Angiogeology and Quantum Geophysics

Introduction & Quick Overview

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Agenda

- Introduction – Hydrogeology Key Facts
- Groundwater Flows
  - Downward flow : by infiltration
  - Upward flow : through water vessels
- Optimum Groundwater Collecting Spots
- Detection Technique : Quantum Geophysics
- Picturing Groundwater Flows
- About ANGIOO

Introduction (1/3)

*Exploiting an hydrogeological resource consists in **drawing a geological fluid from a natural flow** (and trying to collect as much as possible from as big a flow as possible)*

whereas

*Exploiting **any** other geological resource consists in **extracting that resource from a deposit** (and emptying that deposit to an "economically justifiable" extent)*

- In hydrogeology only the ***flow*** – and ***not*** the size of resource – matters.
- ***Declining flow over time is the #1 problem*** of all hydrogeological exploitations.
- An hydrogeological exploitation ***must*** achieve ***sustainability*** *(through achieving a constant yield over time).*
- ***You don't find sustainable and exploitable groundwater flows by chance*** *(as these are always very localized). The probability of finding an aquifer by chance is higher [than that of an exurgence point]- but the drawing location is then likely to be suboptimal (whereby the drawdown will undergo clogging and ultimately run dry over time).*

Introduction (2/3)

- All exploitable underground reservoirs and aquifers are **confined** and integrated into a **flow:**
  - *Fossil* water reservoirs are exceptional and of no interest to **geothermal, hydrothermal** or **hydro-mineral** exploitations.
- The deeper the reservoir or aquifer, the closer its hydrodynamics to **stationary.**
- Stationary flow supposes equal **incoming** and **outgoing flows** (through the aquifer) – possibly over periods spanning geological era(s).
- **Sustainable** hydrogeological exploitations suppose drawing from the natural flow without emptying the reservoirs integrated to that flow.
- **Optimal** exploitation supposes **drawing as much as possible from the natural flow** (without exceeding that natural flow otherwise one starts drawing from stores).
- ANGIOO's approach to hydrogeology is about achieving ***both sustainable and optimal exploitation of hydrogeological resources.***

Introduction (3/3)

- All current geophysical survey and exploration ***techniques*** aim at locating ***static*** geological resources which, in the case of hydrogeology, correspond with hydrothermal / geothermal reservoirs and /or aquifers.
  - While the localization of ***deposits*** makes perfect sense for *most* geological resources it ***doesn't*** for hydrogeology (for which only the flow matters).
- Hydrogeologists traditionally associate groundwater ***flow*** with hydraulic gradient (which is relevant ***inside*** an aquifer but not for flows through water vessels).
- ***Angiogeology*** is the complementary approach to hydrogeology : it focusses on flows; not on stores (such as reservoirs and aquifers).
- The detection technique used by angiogeology is called ***quantum geophysics***.
- ***Quantum geophysics detects groundwater flows (and only that) through water vessels.***
  - It does not detect reservoirs and/or aquifers. The great news is that it doesn't need to, as ***only the flow matters*** for hydrogeologoical exploitations.
- The detection of groundwater flows combined with groundwater flow models open extraordinary perspectives for exploiting hydrogeological resources.

Think Flows … not Stores

Hydrogeology must focus on flows, not on stores

… just as …

- *Economy should primarily focus on goods and money **flows** rather than on how much of them is stored or available and who owns them.*
- *Transportation and mobility should primarily focus on goods and people **flows** rather than where these are located and how much of them is concentrated at these locations.*
- *…*

*Unfortunately there is a human brain bias that focusses on **static** aspects rather than on dynamic and moving aspects.*

The great news is that, in hydrogeology, you don't need to bother about stores (such as reservoirs, aquifers,…) to exploit optimally hydrogeological resources.

Groundwater Flows

- Groundwater flows are either :
  - ***Downward flows*** associated with the infiltration of surface water and rainfalls.
    - The downward flow mainly replenishes phreatic zones (and barely goes deeper).
    - The downward groundwater flow is ***not*** exploitable in hydrogeology (it is too diffused for that); only the upward flow is.
  - ***Upward flows*** rising from the depth of the earth crust.
    - The upward flow is initiated by the ***subduction*** of tectonic plates which act as rolling mills on soaked plates.
    - The groundwater so extracted from the tectonic plates has a high enthalpy (high pressure caused by the plate compression and high temperature caused by the heating by the magma).
    - This upward flow starts in geothermal reservoirs, then rise further to feed aquifers and rise even further to feed the phreatic zone.
  - In the preatic zone, the upward flow balances the downward flow (over "*long enough*" periods of time).

Upward Groundwater Flow (1/4)

- The ***upward groundwater flow*** is alternating between :
  - ***Low flow rates*** in high porosity areas (which correspond to geothermal/hydrothermal reservoirs, aquifers, phreatic zones).
    - *These low flow rates typically translate themselves in an hydraulic gradient.*
  - ***High flow rates*** going exclusively through natural conduits called water vessels.
    - *These natural conduits are very stable in space and time.*
    - High flow rates optimize the ***energy lost in friction*** (the larger the section of the conduit, the better) and ***energy lost in turbulence*** (the smaller the section, the better). The balance so achieved is called the ***law of radial determination*** of the water vessel section.
    - The "*variable*" played upon by Nature to minimize the energy loss is the ***number*** of conduits produced (not their section which stems from the ***law of radial determination*** of the water vessel).
    - There is *no "medium flow rate" (as hydrodynamics leaves no room for that type of "hybrid" flow).*

Upward Groundwater Flow (2/4)

- The upward groundwater flow typically goes through three to four regions of high porosity before ultimately reaching the surface.
  - It originates in a geothermal reservoir and goes to the surface through one or more aquifers and ultimately through the phreatic zone.
  - When the upward flow goes ***directly*** from a geothermal reservoir to the surface, it produces surface thermal manifestations (like hot springs, mud pools, geysers, salses, solfatares …). This situation is rather exceptional with respect to the total number of geothermal reservoirs (only a tiny fraction of them have efferent conduits reaching ***directly*** the surface).
- The upward groundwater flow produces a tree-like network of conduits. These ramifications evoke that of the blood system, hence angiogeology uses the following terminology by "*a loose*" analogy:
  - The generic term for geofluid conduits is ***"water vessels" (***which include both water arteries and water veins).
  - Conduits rising from geothermal / hydrothermal reservoirs are called ***"water arteries"*** (they are characterized by high enthalpy and feed deep aquifers).
  - Conduits rising from aquifers are called ***"water veins"*** (they feed higher level aquifers or the phreatic zone).

Upward Groundwater Flow (3/4)

- The transitions between high porosity zones and water vessels (called initial feedings) can be viewed as "*leaks*". These leakage points are called **exurgences** (from the Latin "**ex urgere**" : squeeze out) which are spots where the upward flow is concentrated the most.
- Groundwater hydrodynamics determines that :
  - there can only be a ***small number*** of these leaks per reservoir.
  - these leaks are ***very localized*** and located above the reservoir/aquifer (because the flow is going up).
  - ***the deeper the reservoir or aquifer, the fewer the leaks*** (generally just one for deep geothermal and hydrothermal reservoirs).
- Exurgences give rise to "***connate***" conduits (from the Latin "**cum natus**" : born with) originating from the same point and forming a regular star-like structure in all [horizontally-projected] directions.
- ***The exurgence points are the best places to collect the upward flow :***
  - They are the locations where the flow is concentrated the most.
  - The collected flow would not compete with the natural outgoing flow (*because they occur at the same spot*).

Upward Groundwater Flow (4/4)

- The upward flow forms a tree-like network of conduits :
  - the closer to the ground surface, the ***higher*** the density of water vessels.
  - the closer to the ground surface, the ***smaller*** the average flow rate per water vessel (to globally balance the higher number of water vessels).
- Exurgence points of geothermal / hydrothermal reservoirs have a ***much higher flow rate*** than exurgence points of [deep] aquifers but they are less numerous and also ***substantially deeper*** (typically ~ 1000 m instead of ~ 100 m).
- Drawing the flow ***precisely*** at the location of the stub of the tree-like structure of water vessels (i.e. the connate exurgence) requires a precision in the detection technique that only ***quantum geophysics*** can achieve.
- The topographic characteristics of the upward groundwater flows provide a wealth of information over the potential yield of the hydrogeological resource producing those flows or integrated to those flows.

Optimum Collecting Spots

- ***Exurgence points*** are ***the optimum collecting spots*** because:
  1. that's where ***the flow is concentrated the most.***
  2. the well drawing the flow at that very location is ***not competing with the natural flow***: it merges with it (and diverts it to the surface).
  3. for geothermal / hydrothermal reservoirs, that's where ***the temperature is the highest*** (i.e. where there is the least heat lost in conduction).
  4. that's where the ***pressure is the highest*** (as the head losses are minimized).
  5. they are the ***closest to the earth surface*** as the "*neck*" of the reservoir opens up progressively downwards (drilling elsewhere requires to drill deeper).
  6. they ***minimize the cluttering risk*** (e.g. through sands) as they correspond with the maximum flow rate (and therefore will wash sands more easily).
  7. that's where ***the brine is the purest*** (i.e. has the least particles in suspension and the least non dissolvable gas).
  8. Drawing the flow there ***alters the least the natural groundwater flow hydrodynamics*** and therefore minimizes artificial lithological tensions as well as the risk of induced seismicity.
- This applies to ***all types of*** hydrogeological resources.

Detection Technique (1/2)

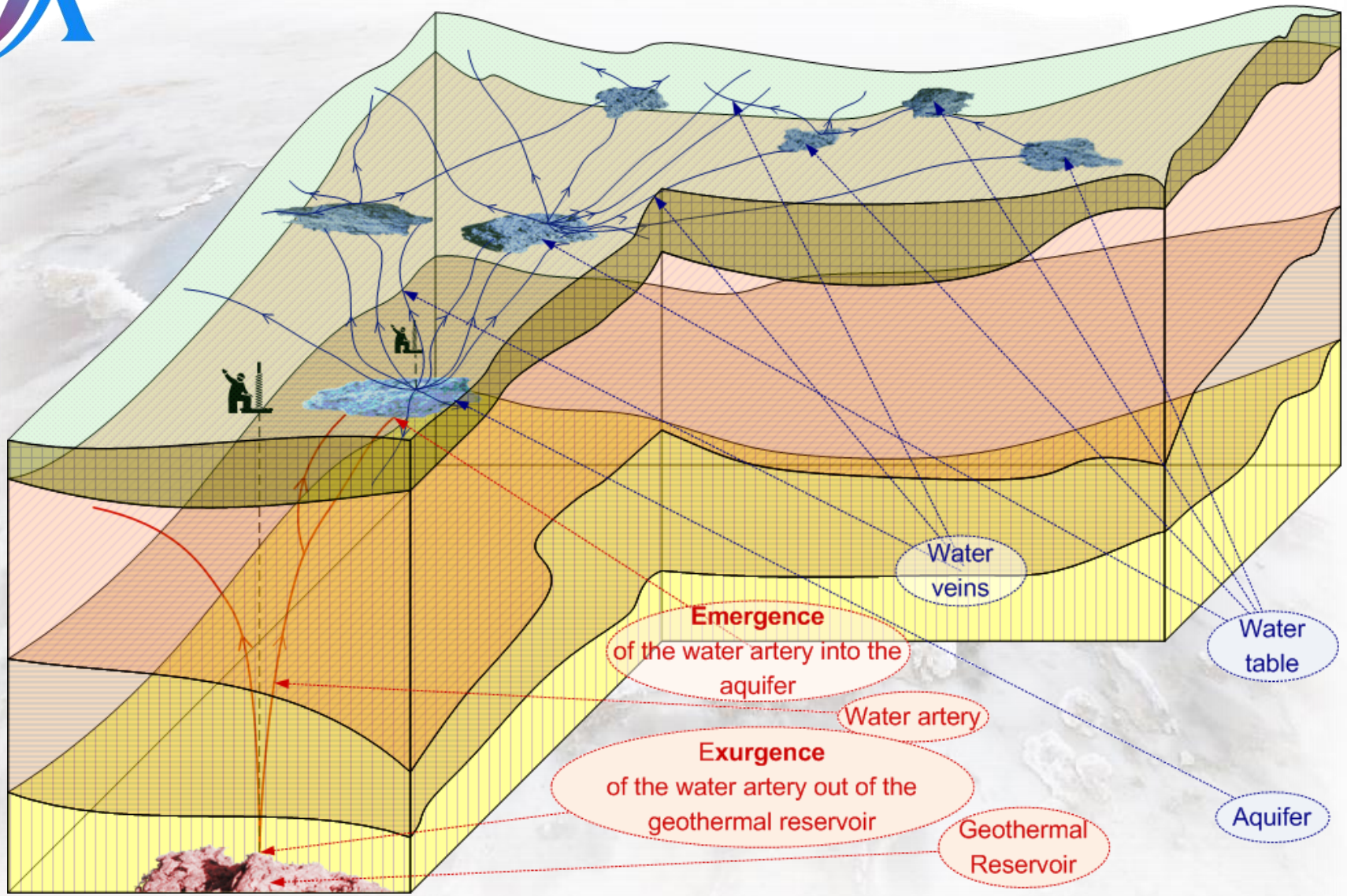
- The detection technique used in angiogeology is called ***quantum geophysics.*** Heuristically it works in the following way:
  - Upward underground natural flows (through water vessels) cause water molecules to vibrate at a consistent frequency.
  - The vibration frequency achieved by those water molecules lies in a frequency range capable of influencing the geoneutrinos energy (defined by : $E = h\nu$).
  - While going through water vessels, geoneutrinos enter in resonance with the vibrating water molecules. The frequency of their associated wave packets become coherent.
  - The coherent wave packets associated with all geoneutrinos passing through the same water vessel interact and produce a macroscopic phenomenon which can be viewed as a **wake** arising vertically from the exact position where the geoneutrino passes through the water vessel (a boat's wake is the best analogy to illustrate the cumulative effect of these coherent wave packets).
  - The so-formed wake goes up vertically (because geoneutrinos come from all locations of the earth sphere which enforces vertical symmetry).
  - ***Quantum geophysics detects those wakes*** and therefore the underlying water vessels.
  - The topological proprieties of the water vessels so detected combined with flow models enable to locate the exurgence points and to determine whether they are associated with a geothermal reservoir or with an aquifer, as well as their potential yield.

The Detection Technique (2/2)

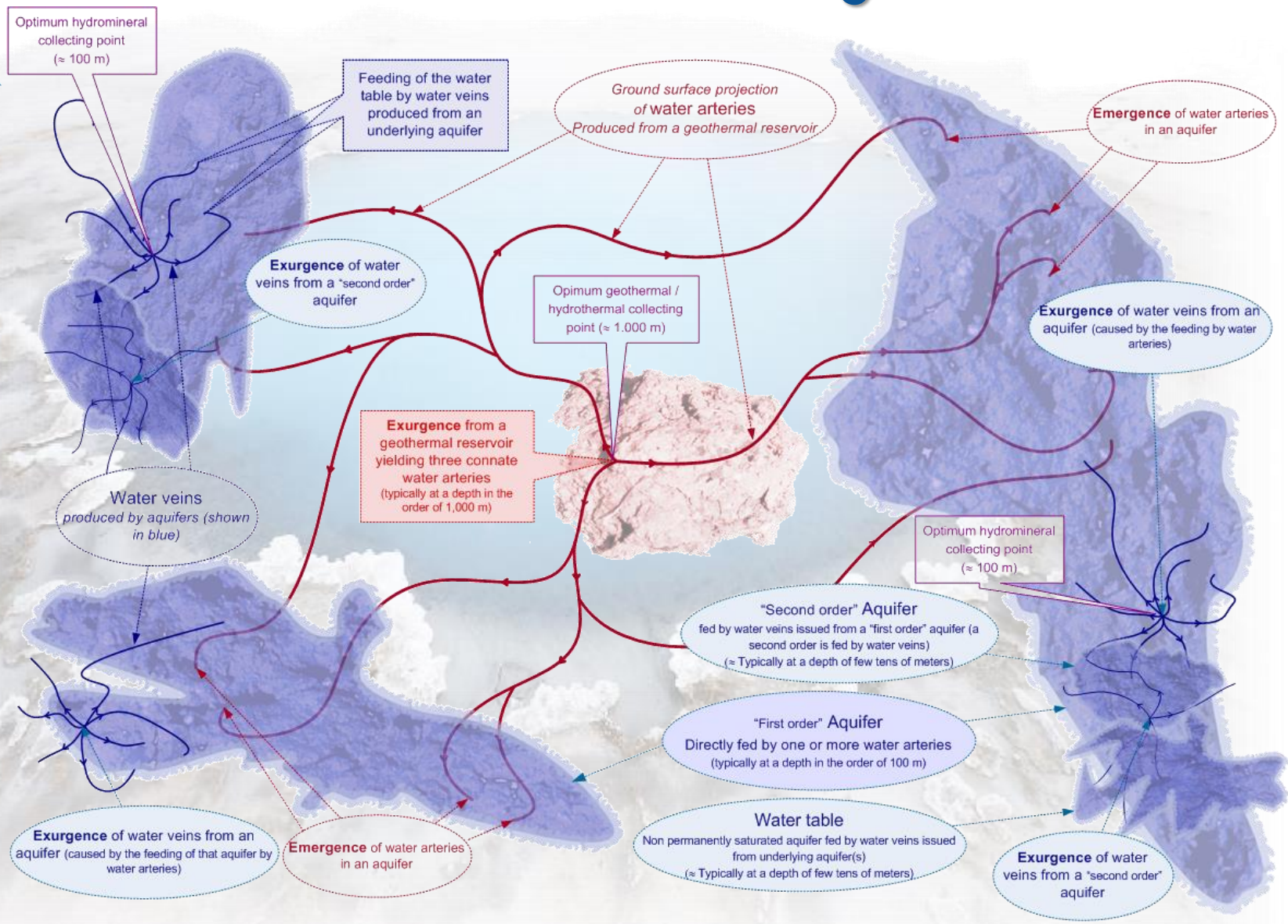
- ***Quantum geophysics*** enables, sometimes in a week or so and for a survey territory of a few km^2, to determine :
  - the ***optimum collecting points*** of deep water reservoirs:
    - with a ***precision of a few centimeters on their projection*** on the earth surface
    - with a precision of about 30% on their depth (hence we can only recommend vertical drilling).
  - the ***projection of their path on the earth surface*** as well as an estimate of their depth along their curvilinear abscissa (measured from their exurgence point up to their terminating or emergence point).
  - the exact ***number of connate water vessels*** formed at the exurgence point(s) (which is directly correlated with the efferent flow, this correlation being always modulated by the estimated depth).
  - the possible relationships between detected water vessels forks and known geological layers transitions (to calibrate the depth).
  - the interval lengths between capillaries formed along the path of the water vessels (correlated with the pressure gradient).

… and therefore assess the productivity potential of any geothermal / hydrothermal reservoir or deep aquifer.

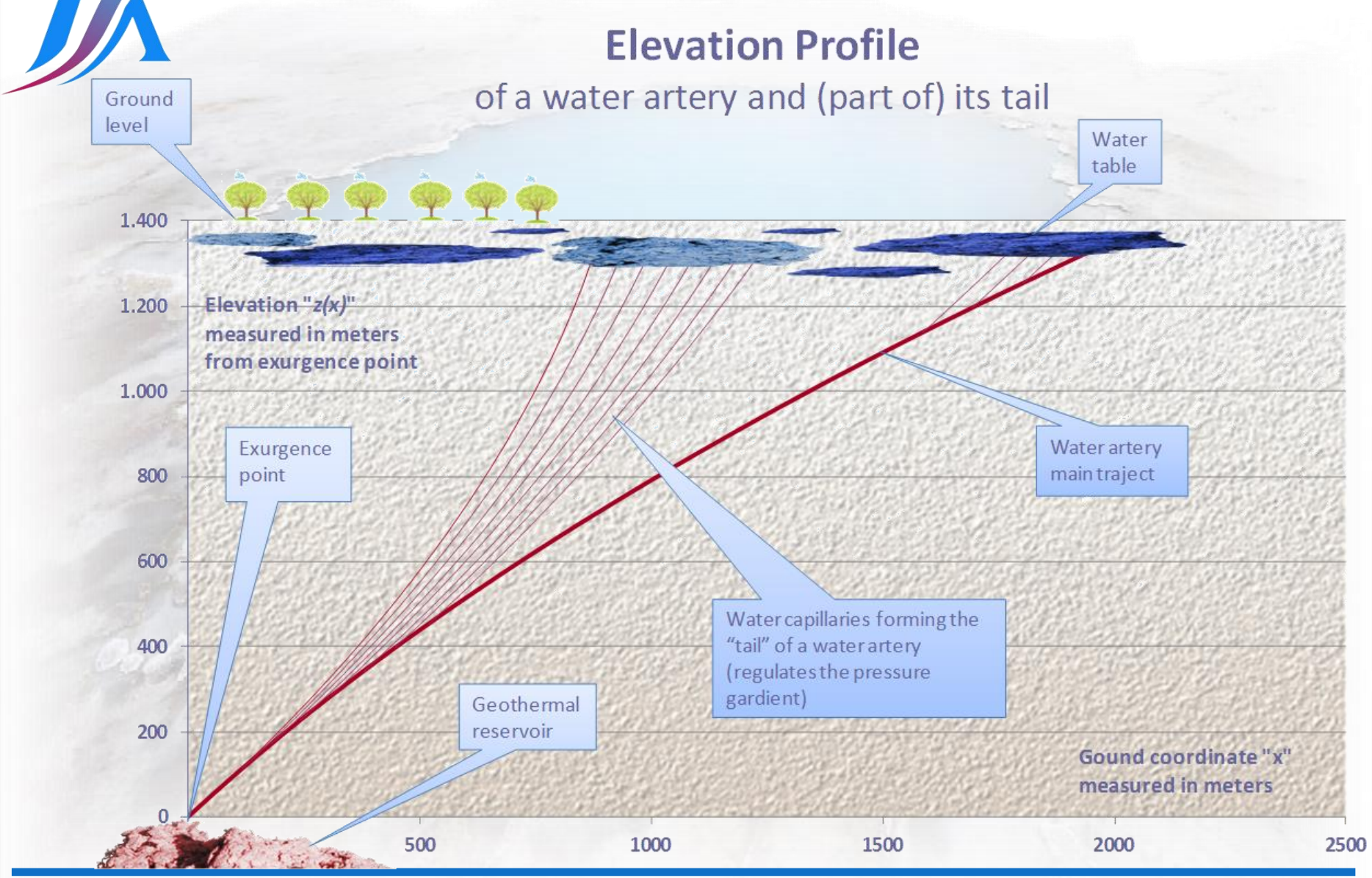
How does it look like in 3D ?



How does it look like in 2D ground view ?



How Does the Elevation Profile Look Like?



How does it look like in the field ?

About Angioo Ltd

- **Specialized** in precisely locating the optimum drilling location for exploiting ***geothermal*** (*for power generation*), ***hydrothermal*** (*for balneotherapy*) and ***hydromineral*** (*for mineral water extraction*) resources.
- Founded by 2 scientists with a background in fluid dynamics, quantum physics, control (on which our models are built) and hydrogeology.
- Has developed a proprietary detection method (called ***quantum geophysics***) enabling to precisely locate upward groundwater flows (only flows through water vessels, not high porosity stores such as reservoirs nor aquifers).
- Has developed groundwater flow models to assess, in combination with field detection, the long-term yield ***potential*** of hydrogeological resources.
- Operates worldwide (in stable countries where the rule of law applies).
- Works ***result-based*** and makes its fee depend on the actual yield of the hydrogeological resource exploited.
- More info on www.angioo.com