_to_res_element(GU11, distributary_channel).
belongs_to_res_element(GU14, feeder,_channel).

Scenario 3
belongs_to_res_element(GU5, lobe_fringe).
belongs_to_res_element(GU8, lobe).
belongs_to_res_element(GU11, distributary_channel).
belongs_to_res_element(GU14, feeder,_channel).

Scenario 4 and so on



Summary

- GU X has good reservoir potential if GU X belongs to reservoir elements: lobe, sheet, distributary channel, levee, feeder channel.
- GU X has poor to no reservoir potential if GU X belongs to reservoir elements: lobe fringe, basin plain.

- GU X has good carrier bed potential if GU X belongs to reservoir elements: lobe, sheet, distributary channel.
- GU X has poor to no carrier bed potential if GU X belongs to reservoir elements: lobe fringe, feeder channel, basin plain.