Groundwater & Aquifers at Zuuvch Ovoo area

Water is a vital natural resource. Understanding where it is and how it moves under the ground is essential in protecting this resource. By using geological maps and taking samples of underground and surface water for analysis, hydrogeologists are building a detailed picture of how water flows underground.

Employee measuring groundwater level in a monitoring well

Aquifer: an underground layer of permeable rock or unconsolidated materials (gravel, sand or silt), where water is stored and moves slowly over time. It is not an underground lake but more like wet sand.

Groundwater: water stored in the aquifer.

Aa aquifer is part of the water cycle and is heavily dependent on the climate.

An aquifer is **replenished or recharged** naturally by rain and snow melt but also by surface water, if present.

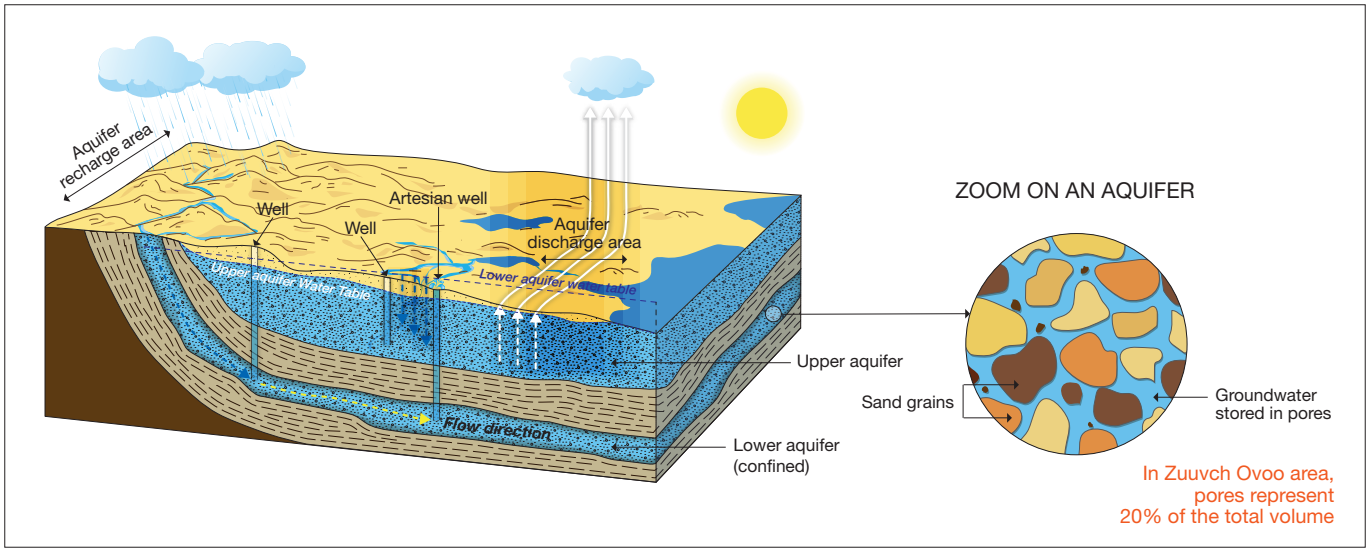
Discharge from the aquifer occurs through evaporation in temporary lakes or outlets such as springs.

The groundwater flows from recharge areas to discharge areas.

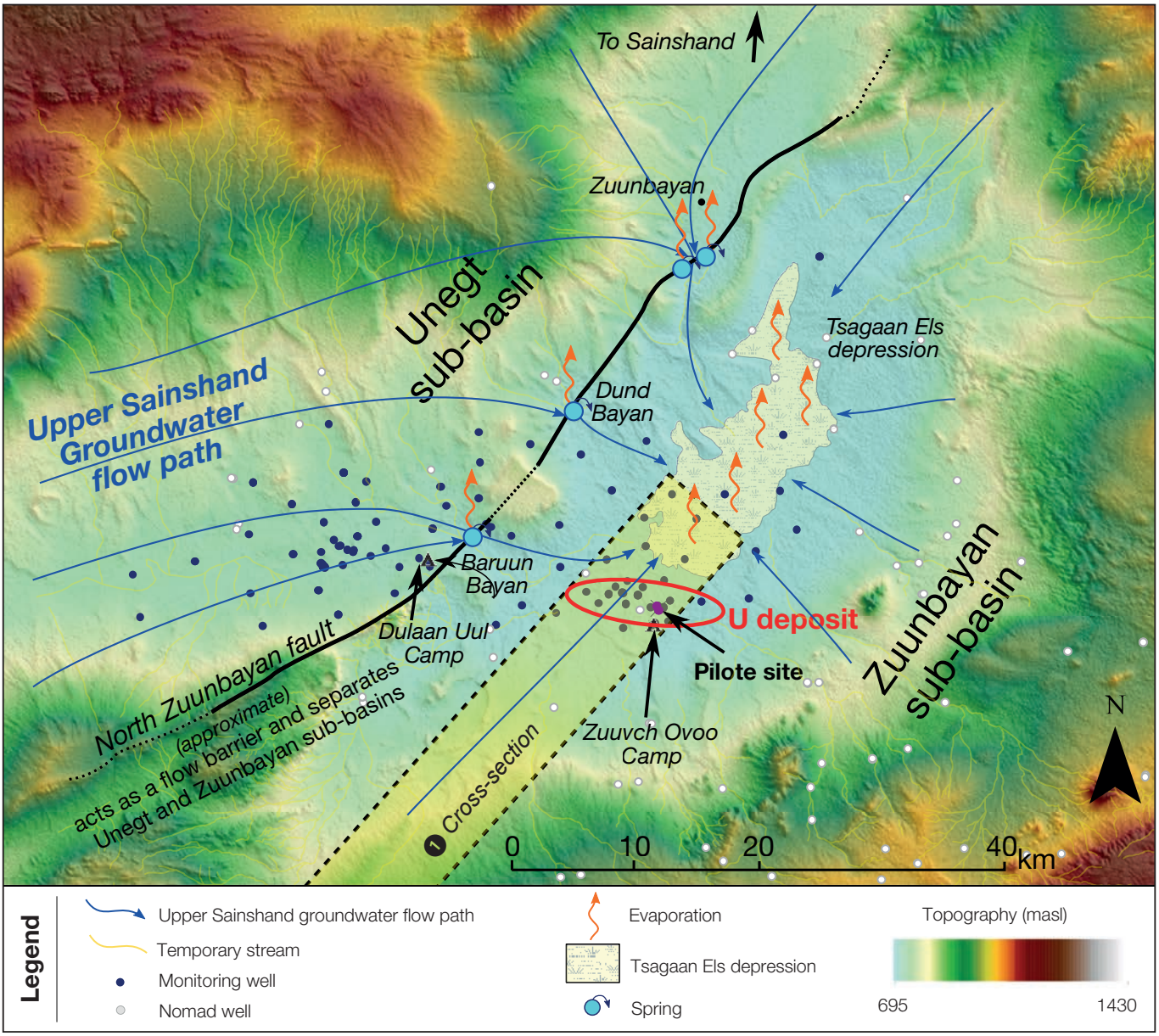
Even if annual precipitation is small, a small portion, less than 3%, manages to infiltrate deep into the soils into recharge areas.

Near Zuuvch Ovoo, most of the precipitation falls in summer when evaporation is at its maximum. These conditions prevent the existence of permanent surface water except at a few springs.

Water levels are used to estimate the direction of groundwater flow. They are measured manually in monitoring wells.



Groundwater flow direction



Groundwater flows at the Zuuvch Ovoo areas

Groundwater coming from Unegt Sub-basin emerges along the North Zuunbayan fault and creates springs*.

Evaporation occurs at these springs and in the Tsagaan Els depression, which is the terminal discharge area of the aquifer.

Groundwater moves slowly

In Zuuvch Ovoo, groundwater moves slowly, between 1 and 10 meters per year.

Considering these low velocities and the size of the basin, several thousand years may be necessary for the groundwater to reach the Uranium deposits.

GROUNDWATER AGE

The radiocarbon dating method applied to different water samples taken at Zuuvch Ovoo area estimated the groundwater age as:

- between 2,000 and 12,000 years for the Upper Sainsahnd aquifer
- between 1,000 and 8,000 years for the shallow Bayanshiree aquifer

The groundwater has slowly interacted over thousands of years with the minerals present in the aquifers. The groundwater age and low velocity partially explain the poor quality of the groundwater.

* See photos on the page 3

Aquifers in Zuuvch Ovoo Areas

Two geological formations are considered as aquifers: Bayanshiree (shallow) and Upper Sainshand (deep).

These aquifers are mainly made of unconsolidated sand with interbedded layers of clay.

Geological data and long-term pumping tests have demonstrated that there are no hydraulic connexions between these aquifers.

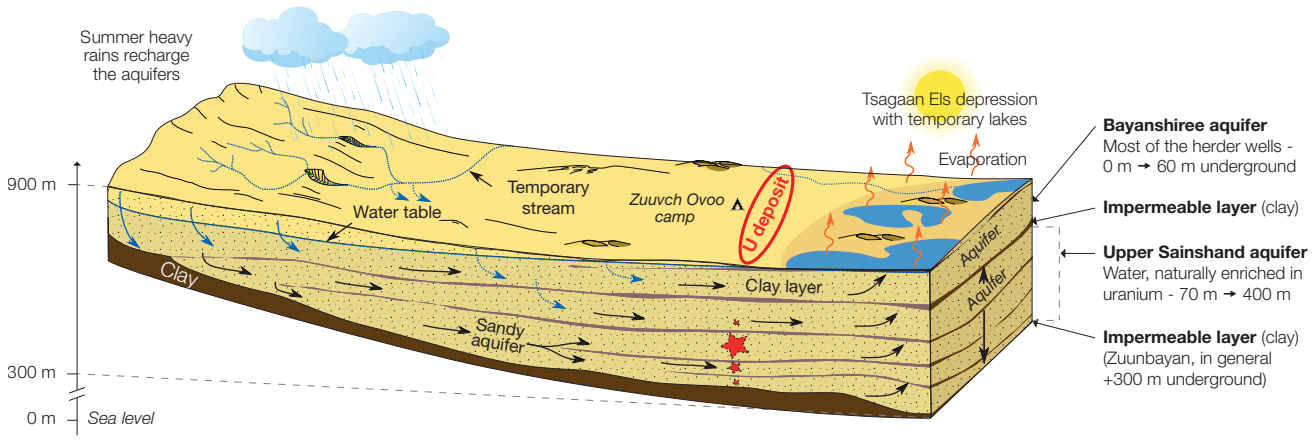
- **The uranium deposit** is located at the bottom /middle of the Upper Sainshand aquifer, which is well isolated from the shallow Bayanshiree aquifer by numerous clay barriers
- **Nomad wells** are located at the shallow Bayanshiree aquifer

- **Bayanshiree aquifer = up to 60 m deep**
- **Upper Sainshand aquifer = 150 /200 m deep**

Pastoral well

1 *Simplified 3D Cross-section*

Hydrogeology at the Zuuvch Ovoo Area



Zuunbayan discharge area - september 2016

Baruun Bayan discharge area - september 2016

Water chemical composition in the Zuuvch Ovoo area

Examples of parameters exceeding standards	Unit	Standard (MNS 900:2005 or MNS 6148:2010 or WHO 2011)	Upper Sainshand (deep aquifer)[1]		Bayanshiree (shallow aquifer)[2]	
			Typical range of observed concentrations	% of samples exceeding standards	Typical range of observed concentrations	% of samples exceeding standards
Salinity	mg/l	1,000	630 - 20,200	98%	708 - 2,020	76%
Chloride	mg/l	350	62 - 8,330	90%	55 - 589	29%
Sodium	mg/l	200	195 - 6,560	98%	216 - 658	100%
Gross alpha activity	Bq/l	0.1	< 0.05 - 15.7	98%	< 0.05 - 0.91	79%
Uranium	µg/l	15	0.5 - 1,990	83%	10.2 - 129	95%
Sulfate	mg/l	500	123 - 3,330	66%	119 - 481	0%
Fluoride	mg/l	1.5	< 0.1 - 6.2	50%	1.4 - 4.4	95%
Manganese	µg/l	100	< 1 - 2,190	50%	< 0.5 - 67	0%
Selenium	µg/l	10	0.2 - 240	41%	< 0.2 - 161	71%

Data from the COGEGOBI Hydro-chemical database. The sampling period covers from 2010 to 2016.
Elements also exceeding water quality standards include arsenic, boron, molybdenum, radium and nickel

1: Statistics obtained from 58 monitoring wells - 2: Statistics obtained from 21 monitoring wells

Groundwater quality

The groundwater in the Zuuvch Ovoo area is unfit for human consumption, according to both international and Mongolian standards, because of its chemical composition.

Groundwater slowly interacts with the minerals present in the aquifers over thousands of years.

Data collected from the numerous wells indicate that groundwater contains high concentrations of sodium (Na+) and chlorine (Cl-).

These elements give the water a salty taste. In the deepest part of the basin, groundwater can even contain as much salt as seawater.

Many other elements, in particular uranium, are present in high concentrations.

Although the groundwater quality of the Bayanshiee aquifer is better, it still does not meet drinking water standards.

Badrakh Energy takes water samples in nomad wells and in the piezometers several times per year and sends them for analysis to the independent laboratories of Mongolia.

KEY POINTS TO REMEMBER

- Aquifers in the Zuuvch Ovoo area are underground permeable layers that are mostly made of sand, where groundwater is stored and moves **slowly** over time
- Groundwater is part of the water cycle and is heavily dependent on the climate
- Groundwater conditions in the Zuuvch Ovoo area have been studied since 2006 through a network of 200 monitoring wells
- The groundwater is not suitable for drinking, according to national and international standards
- This poor groundwater quality is partially due to the fact that groundwater has been slowly interacting with minerals in the aquifer over thousand years

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